FRASER RIVER ACTION PLAN

Pollution Abatement
Technical Summary Report

DOE-FRAP 1998-01

OCTOBER 1998

Environmental Protection Branch

Pacific and Yukon Region

ACKNOWLEDGEMENTS

This document is the product of a team of Environment Canada staff who worked on the pollution abatement component of the Fraser River Action Plan (FRAP). Andrew Green contributed to the completion of the industrial discharges projects and prepared Chapters 2 and 7. Phil Wong coordinated the municipal discharges projects, building on the original work of Alain David, and prepared Chapter 3. Marielou Verge contributed to the completion of the urban runoff projects and prepared Chapter 4. George Derksen developed the program strategy for agriculture, coordinated the agricultural runoff projects and prepared Chapter 5. Richard Glue coordinated the contaminated sites projects, and prepared Chapter 6 with the assistance of Rob Jones and Vince Haugland. Lisa Walls supervised the preparation and editing of this report and wrote the introduction and conclusions and recommendations in Chapters 1 and 8. Mike Nassichuk provided valuable guidance and editorial reviews.

Many other present and former Environment Canada staff contributed to the work of the pollution abatement component during the 7-year period of FRAP, including: Ed Wituschek, Stan Liu, Martin Pomeroy, Peggy Evans, Bert Kooi, Larry Adamache, Vivian Au, Bruce Galbraith, David Poon and Bob Shepherd.

Editing and layout services for this report were provided by Polestar Communications. Cover design was provided by Iris Communications Inc.

COMMENTS

This report contains a synthesis of many studies funded in part or in total by Environment Canada under the Fraser River Action Plan. To the knowledge of Environment Canada, and the other contributors to this report, the information contained herein is technically accurate. The reader is encouraged to advise Environment Canada, Pacific and Yukon Region, of any errors or omissions noted in the report.

Comments may be sent to:

Fraser River Action Plan
c/o Pollution Prevention and Assessment Division
Environmental Protection Branch
Environment Canada
Pacific and Yukon Region
224 West Esplanade
North Vancouver, B.C. V7M 3H7

Photo Credit:
Cover: G. Derksen; V. Au
Back cover: Environment Canada; G. Derksen

EXECUTIVE SUMMARY

The Fraser River, the fifth longest river in Canada, contributes significantly to the economic and social needs of both British Columbians and Canadians. The Fraser River Basin is a complex watershed sustaining the well being of its residents and the environmental integrity of numerous aquatic and terrestrial ecosystems. Two and one-half million people, over 60 per cent of British Columbia's population, live and work in the Fraser Basin, and this number is expected to grow by 50 per cent by 2021. The watershed drains more than 25 per cent of the province's land and encompasses 11 of the province's 14 biogeoclimatic zones.

During the 1980s, it became evident that the Fraser River ecosystem was facing considerable environmental stress. By the end of the decade, it was clear that an expanding human population—with its urban sprawl, expanding industrial development and increased agricultural production—was placing the Fraser Basin under tremendous and increasing stress.

THE FRASER RIVER ACTION PLAN

In response to concerns about the need to better manage and protect Fraser River ecosystems, the Government of Canada's Green Plan (1990) included a commitment to target the Fraser River basin for remedial action. On June 1, 1991, the Fraser River Action Plan (FRAP) was jointly announced by the Ministers of the Environment and of Fisheries and Oceans.

The three goals of FRAP were:

- to restore the natural productivity of the Fraser Basin,
- to reduce and clean up pollution, and
- to develop a management program for the basin based on principles of sustainable development

To meet these goals, Environment Canada (EC) organized FRAP into five components: planning and communication, habitat conservation, environmental quality, pollution abatement, and enforcement. The pollution abatement, environmental quality, and enforcement components shared responsibility for the pollution reduction and cleanup goal. Environment Canada's goals were further described as 48 "deliverables," which defined the objectives of the three broad goals.

From the start, it was recognized that FRAP could succeed only with the support of the province, numerous municipal and regional agencies, and non-government stakeholders.

ROLE OF THE POLLUTION ABATEMENT COMPONENT

The overarching goal of the pollution abatement component, stated in the FRAP 48 deliverables, was "to arrest and reverse the existing environmental contamination and degradation of the Fraser River ecosystem by developing targets and strategies to reduce pollution and by virtually eliminating the discharge of persistent toxic substances in the Fraser River."

Specifically, the pollution abatement component was charged with developing and implementing measures to meet FRAP deliverables 8 through 17:

8. Develop and maintain an inventory of major pollution sources and loadings in the basin.
9. Reduce environmentally disruptive industrial effluent discharges by 30% to meet environmental quality objectives.
10. Reduce contaminant loadings from combined sewer overflows and untreated sewage discharges by 30% to meet environmental quality objectives.
11. Reduce the contaminant load from inadequately treated sewage discharges by 30% to meet environmental quality objectives.
12. Implement a strategy to reduce the loading of nutrients, bacteria and agrochemicals from agricultural operations to ground and surface waters by 30% to meet environmental quality objectives.
13. Implement a strategy to reduce the contaminant loading from urban runoff by 30% to meet environmental quality objectives.
14. Establish a Groundwater Protection Strategy, which includes the remediation of high priority sites.
15. Clean up 70% of contaminated federal waste sites to Canadian Council of Ministers of the Environment standards.
16. Develop and maintain a toxics air emission inventory for major industrial sectors.
17. Reduce the release of persistent toxic substances pursuant to the *Canadian Environmental Protection Act* and identified as priority from inventories and environmental data to the extent allowable by best practicable technology.

To tackle these ten deliverables, the pollution abatement component was organized into six program areas: industrial discharges, municipal discharges, urban runoff, agriculture, contaminated sites and airborne contaminants.

IMPLEMENTING THE POLLUTION ABATEMENT COMPONENT

FRAP's enforcement and compliance component largely utilized inspection and enforcement mechanisms to achieve regulatory compliance. However, many activities in the basin were not subject to any federal environmental regulations *per se*. The pollution abatement deliverables challenged FRAP to move beyond strict regulatory compliance to voluntary actions and the development of innovative technologies and techniques for preventing and reducing pollution. This was largely undertaken through joint projects involving partnerships with industry and community associations, and with provincial, regional and municipal governments.

The six pollution abatement program areas employed three broad strategies:

- conducting inventories to describe sources and amounts of various pollutants being discharged and to provide benchmarks against which to measure progress;
- carrying out pilot projects and demonstrations to assess and demonstrate the effectiveness of technologies and practices in preventing and cleaning up pollution; and
- promoting the adoption of measures to prevent and clean up pollution.

In the latter part of FRAP, the pollution abatement component shifted to a preventative approach to reducing pollution, by attempting to eliminate or minimize the discharge of pollutants at the source. This approach addressed the root causes of pollution—excessive use of energy and toxic substances and generation of waste—rather than treating its symptoms. FRAP developed practical tools such as pollution prevention technical guidelines to enable industries to prevent pollution at the operational level; sponsored workshops and seminars promoting pollution prevention; and worked with industry to develop model pollution prevention plans, demonstrate clean technologies and promote their successes.

CONCLUSIONS AND RECOMMENDATIONS

The pollution abatement component of the Fraser River Action Plan, which undertook to reduce pollution from a broad range of point and non-point pollution sources in the Fraser River Basin, was a challenging and ambitious initiative.

Pollution reductions have been accomplished for some municipal and industrial discharges. Once the Greater Vancouver Regional District's (GVRD) Annacis Island and Lulu Island sewage treatment plants are upgraded to secondary treatment at the end of 1998, loadings of biochemical oxygen demand (BOD) and total suspended solids (TSS) to the basin will be reduced by approximately 84 per cent and 68 per cent, respectively. The Annacis Island and Lulu Island upgrades are also expected to reduce metals and organic pollutant loadings by over 50 per cent. Since 1991, discharges from the pulp and paper industry, which accounts for over 90 per cent of the permitted industrial TSS and BOD discharged in the basin, have shown steady reductions. Loadings of TSS, BOD, dioxins and furans from pulp and paper effluents declined 39 per cent, 38 per cent, 92 per cent and 93 per cent, respectively.

Contaminated sites have become an important environmental management issue in the Fraser Basin. Since the beginning of FRAP, approximately 635 contaminated sites have been remediated in the Fraser Basin, which represents 39 per cent of the total sites identified.

In other sectors, FRAP contributed to improving the management techniques available for environmental stewardship and protection. In the agricultural sector, for instance, Environment Canada worked with other government agencies and agricultural producer groups to identify better management practices, develop environmental guidelines and monitor practices at individual farms. FRAP also contributed to the development of a nutrient management model in order to identify risk areas for nutrient imbalances in the lower Fraser Valley.

With regard to discharges from some smaller industrial operations and sewage treatment systems, the numerous pollution abatement tools and techniques developed provide the potential for longer-term pollution reductions in the Fraser Basin. At the conclusion of FRAP, there will still be a need for Environment Canada to continue the transfer and promotion of these products, through ongoing federal government programs and activities, to ensure that this potential is realized.

Pilot projects to reduce pollution at the watershed or sub-watershed scale provide a unique and valuable opportunity to involve multiple stakeholders, integrate various environmental management approaches, and measure environmental responses.

Although discharges of a number of pollutants have been reduced during FRAP, non-point sources such as agricultural and urban runoff remain a major challenge for water quality protection in the Fraser Basin. Concern about releases from small and medium-sized industries in the basin have also increased in significance. As the basin's population grows, additional effort will be needed to prevent and reduce contaminant releases from these sources.

Specific conclusions and recommendations from the FRAP pollution abatement component are detailed in Chapter 8 of this report.

SOMMAIRE

Le fleuve Fraser, le cinquième en importance au Canada, joue un rôle économique important pour les habitants de la Colombie-Britannique et du reste du pays. Le bassin du Fraser est un réseau hydrographique complexe qui assure le bien-être économique de la population de la région et l'intégrité écologique de nombreux écosystèmes terrestres et aquatiques. Deux millions et demi de personnes — 60 % de la population de la Colombie-Britannique — vivent et travaillent dans la région traversée par le fleuve Fraser, et on prévoit que ce chiffre augmentera de 50 % d'ici l'année 2021. Le réseau hydrographique du Fraser draine plus de 25 % des terres de la province et englobe onze des quatorze zones biogéoclimatiques de la province.

Au cours des années 1980, l'écosystème du fleuve Fraser était soumis à d'importantes pressions environnementales. À la fin de la décennie, la croissance de la population — avec son développement urbain tentaculaire, son expansion industrielle et sa production agricole de plus en plus intense — constituait une menace de plus en plus grande pour l'équilibre écologique du bassin du Fraser.

PLAN D'ACTION DU FRASER

En réponse à la nécessité évidente de mieux gérer et protéger les écosystèmes du fleuve Fraser, le gouvernement du Canada, par le biais de son Plan Vert (1990), s'est engagé à mettre en oeuvre un programme d'assainissement du bassin du fleuve Fraser. C'est pour faire suite à cet engagement que fut annoncée le 1er juin 1991 la création du Plan d'action du Fraser (PAF) par le ministre de l'Environnement et le ministre des Pêches et des Océans du Canada.

Le PAF avait trois buts principaux :

- restaurer la productivité naturelle du bassin du Fraser;
- réduire les sources de pollution et dépolluer les zones contaminées;
- établir un programme de gestion conforme aux principes du développement durable.

Pour réaliser ce programme, Environnement Canada (EC) organisa le PAF en cinq grandes composantes : planification et communication; mise en valeur de l'habitat (non-aquatique); qualité de l'environnement; réduction de la pollution; contrôle de l'application des mesures. Les composantes de la réduction de la pollution, de la qualité de l'environnement et du contrôle de l'application des mesures avaient pour fonction commune de réduire la pollution et de dépolluer les zones contaminées. Le programme d'Environnement Canada décrit en détail 48 « actions d'intervention » qui définissaient les objectifs des trois grands buts du PAF.

Il fut établi dès le début que la réussite du PAF serait conditionnée par l'appui de la province, des organismes municipaux et régionaux et des organisations non gouvernementales.

RÔLE DE LA COMPOSANTE DE LA RÉDUCTION DE LA POLLUTION

Le but ultime de la composante de la réduction de la pollution, tel qu'il est décrit dans les 48 « actions d'intervention » du PAF, est de « mettre fin à la pollution et à la détérioration environnementale de l'écosystème du Fraser et à cette fin, fixer des objectifs et concevoir des stratégies pour réduire la pollution et pour éliminer le déversement de matières toxiques persistantes dans le Fraser. »

Plus spécifiquement, la composante de réduction de la pollution avait pour objectif d'élaborer et de mettre en oeuvre les moyens nécessaires à la réalisation des actions 8 à 17 du PAF :

8. Dresser et tenir à jour un inventaire des principales sources et charges de pollution du bassin.
9. Réduire de 30 % les effluents industriels nuisibles pour l'environnement afin d'atteindre les objectifs de qualité environnementale.
10. Réduire de 30 % les charges de pollution provenant des débordements des égouts et des eaux usées non traitées afin d'atteindre les objectifs de qualité environnementale.
11. Réduire de 30 % les charges de pollution provenant des eaux usées insuffisamment traitées afin d'atteindre les objectifs de qualité environnementale.
12. Mettre en place une stratégie en vue de réduire de 30 % la pollution des eaux de surface et souterraines par les substances nutritives, les bactéries et les produits agrochimiques provenant des exploitations agricoles et ainsi atteindre les objectifs de qualité environnementale.
13. Mettre en place une stratégie en vue de réduire de 30 % la pollution par les eaux de ruissellement urbaines et ainsi atteindre les objectifs de qualité environnementale.
14. Établir une stratégie de protection des nappes phréatiques qui englobe la dépollution des sites prioritaires.
15. Dépolluer 70 % des décharges fédérales polluées pour atteindre les normes du CCME.
16. Dresser et tenir à jour un inventaire des émissions atmosphériques toxiques destiné aux principaux secteurs industriels.
17. Conformément à la *Loi canadienne sur la protection de l'environnement,* diminuer le rejet des matières toxiques persistantes jugées prioritaires d'après les inventaires et les données environnementales dans la mesure du possible, compte tenu des meilleures techniques actuelles.

Pour réaliser ces dix actions d'intervention, la composante de réduction de la pollution a été structurée en six secteurs: rejets industriels, rejets municipaux, eaux de ruissellement, agriculture, sites contaminés et contaminants atmosphériques.

MISE EN OEUVRE DE LA COMPOSANTE DE RÉDUCTION DE LA POLLUTION

La composante du contrôle de l'application et de la conformité fait largement intervenir les mécanismes existants d'inspection et de contrôle de l'observation des règlements. Mais il reste que plusieurs activités qui ont cours dans le bassin ne sont pas à proprement parler assujetties à la réglementation environnementale fédérale. Les actions de réduction de la pollution ont obligé le PAF à sortir du strict cadre des mesures de réglementation pour recourir aux actions volontaires et au développement de nouvelles techniques de prévention et de réduction de la pollution. Cela a été réalisé en grande partie par le biais de projets conjoints faisant intervenir des actions de partenariat avec l'industrie et les associations, et avec les administrations provinciales, régionales et municipales.

Les six secteurs d'intervention du programme de réduction de la pollution s'articulaient autour de trois stratégies principales :

- création d'inventaires des divers polluants rejetés dans le milieu et de critères d'évaluation des progrès accomplis;
- exécution de projets pilotes visant à évaluer et à démontrer l'efficacité des pratiques et technologies de prévention et de dépollution utilisées;
- promotion de mesures visant à prévenir la pollution et à dépolluer l'environnement.

Dans la dernière phase du PAF, la composante de réduction de la pollution est passée à une approche préventive consistant à essayer d'éliminer ou de minimiser les rejets de polluants à leur source. Cette approche visait à enrayer les causes de la pollution — surconsommation d'énergie et de substances toxiques et génération de déchets — plutôt que de traiter les symptômes. Les responsables du PAF ont proposé pour cela des moyens d'intervention concrets : établissement de directives techniques en matière de prévention de la pollution, pour donner aux industries des moyens de prévention au niveau opérationnel; parrainage d'ateliers et de séminaires sur la prévention de la pollution; collaboration avec l'industrie à l'établissement de plans modèles de prévention de la pollution; démonstration et promotion de technologies propres.

CONCLUSIONS ET RECOMMANDATIONS

La composante de réduction de la pollution du Plan d'action du Fraser avait un défi de taille : celui de réduire les rejets émis par une grande diversité de sources de pollution localisées et diffuses dans le bassin du Fraser.

Des progrès ont été réalisés dans les taux de pollution produits par certains effluents municipaux et industriels. Lorsque les usines de traitement des eaux usées des îles Annacis et Lulu (District régional du Vancouver métropolitain/GVRD) auront été converties en usines de traitement secondaire (fin 1998), la charge en demande biochimique d'oxygène (D.B.O.) et le total des solides en suspension (TSS) dans le bassin seront réduits d'environ 84 % et 68 % respectivement. Les améliorations apportées aux centres d'épuration de l'île Annacis et de l'île Lulu devraient également réduire de 50 % les charges de pollution métallique et organique. Depuis 1991, on a enregistré une diminution progressive des rejets de l'industrie des pâtes et papiers, qui représentent plus de 90 % de la charge de solides en suspension et de la charge en D.B.O. rejetées dans le bassin. Les charges de solides en suspension et les charges en D.B.O., et les rejets de dioxines et de furannes émis par les usines de pâtes et papiers ont diminué de 39 %, de 38 %, de 92 % et de 93 % respectivement.

Dans les autres secteurs, le PAF a contribué à l'amélioration des méthodes de gestion disponibles en matière de protection environnementale. Ainsi, Environnement Canada a travaillé, de concert avec les autres organismes gouvernementaux et les associations de producteurs agricoles, à l'établissement de meilleures pratiques de gestion, à l'élaboration de directives environnementales et à la surveillance des méthodes employées dans les exploitations agricoles. Le PAF a également contribué au développement d'un modèle de gestion des rejets de substances nutritives afin d'identifier les zones menacées de déséquilibre dans la région du bas Fraser.

En ce qui concerne les rejets des industries et des usines d'épuration de petite taille, les nombreuses méthodes et techniques de réduction de la pollution qui ont été développées devraient donner des résultats intéressants à long terme. Au terme du PAF, il continuera d'être nécessaire qu'Environnement Canada poursuive les actions de promotion et de transfert technologique concernant ces méthodes, dans le cadre des programmes et activités du gouvernement fédéral.

Les projets pilotes visant à réduire la pollution à l'échelle du bassin sont une occasion unique de mettre à contribution les divers acteurs, d'intégrer les diverses approches de gestion environnementale et de mesurer les résultats environnementaux.

Les sites contaminés sont devenus un important problème de gestion environnementale dans le bassin du Fraser. Depuis le début du PAF, environ 620 sites de contamination ont été dépollués, soit 38 % du nombre total de sites recensés.

Bien que les rejets de plusieurs types de polluants ont diminués au cours de la durée du PAF, les sources diffuses de pollution, notamment les eaux de ruissellement agricoles et urbaines, demeurent un problème important de pollution aquatique dans le bassin du Fraser. Les problèmes de rejets des industries de petite et de moyenne taille sont également une source de préoccupation de plus en plus importante. Comme la population de la région ne cesse de s'accroître, il faudra faire davantage d'efforts pour prévenir et réduire les rejets émis par ces industries.

On trouvera les conclusions et recommandations spécifiques de la composante de réduction de la pollution du PAF dans le chapitre 8 du présent rapport.

CONTENTS

FIGURES AND TABLES

1.0 INTRODUCTION

This report summarizes the activities carried out and the results achieved by the pollution abatement component of the Fraser River Action Plan (FRAP), which ran from 1991 to 1998. Many positive results have been achieved, thanks to the joint efforts of FRAP's government and non-government partners.

1.1 THE FRASER RIVER BASIN

The 1,375-km-long Fraser River is the fifth longest river in Canada (Dorcey and Griggs, 1991) and has the second greatest mean annual flow, at 3,972 m^3/s (Water Survey of Canada, 1997). By any measure, the Fraser is British Columbia's largest river. With a 234,000-km^2 drainage basin, the Fraser River Basin covers nearly 25 per cent of the province (Dorcey and Griggs, 1991) and encompasses 11 of the 14 biogeoclimatic zones in British Columbia (Canadian Cartographics Ltd., 1989, 1992, for the Province of British Columbia Ministry of Forests, in Harding and McCallum, 1994). From its headwaters in the Rocky Mountains to its mouth in the Strait of Georgia, the Fraser River Basin takes in the watersheds of dozens of tributaries including the Nechako, Quesnel, Chilcotin and Thompson Rivers (Dorcey and Griggs, 1991). (See Figure 1.1 for a map of the Fraser River Basin).

Two and a half million people, over 60 per cent of British Columbia's population, live and work in the Fraser Basin—and this number is expected to grow by 50 per cent by 2021 (Fisheries and Oceans Canada, 1997). The history of many of the province's people can be traced through the Fraser River system, from the earliest activities of the First Nations, through European contact, to today's cultural mosaic. The Fraser has been a vital transportation link for trade and exploration throughout B.C.'s human history; it brought the fur traders and provided access to overland trails. It was both the site and the access route of many gold rushes, and has provided for a multicultural influx across B.C.

Today, the Fraser remains a focus for human settlement and industrial growth. The Fraser River Basin supports 48 per cent of B.C.'s commercial forests, 60 per cent of its metal mining operations and nearly 45 per cent of its precious farmland (Dorcey and Griggs, 1991). The lower portion of the basin is one of the most productive agricultural areas in Canada. Tourism and outdoor recreation are also significant contributors to the economy of the basin. The Fraser River Basin accounts for 80 per cent of the gross provincial product (Fisheries and Oceans Canada, 1997).

Throughout its length, the Fraser River provides critical habitat for hundreds of thousands of migratory birds and waterfowl. At its mouth is a vital staging area on the Pacific Flyway, one of the world's major bird migration routes extending from the Bering Sea nearly to Antarctica, and supporting the highest densities of wintering waterfowl, shorebirds, and raptors in Canada (Environment Canada, 1992).

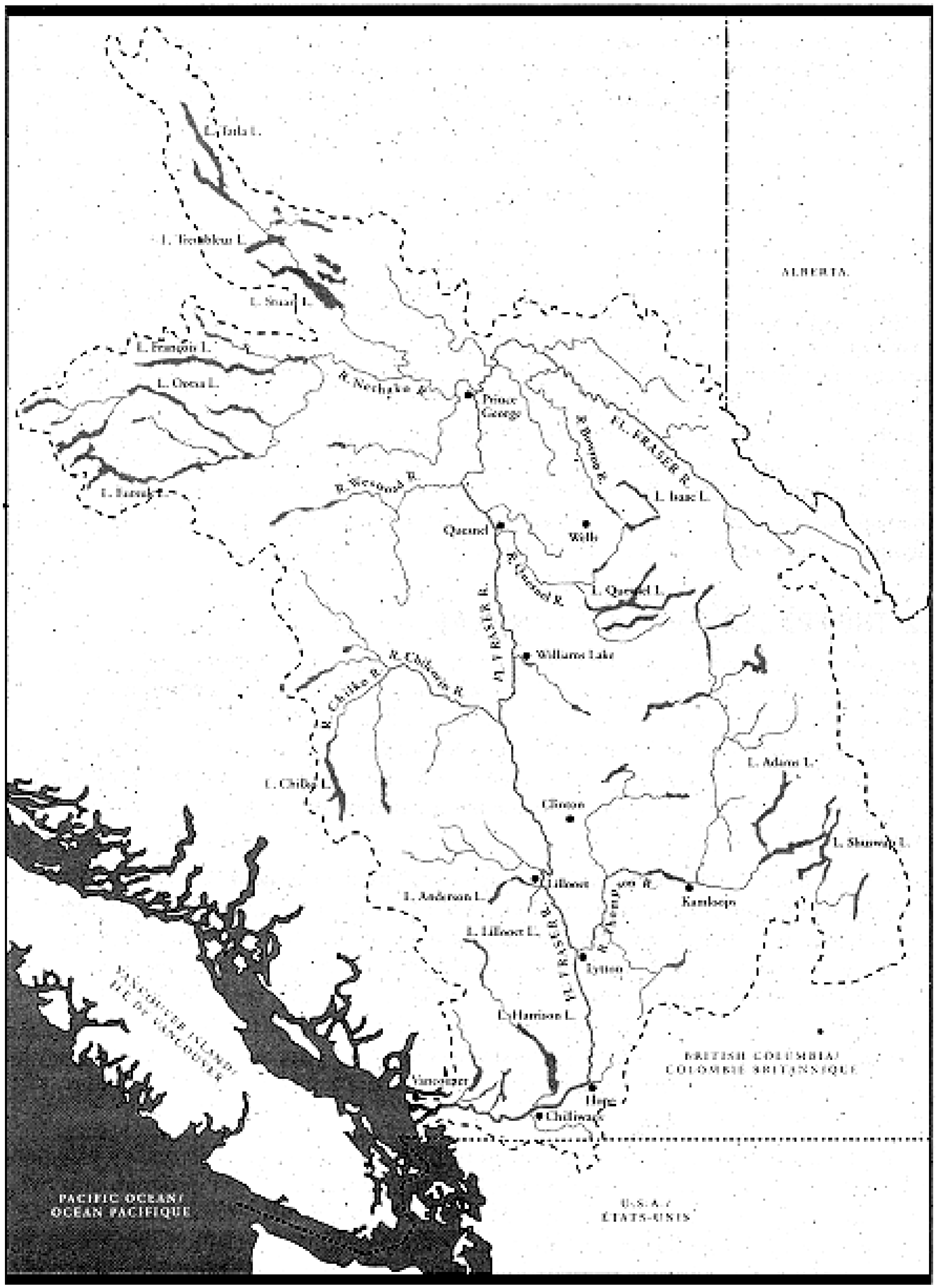


Figure 1.1 The Fraser River Basin

Fifty-eight species of fish inhabit the Fraser River Basin (McPhail, et al., 1998), including five species of Pacific salmon; cutthroat, steelhead, and rainbow trout; Dolly Varden char; and sturgeon, one of the world's most ancient living species of fish (Dorcey and Griggs, 1991). Fifty of the Fraser Basin's 58 fish species are fresh water species, while 8 are marine species that regularly enter the river (McPhail, et al., 1998). The Fraser River system is the largest salmon production system in B.C. and possibly the world. It accounts for approximately 50 per cent of the total annual wholesale value to the commercial fishery. It provides over 65 per cent of B.C.'s sockeye, 60 per cent of the pink and 16 per cent of the chinook salmon catches, and gives an average annual return of about $270 million from the commercial food catch. (Dorcey and Griggs, 1991).

During the early phase of the Fraser River Action Plan (FRAP), it was determined that, in general, the level of contamination of water, sediments and fish in the Fraser River ecosystem was fairly low. However, billions of litres of wastewater from industrial and municipal facilities were discharged into the Fraser every day, and in parts of the river close to human activities, metals and other contaminants had accumulated in fish and sediments. In addition, groundwater was contaminated locally, and tributaries showed impacts of pesticides and nutrients from agricultural activities. It was evident that, while the overall health of the Fraser Basin ecosystem was robust, a burgeoning human population—with its urban sprawl, expanding industrial development and increased agricultural production—was placing it under tremendous and increasing stress.

1.2 THE FRASER RIVER ACTION PLAN

In response to concerns about the need to protect the vast and complex Fraser River ecosystem, the Government of Canada's Green Plan (1990) expressed a commitment to target the Fraser River Basin for remedial action. On June 1, 1991, the Fraser River Action Plan was announced by the Ministers of the Environment and of Fisheries and Oceans. The original goals of FRAP were to restore natural productivity, reduce and clean up pollution, and develop a management program for the basin based on principles of sustainable development.

The legislative authorities for FRAP's cleanup efforts are the *Canadian Environmental Protection Act* and the pollution prevention provisions of the *Fisheries Act*, for which Environment Canada has responsibility. Environment Canada also encourages stewardship and voluntary actions by organizations wishing to move beyond compliance. From the beginning, however, it was recognized that FRAP was an ambitious plan that could not be achieved alone by the two federal departments. Accordingly, Environment Canada and the Department of Fisheries and Oceans joined with numerous provincial and municipal departments and non-government partners to co-ordinate activities to clean up and restore the Fraser River ecosystem.

Initially, Environment Canada's commitment to FRAP was a six-year, $50-million program. To meet FRAP's broad goals, Environment Canada organized its FRAP program into five general areas or components: planning and communication, habitat conservation, environmental quality, pollution abatement and enforcement. The pollution abatement, environmental quality and enforcement components share the lead for meeting FRAP's pollution reduction and cleanup goal.

Beginning in 1993, federal budget cuts resulted in Environment Canada's FRAP budget being reduced to $40 million. Sixteen per cent of the reduced budget was allocated for pollution abatement. In 1995, Environment Canada's FRAP commitment was reprofiled into a seven-year program. Environment Canada's FRAP goals were also further described in 48 "deliverables," or program objectives, which retained the overall thrust of the original three goals.

1.3 ROLE OF THE POLLUTION ABATEMENT COMPONENT

The pollution abatement component of the Fraser River Action Plan worked through partnerships to reduce pollutants discharged into the environment of the Fraser River Basin. The component's overarching goal, stated in the FRAP 48 Deliverables, was "to arrest and reverse the existing environmental contamination and degradation of the Fraser River ecosystem by developing targets and strategies to reduce pollution and by virtually eliminating the discharge of persistent toxic substances in the Fraser River." More specifically, the pollution abatement component was charged with developing and implementing measures to meet deliverables 8 through 17 of the FRAP 48:

8. Develop and maintain an inventory of major pollution sources and loadings in the basin.
9. Reduce environmentally disruptive industrial effluent discharges by 30% to meet environmental quality objectives.
10. Reduce contaminant loadings from combined sewer overflows and untreated sewage discharges by 30% to meet environmental quality objectives.
11. Reduce the contaminant load from inadequately treated sewage discharges by 30% to meet environmental quality objectives.
12. Implement a strategy to reduce the loading of nutrients, bacteria and agrochemicals from agricultural operations to ground and surface waters by 30% to meet environmental quality objectives.
13. Implement a strategy to reduce the contaminant loading from urban runoff by 30% to meet environmental quality objectives.
14. Establish a Groundwater Protection Strategy, which includes the remediation of high priority sites.
15. Clean up 70% of contaminated federal waste sites to Canadian Council of Ministers of the Environment standards.
16. Develop and maintain a toxics air emission inventory for major industrial sectors.
17. Reduce the release of persistent toxic substances pursuant to the *Canadian Environmental Protection Act* and identified as priority from inventories and environmental data to the extent allowed by best practicable technology.

To address these specific objectives, the work of the pollution abatement component was divided into six program areas: industrial discharges, municipal discharges, urban runoff, agriculture, contaminated sites and airborne contaminants.

Environmental quality objectives specify, in quantitative or qualitative terms, the goals and purposes toward which an environmental abatement or prevention effort is directed. For example, they could refer to protection of fish and wildlife, effects on aquatic biota or the protection of human health. For the purposes of pollution abatement, environmental quality objectives were considered in qualitative terms as abatement and prevention measures needed to protect fish and minimize effects on aquatic biota. The FRAP environmental quality component led the effort to develop quantitative water quality objectives in partnership with the B.C. Ministry of Environment, Lands and Parks, and to assess whether existing environmental quality objectives were being met in the Fraser Basin (See *Health of the Fraser River Aquatic Ecosystem – A Synthesis of Research Conducted under the Fraser River Action Plan, 98-11*).

At the start of FRAP in 1991, a Fraser Pollution Abatement Office (FPAO) was established to coordinate the pollution abatement activities of FRAP. In 1995, as a result of a program review by the federal government, the FPAO was merged with the regional pollution prevention and environmental technology programs and a new organizational unit called the Technology and Pollution Prevention Section was formed to continue the work of the FPAO. The Environmental Assessment and Waste Prevention Section also contributed substantially to the pollution abatement component.

While the enforcement and compliance component of FRAP emphasized inspections and enforcement to achieve regulatory compliance, the pollution abatement deliverables challenged FRAP to move beyond compliance to voluntary actions and the development of innovative technologies and techniques for reducing pollution. This was undertaken through joint projects involving partnerships with industry and community associations, and with provincial, regional and municipal governments.

1.4 ACTING AT THE SOURCE

In the last few years, FRAP's pollution abatement component set an additional goal for itself: to achieve pollution reductions by eliminating the discharge of contaminants at the source. This approach, called Pollution Prevention (P2), addresses the root causes of pollution—excessive use of energy and toxic substances and generation of waste—rather than treating its symptoms. The expanded goal reflects the Government of Canada's commitment to pollution prevention, embodied in *Pollution Prevention - A Federal Strategy for Action* (1995). Once enacted, the renewed *Canadian Environmental Protection Act* will also enshrine pollution prevention as a national goal.

As a result, recent projects of the pollution abatement component placed a strong emphasis on voluntary actions to prevent pollution, promoting "anticipate-and-prevent" rather than "react-and-cure" approaches. To support this preventative approach, FRAP developed practical tools such as pollution prevention technical guidelines to enable people to prevent pollution at an operational level; sponsored workshops and seminars that promote pollution prevention; and worked with industries to develop model pollution prevention plans, demonstrate clean technologies and promote their successes.

1.5 PURPOSE AND SCOPE OF THIS TECHNICAL SYNTHESIS REPORT

The purpose of this report is to amalgamate information about the pollution abatement activities of FRAP, which numerous federal and provincial departments, regional governments, research institutes, private sector companies, and industry and community groups participated in.

The report describes the work approach taken in each of six pollution abatement program areas and provides an overview of the results that were achieved. In some cases, FRAP results are supplemented with other data, such as the National Pollution Release Inventory, for trend evaluation purposes. Finally, relevant conclusions and recommendations are presented.

Four appendices are attached. Appendix A lists the FRAP 48 deliverables. Appendix B lists the publications resulting from the pollution abatement component. Where FRAP publications are cited in the text their FRAP report number is provided in brackets. The findings presented in this report are the result of the cooperative efforts of more than 30 organizations who participated in pollution abatement projects; these partners are listed in Appendix C. Finally, Appendix D describes the key environmental legislation and other relevant control mechanisms of federal, provincial and municipal environmental agencies applicable to each program area.

The geographic scope of the Fraser pollution abatement component is defined as the watershed of the Fraser River and its tributary rivers. However, because of the similarity between the pollution abatement objectives of FRAP and the Burrard Inlet Environmental Action Program objectives of FRAP (particularly deliverables number 32 to 36), some of the work was carried out in tandem. In such cases, it was necessary to summarize the findings for Fraser Basin and Burrard Inlet together in this report. A summary of the activities carried out and the results achieved in Burrard Inlet under FRAP is provided in a companion technical summary report (98-02).

REFERENCES

Dorcey, Anthony H. J. and Julian R. Griggs (eds). 1991 *Water in sustainable Development: Exploring Our Common Future in the Fraser River Basin* Vancouver: Westwater Research Centre, University of British Columbia.

Environment Canada. 1992. *State of the Environment Report for the Lower Fraser River Basin,* SOE Report No. 92-1. Co-published with B.C. Ministry of Environment, Lands and Parks.

Environment Canada. 1998. *Fraser River Action Plan, Burrard Inlet Technical Summary Report.* (98-02)

Fisheries and Oceans Canada. 1997. *Legacy for the Fraser — A Final Report on the Fraser River Action Plan by Fisheries and Oceans Canada 1991–1997.*

Government of Canada, 1990. *Canada's Green Plan for a Healthy Environment.*

Government of Canada, 1995. *Pollution Prevention, A federal strategy for action.*

Gray, Colin and Taina Touminen, (eds). *Health of the Fraser River Aquatic Ecosystem – A Synthesis of Research Conducted under the Fraser River Action Plan. (98-11)*

Harding, Lee and Emily McCullum. 1994. *Biodiversity in British Columbia Our Changing Environment.* Environment Canada, Canadian Wildlife Service.

McPhail, J.D., E.B. Szenasy and B. Watson. 1997. *An Atlas of Fraser River Fishes: Fish Distribution and Assemblages in the Fraser Basin.* Technical report submitted to the Fraser River Action Plan. (98-13). Environment Canada, Environmental Conservation Branch, Vancouver, B.C.

Water Survey of Canada. 1997. Unpublished Fraser River mean annual discharge data.

2.0 INDUSTRIAL DISCHARGES

2.1 OBJECTIVES

Industrial operations can affect the environmental quality of Fraser River Basin water bodies through point source discharges of liquid wastes or through diffuse discharges such as stormwater runoff, spills or deposition of atmospheric pollutants.

Of the 48 Fraser River Action Plan deliverables, three directly related to industrial operations.

- develop and maintain an inventory of major [water] pollution sources and loadings in the basin (deliverable 8);
- reduce environmentally disruptive industrial effluent discharges by 30% to meet environmental quality objectives (deliverable 9); and
- reduce the release of persistent toxic substances pursuant to the *Canadian Environmental Protection Act* and identified as priority from inventories and environmental data to the extent allowed by best practicable technology (deliverable 17).

Guided by these deliverables, the FRAP industrial program was carried out in six stages in order to better understand and reduce industrial pollution in the Fraser Basin, as follows:

- characterize discharges (section 2.2.1.1)
- inventory discharges (section 2.2.1.2)
- improve industrial practices (section 2.2.2.1)
- promote pollution prevention planning (section 2.2.2.2)
- demonstrate pollution prevention planning (section 2.3.1)
- demonstrate clean industrial processes (section 2.3.2)

This report discusses activities undertaken by the pollution abatement component of FRAP only. Activities undertaken by other agencies and programs—notably the FRAP enforcement component and the B.C. Ministry of Environment, Lands and Parks (BC MELP)—were also aimed at reducing industrial pollution but are reported elsewhere. For example, see Environment Canada's 1996 compliance status reports, available at *http://www.pwc.bc.doe.ca/ep/programs/eppy/enforce/0main96.htm*.

2.2 ACTIVITIES

2.2.1 Understanding Industrial Water Pollution

At the time FRAP began in1991, industrial water pollution in the Fraser Basin was not comprehensively understood. Although conventional pollutants such as total suspended solids (TSS) and biochemical oxygen demand (BOD)[1] were monitored in industrial effluents, efforts tended to be focused only on certain sites or industries, concentrations of trace contaminants were largely unknown, overall mass loadings of pollutants had not been assessed and there was no consolidated database of industrial effluent discharges. Without

[1] BOD (biochemical oxygen demand) is a measure of the oxygen consumed by the biodegradation of organic matter.

this knowledge, efforts to comprehensively reduce pollution from industrial sources were unlikely to be effective. Thus, the industrial program's first step was to better understand industrial pollution within the Fraser Basin. This was undertaken primarily through a series of wastewater characterization studies and two pollutant release inventories.

2.2.1.1 Characterizing Discharges

A series of wastewater characterization studies was carried out to analyze industrial wastewaters in order to determine their physical and chemical characteristics, as well as their toxicity to certain biological organisms.

2.2.1.1.1 Wastewater Characterization Guidelines

Before beginning wastewater characterization studies, however, a common set of measurements and procedures for the characterization of different wastewaters was needed. *Recommended Guidelines for Wastewater Characterization in the Fraser Basin* (93-10 and 93-11) were produced. The guidelines prescribed parameters to measure in different industry sectors, preferred chemical analysis methods, and procedures for field sampling, flow rate measurement, field quality assurance, data reporting and toxicity testing. The guidelines applied to both industrial and municipal wastewater discharges to surface water or to ground.

The guidelines specified, and prescribed procedures for, tests that indicate acute and chronic effects of wastewaters on four biological organisms, representing different trophic levels:

- Rainbow trout acute lethality determines the concentration at which 50 per cent of a rainbow trout (*Oncorhynchus mykiss*) bioassay test population dies within 96 hours;
- Luminescent bacteria toxicity, also known by the commercial name, *Microtox*™, measures the sample concentrations causing 20 per cent and 50 per cent inhibition of light production by the bacterium *Photobacterium phosphoreum*;
- *Selenastrum capricornutum* growth inhibition measures the concentrations that cause 25 per cent and 50 per cent inhibition of algal growth over 72 to 96 hours; and
- *Ceriodaphnia dubia* reproduction and survival records the mortality and number of young produced by daphnids over a seven-day period.

These wastewater characterization guidelines were critical to ensure comparability of data, since the wastewater characterizations for different sites were undertaken by different consulting firms and different government agencies.

Some of the earlier wastewater characterizations included an additional test:

- *Daphnia magna* determines the concentration at which 50 per cent of the daphnid bioassay test population dies within 48 hours.

2.2.1.1.2 Wastewaters Characterized

Wastewater characterization studies were undertaken at several industrial sites in the Fraser Basin. The sites are listed in Table 2.1, and results are summarized in Tables 2.2 [a] through [e]. These tables provide loadings for a subset of the parameters measured, *i.e.*, TSS, BOD, arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, dioxins and furans, total polycyclic aromatic hydrocarbons (PAHs), total resin acids and chlorophenolics. Each of these parameters was selected because: 1) it is representative of the classes of contaminants monitored in the Fraser River aquatic environment, 2) it is listed on the *Canadian Environmental Protection Act* Priority Substances List, and/or 3) it is frequently detected in the effluents. The tables also show whether bioassays indicated acute or chronic toxicity to rainbow trout, *Daphnia magna*, luminiscent bacteria, *Selenastrum capricornutum* or *Ceriodaphnia dubia*, according to the criteria listed in section 2.2.1.1.1. Results must be considered "snapshots" of wastewater characteristics, since effluent samples were collected on only two or three days for most sites, with the results reported as averages.

The most obvious conclusion to be drawn from Tables 2.2 [a] to [e] are that loadings to Fraser Basin waters from pulp and paper mills were universally far greater than loadings from the other sources characterized. Pulp and paper mills accounted for 98 per cent of the BOD loadings, 99 per cent of the TSS loadings, and even larger percentages of the loadings of metals, dioxins and furans, PAHs, resin acids and chlorophenolics.

A second major conclusion is that chronic or sublethal toxicity to biological organisms was observed for most of the effluents tested. Chronic toxicity was detected in at least one sample in all nine effluents tested with luminscent bacteria, 17 of 18 tested with *Ceriodaphnia dubia,* and six of nine tested with *Selenastrum capricornutum*. With regards to acute toxicity, 12 of 18 effluents tested were not lethal to rainbow trout, while five of 11 were not lethal to *Daphnia magna*. Even wastewaters that did not contribute large pollutant loadings to Fraser Basin waters could cause biological effects on any sensitive organisms in the receiving environment, particularly within the dilution zones of effluent outfalls. It should be noted that interpretation of results from such bioassays is difficult. For example, brackish estuary intake water likely contributed to the toxicity observed in two of the effluents (Lafarge Canada and Tilbury Cement, FRAP 93-13).

A third conclusion to be drawn from Tables 2.2 [a] to [e] is that copper and zinc were detected in most of the wastewaters characterized (20 of 25 for copper, and 24 of 25 for zinc). Arsenic was also frequently detected (15 of 25).

Some sector-specific comments follow.

Table 2.1 Wastewaters Characterized

Company	Facility Type	Location	Wastewaters Sampled	FRAP, Report Number
Scott Paper Ltd.	paper mill	New Westminster	paper mill effluent	93-13
Canadian Forest Products Ltd.	bleach kraft pulp and paper mill	Prince George	final effluent	94-09
Northwood Pulp and Timber Ltd.	bleach kraft pulp mill	Prince George	secondary treated wastewater, final effluent holding pond	93-08, 97-10
Weyerhaeuser Canada Ltd.	bleach kraft pulp mill	Kamloops	final effluent	94-09
Quesnel River Pulp Company	pulp mill	Quesnel	final effluent	94-09
IFP Ltd. Fraser Mills	sawmill and planer	Coquitlam	non-contact cooling and storm water	93-13
IFP Ltd. Hammond Cedar	sawmill and planer	Maple Ridge	non-contact cooling water, kiln condensate, boiler blowdown	93-13
MacMillan Bloedel Ltd.	sawmill and planer	New Westminster	cooling water, boiler blowdown and runoff, stormwater and kiln condensate	93-13
Domtar Inc.	wood preserver	New Westminster	steam condensate and boiler blowdown	93-13
Bella Coola Fisheries	fish processor	Delta	process effluent only	93-39
B.C. Packers	fish processor	Richmond	process effluent only	93-39
Lions Gate Fisheries	fish processor	Delta	process effluent only	93-39
Ocean Fisheries	fish processor	Richmond	process effluent only	93-39
Lafarge Canada Inc.	cement plant	Richmond	non-contact cooling and storm water, non-contact cooling and surface runoff	93-13
Tilbury Cement Ltd.	cement plant	Delta	non-contact cooling water, ditch discharge	93-13
Westshore Terminals Ltd.	bulk coal storage and shipping terminal	Delta	surface runoff discharge, septic	93-13
FMC of Canada	hydrogen peroxide plant	Prince George	final effluent	94-09
Hilinex Packaging Inc.	paper and plastic bag manufacturer	Burnaby	effluent	93-13
Tree Island Industries	wire and nail manufacturer	Richmond	process effluent, non-contact cooling water	93-13

Pulp and Paper Mills

As shown in Table 2.2 [a], the pulp and paper mills each typically released several tonnes of TSS and BOD to Fraser Basin waters each day. TSS loadings ranged from one to 14 tonnes per day, while BOD loadings ranged from 0.7 to 7.9 tonnes per day.

Zinc was found in all pulp mill effluents, typically at loading rates of seven to 14 kilograms per day, but ranging as high as 100 kg/d. Chromium was found in all but one effluent, at loading rates ranging from 0.2 to 100 kg/d. Copper was found in all effluents, typically at loading rates of 0.15 to 0.62 kg/d, but ranging as high as 15 kg/d. Nickel, lead, arsenic and cadmium were occasionally found. Loadings of these metals typically ranged from 0.05 to 3 kg/d.

Dioxins and furans were found in all pulp mill effluents for which the analysis was carried out. Loadings ranged from 16 to 4,300 micrograms per day, expressed as 2,3,7,8 TCDD toxicity equivalents (TEQs).

Resin acids were usually detected at levels of tens of kg/d. Chlorophenolics were normally detected at levels in the kg/d range. PAHs were normally detected, but at widely divergent loading levels of 0.002 to 2.9 kg/d.

Most pulp mill effluents were not acutely toxic to rainbow trout. However, chronic toxicity to luminescent bacteria, *Selenastrum capricornutum* and *Ceriodaphnia dubia* was measured repeatedly.

Sawmills and Planers, Wood Preservers

Table 2.2 [b] shows that the sawmills sampled released very low levels of BOD and TSS to Fraser Basin waters.

Arsenic, copper and zinc were discharged at loadings ranging from tens of milligrams per day for arsenic, to about one gram per day for copper, and up to 18 grams per day of zinc from one particular mill.

Dioxins and furans were detected at levels corresponding to loadings of tens of nanograms per day (2,3,7,8 TCDD toxicity equivalents). PAH loadings were at milligrams per day levels at one mill. No resin acids or chlorophenolics were detected.

Sawmill effluents sometimes displayed acute toxicity to rainbow trout and *Daphnia magna*, and repeatedly indicated chronic toxicity to *Ceriodaphnia dubia*.

The one wood preserver effluent sampled had characteristics generally similar to those of the sawmills (in terms of the parameters listed).

Fish Processors

Wastewater flow rates and daily loading data were not reported for fish processors; there was concern that they could be used to back-calculate confidential production levels. Loadings were reported per tonne of fish processed. The loadings in Table 2.2 [c] are reported as releases per 15 tonnes of fish processed. There is no typical daily production rate in the fish processing sector, but 15 tonnes represents a rough approximation of an average daily quantity of fish processed during the nine to 10 month season.

Fish processor TSS loadings were found to be in the tens of kg per 15 tonnes of fish processed. BOD loadings were slightly higher, around a hundred kg per 15 tonnes of fish. Copper and zinc were detected, generally at loading levels of tens of grams per 15 tonnes of fish processed.

Both acute and chronic toxicity were measured for all fish processor effluents tested.

Miscellaneous

The remaining sources characterized (see Tables 2.2 [d] and [e]) generally released a few kilograms a day of TSS to Fraser Basin waters, and very low levels of BOD. Copper and zinc loadings were generally tens of grams per day, with lesser loadings of some the other metals as well. Acute toxicity was measured frequently, and chronic toxicity was measured slightly more often.

Table 2.2 a. Characteristics of Pulp and Paper Mill Wastewaters

	Loadings					
	Scott Paper Ltd.	Canadian Forest Products Ltd.	Northwood Pulp and Timber		Weyer-haeuser Canada Ltd.	Quesnel River Pulp Company
	Papermill Effluent	Final Effluent	Secondary Treated Waste-water	Final Effluent Holding Pond	Final Effluent	Final Effluent
	1993	1993	1992	1995/6	1993	1993
Conventional Parameters (kg/d)						
TSS	1,000.	12,000.	7,600.	8,200.	6,000.	14,000.
BOD	700.	7,900.	6,100.	6,200.	5,700.	3,500.
Metals (total, g/d)						
Arsenic	8.5	*nd*	160.	*nd*	*nd*	*nd*
Cadmium	*nd*	*nd*	*nd*	270.	*nd*	*nd*
Chromium	*nd*	1,100.	*nt*	100,000.	10,000.	240.
Copper	150.	430.	810.	15,000.	620.	290.
Lead	48.	*nd*	*nd*	40,000.	*nd*	*nd*
Mercury	*nd*	*nd*	*nd*	*nt*	9.2	*nd*
Nickel	*nd*	*nd*	*nd*	820.	3,100.	*nd*
Zinc	590.	14,000.	9,300.	100,000.	7,700.	7,000.
Dioxins & Furans (ug/d, TEQ)	16.	290.	430.	*nt*	4,300.	*nt*
PAHs (g/d)	2.0	2,900.	nd	*nt*	37.	27.
Resin Acids (kg/d) (including fatty acids)	3.4	71.	100.	52.	*nd*	8.0
Chlorophenolics (kg/d) (chlorophenols, chloroguaiacols, chlorocatechols, chloroveratroles, syringaldehydes, syringols, chlorovanillins, etc.)	*nd*	1.4	4.9	*not published*	0.37	*nt*
	Bioassay Toxicity					
Rainbow trout	No	No	No	*nt*	Yes	No
Daphnia magna	No	*nt*	No	*nt*	*nt*	*nt*
Luminescent bacteria	*nt*	Yes	Yes	*nt*	Yes	Yes
Selenastrum capricornutum	*nt*	Yes	Yes	*nt*	No	Yes
Ceriodaphnia dubia	Yes	Yes	Yes	*nt*	Yes	Yes

Notes to Table 2.2 a

- *nd* - not detected *nt* - not tested
- In calculating totals or averages (*e.g.*, total PAHs, or dioxin and furan TEQs), non-detects were taken as zero.
- Yes - Toxicity (according to the criterion(a) in section [2.2.1.1.1]) was measured in at least one effluent sample.
- No - Toxicity (according to the criterion(a) in section [2.2.1.1.1]) was not measured in any effluent sample.
- Northwood Pulp and Timber (1995/96) loadings were calculated using average results from two laboratories which analyzed split samples.
- Northwood Pulp and Timber (1995/96) chlorophenolics were tested for, but the results were deemed insufficiently reliable for publication.

Table 2.2 b. Characteristics of Sawmill and Wood Preservation Wastewaters

	Loadings						
	IFP Ltd. Fraser Mills	IFP Ltd. Hammond Cedar			MacMillan Bloedel Ltd.		Domtar Inc.
	Non-contact Cooling and Stormwater	Non-Contact Cooling Water	Kiln Condensate	Boiler Blowdown	Cooling Water, Boiler Blowdown and Runoff	Stormwater and Kiln Condensate	Steam Condensate and Boiler Blowdown
	1993	1993	1993	1993	1993	1993	1993
Conventional Parameters (kg/d)							
TSS	0.04	*nd*	0.001	0.28	1.3	1.5	0.098
BOD	*nd*	*nd*	*nd*	*nd*	0.35	0.26	*nd*
Metals (total, g/d)							
Arsenic	*nd*	*nd*	0.0008	0.015	0.088	0.014	0.0036
Cadmium	0.004	*nd*	*nd*	0.00096	*nd*	*nd*	*nd*
Chromium	*nd*	*nd*	*nd*	0.36	*nd*	*nd*	*nd*
Copper	1.6	0.02	*nd*	1.1	1.8	1.3	*nd*
Lead	*nd*	*nd*	*nd*	0.19	0.76	0.08	*nd*
Mercury	*nd*	*nd*	*nd*	*nd*	*nd*	*nd*	*nd*
Nickel	*nd*	*nd*	*nd*	0.33	*nd*	*nd*	*nd*
Zinc	0.56	0.04	0.007	2.5	16.	18.2	0.056
Dioxins & Furans (ug/d, TEQ)	*nt*	*nt*	*nt*	0.0015	0.31	0.075	0.017
PAHs (g/d)	*nt*	*nt*	*nt*	*nd*	0.036	0.0044	0.0009
Resin Acids	*nt*	*nt*	*nt*	*nd*	*nd*	*nd*	*nd*
Chlorophenolics (chlorophenols, chloroguaiacols, chlorocatechols, chloroveratroles, syringaldehydes, syringols, chlorovanillins, etc.)	*nt*	*nt*	*nt*	*nd*	*nd*	*nd*	*nd*
	Bioassay Toxicity						
Rainbow trout	Yes	*nt*	*nt*	No	No	*nt*	No
Daphnia magna	Yes	*nt*	*nt*	No	Yes	*nt*	No
Luminescent bacteria	*nt*	*nt*	*nt*	*nt*	*nt*	*nt*	*nt*
Selenastrum capricornutum	*nt*	*nt*	*nt*	*nt*	*nt*	*nt*	*nt*
Ceriodaphnia dubia	Yes	*nt*	*nt*	Yes	Yes	*nt*	Yes

Notes to Table 2.2 b

- *nd* - not detected *nt* - not tested
- In calculating totals or averages (e.g. total PAHs, or dioxin & furan TEQs), non-detects were taken as zero.
- Yes - Toxicity (according to the criterion(a) in section [2.1.1.1]) was measured in at least one effluent sample.
- No - Toxicity (according to the criterion(a) in section [2.1.1.1]) was not measured in any effluent sample.

Table 2.2 c. Characteristics of Fish Processor Wastewaters

	Loadings			
	Bella Coola Fisheries Ltd.	British Columbia Packers Ltd.	Lions' Gate Fisheries Ltd.	Ocean Fisheries Ltd.
	Process Effluent Only	Process Effluent Only	Process Effluent Only	Process Effluent Only
	1993	1993	1993	1993
Conventional Parameters (kg/15tonnes fish processed)				
TSS	69.	51.	27.	81.
BOD	90.	110.	100.	170.
Metals (total, g/15t fish processed)				
Arsenic	*nd*	*nd*	*nd*	*nd*
Cadmium	*nd*	*nd*	*nd*	*nd*
Chromium	*nd*	*nd*	*nd*	*nd*
Copper	1.7	89.	11.	13.
Lead	*nd*	*nd*	*nd*	*nd*
Mercury	*nt*	*nt*	*nt*	*nt*
Nickel	*nd*	*nd*	*nd*	*nd*
Zinc	8.6	340.	23.	50.
Dioxins & Furans	*nt*	*nt*	*nt*	*nt*
PAHs	*nt*	*nt*	*nt*	*nt*
Resin Acids	*nt*	*nt*	*nt*	*nt*
Chlorophenolics	*nt*	*nt*	*nt*	*nt*
Bioassay Toxicity tested at 3 unidentified processors (of the 4 listed above).				
Rainbow trout		Yes	Yes	Yes
Daphnia magna		*nt*	*nt*	*nt*
Luminescent bacteria		Yes	Yes	Yes
Selenastrum capricornutum		Yes	Yes	Yes
Ceriodaphnia dubia		Yes	Yes	Yes

Notes to Table 2.2 c

- *nd* - not detected *nt* - not tested
- In calculating totals or averages (e.g. total PAHs, or dioxin & furan TEQs), non-detects were taken as zero.
- Yes - Toxicity (according to the criterion(a) in section [2.1.1.1]) was measured in at least one effluent sample.
- No - Toxicity (according to the criterion(a) in section [2.1.1.1]) was not measured in any effluent sample.
- Loadings per day were not reported for fish processors due to concern that confidential production levels might be back-calculated. There is no typical daily production level, but 15 tonnes represent a coarse approximation of average daily quantity of fish processed in a season.
- Loadings for TSS and BOD are geometric means calculated using data from FRAP wastewater characterizations and historical data. Loadings for metals are geometric means calculated using FRAP wasterwater characterization data only.
- Wastewaters were sampled during salmon season. Wasterwater characteristics may differ during other seasons. These fish processors typically operate 9-10 months a year.

Table 2.2 d. Characteristics of Cement Plant and Bulk Terminal Wastewaters

	Loadings				
	Lafarge Canada Inc.		Tilbury Cement Ltd.	Westshore Terminals Ltd.	
	Non-contact Cooling and Stormwater	Non-contact Cooling and Surface Runoff	Non-contact Cooling Water	Surface Runoff Discharge	Septic
	1993	1993	1993	1993	1993
Conventional Parameters (kg/d)					
TSS	2.4	27.	2.7	4.7	1.9
BOD	*nd*	*nd*	*nd*	*nd*	1.2
Metals (total, g/d)					
Arsenic	0.19	1.6	0.23	0.3	0.0094
Cadmium	*nd*	*nd*	0.0037	0.047	0.0059
Chromium	*nd*	*nd*	*nd*	*nd*	*nd*
Copper	3.8	7.8	*nd*	1.	6.2
Lead	*nd*	3.6	*nd*	1.5	0.17
Mercury	*nd*	*nd*	*nd*	*nd*	0.00059
Nickel	*nd*	*nd*	*nd*	*nd*	*nd*
Zinc	9.8	25.	*nd*	13.	5.6
Dioxins & Furans	*nt*	*nt*	*nt*	*nt*	*nt*
PAHs (g/d)	*nt*	*nt*	*nt*	0.0085	*nt*
Resin Acids	*nt*	*nt*	*nt*	*nt*	*nt*
Chlorophenolics	*nt*	*nt*	*nt*	*nt*	*nt*
Bioassay Toxicity				1994	
Rainbow trout	No	*nt*	No	No	*nt*
Daphnia magna	Yes	*nt*	Yes	Yes	*nt*
Luminescent bacteria	*nt*	*nt*	*nt*	Yes	*nt*
Selenastrum capricornutum	*nt*	*nt*	*nt*	No	*nt*
Ceriodaphnia dubia	Yes	*nt*	Yes	Yes	*nt*

Notes to Table 2.2 d

- *nd* - not detected *nt* - not tested
- In calculating totals or averages (e.g. total PAHs, or dioxin & furan TEQs), non-detects were taken as zero.
- Yes - Toxicity (according to the criterion(a) in section [2.1.1.1]) was measured in at least one effluent sample.
- No - Toxicity (according to the criterion(a) in section [2.1.1.1]) was not measured in any effluent sample.
- Westshore surface runoff discharge toxicity results are from a 1994 re-sampling program.

Table 2.2 e. Characteristics of Miscellaneous Wastewaters

	Loadings			
	FMC of Canada (hydrogen peroxide plant)	Hilinex Packaging Inc. (paper and plastic bag manufacturer)	Tree Island Industries (wire and nail manufacturer)	
	Final Effluent	Effluent	Process Effluent	Non-Contact Cooling Water
	1993	1993	1993	1993
Conventional Parameters (kg/d)				
TSS	*nd*	0.037	6.1	2.3
BOD	*nt*	0.039	*nd*	*nd*
Metals (total, g/d)				
Arsenic	*nd*	0.0012	0.45	0.17
Cadmium	*nd*	0.00015	*nd*	*nd*
Chromium	*nd*	*nd*	*nd*	*nd*
Copper	74.	0.2	*nd*	*nd*
Lead	*nd*	0.012	27.	1.2
Mercury	*nd*	*nd*	*nd*	*nd*
Nickel	*nd*	*nd*	*nd*	*nd*
Zinc	120.	0.14	330.	0.16
Dioxins & Furans (ug/d, TEQ)	*nt*	0.00068	*nt*	*nt*
PAHs	*nd*	*nd*	*nt*	*nt*
Resin Acids	*nt*	*nd*	*nt*	*nt*
Chlorophenolics (chlorophenols, chloroguaiacols, chlorocatechols, chloroveratroles, syringaldehydes, syringols, chlorovanillins, etc.)	*nt*	*nd*	*nt*	*nt*
	Bioassay Toxicity			
	1994			
Rainbow trout	No	Yes	*nt*	No
Daphnia magna	*nt*	Yes	*nt*	No
Luminescent bacteria	Yes	*nt*	*nt*	*nt*
Selenastrum capricornutum	No	*nt*	*nt*	*nt*
Ceriodaphnia dubia	No	Yes	*nt*	Yes

Notes to Table 2.2 e

- *nd* - not detected *nt* - not tested
- In calculating totals or averages (e.g. total PAHs, or dioxin & furan TEQs), non-detects were taken as zero.
- Yes - Toxicity (according to the criterion(a) in section [2.1.1.1]) was measured in at least one effluent sample.
- No - Toxicity (according to the criterion(a) in section [2.1.1.1]) was not measured in any effluent sample.
- FMC toxicity results are from a 1994 re-sample

2.2.1.2 Inventorying Discharges

The detailed characterizations of discharges from individual sites provided useful information about which types of operations released which types of pollutants and in what quantities. But because they necessarily focused on only a subset of Fraser Basin industrial operations, they did not provide an overall picture of Fraser Basin industrial water pollution. For example, they did not indicate what the main pollutant loadings from industrial sources were, which sectors were most responsible for releases of which parameters, or the relative importance of industrial releases compared to other effluent sources in the basin.

Overall inventories of all Fraser Basin industrial wastewater discharges were needed. Two were developed.

2.2.1.2.1 *Fraser Point Source Inventory*

The first of these was the *Fraser Point Source Inventory*, which documented all Fraser Basin effluent discharges authorized in waste management permits issued by BC MELP (93-05, 93-06). Both industrial and municipal sources were included. Any discharge limits specified in the permit, such as the maximum discharge flow rate or the maximum allowable concentrations of particular parameters, were also recorded in the inventory.

The combined total of all maximum allowable effluent flow rates in Fraser Basin industrial permits in 1997 was 1.2 million m^3/day. The pulp and paper sector accounted for 65 per cent of this total allowable effluent flow. The 1997 total could also be broken down as follows: 82 per cent process wastewater, eight per cent cooling water, eight per cent stormwater and two per cent industrial facility sewage. For the sake of comparison, the total of all maximum allowable effluent flow rates for municipal sewage treatment plants in the Fraser Basin in 1997 was 1.0 million m^3/day.

By multiplying the maximum allowable flow rate (in a permit) by the maximum allowable concentration of a particular parameter, the allowable mass discharge, or loading, of that parameter can be calculated. Considering the whole Fraser Basin, the combined total of all allowable loadings of a parameter provides an estimate of the maximum potential loadings to the aquatic environment from all permitted industrial discharges. The *Fraser Point Source Inventory* performed this basin-wide loading calculation. These values are referred to here as "maximum permissible loadings."

The 1997 (industrial only) maximum permissible loading of TSS to Fraser Basin waters was larger than the maximum permissible loading of any other parameter at 147,000 kg/day. TSS may be a more accurate indicator of "overall" contaminant loadings than total effluent flow due to the fact that many common chemical pollutants adsorb to particles in effluent. The four next largest maximum permissible loadings were: sulphate at 145,000 kg/day, BOD at 60,000 kg/day, adsorbable organic halides (AOX) at 2,600 kg/day, and oil and grease at 680 kg/day. Maximum permissible loadings for other parameters in 1997 are listed in Table 2.3.

Table 2.3 Maximum Permissible Loadings to Fraser Basin Waters

Parameter	Maximum Permissible Loading (kg/d)	Number of Permits	Parameter	Loading (kg/d)	Number of Permits
			continued...		
Residue, Nonfilterable	147,000	87			
Residue, Total	515	2	Toluene	13	5
Residue, Fixed Nonfilterable	430	2	Copper, Dissolved	6.4	7
Sulphate	145,000	3	Copper	6	7
Sulphate, Dissolved	2,500	1	Antimony	5.8	3
Biochemical Oxygen Demand	60,000	50	Chlorine, Residual, Total	5.3	5
Chemical Oxygen Demand	310	1	Chlorine	1.62	1
Adsorbable Organic Halides	2,600	1	Lead, Dissolved	4.8	6
Oil & Grease	680	31	Lead	3.5	5
Hydrogen Peroxide	385	1	Phenols	4.8	3
Nitrogen, Nitrate, Total	160	9	Cobalt	4.3	1
Nitrogen, Ammonia, Dissolved	124	1	Phosphorous, Total	1.8	4
Nitrogen, Ammonia, Total	85	13	Phosphorous, Total Dissolved	1.5	1
Nitrate, Soluble	12	3	Phosphorous, Total Soluble	0	1
Ammonia	2.75	3	Chromium	1.35	4
Nitrogen, Nitrite, Total	0.1	1	Sulphide, Total	1.15	2
Nitrogen, Nitrite, Dissolved	0.07	1	Sulphide, Dissolved	0.2	1
Carbon, Total Organic	275	2	Cyanide, Total	1.1	1
Iron, Dissolved	133	6	Cyanide, Strong Acid Dissociable	0.06	1
Iron	55	5	Cadmium, Dissolved	0.9	3
1,2 Dichloroethane	167.5	1	Selenium	0.58	3
Hydrocarbon, Total	100	6	Silver	0.232	4
Aluminum	60	4	Tetrachlorophenols	0.118	3
Oxygen, Dissolved	59	8	Pentachlorophenol	0.115	3
Zinc, Dissolved	23	7	Trichlorophenols	0.115	2
Zinc	22.5	5	Mercury	0.065	5
Manganese, Dissolved	34	2	Arsenic	0.05	1
Manganese	9	4	Xylene	0.013	4
Phosphate, Soluble	34.5	8	Furans	0.00000595	1
Benzene	26	5	Dioxins	0.000001775	1
Molybdenum, Dissolved	14	1	Ethylbenzene	0	2
Molybdenum	5.85	3	Organochlorines	0	2

(From BC MELP industrial permits, ranked by parameter group)

Parameters in this table are grouped into similar chemical entities. Groups are represented by shading. Permits can specify different variations of similar chemical entities. For example, a permit might restrict total zinc, dissolved zinc, or both. These different parameters are neither completely exclusive or totally overlapping – they overlap partially.

The groups are ranked according to total "*maximum permissible loading*" for each group. By multiplying the maximum allowable flowrate in a permit by the maximum allowable concentration of a particular parameter, the allowable mass discharge, or loading, of that parameter can be calculated. Considering the whole Fraser Basin, the combined total of allowable loadings of the parameters (in all industrial permits) provides an estimate of the maximum potential loading to the aquatic environment from all permitted industrial discharges. These values are referred to here as "*maximum permissable loadings*."

Table 2.4 provides a breakdown of the maximum permissible loadings of TSS and BOD by industrial sector. The pulp and paper sector accounts for 93 per cent of the maximum permissible loadings of TSS and 94 per cent of the maximum permissible loadings of BOD.

Table 2.4 Maximum Permissible TSS and BOD Loadings by Industry Sector

Sector	TSS		BOD	
	Loading (kg/day)	Number of Discharges	Loading (kg/day)	Number of Discharges
Pulp and Paper	137,000	7	56,700	7
Mining	4,000	10		0
Primary Metal Industries	2,300	2		0
Food Industries	1,200	10	2,500	10
Fishing Industries	820	13	630	10
Placer Mines	820	1		0
Recycling Operations	400	1	300	1
Wholesale Petroleum Products	360	3		0
Industrial Chemicals	150	1		0
Non-Metallic Mineral Products	130	9		0
Natural Gas Pipeline Transport	110	2		0
Waste Disposal	80	1	60	1
Petroleum and Coal Products	61	2		0
Wood Industries	11	4	0.41	2
Sand and Gravel Pits	5.3	1		0
Motor Vehicle Industry	2.1	1		0
Poultry Services	0.0055	1	0.005	1
Total	147,100	68	60,200	32

Table 2.5 breaks the totals down by Fraser Basin region.

Table 2.5 Maximum Permissible Industrial TSS and BOD Loadings by Fraser Basin Region

Region	TSS		BOD	
	Loading (kg/day)	Number of Discharges	Loading (kg/day)	Number of Discharges
Upper Fraser	61,200	7	24,500	6
Middle Fraser	38,400	7	14,800	2
Thompson	30,600	13	11,200	5
Lower Fraser	16,900	41	9,700	19
Total	147,100	68	60,200	32

Maximum permissible loadings to Fraser Basin waters remained largely unchanged from 1994 to 1997.

The main limitation of the *Point Source Inventory* was that it did not indicate the quantities of these permitted parameters that were actually released. Industrial operations commonly discharge less than their permits allow, especially where their discharges vary according to production level and/or season. For example, hydrogen peroxide ranked quite high in Table 2.3 with a basin-wide maximum permissible loading of 385 kg/day, but this was all due to one permit (FMC Canada), and the wastewater characterization program at FMC found no measurable hydrogen peroxide discharge. And although exceedences of permit levels are prohibited, they can also occur. At best, if discharges greater than permitted were the exception, while discharges less than permitted were the rule, and if all significant discharges of a parameter were specified in permits, then the maximum permissible loading would provide an upper bound on the actual loading of that parameter to Fraser Basin waters.

2.2.1.2.2 *Fraser Basin Effluent Monitoring Database*

In order to obtain a more accurate assessment of actual loadings to Fraser Basin waters, the *Fraser Basin Effluent Monitoring Database* was developed. This database compiled actual monitoring data from industrial and other wastewater discharges. Industrial dischargers are required to monitor and report certain characteristics of their wastewater discharges, either as a condition of their permits, or as required under regulations. For example, the federal *Pulp and Paper Effluent Regulations* require pulp and paper mills to monitor and report the flow, BOD, TSS, rainbow trout toxicity and *Daphnia magna* toxicity of their effluent at prescribed frequencies and to report information monthly. Dioxin and furan information must also be reported monthly under the *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations*. Compliance monitoring data were entered into the database. The results of other non-regulatory data-gathering, such as the wastewater characterization studies described in section 2.2.1.1, were also entered into the database. The *Fraser Basin Effluent Monitoring Database* was a component of Envirodat, Environment Canada's national environmental quality database.

Pulp and paper mill effluent quality data in the *Fraser Basin Effluent Monitoring Database* were most complete for TSS and BOD, post-December 1992, primarily because of the promulgation of the *Pulp and Paper Effluent Regulations.* For example, the database literally contained a TSS measurement for each mill for every day after December 1992 that the mill operated. This enabled detailed analysis such as that illustrated in Figure 2.1, which shows a significant reduction since January 1990 in the average daily TSS loading from the Weyerhaeuser Canada Ltd. pulp mill.

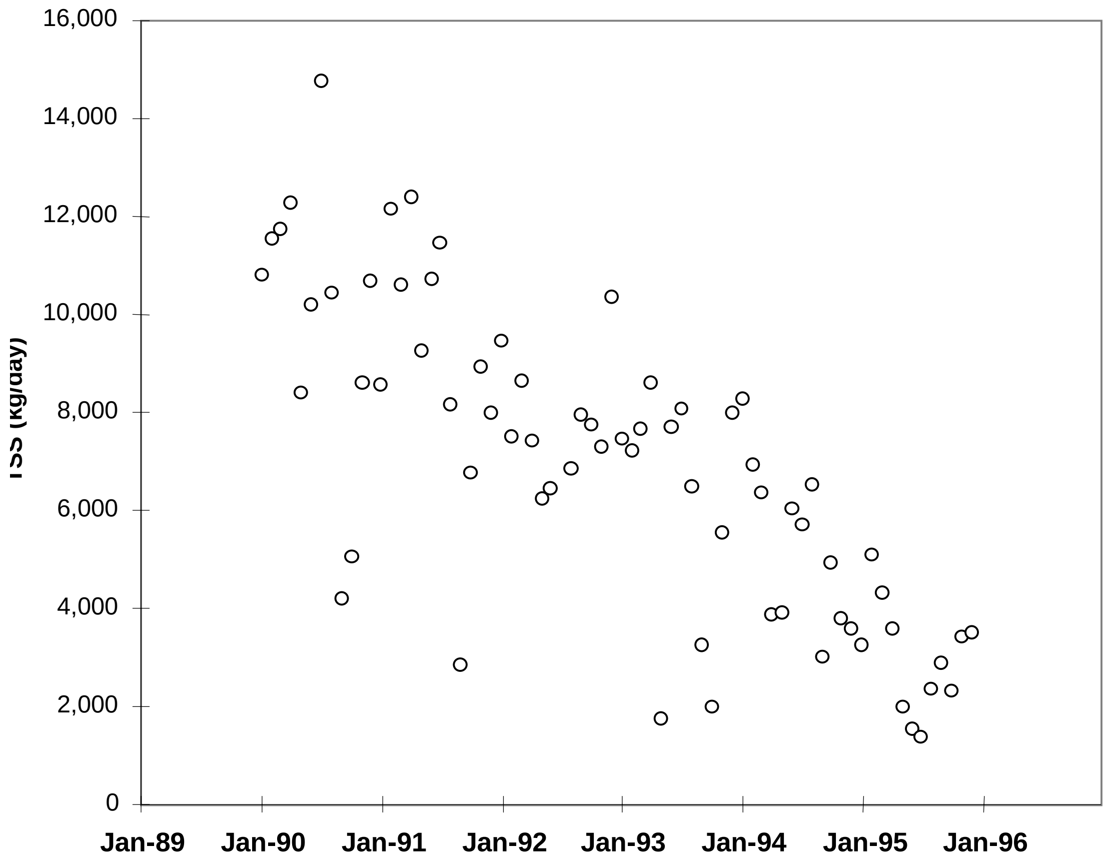


Figure 2.1 Loading of Total Suspended Solids from Weyerhauser Canada Ltd. Pulp Mill

In general, however, establishing and maintaining the database and related data acquisition and transfer was difficult. Most of the data had to be located from a variety of government agency filing systems and manually transcribed into the database from paper documentation. Quality assurance procedures were developed slowly over time. Even by 1997, compliance monitoring data from pulp and paper mills formed the only comprehensive set in the database. These data nonetheless provided useful information concerning industrial water pollution because the pulp and paper sector was a substantial contributor to total industrial discharges.

2.2.2 Reducing Industrial Water Pollution

Armed with a much better understanding of industrial water pollution, the Fraser River Action Plan set out to reduce it.

The characterization and inventory work described above showed that pollutants were released not only by large industries such as the pulp and paper industry but also by small and medium operations such as food industries and fish processors. While large industries such as the pulp and paper industry certainly discharged a large percentage of industrial water pollutant loadings, collectively the smaller industries were not insignificant. Furthermore, the large industries were already under considerable regulatory and public pressure to reduce their pollutant discharges, while many of the smaller industries faced only general legislative requirements and little or no public pressure. For example, starting in 1992, the pulp and paper sector had to comply with the strict new federal *Pulp and Paper Effluent Regulations,* whereas the much smaller printing industry for the most part faced only general sewer use bylaws. Finally, the large industries generally already possessed the in-house technical expertise necessary to reduce their pollution, while smaller industries often did not, and could therefore benefit more from the knowledge that FRAP could offer.

For these reasons, the industrial discharges program of FRAP focused mainly on small and medium industries in trying to achieve reductions in industrial pollution.

2.2.2.1 Improving Industrial Practices

A means of reducing pollution from small and medium industries, beyond compliance with general legislative provisions, was desired. FRAP also sought to incorporate the concepts of cost efficiency and economic health of the small and medium industries in this undertaking, in support of deliverable 7: "Provide decision makers with knowledge of the cost effectiveness of various pollution abatement… alternatives." As a first step, therefore, the preferred approach was to develop "codes of practice" or "best management practices" (BMPs) and to encourage and assist small and medium industrial dischargers to improve their practices voluntarily. Codes of practice and BMPs emphasized low-cost methods of improving environmental performance through changes to operational practices rather than through expensive treatment options. It was hoped that incorporation of economic factors would increase industry stewardship. Use of the voluntary approach as a first step was expected to lower government costs for enforcement and inspection.

Codes of practice and BMPs compile specific industrial practices (often concerning routine, day-to-day activities) that are the most ecologically-sound practices realistically achievable within a particular sector. Sectors for which BMPs or codes of practice would be developed were selected according to several criteria. In general, they were sectors with small and medium facilities discharging to the waters of the Fraser Basin or Burrard Inlet, for which best practices were not already documented. Some sectors, such as fish processing, were chosen because wastewater characterizations performed earlier in the program suggested that improvement was needed. Certain practical considerations also influenced BMP or code development, for example, where a sector was a priority for a FRAP partner.

Other reasons for choosing particular sectors included: rapid growth in the sector, lack of active enforcement of sewer use bylaws, increasing waste management and cleanup costs, and out-of-date regulations.

Best management practices or codes of practice were developed for eight sectors: ready mix concrete, dry bulk terminals, fish processing, car and truck wash, ship/boat building and repair, marinas and small boatyards, microbreweries and U-brew, and exposed aggregate. These BMPs and codes of practice addressed pollution to air, water, sewer and land, as well as other environmental issues. In addition, the program produced a compilation of BMPs relating to stormwater management only for 19 different sectors. The exact titles of these documents are listed in Appendix B.

The development of each set of best practices began with an analysis of the environmental issues faced by the sector and a survey of its current operating practices. This survey usually involved both a review of the literature (for practices in use at facilities outside the basin) and several site visits (for practices in use at facilities within the basin). Following the analysis, best practices were identified.

The best practices recommended for the different sectors had several common themes.

Minimizing the creation of difficult-to-treat wastewaters was generally found to be more economical than treating them. Water use reductions were recommended for all sectors, especially the ready mix concrete and fish processing sectors. Conversion to high-pressure, low-flow nozzles, installation of flow restrictors, measurement of water consumption and staff training were among the practices proposed. Recycling of wastewater was also encouraged.

Many of the suggested practices focused on avoiding the mixing of oily or solid contaminants with wastewaters. Dry cleaning of equipment and process areas, for example broom cleaning of spilled grain or vacuuming of fish blood, were promoted. The documents often advised keeping stormwater separate from process wastewater by, for example, covering process areas or paving and curbing sites to divert stormwater away from areas that might be covered with contaminants such as car wash detergents or salt stored at chlor-alkali plants. Another recommendation for keeping oily or solid contaminants out of wastewaters was to minimize the availability of potential contaminants around industrial sites. This can be accomplished through the use of good housekeeping practices such as capturing dispersed materials such as paint drips or sandblasting grit; regularly cleaning and maintaining equipment; providing secure covered storage of chemicals, paints, solvents, fuels and other hazardous materials; properly labelling materials and keeping records; and promptly repairing leaks. Secondary containment around liquid storage and formal spill response procedures and training were also frequently suggested.

With regard to wastewater streams that continued to exist despite minimization efforts, the BMP documents advocated that, at a minimum, these wastewaters be collected and routed to sanitary sewers, and not be allowed to drain to the ground, as at a boatyard on an unpaved surface. Some sectors were advised to treat their wastewaters through such methods as screening, solids settling, and oil/water separation. The documents also counselled the proper maintenance of wastewater treatment systems, such as the cleaning of solid sludges from ready mix concrete plant settling tanks.

Finally, the management of wastes was also addressed. The return of unused paints, solvents, chemicals and their containers to vendors for reuse or recycle was recommended. The preferred practice for solid wastes such as fish offal was reuse or recycle; proper disposal by a qualified contractor was also listed as acceptable.

The published BMPs and codes of practice were (and are still) publicly available at no charge. Copies of the documents were distributed to industrial associations and other government agencies, and often to all the relevant industrial operations in the Fraser Basin. In addition to this passive promotion, the BMPs and codes were also actively promoted to the key individuals who can actually implement the recommended changes at their facilities. For example, the BMP for exposed aggregate was promoted in two construction industry publications, *Journal of Commerce* and *Building Right*. For the ready mix concrete sector, a workshop was held. The recommended operating practices, and the rationale for adopting them, were explained in detail, and operators were able to have their questions answered. Finally, for some sectors, FRAP went beyond promotion. For example, for the ship/boat building and repair sector and the marina/small boatyard sector, a marketing consultant was retained to determine the most effective strategy for getting key individuals at each facility to begin implementing the relevant best management practices.

In addition, FRAP's enforcement component undertook inspections for compliance with the best management practices within four of the sectors: ready mix concrete, dry bulk terminals, fish processing, and ship/boat building and repair. The 1996 compliance reports for these sectors (available at *http://www.pwc.bc.doe.ca/ep/programs/eppy/enforce/0main96.htm*) provide detailed explanation of, and context for, these inspections. Inspectors visited several, but not all, of the facilities within each sector. Checklists incorporating BMPs were used to audit each area of operations within each sector, and per cent-implementation figures were generated. Overall BMP implementation was 47 per cent for Fraser Basin fish processors, 48 per cent for Fraser Basin grain terminals (68 per cent for Burrard Inlet grain terminals), 58 per cent for ship and boat builders/repairers province-wide, and about 70 per cent for ready mix concrete plants in the lower mainland. The FRAP inspector inspecting grain terminals was able to suggest a relatively minor change in operating practices—the cessation of direct flushing of spilled grain into receiving waters—that yielded a substantial reduction in environmentally disruptive discharges; BOD and TSS measurements in inspection samples decreased by 95 per cent and 89 per cent, respectively, from 1995 to 1996. BMP inspections for other sectors will continue beyond the life of FRAP.

Some of the BMPs and codes of practice have also been used by BC MELP in amending permit conditions for individual facilities.

2.2.2.2 Promoting Pollution Prevention Planning

As discussed in the Introduction, part way through the Fraser River Action Plan, new emphasis was placed on achieving pollution reductions by eliminating the release of pollutants at the source. For the industrial program, this meant that efforts shifted from producing best management practices or codes of practice, to producing pollution prevention guides.

Pollution prevention guides (P2 guides) are manuals to guide a facility through the process of preparing a pollution prevention plan. A pollution prevention plan is a comprehensive evaluation of a facility's options for avoiding or minimizing the creation of pollutants in the first place, instead of controlling or treating them once they already exist. A P2 guide can include suggested industrial practices for consideration in developing pollution prevention actions.

The first P2 guide produced, "Reference Workbook: Pollution Prevention Plans," explained the basics of how to prepare a pollution prevention plan in any sector (94-35). Table 2.6 lists the elements of a pollution prevention plan. The reference workbook walked through these steps, providing detailed "how to" procedures, itemized task lists, worksheets to complete and references to related guidance documents (including several by the U.S. Environmental Protection Agency).

Table 2.6 Elements of a Pollution Prevention Plan

Industry Profile

- Industry Description
- Raw Materials, including ingredients of concern, loading and storage methods
- Process Description, including operating schedule, energy use
- Products, including ingredients of concern, storage
- Waste Materials, including origin, media, properties, components of concern
- Waste Management Methods, including best management practices
- Environmental Permit Requirements and Performance

Preliminary Review and Assessment - *identify all waste streams, their sources and the costs of treatment and disposal, then identify areas of opportunity for pollution prevention.*

- Plant Data Compilation - consider all waste streams, their sources and costs of control, treatment and disposal
- Site Inspection
- Identification of Pollution Prevention Potentials
- Prioritization of Pollution Prevention Potentials

Detailed Assessment - *based on prioritized list of waste streams from preliminary assessment, identify appropriate pollution prevention options for implementation. Evaluate options for technical, environmental and economic feasibility.*

- Process and Waste Treatment Data Collection - characterize in detail the process areas with high pollution prevention potential waste streams
- Organization and Documentation of Process and Waste Stream Data, including material balances - organize in accordance with pollution prevention hierarchy
- Process and Waste Treatment Data Review and Site Inspection
- Identification, Organization, Ranking and Screening of Pollution Prevention Options
- Feasibility Assessment, including total cost assessment
- Assessment Report Preparation

Pollution Prevention Progress Assessment - *conduct quantitative evaluations of pollutant reduction after implementation of pollution prevention options.*

The reference workbook also provided guidance in developing nine sector-specific P2 guides which were published by FRAP. These guides went further than the reference workbook, providing detailed information on each sector's industrial processes, waste characteristics and recommended pollution prevention measures. The sector-specific guides made it easier for smaller operations to develop facility-specific pollution prevention plans.

Pollution prevention guides were developed for the following sectors: automobile recycling, dry bulk terminals, fish processing, fruit and vegetable processing, asphalt preparation, ready mix concrete, foundries, wood preservation, brewery and winery, and dairy. Note that best management practices or codes of practice had previously been developed for some of these sectors. The exact titles of the documents are listed in Appendix B.

Like the BMPs and codes of practice, the P2 guides were distributed to industrial associations, other government agencies, and often to relevant industrial operations; and like the BMPs and codes of practice, they were (and are) publicly available at no charge. The P2 guides were also actively promoted to key individuals within the various sectors. Workshops explaining pollution prevention measures in detail were held for operators in the automobile recycling, asphalt preparation and dairy sectors.

Because the P2 guides were mostly published near the end of FRAP, as of late 1997 there was as yet little information available concerning the implementation of pollution prevention plans using the guides. Operations within some sectors, notably dry bulk terminals, were beginning to develop facility pollution prevention plans. In the case of the auto recycling industry, BC MELP developed a draft environmental stewardship regulation based on the FRAP pollution prevention guide.

2.3 IMPLEMENTATION AND RESULTS

2.3.1 Demonstrating Pollution Prevention Planning

For two sectors, instead of developing sector-wide pollution prevention guides, FRAP co-funded the development of pollution prevention plans at individual facilities. An advantage of this approach was that tangible actions to reduce pollution took place sooner, although only at the facilities in question. These pollution prevention plans, which included lists of all pollution prevention options considered—even those found to be infeasible at the particular facility—could serve as examples for other facilities in future.

The first pollution prevention plan was developed by Ecowaste Industries for its Richmond Landfill, where about 630,000 m^3 of industrial waste material, mostly from demolition, land clearing and construction, was received each year (97-07).

The Ecowaste pollution prevention plan resulted in the replacement of two fuel tanks, enhanced salvaging of recyclable materials (including an incentive system for salvagers), and training of gatehouse personnel, equipment operators and salvagers. The new double-walled above-ground storage tanks reduced the possibility of release of 25,000 litres of fuel. Enhanced recycling reduced the amount of landfilled material and displaced the use of virgin materials. Well-trained personnel could detect and reduce illegal delivery of hazardous materials such as batteries, used oil, paints and solvents to the landfill, keeping hazardous substances out of the landfill leachate. In addition, as part of the P2 planning process, other options were identified that, although not feasible at the Richmond Landfill, would reduce the landfilling of wood, fill, compostables and/or hazardous materials if implemented elsewhere in the Fraser Basin.

The second facility-specific pollution prevention plan was prepared by Riverside Forest Products for its Williams Lake Sawmill, whose annual production was about 145,000 thousand board measure kiln-dried dimension lumber (98-04).

The pollution prevention planning process generated 48 pollution prevention options for the facility to consider. In the plan itself, the company selected all but eight of these options to implement, mostly in 1997 or 1998. Highlights of these actions follow.

To reduce air emissions such as hydrocarbon combustion products, greenhouse gases and road dust, the mill reduced its on-site speed limit from 30 km/h to 20 km/h, and began maintaining vehicle service records to maximize vehicle performance. The facility also planned to increase the frequency of dust suppressant applications, plant windbreaks around the mill boundary and begin replacing some of its gas-powered pickups and forklifts with propane-powered vehicles.

To combat erosion of the Williams Lake River bank and the resulting transport of suspended sediments into the river, Riverside pledged to prepare a stormwater management plan, prepare an engineering design for upgrading an important culvert and initiate discussions with the neighbouring uphill golf course about reducing water flows. The company also planned to determine the feasibility of constructing detention ponds for stormwater reuse, to reduce its consumption of potable water.

The company selected several actions to reduce the potential for contamination of soil, groundwater and/or surface water runoff. In addition to cleaning up old equipment that had been discarded on-site, it committed to review its use of lubricants with the objective of minimizing their use, investigate the use of biodegradable hydraulic oils in high risk areas, replace three underground tanks with aboveground double-walled tanks, install some oil/water and oil/water/sediment separators, centralize the storage of hazardous materials, initiate a hazardous inventory tracking system (including fuel in/out reconciliation) and update its spill response plan. The mill also proposed to extend its connection to the municipal sewage system, in order to eliminate on-site underground disposal of sewage.

Riverside established the target of reducing its annual volume of woodwaste landfilled by 50 per cent by 2000. The company purchased a new letourneau, whose net effect was to reduce log handling, consequently reducing the amount of loose wood and bark sent to landfill and the amount of smoke from woodwaste burns. In addition, Riverside planned to cover some finished portions of the landfill to reduce potential leachate production, and install a gate to prevent unauthorized dumping of hazardous materials.

The pollution prevention planning process included a public advisory committee, which identified noise as a public concern. In response, the mill eliminated the use of outdoor shift whistles, improved its chip blower procedures and committed to install ultra-high molecular weight plastic in conveyor troughs to eliminate metal-to-metal contact.

The Riverside pollution prevention plan included targets and a monitoring program to track implementation progress over time.

2.3.2 Demonstrating Clean Industrial Processes

While improved operating practices through best management practices or pollution prevention plans were appropriate for many small and medium industries, in some cases new and innovative industrial processes or technologies were needed to further reduce pollution. But a new industrial process or technology can achieve widespread implementation only after it has earned the confidence of the industry. One way to earn such confidence is to successfully demonstrate that the process will work on an industrial scale. Therefore, FRAP co-funded the demonstration of two new industrial processes that, if applied at similar operations throughout the Fraser Basin, could reduce pollutant discharges.

The first demonstration took place at Transcontinental Printing, on Annacis Island (97-12). The project demonstrated that a combination of pre-, ultra- and nano-filtration of used process water could reduce discharges of several pollutants by over 95 per cent, and allow for near-closed-loop water reuse (99 per cent). TSS releases were reduced by 97 per cent, BOD by 99 per cent, COD by 99 per cent, total oil and grease by over 99 per cent, hydrocarbon oil and grease by over 99 per cent, and total metals (*i.e.*, Al, Sb, As, Cd, Cr, Co, Cu, Fe, Pb, Mn, Mo, Ni, Ag, Sr, Sn, Ti, V, Zn and Zr) by 95 per cent. The success of this project resulted in both the company and its manufacturing manager receiving awards from the federal Minister of the Environment.

In 1997, Transcontinental was the only printing facility in the Fraser Basin using this filtration technology. The potential therefore exists for other printers to reduce their pollutant discharges by similar amounts.

The second demonstration project addressed rainwater runoff from chromated copper arsenate (CCA)-treated hydro poles at pole yards (98-05). The project tested the use of iron-treated cedar shavings to trap metals from runoff before these pollutants could contaminate the soil. Preliminary results indicated that the shavings absorbed 99 per cent of the arsenic, 95 per cent of the copper, and 94 per cent of the chromium present in the pole runoff, so that the resulting runoff was that much cleaner. Similar results should be possible at pole yards throughout the Fraser Basin.

However, preliminary tests also indicated that the resulting runoff could be quite toxic to luminescent bacteria. Cedar itself contains toxic extractives; however, the iron treatment of the cedar shavings was expected to reduce the extractability of these toxics to acceptable levels. This issue would have to be resolved prior to the adoption of this method as industry practice.

2.3.3 Achievement of Objectives

FRAP deliverable 8, to "develop and maintain an inventory of major [water] pollution sources and loadings in the basin," was accomplished by the completion of the *Fraser Point Source Inventory*, discussed in section 2.2.1.2.1. All provincially-permitted industrial effluent discharges in the Fraser Basin were enumerated in the Point Source Inventory, which was continually updated until March 31, 1997. Information on permissible effluent loadings contained in the Point Source Inventory was augmented by actual effluent characterization studies at 19 industrial sites and the development of the *Fraser Basin Effluent Monitoring Database*.

FRAP deliverable 9 was to "reduce environmentally disruptive industrial effluent discharges by 30% to meet environmental quality objectives." Per cent reductions were calculated on an individual parameter basis for parameters where adequate data were available.

According to the *Point Source Inventory*, maximum permissible loadings to the basin remained largely unchanged from 1993 to 1997 for most parameters. However, there is a strong incentive for industrial operations to maintain high permit levels, even if their actual discharges are much lower, for the sake of operational flexibility. Therefore, unchanged permit levels do not necessarily indicate unchanged pollution levels.

In terms of actual discharges, reliable, comprehensive data were available in the *Fraser Basin Effluent Monitoring Database*, but for pulp and paper mills only. Figure 2.2 plots annual average daily loadings for Fraser Basin pulp and paper mills. Both TSS and BOD show steady declines: TSS discharges decreased by 39 per cent and BOD discharges decreased by 38 per cent. Figure 2.3, which is plotted on a logarithmic scale, shows a pronounced drop in dioxin and furan discharges from 1991 to 1996. The average 1996 dioxin loading to basin waters was 92 per cent lower than the average 1991 loading, and the average furan loading was 93 per cent lower. These reductions all exceed the 30 per cent deliverable.

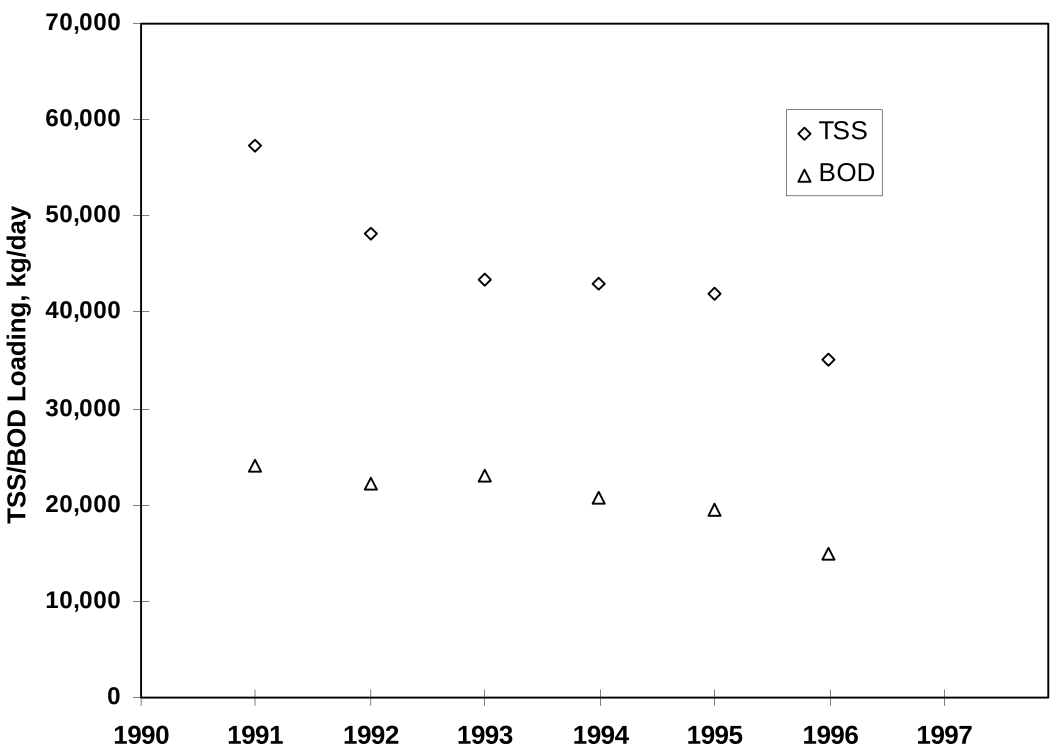


Figure 2.2 Total Loading of TSS and BOD from Fraser Basin Pulp and Paper Mills

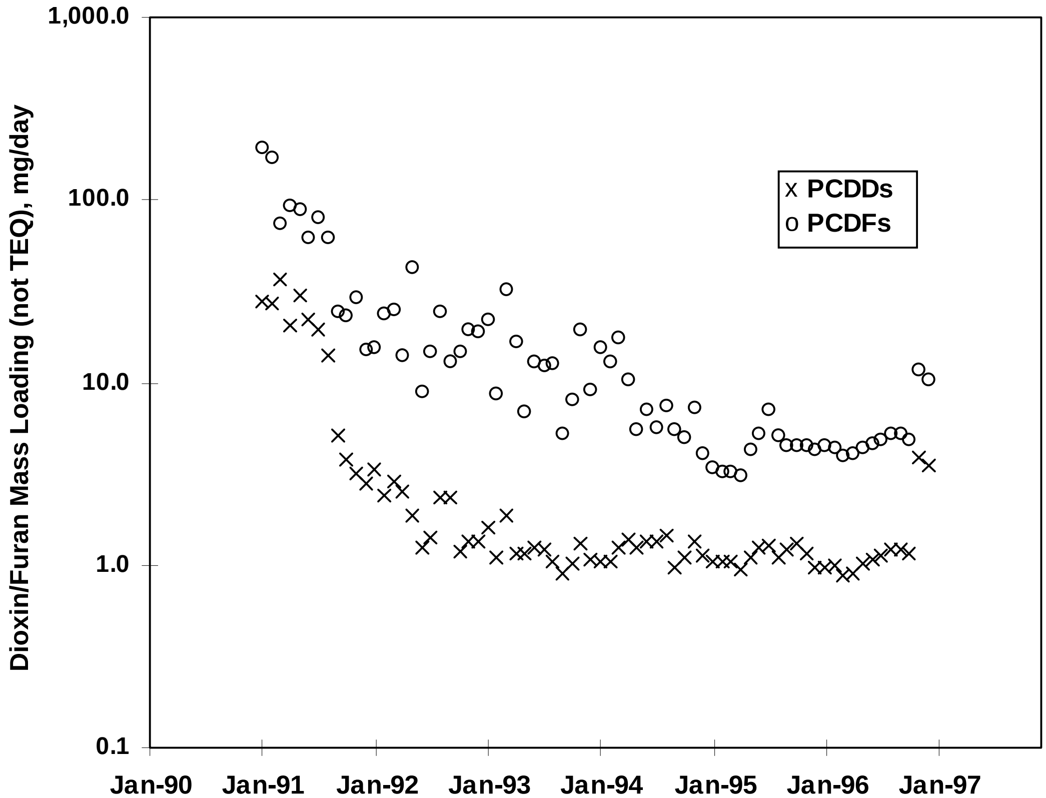


Figure 2.3 Total Loading of Dioxins (PCDDs) and Furans (PCDFs) from Fraser Basin Pulp Mills

The industrial discharges component of FRAP, however, focused on small and medium industries rather than the pulp and paper sector. For these other sectors (and some other parameters), the reduction in industrial water pollution could not be calculated because of problems with data acquisition and quality. Nonetheless, it is unlikely that basin-wide reductions for these other sectors reached 30 per cent.

The projects undertaken by the industrial discharges component of FRAP may deliver even greater reductions, but over the long run, not immediately.

The several codes of practice, best management practice compilations and pollution prevention guidelines should ultimately lead to widespread pollution reductions—for example, where implemented, the fish processor best practices could reduce organics loadings by 50 per cent— but it is simply too early to determine their long-term effect on industrial practices. Changes in industrial practices, especially pollution prevention changes, offer fundamental and far-reaching pollutant reductions, but they also tend to be less tangible and harder to quantify in the short term. There are indications of some short-term changes as a result of these guidelines (for example, grain terminals stopped flushing spilled grain into the water and reduced their BOD discharges by 95 per cent and their TSS discharges by 89 per cent), but changes are not yet basin-wide.

Similarly, the individual facility pollution prevention plans are only in their first year or two of implementation, and though they too promise significant change, such as a 50 per cent reduction in landfilled woodwaste at Riverside, the pollution preservation actions they have generated have yet to be transferred to other similar facilities. Finally, the innovative industrial processes demonstrated under FRAP, while demonstrating impressive pollutant reductions—over 94 per cent reduction of all key parameters—have also not been adopted across the basin.

FRAP deliverable 17 was to "reduce the release of persistent toxic substances pursuant to the *Canadian Environmental Protection Act* and identified as priority from inventories and environmental data to the extent allowed by best practicable technology." This objective concerned substances listed in Schedule I of the *Canadian Environmental Protection Act* and substances on the Priority Substances List (PSL) established under the same Act.

The development of the FRAP wastewater characterization guidelines (section 2.2.1.1.1) revealed that several PSL substances would not be expected in industrial water effluents in the Fraser Basin, either because of the nature of the pollutant or the industries it was associated with. Other substances were definitely released to Fraser Basin waters. Quantitative reductions in releases of pulp mill effluents, dioxins and furans were discussed above. In addition, reductions in metal releases resulted from the two technology/process demonstration projects conducted under FRAP (section 2.3.2). Others of the persistent toxic substances in Schedule I or on the PSL were found by the industrial wastewater characterizations (section 2.2.1.1) to be released in either small or undetectable quantities to Fraser basin waters. Finally, for some of the listed substances, data on releases to Fraser Basin waters were not available.

2.4 CONCLUSIONS AND RECOMMENDATIONS

The Fraser River Action Plan industrial discharges component set out to better understand industrial water pollution and to reduce it. Fraser Basin industrial water pollution is now much better understood than it was prior to FRAP. Pollution reduction has been achieved by some sectors and at some facilities, but the overall pollution reduction effort will have to continue beyond the life of FRAP.

Wastewater characterization studies revealed the characteristics of industrial wastewater discharges in terms of a broad range of contaminants. Among the industries characterized, pulp and paper mills were the major source of BOD, TSS, zinc, chromium, copper, dioxins and furans, PAHs, resin acids and chlorophenolics. However, smaller industrial operations also contributed significant contaminant loadings to Fraser Basin waters. Sawmills, fish processors, cement plants, and chemical and manufacturing industries were shown to be sources of copper, zinc and arsenic. Comparison of toxicity responses revealed that while most of the pulp mill effluents characterized were not acutely toxic to rainbow trout, acute toxicity was often measured in the effluents tested from the smaller industries.

Recommendation:

1. Future ecosystem initiatives should place greater emphasis on efforts to inventory and reduce pollution from smaller industrial operations. Liquid waste management planning, sewer use control and pollution prevention planning processes present good opportunities to address these sources.

The *Fraser Point Source Inventory* database documented all direct effluent discharges to Fraser Basin waters authorized in permits issued by the BC MELP. This geo-referenced database contains information on allowable discharge volumes and parameter concentration limits and could be used to calculate maximum permissible loadings for different parameters. No such capability or information base existed at the outset of FRAP. In the final years of FRAP, BC MELP upgraded its permit system so that all permit information is now recorded in a "WASTE" database maintained by BC MELP regional offices.

Recommendation:

2. Future efforts to compile inventories of direct effluent discharge sources and allowable releases should be based on extraction and manipulation of data from the BC MELP WASTE permit system.

The *Fraser Basin Effluent Monitoring Database*, a component of Environment Canada's national Envirodat database, is capable of storing and searching actual monitoring data for the complete spectrum of effluent quantity, quality and toxicity parameters. Effective utilization of this database was limited by two factors: the lack of accessible, quality data to enter in the database; and the tedious and error-prone nature of transcribing paper data into the database. By 1997, pulp and paper compliance monitoring data was the only comprehensive set in the database. Even so, because the pulp and paper industry accounted for the bulk of industrial loadings to Fraser Basin waters, the *Fraser Basin Effluent Monitoring Database* enabled better tracking of industrial water pollution releases than was possible at the outset of FRAP.

Under the terms of BC MELP discharge permits, permit holders are required to monitor effluent quantity and quality. Pulp and paper mills now submit their compliance monitoring reports electronically to Environment Canada and BC MELP. BC MELP has launched a database (EMS) for environmental monitoring data including permittee reports, but the only permit data currently entered into EMS are those submitted by the pulp and paper industry. The remainder of the data reside in paper or electronic reports in individual regional BC MELP office files, making it difficult to use the data for ecosystem-level assessments.

Recommendations:

3. Government agencies involved in effluent monitoring should co-ordinate efforts to ensure that all future effluent monitoring results—whether generated by government or through compliance monitoring by industry—are reported in an easily manipulated electronic format, and made readily available (subject to legal confidentiality requirements).
4. Regulated industries should be encouraged to report their compliance monitoring data electronically to the relevant jurisdictions.
5. Entry of permittee and BC MELP-measured data into BC MELP's EMS database should be expedited for regions involved in future ecosystem initiatives.

Building on the results of the wastewater characterizations and the inventories, compilations of environmentally-sound industrial practices and/or manuals for preparing facility-specific pollution prevention plans were prepared for 15 sectors, in addition to some generic industrial guidance documents. The wealth of practical, "how-to" information which now exists in the documents should continue to assist the industries of the Fraser Basin to reduce their pollution far into the future. But they can do this only if they continue to be supported by promotion, dialogue, incentive programs, legislation and/or active inspections beyond the FRAP timeframe.

Finally, a handful of specific projects demonstrated that at individual industrial facilities, water pollution could be reduced by amounts greater than the 30 per cent FRAP target, by installing new processes or implementing pollution prevention plans. This potential has been established by the Fraser River Action Plan, but if it is to be realized these successes will have to be transferred to other facilities throughout the basin. This work remains to be accomplished post-FRAP.

Recommendations:

6. The solutions to industrial pollution developed under FRAP have the potential to provide long-term reductions beyond the 30 per cent target, but this will be achieved only if the information that has been reported on environmentally sound industrial practices and pollution prevention techniques continues to be disseminated. Practices and techniques developed under FRAP should be supported through dialogue with industry and inspections by government or third-party auditors.
7. Environment Canada should support the efforts of provincial, regional and municipal regulatory agencies, and industrial associations who have direct involvement with small and medium-sized industries, to build the pollution prevention guidelines into their respective regulatory frameworks. The development of a draft stewardship regulation based on the FRAP pollution prevention guideline for the auto recycling industry serves as one potential model for this transition.

3.0 MUNICIPAL DISCHARGES

CONTENTS

3.1 OBJECTIVES

The objectives of the municipal discharges component of FRAP were:

- to develop and maintain an inventory of major pollution sources and loadings in the basin (FRAP deliverable 8);
- to reduce the contaminant loadings from untreated or inadequately treated sewage discharges and from combined sewer overflows by 30% to meet environmental quality objectives (FRAP deliverables 10 and 11); and
- to assist in achieving the long-term sustainability of the Fraser River Basin.

Although landfill leachate sources and loadings were not specifically included in the original FRAP program, landfills were subsequently identified as a possible significant source of pollution and therefore have been included in the municipal discharges component of the pollution abatement program. Urban runoff, often considered a component of municipal discharges, is addressed separately in Chapter 4.

3.2 ACTIVITIES

The following activities were carried out to meet the objectives of FRAP.

3.2.1 Contaminant Loadings Estimate

An inventory of municipal discharges—including sewage discharges, combined sewer overflows and landfill leachate—has been developed.

3.2.1.1 Sewage Discharges

Permits issued by the B.C. Ministry of Environment, Lands and Parks (BC MELP) pursuant to the *Waste Management Act* were entered into a point source database. Eighty-six sewage treatment facilities directly discharge effluent to surface waters within the basin, of which 33 are community or municipal facilities. The remainder, generally more minor sewage discharges of less than 100 m^3 per day, serve private residential developments, floating home villages and industrial sites such as pulp and paper, fish processing, and mining operations. By far, the single largest sewage discharge to the basin is the Greater Vancouver Regional District's Annacis Island Wastewater Treatment Plant, which has a maximum authorized rate of discharge of 586,430 m^3 per day. From 1990 to 1993, the daily discharge averaged 368,400 m^3 per day, or approximately 66 per cent of total sewage discharges to the basin.

Actual flow and pollutant loading data were obtained from BC MELP for all of the major discharges as well as for all permits administered by BC MELP's lower mainland Regional Office. For the remaining discharges where actual monitoring data were not readily available, flows and loadings were estimated based on the authorized discharge limits specified in permits issued by BC MELP. Flows were assumed to be one-half the maximum authorized rate of discharge, and five-day biochemical oxygen demand (BOD) and total suspended solids (TSS) concentrations were both assumed to be 30 mg/L where secondary treatment is in place. These approximations are considered acceptable since the loadings from these lesser discharges are minor compared to those from large facilities. Estimated flows and loadings within each region of the basin at the start of FRAP in 1991 are shown in Table 3.1.

Table 3.1. Municipal Flows and Loadings

Region	Flow (m^3/day)	BOD Loading (kg/day)	TSS Loading (kg/day)
Upper Fraser	43,300	1,190	1,440
Middle Fraser	6,400	270	340
Thompson	16,900	350	350
Lower Fraser	491,900	57,600	27,230
Total	558,600	59,410	29,360

3.2.1.2 Combined Sewer Overflows

Combined sewer systems are designed to collect and convey both sewage and urban stormwater runoff. During wet weather, the ingress of large volumes of stormwater can result in the piping system capacity being exceeded. To reduce public health concerns and the risk of flooding and property damage, overflow structures have been constructed to discharge excess flows, including untreated sewage, to nearby receiving waters.

An inventory of combined sewer overflow (CSO) outfalls within the Fraser Basin and Burrard Inlet (93-21) was developed and 53 outfalls were identified, all within the Greater Vancouver Regional District (GVRD): 35 in Vancouver, 13 in New Westminster, and five in Burnaby. Twenty of these CSOs, with an estimated total annual volume of 6,274,000 m^3, discharge to the Fraser Basin. Monthly discharge volumes and frequencies were estimated for each of the CSO facilities.

Characterization studies of four CSO systems in the GVRD found that concentrations of BOD, TSS, and nutrients (ammonia and phosphorus) were four to 14 times lower than typical GVRD raw sewage, indicating relative rates of stormwater dilution. The study also confirmed that wastewater quality varies widely during CSO events. In addition, a CSO assessment program carried out in the City of Vancouver generally found contaminant levels similar to those of the GVRD monitoring program.

Total estimated flows and loadings from the 20 CSOs discharging to the Fraser Basin—all within the lower Fraser region—are 17,200 m^3/day, 770 kg BOD/day, and 670 kg TSS/day. Although overflows are highly variable on both a daily and seasonal basis, the loadings have been expressed on an average daily discharge basis for the purpose of comparison with sewage discharges. The BOD and TSS loading estimates are based on average concentrations found in the Glenbrook CSO at New Westminster, the only CSO system characterized that discharges to the Fraser Basin.

3.2.1.3 Landfill Leachate Discharges

A landfill inventory (97-19) identified 180 municipal landfills within the basin. Six landfills within the GVRD discharge leachate to the Annacis Island Wastewater Treatment Plant. A preliminary estimate of landfill leachate loadings within each region of the basin is shown in Table 3.2. Given the minor leachate loadings determined in the preliminary assessment, more detailed estimates are not deemed necessary.

Table 3.2. Landfill Leachate Discharges

Region	Flow (m^3/day)	BOD Loading (kg/day)	TSS Loading (kg/day)
Upper Fraser	70	3	6
Middle Fraser	80	3	8
Thompson	190	8	18
Lower Fraser	7,890	240	270
Total	8,230	254	302

3.2.2 Fate of Discharges

3.2.2.1 Sewage Discharges

An effluent plume delineation study was carried out at the City of Prince George Lansdowne Treatment Centre (94-05) to evaluate the performance of the outfall in terms of dilution rate and distribution of the effluent down-river under low river flow conditions. Initial dilution was rapid, with less than 0.65 per cent effluent concentration 250 m from the outfall, and vertical mixing was complete one km downstream.

As part of the development of a Watershed Management Plan for the Lillooet River system being led by BC MELP and to be completed in the year 2000, FRAP was involved in a review of urban and environmental planning conflicts, a survey of point source effluent and stormwater quality, and the development of a management strategy to protect valuable aquatic, riparian and wetland habitats from impacts of human activities. The Lillooet system was given priority because land development is predicted to increase due to the region's close proximity to nearly two million people in the Greater Vancouver area, along with expected increases in recreation and tourism. The review of conflicts concluded that there is no reason that acceptable measures cannot be adopted by all communities to ensure that development and expansion do not result in increased pollutants being released into the environment.

The point source effluent and stormwater quality survey concluded that:

- sewage treatment plant effluent qualities were generally good;
- stormwater runoff quality was comparable to or worse than sewage effluent;
- stormwater runoff exhibited elevated levels of iron, copper, chromium, zinc, specific conductance, turbidity and TSS; and

- water quality in Pemberton Creek systems receiving stormwater was generally acceptable, but water quality in Fitzsimmons Creek indicated signs of stormwater inputs.

The overall objective of the habitat inventory and classification report was to inventory, classify and produce management guidelines for sensitive areas of the Lillooet, Birkenhead and Green River systems within the Pemberton Valley and the Whistler/Pemberton corridor. The report also identified several habitat enhancement opportunities.

3.2.2.2 Combined Sewer Overflows

A wastewater plume delineation study was carried out on the Glenbrook CSO facility (95-22), which discharges into Sapperton Channel at New Westminster. In general, it was found that the plume was confined to the north shore of the Fraser River, forming a narrow streak less than 150 m in width downstream of the outfall. The highest concentrations were observed next to the shore, and the plume remained in continuous contact with the shore from the outfall to the North Arm of the Fraser River. The plume was carried upstream on the flood tide for a distance of 2,600 m. Vertical mixing was found to be rapid, producing nearly uniform concentrations over the water column within 200 m of the outfall. These dispersion results, in conjunction with the results of the Glenbrook CSO characterization study, will be used by the GVRD for a Glenbrook fate and effects study in 1998, which will assist in setting priorities for pollution abatement measures.

3.2.2.3 Landfill Leachate Discharges

An impact assessment, based on a "source-pathway-receptor" model, was carried out on the Old Quesnel Landfill located on the south bank of the Fraser River west of the City of Quesnel (95-05). This study found that the landfill is located on a bench of silt and clay soils of low permeability, which retards leachate infiltration and promotes contaminant attenuation. Some leachate was observed as small surface seeps along the slope face and in some small drainage draws. However, a limited water quality and benthic organism sampling program failed to detect an impact on the Fraser River.

3.2.2.4 General

Discharge characterization studies and receiving-environment impact assessments are very costly; given the budget and resource constraints under the pollution abatement component of FRAP, these investigations have been limited in number and scope. However, Environment Canada's Aquatic and Atmospheric Science Division has carried out a number of receiving environment studies, which are reported in the *Environmental Quality Technical Synthesis Report*. In addition, under its liquid waste management planning process, the GVRD launched a $5 million environmental monitoring and assessment program in 1993, which will run to 1999. This program has provided substantial information and will be used in planning and setting priorities for pollution abatement measures within the GVRD.

3.2.3 Sensitization and Influence of Dischargers

3.2.3.1 Sewage Discharges

A wastewater characterization study was carried out at the Lansdowne Wastewater Treatment Centre in Prince George, and a treatment assessment and an optimization study were conducted at the District of Hope's lagoon facility (94-12). At the Lansdowne Wastewater Treatment Centre, some toxic influent sources were identified and eliminated, plant malfunctions were minimized by implementing operational improvements and the treatment plant was subsequently upgraded to full secondary treatment. As recommended in the optimization study, the District of Hope has implemented some operational improvements in sludge and septage management, which have resulted in improved effluent quality.

Although not directly related to FRAP, other federal initiatives have led to a number of local governments proceeding with sewerage upgrades.

In May 1995, then DFO Minister Tobin, with the support of then EC Minister Copps, formally requested that the GVRD proceed with upgrades of the Annacis and Lulu plants. In response, the GVRD committed to completing these upgrades by the end of 1998.

Federal funding under the Canada/B.C. Infrastructure Works Program contributed towards the upgrading of several treatment facilities. The Infrastructure Program provided funding of $1 million or more to the GVRD for the Annacis plant ($207 million), City of Prince George for the Lansdowne plant ($8 million), District of Sicamous ($6.8 million), Central Fraser Valley Regional District ($3.9 million), District of Kent ($3.1 million), and City of Williams Lake ($1.3 million).

3.2.4 Development of Control Technologies, Design Guidelines and Education Programs to Assist in Long-Term Sustainability

3.2.4.1 Sewage Discharges

Lagoon treatment systems are common in rural settings where land is readily available. A manual was developed with guidelines for lagoon design, optimization and operation to achieve non-acutely toxic effluent (94-34). Effluent toxicity is most often the result of elevated levels of ammonia. The major mechanism for removing ammonia in lagoons is volatilization during warm weather. The manual advises that in cold climates, upgrading lagoons with technologies such as winter storage ponds and wetland treatment should be considered. A presentation on this project was made at the 1996 B.C. Water and Waste Association annual conference.

The discharge of sewage effluents rich in nitrogen and phosphorus into environmentally sensitive surface waters can cause algal blooms, promote the growth of aquatic vegetation and lead to serious deterioration of water quality. A pilot project was carried out to optimize a biological nutrient removal technology (94-24). The process combined a fixed (trickling filter) and suspended (activated sludge) growth wastewater treatment system. Under optimum conditions, the process produced an effluent with non-detectable ammonia concentrations and mean orthophosphate concentrations of 0.10 to 0.27 mg P/L. This technology is to be used in the Salmon Arm treatment plant upgrade. Outside of the Fraser Basin, it will be used in the Whistler treatment plant upgrade and has been marketed in

China by a consortium of B.C. engineering firms, sponsored by Environment Canada. Presentations on the pilot project were made at the 1996 B.C. Water and Waste Association annual conference and at the 1996 Water Environment Federation annual conference.

Many of the potentially toxic or hazardous contaminants found in municipal wastewater originate from industrial and commercial sources. A sewer use document (93-20) was developed to help local governments control contaminants of concern. The report presents a list of the chemicals of concern and their possible deleterious effects, a review of source control programs in other jurisdictions, a model sewer use control program and methods to minimize wastewater in industrial and commercial facilities. A model sewer use bylaw, part of the model sewer use control program, has been used by a consultant working for the City of Prince George and the City of Abbotsford. Much more widespread use is anticipated within the Fraser Basin once other regional districts begin to develop liquid waste management plans, since source control is to be addressed in the plans. A presentation on this project was made at the 1997 B.C. Water and Waste Association annual conference.

A study of on-site sewage disposal systems in the Fraser Valley was carried out. Given the number of historical failures observed and the recent increase in knowledge about appropriate septic system design and installation, the objective of this project was to review on-site sewage system practices and make recommendations for improvement. The report made 77 recommendations regarding design, construction, operation, maintenance, inspection, monitoring and future research needs, and pointed out a number of problems with the existing regulatory framework. Key recommendations included changing current guidelines, educating and registering personnel involved in design and installation, and educating the public about the necessity of maintenance. These recommendations are being considered in a revision of the provincial Sewage Disposal Regulation currently underway by the Ministry of Health. BC MELP is also in the process of developing a Municipal Sewage Regulation.

A video, brochure, and poster on septic tank and tile field operation and maintenance were developed. These products introduce homeowners, contractors, health agencies and the general public to the workings and care of on-site septic systems. Wide distribution has been accomplished through the B.C. Ministry of Health, the Shellfish Section of Environment Canada and the B.C. Water and Waste Association's 1997 annual conference. In addition, the products have been translated into Punjabi, Cantonese and French for use in other jurisdictions within Canada and around the world.

In 1997, FRAP sponsored a two-day B.C. Water and Waste Association seminar on package wastewater treatment technologies, proposed regulatory changes and on-site system design guidelines. The field has advanced rapidly in recent years and there was a need to transfer new technology to industry stakeholders. Approximately 190 designers, installers, regulators, suppliers and developers attended the seminar.

A study was undertaken to evaluate the feasibility of using a fluorometer to detect subsurface inflows of septic seepage to lakes (96-31). The fluorometer detects sewage presence by measuring peaks in fluorescence caused by optical brighteners in detergents. A methodology was developed to conduct a preliminary fluorometer survey as a first step, and to complement the initial survey with secondary sampling methods to verify that the high readings measured were caused by sewage-related seepage. BC MELP has used this tool to assess seepage in high priority lakes in the Bridge Creek Basin in the Cariboo Region.

Guidelines for the design of pressure distribution for on-site disposal systems were developed. Pressure distribution is the introduction of dosed quantities, under low pressure, of septic tank or other treated sewage effluent to a subsurface disposal field. Use of these systems, rather than conventional gravity feed systems, results in improved performance and increased lifespan of tile fields. These guidelines are currently being reviewed by the B.C. Ministries of Health and Environment, Lands and Parks for possible endorsement.

Several investigations have been carried out to advance technologies to manage biosolids, or sludge, from sewage treatment facilities in order to reduce sewage-related contaminant loadings to the receiving environment. One study investigated a micro-aerobically enhanced sludge digestion process. Conventional anaerobic digestion of municipal wastewater sludge is a two-step process. In the first step, facultative micro-organisms convert complex organic waste sludge substrate into simple organic fatty acids, such as acetate and other longer chain byproducts, by hydrolysis and fermentation. In the second step, anaerobic micro-organisms convert some of the organic acids to methane, carbon dioxide and water. A pilot-scale investigation was carried out to build on bench-scale research at the University of B.C. that had shown that the controlled addition of small quantities of oxygen in the first stage results in greater destruction of solids, increased production of acetate and more rapid conversion of the wastes into acetate. Methanogenic bacteria can use only a very narrow range of substrates, such as acetate, to generate methane. The benefits of the micro-aerobically enhanced process include a reduction in the amount of sludge requiring disposal, an increase in facility treatment capacity resulting from more rapid waste conversion, and greater production of methane, which is a potential energy source. Results to date have been promising; development of this technology is continuing outside of FRAP.

A second study, underway in the City of Prince George, is assessing the use of biosolids as a fertilizer and soil amendment. The objectives of the trial are to compare low, medium and high rates of biosolids application as a slow-release source of nitrogen fertilizer for forage grass over three years, to compare crop response from biosolids versus inorganic nitrogen fertilizer at the recommended agronomic rate, to measure crop uptake of metals at the various application rates and to determine the economic value of biosolids as a fertilizer for forage grass. Although there are some initial findings, the field trial program will not be completed until 1998, so more definitive results will not be available until 1999.

A third investigation involved a biosolids composting optimization project designed to achieve both heat treatment (for pathogen reduction) and moisture reduction over a short processing time. The addition of 25 per cent broiler litter, composed of manure and sawdust bedding for poultry raised for meat, was effective in maintaining the temperatures required to yield negligible coliform counts and in reducing moisture content. Metal concentration requirements in B.C. regulations currently being drafted will determine the feasibility of this process. Potential products may include potting media or a fertilizer base.

A fourth project evaluated the application of radio frequency drying technology to wastewater treatment plant biosolids to sterilize and dewater them (97-26). The equipment used in the study, originally designed for drying lumber, proved to be ineffective for treating loosely packed biosolids. The main problem was that the biosolids shrank during treatment, which increased the air gap between the electrode plates and the solids, leading to inefficient energy transfer to the biosolids.

3.2.4.2 CSO Discharges

Guidelines were developed for carrying out assessments of CSO and urban runoff discharges (93-37). The guidelines provide investigators with a step-by-step methodology for planning and implementing assessment programs. The document recommends a three-stage process: first, an investigative assessment to provide qualitative information that allows prioritization of discharges for detailed assessment; second, a detailed assessment to estimate contaminant loadings and impacts to the receiving environment; and third, a process assessment to determine remedial measures to reduce contaminant discharges. A presentation on this project was made at the 1997 B.C. Water and Waste Association annual conference.

3.2.4.3 Landfill Leachate

FRAP was a partner in the preparation of the GVRD's Solid Waste Management Plan - Stage 2 Report, which entailed a detailed study of solid waste management options. The purpose of the plan was to develop realistic, environmentally sound methods of reducing and managing the region's waste. Provincial legislation requires a 50 per cent per capita reduction in wastes requiring disposal by the year 2000. The three major criteria used in developing a comprehensive waste management strategy included: promoting waste reduction, reuse, and recycling; using cost-effective methods; and minimizing environmental and social impacts. Major recommendations included a manufacturer responsibility program, a national packaging protocol, subsidized backyard composting, a residential user pay system, and education and training. The report emphasizes that, because of the interdependence of its many components, the strategy's success depends all levels of government fulfilling their roles and responsibilities, and carrying out the key recommendations. The products of the report, particularly the strategies for waste reduction and reuse and the identified actions required by senior governments, are useful and applicable to other communities in B.C. In general, senior governments are proceeding with the recommended actions.

3.2.4.4 General

FRAP sponsored the 1996 and 1997 B.C. Water and Waste Annual Conferences, each of which was attended by over 700 people. Two FRAP projects were included in the technical program of each conference. In addition, FRAP had an exhibit at the 1997 conference and over 200 FRAP documents were distributed.

3.3 IMPLEMENTATION AND RESULTS

3.3.1 Implementation of Abatement Plans

The following indicates local governments that have implemented, or are currently implementing, sewage treatment plant upgrades or other abatement measures.

3.3.1.1 Sewage Discharges

As noted under Section 3.2.3.1, the GVRD will upgrade the Annacis Island and Lulu Island wastewater treatment plants to full secondary treatment by the end of 1998, at a cost of $591 million. When these upgrades are completed, loadings from the Annacis and Lulu plants will be reduced by approximately 89 per cent and 75 per cent for BOD and TSS, respectively. This is equivalent to reducing the total loadings from municipal sewage treatment plants to the Fraser Basin by approximately 83 per cent and 66 per cent for BOD and TSS, respectively.

Also as noted in Section 3.2.3.1, other jurisdictions that have completed or are carrying out treatment plant upgrades include the City of Prince George, District of Sicamous, Central Fraser Valley Regional District (Abbotsford), City of Chilliwack, District of Kent and City of Williams Lake. Although these upgrades will significantly reduce discharge loadings from each of these facilities (except Sicamous, which is replacing individual on-site systems), the overall reduction in loadings to the Fraser Basin will be relatively insignificant compared to the reduction achieved by the Annacis and Lulu plants. For example, the City of Prince George's $8 million upgrade of the Lansdowne treatment plant to full secondary treatment will achieve reductions of 43 per cent and 56 per cent for BOD and TSS, respectively; this translates into a reduction in the total loadings from municipal sewage treatment plants within the basin of 0.6 per cent and 2.1 per cent for BOD and TSS, respectively.

3.3.1.2 Combined Sewer Overflows

There have not been significant reductions made in CSO loadings to the Fraser. However, the GVRD has recently completed a $3 million operational upgrade of the Burrard Inlet CSO system (which does not discharge to the Fraser Basin), reducing CSO discharge volumes to the Inlet by over 30 per cent. These improvements were given priority because the existing receiving water quality had been designated as poor and because CSOs were a significant source of contaminants. CSO discharges to Burrard Inlet amount to approximately 82 per cent of total volume, while CSO discharges to the Fraser River amount to only about 18 per cent of total volume.

The GVRD Board has approved operational improvements of CSOs in the New Westminster waterfront area, which do discharge to the Fraser Basin, subject to 50 per cent cost-sharing from the province. If and when these improvements are completed, at a cost of approximately $1 million, CSO discharge volumes should be reduced by approximately 15 per cent at New Westminster, equivalent to a reduction of approximately 5 per cent within the Fraser Basin. The GVRD Stage 2 Liquid Waste Management Plan will set other more specific objectives and priorities for a long-term CSO management program. For example, a study by the GVRD is underway to identify low-cost operational improvements to CSOs within the City of Vancouver discharging to the North Arm of the Fraser. In addition, the City of Vancouver is approximately 35 years into an 100-year sewer separation program.

3.3.1.3 Landfill Leachate Discharges

There are no known specific leachate abatement measures currently being undertaken in the Fraser Basin. However, indirect abatement measures are being implemented through the upgrade of the Annacis treatment plant, where six of the largest landfills discharge leachate. As a result of improved treatment at Annacis, loadings are estimated to be reduced by 89 per cent and 75 per cent for BOD and TSS, respectively.

3.3.2 Achievement of Objectives

Achievement of the first objective of the municipal discharges component of FRAP—to develop and maintain an inventory of major pollution sources and loadings—has been described in Section 3.1. Achievement of the third objective—to assist in achieving the long-term sustainability of the Fraser River Basin—has been described in Sections 3.2.2 to 3.2.4.

Achievement of the second objective—a 30 per cent reduction in contaminant loadings to the Fraser Basin from municipal discharges—is discussed below. Because of the enormous financial implications for local governments and FRAP's lack of available mechanisms to effect major pollution abatement measures, the realization of target contaminant loading reductions was generally far beyond the control of FRAP. For example, a request by the Minister of Fisheries and Oceans, as well as substantial funding from senior governments, has resulted in the GVRD undertaking the Annacis and Lulu treatment plant upgrades. Without these other forces, it is unlikely that target reductions could have been achieved.

Overall, the projects carried out under FRAP contribute greatly to scientific knowledge of the magnitude and importance of the various municipal discharges and the technologies and actions available to reduce contaminant loadings, and they will assist in ensuring the long-term sustainability of the Fraser River Basin. However, other influences, such as financial incentives, regulatory enforcement and an improved legislation framework, may also be necessary.

3.3.2.1 Sewage Discharges

As indicated in Section 3.3.1.1, upgrades of the Annacis, Lulu and Lansdowne treatment plants to full secondary treatment will result in reductions of approximately 84 per cent and 68 per cent of BOD and TSS loadings—well in excess of the 30 per cent target. Upgrades at Chilliwack, Abbotsford, Williams Lake and Kent will also contribute to minor reductions in loadings to the Fraser.

BOD and TSS have been the only contaminant parameters discussed in the municipal discharges section of this report since they are considered the "conventional" contaminants for sewage. Seattle Metro's Toxicant Pretreatment Planning Study provides a rough indication of the loading reductions that could be expected for other contaminants; the study indicates that secondary treatment removes 96 per cent of conventional pollutants, 77 per cent of all metals, and 69 cent of total organic pollutants, compared to 44 per cent, 46 per cent and 8.5 per cent, respectively, for primary treatment. Based on these rough indications, loadings of metals and total organic pollutants discharged from the Annacis and Lulu plants should be reduced by approximately 54 per cent and 66 per cent, respectively.

3.3.2.2 CSO Discharges

As noted in Section 3.3.1.2, the GVRD has completed operational improvements to the Burrard Inlet CSO system, which are estimated to reduce discharge volumes to Burrard Inlet (not within the Fraser Basin) by over 30 per cent. There is no firm schedule for the reduction of CSO contaminant loadings to the Fraser Basin.

3.3.2.3 Landfill Leachate Discharges

Total leachate loadings to the Fraser Basin should be reduced by approximately 67 per cent and 57 cent for BOD and TSS, respectively, when the Annacis wastewater treatment plant upgrade is completed in 1998. Six landfills, including Burns Bog and Port Mann, which are major active municipal waste landfills, discharge to the plant.

3.4 REGIONAL ANALYSIS

Table 3.3 compares the estimated BOD and TSS loadings to the four regions of the Fraser River Basin from the various components of municipal discharges in the years 1991 and 1998.

Table 3.3 BOD and TSS Loadings

Com-ponent	Loadings to Region (kg/day)											
	Upper Fraser			Middle Fraser			Thompson			Lower Fraser		
	1991	1998	% Reduc-tion	1991	1998	% Reduc-tion	1991	1998	% Reduc-tion	1991	1998	% Reduc-tion
Sewage Discharges												
- BOD	1,190	830	30	270	270	0	350	350	0	57,600	8,420	85
- TSS	1,440	830	42	340	340	0	350	350	0	29,360	7,940	71
CSOs												
- BOD	0	0	N/A	0	0	N/A	0	0	N/A	770	770	0
- TSS	0	0	N/A	0	0	N/A	0	0	N/A	670	670	0
Landfill Leachate												
- BOD	3	3	0	3	3	0	8	8	0	240	30	89
- TSS	6	6	0	8	8	0	18	18	0	270	70	75
Total												
- BOD	1,193	833	30	273	273	0	358	358	0	58,610	9,220	85
- TSS	1,446	836	42	348	348	0	368	368	0	30,300	8,680	71

3.5 CONCLUSIONS AND RECOMMENDATIONS

On a basin-wide basis, the component of municipal discharges that is of greatest concern in terms of loadings is sewage discharges, with a total flow of 558,600 m^3/day, BOD loadings of 59,410 kg/day and TSS loadings of 29,360 kg/day.

CSO loadings (with a flow of 17,200 m^3/day, BOD loadings of 770 kg/day and TSS loadings of 670 kg/day) and landfill leachate loadings (with a flow of 8,230 m^3/day, BOD loadings of 254 kg/day and TSS loadings of 302 kg/day) are estimated to be less than five per cent of loadings from sewage discharges and thus should be of lower priority. However, this does not preclude possible site-specific concerns resulting from factors such as the quantity and quality of the discharge, the sensitivity of the receiving environment and the resources at risk.

The FRAP target of reducing contaminant loadings by 30 per cent will be met by the end of 1998 for sewage discharges (BOD and TSS reductions of approximately 84 per cent and 68 per cent, respectively) and landfill leachate (BOD and TSS reductions of approximately 67 per cent and 57 per cent, respectively), primarily due to the upgrading of the GVRD's Annacis Island and Lulu Island wastewater treatment plants to secondary treatment. This target will not be met in the near future for CSOs within the basin, since the GVRD directed its resources to higher priority CSOs within Burrard Inlet. If this 30 per cent reduction target is applied to landfill leachate discharges, the estimated reductions of 89 per cent and 75 per cent of BOD and TSS respectively, will easily exceed the target.

The programs carried out under FRAP will assist in ensuring the long-term sustainability of the Fraser River Basin. However, it is apparent that other influences such as financial incentives, regulatory enforcement and an improved regulatory framework may be necessary.

The B.C. Ministries of Environment, Lands, and Parks and Health are in the process of revising outdated objectives and regulations related to sewage management. These revisions will significantly improve the regulatory regime for the control of sewage discharges, and Environment Canada looks forward to their early completion.

Recommendations:

1. The administration of Section 36(3) of the *Fisheries Act* as it pertains to municipal discharges is a long-standing issue. The main concerns include legal uncertainty for local governments and inconsistent interpretation and application of the *Act*. A national municipal wastewater effluent strategy would assist in the resolution of outstanding legal, policy, environmental and technical issues. Thus, it is recommended that completion of the strategy and the development of new regulatory tools be pursued on an expeditious basis.

2. Local governments should be encouraged to develop liquid waste management plans under the provincial *Waste Management Act.* In addition to committing to schedules for upgrading sewage treatment facilities where they are inadequate, these plans should also address issues such as source control, waste volume reduction, water recycling, beneficial reuse of biosolids, the capacity of water bodies and land to accept waste, stormwater management and environmental impacts. A number of FRAP documents, such as those on sewage and biosolids treatment and disposal, sewer use control, and CSO and urban runoff assessments, would be useful in the development of these plans.

3. The development of a watershed management plan for the Lillooet River system should be continued in order to help ensure the protection of water quality in the system.

4. Although FRAP is now concluding, there will be a continued need for technology transfer and marketing of the products of FRAP. This should be carried out by Environment Canada during ongoing *Fisheries Act* activities and within the Georgia Basin Ecosystem Initiative. As well, Environment Canada should examine technology transfer and marketing opportunities with partners such as the B.C. Ministries of Health and Environment, Lands and Parks, DFO, and the B.C. Water and Waste Association.

4.0 URBAN RUNOFF

4.1 OBJECTIVES AND STRATEGIC APPROACH

FRAP identified pollution from urban runoff as an area of investigation because of increasing concern about its impact on aquatic environmental quality. Limited information available at the beginning of FRAP pointed to a need for more work in urban runoff characterization, development of monitoring and management techniques, and public education.

4.1.1 Urban Runoff Program Objectives

Environment Canada identified two objectives for the urban runoff component of FRAP:

- develop and maintain an inventory of major pollution sources and loadings in the basin (deliverable 8); and
- implement a strategy to reduce the contaminant loading from urban runoff by 30% to meet environmental quality objectives (deliverable 13).

4.1.2 Strategic Approach for Achieving Targets

The strategy for achieving the FRAP urban runoff objectives involved the following four areas of activity: inventory and characterization, regional demonstration sites, guideline development for urban runoff monitoring and management, and education and guideline promotion. The complexity of urban runoff sources, together with the fact that no one jurisdiction is wholly responsible for the problems and solutions of urban runoff pollution, led to the need for co-operative partnerships to carry out the FRAP urban runoff program.

4.2 URBAN RUNOFF ISSUES

The following overview provides background on the urban runoff issues that are relevant to the Fraser River Basin.

4.2.1 Problem Definition

Historically, stormwater management has focused on flood and erosion control, with little consideration for pollutant loadings. As pollution inputs from point sources such as sewage treatment plants and industrial facilities have gradually been reduced as a result of improved treatment works, non-point sources of pollution, including urban runoff, agricultural runoff and on-site sewage systems, are becoming important sources of contaminants impacting water quality. Pollution from agricultural runoff and on-site sewage systems are addressed separately in other chapters of this report.

Urban runoff is a general term for pollution that originates from a variety of diffuse sources in urban areas, the cumulative effect of which can be water pollution. Urban runoff sources can include stormwater from lawns, gardens, streets, parking lots, roof tops, industrial and commercial operations, construction activities and even pet wastes.

While each urban runoff source typically accounts for a relatively insignificant proportion of contaminant discharges, cumulatively they can impact the environment. It is projected that contamination from urban stormwater runoff will be the major water pollution issue facing water resource managers in the Greater Vancouver region once upgraded treatment systems are installed at the municipal wastewater treatment plants (GVS&DD, 1997). The B.C.

Ministry of Environment, Lands and Parks (BC MELP) has recently stated that, given the dramatic population growth predicted for B.C., all levels of government must act now in a determined way to deal with non-point source pollution, or B.C. can anticipate a continuing, gradual decline in the water quality. BC MELP has drafted a non-point source pollution action plan in response to this concern (BC MELP, 1997).

4.2.2 Contaminants and their Sources

The pollutants in urban runoff originate from both natural and man-made sources. Man-made pollution arises from activities including urbanization, transportation, and industrial and commercial activities. Typical contaminants of concern in urban runoff, along with examples of their potential sources, are summarized in Table 4.1.

Urbanization has been described as the land use with the greatest impact per unit area on the hydrological regime of a watershed (DFO, 1997). The replacement of the natural environment with impermeable surfaces such as roads, parking lots and buildings decreases water absorption by soils, the interception of precipitation by foliage and evapo-transpiration from plants. This results in greatly accelerated surface runoff and increased peak flows during and after precipitation. Also, inadequate planning and precautions during clearing and excavation for land development can result in high sediment loads in surface runoff (DFO, 1997). Other activities, including the use of pesticides and fertilizers, the improper disposal of hazardous products such paints and solvents, and car washing and maintenance, all contribute to the urban runoff problem.

Table 4.1 Urban Runoff Contaminants and Their Sources

CONTAMINANT	Potential sources
Suspended Solids:	
	• Exposed soil • Eroded soil from construction activities • Raindrop impact dislodging exposed soil particles • Residue from atmospheric dustfall • Vehicle traffic • Sanding and de-icing highways
Oxygen-Demanding Substances:	
	• Animal and bird feces • Decaying vegetation • Household wastes • Landfill and wood waste leachate • Sewage
Nutrients:	
P, N, K	• Vegetation from urban trees • Fertilization (e.g. household lawns, golf courses, cemeteries) • Landfill leachate
N, P	• Animal and bird feces
N	• Atmospheric pollution (minor contributor)
Organic Contaminants:	
Organochlorine pesticides	• Pesticide applications (e.g. golf courses, cemeteries, lawns)
Phthalate esters	• Leaching of plastic products (e.g., garden hoses, floor tiles, plastic containers, food packaging)
Chloroform, naphthalene	• Interactions between road salt, gasoline, asphalt.
Pentachlorophenol (PCP)	• Wood preservatives (anti-sapstain) • Paints and stains
Chlorinated benzenes	• Industrial emissions/fallout
PCBs: Polychlorinated biphenyls	• Leaks from storage facilities, transportation, and disposal • Transformer/capacitor leakage
PAHs: polynuclear aromatics hydrocarbons	• Natural sources • Heating systems • Industrial processes • Incineration, open fires • Asphalt particles • Creosote structures • Motor vehicles operation • Used crankcase oil • Combustion • Tire wear
	• Fossil fuel combustion
Metals and Trace Elements:	
Zn, Cu, Cr, Cd, Ni, Pb	Motor vehicles: • Exhaust emissions • Tire wear & brake linings • Oil and grease • Corrosion from metal parts • Breakdown of the road surface • Lane markers (Cr, Pb, Zn)
Cr, Pb, Zn	• Paint and stain pigments
Zn, Ni, Cr, Pb, Cyanides	• Road salts
Al, Cd, Cr, Cu, Pb, Ni, Zn	• Roof runoff
Zn, Cu	• Road salts
Sodium, chloride ions	• Water chlorination
Various	• Atmospheric deposition (e.g., industrial sources, vehicle exhaust)
Oil and Grease	
	• Motor vehicle operation and washing • Spills of oil and fuel
Pathogens:	
bacteria, viruses, protozoa	• Seepage from leaking/aging sewage collection systems • Animal and bird feces • Improper sanitary service connections
Chlorine	• Water chlorination

Adapted from: BC Research Corp. 1991

Many pollutants in urban stormwater runoff are attributed to transportation sources. Runoff from heavily used urban roads usually carries more contaminants than that from general urban land uses (BC Research Corp., 1991). Contaminants from vehicle corrosion, wear, exhaust and leaks are washed from impermeable street surfaces and parking lots into streams and river. Runoff from high-traffic highways frequently contains relatively high concentrations of pollutants, including suspended solids, oxygen-demanding substances, metals and trace elements, organic contaminants and nutrients (BC Research Corp., 1992). This is a growing concern in an area such as the Lower mainland, where vehicle use is continually increasing.

Because many small industries such as car washing and boat building do not have on-site stormwater/runoff collection systems, their operations can contribute to urban runoff pollution. Inappropriate maintenance of equipment, leaks and accidental spills are other potential sources of stormwater pollution from industrial activities.

4.2.3 Challenges with Managing Urban Runoff

The characteristics of urban stormwater runoff cannot be generalized because of the intermittent, highly variable and widely dispersed nature of urban runoff. Pollutant types, concentrations and loadings vary widely and are influenced by both storm-specific and catchment-specific factors such as:

- First flush effect.[1]
- Intensity and duration of rainfall
- Antecedent dry period
- Topography
- Land use category
- Per cent impervious area
- Traffic intensity

Given the wide variation and fluctuation in the above factors, and the fact that there is definite uncertainty in extrapolating results from a particular catchment to other areas (BC Research Corp., 1991), comprehensive long-term studies are necessary to investigate urban stormwater on a site-specific basis. In addition, there are a great many stormwater discharges—an estimated 1,750 outfalls in the GVRD, for example (BC MELP, 1997)—and they are for the most part unregulated. These circumstances, together with the limited current state of knowledge on urban runoff quality and management, presented a major challenge to the FRAP urban runoff program.

4.3 ACTIVITIES

This section presents the results of the studies undertaken to address the urban runoff objectives of FRAP.

---

[1] Typically the runoff generated early on in a storm event and preceding the peak discharge will contain the highest concentration of contaminants, as accumulated contaminants are washed from land surfaces into stormwater (DFO, 1997).

4.3.1 Urban Runoff Inventory and Characterization

4.3.1.1 Inventories of Urban Runoff Sources

The FRAP urban runoff program did not attempt to inventory all urban stormwater discharges within the basin, since it would have been a daunting and costly exercise of questionable value. Rather, the approach taken was to carry out an inventory of municipal stormwater discharges within the Fraser River Estuary, and other studies focusing on select areas and land uses.

The *Inventory of Municipal Stormwater Discharges Within the Fraser River Estuary* (93-38) reports on stormwater discharges within the most heavily urbanized areas of the basin. From information supplied by the municipalities and other governing agencies within the estuary and verified through a field reconnaissance program, 252 stormwater discharges were identified in the estuary (not including tributaries) downstream of Kanaka Creek in Maple Ridge. The field program included visual confirmation of documented outfalls, the identification of undocumented outfalls, a determination of universal transverse mercator (UTM, or geographical location co-ordinates) for all outfalls, a photographic record of each outfall site and an evaluation of the environmental sensitivity at each location. To evaluate environmental sensitivity, an environmental assessment matrix considering five criteria (flushing characteristics, discharge flow, habitat sensitivity, drainage area/land use characteristics and public use) was used. Detailed information on each outfall—such as number of pipes, pipe size, pipe material, invert depth, outfall length, flap gates or tide gates, pump details, owner and location relative to known landmarks—was also compiled and summarized.

Stormwater is also discharged through 20 combined sewer overflow (CSO) outfalls within the Fraser Basin, all within the Greater Vancouver Regional District. Discussion of CSOs is included in the municipal discharges chapter of this report.

As part of the report, *Chemical Use and Pollution Prevention Practices for Car and Truck Wash Facilities* (95-06), an inventory of the vehicle wash facilities in the Fraser River Basin and Burrard Inlet drainage basin was conducted in late 1994 and early 1995 to obtain current information on wash practices and potential contaminants in washwater. Vehicle washes are a potential source of pollution, as a result of either surface runoff or inappropriate sewer discharge. In the Fraser River Basin and Burrard Inlet, the study inventoried 166 commercial facilities, 19 industrial facilities and 49 municipal facilities.

A reconnaissance survey was carried out along the foreshore of the Fraser River and its major tributaries using an aerial video imaging and mapping system to record urban, industrial and rural activities from Vancouver to Hope, and at Lytton, Lillooet, Kamloops and some smaller centres. This aerial video shoreline inventory was compiled using methods developed to detect shoreline pollution sources and general shoreline characteristics.

Given the rapid growth of the golf industry in B.C. in recent years, environmental concerns have arisen regarding its intense land management practices and extensive use of pesticides and fertilizers. These concerns are primarily related to surface and groundwater quality and wildlife protection. A 1995 study identified over 230 golf courses in B.C., including 76 within the Fraser Basin, resulting in the report, *Inventory of Golf Courses in the Fraser Basin* (96-25).

The report, *Protection of Aquatic and Riparian Habitat by Local Governments: An Inventory of Measures Adopted in the Lower Fraser Valley* (DFO and EC, 1995), documents environmental protection measures adopted by local governments in the Lower Fraser Valley to protect aquatic and riparian habitat. The review included stormwater management measures. In 1995, it was found that only three local governments, or 10 per cent of the total, had substantial policies, plans and programs to maintain natural stream flows, control pollutants at source, and promote stormwater quality through proactive monitoring, enforcement and treatment programs. Another 14, or 48 per cent, have partially developed these initiatives or are in the process of developing them.

Recognizing the need to focus more effort on stormwater management issues, the GVRD is developing an urban stormwater management plan for the region as part of its Liquid Waste Management Planning (LWMP) process. Environment Canada is a member of the stormwater management task group of the GVRD's LWMP. Recently, a survey determined current stormwater management practices and expenditures by local governments in the Greater Vancouver Sewerage and Drainage District (GVS&DD) area. Some of the results are:

- In 1996, approximately $33,100,000 was spent on stormwater management by the municipalities and the GVRD in the GVS&DD area.
- Maintenance of catch basins and street cleaning are conducted by all responding municipalities, and 39 per cent of them indicated they have a policy in place to eliminate inappropriate discharges to the stormwater system.
- Best Management Practices are used, with dry ponds being the most common, followed by infiltration catch basins and debris basins in creeks.
- Responding municipalities have various bylaws to help regulate stormwater management. These bylaws regulate areas ranging from subdivision control and construction practices to stream preservation and sediment control.
- Twenty-seven per cent of the surveyed municipalities have sand recovery programs in place and reclaim approximately 1.6 per cent of the reported total applied.

The information collected provides data to evaluate initiatives for the stormwater component of the LWMP. It will also help to rationalize future decisions about stormwater management in the GVS&DD area.

4.3.1.2 Urban Runoff Characterization and Loadings

The following studies examined the extent of urban runoff pollution in the Fraser Basin.

The report, *Urban Runoff Quantification and Contaminants Loading in the Fraser Basin and Burrard Inlet* (93-19), summarizes a planning-level assessment of urban runoff loadings to the Fraser Basin and Burrard Inlet. This study estimated total runoff volumes and loadings for 25 municipalities with populations greater than 5,000 people. Limiting the study to these 25 municipalities was considered reasonable since only nine per cent of the basin's population lives in the smaller centres and rural areas that were not included. These smaller centres and rural areas typically have a less developed urban core, or none at all, so they do not contribute significantly to basin-wide urban runoff.

The study estimated urban runoff contaminant concentrations and loadings, based on precipitation and temperature data and estimated runoff coefficients. Typical summer and winter seasonal runoff coefficients were determined, and adjustments were made to these coefficients for each municipality to consider site-specific precipitation and topography information. Runoff volumes and loadings for 20 selected pollutants were quantified on a mean monthly and annual basis for the 25 municipalities within the Fraser and Burrard Inlet Basins with a population greater than 5,000; these are summarized in Table 4.2. These data are useful in providing an overview of the magnitude of urban runoff loadings to Fraser Basin watercourses. Table 4.2 clearly illustrates that the lower Fraser region is the largest contributor of urban runoff in the basin and is the prime location to focus subsequent investigation. There may be discharges with localized concerns because of factors such as the quantity and quality of the discharge, sensitivity of the receiving environment, and resources at risk, but the identification of such discharges was beyond the scope of this study.

Table 4.2 Estimated Contaminant Loadings in Urban Runoff

Contaminants (kg/d)	Upper Fraser (kg/d)	Middle Fraser (kg/d)	Thompson (kg/d)	Lower Fraser (kg/d)	Total (kg/d)
Conventional Parameters					
TSS	15 000	2 500	4 500	150 000	172 000
BOD	1 100	200	300	11 000	12 600
COD	8 600	1 400	3 000	84 000	97 000
Total Metals					
Arsenic	2	0.3	0.6	16	19
Cadmium	1	0.2	0.3	10	12
Chromium	1.2	0.2	0.4	12	14
Copper	4.4	0.8	1.4	42	49
Lead	18	3.0	6	180	207
Nickel	3.0	0.5	1	30	35
Zinc	18	3.0	6	180	207
Others					
Total Nitrogen	2408	2094	65	35	215
Total Phosphorus	43	7	13	419	482
Nitrate/Nitrite	86	14	26	837	963
Ammonia	18	3	6	179	206

Notes for Table 4.2:

1. The contaminant concentrations used are considered typical concentrations suitable only for planning-level assessments.
2. Since a uniform concentration for each parameter was used for all municipalities, the variation in loadings between locations results from differences in estimated urban runoff volumes for the various municipalities.
3. The original values were expressed in tonnes/year. Although urban runoff is highly variable on both a daily and a seasonal basis, the loadings in this table have been expressed on an average daily basis for the purpose of comparison with other loadings shown in this report.

A pilot wastewater characterization study was carried out in 1992 for three effluent sources: municipal wastewater, pulp mill effluent and urban runoff. The street runoff was sampled from a GVRD storm sewer located in Still Creek basin on Collingwood Trunk Road for a wide range of parameters. The sewer receives runoff from both commercial and residential areas and eventually drains into the North Arm of the Fraser River. Results are documented in the report, *Chemistry and Toxicity of Three Wastewaters* (93-08). Some findings are:

- Total suspended solids (TSS) appeared to be largely inorganic, probably consisting mostly of grit and soil suspended by the current;
- Metals, in particular, aluminum, copper, zinc and nickel, were found. These metals are typically components of automobile parts, which tend to be the predominant contributors to metals in drainage water; and
- 2,4-D was the only pesticide detected.

All concentrations of measured parameters were lower than the aquatic life criterion in the Canadian Water Quality Guidelines developed by the Canadian Council of Resource and Environment Ministers (CCREM, 1987) or were under the detection limit. Toxicity tests revealed that the GVRD storm sewer sample had low chronic toxicity to *Ceriodaphnia* and no acute toxicity to either trout or *Daphnia.*

With FRAP's support, the Westwater Research Centre at the University of British Columbia (UBC) included street runoff monitoring in a study of ecosystem health in the Brunette River Basin and expanded the base flow and stormwater monitoring done to date. The street runoff study sampled urban runoff from four small regions within the watershed. The report, *Water Quality and Stormwater Contaminants in the Brunette River Watershed*(97-04), includes results for pH, alkalinity, turbidity, suspended solids, oxygen-demanding substances, nutrients and metals. Some findings are:

- Higher levels of TSS and metals were recorded at the stations with higher traffic intensity;
- The type of vehicle traffic (*e.g.,* trucks vs. cars) and other use factors may be as important in contaminant loading as the traffic intensity; and
- Levels of contaminants in the street runoff were generally higher than in other stormwater runoffs.

The report, *Chemical Use and Pollution Prevention Practices for Car and Truck Wash Facilities*(95-06), includes results from site assessments of six commercial, industrial, and municipal facilities. Factors affecting washwater quality may include the type of client served, services offered, wash process, chemicals used, and the geographic location. Some of the chemicals being used at facilities in the Fraser River Basin include soaps, synthetic detergents, heavier degreasers and engine cleaners, acids, caustics, rust inhibitors, aluminum brighteners, and mag cleaners. At the six vehicle washes investigated, the washwater discharged to the sewer was for the most part found to be comparable to a moderately strengthened domestic wastewater and was below the GVRD Sewer Use Bylaw limits. Typical contaminants found in car wash wastewater are suspended solids, oil and grease, and metals (in particular, lead, zinc, copper and nickel). Both pH and BOD levels depended on the facility. Pollutants from truck wash facilities are numerous and varied, since they vary with the nature of different cargoes.

The inventory of golf courses (96-25) discussed in the previous section also included site assessments at five golf courses to specifically address the potential for surface water contamination. These assessments included an examination of topography, soils, turf, drainage, irrigation practices, maintenance areas and housekeeping, chemical use and storage, and water quality. A limited water and sediment sampling program was conducted to characterize the quality of runoff from the five golf courses. For each site, one background water sample, two rain event samples and two sediment samples were taken. The results showed elevated levels of metals (copper, arsenic, chromium, lead, and zinc) in many of the samples collected, above BC MELP's Water and Sediment Quality Criteria and the CCME Water Quality Guidelines. The presence of these metals may be attributed to a number of factors, including natural sources such as soil composition, or anthropogenic source such as atmospheric deposition, road runoff, fertilizers or pesticides. However, because of the limited sampling conducted, actual causes of the elevated metals levels cannot be confirmed. Pesticides (2,4-D, dicamba, mecoprop and iprodione) were detected in 20 per cent of the water and sediment samples. Of the pesticides detected, recommended limits were available only for 2,4-D and dicamba. One water sample revealed a 2,4-D level above the detection limit, but only by 0.004 mg/L.

As part of the Lillooet River System Watershed Management Plan, FRAP contributed to a Lillooet River point source and stormwater quality survey. The study identified point and non-point source discharges into the aquatic environments in the watershed. Relevant conclusions of the study were:

- Stormwater runoff exhibited elevations in iron, copper, chromium, zinc, specific conductance, turbidity and Total Suspended Solids (TSS). Many of these parameters exceeded the B.C. Ambient Water Quality Criteria for the protection of aquatic life.
- Water quality in systems receiving stormwater was generally acceptable for Pemberton Creek, but the water quality for Fitzsimmons Creek showed signs of stormwater inputs.

The study also provided watershed-specific recommendations on stormwater characterization planning.

Land Use and Water Quality Management in the Bridge Creek Basin (94-25) documents key findings of a study that evaluated the effects on water quality of several basin uses, including roads, agriculture, forestry, rural residences, cottages and resorts, and urban and industrial development. The most significant land use impacts on water quality were determined to be from urban and industrial development, and agricultural land development. Some key recommendations were to investigate the feasibility of constructing wetlands to treat urban runoff at specific sites and to establish a long-term monitoring program to evaluate water quality change at the basin scale.

A characterization study in Vancouver sampled urban stormwater from an industrial catchment (a manhole at the north end of the City of Vancouver) and a residential catchment (a storm sewer outfall in South Vancouver). One of the objectives of the study was to monitor the quality and quantity of stormwater from two separate stormwater catchments adjacent to the Clark Drive catchment area in order to estimate the contribution of contaminants from stormwater to the CSO discharge.

Some of the results included in the report, *Characterization of the Clark Drive CSO and Stormwater From a Residential and an Industrial Catchment: Spring 1994; Draft study,* are:

- PAHs and phthalate esters were the most frequently detected organic parameters;

- Stormwater from industrial catchments appears to be a significant source of lead and zinc;
- A greater diversity of dioxin and furan congeners occurred in sediments from the stormwater sites than in sediments from the combined sewer; and
- The residential stormwater had the lowest toxicity to luminescent bacteria (Microtox™) and the lowest contaminant concentrations of the wastewaters tested.

4.3.2 Regional Demonstration Projects

FRAP worked on a number of site-specific projects to evaluate the effectiveness of management techniques for protecting urban watersheds. Three of these projects looked at management options for snow disposal in the City of Prince George, and one examined dredging options to rejuvenate Burnaby Lake. In addition, background sampling was carried out at two areas slated for construction to establish a baseline for the future evaluation of the best practices for managing urban runoff.

A city's snow disposal activities may have environmental impacts on surface and groundwater, the atmosphere, vegetation and aquatic life. Water quality may be impacted by the snowmelt runoff, which typically contains high levels of sodium chloride, some dissolved heavy metals, minor organic hydrocarbons, and minor inorganic nitrates and sulphates. For a number of years, the City of Prince George has operated seven municipal snow dumps that discharge snowmelt water. This practice has resulted in concerns about water quality and physical damage to fish habitat. When some sites became unavailable, the City began to investigate other disposal options.

A preliminary study at Prince George revealed the economic, environmental and engineering factors that must be considered when evaluating snow disposal options. This assessment concluded that the City has three basic options: installation of a snow melter in the downtown area, expansion of existing land disposal sites and development of a new land disposal site approximately 4.5 km from the downtown core. Following the preliminary study, a detailed study evaluated the option of snow disposal at the Lansdowne Wastewater Treatment Centre. Snow melting was accomplished by utilizing waste heat from the plant effluent. The evaluation concluded that the treatment centre was suitable for snow disposal, subject to several limitations. The primary factor limiting snow disposal capacity was the presence of solids in collected snow. As well, the addition of snow caused a significant increase in the TSS concentration of the plant's effluent. Recently, a study was initiated to provide an environmental impact assessment as well as a feasibility study for the treatment of snowmelt and stormwater using passive technologies such as wetlands. Results of this study will not be available until mid-1998.

A second study reviewed the potential environmental implications of dredging Burnaby Lake for environmental rejuvenation (97-11). Burnaby Lake is the largest urban lake in the Fraser Basin. A key concern about dredging the lake is the quality of sediments on the lake bottom, which include metal and hydrocarbon contaminants originating from runoff from urbanized areas around the lake. This study formed an important step in the development of a contemporary management plan for Burnaby Lake Regional Nature Park. The plan's mandate is to implement an ecosystem-based management approach to rejuvenating the lake, improving water quality, enhancing fish and wildlife habitat, and providing recreation opportunities. The report evaluated several dredging techniques, their costs and their potential environmental impacts and benefits. A pilot-scale dredging program is recommended. It would provide opportunities to determine the extent of potential environmental impacts and the corresponding mitigation methods, determine more accurately the rate at which dredgeate could be removed from the lake, evaluate the disposal site(s) and gain understanding of the overall implications to the park.

Two other sampling and monitoring projects were designed to establish baseline water quality data before work began on two developments, a residential development in Langley and a wetpond to be used for urban runoff treatment in 100 Mile House. For both projects, construction was delayed beyond the term of FRAP, preventing the collection of post-development and post-construction data. Nonetheless, data collected in both cases provide baseline data on contaminants entering the environment before development.

The purpose of the monitoring project in Langley's Walnut Grove area was to evaluate the effects of residential development on water quality by assessing water quality before and after development. Baseline data was collected from three sample locations, after three different rain events. All samples except one showed the presence of metals (total aluminum and total iron), and concentrations of total aluminum and total iron were significantly high, in excess of the Canadian Water Quality Guidelines. (CCREM, 1987)

The purpose of the project on Little Bridge Creek in 100 Mile House was to evaluate the effectiveness of a wetpond for urban runoff treatment. The pond was part of a new residential development proposal. Water quality was to be sampled before and after construction of the wetpond. Water quality samples were collected prior to construction from five locations, after two different rain events. Results included the presence of metals (total aluminum, iron, manganese, titanium, chromium, copper and zinc) in all samples. Again, all metal concentrations were significantly above the Canadian Water Quality Guidelines for Freshwaster Aquatic Life (CCREM, 1987).

4.3.3 Guidelines on Techniques and Practices to Minimize Stormwater Impacts

A number of guidelines were developed as tools to assist government and private sector environmental managers in the best management techniques and practices for monitoring and protecting urban stormwater quality.

The reports *CSO and Urban Runoff Investigative Assessment Guidelines* (93-37) and *Sampling Procedures and Protocols for Combined Sewer Overflows and Urban Runoff* (93-22) were developed to provide agencies with a methodology to characterize discharges and with procedures for planning and implementing monitoring programs. Elements to be considered include monitoring objectives, physical constraints, resource requirements and a monitoring schedule.

The document *Greening your BC Golf Course: A Guide to Environmental Management* (96-26) is intended to guide managers and developers in the design and maintenance of golf courses in an environmentally sound manner. Construction activities, pesticide use, irrigation needs and other routine procedures can harm fish and wildlife habitat if performed without consideration for environmental values. The guide explains how the responsible environmental management of golf courses offers advantages not only to the golfing community, but to the public as well. Examples of responsible management practices are to avoid developments near wetlands, limit stream crossings, fence off sensitive habitat during construction, and consider better practices for managing stormwater, irrigation, maintenance areas, and integrated pest control.

The inventory and site assessment work carried out for part one of the report *Chemical Use and Pollution Prevention Practices for Commercial Car and Truck Wash Facilities*(95-06) culminated in the development of *Best Management Practices for Fixed Commercial Vehicle Washes and Guidelines for Mobile Vehicle Washes.* Part two of the report addresses seven areas in which BMPs may be applied:

- Material management (choice of material, inventory controls and appropriate storage of chemicals)
- Solid waste disposal
- Spill control measures
- Education
- Good housekeeping practices
- Regular repair and maintenance
- Record-keeping

The second part also addresses BMPs directed specifically at truck wash facilities and discusses pre-treatment technologies applicable to vehicle wash wastewater.

The objective of *Stormwater Best Management Practices for Selected Industrial Sectors in the Lower Fraser Basin* (97-03) is to provide guidance for reducing pollution from stormwater runoff in industrial operations in the lower Fraser Basin. The report sets out source control and runoff control measures as well as treatment best management practices (BMPs) for 19 industrial sectors such as fish products, sand and gravel pits, meat products and brewery products. Details on these practices are included in the industrial section of this report.

4.3.4 Education and Promotion of Guidelines

In the last two years of FRAP, the urban runoff program has placed a strong emphasis on public education. As urban runoff projects wrap up, results need to be reported. Public education is one of the most effective ways to transfer the information to the right stakeholders. Also, of all the pollution sources, urban runoff is the area where the general public can make the greatest difference by changing habits. Education programs focus on many audiences, from the general public to professionals, and products range from a general information brochure to a workshop promoting a specific guidelines.

Intensive studies of three watersheds of the lower Fraser Basin—the Salmon, Sumas and Brunette rivers—were completed by the Westwater Research Centre at UBC with the financial help of FRAP and other organizations. These studies linked land uses, primarily urban and agricultural development, to impacts in the receiving environment. The publication *Current Trends*, a non-technical, newspaper-style report of the three studies, explains how current land uses and activities affect the environment, using a watershed context. It informs the reader about actions that individuals can take to reduce their own impacts on the environment and identifies the need and opportunities for improved decision-making approaches. Over 40,000 copies of the publication was distributed widely to residents, schools, libraries, local governments, and organizations in the Lower mainland.

The Fraser River Interactive Pollution Urban Runoff model, developed by the environmental quality component of FRAP, is a three-dimensional, table-top model of the lower mainland from Fort Langley to the Strait of Georgia designed for public and educational events. The model uses a hands-on approach to demonstrate what non-point source pollution is, where it comes from, where it goes and what actions people can take to reduce this type of pollution.

The Non-Point Source Pollution Awareness Campaign, undertaken by FRAP, the GVRD and DFO, was the most diverse public education program carried out by the urban runoff program. It included posters, fact sheets, stickers, and newspaper and television ads to encourage behavioural changes and the proper use of potentially toxic products in order to reduce pollution and prevent harm to fish, wildlife and aquatic habitats. Campaign venues included community newspapers, web sites, presentations, television and trade shows. The program focused on potential water pollution resulting from day-to-day domestic activities such as landscaping and lawn care, automobile washing and maintenance, and household maintenance and cleaning. The principal audience was the general public, mainly those living in urban areas in the lower mainland and other centres such as Prince George, Kamloops and 100 Mile House.

The environmental guide developed for golf courses in British Columbia was presented to and discussed by over 250 delegates at the 1998 Western Canada Turfgrass Association Annual Conference in Victoria. The audience was composed of golf course superintendents, managers and designers, turf grass specialists, college teachers, and golfers. EC received many positive comments and over 50 requests for new documents.

4.4 IMPLEMENTATION AND RESULTS

4.4.1 Demonstration Projects

The two projects discussed in section 4.3.2, in Langley and 100 Mile House, were designed to test the effectiveness of treatment methods for urban runoff. At both sites, pre-construction monitoring is completed and provides a valuable baseline for future comparisons. It is intended that runoff from the sites will be monitored again after development.

A FRAP project funded jointly by EC and DFO is evaluating the effectiveness of Chantrell Pond, an urban wetpond, for treating runoff from a new residential development that discharges to a fish-bearing creek in south Surrey. The specific objectives of this project are to determine the overall and seasonal effectiveness of a wet detention pond in removing contaminants from urban stormwater, the suitability of suspended sediment removal as a proxy for overall pollutant removal (or BMP effectiveness), and the pollutants of significance associated with accumulated sediments in wet detention ponds. Water quality sampling will be carried out upstream and downstream of the pond until March 1998, after which a summary report of the results will be produced.

FRAP, the GVRD and the City of Surrey were involved in a project to evaluate the practicality of wetponds as a treatment system in reducing the quantity of urban runoff pollutants entering receiving waters by using a case study in the Fraser Glen area of Surrey. A secondary objective was to collect more information on the contaminant loads typically carried by stormwater runoff from urbanized areas of Greater Vancouver. Results indicated that the wetpond worked well in removing contaminants from stormwater runoff and in reducing peak stormflow. A summary of the wetpond removal efficiency is detailed in Table 4.3 below. Typical contaminant removal efficiencies for wetponds based on field studies in other regions of North America are included for comparison purposes. The data shows the wetpond is effective in removing all contaminants monitored.

Table 4.3. Per cent contaminant removal efficiency for Fraser Glen Wetpond

Parameter	Fraser Glen Wetpond	Reported Field Studies
Suspended Solids	36 % *	5-91 %
COD	38 % *	2-69 %
Total Lead	40 % *	9-95 %
Total Zinc	48 % *	0-79 %
Total Phosphorus	25 %	3-79 %
Total Nitrogen	19 %	0-60%

* Accuracy of calculated removal efficiency is limited because some of the sampling data were measured below detection limits.

4.4.2 Achievement of Objectives

Although the objective of a 30 per cent reduction in contaminant loading from urban runoff has not been achieved by the end of FRAP, the urban runoff program has developed a number of tools and initiated a number projects that will help achieve the objective in the long term.

Several inventories of sources contributing to urban runoff pollution and tools to help prevent pollution in the Fraser Basin were prepared over the course of FRAP. These inventories covered stormwater discharges, combined sewer overflow outfalls, car and truck wash facilities, golf courses and environmental protection measures adopted by local governments. These results, combined with those of the agricultural and industrial programs, provide a good overview of contributors to urban runoff and, in some cases, a snapshot of major loadings to the basin.

BC MELP is currently leading the development of a Non-Point Source (NPS) action plan and implementation strategy for the province. This NPS action plan, which includes urban stormwater runoff, is expected to be implemented over a five-year time frame. At this point, Environment Canada has provided input on the draft and has committed to work with BC MELP to co-ordinate urban runoff NPS activities proposed under the Georgia Basin Ecosystem Initiative with the action plan. The experience and tools gained from the FRAP urban runoff program will be applied to this continuing effort to reduce urban runoff pollution.

4.5 CONCLUSIONS AND RECOMMENDATIONS

Non-point source water pollution is difficult to manage using conventional regulatory approaches because of the difficulty of identifying and controlling the many sources of pollution over a large area. Stormwater discharges are especially challenging to manage because they arise from human activities fundamental to existing urban settlement patterns (FREMP, 1996b). Urban runoff management has previously focused on the control of erosion and flooding, and it was mainly the domain of engineers and hydrologists. Recent guidelines (BC Research Corporation, 1992) have emphasized the need to manage urban runoff quantity and quality through an interdisciplinary approach. An integrated stormwater management strategy should include urban design, source control and treatment. It requires a team of disciplines including engineering, planning, hydrogeology, public health, environmental chemistry, biology, landscape architecture and public education (Westwater Research Centre, UBC, 1997).

A preventative approach, involving planning and coordination, education and source control, is the key to addressing this problem (BC MELP, 1997). Two initiatives underway are approaching urban runoff management from a promising perspective. The GVRD LWMP's stormwater management task group will provide coordination of regulations, guidelines and approaches to urban runoff management among GVRD municipalities. The province's NPS action plan has initiatives planned in many sectors that encourage the support and involvement of all levels of government, First Nations, community groups and the public.

Non-point source pollution and potential solutions must be discussed and developed within a local context, ideally at a watershed-specific scale. For example, agriculture may be a key non-point source pollution issue in the lower Fraser Valley, while stormwater may be the main concern in an urban setting. Therefore, solutions to non-point source pollution are best led by the local community or local government (BC MELP, 1997). Environment Canada can play a useful role in transferring knowledge and information, promoting BMPs and guidelines, and participating in the planning process in support of urban runoff management.

Given that urban runoff pollution abatement has only very recently become an issue in B.C., the focus of the FRAP program has been on assessment, guideline development and education, which are necessary initial steps before contaminant loading reductions can be achieved.

Recommendations:

1. The knowledge gained under FRAP with respect to urban runoff will be best used if it is appropriately transferred to the right individuals and organizations. To promote the guidelines and BMPs developed for various urban runoff components, a follow-up targeted awareness campaign with a distribution plan and an inspection/monitoring plan should be pursued by EC as opportunities arise. This would improve understanding of the various sources, the current challenges and the priorities to target in the future.
2. EC, in co-ordination with other organizations, should conduct pilot projects on a small watershed basis to allow an integrated approach to the management of urban runoff. This small-scale approach over a few years would allow thorough knowledge of the land uses and related impacts, better characterization and monitoring results, the implementation of a few projects in different sectors and the potential to monitor results.
3. Local governments should be encouraged to develop Liquid Waste Management Plans (LWMPs) under the provincial *Waste Management Act*. Environment Canada can provide technical expertise on the various components of a LWMP.

4. Environment Canada should support the provincial Non-Point Source Action Plan by providing professional expertise and by co-ordinating non-point source activities (*e.g.,* pilot projects, public education campaign, monitoring program) of both organizations to avoid duplication.
5. Environment Canada should establish links and work with established community groups and organizations already involved in issues related to urban runoff. For example, the various working groups of the GVRD's LWMP initiative offer great potential for contacts with different municipalities. Many urban runoff management programs could be linked to the stormwater task group and its activities. Environmental community groups are involved in many field activities and provide an excellent venue for public education. All governments and organizations involved in the management of urban runoff should try to co-ordinate their efforts and activities.

REFERENCES

BC Research Corporation. 1991. *Urban Runoff Quality and Treatment: A Comprehensive Review.* 1992. Vancouver. 194 pages.

BC Research Corporation. 1992. *Urban Runoff Quality Control Guidelines for the Province of British Columbia.* BCMELP.1992. Vancouver. 132 pages.

BCMELP. 1997. *Tackling Non-Point Source Water Pollution in British Columbia* (Draft). Water Management Branch. Victoria. 78 pages.

Canadian Council of Resource and Environment Ministers. 1987 Canadian Water Quality Guidelines, Government of Canada

Dayton & Knight Ltd. 1996. *City of Prince George: Snow Disposal Study at the Lansdowne Road Wastewater Treatment Centre.*

Department of Fisheries and Oceans. 1997. *Fraser River Basin Strategic Water Quality Plan - Lower Fraser River.* Fraser River Action Plan. Vancouver.

Department of Fisheries and Oceans and Environment Canada. 1995. *Protection of Aquatic and Riparian Habitat by Local Governments.* Fraser River Action Plan. Vancouver.

Dorcey, A. 1991. *Water in Sustainable Development: Exploring Our Common Future in the Fraser River Basin.* Westwater Research Center, UBC. 288 pages.

Fraser River Estuary Management Plan. 1996a. *Water Quality in the Fraser River Estuary - January 1993 to March 1994.* Vancouver. 107 pages.

Fraser River Estuary Management Plan. 1996b. *Environmental Quality Report.* FREMP. Burnaby. 164 pages.

Greater Vancouver Regional District. 1994. *Fraser Glen Wet Pond Urban Stormwater Characterization Study* (Draft). Vancouver.

Greater Vancouver Sewerage and Drainage District. 1997. *Liquid Waste Management Plan - 1996-1999.* Background Information Stormwater Management Planning. Vancouver. 20 pages.

Larkin, G. 1995. *Hydrocarbon Pollution from Urban Runoff in the Brunette Watershed.* University of British Columbia. Vancouver. 142 pages.

McCallum, D. 1995. *An Examination of Trace Metal Contamination and Land Use in an Urban Watershed.* University of British Columbia. Vancouver. 217 pages.

Stanley. 1993. *City of Prince George: Preliminary Assessment of Snow Disposal.* City of Prince George.

Westwater Research Center, UBC. 1997. *Water Quality and Stormwater Contaminants in the Brunette System.* Fraser River Action Plan, Environment Canada. (97-04)

5.0 AGRICULTURE

5.1 OBJECTIVE

FRAP's agricultural abatement program deliverable was to:

- implement a strategy to reduce the loading of nutrients, bacteria and agrochemicals from agricultural operations to ground and surface waters by 30% to meet environmental quality objectives (deliverable 12).

FRAP's ability to implement an appropriate strategy was largely dependent on the existence of a framework to work within. Agency mandates and activities related to agriculture were generally understood, but not necessarily well linked or coordinated. The ability to reduce loadings by 30% required a detailed understanding of agricultural impacts and a solid baseline of information throughout the basin. Unfortunately, the impacts were not well understood and baseline information was not well documented.

At the beginning of FRAP, regional agency stakeholder meetings were held to identify the key elements of an agricultural program. These elements were:

- Identify current agriculture initiatives in the province, and specifically in the Fraser Basin, that were or in the future would be working towards addressing FRAP needs ;
- Support and if possible advance the timeline of those initiatives dealing with the development, promotion and implementation of appropriate waste management prevention and abatement practices;
- Initiate projects to advance or set the groundwork for a better understanding of agricultural issues in the Fraser Basin;
- Initiate projects to establish benchmarks with which to assess the progress of FRAP; and
- Support activities with strong linkages to other FRAP program areas.

FRAP identified several key initiatives to link with and support, including:

- Canada-B.C. Green Plan for Agriculture (Advisory Committee, 1993);
- Ministry of Environment, Lands and Parks' (BC MELP) *Agricultural Waste Control Regulation* proclaimed in 1992;
- BC MELP's Pesticide Management Program Five-year Strategic Plan (BC MELP, 1993);
- University of British Columbia Westwater's Lower Fraser Basin Eco-Research Project (Eco-Research, 1991; Westwater, 1995); and
- Department of Fisheries and Oceans (DFO) FRAP initiatives.

The program that evolved over the course of FRAP was diverse and covered a spectrum of activities. It was intended to contribute to the development of a "blueprint for sustainability" for the Fraser Basin, which was being prepared under the Fraser River Management Program, managed by the Fraser Basin Management Board (FBMP, 1994). The provincial government started to gather information for developing a provincial Non-Point Source (NPS) Action Plan that included both agricultural and urban NPS. FRAP supported this process (NDM, 1996; KPMG, 1996; ESSA, 1996).

5.2 BACKGROUND

5.2.1 Nature of Agricultural Pollution

Agricultural pollution falls within the broad area of NPS pollution. Non-point sources are now widely described as major contributors to the degradation of both surface and groundwaters (Chesters and Schierow, 1985; EPA, 1993; Puckett, 1995). Efforts to reduce NPS pollution have been relatively limited, not only because of the inherent characteristics of this type of pollution (diffuse movement, widespread occurrence, random timing of loads and source-specific nature), but also because of socio-political factors, including political sensitivity over land use regulation, overlapping agency jurisdictions paired with conflicting agency goals, and low public awareness (Gannon *et al.*, 1996). These factors presented a challenge to the development and delivery of FRAP's agricultural program.

5.2.2 Lessons from the Environmental Protection Agency

The United States Environmental Protection Agency's Rural Clean Water Program—a focused NPS program to assess the effectiveness of watershed technologies in controlling NPS pollution—found that a six to 10-year evaluation period was generally required (EPA, 1993).

The Rural Clean Water Program provided valuable insight on where to focus the limited resources available to make progress in reducing NPS pollution. Five key lessons learned from the Rural Clean Water Program are:

- The most effective information and education approach to gaining producer participation is one-to-one contact between project personnel and farmers;
- The availability and attractive level of cost-share assistance is the most important factor in obtaining producer participation in voluntary NPS control programs;
- Farmer involvement in project planning and problem identification often results in greater participation in voluntary NPS pollution control projects;
- Awareness of the impacts of agriculture on water quality does not necessarily translate into ownership of water quality problems by farm operators; and
- A well-defined structure with clearly stated roles for participating agencies is an essential component of a successful NPS pollution control program.

5.3 REGIONAL ANALYSIS

According to the 1991 census, there were 9,869 farms within the Fraser Basin, with a total capital investment in land, buildings and equipment of $6 billion. The Agricultural Land Reserve, administered by the Agriculture Land Commission, is the primary means of maintaining the agricultural land base necessary for a soil-based agriculture industry. Approximately 50 per cent of the total provincial farms falls within the Fraser Basin. The type of agriculture within the basin varies; the Interior is generally dominated by extensive cattle production, while the Coastal area is dominated by intensive livestock and horticulture production.

5.3.1 Lower Fraser Region

Prior to FRAP, environmental issues related to intensive agricultural production in the lower Fraser Valley—such as manure and nutrient management, pesticide management and horticultural practices—had not been comprehensively summarized, although some problems had been described (Hagen, 1990; Hutton, 1987; Schreier *et al*., 1991). The Canada-B.C. Soil Conservation Program (precursor to the Canada-B.C. Green Plan for Agriculture) had already started to describe and address a number of waste and nutrient management issues in the Fraser Valley. Environment Canada's programs had not previously been linked to the activities of other agencies in relation to broader agricultural land use and NPS management issues.

The agricultural program also included initiatives to develop information on groundwater resources and to promote education and awareness of groundwater issues in the lower Fraser Basin. A limited effort was made to develop Geographic Information System products to describe the region, but this did not progress to a modelling or predictive capability.

5.3.2. Interior Regions

The Thompson Basin Pre-Planning Task Force reported that livestock operations, feedlots, over-wintering of cattle near streams and removal of vegetation from stream banks were causing water quality and stream degradation problems throughout the basin (Task Force, 1981). Similar issues existed in the Cariboo-Chilcotin region (Hart and Mayall, 1990; 1991).

5.4 ACTIVITIES

Program activities were largely integrated with other stakeholder efforts. The agriculture program focused on three areas of activity:

- developing commodity environmental guidelines;
- conducting inventories to establish benchmarks against which to measure progress; and
- supporting research efforts to assess and demonstrate pollution prevention and abatement practices that agriculture could use to address environmental problems.

5.4.1 Supporting Environmental Guideline Development

In 1992, BC MELP introduced the *Agricultural Waste Control Regulation* (*AWCR*) and the Code of Agricultural Practice for Waste Management (the Code). These regulations are designed to prevent pollution from private land, including the majority of farms in the Fraser Valley and over-wintering sites in the Interior. Since the introduction of the AWCR, BC Ministry of Agriculture, Fisheries and Food (BC MAFF) has been preparing commodity environmental guidelines for dairy, cattle, poultry and swine producers in support of the Code. These guidelines described generally acceptable farming practices that could be used to evaluate farm management practices. FRAP supported this process in order to advance the development and transfer of information and education material for additional commodities (BC MAFF, 1994, 1994a, 1994b, 1995, 1996).

FRAP supported the development of an evolving peer advisor process that was already in place and was designed to deal with agriculture's environmental problems. The process was administered by the B.C. Federation of Agriculture (BCFA, now the B.C. Agriculture Council, or BCAC) with BC MELP and BC MAFF, largely through the various commodity groups. Other activities that FRAP supported included:

- BC MAFF's development of a manual for evaluating Best Agricultural Waste Management Practices (BAWMPs), still in progress (R. Van Kleeck, pers comm., BC MAFF);
- a guide for agricultural watershed stewardship (DFO, 1997);
- a forage grass production guide, still in progress (S. Bittman, pers comm., Agriculture and Agri-Foods Canada [AA-FC]);
- the development of Integrated Pest Management (IPM) options (Windwalker Consulting Service, 1995; Zbeetnoff Consulting, 1995; Szeto and Wan, 1996); and
- a description of basin groundwater resources (Ronnesth *et al.*, 1995; 93-33, 93-34).

5.4.2 Conducting Inventories to Establish Benchmarks

5.4.2.1 Lower Fraser Region

5.4.2.1.1 Manure and Nutrient Management

The management and use of livestock manure and commercial fertilizers was considered the major issue in the lower Fraser Basin. Inventories covered a range of topics related to waste management in 20 zones in the Lower Fraser Valley (94-28, 95-31, 95-28, 95-27, 95-26, 96-15, 96-28, 96-29, 96-30; and Zebarth *et al.*, 1997); fertilizer sales (97-49); groundwater quality (95-29); and atmospheric nitrogen loading (97-23).

5.4.2.1.2 Pesticide Sales

Farmers using a pesticide on private land owned or leased, or on neighbouring private land free of charge are exempt from provisions of the *Pesticide Control Act Regulation* and are not required to submit pesticide use information to the province. Thus, there was no mechanism in place to inventory the type and quantity of pesticides used at the farm level. The alternative was to develop use patterns based on 1991 and 1995 inventories of reportable pesticide sales by lower mainland pesticide vendors (93-35, 97-16). Reportable pesticides are all products that have a Restricted or Commercial use label; they include pesticides used for agriculture and industrial applications. This does not include domestic sales, since vendors of domestic label pesticides are also not required to report that information.

5.4.2.1.3 Code Assessment

The *AWCR*, with its associated Code, is the principal tool for managing agricultural wastes in the province. Monitoring activities related to the *AWCR* and the Code was the main way of identifying problems and determining where progress was being made. Over the duration of FRAP, the initial approach of having individual commodity groups monitor themselves via BCFA's Agricultural Environmental Protection Council through a peer advisor complaint response process shifted to more direct intervention by BC MELP. For continuity purposes, BC MELP tracked the commodity groups' activities within the same 20 geographic zones that were used to estimate nutrient balances.

In order to assess producers' response to the *AWCR* and to other initiatives that were developed to address environmental issues, such as the Canada-B.C. Green Plan for Agriculture and FRAP, two watersheds (Matsqui Slough and Sumas River) were selected for on-farm practices surveys mid-way and at the end of FRAP (94-21, 94-22, 97-48). A concurrent water quality study was conducted on the Matsqui Slough watershed to establish a baseline of information and to try to measure a response to changes in land use practices over time (Top *et al.*, 1997). As well, the Tri-Council Eco-Research Study, carried out by UBC's Westwater Research Institute and supported by FRAP, looked at water quality in the Salmon River and Sumas River watersheds (Berka, 1996; Wernik, 1996; Schreier *et al.*, 1996).

5.4.2.2 Interior Regions

5.4.2.2.1 Code Assessment and Groundwater Mapping

FRAP supported studies to assess agricultural practices and the implementation of the AWCR and Code in the Interior regions of the Fraser Basin. In the Thompson region, repeated synoptic helicopter surveys were carried out to identify sites near watercourses that were being impacted by livestock operations. These sites were rated and, based on the degree of potential concern, were followed up with one-on-one contact with ranchers to correct any problems (94-26, 96-14, 97-44). Some assessment activities focused on manure application practices in the Salmon River watershed. FRAP also supported public involvement through a Salmon River Watershed Project workshop as part of the ecosystem objectives program (96-16).

In the Cariboo region, FRAP supported *AWCR* and Code assessment studies on ranches in the Bridge Creek watershed (94-25, 96-03). As well, FRAP supported a water quality assessment of the watershed as a means of linking water quality to NPS prevention activities and to prepare a baseline for future reference (97-50). FRAP also supported regional "Cariboo Community" awareness and involvement activities led by BC MELP (96-13).

FRAP supported activities to delineate aquifers in various regions of the Interior, including Salmon Arm, Merritt, Quesnel and Prince George (Ronneseth, 1995).

5.4.3 Assessing and Demonstrating Prevention and Abatement Practices

The Canada-B.C. Green Plan for Agriculture provided a linkage to research in the basin. FRAP supported research that was designed to assess and demonstrate NPS pollution prevention and abatement practices. Research projects included studies on silage corn production (Zebarth *et al.*, 1994; 1996); raspberry production (Zebarth *et al.*, 1996a, 1996b, 1997a, 1997b; Dean, 1996); best management practices and silage corn field runoff (van Vliet, 1997); forage grass production (Bittman, 1997); atmospheric nitrogen losses from poultry manure (Paul *et al.*, 1996, 1997; Scott *et al.*, 1996; Barton, 1996); lime pasteurization of organic wastes (Beames, 1997); poultry manure management (96-04); wetland treatment of greenhouse wastewater (Prystay, 1997); and characterization of mushroom washwater (97-47).

5.5 IMPLEMENTATION AND RESULTS

5.5.1 Developing Commodity Environmental Guidelines

Evaluating the effectiveness of information and education in changing producers' attitudes and encouraging them to implement new management practices was not a component of the FRAP agriculture program. However, B.C. producers and food processors were surveyed as part of the Canada-B.C Green Plan for Agriculture in 1994 and 1996 to measure trends in industry perspectives (FORUM, 1996). This information is relevant to FRAP because it provides some indication of farmers' response to initiatives supporting the agriculture community. The surveys found that hog producers were more concerned with manure handling in 1994 than in 1996 (71 per cent *vs.* 36 per cent), poultry producers remained concerned about litter handling, and manure handling remained a primary concern for almost 60 per cent of dairy farmers.

Respondents who identified environmental problems in their operations increased between 1994 and 1996 (29 per cent *vs.* 42 per cent). As Table 5.1 shows, from 62 per cent to 85 per cent of livestock producers reported that they had made physical and/or management changes in the last two years, and from 37 per cent to 47 per cent said they were planning to make changes in the next two years, because of environmental concerns. Similar responses were obtained from greenhouse and field crop producers. Neither the types of changes nor the specific reasons for choosing them were identified in the survey.

Table 5.1 Percentage of Producers Making Changes Because of Environmental Concerns

Category/Commodity	Hog	Poultry	Beef	Dairy	Green-house	Field Crops
Physical or Management Change Was Made in Last Two Years	62%	85%	70%	73%	69%	67%
Physical or Management Change Planned in Next Two Years	42%	37%	43%	47%	49%	47%

Ninety-seven per cent of Interior cattle producers who responded to a FRAP survey reported that they had changed some operational practice (not specified) in order to correct environmental concerns over the past three years (see Section 5.5.2.4 and Table 5.14). Of this group, 85 per cent said they initiated the change on their own, but 45 per cent of these reported that a BC MELP inspection or BC MAFF advice was also a factor in their decision to make the change.

The B.C. Horticultural Coalition (BCHC), which represents some 3,000 producers, is currently using the various commodity environmental guidelines prepared during FRAP to develop self-auditing protocols (K. Zimmerman, pers. comm., BCHC).

The U.S. Environmental Protection Agency has found that information and education efforts were most successful in reaching farm operators who had higher economic indicators (farm income, property and equipment values) and who worked their farms full-time, receiving most of their income from farming (EPA, 1993).

5.5.2 Inventories in the Lower Fraser Basin

5.5.2.1 Manure and Nutrient Balance Management

5.5.2.1.1 Nutrient Balance Model

Because the lower Fraser Valley is intensively farmed, there are concerns about the use of nutrients in agricultural production. Chief among these concerns are the contamination of water and air by the use of nitrogen (N) and the contamination of water with phosphorus (P), organic oxygen-consuming substances and bacteria. The contamination of soil with potassium (K) is a dairy herd health issue. Before effective strategies to control non-point source agricultural pollution and best management practices could be developed, the considerable regional agricultural diversity within the valley needed to be described. This was accomplished through the development of a nutrient model using 1991 agriculture census information to identify zones with a higher risk of potential contamination. The results represent the best estimate of what is happening on farms, at a regional level.

The lower Fraser was divided into 20 zones, each of which was treated as an individual management unit (Figure 5.1). To gauge the nitrogen balance, five key variables—manure nutrient production, commercial fertilizer use, atmospheric deposition, crop removal and soil denitrification—were estimated for each unit. For each variable, in each zone, an estimate of nutrient additions and losses (expressed as kg nutrient/ha) was determined. The original model analysis to determine the nutrient balance for each zone focused on an evaluation of large farms with gross annual farm receipts of $40,000 or above (95-27).

In a subsequent analysis of nitrogen, no distinction was made between large and small farms (Zebarth *et al.*, 1997). This resulted in an increase in the overall available cropped area and the addition of a smaller per unit (kg N/ha) amount of nitrogen, relative to a large-farm-only analysis. In the second analysis, nitrogen balances included both large and small farms. As well, some small changes were made to the initial model assumptions. Nitrogen zonal balances were re-estimated. In both cases, different management scenarios, including improved manure storage and application, reduced commercial fertilizer use and changes in diet, were assessed to determine how they would affect the zonal balances.

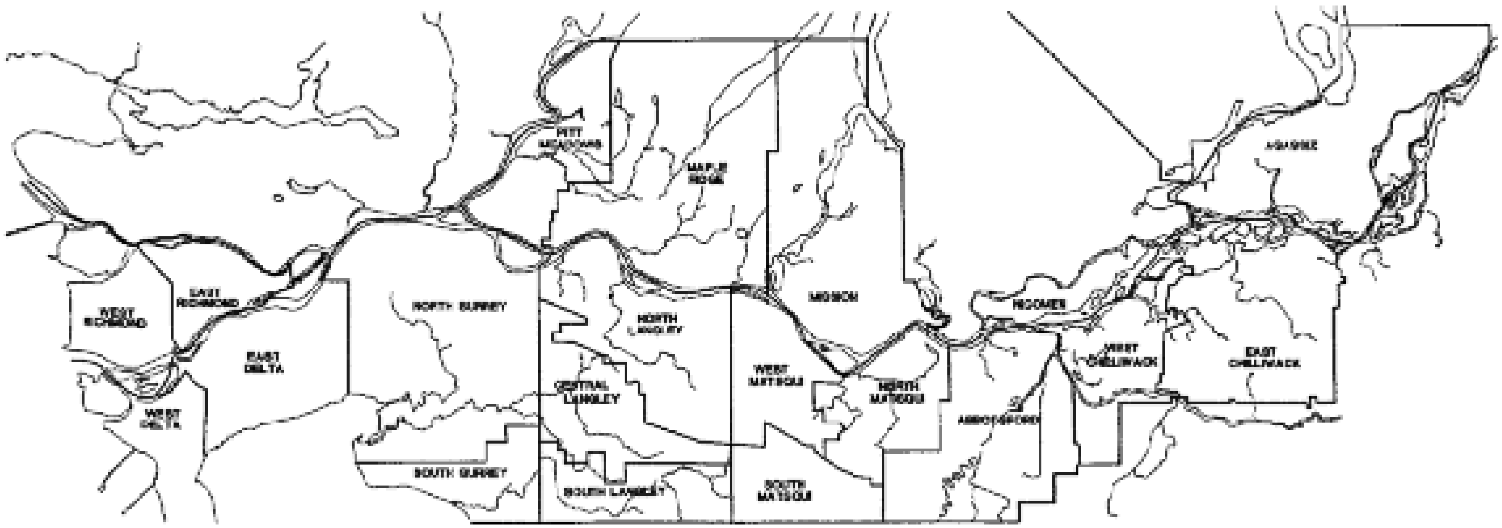


Figure 5.1 Twenty Agricultural Waste Management Zones Used in the Management of Agricultural Wastes in the Lower Fraser Valley Program

The zonal nitrogen balances for the large-and-small-farm analysis based on the original assumptions and revised assumptions are shown in Figure 5.2 (a, b and c). For the south Fraser area covering the eastern sector of the valley, including Langley (Central Langley, North Langley and South Langley), Abbotsford (West Matsqui, South Matsqui, North Matsqui and Abbotsford), and Chilliwack (West Chilliwack and East Chilliwack), both scenarios indicated similar patterns. South Matsqui (approximately covering the Abbotsford aquifer) had the highest net N balance of the nine zones in this sector, followed by West Matsqui [Figure 5.2(a)]. Overall, the balances are appreciably different, largely due to a reduced atmospheric N contribution in Zebarth's analysis (18.6 per cent return of the manure N lost by volatilization calculated on a valley-wide basis) compared to Brisbin's 30 per cent return calculated on a zone-wide basis (e.g. Figure 5.3). Zebarth considered this to better approximate the spatial distribution of atmospheric N additions, but reportedly under estimated atmospheric N additions in areas of high animal densities. This approach was supported, based on limited new information estimating background atmospheric N additions (97-23). The lack of research on the atmospheric input of nitrogen has led to uncertainty in the atmospheric N contribution and its significance in modelling nitrogen balances (95-27).

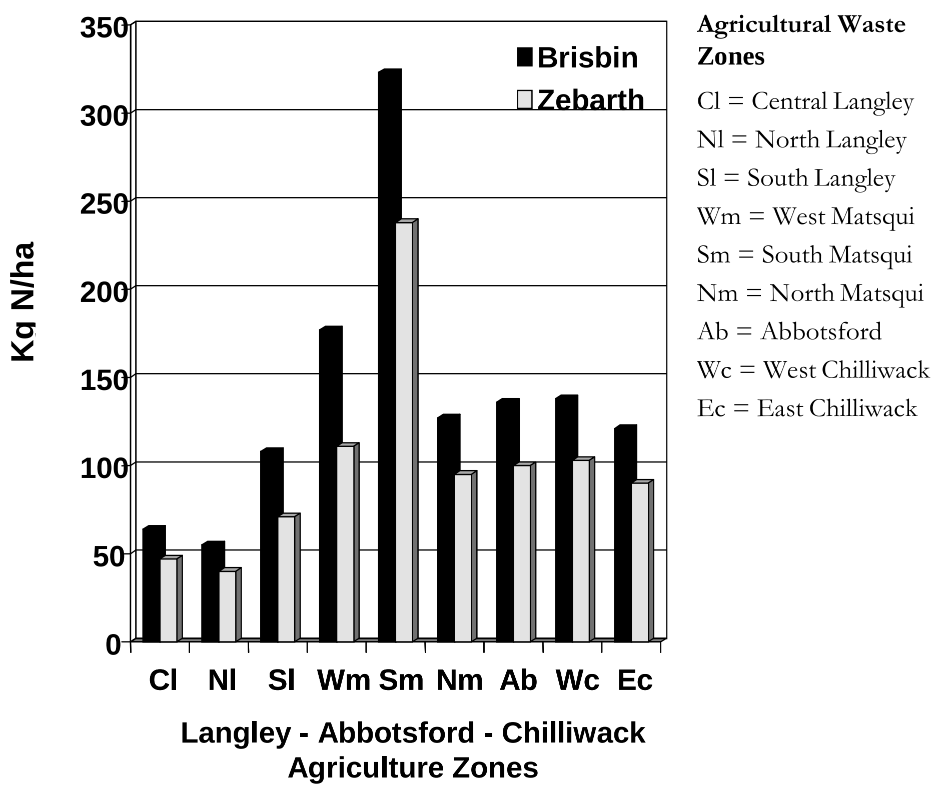
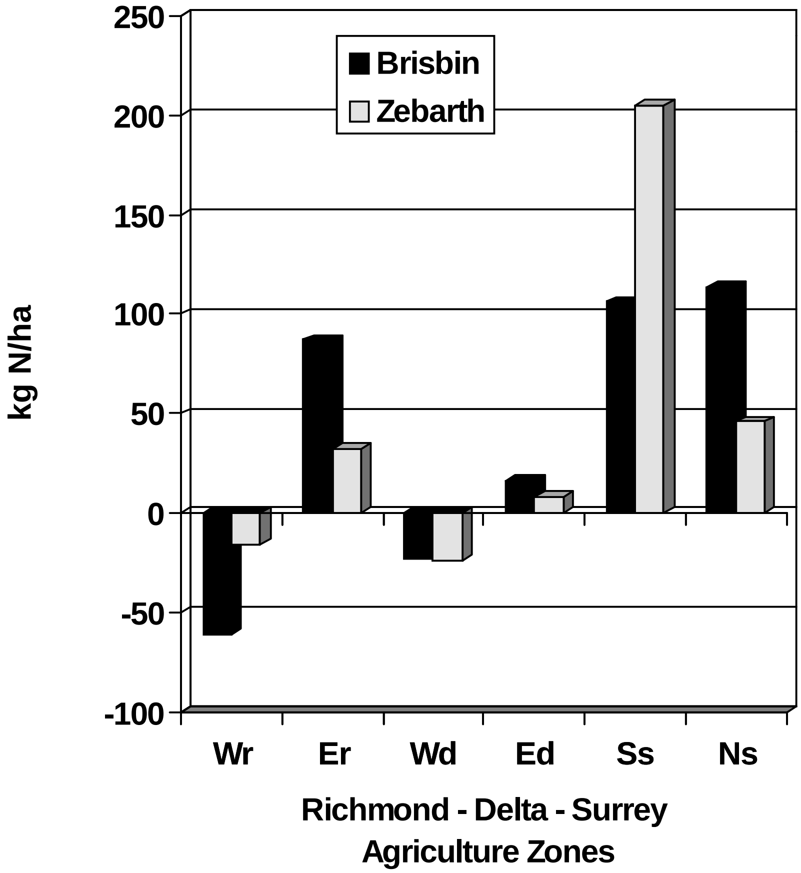


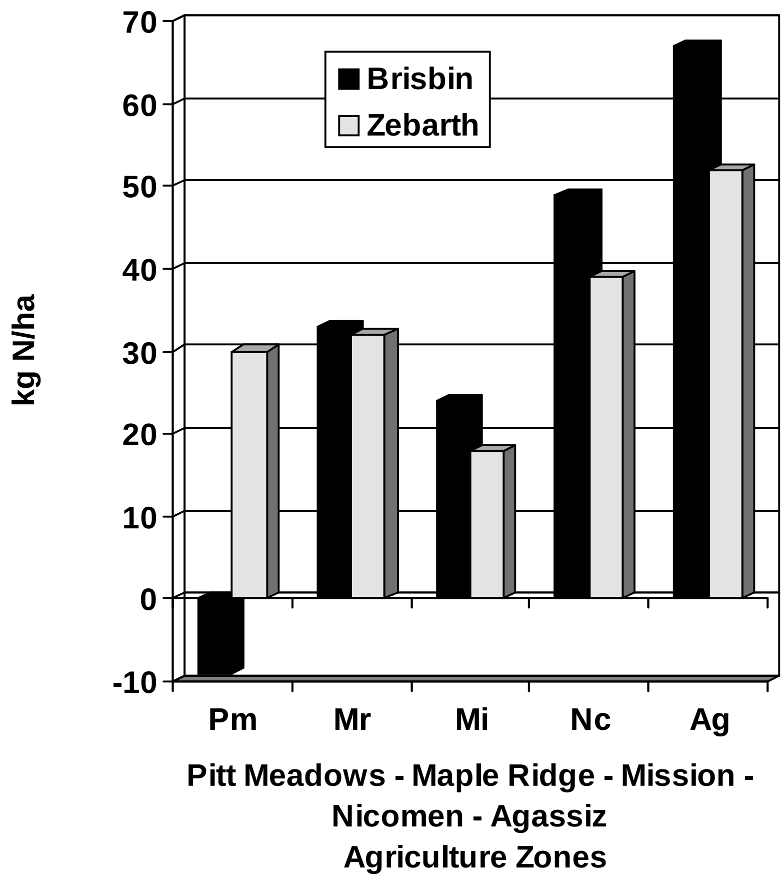
Figure 5.2 (a) South Fraser – Eastern Sector Agricultural Zonal Nitrogen Balances – 1991



Agricultural Waste Zones

Wr = West Richmond
Er = East Richmond
Wd = West Delta
Ed = East Delta
Ss = South Surrey
Ns = North Surrey

Figure 5.2 (b) South Fraser – Western Sector Agricultural Zonal Nitrogen Balances – 1991



Agricultural Waste Zones

Pm = Pitt Meadows
Mr = Maple Ridge
Mi = Mission
Nc = Nicomen
Ag = Agassiz

Figure 5.2 (c) North Fraser Agricultural Zonal Nitrogen Balances – 1991

For the south Fraser area covering the western sector of the valley, including Richmond (West Richmond and East Richmond), Delta (West Delta and East Delta), and Surrey (South Surrey and North Surrey), the highest net N balance reported by Zebarth was in South Surrey, whereas Brisbin found that North Surrey had the highest balance [Figure 5.2 (b)]. The shift was a result of a modification to the census input data based on an apparent anomaly and which resulted in the addition of 4,500 beef animals to the South Surrey zone.

In the north Fraser area, including Pitt Meadows, Maple Ridge, Mission, Nicomen and Agassiz, the highest net N balance was reported in Agassiz for both evaluations [Figure 5.2 (c)]. The boundaries of the Maple Ridge, Mission, Nicomen and Agassiz zones were modified in Zebarth's analysis to exclude large portions of the zones that were considered outside the airshed of the lower Fraser Valley. The difference in the Pitt Meadows balance was also a result of a change in the census input data.

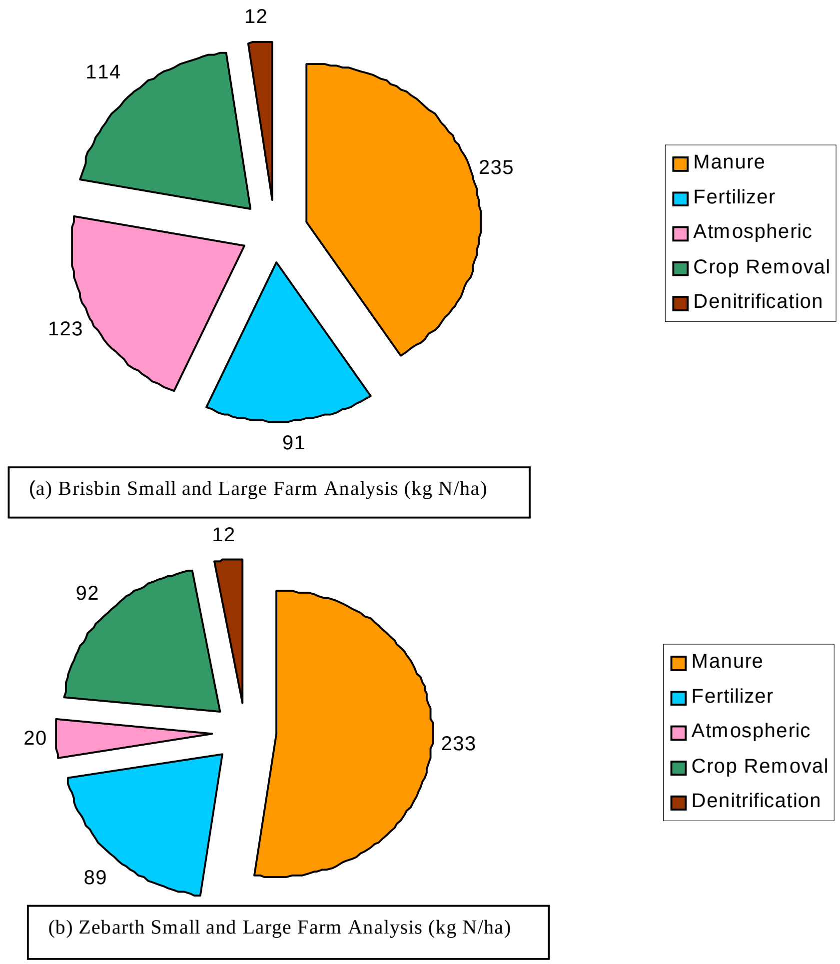


Figure 5.3 Nitrogen Balance Components Used in South Matsqui Zone (a) Brisbin Small and Large Farm Analysis (kg N/ha) and (b) Zebarth Small and Large Farm Analysis (kg N/ha)

In the evaluation of the significance of the nitrogen results, a balance in excess of a 50 kg N/ha benchmark was considered to possibly represent an excessive N loss. The results of the original large-farm-only analysis indicated that some 10 zones representing approximately 28,600 cropped hectares had nitrogen balances of greater than 50 kg N/ha above the 50 kg N/ha benchmark (*i.e.*, overall balances greater than 100 kg N/ha) (Table 5.2). Six zones had overall balances between 58 to 95 kg N/ha and four zones had deficits.

In the large-and-small-farm analysis, with the original model assumptions incorporated, nine zones representing 38,773 cropped hectares (52 per cent of cropped land) had a nitrogen balance 50 kgN/ha or more greater than the benchmark (Table 5.3). With the revised assumptions incorporated into the model, four zones representing 10,710 cropped hectares (14.5 per cent of cropped land) had a balance 50 kgN/ha or more greater than the benchmark. The highest N surpluses were found in zones with intensive animal production, primarily poultry, swine and beef feedlots. Dairy operations use the local land base to produce a significant proportion of their feed requirements and manure nutrients are recycled to produce that feed. For poultry and swine, essentially all of the animal production depends on imported feed. Beef feedlot operations can also largely depend on imported feed. This results in a net importation of nutrients in areas not dependent on producing their own feed.

Table 5.2 Waste Zones with Positive Nitrogen Balances Above a 50 kg N/ha Benchmark – Brisbin Original Large Farm Analysis

Brisbin Original Analysis	**Number of Zones**	**Benchmark 50 kg N/ha**			
Location in Lower Fraser Valley		**Zones With a Positive Balance Greater Than 50 kg N/ha Above Benchmark**	**Area (ha) Affected (Large Farm Cropped Area)**	**Zones With a Positive Balance Less Than 50 kg N/ha Above Benchmark**	**Area (ha) Affected (Large Farm Cropped Area)**
Richmond – Delta	4	-	-	1 (45 kg N/ha)	1,483
Surrey	2	2	4,632	-	-
Langley	3	2	1,772	1 (41 kg N/ha)	2,336
Abbotsford	4	4	13,862	-	-
Chilliwack	2	2	8,322	-	-
Pitt Meadows – Maple Ridge	2	-	-	1 (8 kg N/ha)	795
Mission – Nicomen – Agassiz	3	-		3 (9-24 kg N/ha)	6,399
Total	20	10	28,588	6	11,013

Table 5.3 Waste Zones with Positive Nitrogen Balances Above a 50 kg N/ha Benchmark – Comparison of Brisbin and Zebarth Small and Large Farm Analysis

Brisbin Revised Analysis	**Number of Zones**	**Benchmark 50 kg N/ha**			
Location in Lower Fraser Valley		**Zones With a Positive Balance Greater Than 50 kg N/ha Above Benchmark**	**Area (ha) Affected (Large + Small Farm Cropped Area)**	**Zones With a Positive Balance Less Than 50 kg N/ha Above Benchmark**	**Area (ha) Affected (Large + Small Farm Cropped Area)**
Richmond – Delta	4	-	-	1 (37 kg N/ha))	1,642
Surrey	2	2	6,939	-	-
Langley	3	1	3,119	2 (5-14 kg N/ha))	7,647
Abbotsford	4	4	17,936	-	-
Chilliwack	2	2	10,779	-	-
Pitt Meadows – Maple Ridge	2	-	-	-	-
Mission – Nicomen – Agassiz	3	-	-	1 (17 kg N/ha)	3,045
Total	**20**	**9**	**38,773**	**4**	**12,334**
Zebarth Analysis	**Number of Zones**	**Benchmark 50 kg N/ha**			
Location		**Zones With a Positive Balance Greater Than 50 kg N/ha Above Benchmark**	**Area (ha) Affected (Large + Small Farm Cropped Area)**	**Zones With a Positive Balance Less Than 50 kg N/ha Above Benchmark**	**Area (ha) Affected (Large + Small Farm Cropped Area)**
Richmond – Delta	4	-	-	-	-
Surrey	2	1	1,088	-	-
Langley	3	-	-	1 (21 kg N/ha)	3,119
Abbotsford	4	2	6,397	2 (45-50 kg N/ha)	11,539
Chilliwack	2	1	3,225	1 (40 kg N/ha)	7,554
Pitt Meadows – Maple Ridge	2	-	-	-	-
Mission – Nicomen – Agassiz	3	-	-	1 (2 kg N/ha)	3,045
Total	**20**	**4**	**10,710**	**5**	**25,257**

The model was never intended to provide more than a broad regional analysis of the relatively distinct agricultural areas within the Fraser Valley. Irrespective of either assessment, the results provided a means to rank zones in terms of potential risk of surface and ground water contamination, and to evaluate management scenarios that could reduce that risk. Four of the top five ranked zones were common to both evaluations (Table 5.5).

Estimates of the total nitrogen (ammonia) released from manure range from 7,260 to 7,580 t N/yr. The significance of these losses is not well understood, but ammonia has been identified as a key component in the formation of small particulates, which create a "white haze" in the eastern Fraser Valley. When combined with acidic nitrates and sulphates from automobiles and industry, ammonia produces fine particulates (<2.5 um). Fine particulates are small enough to penetrate deep within the lungs and cause respiratory problems (95-28).

For large farms, the net phosphorus application was more than four times the potential crop removal in 11 zones and more than six times higher in three of these zones (South Langley, West Matsqui and South Matsqui). The net potassium application was more than three times the potential crop removal in three zones (South Langley, West Matsqui and South Matsqui). Surplus applications of phosphorus are a water quality concern, and potassium surpluses are a concern for animal health (95-28).

5.5.2.1.2 Management Change Scenarios

To assess where improvements in farm management might be effective in reducing the nutrient balance, several scenarios were evaluated (95-27; *Zebarth et al.*, 1997). The scenarios were based on changes in manure management and application practices, reduced inorganic fertilizer use and changes in animal diet.

Factors in the model were changed to reflect management practices that would be in compliance with the Code with respect to manure storage and the timing of manure application. They did not reflect compliance with respect to an adequate land base for application of manure. The key land application assumptions—timing and incorporation—for the two evaluations are described in Table 5.4.

In both evaluations, the commercial fertilizer application rate was reduced, for most crops, to 30 per cent of crop removal estimates, with the remainder of the nutrients provided by manure. Rates were not reduced for crops when there was an agronomic justification for not using manure. The most notable difference in the two evaluations in terms of nitrogen removal and reduced fertilizer application involved raspberries. The N removal rate was lower in the re-evaluation, and this was reflected in the amount of commercial fertilizer and manure nitrogen applied (Table 5.6). The third variable in improved management practices involved diet changes. The assumptions used in the two evaluations are reported in Table 5.7.

Table 5.4 Management Practice Assumptions Made to Assess Potential Benefits in Reducing Nitrogen Balances

Dairy Manure Land Application (A) (% of annual) and Incorporation (I) (%)

Management		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1991	A	7	2	2	2	27	3	21	10	8	8	8	2
	I	0	0	0	0	0	0	5	0	0	0	0	0
Brisbin Change	A	0	0	0	0	33	8	30	13	8	8	0	0
	I	0	0	0	0	0	0	5	0	0	0	0	0
Zebarth Change	A	0	0	0	0	33	8	30	13	8	8	0	0
	I	0	0	0	0	50	50	50	0	0	0	0	0

Poultry Manure Land Application (A) (% of annual) and Incorporation (I) (%)

Management		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1991	A	7	3	3	16	16	16	16	3	3	3	7	7
	I	0	0	0	0	0	0	0	0	0	0	0	0
Brisbin Change	A	0	0	0	0	33	8	30	13	8	8	0	0
	I	0	0	0	0	0	0	0	0	0	0	0	0
Zebarth Change	A	0	0	0	10	40	40	10	0	0	0	0	0
	I	0	0	0	0	50	50	50	0	0	0	0	0

Hog Manure Land Application (A) (% of annual) and Incorporation (I) (%)

Management		Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1991	A	7	2	2	3	27	4	20	10	8	8	7	2
	I	0	0	0	0	0	0	5	0	0	0	0	0
Brisbin Change	A	0	0	0	0	33	8	30	13	8	8	0	0
	I	0	0	0	0	0	0	5	0	0	0	0	0
Zebarth Change	A	0	0	0	0	33	8	30	13	8	8	0	0
	I	0	0	0	0	50	50	50	0	0	0	0	0

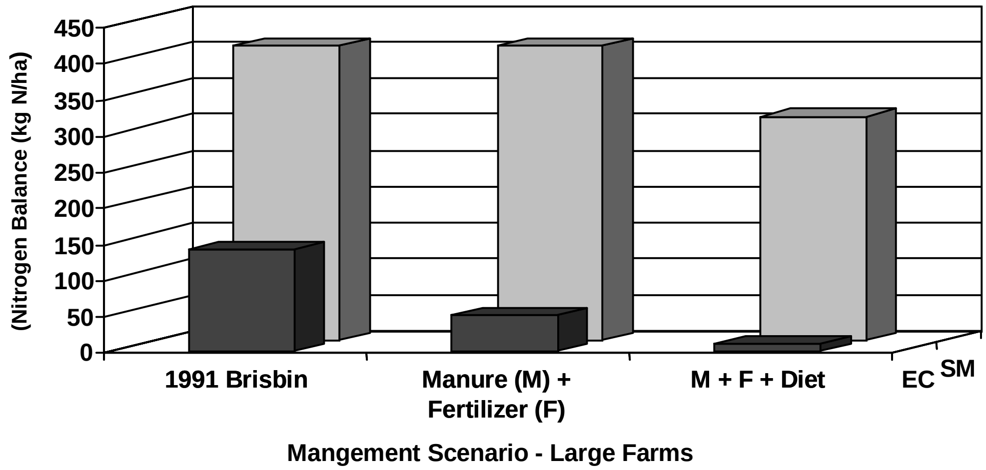


Figure 5.4 (a) Effect of Improved Management Practices In Reducing Zonal Nitrogen Balance – Large Farms in East Chilliwack (EC) and South Matsqui (SM)

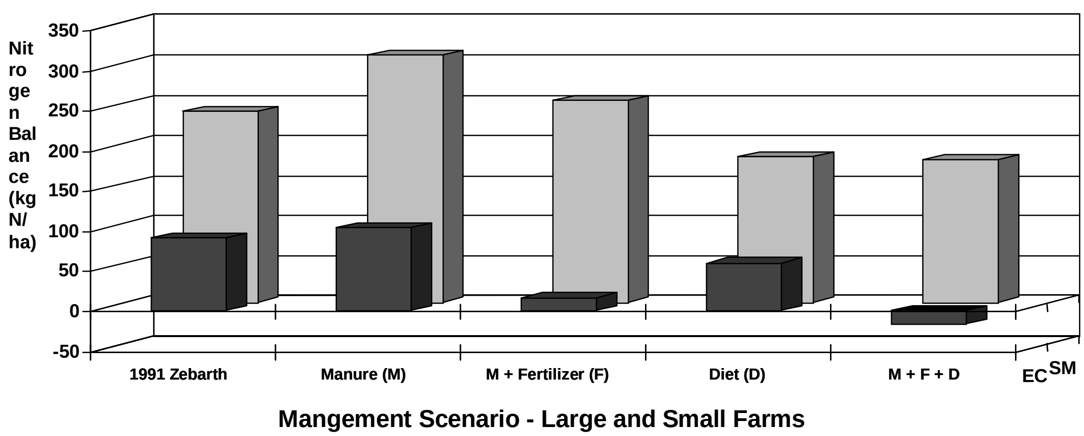


Figure 5.4 (b) Effect of Improved Management Practices In Reducing Zonal Nitrogen Balance – Large and Small Farms East Chilliwack (EC) and South Matsqui (SM)

Figure 5.4 (a) shows the potential effects of introducing two management scenarios based on the large-farm-only analysis, and Figure 5.4 (b) shows the effects of four management scenarios based on the large-and-small-farm analysis. In Figure 5.4 (a), the differences in response for the two zones described reflect the nature of the animal commodity and associated cropping systems. In South Matsqui, which is dominated by poultry production, manure management changes combined with fertilizer reductions had no effect. However, the incorporation of diet changes resulted in an overall 24 per cent reduction in the zone N balance. In East Chilliwack, which is dominated by dairy production, manure and fertilizer management changes brought about a 65 per cent reduction in the N balance. The net overall reduction was 93 per cent when diet changes were also included. Figure 5.4 (b) shows that improving manure management alone increased the net balance in both zones because of reduced leakage. Diet changes alone reduced the balance by 24 per cent in South Matsqui and by 34 per cent in East Chilliwack. For East Chilliwack, when manure and fertilizer management changes were introduced together, the net balance was reduced by 82 per cent, and a deficit situation resulted when diet changes were also included.

The model and the management scenarios tested indicate that, in zones like South Matsqui, the nitrogen balance responds to dietary changes but that the net zonal balance remains high (182 kgN/ha, Figure 5.4 (b). Other management options, such as manure export and/or reduced poultry production, are required to reduce the risk of groundwater contamination. In zones dominated by dairy production, the zonal nitrogen budget increases when manure management and application practices are improved to meet the Code, but it is greatly reduced (from 90 to 16 kg N/ha, Figure 5.4 (b) when those measures are combined with improved commercial fertilizer management. In order to determine whether the agriculture industry is implementing the assumptions incorporated into the model, indicators such manure storage (see Section 5.5.2.6), manure application timing, manure incorporation and fertilizer use (see Section 5.5.2.5) need to be tracked.

The steering committee looking at the management of agricultural wastes in the lower Fraser Valley identified four key actions needed to achieve acceptable nutrient balances (96-30):

- implementing a Best Agricultural Waste Management Plan (BAWMP) process;
- regularly evaluating management options for individual farms and zones with excess nutrients, including the relocation of manure within or outside of the lower Fraser Valley;
- preserving the agricultural land base and broadening planning at the watershed level; and
- increasing education and awareness to foster changes in attitude and to ensure enforcement of regulations when voluntary action is not sufficient.

The potential for nitrogen losses to surface and ground waters can be reduced substantially through improved management practices. However, in the case of improved manure and commercial fertilizer management practices, the potential to achieve those benefits is likely limited by three factors (Zebarth *et al.*, 1997):

- Sufficient manure is not available in all zones to replace the use of commercial fertilizer N in crop production, but this can be overcome to some extent by transport of poultry manure among zones (see Section 5.5.4.2).
- The feasibility of replacing fertilizer N with manure N assumes that the receiving operation is capable of handling the manure, but this may be more of a limitation in smaller operations that may not have the necessary equipment or storage facilities (see Section 5.5.4.2).

- There must be systems available to identify the extent to which fertilizer N can be replaced with manure N while maintaining optimal crop yields (see Section 5.5.4.1), and such systems do not exist for all crops.

To take the next step and determine how best to advance the process of implementing the key actions, the Fraser Basin Council (formerly the Fraser River Management Board, FRMB) has identified an interest in conducting stakeholder discussions on these key actions and reporting back to BC MELP and BC MAFF on their findings (FBC, 1998).

Table 5.5 Agriculture Zones Ranked in Terms of Surplus Nitrogen (+kg N/ha) Greater than a 50 kg N/ha Benchmark – Large-and-Small-Farm Analysis

Ranking	**1**	**2**	**3**	**4**
Brisbin	South Matsqui (+273)	West Matsqui (+127)	West Chilliwack (+88)	Abbotsford (+86)
Zebarth	South Matsqui (+188)	South Surey (+155)	West Matsqui (+61)	West Chilliwack (+53)
Ranking	**5**	**6**	**7**	**8**
Brisbin	North Matsqui (+77)	East Chilliwack (+71)	North Surrey (+64)	Central Langley (+58)
Zebarth	Abbotsford (+50)	North Matsqui (+45)	East Chilliwack (+40)	Central Langley (+21)

Table 5.6 Inorganic Fertilizer and Manure Nitrogen (kg N/ha/yr) Crop Requirement Assumptions Used in Nitrogen Model

Crop	**Removal kg N/ha/yr (Brisbin)**	**Removal kg N/ha/yr (Zebarth)**	**Reduced Inorganic Fertilizer use (Brisbin)**	**(Brisbin)**	**Reduced Inorganic Fertilizer Use (Zebarth)**	**(Zebarth)**
			Fertilizer	Manure	Fertilizer	Manure
Raspberry	70	25	21	49	10	15
Strawberry	70	25	70	0	25	0
Blueberry	75	25	70	0	25	0

Table 5.7 Diet Nitrogen Reduction Assumptions Used in Nitrogen Model

Livestock Manure Excretion	N Reduction (%) (Brisbin)	N Reduction (%) (Zebarth)	Reduced Manure Loss (%) to Atmosphere During Housing (Brisbin)	Reduced Manure Loss (%) to Atmosphere During Housing and Storage (Zebarth)
Dairy	25	20	20	10
Swine	25	25	20	0
Poultry	25	25	20	0

5.5.2.2 Groundwater Mapping and Quality

FRAP supported the development of groundwater mapping and assessment in the Fraser Basin. A classification system was used to categorize different types of aquifers; the components of the system are described in Table 5.8 (Kreye and Wei, 1994). For illustrative purposes, the Class IA and IIA aquifers in the Lower Fraser Valley are shown in Figure 5.5.

Table 5.8 Aquifer Classification System Components

(Development Sub-class)

I	II	III
Heavy (demand is heavy in relation to productivity)	Moderate (demand is moderate in relation to productivity)	Light (demand is light in relation to productivity)

(Vulnerability Sub-class)

A	B	C
High (aquifer is highly vulnerable to contamination from surface sources)	Moderate (aquifer is moderately vulnerable to contamination sources)	Low (aquifer is not very vulnerable to contamination from surface sources)

(Aquifer Class Matrix)

	I	II	III
A	IA – heavily developed, high vulnerability	IIA – moderately developed, high vulnerability	IIIA – lightly developed, high vulnerability
B	IB – heavily developed, moderate vulnerability	IIB – moderately developed, moderate vulnerability	IIIB – lightly developed, moderate vulnerability
C	IC – heavily developed, low vulnerability	IIC – moderately developed, low vulnerability	IIC – lightly developed, low vulnerability

The Abbotsford aquifer is a Class IA aquifer and has been the focus of attention in the last decade because of rising nitrate levels. The source of nitrate contamination has been attributed to long-term agricultural land use practices (FRAP 95-29). Changes in land use and animal production between 1971 and 1991 were reported using the model described previously (Zebarth and Paul, 1995). These changes are simplified schematically in Figure 5.6 and show an increasing nitrogen balance, from 200 kg N/ha in 1971, to 258 kg N/ha in 1981, to 330 kg N/ha in 1991. This review illustrates the value of both the model and land use tracking, especially in vulnerable areas, in developing strategies to avoid environmental problems.

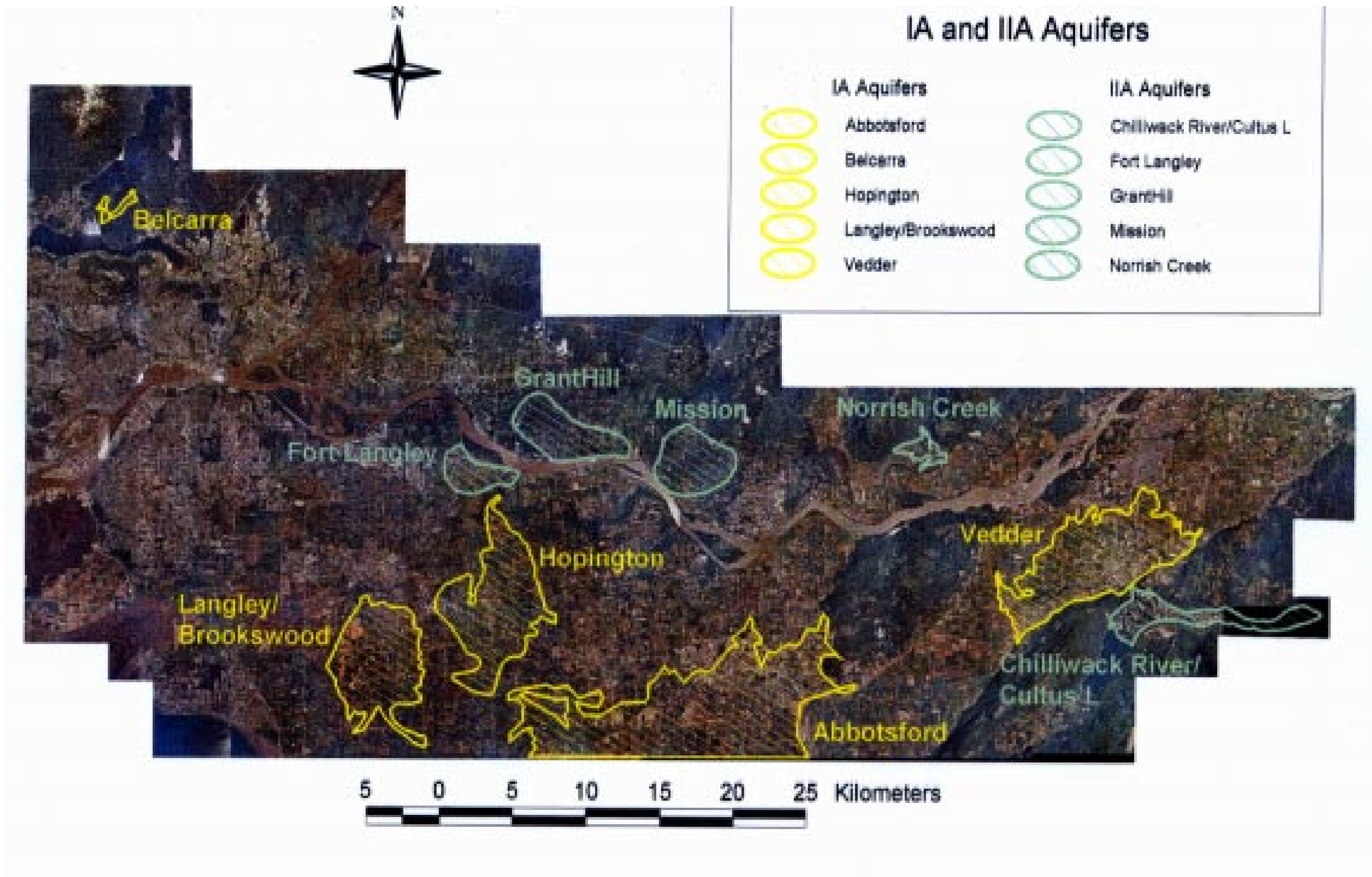
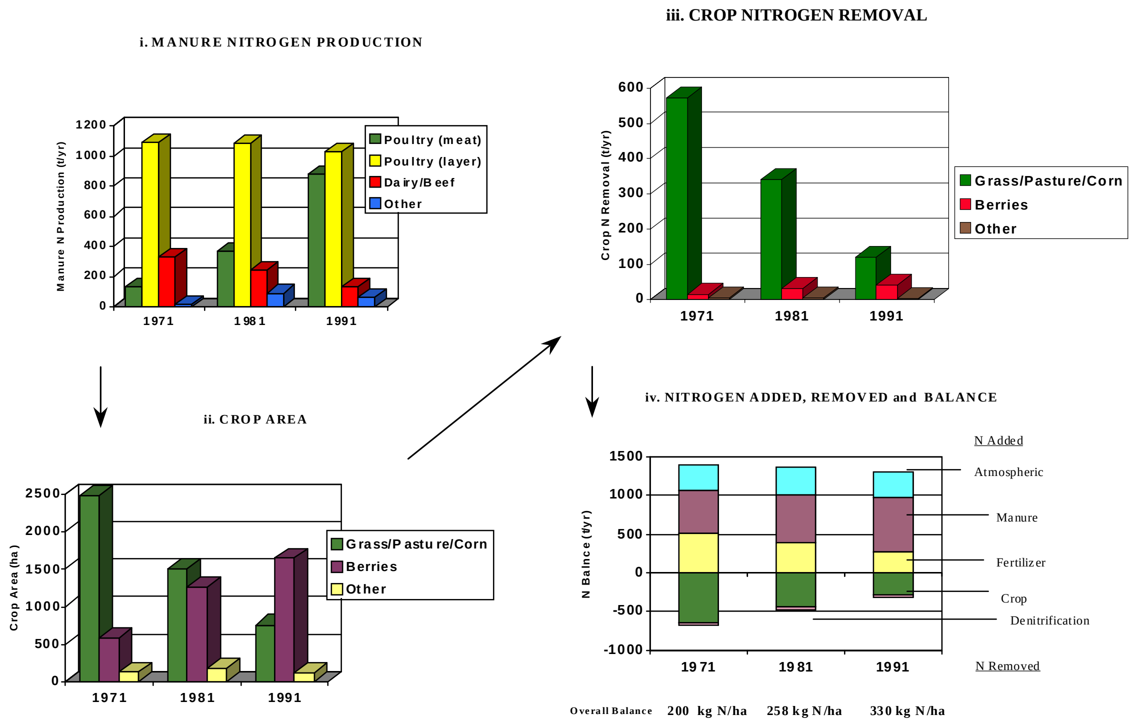


Figure 5.5 Lower Fraser Valley Class IA and IIA aquifiers overliad on 1995 digital orthophoto



Source: Zebarth and Paul, 1995

Figure 5.6 Increasing Overall Nitrogen Balance Between 1971 and 1991 With Changes in Land Use and Animal Production – Abbotsford Aquifer

Using the isotopes of ^{15}N and ^{18}O in nitrate, it was demonstrated that the nitrate in the aquifer was predominantly derived from poultry manure and to a lesser extent from ammonium-based fertilizers. Of 117 wells sampled, 54 per cent had nitrate concentrations exceeding the accepted drinking water quality limit of 45 mg/L NO_3^- (10 mg/L as N). These results suggest that widespread nitrate contamination will continue, unless agricultural land management practices are dramatically changed. Even then, because the residence time of the groundwater is in the order of decades and there is an apparent lack of bacterial denitrification, the only form of nitrate removal from the aquifer will be through continued flushing from recharge.

5.5.2.3 Pesticide Sales and Integrated Pest Management

5.5.2.3.1 Pesticide Sales: 1991 and 1995

FRAP supported projects to survey 1991 and 1995 pesticide sales in B.C. Each year, a pesticide vendor is required to file a summary of pesticide sales over the past year in order to renew a license. This reporting applies only to products sold to end users and not for resale. It was assumed that pesticides sold in one year were used the same year. Similarly, holders of pest control service licenses must report summaries of their pesticide use annually when they apply for license renewal. For both years, the surveys obtained and summarized the annual reports for pesticide vendors for all regions and pest control services licensees in BC MELP's Region 2 (Lower mainland) for the landscape category only. Since most agricultural pesticides are applied by farmers to their own property, a use which requires no license, the service license data alone would not adequately characterize the agriculture sector. Region 2 was considered to represent the lower Fraser region, although it extends beyond this area.

Pesticide sales can vary substantially from year to year as a result of weather (wet weather promotes fungal growth, increasing the use of fungicides), outbreaks of particular insect pests, changes in crop prices (affecting area of crop planted), pesticide prices and other economic factors. Two data points are insufficient to suggest any trends.

Of the top 10 reportable pesticide sales in 1991, five were again reported in the top 10 in 1995. These included glyphosate, metam, captan, mineral oil (herbicidal) and mancozeb (Table 5.9). In 1991, eight pesticides federally labeled as Restricted exceeded sales of 1,000 kg in B.C. (Table 5.10). From 19 to 97 per cent of the sales for these pesticides occurred in the lower mainland, except for azinphos-methyl, of which only five per cent of sales occurred in the lower mainland. Methyl bromide and dinoseb sales were much lower in 1995 than in 1991.

Table 5.9 Comparison of 1991 Top Ten Reported Pesticide Sales in British Columbia and Fraser Valley Region 2 with 1995 Sales

Region 2 - 1991 Top 10 Pesticides	1991 Sales (kg ai*)	Percentage of Total 1991 Sales	1995 Sales (kg ai) and [1995 Ranking]	Percentage of Total 1995 Sales	Total 1991 Sales (kg ai)	Total 1995 Sales (kg ai)
Glyphosate	77,575	70	79,035 [1]	63	110,157	124,698
Metam	25,777	94	16,345 [6]	80	27,437	20,422
Methyl Bromide	21,658	99	3,805 [32]	100	21,958	3,805
Captan	16,164	57	20,853 [4]	72	28,451	29,160
Atrazine	15,360	67	8,611 [14]	84	22,898	10,298
Mineral Oil (herbicidal)	11,890	31	15,215 [2]	100	38,540	25,215
Malathion	10,843	90	5,749 [19]	88	12,048	6,523
Diazinon	8,153	42	9,459 [13]	42	19,643	22,552
Mancozeb	7,589	26	24,999 [3]	60	29,511	41,907
Metolachlor	7,475	73	5,356 [23]	79	10,202	6,807
Region 2 - 1991 Biological Pesticides	**1991 Sales (kg)**	**Percentage of Total 1991 Sales**	**1995 Sales (kg ai) and [1995 Ranking]**	**Percentage of Total 1995 Sales**	**Total 1991 Sales (kg)**	**Total 1995 Sales (kg)**
Bacillus thuringiensis, serotype H-14	3,106	97	11,105	99	3,188	11,270
Bacillus thuringiensis kurstaki	1,008	33	3,848	31	3,095	12,283

*ai = active ingredient

Table 5.10 Reportable Restricted Pesticide Sales in British Columbia and Fraser Valley Region 2 — 1991 and 1995

1991 Restricted Pesticide Sales >1000 kg ai	1991 BC Sales (kg ai)	1991 Region 2 Sales (kg ai)	1991 Region 2 Percentage of BC Sales	1995 BC Sales (kg ai)	1995 Region 2 Sales (kg ai)	1995 Region 2 Percentage of BC Sales
Methyl Bromide	21,958	21,658	99	3,805	3,805	100
Azinphos-methyl	17,820	889	5	21,804	888	4
Dinoseb	7,233	4,149	57	6	0	0
Parathion	4,054	1,711	41	3,969	2,051	52
Bacillus thuringiensis, serotype H-14	3,188	3,106	97	11,270	11,105	99
Methamidophos	2,947	1,973	67	1,910	1,877	98
Sulfotep	2,131	412	19	3,665	3,442	94
Carbofuran	1,021	503	49	997	925	93

5.5.2.3.2 Integrated Pest Management

FRAP promoted integrated pest management (IPM) in several ways:

- supporting BCFA's development of an IPM business plan;
- supporting an IPM workshop for vegetable and small fruit growers,
- collecting information for BC MELP's Integrated Pest Management Information System and for a review of a pesticide colour classification system; and
- doing research on azadirachtin, a botanical bioactive agent found in the seed kernel of the neem tree.

5.5.2.4 Code Assessment and Farm Surveys

Co-ordinating FRAP's agricultural program with BC MELP set the framework for evaluating implementation of the Code, which began in 1994-95. This was done largely by developing an information base on the number and type of agricultural complaints handled by BC MELP (97-45)

Since the Code came into effect in 1992, BC MELP has responded to over 900 agricultural waste-related issues and complaints, averaging about 180 per year. The majority of problems are caused by a large number of farms experiencing a wide variety of waste management problems, rather than by recurring concerns at a small number of farms. As well, the general public is becoming more aware of the environmental problems associated with poor farm management practices. This, plus the fact that there are more people settling in the lower Fraser Basin along the agricultural land reserve fringe, will likely result in more people observing and reporting on what is happening in agricultural areas.

Figure 5.7 breaks down the agricultural waste management complaints and issues by commodity in each agricultural waste management zone. The majority of complaints are concentrated in the Abbotsford, Matsqui and Langley zones. Most poultry complaints occur in the Matsqui and Langley zones, dairy complaints are dispersed throughout the valley east of Delta, horse complaints originate primarily in the Langley and Maple Ridge areas, and mushroom complaints occur mainly in the Langley, Surrey and Abbotsford areas.

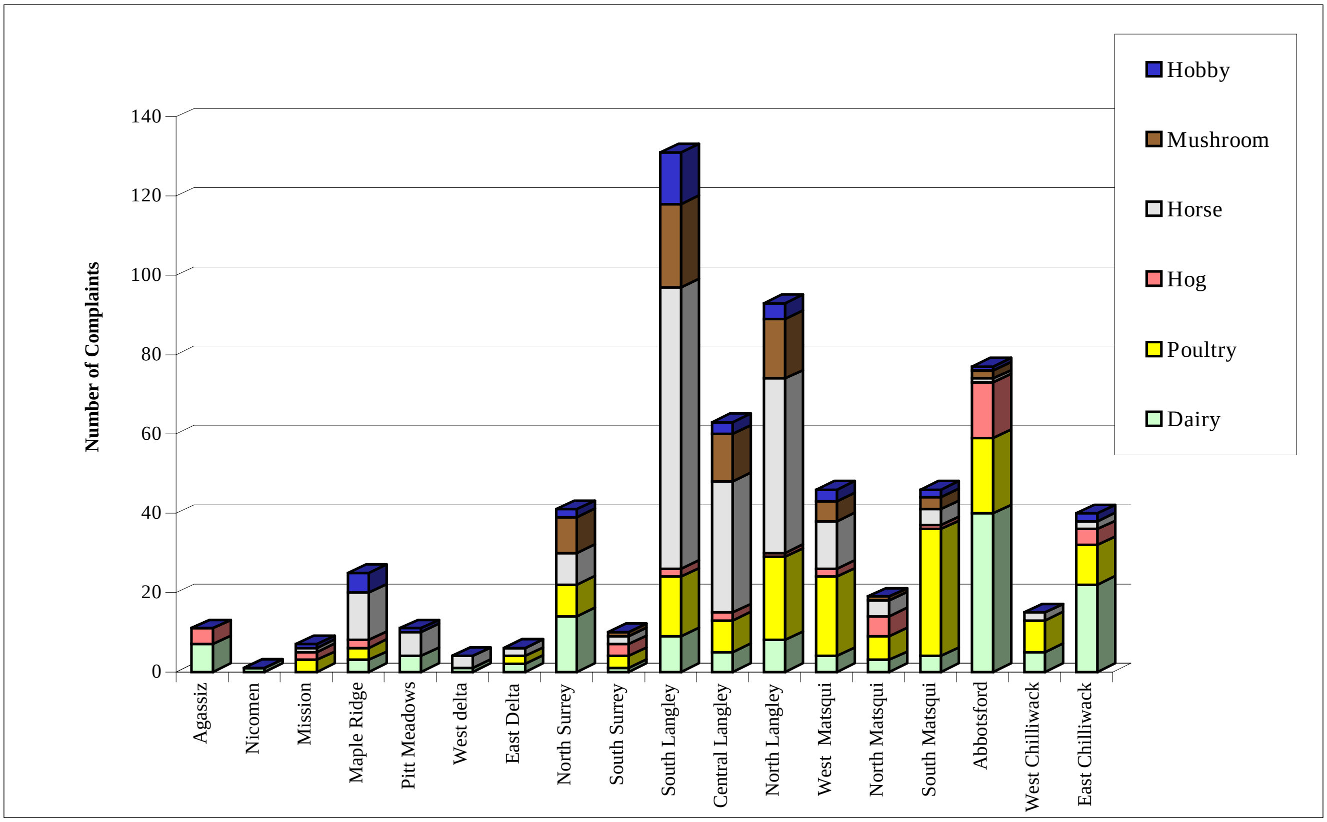


Figure 5.7 Agricultural Complaints Handled by Commodity by BCMELP in the Lower Fraser Valley 1992-1998

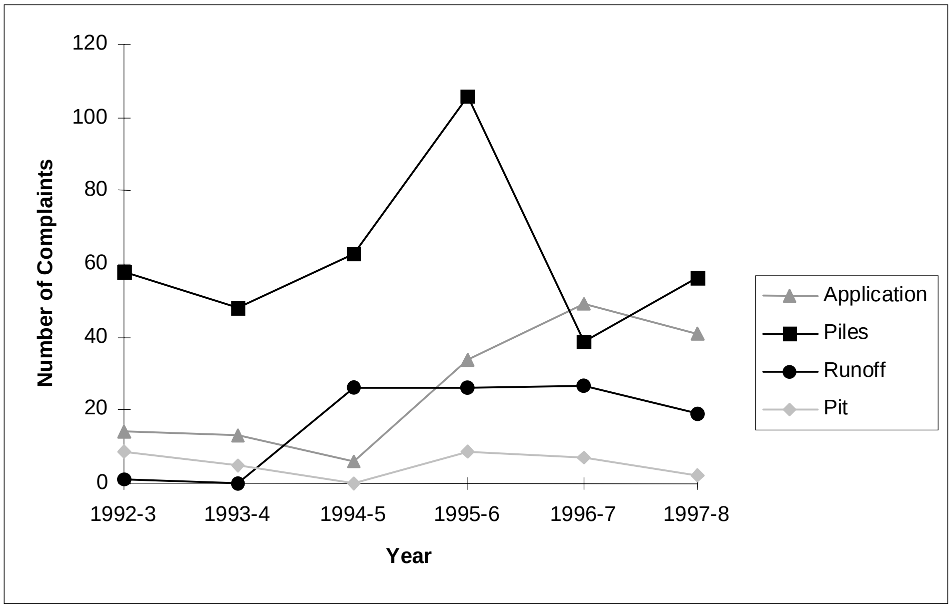


Figure 5.8 Trends in Four Types of Agricultural Complaint Broken down by Fiscal Year

Figure 5.9 Trend in South Matsqui – Abbotsford Aquifer Manure Pile Storage Complaints

Figure 5.8 breaks down the complaints by the type of issue it involves. The majority of issues relate to manure piles and the application of manure to land. The sources and number of complaints largely reflect the visibility of these practices. Contaminated runoff is another significant issue. It can occur as direct discharges into the environment from feedlots, solid manure and silage storage areas, manured fields, milk parlours, mushroom farms, greenhouses and nurseries. Other sources of contaminants are manure pits and lagoons, discharges from woodwastes, improper disposal of mortalities, and improper pesticide application and storage.

Approximately one-third of the agricultural waste management complaints related to improper storage of solid agricultural waste piles. Although the number of storage-related complaints in 1996-97 was notably lower than the numbers for the two previous years, the degree of annual variability makes it impossible to determine whether a definite improvement is taking place. However, clear progress can be seen in the South Matsqui zone in recent years (Figure 5.9), with the number of storage-related complaints being reduced substantially.

As Figure 5.8 shows, complaints related to the application of manure to land have increased. This increase may reflect increased awareness of this issue. Common practice has been to empty manure storage facilities on bare soil in the fall, principally on land recently harvested of corn, in order to maximize winter storage. Research has shown that most of the nitrogen applied in the fall on bare ground where corn had been harvested was lost over-winter, so there was little apparent value for the subsequent crop. However, manure spread between mid-September to mid-October on perennial forage grass species or on fall-planted cover crops benefited subsequent spring harvests (Bittman, 1997).

Some farmers may consider manure a waste that needs to be disposed of, rather than a valuable resource to be managed for crop production. Thus, depicting the boundaries of acceptable risk to protect the environment is important. Manure management guidelines were developed for the Fraser Valley and were intended to help the agricultural community and government agencies identify activities that, under certain conditions, have a high risk of causing pollution (BC MELP, 1996). The guidelines outline the risks of spreading manure during various times of the year on established grassland, cover crops, fall seeded grassland, berry crops and bare land, and also address the proper storage of manure piles.

As Figure 5.10 shows, there is considerable yearly variation in rainfall in the lower Fraser Basin. While there are some years with extended periods of low rainfall in the fall, more often, the pattern is frequent heavy rainfall events between short periods (one to three days) of low or no rainfall. Thus, manure management needs to emphasize ensuring adequate storage and nutrient management planning, rather than trying to find disposal opportunities with an unpredictable variable such as rainfall.

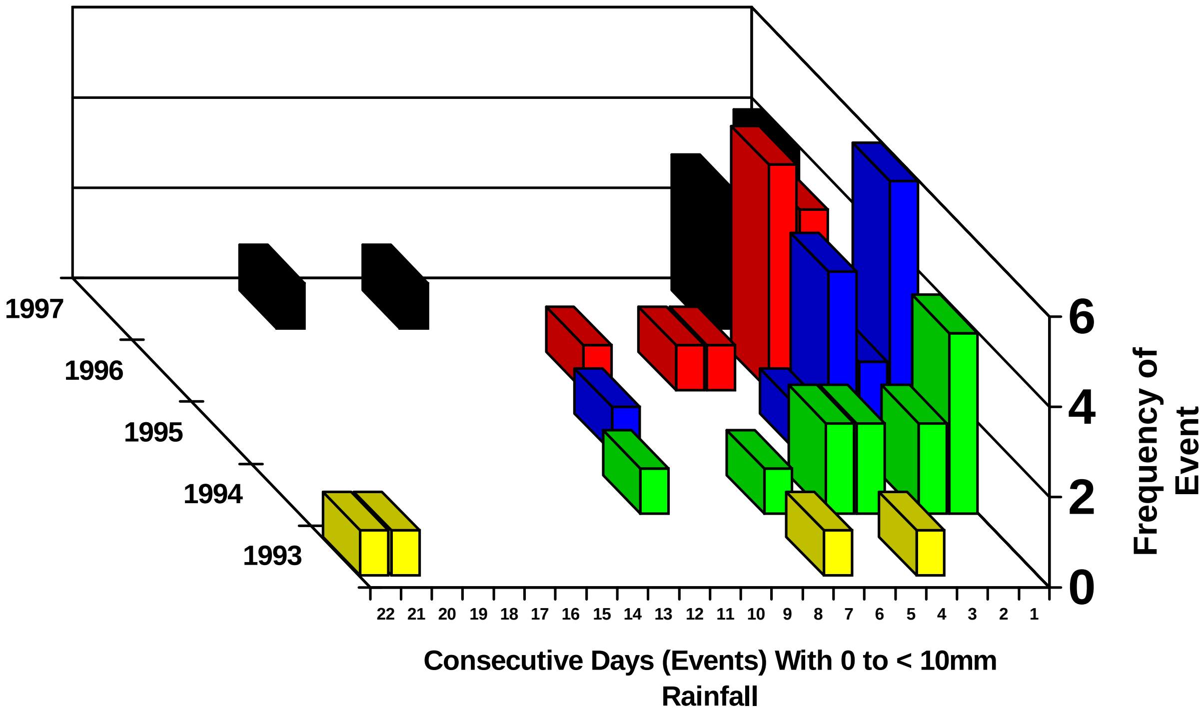


Figure 5.10 Abbotsford Fall Rainfall Distribution, October 1 to November 30 Period Showing Pattern of Frequent Heavier Rainfall Events Between Short Periods of Low Rainfall

The preferred approach is to provide producers with education and information with respect to the environmental impacts caused by poor agricultural waste management practices. This approach has resulted in real progress being made towards achieving environmental sustainability. However, in some cases, that approach is not effective, so stronger enforcement action is required. Fines in three cases have ranged between $1,500 and $2,500 on each count, two cases are still in progress and one case is pending charges.

Since the Code came into effect, 83 orders have been issued within the 20 zones, of which 67 have so far been complied with. To date, three orders have been appealed. At the time this report was being prepared, the most recent appeal, involving the application of dairy manure to a harvested corn field, with runoff entering a drainage ditch, had not been heard. The other two appeals concerned the pollution of a drinking water well as a result of a discharge originating from the deposition of turkey manure on the property of the appellant, and the excess application of dairy manure to a harvested corn field, with runoff entering the Fraser River. Both appeals were set aside by the Appeal Board in favour of the appellant.

When the BCFA formed the Agricultural Environmental Protection Council, the intention was to address agricultural complaints largely using a peer advisor process. Given the opportunity to interact one-on-one, and being provided with environmental and technical information, individual farmers were expected to adopt sustainable measures voluntarily. This was expected to reduce the need for regulatory agency involvement. The main premise of the peer group process was that farmers would be well equipped to advise fellow producers on alternative, more acceptable and practical methods. FRAP supported the development of resource material and a computer tracking system for registering complaints and following up on whether the complaint had been dealt with. However, the system is not compatible with BC MELP's system and has yet to be effectively demonstrated.

Because of a number of factors, the peer process has not been fully implemented. A shortage of peer advisors, a lack of support from commodity groups, and insufficient environmental training appear to be the primary obstacles. Since much of the earlier training was production-oriented, the peer advisors may not have been adequately informed on environmental issues, and thus unable to relay that information to fellow producers. In some cases, environmental problems were not passed on for action, resulting in future and/or continuing environmental impacts. As volunteers, peer advisors must schedule times to address complaints when they may already be busy with their own farming operations. In many cases, follow-up inspections by peer advisors were not conducted, so agricultural waste management concerns remained unresolved and/or unreported. One obstacle which, even after five years, seems to prevent the system from working satisfactorily is misunderstanding and confusion by producers over the roles of the provincial ministries and the peer advisory service.

Efforts to address agricultural issues in the Fraser Valley have been largely reactive, since a lack of resources limits much proactive involvement. Increasing interaction between producers and the ministry is necessary, over the long term, to promote stewardship and prevention. Examples of proactive involvement include participation in short courses sponsored by the horse, dairy and horticulture commodity groups.

Since 1994, the Township of Langley's planning department has referred applicants for a building permit for a farm operation to BC MELP, for input prior to issuing a permit. Through this informal process, the applicant is made aware of proper waste management practices. The process involves the provision of information packages and, in some cases, on-site visits. A similar process, but on a smaller scale that involves intensive farm operations only, has been developed with both the City of Abbotsford and the City of Surrey planning departments. Although it is proactive, this process has been limited by available resources.

5.5.2.5 Fertilizer Sales and Use

Data on retail fertilizer sales in Canada are compiled by the Canadian Fertilizer Institute. Sales data for the southern British Columbia area include all of B.C. except the Peace River area. Data are not available for smaller geographic areas. Total retail sales include all sales, whether for agricultural or non-agricultural (*e.g.*, forestry or residential) uses, and separation at this level of detail was not available. Retail sales for 1983 to1997 are reported in Table 5.11. The data show considerable variation from year to year, but no obvious trends up or down.

Table 5.11 Retail Fertilizer Sales in Southern British Columbia – 1983 to 1997

(tonnes/yr)	1983	1984	1985	1986	1987	1988	1989	1990
N	11852	12361	15734	15520	14707	14315	16816	15841
P_2O_5*	6982	7020	8879	8648	8187	8217	8942	9347
K_2O*	6268	4824	7277	6097	7024	6604	6044	5881
(tonnes/yr)	1991	1992	1993	1994	1995	1996	1997	-
N	15670	15611	19996	18248	14356	14453	17271	-
P_2O_5	8840	8161	10347	12389	8100	7081	9277	-
K_2O	6969	5168	7894	7515	5976	5012	6602	-

* Multiply by 0.437 to convert to P and by 0.83 to convert to K.

An analysis was made to try to estimate changes in commercial fertilizer use between 1991 and 1997, based on crop type (97-49).

5.5.2.5.1 Forage Grass

From information collected during a 1997 survey of 100 farms (see Section 5.5.2.6), representing 2,809 hectares of forage grass land, the average annual fertilizer application rates for forage grass were determined to be 155 kg/ha of N, 4 kg/ha of P_2O_5 and 3 kg/ha of K_2O. Compared to estimated 1991 application rate estimates, application rates fell 17 per cent, 91 per cent and 94 per cent, respectively. Applying these application rates to the 25,135 ha of land in forage production in 1996 (excluding alfalfa and alfalfa mixes) results in reductions, relative to 1991 application rates, of 779 tonnes of nitrogen, 428 tonnes of phosphorus and 1,064 tonnes of potassium (Figure 5.11). About 92 per cent of the surveyed farms growing forage grass had relied on some form of soil fertility testing over the last several years.

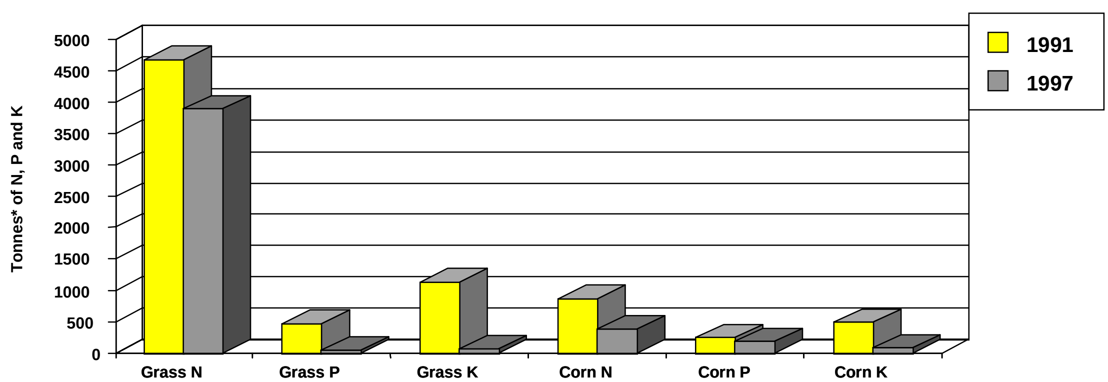


Figure 5.11 Estimated Reductions in Fertilizer Application Between 1991 and 1997 for Forage Grass and Silage Corn

5.5.2.5.2 Silage Corn

The same 1997 farm survey, representing 1,837 hectares of silage corn land, found that the average annual fertilizer application rates for silage corn were 62 kg/ha of N, 67 kg/ha of

P_2O_5 and 16 kg/ha of K_2O. The corresponding reductions compared to 1991 application rates were 56 per cent, 20 per cent and 83 per cent, respectively. Applying these application rates to the 6,201 ha of land in silage corn production in 1996 results in reductions, relative to 1991 application rates, of 484 tonnes of nitrogen, 62 tonnes of phosphorus and 407 tonnes of potassium (Figure 5.11). About 63 per cent of the surveyed farms growing silage corn did not sidedress any fertilizers, indicating high usage of the pre-sidedress nitrogen test (PSNT)(see Section 5.5.4.1).

5.5.2.6 Farm Practices Survey

A key strategy for improving nutrient management to reduce environmental contamination is to increase manure storage capacity in order to reduce applications during higher risk rainfall periods and to optimize manure nutrient use over the use of commercial fertilizers. Developing an inventory of farm management practices for the whole lower Fraser Valley to track changes would be difficult, so two watersheds (Sumas River and Matsqui Slough) were surveyed to develop this type of information. Surveys in 1994 and 1997 appear to indicate that for the dairy group—the largest group in the two watersheds—median manure storage time has increased from approximately 2.7 months to 3.5 months (Figure 5.12) (97-48). The percentage of dairy farms with a storage capacity greater than five months also increased. However, a large percentage (36 per cent) of farms still have a storage capacity of less than three months.

The density of animals, as reflected by the available manure nitrogen on the farm (kg N/ha), did not change in the Sumas watershed (median values: 185 kg N/ha in 1994 and 185 kg N/ha in 1997) (Figure 5.13). Similarily, for the Matsqui Slough survey area, the median manure nitrogen only decreased slightly from 193 kg N/ha to 185 kg N/ha. In both watersheds, for the majority of farms, the amount of nitrogen applied to the land in manure is well below annual forage grass crop requirements of 360 kg N/ha. However, when commercial fertilizer nitrogen sources are also accounted for, 41% of farms surveyed in Matsqui Slough were applying nitrogen above 350 kg N/ha and eighteen percent in the Sumas River.

For phosphorus, when both manure and commercial fertilizer are accounted for, 97% of the farms surveyed in Matsqui Slough exceeded the application rate of 100 kg P_2O_5/ha (forage grass requirement for phosphorus is 90 kg P_2O_5/ha). All of the farms surveyed in the Sumas River were applying phosphorus above that rate. Manure was the primary phosphorus source in both areas.

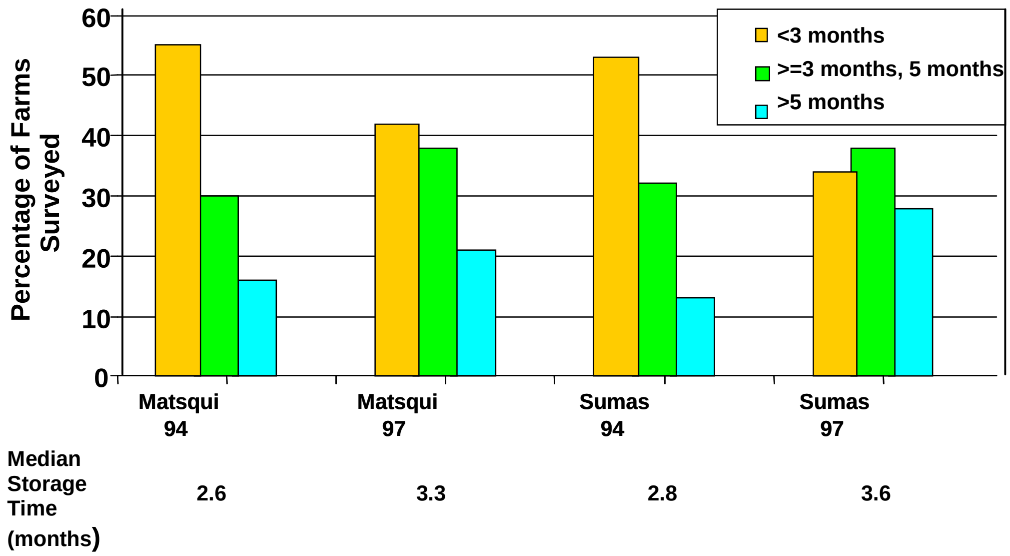


Figure 5.12 Agricultural Survey of Matsqui Slough and Sumas River Watersheds – Changes in Dairy Farms Manure Storage Capacity Between 1994 and 1997

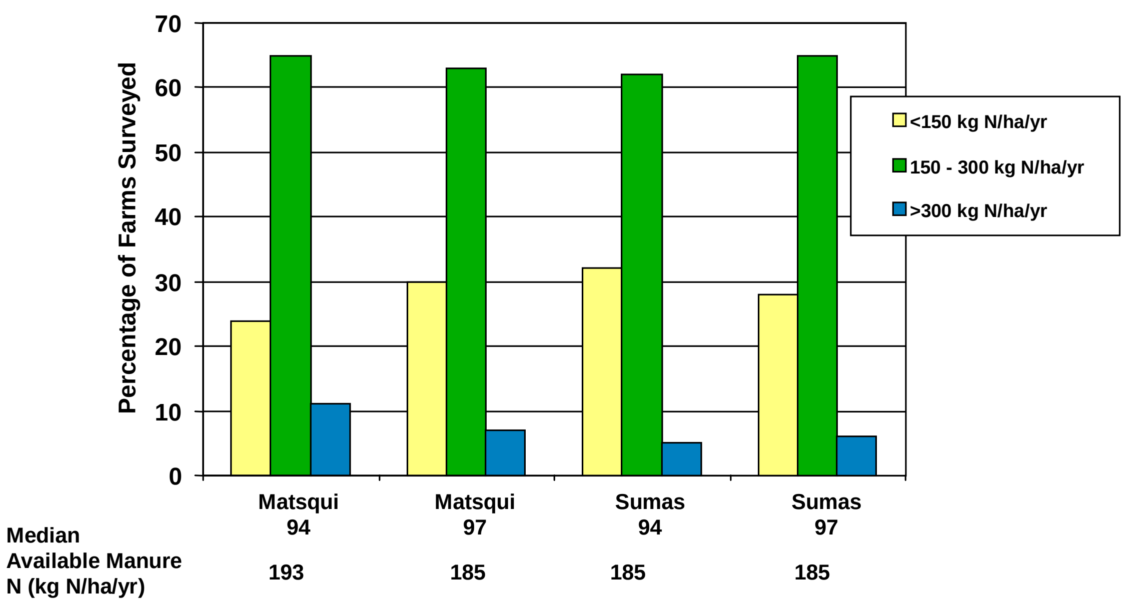
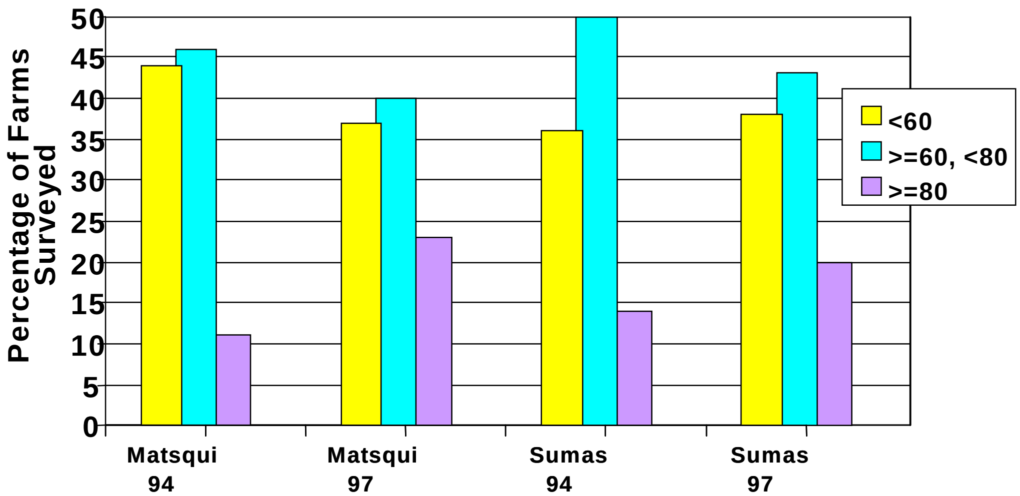


Figure 5.13 Agricultural Survey of Matsqui Slough and Sumas River Watersheds – Changes in Dairy Farm Manure Nitrogen Applied to the Land Between 1994 and 1997

As part of the study, a farm rating system was developed for comparing the potential for the contamination of surface and groundwater from agricultural operations. The information from individual farm questionnaires and site visits was ranked to develop a single score called an Environmental Sustainability Parameter (ESP). An ESP score of 80 to 100 indicated that the farm was likely being managed in an environmentally sustainable manner. While a relationship between the ESP score and actual environmental contamination was not established, the system was useful in identifying specific areas that needed to be addressed on a farm, such as silage runoff and milk parlour waste disposal.

Median scores for both watersheds did not change appreciably between the two surveys (median values: Matsqui = 61 in 1994 and 62 in 1997; Sumas = 65 in 1994 and 64 in 1997) (Figure 5.14). There did appear to be an increase in the percentage of dairy farms in both watersheds with scores greater than 80.



Median ESP Score	61	62	65	64

Figure 5.14 Agricultural Survey of Matsqui Slough and Sumas River Watersheds – Changes in Dairy Farm Environmental Sustainability Parameter Between 1994 and 1997

5.5.2.7 Water Quality Indicators

The U.S. EPA's Rural Clean Water Program and Section 319 National Monitoring Program found that six to 10 years were needed to assess the effectiveness of watershed best management practices (BMPs) in controlling non-point source pollution, even in ideal situations (Osmond et.al., 1995). Paired watershed studies were viewed as a more efficient and successful way to demonstrate improvements in water quality as a result of the implementation of BMPs. This required the adoption of BMPs in one watershed while the other continued to use potentially polluting practices.

The monitoring that was conducted in the Matsqui Slough watershed and some adjoining streams was a mixture of traditional upstream/downstream and single downstream approaches. Because the AWCR had not been imposed *per se* on the agricultural industry, and because adherence to it had been largely unmonitored, improvements in water quality cannot be demonstrated quickly, if at all, in many areas of the lower Fraser region.

Measuring improvements is even more complicated in watersheds such as Matsqui Slough, which are hydrologically complex, with a mixture of upland forest and urban catchments, lowland intensive and diverse farming activities, and flood control gates regulated principally on Fraser River flow conditions. Nevertheless, monitoring provides a record of current conditions and provides a benchmark from which to measure improving or deteriorating conditions.

Nitrate could serve as an indicator of changes in nutrient management in some areas of the Fraser Valley. Some observations can be made with respect to stream nitrate levels. There appears to be a close relationship between rainfall intensity (three-day cumulative total of sample day and preceding two days) and surface water nitrate levels earlier in the fall rainfall season. This is demonstrated for water quality Site #4 in 1994 on Clayburn Creek (see Figure 5.15 for monitoring site locations), the downstream agricultural area site, compared to the upstream water quality control Sites #1 and #2. (Figure 5.16). The downstream increase in nitrate is not surprising, since nitrate is highly mobile and is flushed from soil quickly. Later in the rainy season, stream nitrate levels do not appear to show as close a relationship with rainfall. This is an important relationship to establish for future comparisons. The North Matsqui zone, which is drained by Matsqui Slough, was found to have a large farm nitrogen balance of 152 kg N/ha over what crops required (95-27). This same relationship is evident in other streams (Figure 5.17). In 1994, water quality Site #7 on McLennan Creek had even higher nitrate levels than Site #4. Site #7 drains part of the West Matsqui zone, which had an even larger large farm nitrogen balance of 302 kg N/ha.

.

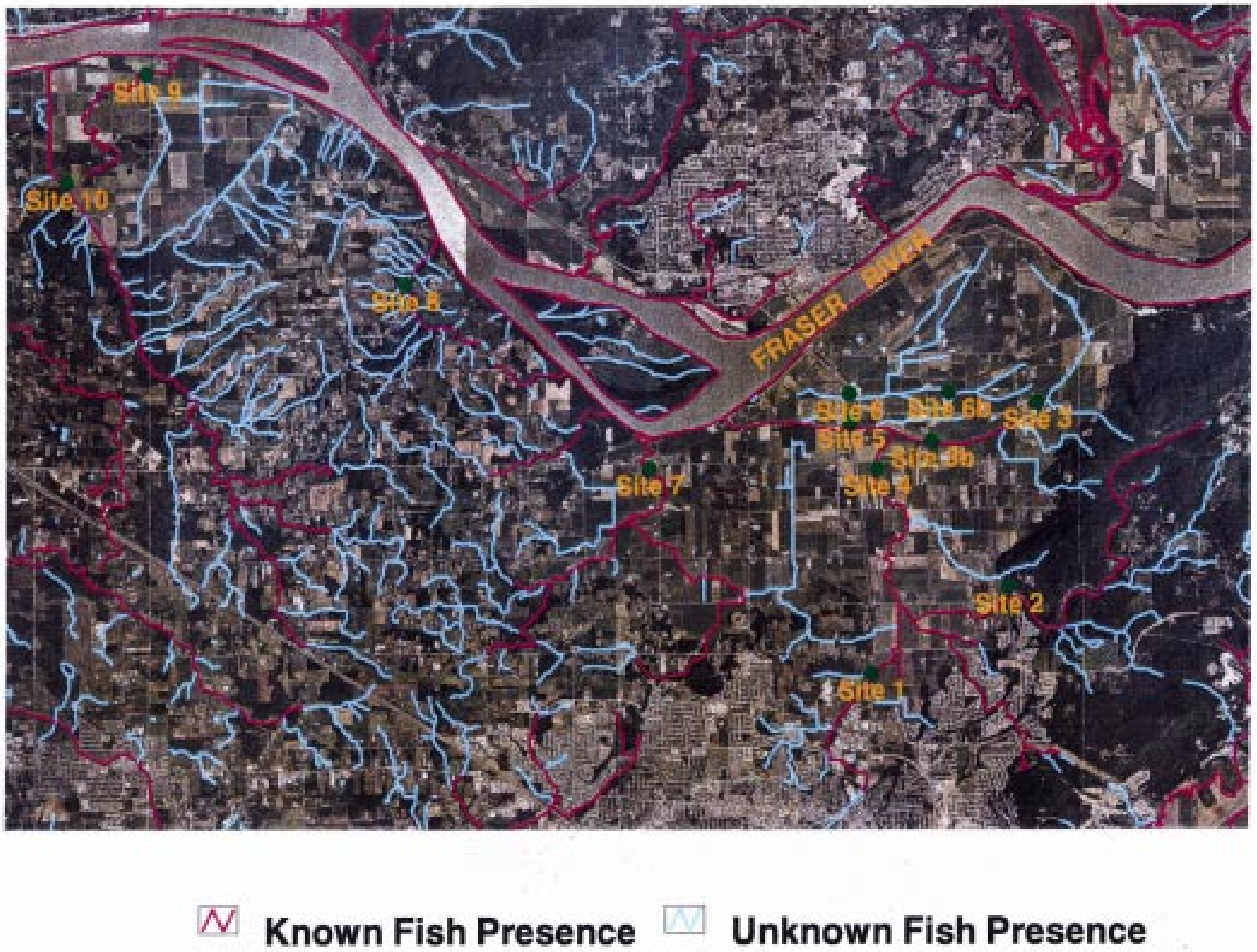


Figure 5.15 Matsqui Slough and Adjacent Stream Water Quality Monitoring Site Locations

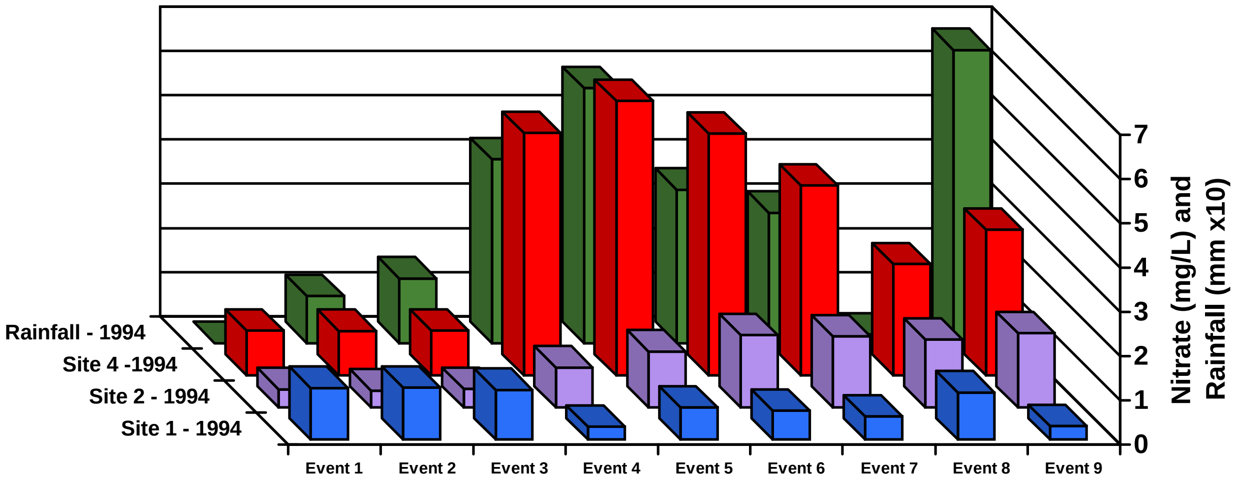


Figure 5.16 Increased Nitrate Levels at Downstream Agricultural Site on Matsqui Slough in Relation to Fall Rainfall Events

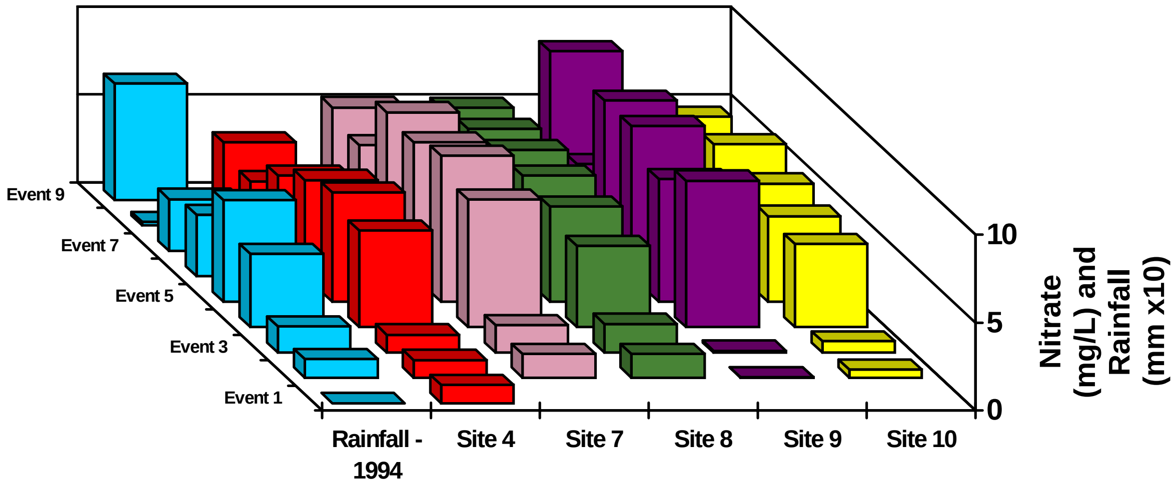


Figure 5.17 Relationship Between Rainfall and Stream Nitrate Levels in West and North Matsqui Streams – 1994

In the fall, median dissolved oxygen saturation levels were clearly lower at the downstream areas of Clayburn Creek at water quality Sites #4 and #5 than at upstream control Site #2 (Figure 5.18). However, Site#1, which was also an upstream control site, but drained an urban catchment, also had reduced dissolved oxygen saturation levels. It has been recommended that, for a high level of protection for important fish stocks (level A), dissolved oxygen saturation levels should be greater than 76 per cent to protect freshwater salmonid populations (Davis, 1975). Monitoring to date has showed reduced oxygen levels in a number of intensively cultivated, flow-regulated agricultural lowland streams (Top et al., 1997). However, the monitoring did not fully demonstrate the extent of the situation spatially or temporarily; this would be important from a fisheries perspective.

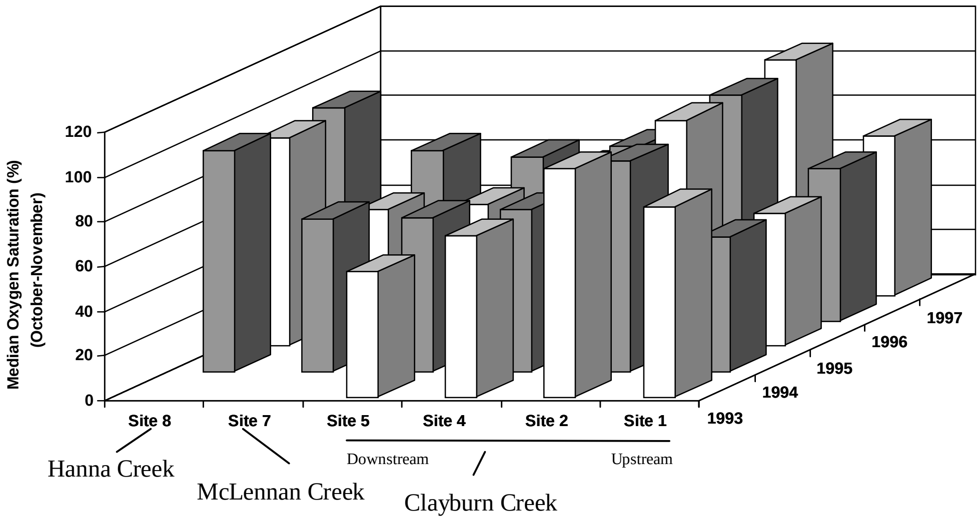


Figure 5.18 Fall Oxygen Saturation Levels in North and West Matsqui Zone Streams Between 1993 and 1997

5.5.3 Inventories in the Interior Regions

5.5.3.1 Thompson Region Code Initiative

The Survey of Agricultural Practices in the Thompson Basin (SAPTB) initiative linked FRAP's agricultural program with BC MELP. This set the framework for evaluating implementation of the Code in the Interior, provided one-to-one contact needed for effective NPS information and education transfer, and helped to gain producer participation (97-44). In the Thompson region, BC MELP carried out general synoptic surveys, while in the Cariboo region, contractors conducted more watershed-specific surveys.

In the Thompson Basin, some 204 sites were identified by helicopter and scored subjectively on the degree of potential impact, ranging from 1 (low), to 3 (moderate), to 5 (high). Forty-four sites were rated 5 and were considered likely to be in non-compliance with the Code (Table 5.12). Overall, the number of helicopter-identified problems that were resolved in the Thompson Basin may appear low (Table 5.13). Many of the non-conforming sites were essentially pens within a 30-metre setback from a watercourse and had been in use prior to the introduction of the Code. Relocating these pens does not appear to be as simple a management option as might be expected; in these cases, innovative solutions requiring one-on-one interaction are required to reduce the environmental risk.

As in the lower Fraser region, the B.C. Cattlemen's Association's complaint referral process in the Interior has evolved during FRAP. The process has recently undergone a review to provide policy and procedural guidance and to promote a consistent approach among government agencies and peer group organizations when resolving Code complaints.

Since the initiation of SAPTB, seven orders have been issued (Table 5.12). Two of these related to problems initially identified by helicopter flyovers, and five related to problems identified through public complaints. Charges laid as a result of the first order resulted in a $10,000 fine for the introduction of a deleterious substance under Section 36 (3) of the

Fisheries Act. A $500.00 fine for the discharge of a business waste to the environment was issued as a result of another order. Charges are expected to be laid in relation to two other orders.

Table 5.12 Summary of SAPTB Initiative Potential Problem Site Files

Year	Helicopter Flyovers*	Sites Identified *	Sites Rated as Moderate Impact 3 Scores	Sites Rated as Higher Impact 4-5 Scores	Public Complaints **	Orders Issued **
1994	4	103	13	18	-	1
1995	3	70	28	16	33	2
1996	1	32	10	10	33	3
**1997	0	-	-	-	20	1
Totals	7	204	51	44	86	7

* Sites identified from helicopter as having a potential Code environmental problem.

** 1997 Public complaints and orders represent first 8 months of fiscal year.

The experience gained through SAPTB has demonstrated that there is a need to maintain an active agency presence, at least in the near future, in order to reduce the impact from contaminated runoff and to monitor compliance with the Code, using enforcement capabilities when necessary. Because of the dynamic nature of many farm operations, a rotational inspection program may be one means to cover a large geographic area and maintain a one-on-one dialogue with producers.

A helicopter inspection of the Salmon River watershed near Salmon Arm showed that the winter application of manure likely resulted in contaminated spring runoff and was identified as an issue (BC MELP, 1996). It may be necessary to develop an NPS action plan specifically for agriculture in this watershed to help identify and select appropriate land treatment BMPs and to identify target areas to reduce the risk of the occurrence of contaminated runoff in the spring.

Table 5.13 Summary of Impact Ratings of Non-Compliance Sites as Assessed from Aerial Photographs – 1994-96

		Problem as Assessed from Aerial Photographs – 1994-96							
		Runoff	Access General	Access Seasonal	Access Confined	Feeding	Storage	Non Conforming	Other
IMPACT RATING									
1	low	1	1	4	0	0	1	4	16
2		0	5	3	5	2	1	6	5
3	moderate	7	10	6	14	12	1	23	3
4		6	0	4	19	2	0	14	1
5	high	4	0	0	4	0	0	7	0
unable to rate		1	8	2	3	2	0	2	22
TOTALS	1994-96	18	16	17	42	16	3	54	42
Closed site files		1 (6%)	7 (44%)	4 (24%)	6 (14%)	4 (25%)	2 (67%)	5 (9%)	17 (41%)

SAPTB surveyed producers in 1997, and 81 per cent of the respondents indicated that they considered their environmental awareness to have increased in the previous three years (Table 5.14). Producers were generally comfortable voluntarily requesting a site visit from either BC MELP (35 per cent) or BC MAFF (50 per cent), possibly reflecting the value of a one-on-one approach to resolving issues. Of the respondents who said they had increased both their environmental awareness and their stewardship and riparian awareness, 60 per cent had had a Code problem, while 30 per cent indicated that they were always in compliance.

Table 5.14 Summary of SAPTB 1997 Producer Questionnaire on Environmental Action

Indicator	Operational Changes Were Made	Time Investment (days)	Financial Investment $(1000)	Environmental Awareness had Increased
In previous three years	• 97%	• 1-5 days (24%) • >5-10days (14%) • >10-20 days (24%) • >20days (24%)	• 1-10 (38%) (average 2.5) • 20-100 (16%) (average 38)	• 81%
Indicator	Level of Awareness of Group With Increased Awareness to Stewardship and Riparian Issues	"Code" Compliance of Group With Increased Awareness and Higher Stewardship and Riparian Awareness	Felt Comfortable Requesting Site Visit by:	Future Plans to Within:
In previous three years	Scale 1 (low) to 5 (high) • Scored as 3 (19%) • Scored as 4 (48%) • Scored as 5 (23%)	Scale 1 (never) to 5 (always) • Scored as 4 (60%) • Scored as 5 (30%)	• BC MELP (35%) • BC MAFF (50%)	• 12 months (19%) • 5 Years (29%) • Time Available (42%) • Money Available (45%)

5.5.3.2 Cariboo Region Code Initiative

Experience in the Cariboo indicated that a staged approach to problem identification might be useful. Initially, a knowledgeable field contractor evaluated potential site problems and provided advice on what needed to be corrected to meet the Code. For example, in 1994, the emphasis was placed on identifying and rating potential impacts, not on finding specific ways to improve feeding practices; ranchers were informed of their impact ratings and advised to make changes. The 1996 inspections re-evaluated these areas to determine whether changes had been made and to measure the net effect. Limited net improvement was observed between 1994 and 1996, so the contractor met with ranchers to provide planning for future improvements (Table 5.15). There is a clear need for planning these measures with ranchers and a definite requirement for follow-up inspections by BC MELP to ensure that changes are carried out within a reasonable timeframe. In 1997, BC MELP followed up on 39 classified sites where improvement plans had been provided to ranchers. The results indicated a positive trend, with the number of moderate and moderate-high sites dropping from 24 in 1996 to seven in 1997 (Table 5.16).

Table 5.15 Summary of Potential Impacts of Livestock Wintering Sites – Bridge Creek Watershed 1994 and 1996

Potential Impact Classes by Sub-Basin	Number of Sites 1994	Number of Sites 1996
Upstream from Horse Lake Outlet:		
- low	31	27
- low-moderate	9	12
- moderate	12	16
- moderate-high	4	1
Downstream from Horse Lake Outlet:		
- low	11	11
- low-moderate	6	11
- moderate	9	4
- moderate-high	0	3
Total Overall	82	85
Total moderate	21	20
Total moderate-high	4	4
Total moderate+moderate-high	25	24

Table 5.16 Potential Impact and "Code" Compliance of Classified Sites – 1996-1997

Potential Impact	Sites in 1996	Sites in 1997
low-moderate	15	32
moderate	20	6
moderate-high	4	1

FRAP contributed to an increase in the understanding of land use concerns in the Horse Lake-Bridge Creek system and to identification of future needs (94-25; 97-50).

Community awareness has evolved along with active participation in environmental monitoring (96-13). There were indications of increasing phosphorus levels in Horse Lake between the early 1980s and the mid-1990s (Figure 5.19), but lake clarity did not appear to be affected. Streams with more cattle wintering sites tended to have greater phosphorus loading, and inspection of agricultural sites need to be continued.

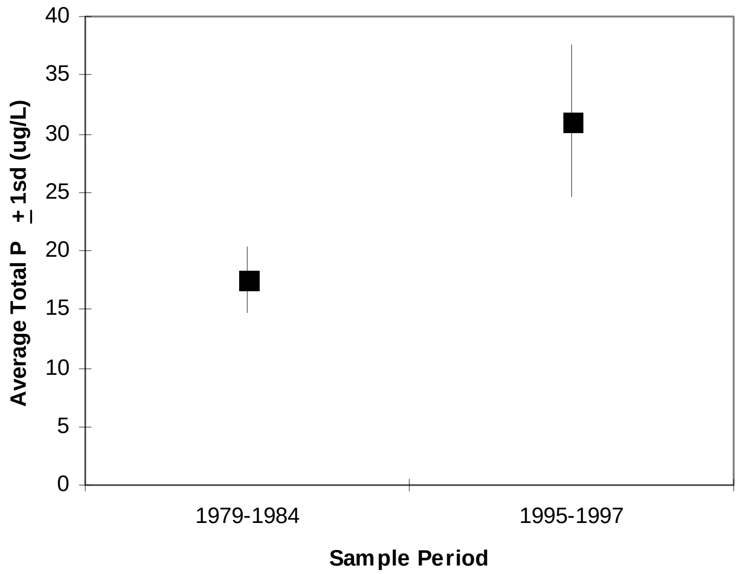


Figure 5.19 Horse Lake Average Overturn Phosphorus Concentration in Early 1980's Compared to mid-1990's

5.5.3.3 Groundwater Mapping

Four regions of the Fraser Basin Interior were selected for review and for implementation of the aquifer classification system described in Section 5.5.2.2. A total of 115 aquifers were identified, classified and mapped (Table 5.17).

Table 5.17 Fraser Basin Interior Groundwater Aquifers

Basin Area	Number of Aquifers Mapped
Thompson	
Merritt	7
Salmon Arm	19
Cache Creek	4
Kamloops	26
Cariboo	
100 Mile House	7
Green Lake	2
Williams Lake	17
Upper Fraser	
Quesnel	9
Prince George	15
Vanderhoof	9

5.5.4 Assessing and Demonstrating Prevention and Abatement Practices

FRAP was involved in several multi-stakeholder research studies to develop and demonstrate abatement measures that might lead to improvements in agriculture's performance in addressing environmental concerns.

5.5.4.1 Silage Corn

5.5.4.1.1 Silage Corn Nutrient Management

One of the obstacles to implementing management changes to reduce nutrient balances is the fact that, for a number of crops, the extent to which commercial fertilizer nutrients (*e.g.*, N) can be replaced with manure and still maintain optimal yields has not been identified. A second obstacle is the reluctance of farmers to accept new information and adopt new tools. FRAP supported research work in the area of silage corn production to develop the type of information necessary to demonstrate that commercial fertilizer use could be reduced. An analysis of the results of a three-year field study is still in progress (B. Zebarth, pers comm., AA-FC), but results described to date are encouraging (Zebarth *et al.*, 1994 and 1996).

The guesswork involved in making fertilizer nitrogen recommendations can be reduced by using the pre-sidedress nitrate test (PSNT) (see Section 5.5.2.5.2). The test provided better estimates of the nitrogen available from spring-applied manure and from soil organic matter. The PSNT is done in mid-June, just prior to the period of rapid corn growth and nitrogen uptake in late June and July. A PSNT result of 30 ppm or higher indicates that no increase in yield would be expected with an additional sidedress commercial fertilizer application.

The distribution of PSNT values in 1994, 1995 and 1996 are shown in Figure 5.20. In 1994, 76 per cent of the fields had PSNT values greater than 30 ppm, and in 1995, the level was 85 per cent. However, in 1996, only 10 per cent of the fields had values greater than 30 ppm. This indicates that PSNT testing needs to be conducted on a regular basis, so producers have accurate and timely results. Relying on out-of-date information might result in reduced yields, and this could cause producers to give up on this valuable new tool. Based on the 1995 results, the estimated fertilizer savings for a farm with 20 hectares in corn would be in the order of $1,700/year ($85 per hectare per year).

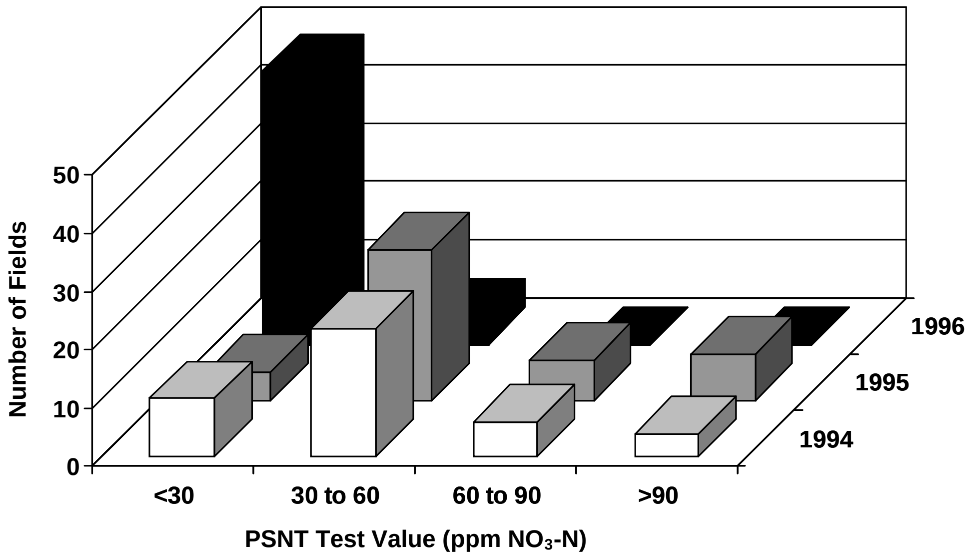


Figure 5.20 Distribution of PSNT Values in Fraser Valley Silage Corn Fields – 1994 to1996

5.5.4.1.2 Silage Corn Field Runoff

In 1996, BC MELP introduced manure management guidelines for the Fraser Valley based on the relative risk of contaminated runoff (see Section 5.5.2.4). For silage corn, the BMPs were based on two factors: supplying crop N needs primarily with manure (reduced commercial fertilizer N); and planting a summer relay crop of Italian Ryegrass so that, after corn harvest in the fall, when rainfall and the risk of runoff were high, the ground would not be bare and could be fall-manured. Fall manuring has been shown to benefit forage grass production the following spring (Bittman, 1997). In order to compare the BMPs with more conventional practices, such as fall manuring on corn fields without a cover crop, from the perspective of water quality protection rather than strictly soil conservation, FRAP participated in a research project with AA-FC and BC MELP to monitor runoff from test plots (Table 5.18) (van Vliet, 1997). The results represent potential losses from fields under similar conditions. This research is still in progress, but preliminary results demonstrate the water quality protection benefits of relay crops.

Total volatile residue is an indicator of organic material that is lost with soil and that consumes oxygen in a stream. The total volatile residue results in Figure 5.21 show the variability in the loading of runoff that occurs between the various treatments and between rain events for the same treatment. The largest bars in Figure 5.21 for the fall-manured relay crop (P3) represent the “first flush” of oxygen-consuming material leaving the field, compared to smaller amounts from the control site, a non-manured, bare-ground plot (P1). The mass of material lost from the manured, bare-ground harvested plot (P2) caused the runoff collection system to become plugged, with the result that the amount lost could not be quantified.

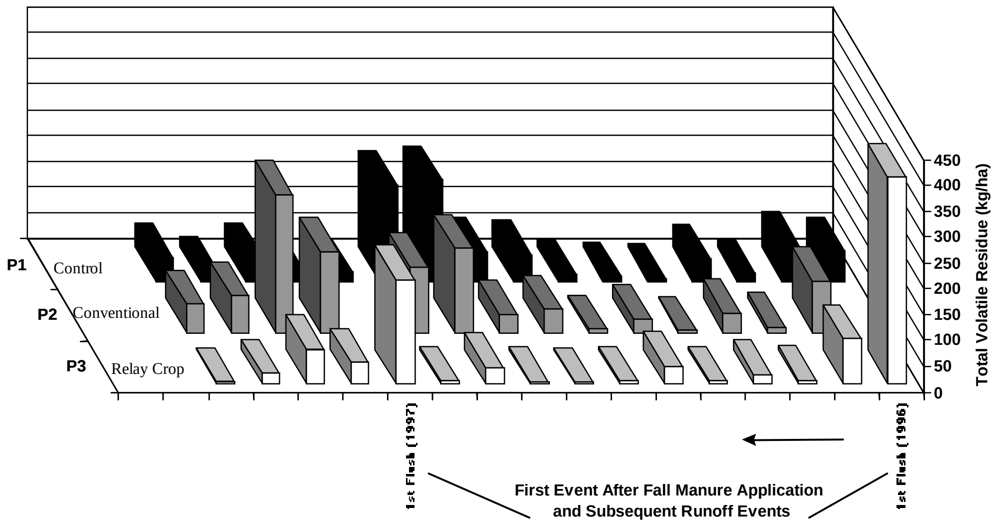


Figure 5.21 Total Volatile Residue Losses From Silage Corn Plots Following Fall Manure Application

The effect of the relay crop is clearly demonstrated in reduced runoff losses of total volatile residue in the spring and fall of 1997 (Figure 5.22). In the spring, cumulative total volatile residue losses from the relay crop plots were 74 per cent and 82 per cent lower than those from plots P2 and P1, respectively. In the fall, the relay crop plot losses were 82 per cent and 40 per cent lower than those from plots P2 and P1, respectively. Total soil losses from the relay crop plots were substantially lower than the actual amount of surface runoff, relative to the other plots (L. van Vliet, pers comm., AA-FC).

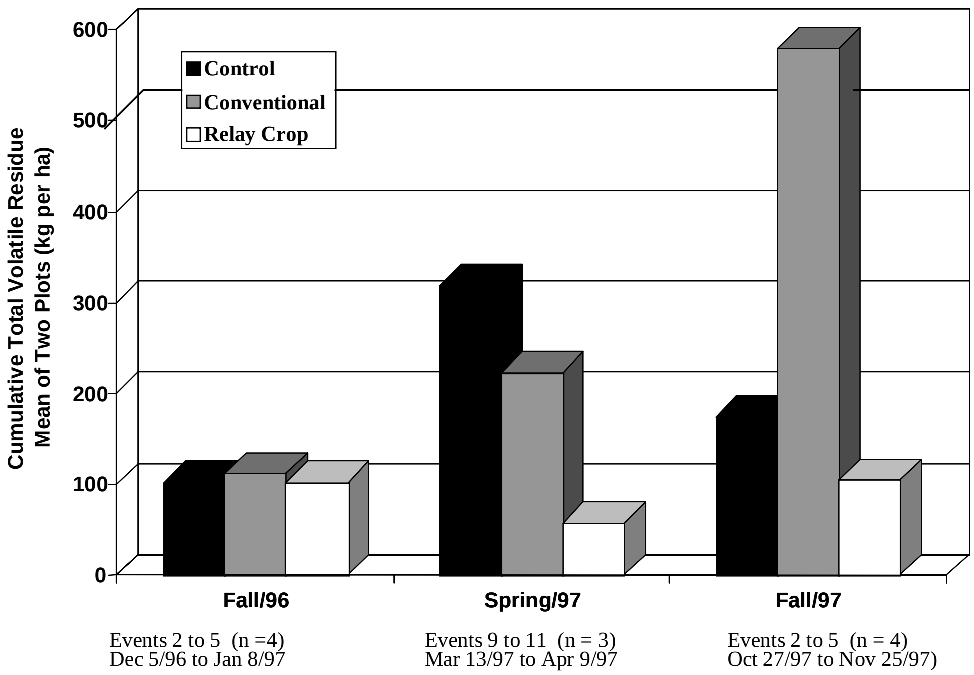


Figure 5.22 Treatment Differences in Total Volatile Residue Losses from Silage Corn Plots

The "first flush" of runoff can be highly contaminated with oxygen-consuming material and nutrients such as ammonia, which can be toxic to fish at low concentrations and even more toxic at reduced concentrations of dissolved oxygen (Thurston *et al.*, 1981). The relay crop plot runoff had total ammonia nitrogen concentrations of 55 mg/L (pH 7.5) in fall 1996 and 120 mg/L (pH 7.2) in fall 1997 (approximately 0.22 mg/L and 0.47 mg/L unionized ammonia at 5^0C). Examples of 96-h LC_{50} values range from 0.16 to 1.1 mg/L (11 to 48 mg/L total ammonia-nitrogen) for rainbow trout (Thurston and Russo, 1983). Whether a field has an established grass or a relay crop, runoff from the fall application of manure has the potential to seriously impact water quality, and farmers must use caution when applying manure in high risk areas such as sloping land and sites adjacent to a ditch or watercourse.

Table 5.18 Description of Conventional and Recommended Silage Corn Management Practices Used on Experimental Plots to Assess Potential Improvements in Runoff Quality

Management Details	**Control (Plots 1 & 6)**	**Conventional (Plots 2 & 4)**	**Best Practices (Plots 3 & 5)**
(1996/97) • Spring Manure Incorporated (28/04/96)	135 kg N/ha	135 kg N/ha	135 kg N/ha
• Sidedress	None	None	None
• Corn Planted	27/05/96	27/05/96	27/05/96
• Relay Crop Planted	None	None	21/06/96
• Corn Harvested	31/10/96	31/10/96	31/10/96
• Fall Manure	None	115 kg N/ha (not incorporated)	115 kg N/ha (not incorporated)
1st Runoff Event	28/11/96	28/11/96	28/11/96

5.5.4.2 Poultry and Other Manure Management Needs

5.5.4.2.1 Manure Application in Raspberry Fields

In order to remedy the contamination of groundwater with nitrogen, farmers must have the best available information on crop nutrient requirements and on the application of those nutrients; and they must adopt this information when it is warranted. FRAP helped to provide information to improve nutrient application practices (Zebarth *et al.*, 1996a and 1996b; and 1997a and 1997b).

Poultry manure is applied to many raspberry fields to supply nutrients and organic matter. Although the nitrogen requirement can be met using manure alone, to be effective as a nitrogen source, the manure must be applied in a uniform manner and at a controlled rate. This can be difficult to achieve through a broadcast application using a solid manure spreader. When a mulch spreader was tested, it proved to be convenient to use and quick and simple to calibrate. Manure banding along the crop rows placed the manure in the zone of maximum root activity.

To evaluate the performance of banding *vs.* broadcast application, a two-part field study to assess relative crop yield and nutrient availability was conducted. In the first part, nitrogen was applied based on the maximum recommended rate of 100 kg total N per hectare as broiler manure (incorporated within four hours) or 55 kg total N per hectare as commercial fertilizer (applied with sidedresser). Soil nitrate content in August after berry harvest has been used as an indicator of the risk of nitrate leaching during the following fall and winter (Dean, 1996). Excessive nitrate leaching can occur in the Abbotsford area over the fall and winter when August soil nitrate content exceeds about 100 kg N per hectare and no inter-row cover crop is grown (Zebarth *et al.*, 1997b). Results of the first part of the study demonstrated that when nitrogen was applied at the agronomically recommended rate, August soil nitrate levels were less than 100 kg N per hectare, with some variation for site and year (Figure 5.23).

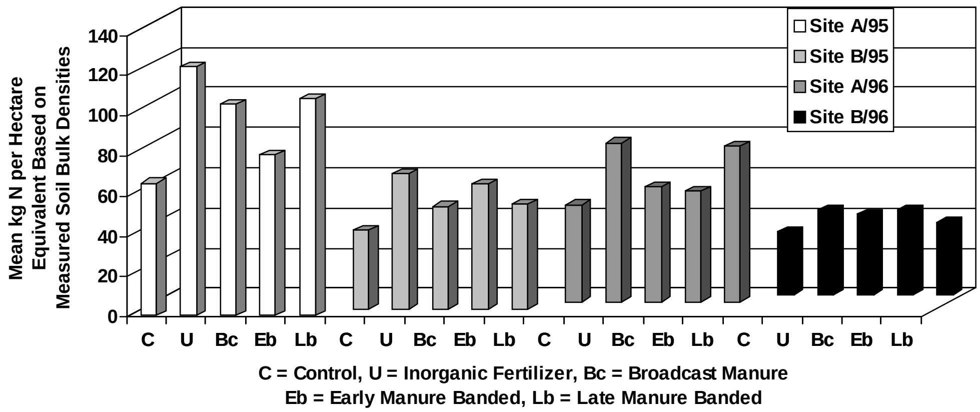


Figure 5.23 Soil Nitrate-N in Mid-August for Broiler Manure and Inorganic Fertilzer Applied at Agronomically Recommended Rate

The second part of the study looked at the availability of two types of manure nitrogen (broiler and layer), differences in incorporation practices and rates of application. Although it is still in progress, this research effort should provide information for establishing and promoting better manure handling and application practices (B. Zebarth, pers comm., AA-FC). The value of research into nutrient management can, in part, be assessed by evaluating the extent to which farmers implement improved management practices. Some indicators of producer acceptance that could be tracked include use of soil nitrogen report card tests (with soil samples taken about mid- August), proper manure storage (see Section 5.5.2.4), application of N at recommended rates, proper timing of application (in spring, before mid-May) and use of a cover crop.

5.5.4.2.2 Poultry Diet and Litter: Atmospheric Nitrogen Losses

In an effort to reduce nitrogen losses from poultry production, FRAP supported the development of an automated ammonia analyzer system to sample four independently ventilated rooms in a poultry barn. This improved the capability for researching the effects of factors such as diet change and bedding material additives on ammonia emissions in the region (Paul *et al.*, 1996; Barton, 1996; Scott *et al.*, 1996).

Feeding a lower crude protein diet and balancing the diet for amino acids is one way to reduce overall protein intake without compromising the birds' protein requirements. Experiments have shown that, with this diet change, bird weight was not affected but bird health indicators improved (*e.g.*, there was less litter burn on the foot pads) and ammonia concentrations in the rooms were lower. Ammonia emissions from the rooms in which the diet was balanced for amino acids were 88 per cent and 78 per cent of the emissions from the rooms in which a control diet was given in the first and second production cycles (seven-week cycles), respectively (Figure 5.24). The cumulative ammonia loss over three seven-week periods (same litter) was 14.9 kg N for the control diet and 11.9 kg N for the balanced diet. This represents a 20 per cent reduction, supporting the assumptions made in Section 5.5.2.1.2 (see Table 5.7).

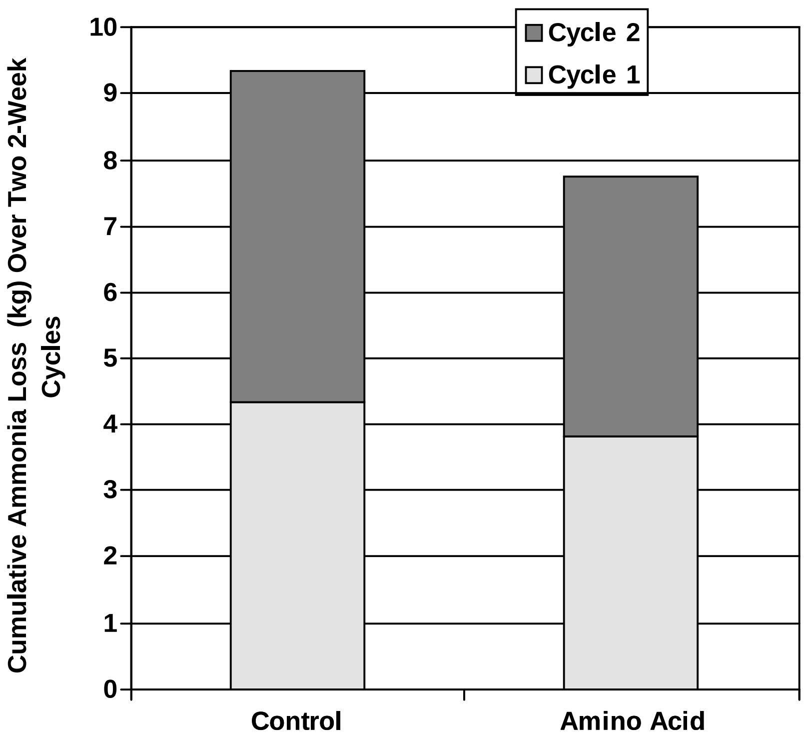


Figure 5.24 Lower Ammonia Losses from Poultry Production Using a Balanced Amino Acid Diet

Amending floor litter is another way to reduce room ammonia levels to improve bird health and reduce ammonia emissions from room exhaust (Paul et al., 1997). Experiments have shown that with alum litter amendments, bird weight was not affected and some bird health indicators improved; for example, there was less litter burn on the foot pads and less bumblefoot. Cumulative ammonia losses from the room exhaust for the alum-treated rooms averaged 3.76 kg, compared to 9.65 kg for the control rooms, for a decrease of 60 per cent. It should be noted that this does not necessarily represent additional ammonia losses from the litter after barn clean-out and field application. Work is continuing in this area.

5.5.4.2.3 Poultry Manure Transportation and Marketing

The movement of poultry manure from areas with high nitrogen imbalances has been identified as one possible solution to reducing the risk of groundwater contamination, especially in the area of the Abbotsford aquifer (see Sections 5.5.2.1 and 5.5.2.2). FRAP worked with the Sustainable Poultry Farming Group to address the development of an overall manure handling strategy for poultry producers in the Fraser Valley (96-04). Markets have been developed in the Delta area, which has low nitrogen balances (see Figure 5.2-b) and in the Princeton/Keremeos, Ashcroft, 100 Mile House and Merritt areas of the Interior. A comparison of shipment volumes in 1996-97 and 1997-98 indicated an increase of about 75 per cent, from 5300 cubic yards (4080 m^3) to 9300 cubic yards (7150 m^3), respectively (Chipperfield, 1997).

Truck sizes transporting the poultry litter have ranged from 40 to 125 cubic metres. It was determined that larger trucks with walking floors can position 62 to 80 cubic metres in the same footprint in which container bins can unload 31 cubic metres. This reduces the need to spend additional time repiling the load within a storage facility.

5.5.4.2.4 Lime Pasteurization of Organic Wastes

FRAP supported research on the development of an alternative, value-added product that had both fertilization and soil pH amendment value, and that used a variety of organic waste sources, including poultry litter, dairy manure, fish offal and municipal biosolids. A demonstration project using a lime-pasteurization process to reduce coliform bacteria levels was conducted to identify some of the potential technical and environmental problems, as well as the soil amendment properties of the product (Beames, 1997). The actual process was successfully demonstrated on all four waste sources.

Ammonia losses during the pasteurization process were evaluated for the various waste types. Poultry manure had the greatest losses during the pasteurization process (5.48 kg N/tonne within 24 hours) and exceeded the control losses over a seven-day period (Figure 5.25). However, it was thought that this problem could be managed with an ammonia scrubber during processing.

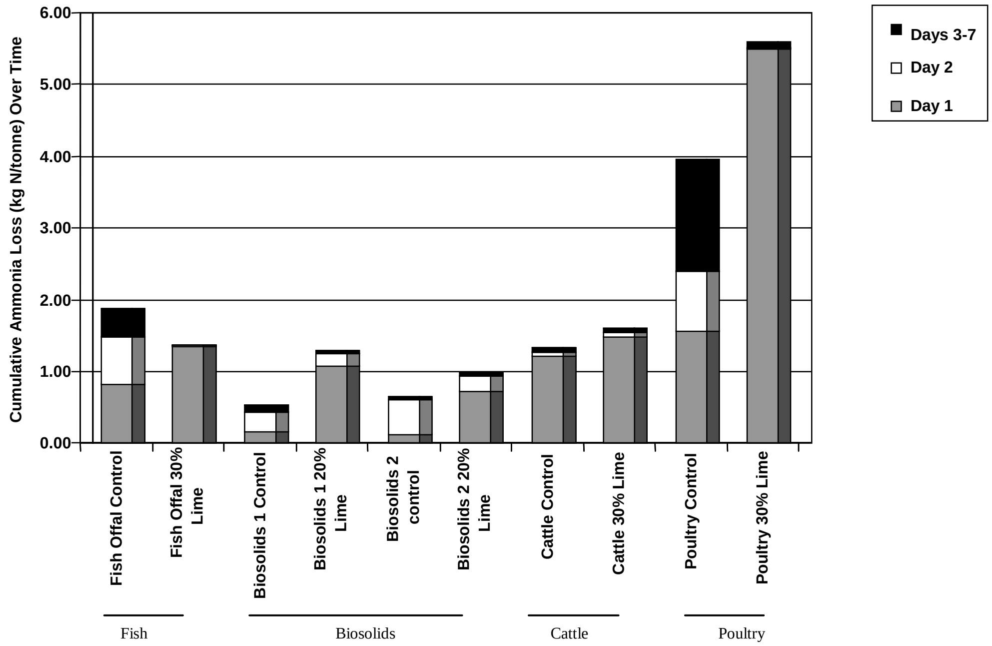


Figure 5.25 Ammonia Emissions for Various Organic Wastes During Quicklime Pasteurization

Since new products from lime pasteurization would have substantial levels of macro-elements when applied at sufficient rates to lime soils to pH 5.5, they would likely be categorized as "novel or new pH-altering products" under the *Fertilizer Act* (FPIB, 1996). Therefore, they would likely require efficacy and safety testing before registration for marketing in Canada. The quantity of animal waste that could economically be handled, along with a marketing analysis, is not yet available.

5.5.4.3 Forage Grass Manure Management Research

Under the Canada-B.C. Green Plan for Agriculture, the fall application of dairy slurry on grass and cover crops was evaluated. FRAP contributed to this research, which is still in progress (Bittman, 1997). This information is important to the development of an Advanced Forage Management Production Guide that will, in part, describe BMPs for forage crops in south Coastal areas of B.C.

5.5.4.4 Wetland Treatment of Greenhouse Wastewater

The greenhouse vegetable industry in the lower Fraser region is a rapidly expanding agricultural sector. For B.C., the area under glass for vegetables (primarily sweet peppers, English cucumbers, tomatoes and butter lettuce) has increased from 56.9 hectares to 125 hectares between 1992 and 1998 (BC MAFF, 1998). Approximately 94 per cent of the current area (118 hectares) is located in the lower mainland. Individual commercial greenhouse vegetable production areas range from 0.2 hectares to 16 hectares, with an average of 2.4 hectares.

FRAP participated in a study to assess constructed wetlands planted with broadleaf cattail (*Typha latifoilia*) as a way to treat overdrain from a large vegetable greenhouse operation

(Prystay, 1997). Although the overdrain (spent feed solution) still has high nutrient concentrations, it is not recirculated because of concerns about disease and reduced crop production, and is discharged untreated. Up to 4.5 litres of high-nutrient runoff may be generated per square meter of production area per day at peak water use. The project was designed to utilize a total of 57,500L/d (0.67 m^3/d) of greenhouse wastewater flow (approximately 10 per cent of the total peak flow) originating from the propagation and pepper production areas. However, during the study, about half of the production area was used for green peppers and the other half for propagation of tomato and pepper starter plants, bedding plants and poinsettias.

Of the five designs tested, the surface flow design emerged as the most appropriate for the remediation of greenhouse wastewater (Figure 5.26). Since the treatment capacity was significantly exceeded for all of the nutrients analyzed, the maximum treatment capacity was not determined. Given the extremely high concentration of nitrate and the very low concentration of organic carbon in the overdrain, a very large area of land, in the order of 0.5 ha of wetland per hectare of greenhouse, would be required to generate sufficient carbon to denitrify all of the nitrate. It was suggested that, if producers could achieve greater control over water and nutrient wastes, appropriately designed natural treatment options, such as constructed wetlands, could provide the necessary level of remediation.

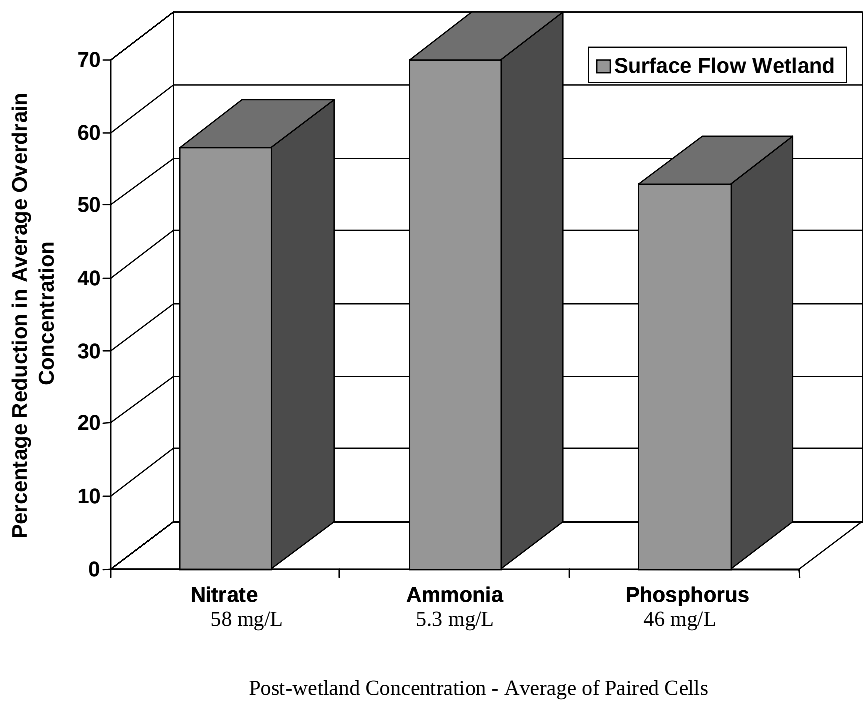


Figure 5.26 Example of Reductions in Greenhouse Overdrain Nutrient Contaminants as a Result of Wetland Treatment

An average vegetable greenhouse crop uses about 10,000L of nutrient solution feed per hectare per day. Of this, from 10 per cent to 40 per cent of the fertilizer needed by plants leaches out and is lost to the environment (BC MAFF, 1994). A typical vegetable greenhouse uses about 7,500 m^3 of water per hectare per year, of which 10 per cent to 30 per cent may be lost as a result of drainage and leaching. At a rate of loss of 20 per cent (1,500 m^3/ha/yr), and with the efficiency of nitrate and ammonia removal demonstrated by the wetland study, the annual loading would be about 95 kg N per hectare. For an average-size vegetable greenhouse of 2.4 hectares, this represents 228 kg N annually, equivalent to 15 typical single-family residences. For untreated overdrain, the numbers would be approximately double.

The study did not include the application and implementation of the wetland research to address environmental concerns related to greenhouse industry discharges. Results of the work have subsequently been used on several projects related to the mushroom industry, urban stormwater problems and the development of wetland treatment designs (I. Whyte, pers comm., Envirowest).

5.5.4.5 Mushroom Production – Barn Washwater Quality

Currently, there are about 60 mushroom-producing facilities in B.C., most of which are in the Fraser Valley and are producing the white, button-type mushroom, *Agaricus biporus*. The number of expanded and new facilities in the valley has increased recently (B. Locken, pers com., BC MELP). With a mix of old and new facilities, the potential environmental concerns associated with individual farms vary.

A study was conducted to investigate barn washwater quality, looking at conventional parameters and selected pesticides, and to identify potential concerns about discharging washwater from a settling tank to ground through drain fields, not unlike a conventional septic tank-absorption field system used in private homes (97-47). The study was not intended as a comprehensive evaluation of the industry. The three sources of water runoff from a typical operation originate within the barn, from the loading pad adjacent to the barn and from roof drainage. Ideally, roof drainage and pad runoff (other than pad washwater) are separated. Six farms, ranging from relatively new (less than three years old) to at least 15 years old, were inspected and monitored. The older farms were not well-configured for control of the pad and barn washwaters.

In general, the washwater has the characteristics of dilute sewage, with the treated water from settling tanks showing lower solids, COD, BOD and TOC concentrations (Table 5.19). All washwaters had significant levels of total and fecal coliform bacteria. The discharge volume was highly variable, ranging from approximately 90 litres per room per week to possibly 10 times that. Groundwater contamination with nitrate has been identified as a concern in various areas of the Fraser Valley. The loading from a typical mushroom farm consisting of a 20-room barn was compared to a typical single-family, three-person residence with a discharge of about 320L per capita per day (97-25). Assuming 80 per cent conversion of TKN (mean = 17.5 mgN/L) to nitrate in the soil, the nitrate loading from such a mushroom operation would be about 1.3 kgN per year. For the typical single-family residence with a total nitrogen concentration of 55.3 mg/L, the loading would be approximately 15.5 kgN per year. Even if the flows are being underestimated by as much as 10 times, the loading is comparable to that from a single-family residence. It should be noted that this estimate does not include other potential nitrogen sources, such as spent compost bed material, that are not being properly managed.

Table 5.19 Summary of Mushroom Farm Washwater Quality

Wash Water Source and Concentration Range	TOC (mg/L)	BOD_5 (mg/L)	COD (mg/L)	TKN or TN (mg N/L)	NO3 (mg N/L)	Total Ammonia (mg N/L)	Fecal Coliform ($X10^6$) per 100ml
Treated*	20-36	16-25	51-95	(TKN) 14.8-19.2	<0.05-1.3	9.2-10.7	0.18-0.74 x 10^6
Untreated	45-166	39-218	203-972	-	0.08-5.83	1.1-85	0.22-3.7 x 10^6
Septic ** (mean)	-	142-174 (158)	-	(TN) 48.9-61.6 (55.3)	0.39-0.82 (0.56)	34.3-43.0 (38.7)	0.29-0.62 (0.42) x 10^6

* Treatment was settling tank.

Septic: ** discharge from tank (Epp, 1984).

Pesticide use was primarily for fly or fungal attack control. The use of the fungicide Benlate (active ingredient = benomyl) and the insecticide Baygon (active ingredient = propoxur) was common to all farms. They were measured at the highest concentrations (benomyl: 85-351 ug/L; propoxur: 13-770 ug/L) and at levels that could be of concern if discharged directly to a stream (benomyl: rainbow trout 96-h LC50 = 170 ug/L); propoxur: rainbow trout 96-h LC50 = 3700 ug/L).

5.6 CONCLUSIONS AND RECOMMENDATIONS

By collaborating with other government agencies and stakeholders, FRAP succeeded in developing a program and implementing a strategy to reduce contaminant loading from agricultural operations. The challenges involved in achieving and demonstrating a basin-wide reduction in agricultural pollution loading were recognized early in the program. Consequently, the program primarily focused on supporting research projects leading to better management practices, developing environmental guidelines and monitoring practices at the individual farm level.

Recommendations:

1. In order for agricultural non-point pollution programs to be successful, their structure must be well-defined; the roles of participating agencies must be clearly stated; and preliminary planning must be done before initiating studies to ensure that the necessary co-ordination and commitment are in place. As well, geographic areas with well-defined pollution problems should be selected.
2. The approach taken in the United States Environmental Protection Agency Section 319 National Monitoring Program and the experience gained in the Rural Clean Water Program should serve as models for future agricultural programs. EPA's experience suggests that, even in ideal cases, six to 10 years may be required to successfully demonstrate and evaluate the results of best practices or management approaches.

FRAP contributed to the development of a nutrient management model in order to identify risk areas for nutrient imbalances in the lower Fraser Valley. The lower Fraser Valley was broken into 20 zones and modelled based on livestock nutrient generation, commercial fertilizer use and crop requirements. South Matsqui was identified as the zone with the most serious nitrogen imbalance. South Matsqui approximately covers the area of the Abbotsford aquifer, which has a documented nitrate groundwater contamination problem. The West Matsqui, West Chilliwack and Abbotsford zones were also characterized as zones with high nitrogen imbalances. All four zones are associated with intensive animal production, including poultry and swine, which do not require a local land base for feed production. This results in a net importation of nutrients in areas not dependent on producing their own feed.

Nutrient imbalances can be managed in several ways. In zones where the land base is simply too small, removal of manure or the relocation of livestock to other areas is required to maintain current production. The former approach has been piloted successfully and is continuing to be developed in the South Matsqui zone. The model showed that changes such as reduced commercial fertilizer use, improvements in manure management and dietary changes could substantially reduce nutrient imbalances.

In practice, performance indicators such as manure storage capacity, commercial fertilizer use, and the adoption of new application methods and management systems need to be tracked in order to demonstrate improvements. Baseline information for some of these indicators has been established in pilot areas in the valley. For the dairy group, there was an apparent increase between 1994 and 1997 in the median manure storage time from 2.7 months to 3.5 months, However, in the order of 36 per cent of farms still had a storage capacity of less than three months.

Total retail fertilizer sales data did not indicate any trends up or down. However, this data was not presented in a way in which small geographic areas or specific users (agriculture, forestry, residential) could be separated. Inorganic fertilizer application rates for forage grass and silage corn, which together represent 31,336 of the total 53,269 hectares of land in crops in 1996, have dropped between 1991 and 1997 in the lower Fraser region. For these two crops combined, estimated annual fertilizer nitrogen use fell by 23 per cent (1,263 tonnes), phosphorus by 68 per cent (490 tonnes) and potassium by 91 per cent (1,471 tonnes).

Recommendations:

3. Tracking the development of animal production and cropping systems in the Fraser Valley should continue to be supported. A mechanism or process for implementing this should be determined through further consultation with stakeholders.
4. Continuing research is required to determine the extent to which commercial fertilizer nutrients can be replaced with manure and still maintain optimal crop yields, and to develop other improvements in management practices. Evaluating the adoption of improved or new practices on a regular basis, such as every three to four years, would serve as a short-term surrogate to actually measuring changes in receiving water quality, which would be expected to respond more slowly. Regular evaluation is particularly important in demonstrating the value of much of the research support provided to agriculture in the lower Fraser Basin, such as the pre-sidedress nitrogen test (PSNT) for silage corn and the fall raspberry soil nitrate test.
5. Monitoring is needed to better understand regional differences in atmospheric nitrogen deposition, which was identified as a limitation in the nutrient modelling exercise.

In North Matsqui, farm practices were tracked along with surface water quality conditions over a number of years to try to link land treatment activities with water quality. A limited cost-share assistance program was incorporated into the Canada-B.C. Green Plan for Agriculture and changes in farm practices were expected to occur as a result of the *Agricultural Waste Control Regulation*. In South Matsqui, nitrate groundwater contamination was also monitored.

Water quality monitoring in the North Matsqui area indicated a close relationship between stream nitrate levels and rainfall. Autumn dissolved oxygen levels in several lowland and flood-gated streams were reduced to saturation levels below the Level A protection level of 76 per cent that is recommended for protecting a freshwater salmonid population. The extent of the autumn-reduced dissolved oxygen levels (temporally and spatially) was not determined. Groundwater monitoring in South Agassiz supported previous studies describing the level of nitrate contamination, but with the use of nitrogen and oxygen isotope tests it was demonstrated that the nitrogen source was primarily poultry manure.

Recommendation:

6. Trends in ground and surface water quality should continue to be monitored. A more comprehensive evaluation of the water quality data collected in the North and West Matsqui zones is needed to learn more about and describe linkages between land uses and water quality. Additional efforts are required to establish the full extent of reduced oxygen levels in lowland and flood-gated streams in the Fraser Valley.

The provincial *Agricultural Waste Control Regulation* and its associated Code of Agricultural Practice for Waste Management marked a significant development in tackling agricultural pollution. Work supported by FRAP in the Thompson/Cariboo and lower Fraser regions demonstrated that an ongoing field presence by government agencies is beneficial to address agricultural waste management issues, largely because of the dynamic and diverse nature of the industry.

Recommendations:

7. An agency presence is desirable in the early implementation of regulations or codes of practice that deal with non-point pollution sources such as agriculture. Once it is determined that practices are being adopted to meet the legislation, other mechanisms involving less government input should be implemented.
8. Adequate baseline information is required prior to or in the early stages of regulation or code introduction in order to measure their success. This could be achieved by monitoring selected watersheds or sub-watersheds.

Information and educational are essential for reducing non-point source pollution. FRAP supported the development of environmental commodity guidelines in four sectors to transfer environmental information to producers. The guidelines are being used by the B.C. Horticultural Coalition (representing approximately 3,000 farmers) to develop self-auditing protocols. A Watershed Stewardship Guide for Agriculture developed jointly by DFO, BC MELP and EC provided producers with an information package on watershed features and stewardship practices. This educational product gave organizations such as the B.C.

Cattlemen's Association an improved understanding of the important connections between land and water and the influence of their land management practices. Similarly, a Best Agricultural Waste Management Plan manual and an advanced forage management production guide were supported by FRAP and are in progress. Surveys indicated that producers were making changes because of environmental concerns.

Recommendations:

9. Because educational material explaining the importance of environmental features and stewardship is an important tool in addressing agricultural pollution, it should continue to be developed and supported by all interested stakeholders. Liaison with producer associations is needed to reinforce the information provided.

While two surveys cannot determine any real trends in pesticide sales, surveys of 1991 and 1995 sales indicated that five pesticides were common to the top-10 list in both years. These included glyphosate, metam, captan, mineral oil (herbicidal) and mancozeb. Agriculture producers as private land owners are not required to report their purchases or actual use of pesticides.

10. Retail sales surveys provide some detail on pesticide "use," and the next survey would be for 1999 retail sales. Farm surveys in pilot areas or on specific commodities, in addition to retail sales surveys, should be used to assess the use and application of pesticides.

When FRAP began, very little information was available on the relationship between farm management practices and potential impacts on runoff and water quality in the lower mainland. A project was initiated to evaluate the manure management guidelines developed for the Fraser Valley. Preliminary results for silage corn indicated the benefits of a summer-planted relay crop in reducing the cumulative winter loading of total volatile residue winter loading. However, even with a relay crop, it is important not to manure fields in high-risk areas (*e.g.*, areas near watercourses or sloped land), since the initial flush from the field can be toxic to aquatic life and carries material with a high oxygen demand.

Recommendation:

11. Experimental designs using test plots incorporating best management practices (BMPs) *vs.* conventional practices should be used to demonstrate the environmental benefits of BMPs. Although this approach requires a multi-year commitment, the benefits would be demonstrated more quickly than they would in an ambient water quality program with the BMP being implemented slowly over time, over a large geographic area.

A lime pasteurization process on a number of wastes including poultry litter, dairy manure, fish offal and municipal biosolids was successfully demonstrated. Poultry manure in particular released large amounts of atmospheric ammonia during processing, but this can be controlled with an ammonia scrubber.

Recommendation:

12. A market analysis for the products produced by lime pasteurization should be conducted in order to determine if there is potential for part of the poultry litter waste stream to be managed in this way.

Vegetable greenhouse wastewater is high in nutrient content, and the surface flow configuration of an experimental constructed wetland reduced the nitrate, ammonia and phosphorus content by as much as 48-63 per cent, 50-70 per cent and 26-54 per cent, respectively. Even with this efficiency, an average size greenhouse of 2.4 hectares would generate the nitrogen loading of 15 typical family residences. The need to implement wetland treatment in this industry to address possible environmental concerns was not evaluated.

Recommendation:

13. Because vegetable greenhouse discharges can contribute large nitrogen loadings, they should be considered in any groundwater protection strategy. The environmental issues related to greenhouse discharges still need to be studied.

Limited monitoring of mushroom barn washwater quality showed that it generally had the characteristics of weak sewage and constituted an individual farm discharge to ground equivalent to a typical family residence. Pesticide levels in the wastewater were unacceptable for a direct discharge to a watercourse.

Recommendation:

14. Additional research needs to be carried out to fully evaluate the quality and quantity of mushroom farm washwater and any relationship to individual farm management practices.

REFERENCES

Advisory Committee, 1993. *A Strategy. Toward Environmental Sustainability in the Agri-food Sector in British Columbia.* Accord on Environmental Sustainability in the Agri-Food Sector.

Barton, P. 1996. *Implementation of an Ammonia Analyzing System for Agricultural Waste Management Research.* BSc Thesis. UBC.

BC MAFF, 1994. *Environmental Guidelines for Greenhouse Growers in British Columbia*.

BC MAFF, 1994a. *Environmental Guidelines for the Nursery & Turf Industry in British Columbia.*

BC MAFF, 1994b. *Environmental Guidelines for Mushroom Producers in British Columbia*.

BC MAFF, 1995. *Environmental Guidelines for the Berry Producers in British Columbia*.

BC MAFF, 1996. *Environmental Guidelines for Field Vegetable Producers in British Columbia*.

BC MAFF, 1998. *Greenhouse Vegetable Opportunities in BC.* Ministry of Agriculture, Fisheries and Food.

BC MELP, 1993. *Pesticide Management Program. A Strategic 5-Year Plan.* Ministry of Environment, Lands and Parks.

BC MELP, 1996. *Manure Management Guidelines for the Lower Fraser Valley. BC Environment*

Beames, R.M. 1997. *Biosolid Stabilization Demonstration Project.* Final Report submitted by Ian Shand and Associates to Environment Canada, December 1997.

Berka, C.S. 1996. *Relationships Between Agricultural Land Use and Surface Water Quality Using a GIS: Sumas River Watershed, Abbotford, B.C.* MSc Thesis. Resource Management and Environmental Studies. UBC.

Bittman, S. 1997. *Fall Application of Dairy Slurry on Grass and Cover Crops.* Interim Report to Environment Canada.

Chesters, G. and L.J. Schierow, 1985. A Primer on Non-point Pollution. *Journal of Soil and Water Conservation* 40(1): 9-13.

Chipperfield, 1997. *Interim Report April 1 – September 8, 1997*. Environment Canada.

Davis, J.C. 1975. Minimal Dissolved Oxygen Requirements of Aquatic Life with Emphasis on Canadian Species: A Review. *Journal of Fisheries Research Board of Cananada* 32: 2295-2332.

Dean, D.M. 1996. *Poultry Manure Use in Raspberry Production: Soil Nitrogen Processes and Crop Nitrogen Uptake.* M.Sc. thesis. Dept. Soil Sc., UBC.

DFO, 1997. *Watershed Stewardship – A Guide for Agriculture*. The Stewardship Series.

Eco-Research, 1991. Program Description. Eco-Research, Tri-Council Secretariat.

EPA, 1993. *Evaluation of the Experimental Rural Clean Water Program.* EPA-841-R-93-005.

Epp, P.F. 1984. *Soil Constraints for Septic Tank Effluent Absorption.* Ministry of Environment. MOE Manual 5.

ESSA, 1996. *Non-point Source Pollution in British Columbia-An Assesment of Environmental Impacts.* Prepared by ESSA Technologies for B.C. Environment, lands and Parks.

FBC, 1998. *Basin News.* The Newsletter of the Fraser basin Council. Vol. 1 No. 1.

FBMP, 1994, *Stategic Plan Update and 1994/95 Action Plans.* Fraser Basin management Program.

FORUM, 1996. Canada-British Columbia Agriculture Component of the Green Plan 1993-1997 – Final Evaluation Report. October 1996.

FPIB, 1996. *Standards for Metals in Fertilizers and Supplements.* Agriculture and Agri-Food Canada. Trade Memorandum (Fertilizers), T-4-93.

Gannon, R.W., D.L. Osmond, F.J. Humenik, J.A. Gale, and J. Spooner, 1996. Goal-Oriented Agricultural Water Quality Legislation. *Water Resources Bulletin* 32(3): 437-450.

Hagen, M. 1990. *Agricultural Runoff Contamination in the Fraser River Estuary-Waste Management Activity Program Discussion Paper.* Fraser River Estuary Management Program.

Hart, S., and C. Mayall. 1990. *Phosphorus Sources in the San Jose River Basin: Effects of Winter Livestock Management Practices.* Prepared for B.C. Environment, Lands and Parks.

Hart, S., and C. Mayall. 1991. *Phosphorus Sources in the Lac la Hache Drainage Basin.* Prepared for B.C. Environment, Lands and Parks.

Hutton, K. 1987. *Lower Fraser Valley Agricultural Waste Management Survey.* Ministry of Environment and Parks. Region 2.

KPMG, 1996. *Issues and Options Paper for Nonpoint Source Pollution Management in B.C.* Prepared by KPMG Consultants for B.C. Environment, Lands and Parks.

Kreye, R. and M. Wei. 1994. *A Proposed Aquifer Classification System for Groundwater Management in British Columbia.* Groundwater Section. Ministry of Environment, Lands and Parks. Victoria.

NDM, 1996. *Non-Point Source Pollution: Problem Definition.* Prepared by Norecol, Dames and Moose for B.C. Environment, Lands and Parks.

Osmond, D.L., D.E. Line and J. Spooner. 1995. Section 319 *National Monitoring Program: An Overview.* North Carolina State University.

Paul, J.W., T.A. Scott and P.K. Barton. 1996. *A Research Barn for Measuring Ammonia Emissions During Poultry Broiler Production.* Pacific Agri-Food Research Centre (Agassiz). Technical Report #127.

Paul, J.W., T.A. Scott, P.K. Barton, T. Kannangara and K. Chipperfield. 1997. *Evaluation of Alum as a Litter Treatment to Reduce Ammonia Related Problems in Heavy Turkeys.* Pacific Agri-Food Research Centre (Agassiz). Technical Report #137.

PCAR, 1981. *Pesticide Control Act Regulation.* B.C. Reg. 319/81. Filed July 31, 1981.

Prystay, W.A. 1997. *An Assessment of Constructed Wetlands for the Treatment of Greenhouse Wastewaters:* Final Report submitted to Environment Canada.

Puckett, L.J., 1995. Identifying the Major Sources of Nutrient Pollution. *Environmental Science and Technology* 29(9): 408A-414A.

Ronneseth, K., M. Wei, and M. Gallo. 1995. *Evaluating Methods of Aquifer Vulnerability Mapping for the Prevention of Groundwater Contamination in British Columbia.* Presented at IAH Conference. Edmonton.

Schreier, H., S.J. Brown, and K.J. Hall. 1991. The Land-Water Interface in the Fraser River Basin. In *Water in Sustainable Development: Exploring our Common Future in the Fraser Basin*: 77-116.

Schreier, H., P. Scales, K. Hall, B. Wernick, W. Tamagi, A. Kenney, W. Thompson, S. Brown, and L.M. Lavkulich. 1996. *A Groundwater Quality Assessment in the Hopington Aquifer.*

Scott, T.A., J.W. Paul, R.C. Newberry and P.K. Barton. 1996. *Balanced Amino Acid Diets Increase Bird Health and Reduce Ammonia Emissions.* Pacific Agriculture Research Centre (Agassiz). Technical Report #128.

Szeto, S.Y., and M.T. Wan. 1996. Hydrolysis of Azadirachtin in Buffered and Natural Waters. *Journal of Agricultural and Food Chemistry.* 44: 1160-1163.

Task Force, 1981. *Thompson River Basin Pre-Planning Task Force Report.* Canada. British Columbia.

Thurston, R.V., and R..C. Russo. 1983. Acute Toxicity of Ammonia to Rainbow Trout. *Transactions of the American Fisheries Society.* 112: 696-704.

Thurston, R.V., G.R. Phillips, R.C. Russo and S.M. Hinkins. 1981. Increased Toxicity of Ammonia to Rainbow Trout (Salmo gairdneri) Resulting from Reduced Concentrations of Dissolved Oxygen. *Cananadian Journal of Fisheries and Aquatic Sciences.* 38: 983-988.

Top, V., J.C. Nener, B.G. Wernick, B.J. Locken, and G.A. Derksen. 1997. *The Influences of Intensive Agriculture on Matsqui Slough, A South Coastal British Columbia* Watershed. Canadian Technical Report of Fisheries and Aquatic Sciences 2160.

van Vliet, J.P. 1997. *Risk of Surface Water Contamination from Manure Management in South Coastal B.C.* 1996/97 Progress Report.

Wernick, B. 1996. *Land Use and Water Quality Dynamics on the Urban-Rural Fringe: A GIS Evaluation of the Salmon River Watershed, Langley, B.C.* Msc Thesis. Resource Management and Environmental Studies. UBC.

Westwater, 1995. *Fraser Basin Ecosystem Study. Annual Report 1994-1995.* Westwater Research Centre and Sustainable Development Research Institute.

Windwalker Consulting Service, 1995. *Green/Yellow/Red Pesticide Classification Feasibility Study.* File Report.

Zbeetnoff Consulting, 1995. *A Business Plan for an Integrated Pest Management Certification Program.* File Report.

Zebarth, B.J., and J.W. Paul. 1995. *Impact of Changes in Agricultural Land Use on Nitrogen Loading to the Abbotsford Aquifer.* Pacific Agriculture Research Centre (Agassiz). Technical Bulletin 119.

Zebarth, B.J., B. Harding, J.W. Paul, C.G. Kowalenko and K. Chipperfield. 1996b. *Enhanced Utilization of Poultry manure in Raspberry Production and Reduced Risk of Groundwater Contamination Through Improved manure Application Technology.* Progress Report for 1995/96.

Zebarth, B.J., C.G. Kowalenko, B. Harding and D. Chapple. 1997a. *Development of a Test-Based Nitrogen Recommendation System for Raspberries to Reduce Nitrate Leaching to the Abbotsford Aquifer.* Pacific Agri-Food Research Centre (Summerland) Technical Report No.97-01.

Zebarth, B.J., J.W. Paul, C.G. Kowalenko, M. Younie, D. Chapple and K. Chipperfield. 1997b. *Banding of Manure in Raspberry Production: Crop Response and Manure Availability.* Pacific Agri-Food Research Centre (Summerland). Technical Report 97-03.

Zebarth, B.J., J.W. Paul, R. Van Kleeck, and C. Watson. 1997. *Impact of Nitrogen Management in Agricultural Production on Water and Air Quality in the Lower Fraser Valley, British Columbia.* Pacific Agri-Food Research Centre (Summerland) Technical Report No. 97-03.

Zebarth, B.J., K. Chipperfield and G. Telford. 1996a. *Banding of Manure in Raspberry Production: Evaluation of a Mulch Spreader.* Pacific Agri-Food Research Centre (Summerland) Technical Report 96-01.

Zebarth, B.J., M. Younie, J.W. Paul and G. Telford. 1996. *Pre-sidedress Soil Nitrate Test for Silage Corn: 1995 Results.* Pacific Agriculture Research Centre (Agassiz). Technical Report 108.

Zebarth, B.J., M. Younie, J.W. Paul and S. Bittman. 1994. *The Pre-sidedress Soil Nitrate Test for Silage Corn; 1994 Results.* Pacific Agriculture Research Centre (Agassiz). Technical Report 108.

6.0 CONTAMINATED SITES

6.1 OBJECTIVES

The Contaminated Sites Program of Environment Canada was created to oversee the management of contaminated sites in the Pacific & Yukon Region, as mandated by the federal *Fisheries Act* and the *Canadian Environmental Protection Act* (*CEPA*). It is responsible for ensuring that owners and operators of contaminated sites comply with the two acts. Assessment and remediation objectives for soil, sediments and water are used to determine the extent of contaminated site impacts and to establish remediation targets for those sites. In response to growing public and regulatory concern about pollution impacts related to contaminated sites, the Fraser River Action Plan (FRAP) allocated additional resources to the Contaminated Sites Program in order to increase its efforts within the Fraser River Basin.

Specifically, FRAP calls for a reduction in contaminant loadings from pollutants entering the Fraser River from industrial and domestic point and non-point sources, including contaminated sites. The approach taken in dealing with contaminated sites has been to identify sites, prioritize them in terms of impact and then develop and implement suitable remediation measures.

Two of the FRAP 48 deliverables are directly related to the Contaminated Sites Program:

- to develop and maintain an inventory of major pollution sources and loadings in the basin (FRAP deliverable 8); and
- to clean up 70% of contaminated federal waste sites to Canadian Council for the Ministers of the Environment (CCME) standards (deliverable 15).

6.2 ACTIVITIES

The following activities were carried out to meet the objectives of FRAP.

6.2.1 Technical Support

The Contaminated Sites Program of Environment Canada has provided technical support and managed the implementation of the National Contaminated Sites Remediation Program (NCSRP), which ran from 1990 to 1996, and of FRAP. By co-ordinating activities with other federal departments and provincial and territorial counterparts, Environment Canada staff have gained experience in contaminated site management that may be beneficial to those developing assessment and remediation projects.

Furthermore, to ensure compliance with relevant legislation, Environment Canada conducts engineering and environmental reviews of assessment and remediation projects, negotiates compliance with those responsible in co-operation with the Province of B.C. and provides guidance when needed. Within the Contaminated Sites Program, measures for providing guidance include strong regulations and enforcement mechanisms; non-regulatory approaches, such as environmental guidelines, codes of practice and incentives with industry; and the development and transfer of pollution measurement and control technologies.

6.2.2 SITE Registry

An inventory of contaminated sites was started in 1992. In November 1994, the Fraser Pollution Abatement Office (FPAO) of Environment Canada and the Contaminated Sites

Remediation and Assessment Section of the B.C. Ministry of Environment, Lands and Parks (BC MELP) agreed to collaborate in the development and completion of the BC MELP Site Information System (SITE), to include non-federal and federal sites. SITE is designed to monitor and manage contaminated site data; prioritize remedial actions; and form the basis of a "Site Registry" pursuant to the British Columbia *Contaminated Sites Regulation*. A public version of this database, called the Site Registry, has become available through *BC On-line*. The benefits of this database are two-fold. First, it provides a tool for the regulatory bodies that facilitate the management of contaminated sites. Second, it provides the public with information on contamination near properties they are interested in, and on possible risks in investing in those properties.

SITE enables information about contaminated sites, such as status, site participants, description and the exact location of contamination, to be retrieved and reviewed for assessment and remediation purposes. This information is updated continuously by BC MELP and Environment Canada.

SITE is a key component in meeting FRAP's overall objective of maintaining an inventory of contaminant sources with potential impacts on the Fraser Basin. Summaries are available on the status and progress of contaminated sites registered in SITE. For more information, please refer to the *Fraser Basin Contaminated Sites Progress Reports, 1994-95, 1995-96,* and *1996-97,* published by the Contaminated Sites section of Environment Canada.

SITE classifies sites as "federal" and "non-federal." Federal sites are those on federal lands such as airports, ports, Indian reserves and national parks. Non-federal sites are those that are not on federal lands; they are generally overseen by the Province of B.C., so the terms "provincial" and "non-federal" are used synonymously in this report.

Once contaminated sites have been identified, action may or may not be taken to clean them up, depending on the extent and severity of the contamination. Sites may be designated as "active" or "inactive." "Active" sites may then be categorized as under assessment, under remediation, assessment complete or remediation complete. "Inactive" sites include two categories: those whose remediation is complete and those for which no further action is needed. The label "no further action" may be applied either because the contamination is slight and no action is needed, or because some remediation has been done and no further steps need to be taken.

6.2.2.1 Status of Contaminated Sites

Table 6.1 provides a summary of the total number of federal, non-federal and combined federal and non-federal contaminated sites registered from 1995 to 1997. These numbers are shown as totals for B.C. as well as for the Fraser Basin. In addition, the percentage of contaminated sites located within the Fraser Basin has been calculated for each category. Since federal sites are not categorized by region like non-federal sites, the percentage of federal sites located within the Fraser Basin was estimated based on the 1996 and 1997 Federal Pacific and Yukon Region Contaminated Sites Working Inventories compiled by the Pollution Prevention and Abatement Division of Environment Canada, which showed that approximately 60 per cent of all federal sites were located within the Fraser Basin. This percentage was used to estimate the total number of federal sites in the Fraser Basin from 1995 to 1997. These totals, in turn, were used to estimate the percentage of federal and non-federal sites in the Fraser Basin.

As Table 6.1 shows, the percentage of Fraser Basin sites has declined from over 90 per cent in 1995 to approximately 50 per cent in 1996 and 1997. This is most likely a result of the fact that, while a large number of Fraser Basin, and in particular lower mainland, contaminated sites were entered into the SITE database in 1995, in subsequent years the number of Fraser Basin sites entered in the registry has declined and the number of sites located outside the Fraser Basin has risen.

Table 6.1 Federal and Non-federal Contaminated Sites in the Fraser Basin, 1995-1997

	Non-federal Sites			Federal Sites			Federal and Non-federal Sites		
Year	1995	1996	1997	1995	1996	1997	1995	1996	1997
B.C. Totals	2866	2550	2931	201	181	234	3067	2731	3165
Fraser Basin Totals	2699	1329	1515	121	109	112	2820	1438	1627
% of sites in Fraser Basin	94%	52%	52%	60%	60%	60%	92%	53%	51%

6.2.2.2 Progress in Remediating Contaminated Sites

Since 1995, the number of contaminated sites given "active" status (*i.e.,* where further assessment or remediation is required) has decreased, while the number of sites designated "inactive" (*i.e.,* where remediation has been completed or no further action is required) has increased. As Figure 6.1 illustrates, the percentage of total federal and non-federal sites under various categories of active status has generally decreased. Most noticeable is the decrease in the percentage of sites undergoing remediation, which is matched by a similar increase in the percentage of sites achieving "inactive" status.

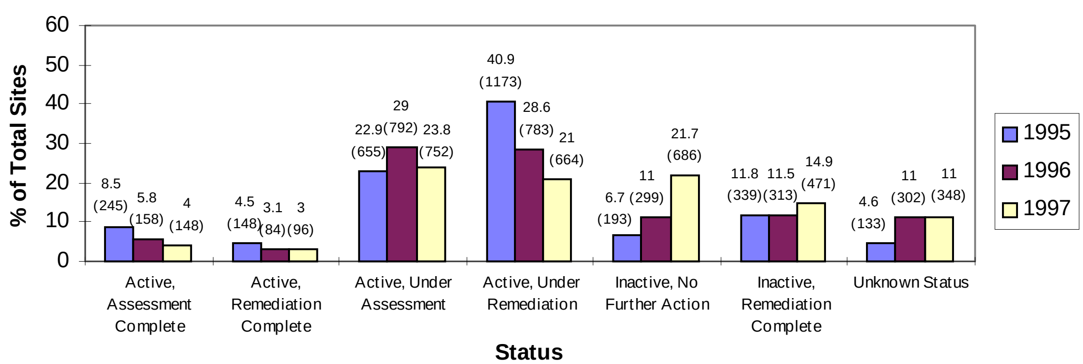


Figure 6.1 Status of Federal & Non-federal Sites Combined As a Percentage of Provincial Totals

(number of sites in brackets)

Table 6.2 provides a summary of the numbers and percentages of federal and non-federal sites achieving remediated/inactive status in both the province and the Fraser Basin. These numbers represent the sum of the separate "inactive" categories (*i.e.*, "Inactive, No Further Action Required" and "Inactive, Remediation Complete"). Combining the numbers and percentages into one category provides a clearer picture of the distribution of inactive sites from year to year and the progression of contaminated sites from active to inactive status. Table 6.2 shows that the total number and percentage of inactive sites in both the federal and non-federal site categories has risen annually since 1996.

Table 6.2 Remediated Sites, 1995-1997

Inactive / Remediated Status	1995 # of Sites	1995 % of Totals	1996 # of Sites	1996 % of Totals	1997 # of Sites	1997 % of Totals
Federal Sites	n/a	N/A	12	6.6%	25	13.8%
Non-federal Sites	n/a	N/A	600	23.5%	1132	38.6%
Federal & non-federal Sites Combined	532	18.6%	612	22.4%	1157	36.6%
Non-federal Fraser Basin Sites	n/a	N/A	357	26.9%	620	40.9%

6.2.3 Guideline Development and Awareness

6.2.3.1 Compliance

Investigation and remediation of contamination is often triggered by private agreements, such as those requiring due diligence at the time of sale, or by lender requirements. Under new British Columbia contaminated sites regulations, consideration of the need for remediation at a commercial or industrial site can be triggered by decommissioning, property subdivision or spills, or by various local development approval applications, rezoning applications and development permits.

The Contaminated Sites Program is responsible for ensuring that contaminated site owners and operators are in compliance with the *Fisheries Act* and *CEPA*. This is accomplished by conducting engineering and environmental reviews of assessment and remediation projects, and by negotiating compliance with those responsible in co-operation with the province.

Public and regulatory concern about pollution and contaminated sites has increased considerably in recent years. In Canada, government policy and legislation pertaining to contaminated sites has attempted to keep pace with the complex issues of pollution prevention and management. The Contaminated Sites Program has co-ordinated projects with the Enforcement and Emergencies Division of EC in legal investigations and inspections of contaminated sites.

6.2.3.2 Compliance Promotion

Apart from its regulatory role, Environment Canada is also involved in promoting environmental stewardship with other government departments and with industry through a variety of programs, including the NCSRP, which ended in 1996, and FRAP. These programs have developed a number of technical publications, including assessment and remediation guidelines, criteria, innovative technologies, annual contaminated sites reports and others. In order to promote compliance with the standards in these publications, a mailing list of more than 150 environmental consultants and stakeholders and 60 other government departments was created. Each firm or agency was individually contacted and relevant information entered into a comprehensive database. Recent publications available from the CCME, Environment Canada and the NCSRP were sent to each party in order to increase awareness of current codes, guidelines and legislation pertinent to contaminated sites.

Environment Canada has also worked in conjunction with Fisheries and Oceans Canada, the Burrard Inlet Environment Action Program and the Fraser River Estuary Management Plan to assess the impacts of point and non-point source contaminants on soil, sediment and surface water, in addition to the ecological effects on biotic receptors.

6.2.3.3 Internet

A contaminated sites web site was developed as part of Environment Canada's national web site Green Lane. The web page consists of three main components managed under the Contaminated Sites Program, including sections on NCSRP, FRAP and a list of various Environment Canada and CCME publications relevant to the assessment and management of contaminated sites. The web page also includes links to other relevant web sites developed by various Environment Canada Regions and agencies, including a link to the Demonstration and Evaluation of Site Remediation Technology, and to BC MELP's home page.

6.2.3.4 Workshops

In December 1996, a three-day national workshop on the Management of Federal Contaminated Sites was offered to federal Contaminated Sites Working Group members. Representatives of Environment Canada, Parks Canada, Fisheries and Oceans Canada, Indian and Northern Affairs Canada, National Defence and other federal government departments attended. The main purpose of the workshop was to develop a common federal approach to the management of contaminated sites under federal custody. Discussion focused on the application of CCME scientific tools to contaminated sites management, the promotion of a consistent federal approach across Canada and the use of both conventional and innovative site remediation technologies for cleaning up contaminated soil, sediment and groundwater.

6.3 IMPLEMENTATION

There are currently 114 contaminated sites in the Fraser Basin in the process of remediation. Cleanup can cost several million dollars each, but joint jurisdiction with the province allows Environment Canada to use the combined weight of federal and provincial environmental laws to expedite cleanup. By the end of FRAP, Environment Canada expects to see approximately 650 contaminated sites in the Fraser Basin remediated, or about 40 to 45 per cent of the total.

Number 36 of the FRAP 48 deliverables refers to sediment management and remediation. It should be noted that some of the contaminated sites under review include contaminated sediments in Burrard Inlet. Remediation is undertaken in conjunction with the Burrard Environmental Review Committee (BERC). Under the BERC process, approximately 25 contaminated sites are currently under assessment and remediation.

When assessing a contaminated site prior to remediation, the protection of human health and the environment may be addressed through the application of environmental quality guidelines or through risk assessment and risk management. Federal and provincial guidelines often used in contaminated site assessment are available for soil, sediment (freshwater and marine) and water (freshwater and marine) media. The main purposes of the guidelines are to determine the extent of non-point impacts and to aid in the establishment of site-specific remediation objectives.

National environmental quality guidelines, which are developed using toxicological information, present concentrations of individual chemicals below which adverse biological effects are not expected. They are developed with the intention of being conservative, national benchmarks to protect and sustain important resource uses. These resource-use based guidelines provide scientifically defined measures to ensure the maintenance, protection and remediation of the environment. National environmental quality guidelines play an important role in the environmental legislative framework through which Environment Canada targets the remediation of contaminated sites.

6.3.1 Specific Targets

Specific targets that environment Canada focuses on when assessing contaminated sites pertain to soil, water and sediments.

6.3.1.1 Soil and Water

Under the NCSRP, environmental quality guidelines were developed for soil and water, including groundwater, for initial assessment purposes (called assessment criteria) and for setting remediation targets for specific land uses (called remediation criteria). The criteria for soil are based on existing guidelines from selected jurisdictions in Canada (Environment Canada, 1991). The criteria for water quality, based on the Canadian Water Quality Guidelines (Canadian Council of Resource and Environment Ministers, 1987), are subject to categories of water use.

Water quality is an important issue for Environment Canada. Canadians are concerned about their water resources and are confronted by a number of problems threatening them. Many surface and groundwaters are used, or may be used, as sources for municipal water supply or for private domestic use. Furthermore, contaminants in both groundwater and surface waters can be carried long distances, thereby contaminating areas far from the source.

Some provinces such as British Columbia have developed soil and water quality guidelines with the same intent as the CCME guidelines. These provincial guidelines should be considered in addition to the CCME guidelines or used for parameters not listed in the CCME guideline documents.

6.3.1.2 Sediments

At contaminated sites, the assessment of impacts on freshwater or marine sediment is often of primary concern. This is of particular importance in situations where target chemicals are known to partition to sediments from surface water or groundwater.

Sediments provide habitat for many benthic and epibenthic organisms and, as such, are a critical component of aquatic ecosystems. They also influence the environmental fate of many chemical substances that enter the aquatic environment, since they act as a sink, and, subsequently, as a source of these contaminants. Potentially toxic substances have been measured in the sediments of freshwater, estuarine and marine ecosystems across Canada. Sediment quality guidelines for the protection of aquatic life assist in interpreting sediment chemistry data and in assessing the potential toxicity of sediment-associated chemicals to aquatic organisms. They are also useful for identifying and prioritizing areas and chemicals of concern. As national benchmarks, these guidelines help to set targets for sediment quality that will sustain aquatic ecosystems and their uses.

Currently, only a few sediment quality guidelines are available for heavy metals (there are guidelines for organics as well), but *Interim Sediment Quality Guidelines for the Protection of Aquatic Life* (Environment Canada, 1995) are generally available for many of the contaminants of concern.

6.4 REGIONAL ANALYSIS

Figures 6.2, 6.3 and 6.4 show the distribution of contaminated sites within and outside the Fraser Basin.

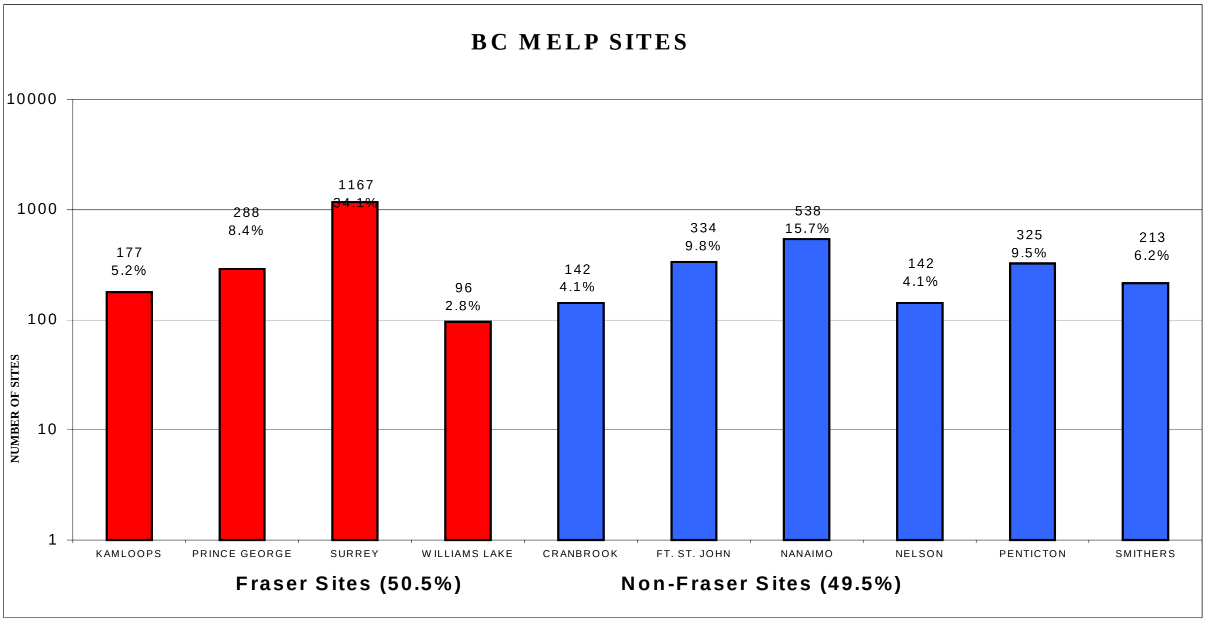


Figure 6.2 Number and Percentage of Provincial Contaminated Sites Per B.C. Region Within and External to the Fraser Basin on the SITE Registry, as of November 1997

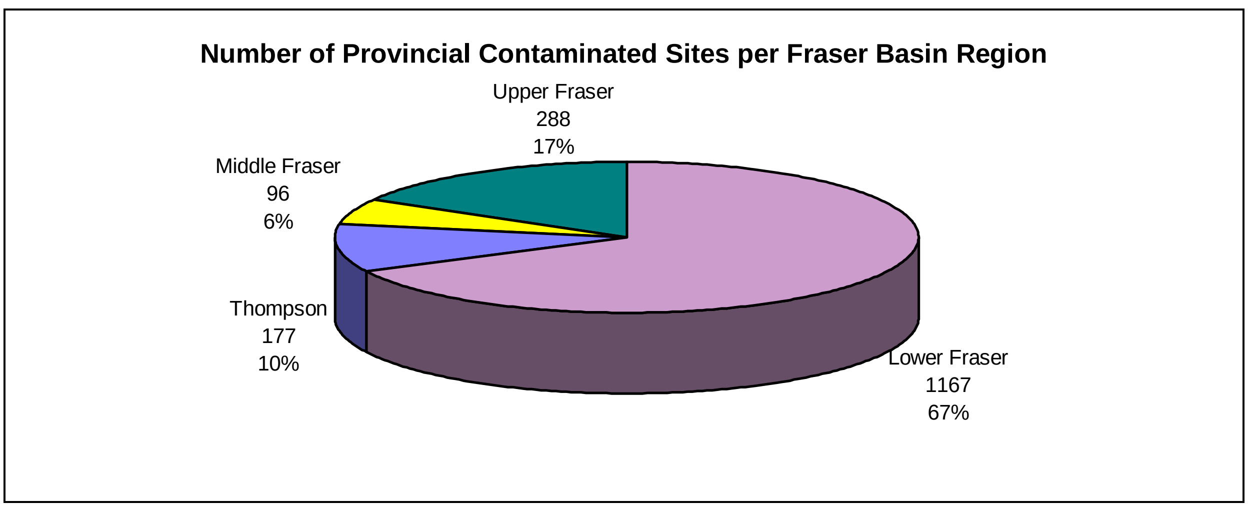


Figure 6.3 Number and Percentage of Provincial Contaminated Sites Within the Fraser Basin on the SITE Registry, as of November 1997

There are a total of 249 federal contaminated sites registered in the SITE database, of which nine are listed as "Inactive - Remediation Complete." Of the 249 contaminated federal sites in British Columbia at this time, 116 are located in the Fraser Basin. Furthermore, there are an estimated 98 federal contaminated sites listed as "Active - Under Assessment."

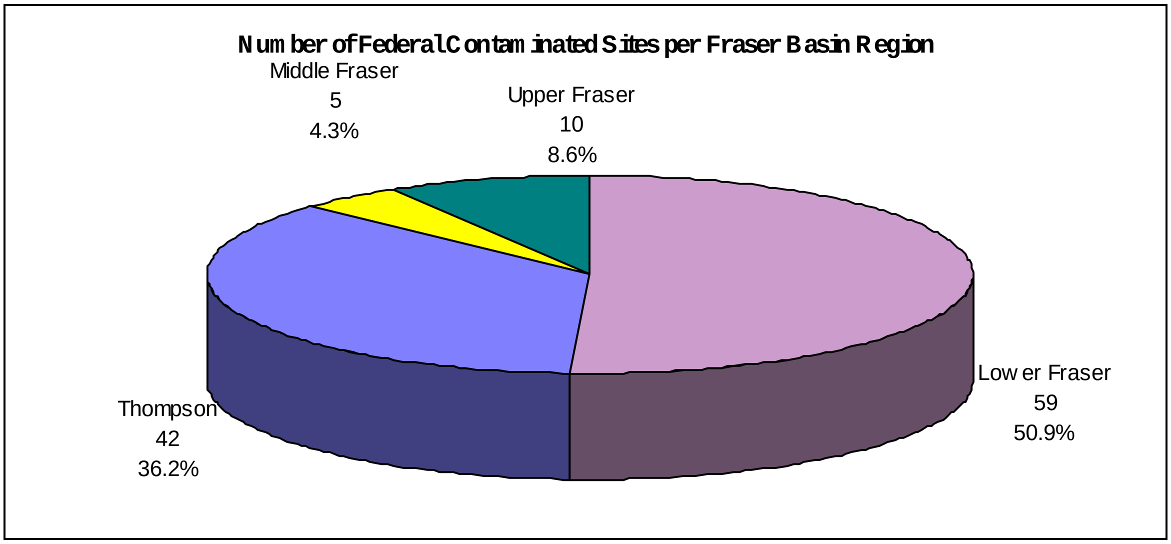


Figure 6.4 Number and Percentage of Federal Contaminated Sites Within the Fraser Basin on the SITE Registry, as of November 1997

6.5 CONCLUSIONS AND RECOMMENDATIONS

At the beginning of FRAP, Environment Canada was involved with approximately 60 sites in the Pacific and Yukon Region, of which 35 were in the Fraser Basin. As of December 1997, Environment Canada was actively involved in negotiating the assessment and cleanup of over 300 contaminated sites in the region, with approximately 140 in the Fraser Basin. Clearly, this increase reflects the public and regulatory concern about contaminated sites in the region and the Fraser Basin.

Approximately 635 contaminated sites have been remediated in the Fraser Basin, which represents 39 per cent of the total sites identified. In general, these results have achieved the pollution abatement objective of FRAP, which is to reduce by 30 per cent the discharge of environmentally disruptive effluents entering the basin by 1997.

Contaminated sites have now become an important issue in the management of environmental receptors in the Fraser Basin. For example, the Environmental Review Committee of the Burrard Inlet Environmental Action Program and the Fraser River Estuary Management Program are now considering contaminated sites in their project reviews. Many of these projects involve sites with contaminated sediments and/or groundwater.

Approximately 39 per cent (635 of 1,627) of all non-federal and federal contaminated sites in the Fraser Basin were remediated during FRAP. The statistic for federal sites alone is lower; about 11 per cent (15 of 140) of identified federal contaminated sites have been remediated in the Fraser Basin. With only the *Fisheries Act* and the PCB regulations of *CEPA* as regulatory controls, there is little incentive for federal departments or agencies to consult with and report on assessment and remediation activities on federal lands to Environment Canada. This means that the actual number of federal contaminated sites recorded and cleaned up in the basin could be higher than reported.

It is also important to note that the number of contaminated sites recognized by Environment Canada is an evolving figure. While Environment Canada strives to lessen the number of sites requiring remediation, new sites demand attention as they continue to be discovered. This trend is particularly noticeable in areas experiencing rapid population and industrial growth.

An important milestone is allowing proper management and control of contaminated sites in British Columbia under provisions of the *Contaminated Sites Regulation* and the *Waste Management Amendment Act*. These progressive new regulations will provide a fair and effective framework to deal with the identification, assessment and cleanup of contaminated sites in B.C., including the Fraser Basin. These regulations also require site profiles for screening potentially contaminated sites on a computer-based site registry accessible to the public. This registry supports FRAP deliverable 8: to develop and maintain an inventory of major pollution sources in the basin.

Recommendations:

1. Resources and regulatory instruments are required for federal lands to ensure that equivalent provincial guidelines and standards are in place for federal departments and agencies managing federal property. A contaminated sites inventory or database should also be established for federal contaminated sites.
2. The remediation of contaminated sediments requires further study and development to ensure that fair, scientific and appropriate remediation guidelines and standards are established.

7.0 AIRBORNE CONTAMINANTS

7.1 INTRODUCTION

Two of the FRAP 48 Deliverables related to airborne contaminants:

- to develop and maintain a toxics air emission inventory for major industrial sectors (deliverable 16).
- to reduce the release of persistent toxic substances pursuant to the *Canadian Environmental Protection Act* and identified as priority from inventories and environmental data to the extent allowed by best practicable technology (deliverable 17).

As FRAP began, emission inventories for common air pollutants such as CO, NO_x, particulate, SO_x and VOCs were available, but inventories for "non-common" or toxic air pollutants were not.

7.2 ACTIVITIES

To remedy this situation, an inventory of sources and emissions of toxic air contaminants and particulate matter was conducted. The Inventory of Sources and Emissions of Toxic Air Contaminants in B.C. (1995) catalogued emissions for the year 1990 in all of B.C., not just the Fraser Basin, and included emissions from point, area and mobile sources. A subset inventory, covering the Greater Vancouver Regional District (GVRD), was also produced.

The database was designed to parallel existing provincial and federal inventory systems for common pollutants, and to specialize in B.C.'s industries and geographical conditions. In order of preference, the inventory employed source monitoring data, engineering calculations, emission factors or speciation profiles to estimate emissions[1]. Monitoring data and engineering calculations were unavailable for most sources. Selection of the most appropriate of the available emission factors for each source in the inventory was critical. Where no satisfactory emission factor was available, the most suitable speciation profile was used. Particulate profiles included PM2.5 and PM10 partitioning where possible. Motor vehicle VOC, NO_x and CO emissions were estimated using a specialized emission factor model developed by the U.S. Environmental Protection Agency.

In order to facilitate summarizing and reporting of emission estimates, all 1,263 toxic substances in the inventory were assigned to an appropriate chemical group. Some substances were assigned to more than one group.

---

[1] Emissions factors are used to estimate emissions by multiplying the factor by a base quantity such as production rate or raw material throughput. Emissions factors for different source categories are available from the U.S. EPA. The factors were originally calculated using air emission sampling results from particular sources.

Speciation profiles are used to estimate emissions by multiplying the amount of particulate matter and/or volatile organic compounds (VOCs) emitted from a particular source, by the typical chemical composition of particulate and/or VOCs emitted from similar sources. Most air toxics are a subset of either particulate (toxic metals and heavy organics) or VOCs (light organics).

Speciation profiles are generally less reliable than emissions factors because they are available for fewer and less-specific source types.

Table 7.1 shows the estimated 1990 B.C. emissions of total suspended particulate (TSP) according to source category. The estimated emissions of total suspended particulate in B.C. in 1990 were 426,000 tonnes, or 419,000 tonnes excluding natural sources. Using the source categorization in Table 7.1, the largest source of particulate emissions was burning, which accounted for 36 per cent of the non-natural total. This was followed by road dust (25 per cent), the paper and allied products industries (12 per cent), and wood industries (10 per cent). Industrial point sources as a whole comprised 28 per cent of the total. Railways (four per cent, mostly coal dust) were also a significant source. Point-source particulate emissions from wood industries likely decreased considerably after the province began phasing out beehive burners in the early 1990s.

Table 7.1 also provides the estimated particle size distribution for the emissions, in terms of the fractions less than 2.5 microns, between 2.5 and 10 microns, and greater than 10 microns. Ninety per cent of particulate from burning was estimated to be smaller than 2.5 microns. Particulate from the paper and allied products industries and from wood industries was also predominantly smaller than 2.5 microns, at 81 per cent and 78 per cent respectively. On the other hand, 56 per cent of road dust was greater than 10 microns. Most of the other industrial point sources had more even distributions between the three fractions estimated.

Table 7.1 Estimated 1990 B.C. Emissions of Total Suspended Particulate

	TSP (tonnes)	Percent of Total (minus natural sources)	> 10 um	2.5 um - 10 um	< 2.5 um
Mobile Sources (32% of non-natural total)					
Aircraft	300	0%	45%	16%	39%
Motor Vehicles					
Light-Duty Gasoline	2,557	1%	7%	9%	84%
Heavy-Duty Gasoline	200	0%	8%	9%	84%
Light-Duty Diesel	589	0%	4%	8%	88%
Heavy-Duty Diesel	7,709	2%	1%	8%	91%
Road Dust	104,411	25%	56%	19%	25%
Railways	16,502	4%	47%	35%	19%
Marine Vessels	827	0%	17%	14%	69%
Off-Road	686	0%	0%	8%	92%
Point Sources (28% of non-natural total)					
Plastic Products	64	0%	39%	17%	44%
Wood Industries	41,736	10%	17%	5%	78%
Paper and Allied Products	48,255	12%	12%	7%	81%
Primary Metals Industry	6,873	2%	34%	16%	50%
Fabricated Metals Industry	238	0%	39%	18%	43%
Non-Metallic Mineral Industry	2,272	1%	35%	23%	42%
Refined Petroleum Industry	565	0%	32%	26%	42%
Chemical Industry	1,384	0%	35%	28%	38%
Transportation Industry	3,989	1%	47%	30%	23%
Storage and Warehousing Industry	2,674	1%	64%	20%	16%
Utility Industries (except Communications)	147	0%	6%	5%	88%
Other Point Sources	10,090	2%	36%	24%	40%
Area Sources (40% of non-natural total)					
Space Heating					
Residential	2,690	1%	3%	1%	95%
Commercial/Institutional/ Industrial	202	0%	20%	22%	58%
Burning	151,714	36%	1%	9%	90%
Agricultural	8,753	2%	90%	8%	3%
Natural Sources	7,019		13%	72%	15%
Solvent Evaporation	0	0%			
Gasoline Marketing	0	0%			
Landfills	1,866	0%	92%	6%	2%
Miscellaneous	1,728	0%	32%	8%	60%
TOTAL	426,038		24%	14%	62%
TOTAL, minus natural sources	419,019				

As Table 7.2 shows, total estimated B.C. emissions of toxic chemical substances for 1990 were 3.73 million tonnes, of which natural sources accounted for 2.83 million tonnes and non-natural emissions for 0.90 million tonnes. Sources contributing the most to the non-natural emissions total were landfills (35 per cent), burning (24 per cent), road dust (12 per cent) and light-duty gasoline motor vehicles (eight per cent). Industrial point sources contributed only two per cent of non-natural emissions.

Table 7.2 also breaks down these toxic emissions by chemical group. The group most emitted was "aliphatics or alicyclics," which comprised 46 per cent of the non-natural total. These were emitted predominantly from landfills. A further 29 per cent of the non-natural total was in an "unassigned" chemical group, which included several commercial chemicals as well as particulate matter from forest fires. Indeed, natural sources of this group were over three times greater than non-natural sources, and burning comprised most of the rest. Metals comprised seven per cent of the non-natural total. Most emitted metals were in road dust. Almost all of the natural emissions came from three chemical groups: unsaturated non-aromatics, terpenes and "unassigned." Although industrial point sources comprised only two per cent of the non-natural total, they contributed large percentages to the estimated emissions of aldehydes (refined petroleum industry and wood industries), inorganic salts (refined petroleum industry), inorganic sulphur compounds (paper and allied products), dioxins (wood industries), furans (wood industries) and polychlorinated biphenyls (non-metallic mineral industry).

Table 7.2 Estimated 1990 B.C. Toxic Air Emissions (tonnes) – Page 1 of 2

Source	**TOTAL of Chemical Groups**	Aliphatics or Alicyclics	Unassigned	Metals	Unsaturated Non-Aromatics	Monocyclic Aromatic Hydrocarbons	Other Organics	Aldehydes	Polycyclic Aromatic Hydrocarbons	Other Inorganics	Alcohols	Inorganic Salts	Esters	Ketones
Mobile Sources														
Aircraft	**1,749**	240	12		518	56	78	385	15	210				38
Motor Vehicles														
Light-Duty Gasoline	**75,374**	38,480	470	245	12,130	18,898	1,081	1,176	1,148	797	481			366
Heavy-Duty Gasoline	**1,730**	960	110	20	298	191	80		1	61				
Light-Duty Diesel	**942**	7	80	38			541	54	2	195				
Heavy-Duty Diesel	**11,196**	93	637	643			4,538	516	4	4,364		370		
Road Dust	**104,411**		49,185	50,502			3,319			1,290		114		
Railways	**18,219**	182	11,824	3,951	460	124	406	505	2	567	1	39		156
Marine Vessels	**7,458**	2,242	434	145	1,409	906	609	1,029	37	262	48	17		318
Off-Road	**3,842**	1,597	135	50	615	477	255	202	16	376	21	30		63
Point Sources														
Plastic Products	**1**													
Wood Industries	**1,364**	18	13	175	18	1	9	1,057	51	13		3		
Paper and Allied Products	**3,760**	7	11	48	1	1	9	520	3	1,340		100		
Primary Metals Industry	**1,134**		2	211					96	821		1		
Fabricated Metals Industry	**1**													
Non-Metallic Mineral Industry	**21**		1	12						7				
Refined Petroleum Industry	**9,643**	4		2		1		6,174	2			3,459		
Chemical Industry	**1,046**		1			3		1		390		641		
Transportation Industry	**4**		3	1										
Storage and Warehousing Industry	**3**		2											
Utility Industries (except Communications)	**1**													
Other Point Sources	**442**	7	4	183	4	6		65	5	165		1		
Area Sources														
Space Heating														
Residential	14,495	294	1,059	37		20	1,183	594	10,087	287	29	123		
Commercial/Institutional/Industrial	**476**	230	29	29		15	15	28		32		97		
Burning	**216,846**	14,050	177,049	1,527	22,473	2	268			231		1,248		
Agricultural	**43,707**	31,459	5,999	1,984						82	1,398	687	699	699
Natural Sources	**2,830,874**		872,437	3,305	1,083,102					3,020		694		
Solvent Evaporation	**36,005**	9,153	312		955	4,864	1,258	133	62		8,087		4,599	3,080
Gasoline Marketing	**13,856**	3,882			870	8,523	82	127	360					7
Landfills	**314,584**	311,734	1,264	430		627				18		154		
Miscellaneous	**17,204**	2	12,856	352		3,094	618	7		123	6	98	5	8
TOTAL	3,730,385	414,639	1,133,930	63,891	1,122,855	37,808	14,349	12,577	11,892	14,653	10,071	7,875	5,304	4,735
TOTAL, minus natural sources	**899,511**	**414,639**	**261,493**	**60,586**	**39,753**	**37,808**	**14,349**	**12,577**	**11,892**	**11,633**	**10,071**	**7,181**	**5,304**	**4,735**

Table 7.2 Estimated 1990 B.C. Toxic Air Emissions (tonnes) – Page 2 of 2

	Inorganic Sulphur Compounds	Halogenated Organics	Phenols	Amines	Ethers	Glycols	Organic Nitrogen Compounds	Terpenes	Epoxides	Carboxylic Acids	Organo – metallics	Anhydrides	Organic Sulphur Compounds	Dioxins (not TEQ)	Furans (not TEQ)	PCBs	Organic Phosphorous Compounds	Inorganic Chlorine Compounds
Mobile Sources																		
Aircraft			3								193							
Motor Vehicles																		
Light-Duty Gasoline							7			95								
Heavy-Duty Gasoline							1			7								
Light-Duty Diesel							2			24								
Heavy-Duty Diesel										30								
Road Dust																		
Railways										3								
Marine Vessels										1								
Off-Road										6								
Point Sources																		
Plastic Products																		
Wood Industries								5						0.27	0.10			
Paper and Allied Products	1,720													0.02	0.01			
Primary Metals Industry																		
Fabricated Metals Industry																		
Non-Metallic Mineral Industry																0.00014		
Refined Petroleum Industry													0.01					
Chemical Industry			10															
Transportation Industry																		
Storage and Warehousing Industry																		
Utility Industries (except Communications)																		
Other Point Sources	1												0.01	0.02	0.01			
Area Sources																		
Space Heating																		
Residential			783															
Commercial/Institutional/Industrial																		
Burning																		
Agricultural				699														
Natural Sources								868,316										
Solvent Evaporation		1,597	9	1	672	554	312	4	312	1		41	0.42					
Gasoline Marketing		4					1											
Landfills		43						314										
Miscellaneous			4		3		1			26								
TOTAL	1,721	1,644	809	700	675	554	325	868,638	312	194	193	41	0.45	0.31	0.11	0.00014	0	0
TOTAL, minus natural sources	**1,721**	**1,644**	**809**	**700**	**675**	**554**	**325**	**322**	**312**	**194**	**193**	**41**	**0.45**	**0.31**	**0.11**	**0.00014**		

For a regional breakdown of the estimated emissions of particulates and toxic chemical substances, see Table 7.3, which provides the percentages of estimated 1990 B.C. emissions that were released within the GVRD. Overall, the GVRD accounted for 14 per cent of non-natural particulate emissions and 27 per cent of non-natural toxic chemical substance emissions in the province. The GVRD's contribution for different sources varied. For example, the GVRD contributed very small percentages of the emissions from railways, wood industries, paper and allied products, the primary metals industry, the chemical industry, burning and natural sources. On the other hand, the GVRD contributed much larger percentages of the emissions from the plastic products industry, the fabricated metals industry, the non-metallic mineral industry and the refined petroleum industry.

Table 7.3 GVRD Contribution to B.C. 1990 Estimated Toxic Air Emissions

	TSP (tonnes)	Percent in GVRD	Total of Chemical Groups (tonnes)	Percent in GVRD
Mobile Sources				
Aircraft	300	35%	1,749	56%
Motor Vehicles				
Light-Duty Gasoline	2,557	48%	75,374	56%
Heavy-Duty Gasoline	200	20%	1,730	23%
Light-Duty Diesel	589	27%	942	28%
Heavy-Duty Diesel	7,709	25%	11,196	26%
Road Dust	104,411	36%	104,411	36%
Railways	16,502	3%	18,219	3%
Marine Vessels	827	32%	7,458	40%
Off-Road	686	28%	3,842	28%
Point Sources				
Plastic Products	64	84%	1	
Wood Industries	41,736	7%	1,364	0%
Paper and Allied Products	48,255	3%	3,760	0%
Primary Metals Industry	6,873	7%	1,134	0%
Fabricated Metals Industry	238	99%	1	
Non-Metallic Mineral Industry	2,272	34%	21	71%
Refined Petroleum Industry	565	74%	9,643	90%
Chemical Industry	1,384	5%	1,046	5%
Transportation Industry	3,989	96%	4	
Storage and Warehousing Industry	2,674	49%	3	
Utility Industries (except Communications)	147	20%	1	
Other Point Sources	10,090	4%	442	0%
Area Sources				
Space Heating				
Residential	2,690	17%	14,495	16%
Commercial/Institutional/Industrial	202	33%	476	48%
Burning	151,714	0%	216,846	0%
Agricultural	8,753	7%	43,707	14%
Natural Sources	7,019	4%	2,830,874	0%
Solvent Evaporation	0		36,005	47%
Gasoline Marketing	0		13,856	40%
Landfills	1,866	44%	314,584	35%
Miscellaneous	1,728	52%	17,204	5%
TOTAL	426,038	13%	3,730,385	7%
TOTAL, minus natural sources	**419,019**	**14%**	**899,511**	**27%**

7.3 IMPLEMENTATION AND RESULTS

Reductions in air pollution were not the subject of a specific FRAP deliverable, but they are discussed briefly here.

According to the National Pollutant Release Inventory (NPRI, a non-FRAP-funded Environment Canada database)[2], Fraser Basin releases of several air pollutants decreased during the latter years of the Fraser River Action Plan. Table 7.4 lists substances released to air in the Fraser Basin, as reported to the NPRI. The table also includes the reported releases of each substance during a base year (usually 1993), projected releases for 1997, the percentage change and the principal operations reporting release of the substance[3].

Fourteen of the 33 substances in Table 7.4 are associated with refineries. Air releases of all but one of these substances decreased by 56 to 100 per cent from 1993 to1997. These reductions resulted from the closing of two refineries and from reductions at two others. Releases of substances associated with pulp mills were generally down, with one exception (sulphuric acid), while emissions associated with a mine were up slightly. Reported releases of two substances (isopropyl alcohol and methyl tert-butyl ether) increased considerably.

---

[2] Any facility of 10 employees or more that manufactures, processes or otherwise uses 10 tonnes/year or more of any of 178 NPRI-listed substances must report releases or transfers of those substances to Environment Canada.

[3] At the time of writing, NPRI data was available for 1993, 1994 and 1995. In addition, with their 1995 submissions (prepared in 1996), facilities provided projections for 1996, 1997 and 1998.

Table 7.4 Fraser Basin Air Releases Reported to the National Pollutant Release Inventory

			Reported Releases to Air (tonnes)		
Substance	**Largest Emitter(s)**	**Base Year**	**Base Year**	**Project-ed for 1997**	**Percent Change**
Methanol	pulp mills	1993	1,267.3	951.8	**down 25%**
Acetone	mine	1993	300.0	353.8	**up 18%**
Isopropyl alcohol	packaging plant	1993	42.0	151.0	**up 260%**
Chlorine dioxide	pulp mills	1994	116.0	87.0	**down 25%**
***Xylene (all isomers)**	refineries	1993	224.3	84.1	**down 62%**
***Toluene**	refineries	1993	196.6	63.2	**down 68%**
Hydrochloric acid	mine, pulp mills	1995	56.7	59.8	**up 6%**
Sulphuric acid	pulp mills	1993	45.7	54.0	**up 18%**
***Styrene**	plastics plants	1994	28.6	35.2	**up 23%**
***Chloroform**	pulp mill	1995	35.0	35.0	**down 0%**
n-Butyl alcohol	packaging plant	1994	22.1	25.0	**up 13%**
***Benzene**	refineries	1993	57.4	20.6	**down 64%**
Ethylene	refineries	1993	51.6	18.1	**down 65%**
Cyclohexane	refineries	1993	37.3	16.3	**down 56%**
Ammonia (total)	wood preserver	1995	15.5	15.0	**down 3%**
Ethylbenzene	refineries	1993	43.4	13.3	**down 69%**
***Methyl *tert*-butyl ether**	refinery	1993	7.7	11.9	**up 55%**
Propylene	refineries	1993	58.7	11.9	**down 80%**
Copper (and its compounds)	bulk terminal	1994	7.0	8.0	**up 15%**
1,2,4-Trimethylbenzene	refineries	1993	38.4	6.2	**down 84%**
Zinc (and its compounds)	bulk terminal	1994	6.7	5.9	**down 12%**
Chlorine	pulp mills	1993	26.9	2.3	**down 91%**
***Lead (and its compounds)**	bulk terminal	1994	2.5	2.3	**down 9%**
Hydrogen fluoride	mine	1994	1.8	1.9	**up 4%**
***1,2-Dichloroethane**	chemical plant	1994	1.3	1.5	**up 16%**
Methyl ethyl ketone	paint plant	1993	2.1	1.0	**down 50%**
Naphthalene	refineries	1993	3.5	0.8	**down 79%**
Manganese (and its compounds)	refinery	1993	14.1	0.3	**down 98%**
Phthalic anhydride	plastics plant	1993	1.1	0.1	**down 91%**
***Ethylene glycol**	bulk terminal	1994	2.3	0.0	**down 99%**
Diethanolamine (and its salts)	refineries	1993	15.3	0.0	**down 100%**
Cumene	refineries	1993	4.4	0.0	**down 100%**
Anthracene	refinery	1993	1.2	0.0	**down 100%**

Notes for Table 7.4

- Any facility of 10 employees or more that manufactures, processes or otherwise uses 10 tonnes/year or more of any of 178 NPRI-listed substances must report releases or transfers of those substances to Environment Canada.
- Data for some substances could not be analyzed due to data limitations. The substances listed account for over 99% of total reported releases.
- At the time of writing, NPRI release data was available for 1993, 1994 and 1995. In addition, with their 1995 submissions (prepared in 1996), facilities provided projections for 1996, 1997 and 1998.
- For some substances, 1993 is an inappropriate base year because of incomplete reporting or inadequate estimation techniques.

* *Canadian Environmental Protection Act* Schedule I or Priority Substances List substances

Deliverable 17 was not media-specific, and therefore related partly to airborne contaminants. It concerned substances listed in Schedule I of the *Canadian Environmental Protection Act* and substances on the Priority Substances List (PSL) established under the same Act. Schedule I and PSL substances in Table 7.4 are indicated with an asterisk. For five of these substances, reported air releases decreased, for one they remained level, and for three they increased.

7.4 CONCLUSIONS AND RECOMMENDATIONS

The Inventory of Sources and Emissions of Toxic Air Contaminants in B.C. incorporated a breadth of information that provided a starting point for better understanding and reducing air pollution in the Fraser Basin. However, some of the data is now out of date. Meanwhile, the National Pollutant Release Inventory provides annual data, which enables tracking of releases over time, but for a much more limited set of pollution sources.

Recommendation:

1. The Inventory of Sources and Emissions of Toxic Air Contaminants should be updated to reflect the current situation, but in a manner that is completely compatible in both format and content with the NPRI. Ideally, the revised data could be seamlessly incorporated into the NPRI. The revised inventory should also allow analyses of different geographic areas, such as the Fraser Basin only.

8.0 CONCLUSIONS AND RECOMMENDATIONS

These conclusions and recommendations are derived from the results of the pollution abatement activities of the Fraser River Action Plan described in the main body of this report. Findings that address water pollution sources and loadings in the Fraser Basin are discussed first. These are followed by specific conclusions and recommendations for each of the six pollution abatement program areas.

The objectives for the pollution abatement component were articulated in a subset of the FRAP 48 deliverables. The key deliverables for each area of activity are identified under each major heading below and indicated by the ⇒ symbol.

8.1 WATER POLLUTION SOURCES AND LOADINGS

⇒ **Develop and maintain an inventory of major pollution sources and loadings in the basin.**

Inventories and wastewater characterization studies conducted in each program area of the pollution abatement component of FRAP provide some information on the major pollution sources in the Fraser Basin. In the process of developing the inventories, FRAP undertook or contributed to the development and maintenance of three new database systems that assist in the management of information on pollution sources and the quantities and qualities of their discharges.

8.1.1 Basin Wide Inventories

The Fraser Point Source Inventory database documents all direct effluent discharges to Fraser Basin waters authorized in permits issued by the B.C. Ministry of Environment, Lands and Parks (BC MELP). This geo-referenced database contains information on allowable discharge volumes and parameter concentration limits, and can be used to calculate maximum permissible loadings for different parameters. No such capability or information base existed at the outset of FRAP. In the final years of FRAP, BC MELP upgraded its permit system so that all permit information is now recorded in a "WASTE" database maintained by BC MELP regional offices.

Recommendation:

1. Future efforts to compile inventories of effluent discharges should be based on the extraction and manipulation of data from the BC MELP WASTE permit system.

The Fraser Basin Effluent Monitoring Database, a component of Environment Canada's national Envirodat database, is capable of storing and searching actual monitoring data for a spectrum of effluent quantity, quality and toxicity parameters. Effective utilization of this database is limited by two factors: (i) the lack of accessible, quality data to enter in the database; and (ii) the fact that the majority of available data were, and still are, in paper format, requiring tedious and error-prone manual transcription into the database. By 1997, pulp and paper compliance monitoring data comprised the only comprehensive set in the database. However, the pulp and paper industry accounts for over 90 per cent of the permissible loadings of total suspended solids (TSS) and biochemical oxygen demand (BOD) to Fraser Basin waters. Therefore, even with limited data, the database enabled better tracking of industrial water pollution releases than was possible at the outset of FRAP.

Recommendations:

2. Government agencies involved in effluent monitoring should co-ordinate their efforts to ensure that all future effluent monitoring results—whether generated by government or through compliance monitoring by industry—are reported in an easily manipulable electronic format, and made readily available (subject to legal confidentiality requirements).
3. Regulated industries should be encouraged to report their compliance monitoring data electronically to the relevant jurisdictions.

Information about federal and non-federal contaminated sites is recorded in the Site Information System (SITE, a provincial database supported by FRAP). SITE enables regulatory agencies to retrieve contaminated site data to assist in the assessment and remediation process, and provides public access to information regarding possible contamination of specific properties. As of December 1997, half of the B.C. contaminated sites registered in the database were located in the Fraser Basin, with the following distribution:

Upper Fraser (Prince George)	17%
Middle Fraser (Williams Lake)	5%
Thompson (Kamloops)	10%
Lower Fraser (Surrey)	68%

Because there is no legal requirement to report assessment and remediation activities on federal lands, accurate reporting on the progress of federal site remediation is not possible.

Recommendation:

4. A contaminated sites inventory or database should be established for federal contaminated sites.

8.1.2 Regional and Sectoral Analysis

Estimates of the total loading of pollutants to various reaches of the Fraser River Basin were inhibited by a lack of available data on the actual flows and concentrations of contaminants delivered to the basin by various sources. While actual monitoring data on pollutant discharges were available for large sewage treatment plants and pulp and paper mills, loadings from other point sources had to be estimated from permits. For combined sewer overflows (CSOs), landfills and urban runoff, loading estimates were extrapolated from very limited wastewater characterization data and studies based on runoff coefficients. In the case of agricultural runoff, comparable data were not available on a regional basis.

Comparison of regional loading estimates required data on a common set of pollution parameters. This further narrowed the evaluation to BOD and TSS, which represent groups of contaminants rather than single compounds. BOD is a measure of the oxygen used in the biochemical degradation of organic matter and the oxygen used to oxidize inorganic material; TSS represents the group of organic and inorganic particles larger than 1 μm. Table 8.1 shows the relative contributions of different types of discharges to overall BOD and TSS loading estimates for each region.

Table 8.1 Regional Comparison of BOD and TSS Loadings

Source	Loadings to Region (kg/day) [1]						
	Upper Fraser		Middle Fraser	Thomp-son	Lower Fraser		Total Basin
	1991	1998	1998	1998	1991	1998	1998
Municipal Sewage							
TSS	1,440	830	340	350	27,230	7,940	9,460
BOD	1,190	830	270	350	57,600	8,420	9,870
CSOs							
TSS	0	0	0	0	670	670	670
BOD	0	0	0	0	770	770	770
Landfill Leachate							
TSS	6	6	8	18	270	70	102
BOD	3	3	3	8	240	30 [2]	44
Urban Runoff							
TSS	15,000	15,000	2,500	4,500	150,000	150,000	172,000
BOD	1,100	1,100	200	300	11,000	11,000	12,600
Industrial [2]							
TSS		22,400	13,710	5,600		8,350	50,060
BOD		10,040	4,600	3,670		4,310	22,630

Notes to Table 8.1

1. Loading estimates provided for 1991 in cases where major sewage treatment plan upgrades will occur.

2. Industrial loadings for pulp mills are based on 1995 effluent compliance monitoring data. Industrialoadings for other industries are estimated as 75 per cent of 1997 BC MELP permit limits.

Except in the lower Fraser, industrial discharges dominate TSS and BOD loadings to basin waters. In the lower Fraser, urban runoff is estimated to be the dominant source of TSS loadings. Once the Greater Vancouver Regional District's (GVRD) Annacis Island and Lulu Island sewage treatment plant upgrades are completed at the end of 1998, municipal and industrial discharges will contribute approximately equal amounts of TSS to the lower Fraser. Industrial discharges will contribute approximately half the BOD loading of municipal or urban runoff.

Looking at aggregate discharges to the entire basin, industrial discharges are the single largest source of TSS and the largest source of BOD, while urban runoff is estimated to be the largest source of TSS and the second largest source of BOD. Once the GVRD sewage treatment upgrades are completed, municipal sewage will rank third in terms of overall loadings of BOD and TSS to the Fraser Basin. The combined loadings from CSOs and landfill leachate comprise less than 5 per cent of the loadings from municipal sewage discharges.

Although Table 8.1 provides an approximation of the relative importance of various effluent sources in four regions of the basin, simply estimating average daily loadings on an aggregate basis does not describe the potential impacts on aquatic life. In reality, the quantities of pollutants released to the Fraser River and its tributaries vary considerably with time and site. The general question of environmental effects, which also depend on the sensitivity of the receiving environment and the resources at risk, is addressed in FRAP report 98-11.

Recommendations:

5. Methods to more accurately assess the quantity of pollutants released by urban and agricultural runoff should be tested in pilot watersheds as opportunities arise.
6. Efforts to reduce municipal effluents in the Fraser Basin should continue to focus on sewage treatment plant discharges. With the exception of site-specific concerns such as along tributary rivers or streams with limited dilution, CSO and landfill leachate effluents should be a lower priority.

8.1.3 Wastewater Characterization Studies

Further insight into the quality of wastewater discharges for a broader range of contaminants was provided by wastewater characterization studies of industrial effluents and urban runoff discharges. The results confirm the finding of the Fraser Point Source Inventory that, among the industries characterized at the outset of FRAP, pulp and paper mill discharges were the major source of BOD and TSS. Additionally, the pulp and paper mill effluents characterized were shown to be important sources of zinc, chromium, copper, dioxins and furans, polycyclic aromatic hydrocarbons (PAHs), resin acids and chlorophenolics. More recent data provided by the Fraser Basin Effluent Monitoring Database show that reductions in BOD, TSS, and dioxin and furan loadings have been achieved by pulp and paper operations during FRAP.

The characterization studies reveal that smaller industrial operations also contribute significant contaminant loadings to the Fraser River Basin. Fish processor TSS loadings were found to be in the range of tens of kg per day. BOD loadings were slightly higher, around a hundred kg per day. Copper and zinc were detected, generally at loading levels in the order of tens of grams per day. Most of the other industrial sources characterized, including sawmills, cement plants, and chemical and manufacturing industries, were also shown to be sources of copper, zinc and arsenic. A comparison of toxicity responses reveals that, while most of the pulp mill effluents characterized were not acutely toxic to rainbow trout, acute toxicity was often measured in the effluents tested from the smaller industries.

Limited characterizations of urban stormwater runoff showed that, although loadings are sporadic and concentrated in rainy fall and winter months, urban runoff discharges are a source of metals (aluminum, copper, arsenic, chromium, lead, nickel and zinc), particularly in high automotive traffic and industrialized catchment areas. The pesticide 2,4-D was detected in urban runoff from a mixed residential/commercial area and a golf course. Toxicity tests indicated that urban runoff was not acutely toxic to rainbow trout.

The characterization and inventory work described above revealed that pollution was released not only by large industrial and municipal sewage treatment plant discharges, but also by small and medium industries and urban runoff. The impact of these smaller, more diffuse sources could be particularly significant during low flow periods of the year or when the collective loadings of their discharges are considered.

Recommendation:

7. Future ecosystem initiatives should continue to emphasize efforts to inventory and reduce pollution from smaller industrial operations and urban runoff. Liquid waste management planning, sewer use control and pollution prevention planning processes present good opportunities to address these sources.

8.2 INDUSTRIAL DISCHARGES

⇒ **Reduce environmentally disruptive industrial effluent discharges by 30% to meet environmental quality objectives.**

Estimates of loadings based on allowed discharge limits and concentrations stipulated in BC MELP permits indicate that, basin-wide, maximum permissible loadings remained fairly constant from 1993 to 1997 for most parameters. However, unchanged permit limits do not necessarily mean unchanged effluent discharges, since industries tend to maintain existing permits even if their discharges are reduced. Effluent compliance monitoring provides a more accurate assessment of industrial effluent discharge trends in the basin. Monitoring data available for the pulp and paper industry, which accounts for over 90 per cent of permissible industrial TSS and BOD discharges in the basin, show steady reductions in discharges. Loadings of TSS, BOD, dioxins and furans from pulp and paper effluents declined 39 per cent, 38 per cent, 92 per cent and 93 per cent, respectively, between 1991 and 1996, although these reductions are not a direct result of FRAP.

The majority of FRAP's industrial projects aimed to deliver widespread pollution reductions over the long run. Actions to reduce pollution included the publication of guidance documents to improve environmental performance for 15 industrial sectors, the development of pollution prevention plans at two industrial facilities, and the demonstration of two new industrial processes.

Because most of the guidelines have been produced in the last two years of FRAP, it is not yet possible to measure the results of their implementation. However, early indications are promising. Experience elsewhere shows that, where implemented, the fish processor best practices could reduce organic loadings by 50 per cent. At grain terminals, application of one particular best practice for spilled grain has already yielded reductions in BOD and TSS discharges of 95 per cent and 89 per cent, respectively. The pollution prevention plan for Riverside's Williams Lake Sawmill pledges to reduce landfilled woodwaste by half. Finally, two innovative industrial processes demonstrated under FRAP demonstrate the potential for over 94 per cent reduction of all key parameters.

Recommendations:

8. The solutions to industrial pollution developed under FRAP have the potential to provide long term reductions beyond the 30 per cent target, but this will be achieved only if the information that has been reported on environmentally sound industrial practices and pollution prevention techniques continues to be disseminated. Practices and techniques developed under FRAP should be supported through dialogue with industry and inspections by government or third-party auditors.

9. Environment Canada should support the efforts of provincial, regional and municipal regulatory agencies, and industrial associations that have direct involvement with small and medium-sized industries, to build the FRAP pollution prevention guidelines and best management practices into their respective management frameworks.
10. Environmental Protection Branch staff should be trained in pollution prevention in order to transfer the wealth of information contained in the FRAP best practices and pollution prevention guidelines to Environment Canada's regulatory activities with industry.

8.3 MUNICIPAL DISCHARGES

⇒ **Reduce contaminant loadings from combined sewer overflows and untreated sewage discharges by 30% to meet environmental quality objectives.**

⇒ **Reduce the contaminant load from inadequately treated sewage discharges by 30% to meet environmental quality objectives.**

Achievement of target contaminant reductions for sewage and CSO discharges required undertakings far beyond FRAP's control. However, a request by the Minister of Fisheries and Oceans, coupled with substantial funding from federal and provincial governments, resulted in the GVRD implementing the Annacis Island and Lulu Island treatment plant upgrades. This essentially enabled the FRAP objective for inadequately treated sewage discharges to be exceeded.

Upgrades of the Annacis Island, Lulu Island and Lansdowne[1] plants to full secondary treatment will result in overall reductions of approximately 84 per cent in BOD loading and 68 per cent in TSS loading. Extrapolating from a Seattle Metro study, the Annacis Island and Lulu Island upgrades are expected to achieve metals and organic pollutant loading reductions of approximately 54 per cent and 66 per cent, respectively. In addition, upgrades at Chilliwack, Abbotsford, Williams Lake and Kent will contribute minor contaminant loading reductions. There are no untreated sewage discharges of significance in the Fraser Basin, except those associated with CSOs.

The GVRD has completed operational improvements to the Burrard Inlet CSO system, which was identified as a priority from inventories and characterization studies. These improvements are estimated to reduce discharge volumes to Burrard Inlet (not within the Fraser Basin) by over 30 per cent.

Within the Fraser Basin, operational improvements to CSOs in the New Westminster waterfront area have been approved by the GVRD Board, subject to 50 per cent cost-sharing with the province. When implemented, these improvements are projected to reduce CSO discharge volumes by approximately 15 per cent at New Westminster, or approximately 5 per cent to the Fraser Basin overall. Finally, the City of Vancouver is 35 years into a 100-year sewer separation program that will reduce CSO discharges to the Fraser River.

The numerous control technologies, design guidelines and educational programs developed by FRAP will assist in achieving the long-term sustainability of the Fraser Basin. Adoption of

[1] Lansdowne municipal wastewater treatment plant, Prince George

technologies and guidelines to improve the performance of cold climate lagoons, biological nutrient removal and on-site sewage disposal systems, biosolids treatment and disposal, and sewer use control programs should help to reduce sewage-related contaminant loadings.

The B.C. Ministries of Environment, Lands and Parks and of Health are in the process of revising outdated objectives and regulations related to sewage management. These revisions will significantly improve the regulatory regime for the control of sewage discharges, and Environment Canada looks forward to their early completion.

Recommendations:

11. Local governments should be encouraged to develop liquid waste management plans under the provincial *Waste Management Act*. In addition to committing to schedules for upgrading sewage treatment facilities where they are inadequate, these plans should also address issues such as source control, waste volume reduction, water recycling, beneficial reuse of biosolids, the capacity of water bodies and land to accept waste, stormwater management and environmental impacts.
12. A number of FRAP documents, such as those on sewage and biosolids treatment and disposal, sewer use control, and CSO and urban runoff assessments, would be useful in the development of liquid waste management plans. When plans are initiated, copies of the relevant documents will be provided to the local government's consultants. The development of a watershed management plan for the Lillooet River system should be continued in order to help ensure the protection of water quality in the system.
13. Although FRAP is now concluded, there will be a continued need for technology transfer and marketing of the products of FRAP. This should be carried out by Environment Canada during ongoing Fisheries Act activities and within the new Georgia Basin Ecosystem Initiative. As well, Environment Canada should examine technology transfer and marketing opportunities with partners such as the B.C. Ministries of Health and of Environment, Lands and Parks, DFO, and the B.C. Water and Waste Association.

8.4 URBAN RUNOFF

⇒ **Implement a strategy to reduce the contaminant loading from urban runoff by 30% to meet environmental quality objectives.**

Urban runoff water pollution is a challenge to measure and manage because its sources are numerous, complex, intermittent, variable and widely dispersed, and because no one jurisdiction is wholly responsible for controlling it. FRAP accomplished a necessary first step toward reducing contaminant loading from urban runoff by providing a much better understanding of both urban runoff pollution and techniques to manage it. Although the potential for reducing contaminant loading was identified, it is unknown whether this loading actually increased or decreased on a basin-wide scale during FRAP.

Overall conclusions of the studies on urban runoff quality and sources are that:

- The lower Fraser is the main source of urban runoff discharges in the basin, with 252 stormwater discharges identified in the Fraser River Estuary alone, not including tributaries;

- Urban runoff contributes suspended solids, oil and grease, metals (in particular aluminum, copper, chromium, zinc, nickel and lead), 2,4-D, PAHs, phthalate esters and trace amounts of dioxins and furans to waters of the Fraser Basin; and
- Vehicle traffic, industrial sites, car and truck washes, and golf courses are important sources of the urban runoff contaminants identified by FRAP.

A survey of stormwater management practices and expenditures in the Greater Vancouver region, as part of the GVRD Liquid Waste Management Planning process, provides more accurate information on current municipal practices and expenditures directed towards stormwater management. Some examples involve road maintenance, stormwater quality monitoring, emergency plans, stormwater facilities, by-laws and regulations, and public education.

FRAP developed best management practices to protect urban watersheds for local governments, car and truck wash facilities, golf courses and industrial facilities. Promotion of these best practices through trade magazines and conferences was carried out to encourage implementation.

Of all pollution sources, urban runoff is the area where individual citizens can make the greatest difference by changing their everyday habits and influencing decisions. Public education on urban runoff pollution was accomplished through distribution of the *Current Trends* publication, demonstration of a table-top urban runoff pollution model and a provincial non-point source pollution awareness campaign.

Four projects are underway to test the effectiveness of best practices and treatment methods for urban runoff at field scale. Most of these evaluations will be completed after the end of FRAP. Results from a wetpond project in the Fraser Glen area of Surrey show that the wetpond is effective in removing all monitored contaminants, with efficiencies ranging from 19 per cent for total nitrogen to 48 per cent for total zinc.

Recommendations:

14. Local governments should be required to include stormwater management practices when they initiate a liquid waste management planning process.
15. The best management practices and guidelines for urban runoff should be promoted through marketing and distribution to targeted individuals and organizations, in conjunction with inspection and monitoring to evaluate their effectiveness.
16. Pilot projects should be undertaken to demonstrate urban runoff best management practices for different sectors in selected small watersheds. The Georgia Basin Ecosystem Initiative should provide an opportunity to use such an integrated approach.
17. Environment Canada should support the proposed BC MELP Non-Point Source Action Plan by participating in technical working groups and co-ordinating with BC MELP on activities to improve urban runoff quality.
18. The involvement of community-based environmental groups in projects to enhance urban watersheds should be fostered by providing limited technical support and by identifying aspects of pilot projects (such as monitoring and education) that the groups could effectively undertake.

8.5 AGRICULTURE

⇒ **Implement a strategy to reduce the loading of nutrients, bacteria and agrochemicals from agricultural operations to ground and surface waters by 30% to meet environmental quality objectives.**

By collaborating with other government agencies and stakeholders, FRAP succeeded in developing a program and implementing a strategy to reduce contaminant loading from agricultural operations. The challenges involved in achieving and demonstrating a basin-wide reduction in agricultural pollution loading were recognized early in the program. Consequently, the program primarily focused on supporting research projects leading to better management practices, developing environmental guidelines and monitoring practices at the individual farm level.

Recommendations:

19. In order for agricultural non-point pollution programs to be successful, their structure must be well-defined; the roles of participating agencies must be clearly stated; and preliminary planning must be done before initiating studies to ensure that the necessary co-ordination and commitment are in place. As well, geographic areas with well-defined pollution problems should be selected.

20. The approach taken in the United States Environmental Protection Agency Section 319 National Monitoring Program and the experience gained in the Rural Clean Water Program should serve as models for future agricultural programs. EPA's experience suggests that, even in ideal cases, six to 10 years may be required to successfully demonstrate and evaluate the results of best practices or management approaches.

FRAP contributed to the development of a nutrient management model in order to identify risk areas for nutrient imbalances in the lower Fraser Valley. The lower Fraser Valley was broken into 20 zones and modeled based on livestock nutrient generation, commercial fertilizer use and crop requirements. South Matsqui was identified as the zone with the most serious nitrogen imbalance. South Matsqui approximately covers the area of the Abbotsford aquifer, which has a documented nitrate groundwater contamination problem. The West Matsqui, West Chilliwack and Abbotsford zones were also characterized as zones with high nitrogen imbalances. All four zones are associated with intensive animal production, including poultry and swine, which do not require a local land base for feed production. This results in a net importation of nutrients in areas not dependent on producing their own feed.

Nutrient imbalances can be managed in several ways. In zones where the land base is simply too small, removal of manure or the relocation of livestock to other areas is required to maintain current production. The former approach has been piloted successfully and is continuing to be developed in the South Matsqui zone. The model showed that changes such as reduced commercial fertilizer use, improvements in manure management and dietary changes could substantially reduce nutrient imbalances.

In practice, performance indicators such as manure storage capacity, commercial fertilizer use, and the adoption of new application methods and management systems need to be tracked in order to demonstrate improvements. Baseline information for some of these indicators has been established in pilot areas in the valley. For the dairy group, there was an apparent increase between 1994 and 1997 in the median manure storage time from 2.7

months to 3.5 months. However, in the order of 36 per cent of farms still had a storage capacity of less than three months.

Total retail fertilizer sales data did not indicate any trends up or down. However, these data were not presented in a way in which small geographic areas or specific users (agriculture, forestry, residential) could be separated. Inorganic fertilizer application rates for forage grass and silage corn, which together represent 31,336 of the total 53,269 hectares of land in crops in 1996, have dropped between 1991 and 1997 in the lower Fraser region. For these two crops combined, estimated annual fertilizer nitrogen use fell by 23 per cent (1,263 tonnes), phosphorus by 68 per cent (490 tonnes) and potassium by 91 per cent (1,471 tonnes).

Recommendations:

21. Tracking the development of animal production and cropping systems in the Fraser Valley should continue to be supported. A mechanism or process for implementing this should be determined through further consultation with stakeholders.
22. Continuing research is required to determine the extent to which commercial fertilizer nutrients can be replaced with manure and still maintain optimal crop yields, and to develop other improvements in management practices. Evaluating the adoption of improved or new practices on a regular basis, such as every three to four years, would serve as a short-term surrogate to actually measuring changes in receiving water quality, which would be expected to respond more slowly. Regular evaluation is particularly important in demonstrating the value of much of the research support provided to agriculture in the lower Fraser Basin, such as the pre-sidedress nitrogen test (PSNT) for silage corn and the fall raspberry soil nitrate test.
23. Monitoring is needed to better understand regional differences in atmospheric nitrogen deposition, which was identified as a limitation in the nutrient modelling exercise.

In North Matsqui, farm practices were tracked along with surface water quality conditions over a number of years to try to link land treatment activities with water quality. A limited cost-share assistance program was incorporated into the Canada-B.C. Green plan for agriculture and changes in farm practices were expected to occur as a result of the *Agricultural Waste Control Regulation*. In South Matsqui, nitrate groundwater contamination was also monitored.

Water quality monitoring in the North Matsqui area indicated a close relationship between stream nitrate levels and rainfall. Autumn dissolved oxygen levels in several lowland and flood-gated streams were reduced to saturation levels below the Level A protection level of 76 per cent that is recommended for protecting a freshwater salmonid population. The extent of the autumn-reduced dissolved oxygen levels (temporally and spatially) was not determined. Groundwater monitoring in South Agassiz supported previous studies describing the level of nitrate contamination, but with the use of nitrogen and oxygen isotope tests it was demonstrated that the nitrogen source was primarily poultry manure.

Recommendation:

24. Trends in ground and surface water quality should continue to be monitored. A more comprehensive evaluation of the water quality data collected in the North and West Matsqui zones is needed to learn more about and describe linkages between land uses and water quality. Additional efforts are required to establish the full extent of reduced oxygen levels in lowland and flood-gated streams in the Fraser Valley.

The provincial *Agricultural Waste Control Regulation* and its associated Code of Agricultural Practice for Waste Management marked a significant development in tackling agricultural pollution. Work supported by FRAP in the Thompson/Cariboo and lower Fraser regions demonstrated that an ongoing field presence by government agencies is beneficial to address agricultural waste management issues, largely because of the dynamic and diverse nature of the industry.

Recommendations:

25. An agency presence is desirable in the early implementation of regulations or codes of practice that deal with non-point pollution sources such as agriculture. Once it is determined that practices are being adopted to meet the legislation, other mechanisms involving less government input should be implemented.

26. Adequate baseline information is required prior to or in the early stages of regulation or code introduction in order to measure their success. This could be achieved by monitoring selected watersheds or sub-watersheds.

Information and educational are essential for reducing non-point source pollution. FRAP supported the development of environmental commodity guidelines in four sectors to transfer environmental information to producers. The guidelines are being used by the B.C. Horticultural Coalition (representing approximately 3,000 farmers) to develop self-auditing protocols. A Watershed Stewardship Guide for Agriculture developed jointly by DFO, BC MELP and EC provided producers with an information package on watershed features and stewardship practices. This educational product gave organizations such as the B.C. Cattlemen's Association an improved understanding of the important connections between land and water and the influence of their land management practices. Similarly, a Best Agricultural Waste Management Plan manual and an advanced forage management production guide were supported by FRAP and are in progress. Surveys indicated that producers were making changes because of environmental concerns.

Recommendation:

27. Because educational material explaining the importance of environmental features and stewardship is an important tool in addressing agricultural pollution, it should continue to be developed and supported by all interested stakeholders. Liaison with producer associations is needed to reinforce the information provided.

While two surveys cannot determine any real trends in pesticide sales, surveys of 1991 and 1995 sales indicated that five pesticides were common to the top-10 list in both years. These included glyphosate, metam, captan, mineral oil (herbicidal) and mancozeb. Agriculture producers as private land owners are not required to report their purchases or actual use of pesticides.

Recommendation:

28. Retail sales surveys provide some detail on pesticide "use," and the next survey would be for 1999 retail sales. Farm surveys in pilot areas or on specific commodities, in addition to retail sales surveys, should be used to assess the use and application of pesticides.

When FRAP began, very little information was available on the relationship between farm management practices and potential impacts on runoff and water quality in the lower mainland. A project was initiated to evaluate the manure management guidelines developed for the Fraser Valley. Preliminary results for silage corn indicated the benefits of a summer-planted relay crop in reducing the cumulative winter loading of total volatile residue winter loading. However, even with a relay crop, it is important not to manure fields in high-risk areas (*e.g.*, areas near watercourses or sloped land), since the initial flush from the field can be toxic to aquatic life and carries material with a high oxygen demand.

Recommendation:

29. Experimental designs using test plots incorporating best management practices (BMPs) vs. conventional practices should be used to demonstrate the environmental benefits of BMPs. Although this approach requires a multi-year commitment, the benefits would be demonstrated more quickly than they would in an ambient water quality program with the BMP being implemented slowly over time, over a large geographic area.

A lime pasteurization process on a number of wastes including poultry litter, dairy manure, fish offal and municipal biosolids was successfully demonstrated. Poultry manure in particular released large amounts of atmospheric ammonia during processing, but this can be controlled with an ammonia scrubber.

Recommendation:

30. A market analysis for the products produced by lime pasteurization should be conducted in order to determine if there is potential for part of the poultry litter waste stream to be managed in this way.

Vegetable greenhouse wastewater is high in nutrient content, and the surface flow configuration of an experimental constructed wetland reduced the nitrate, ammonia and phosphorus content by as much as 48-63 per cent, 50-70 per cent and 26-54 per cent, respectively. Even with this efficiency, an average size greenhouse of 2.4 hectares would generate the nitrogen loading of 15 typical family residences. The need to implement wetland treatment in this industry to address possible environmental concerns was not evaluated.

Recommendation:

31. Because vegetable greenhouse discharges can contribute large nitrogen loadings, they should be considered in any groundwater protection strategy. The environmental issues related to greenhouse discharges still need to be studied.

Limited monitoring of mushroom barn washwater quality showed that it generally had the characteristics of weak sewage and constituted an individual farm discharge to ground equivalent to a typical family residence. Pesticide levels in the wastewater were unacceptable for a direct discharge to a watercourse.

Recommendation:

33. Additional research needs to be carried out to fully evaluate the quality and quantity of mushroom farm washwater and any relationship to individual farm management practices.

8.6 CONTAMINATED SITES

⇒ **Clean up 70% of contaminated federal waste sites to CCME standards.**

Quantifying progress in cleaning up federal waste sites is a challenge because the baseline level of identified contaminated sites is steadily increasing and because there is a gap in the reporting of federal contaminated sites. At the beginning of FRAP, Environment Canada was involved in negotiating the assessment and cleanup of approximately 35 federal sites in the Fraser Basin. As of December 1997, the number of federal Fraser Basin sites that Environment Canada was actively involved with had grown to 140. While Environment Canada's guideline development and compliance promotion activities help to lessen the number of sites requiring remediation, new sites demand attention as they continue to be discovered. This trend is particularly noticeable in areas experiencing rapid population and industrial growth, such as the lower Fraser Basin.

Approximately 39 per cent (635 of 1,627) of all non-federal and federal contaminated sites in the Fraser Basin were remediated during the FRAP period. By comparison, about 11 per cent (15 of 140) of identified federal contaminated sites have been remediated in the basin. With only the *Fisheries Act* and the PCB regulations of the *Canadian Environmental Protection Act (CEPA)* as regulatory controls, there is little incentive for federal departments or agencies to consult with and report on assessment and remediation activities on federal lands to Environment Canada. This means that the actual number of federal contaminated sites recorded and cleaned up in the basin could be higher than reported.

Increased regulatory concern and public awareness have contributed to contaminated sites becoming an important environmental management issue in the Fraser Basin. In response, the Fraser River Estuary Management Program is now reviewing projects dealing with the management of contaminated sediments in its coordinated project review process. Many of the applications reviewed involve sites with contaminated sediments and/or groundwater. Sediment quality guidelines are a necessary tool to assist in the safe management of contaminated sediments for protection of aquatic life. Currently, only a few sediment quality guidelines are available. However, interim guidelines exist for many parameters of concern.

An important milestone in the proper management and control of contaminated sites in British Columbia was the introduction in 1997 of the provincial *Contaminated Sites Regulation* and the *Waste Management Amendment Act*. These progressive new regulations provide an effective framework to deal with the identification, assessment, cleanup and registration of non-federal contaminated sites in B.C., including the Fraser Basin.

Recommendations:

34. Regulatory or policy instruments should be developed to ensure that site assessment, remediation and reporting requirements equivalent to provincial guidelines and standards are in place for federal departments and agencies managing federal property.
35. The remediation of contaminated sediments requires further study and development to ensure that fair, scientific and appropriate remediation guidelines and standards are established.

8.7 AIRBORNE CONTAMINANTS

⇒ **Develop and maintain a toxics air emission inventory for major industrial sectors.**

⇒ **Reduce the release of persistent toxic substances pursuant to the *Canadian Environmental Protection Act* and identified as priority from inventories and environmental data to the extent allowed by best practicable technology.**

The Inventory of Sources and Emissions of Toxic Air Contaminants in B.C. catalogues particulate and toxic substance emissions from point, area and mobile sources as of 1990. The inventory contains valuable baseline information on air pollution in B.C. and the GVRD, thus providing a starting point for reductions.

Emission estimates can be reported by source or by chemical group. In 1990, 3.73 million tonnes of toxic chemical substances (as defined in the database) were emitted in B.C. Natural sources were the main source, accounting for 2.83 million tonnes. Industrial point sources contributed only 2 per cent of non-natural emissions of toxic chemical substance emissions. The GVRD contributed 14 per cent of non-natural particulate emissions and 27 per cent of non-natural toxic chemical substance emissions.

Because the Inventory was one of the early results of FRAP, some of the data are now out of date, and the database does not facilitate searches by geographic area.

The National Pollution Release Inventory (NPRI, a non-FRAP-funded Environment Canada database) provides more current information on airborne contaminants in the Fraser Basin. Between 1993[2] and 1997, emissions of substances associated with refineries declined by between 56 and 100 per cent, and pulp mill substance releases generally declined. Airborne releases from a mine increased, as did releases from two other substances. The NPRI was also used to track the release of persistent toxic substances pursuant to the Canadian Environmental Protection Act, as stated in FRAP deliverable 17. Nine *CEPA* Schedule I and PSL substances were reported as released to air. Emissions decreased for five of these substances, remained level for one substance and increased for three others.

Recommendations:

36. The Inventory of Sources and Emissions of Toxic Air Contaminants in B.C. should be updated to reflect current emissions and to make the database format and content compatible with the National Pollutant Release Inventory.

37. The revised Inventory should enable analysis of emissions from user-defined geographic areas, such as the Fraser Basin only.

[2] 1993 was the first year reported for most NPRI substances; some substances were not reported until 1994 or 1995.

8.8 OVERALL CONCLUSIONS

The pollution abatement component of the Fraser River Action Plan, which undertook to reduce pollution from a broad range of point and non-point pollution sources within the Fraser River Basin, was a challenging and ambitious initiative. Significant pollution reductions have been accomplished for some municipal and industrial discharges.

In the areas of urban runoff and agriculture, FRAP has improved the management techniques available for environmental stewardship and protection. With regard to discharges from some smaller industrial operations and sewage treatment systems, the numerous pollution abatement tools and techniques developed provide the potential for longer-term pollution reductions in the Fraser Basin.

Non-point sources such as agricultural and urban runoff remain a challenge for water quality protection in the Fraser Basin. Contaminated sites and releases from small and medium-sized industries are other important environmental management issues in the Fraser Basin. As the basin's population grows, additional effort will be needed to prevent and reduce contaminant releases from these sources.

APPENDIX A:

FRASER RIVER ACTION PLAN 48 DELIVERABLES

FRASER RIVER ACTION PLAN 48 DELIVERABLES

Sustainability

Develop a management program for sustainable development in the Fraser River Basin in partnership with the provincial and local governments and other basin stakeholders.

1. Prepare a "blueprint" for sustainable development.
2. Involve 5% of the basin's population in the planning and decision making process to create the Blueprint for Sustainability.
3. Expose 40% of the basin's population to the principles of sustainable development.

Pollution Prevention

Arrest and reverse the existing environmental contamination and degradation of the Fraser River ecosystem by developing targets and strategies to reduce pollution and by virtually eliminating the discharge of persistent toxic substances in the Fraser River.

4. Provide decision makers with a knowledge of non-market values produced by a healthy environment/ ecosystem.
5. For both public and private sectors, integrate environmental concerns in the planning and decision making process.
6. Through our partners, initiate the use of economic instruments in the basin.

7. Provide decision makers with knowledge of the cost effectiveness of various pollution abatement and habitat enhancement alternatives.
8. Develop and maintain an inventory of major pollution sources and loadings in the basin.
9. Reduce environmentally disruptive industrial effluent discharges by 30% to meet environmental quality objectives.
10. Reduce contaminant loadings from combined sewer overflows and untreated sewage discharges by 30% to meet environmental quality objectives.
11. Reduce the contaminant load from inadequately treated sewage discharges by 30% to meet environmental quality objectives.
12. Implement a strategy to reduce the loading of nutrients, bacteria and agrochemicals from agricultural operations to ground and surface waters by 30% to meet environmental quality objectives.
13. Implement a strategy to reduce the contaminant loading from urban runoff by 30% to meet environmental quality objectives.
14. Establish a Groundwater Protection Strategy which includes the remediation of high priority sites.
15. Clean up 70% of contaminated federal waste sites to CCME standards.
16. Develop and maintain a toxics air emission inventory for major industrial sectors.
17. Reduce the release of persistent toxic substances pursuant to the Canadian Environmental Protection Act and identified as priority from inventories and environmental data to the extent allowed by best practicable technology.
18. Provide new knowledge for environmental quality assessments and the development of objectives.
19. Measure and report on the condition of the basin.
20. Develop water quality objectives and criteria for contaminants of concern in the four main sub-regions of the basin.
21. Provide a provisional framework for developing ecosystem objectives.
22. Initiate a pilot project for ecosystem objectives.
23. Assess water quality relative to water quality objectives.
24. Assess contamination from major pollution sources.
25. Assess and report on the effectiveness of selected pollution abatements relative to the environment.
26. Achieve 90% compliance with environmental legislation in cooperation with provincial and federal enforcement agencies
    - Annually conduct approximately 180 inspections at federally regulated sectors discharging/ impacting in the basin, and initiate 8 - 10 investigations per year;
    - Prosecute violators having continuous or significant non-compliance;

- Participate in the development of compliance strategies, which include punitive and other instruments (e.g. economic incentives).

27. Target enforcement programs to assist in achieving the pollution abatement goals and environmental quality objectives of the program.
28. Establish an enforcement field office in Prince George and implement a pilot project for delivery of coordinated, effective and efficient enforcement programs in the basin.

In partnership with the other 4 parties to the Burrard Inlet Environmental Action Program Agreement:

29. Establish a sustainable development plan for the Inlet.
30. Develop and implement a long term, integrated, focused monitoring program to identify existing and emerging environmental problems and evaluate the effectiveness of abatement actions.
31. Establish water quality objectives for contaminants of concern as a guide for abatement actions.
32. Develop and maintain an inventory of all contaminant sources and loadings in the inlet.
33. Reduce environmentally disruptive industrial discharges by 30% to meet environmental quality objectives.
34. Reduce contaminant loadings from combined sewer overflows by 30% to meet environmental quality objectives.
35. Reduce contaminant load from urban runoff by 30% to meet environmental quality objectives.
36. Develop and implement a dredge material management plan and sediment remediation strategy for dredging and disposal of contaminated sediments as part of site remediation and maintenance programs.
37. Develop and implement land use classification criteria and strategy to protect existing habitats.
38. Develop and maintain an environmental review process for expanded and new development projects proposed for the Inlet.

Habitat Restoration and Conservation

Restore the productivity of the natural environment by restoring and enhancing environmental quality and the natural productive capacity of the Fraser River ecosystem.

39. Directly protect 15 ha. of estuary land.
40. Track and protect additional habitat in the lower Fraser uplands through cooperative stewardship initiatives and publish two maps and two technical reports.
41. Retain 1200 ha. of farmland, annually, as seasonal bird habitat, and control crop damage.
42. Complete (at least) six interior wetlands demonstration projects
    - Protect 100 ha. at Salmon Arm in Year 2.

43. Deliver annually, and report on, coordination/ extension liaison function with ranchers to
    - Improve ranchers' understanding of wetland values;
    - Reduce the impact of grazing on wetlands;
    - Increase wetland productivity for wildlife on private lands.
44. Map and analyze critical interior habitats and report on forest fragmentation/ biodiversity.
45. Develop procedures to protect critical forest habitats
    - Produce (up to) four operational level pamphlets on selected forest habitat management issues;
    - Produce a technical report on managing for cavity nesters.
46. Jointly develop guidelines for the protection of riparian zones after holding a workshop and publishing proceedings.
47. Integrate wildlife values into forest management policies through participation on PAS, CORE, IRPC, Inter-Ministry Biodiversity Group, and RIC.
48. Demonstrate methods to maintain forest bird diversity
    - Produce a report on integration of Shuswap bird data with other biodiversity attributes;
    - Complete identification of bird groups with common habitat dependency.

APPENDIX B:

FRAP REPORTS

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
INDUSTRIAL				
EFFLUENT POINT SOURCE INVENTORY AND DATABASE FOR THE FRASER RIVER BASIN	93-05	Westwater Research Centre	Apr 93 (revised Mar 95)	Andrew Green
USER'S MANUAL - FRASER POINT SOURCE INVENTORY	93-06	Informatics (DOE)	Jun 94	Andrew Green
EFFECTS OF ABANDONED MINE TAILINGS AT WELLS, B.C. ON THE AQUATIC ECOSYSTEM OF JACK OF CLUBS LAKE, PART I: RECONNAISSANCE STUDY	93-07	Geological Survey of Canada		Andrew Green
EVALUATION OF THE PEEP INDEX AND RECOMMENDED TOXICITY TESTS FOR THE FRASER BASIN	93-09	Environmental Management Associates and Hydrological Laboratories Ltd.	May 93	Andrew Green
EFFLUENT CHARACTERIZATION STUDY	93-13	Technology Resource Inc. and McLeay Associates Ltd.	Feb 94	Andrew Green
INITIAL DILUTION ZONE IMPACT ASSESSMENT OF SELECTED INDUSTRIES IN THE FRASER RIVER ESTUARY	93-14	Norecol, Dames & More Inc.		Andrew Green
READY MIX CONCRETE INDUSTRY ENVIRONMENTAL CODE OF PRACTICE, 1993 UPDATE	93-26	Envirochem Special Projects Inc.	Mar 93	David Poon
EVALUATION OF LEACHATE QUALITY FROM PENTACHLORO-PHENOL, CREOSOTE, & ACA PRESERVED WOOD PRODUCTS	93-36	Envirochem Special Projects Inc.	Jan 94	Stan Liu
CHEMISTRY AND TOXICITY OF THREE WASTEWATERS	93-38	Hydroqual Labs Ltd.	May 93	Andrew Green
WASTEWATER CHARACTERIZATION OF FISH PROCESSING PLANT EFFLUENTS	93-39	NovaTec Consultants Inc. and EVS Environment Consultants	Mar 94	David Poon
WASTEWATER CHARACTERIZATION OF FOUR INDUSTRIAL DISCHARGES IN THE FRASER RIVER BASIN - VOLUME I	94-09	IRC Inc.	Mar 94	Andrew Green

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
WASTEWATER CHARACTERIZATION OF FOUR INDUSTRIAL DISCHARGES IN THE FRASER RIVER BASIN - VOLUME II	94-10	IRC Inc.	Mar 94	Andrew Green
GUIDE FOR BEST MANAGEMENT PRACTICES FOR PROCESS WATER MANAGEMENT AT FISH PROCESSING PLANTS IN B.C.	94-20	Novatec Consultants Inc.	Sep 94	David Poon
PLUME DELINEATION OF A PULP & PAPER MILL OUTFALL USING AIRBORNE MULTISPECTRAL IMAGERY & RHODAMINE DYE	94-23	Borstad Associates	Oct 94	Andrew Green
REFERENCE WORKBOOK: POLLUTION PREVENTION PLANS	94-35	PCA Consultants Ltd.	Dec 94	David Poon
CHEMICAL USE AND POLLUTION PREVENTION PRACTICES FOR COMMERCIAL CAR AND TRUCK WASH FACILITIES	95-06	UMA Engineering Ltd.	Jun 95	Marielou Verge
BMP'S FOR THE SHIP & BOAT BUILDING AND REPAIR INDUSTRY IN B.C.	95-14	PCA Consultants	Sep 95	Stan Liu
BMP'S FOR THE SHIP & BOAT BUILDING AND REPAIR INDUSTRY IN B.C. - BACKGROUND DOCUMENT	95-15	PCA Consultants	Sep 95	Stan Liu
BMP'S FOR MARINAS AND SMALL BOATYARDS IN B.C.	95-16	PCA Consultants	Sep 95	Stan Liu
GUIDELINES ON STORAGE, USE, AND DISPOSAL OF WOOD RESIDUE FOR THE PROTECTION OF FISH AND FISH HABITAT IN BRITISH COLUMBIA	95-18	Liu, Nassichuk & Samis	Mar 96	Stan Liu
TECHNICAL GUIDE FOR THE DEVELOPMENT OF POLLUTION PREVENTION PLANS FOR FISH PROCESSING OPERATIONS IN THE LOWER FRASER BASIN	95-23	Novatec Consultants Inc.	Aug 95	David Poon
ENVIRONMENTAL PROTECTION FOR THE AUTOMOBILE RECYCLING INDUSTRY IN BC - 3 VOLUMES (BMP, P2, C of P)	96-02	El Rayes Environmental	Mar 15 96	David Poon
TECHNICAL POLLUTION PREVENTION GUIDE FOR THE DAIRY PROCESSING OPERATIONS IN THE LOWER FRASER BASIN	96-11	PCA Consultants Ltd.	Dec 97	David Poon
TECHNICAL POLLUTION PREVENTION GUIDE FOR ASPHALT PREPARATION OPERATIONS IN THE LOWER FRASER BASIN	96-12	NovaTec Consultants Inc.	Dec 96	David Poon
TECHNICAL POLLTUION PREVENTION GUIDE FOR DRY BULK TERMINALS IN THE LOWER FRASER BASIN	96-19	PCA Consultants Ltd.	May 95	David Poon
TECHNICAL POLLUTION PREVENTION GUIDE FOR FOUNDRIES IN THE LOWER FRASER BASIN OF B.C.	97-02	Kent Engineering Ltd.	Mar 95	David Poon

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
STORMWATER BEST MANAGEMENT PRACTICES FOR SELECTED INDUSTRIAL SECTORS IN THE LOWER FRASER BASIN	97-03	PCA Consutants Ltd.	Sep 95	David Poon
SUMMARY TECHNICAL REPORT: RICHMOND LANDFILL 1996 POLLUTION PREVENTION PLAN	97-07	Reid Crowther and Partners	Jul 97	Andrew Green
FRASER RIVER PULP MILL EFFLUENTS: INTERPRETATION OF NORTHWOOD EFFLUENT CHARACTERIZATION DATA - FINAL REPORT	97-10	UBC Civil Engineering Dept.	Mar 96	Andrew Green
TRANSCONTINENTAL PRINTING INC.: FULL SCALE DEMONSTRATION OF A TREATMENT TECHNOLOGY TO REDUCE CONTAMINANTS AND RE-USE WATER IN THE PRINTING AND GRAPHICS INDUSTRY	97-12	Novatec Consultants & Maratek Environmental	Sep 97	Andrew Green
TECHNICAL POLLUTION PREVENTION GUIDE FOR READY MIXED CONCRETE OPERATIONS IN THE LOWER FRASER BASIN	97-13	Envirochem Special Projects Inc.	Sep 97	David Poon
TECHNICAL POLLUTION PREVENTION GUIDE FOR PRESSURE WOOD PRESERVATION FACILITIES IN THE LOWER FRASER BASIN	97-14	Envirochem Special Projects Inc.	Sep 97	David Poon
AEROBIC BIOTRANSFORMATION OF TOXIC ORGANICS IN WASTEWATER	97-15	Enviromega Ltd.	Sep 97	Andrew Green
TECHNICAL POLLUTION PREVENTION GUIDE FOR BREWERY AND WINERY OPERATIONS IN THE LOWER FRASER BASIN	97-20	El Rayes Environmental Corp.	Oct 97	David Poon
NORTHWOOD PULPMILL - WINTER 1996. RESIN ACIDS AND 1994-1996 CHLOROPHENOLIC COMPOUNDS SUMMARY REPORT.	97-51		Mar 98	George Derksen
TECHNICAL SUMMARY REPORT POLLUTION PREVENTION PLAN RIVERSIDE FOREST PRODUCTS WILLIAMS LAKE MILL	98-04	Reid Crowther & Partners Ltd.	Mar 98	Andrew Green
REDUCTION OF CHROMATED COPPER ARSENATE (CCA) WOOD PRESERVATIVE LEACHATES FROM POLE STORAGE YARDS IN THE FRASER RIVER REGION	98-05	Powertech Labs Inc.	Mar 98	Andrew Green
BIOSOLID STABILIZATION DEMONSTRATION PROJECT	98-06	Ian Shand and Associates Inc.	Mar 98	Andrew Green
PROCESSING AND HOMOGENEITY TESTING OF A STANDARD REFERENCE MATERIAL FOR ACIDIC ROCK PREDICTION TECHNOLOGIES	No report #	CANMET and MEND		Andrew Green

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT

MUNICIPAL, URBAN, CSOs

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
RECOMMENDED GUIDELINES FOR WASTEWATER CHARACTERIZATION IN THE FRASER RIVER BASIN VOLUME I - DEVELOPMENT DOCUMENT	93-10	Norecol Consultants	Jun 93	Phil Wong
RECOMMENDED GUIDELINES FOR WASTEWATER CHARACTERIZATION IN THE FRASER RIVER BASIN VOLUME II - DRAFT METHODS MANUAL	93-11	Norecol Consultants	Jun 93	Phil Wong
URBAN RUN-OFF QUANTIFICATION AND CONTAMINANTS LOADING IN THE FRASER BASIN AND BURRARD INLET	93-19	Stanley Associates	Dec 92	Marielou Verge
SEWER USE CONTROL FOR THE FRASER RIVER BASIN AND BURRARD INLET DRAINAGE BASIN	93-20	UMA Engineering	Jul 93	Phil Wong
COMBINED SEWER OVERFLOW INVENTORY FOR FRASER RIVER AND BURRARD INLET	93-21	UMA Engineering	Oct 92	Marielou Verge
CSO AND UR INVESTIGATIVE ASSESSMENT GUIDELINES	93-37	NovaTec Consultants Inc.	Nov 93	Marielou Verge
INVENTORY OF MUNICIPAL STORMWATER DISCHARGES WITHIN THE FRASER RIVER ESTUARY	93-38	UMA Environmental	Jan 94	Marielou Verge
EFFLUENT DISPERSION FROM THE LANSDOWNE ROAD WASTEWATER TREATMENT CENTRE - CITY OF PRINCE GEORGE	94-05	Seaconsult Marine Research	Dec 95	Phil Wong
DISTRICT OF HOPE SEWAGE TREATMENT STUDY	94-12	Dayton & Knight Ltd.	Mar 94	Phil Wong
OPTIMIZATION OF BIOLOGICAL PHOSPHORUS & AMMONIA REMOVAL IN A COMBINED FIXED & SUSPENDED GROWTH WASTEWATER TREATMENT SYSTEM	94-24	BCRI	Dec 94	Phil wong
SEWAGE LAGOON DESIGN USING WETLANDS & OTHER UPGRADING TECHNOLOGIES TO ACHIEVE NON-ACUTELY TOXIC EFFLUENT	94-34	Novatec	Feb 95	Phil Wong
EFFLUENT DISPERSION IN THE FRASER RIVER FROM THE GLENBROOK COMBINED SEWER OVERFLOW AT NEW WESTMINSTER, BC	95-22	Seaconsult Marine Research	Jun 95	Phil Wong
INVENTORY OF GOLF COURSES IN THE FRASER RIVER BASIN	96-25	UMA Environmental	Jun 97	Marielou Verge

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
GREENING YOUR BC GOLF COURSE - A GUIDE TO ENVIRONMENTAL MANAGEMENT	96-26	Nautilus Publications and UMA Engineering Ltd.	Mar 97	Marielou Verge
WATER QUALITY AND STORM WATER CONTAMINANTS IN THE BRUNETTE RIVER WATERSHED, B.C. 1994/95	97-04	Westwater Research Center	Jun 97	Marielou Verge
EVALUATING THE ENVIRONMENTAL IMPACT OF DREDGING BURNABY LAKE - FINAL REPORT	97-11	Enkon Environmental	Sep 97	Marielou Verge
FRASER BASIN LANDFILL INVENTORY	97-19	Gartner Lee Ltd.	Dec 97	Phil Wong
CITY OF PRINCE GEORGE: SNOW DISPOSAL AT THE LANSDOWNE ROAD WASTEWATER TREATMENT CENTRE	97-24	Dayton & Knight Ltd.	Dec 97	Phil Wong
NITROGEN LOADINGS FROM SEPTIC SYSTEMS IN THE LOWER FRASER BASIN	97-25	Dayton & Knight Ltd.	Dec 97	Phil Wong
CITY OF PRINCE GEORGE: RADIO FREQUENCY TREATMENT OF PARTIALLY DIGESTED DEWATERED BIOSOLIDS FINAL REPORT	97-26	Dayton & Knight Ltd.	Dec 97	Phil Wong
WATER QUALITY, LAKE SENSITIVITY RATINGS, AND SPETIC SEEPAGE SURVEY OF SIX LAKES IN THE BRIDGE CREEK BASIN	97-46	Norm Zirnhelt & Rider Petch	Feb 98	George Derksen
ASSESSMENT OF BIOSOLIDS AS A FERTILIZER AND SOIL AMENDMENT	No report #			Phil Wong
CHARACTERIZATION OF CLARK DRIVE CSO AND STORMWATER FROM A RESIDENTIAL AND AN INDUSTRIAL CATCHMENT: SPRING 1994	GVRD report	Norecol, Dames and Moore Inc.	Jul 96	Phil Wong
CITY OF PRINCE GEORGE WASTEWATER TREATMENT CENTRE WASTEWATER CHARACTERIZATION STUDY	No report #	Dayton & Knight Ltd.	Nov 93	Phil Wong
CLARK DRIVE COMBINED SEWER SYSTEM WINTER 1993 OVERFLOW CHARACTERIZATION STUDY	Joint DOE/GVRD Report	GVRD	Sep 94	Phil Wong
CLARK DRIVE CSO AND STROMWATER CHARACTERIZATION	Joint DOE/GVRD Report	GVRD		Marielou Verge
CROWE STREET CSO AND STORMWATER CHARACTERIZATION	GVRD Report			Marielou Verge
CROWE STREET SPRING 1994 OVERFLOW CHARACTERIZATION STUDY	Joint DOE/GVRD Report	GVRD	Jun 96	Marielou Verge

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
CURRENT TRENDS ALONG THE LOWER FRASER	Newspaper	Victoria Stevens and Ann Eriksson	Nov 97	Marielou Verge
WESTRIDGE COMBINED SEWER OVERFLOW AND STORMWATER CHARACTERIZATION	Joint DOE/GVRD Report	GVRD	Jun 96	Phil Wong

AGRICULTURE

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
A COMPREHENSIVE SURVEY OF PESTICIDE USE IN BRITISH COLUMBIA	93-35	Norecol Consultants	Nov 93	George Derksen
AGRICULTURAL LAND USE SURVEY IN THE SUMAS RIVER WATERSHED SUMMARY REPORT	94-21	IRC Integrated Resource Consultants Inc.	Jul 94	George Derksen
AGRICULTURAL LAND USE SURVEY IN THE MATSQUI SLOUGH WATERSHED SUMMARY REPORT	94-22	IRC Integrated Resource Consultants Inc.	Jul 94	George Derksen
LAND USE AND WATER QUALITY MANAGEMENT IN THE BRIDGE CREEK BASIN	94-25	JS Hart & Associates	Jan 95	George Derksen
SURVEY OF AGRICULTURAL PRACTICES IN THE THOMPSON BASIN - 1994	94-26	B.C. Environment	Nov 94	George Derksen
AGRICULTURAL INVENTORY OF THE LOWER FRASER VALLEY - DATA SUMMARY REPORT (REPORT #1)	94-28	Charcoal Creek Projects Inc.	Apr 94	George Derksen
LIVESTOCK WASTE MANAGEMENT PRACTICES AND LEGISLATION OUTSIDE BC - JULY 1995 (REPORT #5)	95-26	Runka Land Sense Ltd.		George Derksen
AGRICULTURAL NUTRIENT MANAGEMENT IN THE LOWER FRASER VALLEY (REPORT #4)	95-27	Charcoal Creek Projects Inc.	Dec 95	George Derksen
MANAGEMENT OF LIVESTOCK AND POULTRY MANURES IN THE LOWER FRASER VALLEY (See reports # 1-9 with FRAP # 94-28, 95-26, 95-27, 95-28, 95-31, 96-15, 96-28, 96-29, 96-30)	95-27, 96-15, 96-28, 96-29			George Derksen
AGRICULTURAL NUTRIENT PATHWAYS (REPORT #3)	95-28	Charcoal Creek Projects Inc.	Dec 95	George Derksen
EVALUATION OF THE ORIGIN AND FATE OF NITRATE IN THE ABBOTSFORD AQUIFER USING THE ISOTOPES OF 15N AND 18O IN NO3-	95-29	NHRI	1995	George Derksen

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
STATUS REPORT OF PROJECTS IN WASTE MANAGMENT IN THE LIVESTOCK INDUSTRY IN THE INTERIOR OF BC	95-30		Apr-95	George Derksen
APPLICATION OF INORGANIC FERTILIZERS IN THE LOWER FRASER VALLEY (REPORT #2)	95-31	Charcoal Creek Projects Inc.	Dec 95	George Derksen
ASSESSMENT OF LIVESTOCK WINTERING AREAS IN BRIDGE CREEK BASIN, 1996	96-03	J.S. Hart and Associates Ltd	Aug 96	George Derksen
DEMONSTRATION OF NOVEL, COST-EFFECTIVE, & ENVIRONMENTALLY FRIENDLY APPROACHES TO HANDLING & TRANSPORTING POULTRY MANURE TO DISTANT MARKETS	96-04	Sustainable Poultry Farming Group	Apr 96	George Derksen
BRIDGE CREEK WATERSHED VOLUNTEER LAKE SECCHI DISK MONITORING PROGRAM1996	96-13	Ministry of Environment, Lands, and Parks	Dec 96	George Derksen
SURVEY OF AGRICULTURAL PRACTICES IN THE THOMPSON BASIN - 1995	96-14	Barbara John	Mar 96	George Derksen
A LITERATURE REVIEW OF THE ECONOMICS OF MANURE MANAGEMENT OPTIONS IN THE LOWER FRASER VALLEY (REPORT #6)	96-15	Agricultural Economics, UBC	Apr 96	George Derksen
TECHNICAL POLLUTION PREVENTION GUIDE FOR THE FRUIT & VEGETABLE PROCESSING INDUSTRY IN THE LOWER FRASER BASIN	96-18	PBK Engineering	Sep 96	David Poon
PRODUCER WORKSHOP PROCEEDINGS (REPORT #7)	96-28	Charcoal Creek Projects Inc.	Apr 96	George Derksen
DESCRIPTION OF SELECTED WASTE MANAGEMENT PROBLEMS, OPTIONS AND STRATEGIES (REPORT #8)	96-29	Charcoal Creek Projects Inc	Nov 96	George Derksen
MANAGEMENT OF AGRICULTURAL WASTES IN THE LOWER FRASER VALLEY - SUMMARY REPORT - A WORKING DOCUMENT - (REPORT #9)	96-30	Charcoal Creek Projects Inc.	Mar 97	George Derksen
PESTICIDE SALES SURVEY: 1995	97-16	Norecol, Dames & Moore		George Derksen
FINAL REPORT ON ABATEMENT ACTIVITIES RELATED TO AGRICULTURE IN THE THOMPSON BASIN AND CARIBOO REGION DURING THE FRASER RIVER ACTION PLAN	97-44	Barbara John & George Derksen	Feb 98	George Derksen

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
REPORT ON ABATEMENT ACTIVITIES RELATED TO AGRICULTURE AND WASTE MANAGEMENT IN THE LOWER FRASER VALLEY DURING THE FRASER RIVER ACTION PLAN	97-45	B. Locken and G. Derksen	Mar 98	George Derksen
MUSHROOM WASTE MANAGEMENT PROJECT - LIQUID WASTE MANAGEMENT PHASE 1 AND I AND II	97-47	J. Atwater et al	Mar 98	George Derksen
SUMAS AND NORTH MATSQUI WATERSHEDS - 1997 FARM PRACTICES SURVEY	97-48	J. Carter et al	Mar 98	George Derksen
TRENDS IN COMMERCIAL FERTILIZER USE IN THE LOWER FRASER VALLEY 1997	97-49	P. Brisbin	Feb 98	George Derksen
HORSE LAKE-BRIDGE CREEK WATER QUALITY ASSESSMENT	97-50	N. Zirnhelt et al	Mar 98	George Derksen
AGRICULTURAL LAND USE PRACTICES IN THE LOWER FRASER VALLEY AND WORKING TOWARDS ENVIRONMENTAL SUSTAINABILITY	Report Card Series 1994, Issue #1	EC/FRAP & B.C. Environment	Sep 94	George Derksen
AN ASSESSMENT OF CONSTRUCTED WETLANDS FOR THE TREATMENT OF GREENHOUSE WASTEWATERS	No report #	ECL Envirowest Consultants Ltd.		George Derksen
GUIDELINES FOR MONITORING BENTHOS IN FRESHWATER ENVIRONMENTS	No report #	EVS Consultants	Jan 93	George Derksen

CONTAMINATED SITES

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
IMPACT OF THE OLD QUESNEL LANDFILL - FINAL REPORT	95-05	Gartner Lee Ltd.	Mar 95	Phil Wong
ENVIRONMENT CANADA PACIFIC AND YUKON REGION NATIONAL CONTAMINATED SITES REMEDIATION PROGRAM - ANNUAL REPORT FOR 1995-96	No report #	Environment Canada	1996	Richard Glue
FRASER BASIN CONTAMINATED SITES PROGRESS REPORT, 1994-1995	No report #	Environment Canada	Jul 95	Richard Glue
FRASER BASIN CONTAMINATED SITES PROGRESS REPORT, 1995-1996	No report #	Environment Canada	Jun 96	Richard Glue
FRASER BASIN CONTAMINATED SITES PROGRESS REPORT, 1996-1997	No report #	Environment Canada	Jun 97	Richard Glue

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
AIRBORNE				
DEVELOPMENT OF DESIGN BASIS FOR AN INVENTORY OF OF SOURCES AND EMISSIONS OF TOXIC AIR CONTAMINANTS FOR BRITISH COLUMBIA	No report #	BH Levelton and Associates	Mar 95	Andrew Green
INVENTORY OF SOURCES AND EMISSIONS OF TOXIC AIR CONTAMINANTS IN B.C. FOR 1990 - DRAFT REPORT	No report #	B.H. Levelton & associates Ltd.	Jan 95	Andrew Green
GROUNDWATER				
THE FEASIBILITY OF USING A FLUOROMETER TO DETECT SEPTIC LEACHATE	96-31	Ministry of Environment, Lands, and Parks	Jan 96	George Derksen
GROUNDWATER MAPPING & ASSESSMENT IN B.C. VOL I: REVIEW & RECOMMENDATIONS	93-33	Piteau Associates & Turner Groundwater Consultants	Oct 93	Marielou Verge
GROUNDWATER MAPPING & ASSESSMENT IN B.C. VOL.II: CRITERIA AND GUIDELINES	93-34	Piteau Associates & Turner Groundwater Consultants	Oct 93	Marielou Verge
GROUNDWATER PROTECTION STRATEGY MODEL URL WEBSITE: www.ire.ubc.ca	Website	Hugh Liebscher, Hans Scheirer, UBC Institute for Resources and Environment	1997	
GROUNDWATER RESOURCES OF BRITISH COLUMBIA	No report #	JW Atwater, UBC Department of Civil Engeneering		Marielou Verge

REPORT TITLE	FRAP REPORT #	PREPARED BY	DATE	ENVIRONMENT CANADA CONTACT
GENERAL				
FRASER POLLUTION ABATEMENT OFFICE - PROGRESS REPORT 1992-1993	93-22	Maia Publishing Ltd.	Sep 93	Lisa Walls
FRASER POLLUTION ABATEMENT OFFICE - PROGRESS REPORT 1993-1994	94-19	Maia Publishing Ltd.	Sep 94	Lisa Walls
FRASER POLLUTION ABATEMENT OFFICE - PROGRESS REPORT 1994-95	97-01	Maia Publishing Ltd.	Mar 97	Lisa Walls
FRASER POLLUTION ABATEMENT OFFICE PROGRESS REPORT 1995-1996 & PROGRESS REPORT 1996-1997	97-21	MAIA Publishing Ltd.	Dec 97	Lisa Walls
FRASER RIVER ACTION PLAN-POLLUTION ABATEMENT TECHNICAL SUMMARY REPORT	98-01	Environment Canada	Aug 98	Lisa Walls
FRASER RIVER ACTION PLAN-BURRARD INLET TECHNICAL SUMMARY REPORT	98-02	Environment Canada	Aug 98	Lisa Walls

APPENDIX C:

PARTNERS

Environment Canada worked in close co-operation with other federal and provincial departments, regional and municipal governments, universities, industry groups and local non-government organizations to achieve the objectives of the pollution abatement component of the Fraser River Action Plan. In addition, many private firms participated in this effort through contracts to develop guidelines and conduct studies.

The following is a list of key partners that contributed to the pollution abatement component.

Government of Canada

Department of Fisheries and Oceans
Agriculture and Agri-Food Canada
Health Canada

Government of British Columbia

Ministry of Environment, Lands and Parks
Ministry of Agriculture, Fisheries and Food
Ministry of Transportation
Ministry of Health

Regional and Municipal Governments

Greater Vancouver Regional District
City of Prince George
City of Vancouver
District of Hope
Cariboo Regional District

Industry

Northwood Pulp and Timber Ltd.
B.C. Ready Mixed Concrete Association
British Columbia Auto Recyclers
Ecowaste Industries Ltd.
Riverside Forest Products Ltd.
Transcontinental Printing Inc.
PowerTech Labs Inc.
BC Hydro
Ian Shand and Associates Inc.
Chemical Lime Company of Canada Inc.
Nova Tec Consultants Inc.
Dayton and Knight Ltd.
Insurance Corporation of British Columbia

Producer Groups

Dairy Producers' Conservation Group
BC Federation of Agriculture
Sustainable Poultry Farming Group

Organizations and Commissions

Fraser River Harbour Commission
North Fraser Harbour Commission
B.C. Water and Waste Association
Fraser River Estuary Management Program
Burrard Inlet Environmental Action Program
University of British Columbia

APPENDIX D:

LEGISLATION RELATED TO FRASER POLLUTION ABATEMENT INITIATIVES

A complex array of federal, provincial, and local government statutes governs the pollution abatement sectors addressed under the Fraser River Action Plan. The most relevant federal and provincial legislation, the purpose of each and the pollution abatement sectors it relates to are outlined in the table below.

Federal Legislation	Purposes Related to FPA	Relevant FPA Sectors
Fisheries Act	Prohibits the discharge of substances deleterious to fish and conserves and protects fish and fish habitat.	Contaminated Sites; Urban Runoff; Municipal; Industrial; Agriculture
Canadian Environmental Protection Act	Cradle-to-grave management of toxic substances.	Contaminated Sites; Industrial; Airborne Contaminants, Municipal
Canadian Environmental Assessment Act	Framework for planning projects in an environmentally acceptable way to avoid potential adverse effects.	Contaminated Sites; Industrial; Airborne Contaminants; Municipal, Urban Runoff

Provincial Legislation	Purposes Related to FPA	Relevant FPA Sectors
British Columbia Waste Management Act	Requires permits, approvals or operational certificates for discharges to land, water or air. Classifies *special wastes*, which are potentially hazardous to human health and the environment, and which require special care during handling and disposal.	Contaminated Sites; Municipal; Industrial; Airborne Contaminants; Agriculture
British Columbia Health Act	Regulates approval of sewage disposal (under 22.7 m3/day to land and for single and duplex dwellings to surface waters).	Municipal
Farm Practices Protection (Right to Farm) Act	Ensures farmers can farm in agricultural land reserves, subject to provincial standards and approval, and provides specific powers to local governments.	Agriculture

The following is a brief discussion of each of these statutes, which, along with key associated regulations, make up the regulatory regime relevant to the FRAP pollution abatement program.

The general pollution prevention provisions of the federal *Fisheries Act* (section 36(3)), which prohibits the deposit of deleterious substances in waters frequented by fish, provide a broad and powerful tool to deter pollution. In the application of the *Fisheries Act*, acute lethality (as determined by a 96-hour LC50 rainbow trout bioassay) is one of the measures of whether a substance is deleterious. In addition, any substance with a potentially harmful chemical, physical, or biological effect on fish or fish habitat is considered deleterious. For example, substances that smother spawning grounds or interfere with reproduction, feeding, or respiration of fish may be considered deleterious.

The *Fisheries Act* sets out specific effluent regulations for a few industries, including pulp and paper, petroleum refining and metal mining. These regulations specify maximum limits of contaminants in effluents, effluent monitoring and reporting requirements, and other conditions under which deleterious substances are authorized for deposit. The *Pulp and Paper Effluent Regulations* also require dischargers to undertake Environmental Effects Monitoring to assess whether the discharge is impacting the receiving environment and, over the longer term, to determine whether the regulations are adequately protecting the receiving environment and aquatic biota downstream of the mill discharges. In the absence of a *Fisheries Act* regulation for sectors such as contaminated sites, municipal wastewaters, urban runoff and agriculture, section 36(3) is the principal federal pollution control and prevention instrument.

Although the Department of Fisheries and Oceans (DFO) has legislative responsibility for the *Fisheries Act*, Environment Canada has primary responsibility for pollution prevention and control matters related to section 36(3). Environment Canada is supported in this role by DFO, which has responsibility for managing and protecting the fisheries resource and its habitat.

The *Canadian Environmental Protection Act (CEPA)* is legislation respecting the protection of the environment and of human life and health. The relevant elements of the Act include:

- authority to obtain information on and to require testing of both new substances and existing substances;
- provisions to control all aspects of the life cycle of toxic substances;
- authority to regulate fuels and components of fuel;
- authority to regulate emissions and effluents, as well as waste handling and disposal practices of federal agencies;
- provisions to create guidelines and codes for environmentally sound practices as well as objectives setting levels of environmental quality; provisions to control sources of air pollution in Canada where there are international implications; and
- provisions to control nutrients in water conditioners or cleaning products that can interfere with the use of waters.

Regulations under *CEPA* that may affect the management of contaminated sites include the *Chlorobiphenyls Regulations*, *Federal Mobile PCB Treatment and Destruction Regulations*, *Storage of PCB Material Regulations*, and *Contaminated Fuel Regulations*. *The Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations* and the *Pulp and Paper Mill Defoamer and Wood Chip Regulations* impose requirements on the pulp and paper sector. The *Phosphorus Concentration Regulations* are intended to reduce phosphorus loadings from laundry detergents in municipal wastewaters. Additional *CEPA* implications include Priority Substance List assessments for chloramines and ammonia, which are both constituents of municipal wastewater.

Environment Canada is responsible for the administration of *CEPA*. Health Canada provides advice in relation to human health aspects and jointly recommends regulatory actions, but has no direct enforcement responsibility.

The *Canadian Environmental Assessment Act (CEAA)* is intended to ensure that environmental effects of projects receive careful consideration before actions are taken. Application of *CEAA* is limited to projects in which a federal authority is the proponent, provides financial assistance, administers the lands in which the project is to be carried out, or grants an approval or takes other action for the purpose of enabling the project to be carried out. Thus, although *CEAA* applies to a relatively small number of projects, all issues related to environmental quality are considered in assessments. The *CEAA* is administered by the Canadian Environmental Assessment Agency.

The introduction of wastes into the environment is primarily managed through the provincial *Waste Management Act (WMA)*. Permits, approvals or operational certificates (for local governments that have approved solid or liquid waste management plans) are required for discharges to land, air and water, and for the handling of solid and toxic wastes. Pollution Control Objectives, which were developed under the predecessor of the *WMA* for municipal discharges and B.C.'s major industries (chemical and petroleum industries, mining, smelting and related industries, forest products industry, and food-processing, agriculturally oriented, and other miscellaneous industries), are typically incorporated as standards into the permits, approvals, and operational certificates issued by the Ministry of Environment, Lands and Parks.

The Pollution Control Objectives for Municipal Type Waste Discharges will be superceded by the Landfill Criteria for Municipal Solid Waste (completed), Emission Criteria for Municipal Solid Waste Incinerators (completed), and the *Municipal Sewage Regulation* (currently being drafted). The *Special Waste Regulation* under the *WMA* also impacts the contaminated sites and industrial sectors. As well, the *new Contaminated Sites Regulation* will provide a framework to efficiently deal with the assessment and cleanup of contaminated sites, and will protect the interests of property owners who unwittingly purchase contaminated properties.

The Agricultural Waste Control Regulation under the *WMA* is intended to prevent pollution from private agricultural lands, such as the majority of farms in the Fraser Valley and over-wintering sites in the Interior. The purpose of the Code of Agricultural Practice for Waste Management attached to the Regulation is to describe practices for using, storing and managing agricultural waste that will result in its being handled in an environmentally sound manner.

The Sewage Disposal Regulation under the provincial *Health Act* regulates sewage treatment and disposal for on-site systems with discharges less than 22.7 m3/day. In response to significant advances in the small wastewater treatment and disposal industry and to deficiencies in this regulation, a comprehensive rewrite of the regulation is underway.

The *Farm Practices Protection (Right to Farm) Act* ensures that farmers can farm in B.C.'s Agricultural Land Reserves, provided they use "normal farm practices" and follow other provincial legislation listed in the Act. The Act establishes a complaint resolution process for people who live near farms and have concerns about farm practices that create dust, odour, noise or other disturbances. The Act also provides specific powers to local governments to ensure local bylaws reflect provincial standards for farming.

In addition to the foregoing key statutes, many other senior government statutes pertaining to water quality and pollution control have some relevance to the pollution abatement component of FRAP. These include:

Federal:

- *Atomic Energy Control Act*
- *Navigable Waters Protection Act*
- *International Boundary Waters Treaty Act*
- *Canada Water Act*
- *Transportation of Dangerous Goods Act*
- *Canadian Wildlife Act*
- *Migratory Bird Conventions Act*
- *Indian Act*

Provincial:

- *Water Act*
- *Water Protection Act*
- *Environment Management Act*
- *Environmental Assessment Act*
- *Fish Protection Act*
- *Pesticide Control Act*
- *Fire Services Act*
- *Soil Conservation Act*
- *Litter Act*
- *Municipal Act*
- *Growth Strategies Act* (since 1995, Section 942 of the *Municipal Act*)

In addition to senior government initiatives, many local governments have bylaws, policies and programs to control pollutants at source and to protect receiving environments. Some of these measures include:

- Sewer use bylaws to control the level of contaminants of industrial or commercial origin that are discharged to municipal sewerage systems;
- Storm sewer bylaws to prohibit the discharge of polluted runoff to storm sewers;
- Bylaws to prohibit "fouling, obstructing, or impeding" a watercourse;
- Official Community Plan policies to discourage water-polluting industries; and
- Zoning restrictions that keep pollution-generating activities away from streams.