Fraser River Action Plan

Fraser Pollution Abatement Office

Progress Report 1993-1994

DOE FRAP 1994-19

Environment Canada Environnement Canada

FRASER POLLUTION ABATEMENT OFFICE

PROGRESS REPORT 1993-94

By
Maggie M. Paquet
MAIA Publishing Ltd.
302 East 6th Street
North Vancouver, BC V7L 1P6

For
Fraser Pollution Abatement Office
Environment Canada
224 West Esplanade
North Vancouver, BC V7M 3H7

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EXECUTIVE SUMMARY

The Fraser River Action Plan (FRAP), an initiative of Canada's Green Plan, was announced in June 1991. One of the three primary objectives of FRAP is to clean up pollution in the Fraser River basin. This objective depends on pollution abatement. The Fraser Pollution Abatement Office (FPAO) of the Fraser River Action Plan was established in 1991 with the responsibility to identify and reduce pollutants entering the Fraser River basin. This report provides background on the role of FPAO within the larger framework of the Fraser River Action Plan and the Green Plan.

The FPAO has now completed its second full year of operation. This progress report will summarize the strategic approach, outline the main program areas, and profile the accomplishments of each of the projects undertaken by the Fraser Pollution Abatement Office for the reporting period of 1 April 1993 to 31 March 1994. Some of the projects profiled in this report were begun in the previous reporting period and have continued into this period; others are ongoing or will continue past this reporting period.

Numerous government and nongovernment agencies, research institutes, First Nations groups, and industry associations - not to mention the general public - are concerned with the environmental quality and sustainable development of the Fraser River basin.

The Fraser basin is Canada's fifth largest river basin and contains over 60% of the population of the province of British Columbia. Over 75% of the industrial activity of British Columbia occurs in the Fraser River basin, and the basin is a primary agricultural region for the province.

Pollution, habitat destruction, and urban development have already put the river under stress. As the population continues to grow, demands on the river and competition for land and resource use are increasing, resulting in conflict and the potential for environmental damage. But the Fraser can be protected and the trend to environmental degradation reversed.

Because of the wide range of government jurisdictions and regulatory agencies, the tremendous financial costs involved, and the increased need for integrated management, a number of partnerships and cooperative working arrangements have been set up by FPAO to enable it to achieve its goals. Some of these partnerships may involve different branches within one federal department, federal and provincial levels working together, or industry associations and producer groups working in concert with municipal and higher levels of government. The partnerships may involve a combination of funding contributions and in-kind, technical or personnel support to complete projects.

FPAO's strategy focuses on a variety of domestic and industrial point and non-point sources of contamination of the Fraser River basin. These have been organized into seven main program areas: Industrial Discharges, Municipal Discharges and Urban Runoff, Agricultural Runoff, Groundwater Contamination, Contaminated Waste, Airborne Contaminants, and Technology Transfer.

Within the first six of these areas, contaminant sources must first be catalogued and characterized. In addition, methods for organizing and using large volumes and multiple sources of data need to be formulated. A good deal of this activity occurred during FPAO's first year of operation.

Some of these characterization projects have continued during this second year. In addition, new projects were begun on the development of inventories, databases and digitized maps, guidelines, site-specific impact assessments,

codes of practice, design manuals, industry training courses and workshops, and surveys of land uses.

The seventh program area, Technology Transfer, is an important means of sharing knowledge and information with the various sectors that can best use that information and with the general public. These are all part of the range of projects carried out by FPAO during this reporting period.

Approximately 42 projects, several within each program area, were carried out in 1993-94. Most of these were performed at some level of partnership with other agencies and organizations. All of them contribute to the achievement of FPAO goals to reduce contaminant loading to the Fraser River Basin and develop practices for its sustainable development and use.

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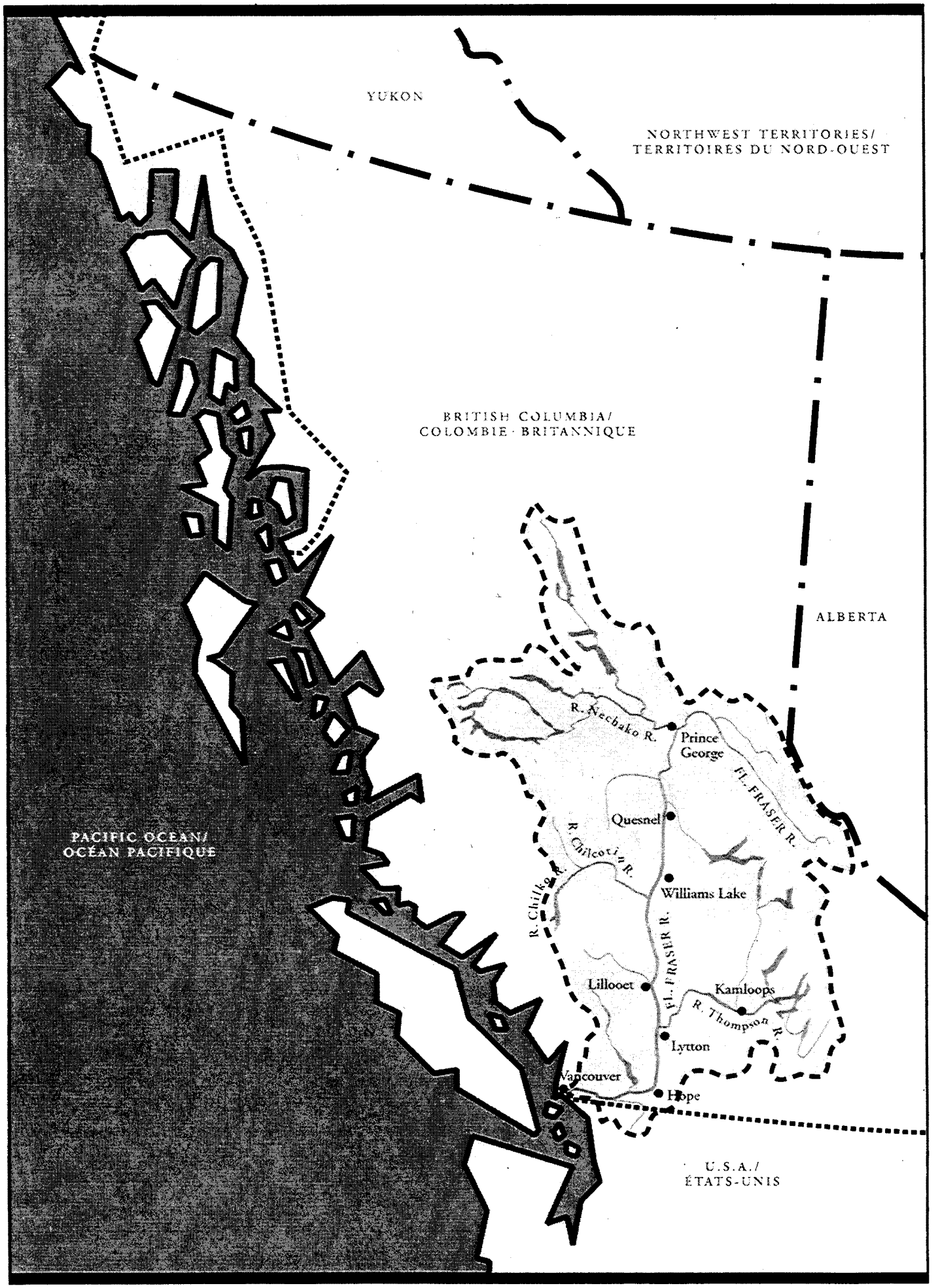
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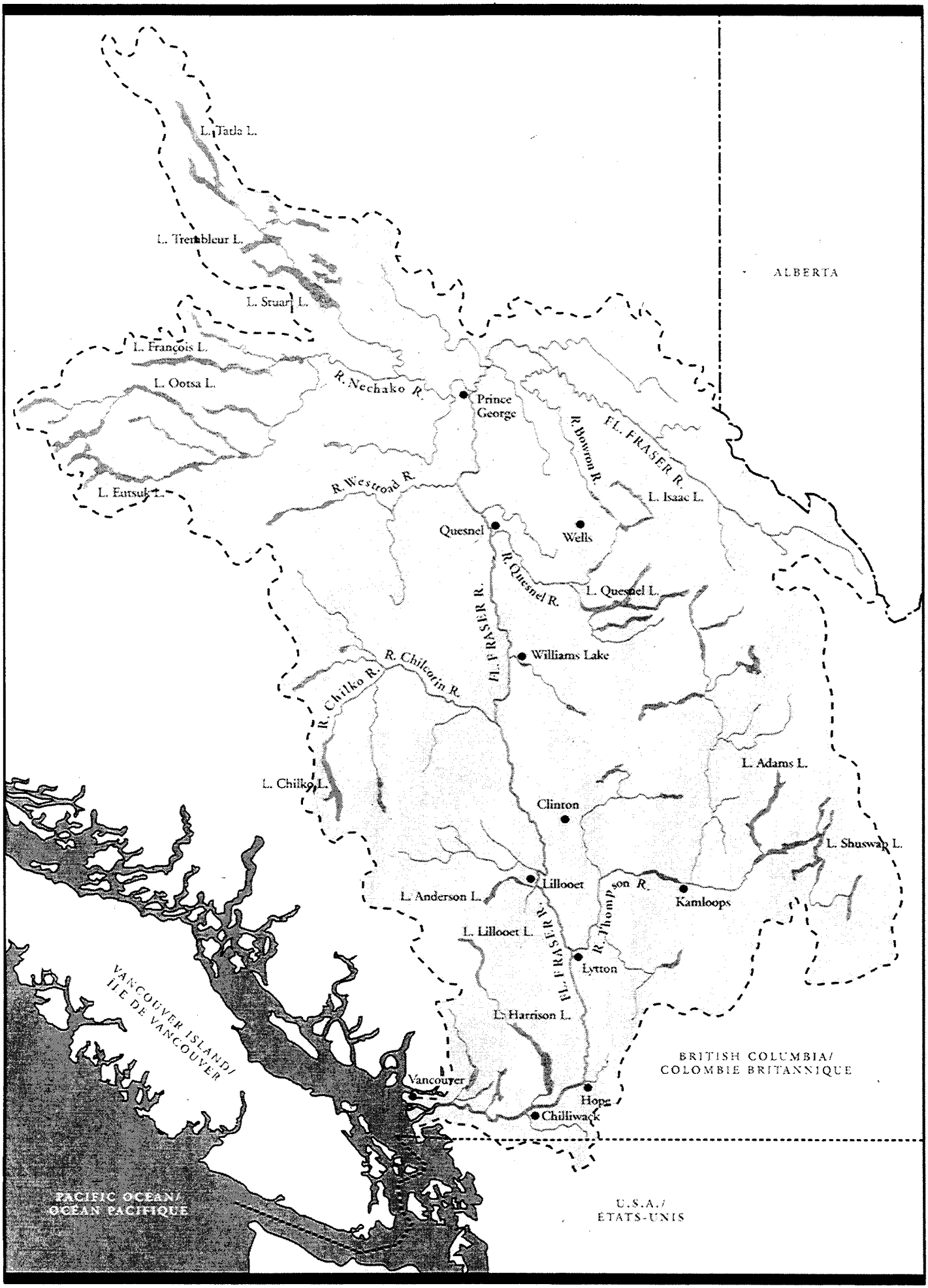
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1.0 INTRODUCTION

1.1 The Fraser River Basin

From its headwaters high in the Park Ranges of the Rocky Mountains in Mt. Robson Provincial Park, to its mouth at the Strait of Georgia, the Fraser River flows - first northwesterly then southwesterly - a length of nearly 1,400 km. Its drainage basin covers 25 percent of British Columbia and is one of the most extensive and productive biological systems in Canada.

Throughout its journey, a tremendous network of lakes and tributaries - including Takla, Stuart, Francois, Ootsa, Eutsuk, Quesnel, Chilko, Anderson, Shuswap, and Harrison lakes, and McGregor, Nechako, Bowron, West Road [Blackwater], Quesnel, Chilcotin, Lillooet, Bridge, Pitt, Chilliwack, and Coquitlam rivers, plus all the rivers in the Thompson system - feeds the Fraser and connects all life within its sphere of influence. The numerous watersheds of these tributaries combine to form the Fraser River basin, the fifth largest river basin entirely within Canada.

Throughout its reaches and tributaries, 13 of the 14 major ecosystems and climatic zones of the province are represented. This mighty river slices through the Rocky Mountains and churns its way across the highlands and plateaus of the Cariboo, where its volume swells with the addition of the Thompson and Chilcotin rivers. Flowing southward, it is compressed through the 600- to 1000-metre-deep rocky confines of the Fraser Canyon, incises a path through the Coast Ranges, then widens at the coastal plain as it passes through the incredibly fertile Fraser Valley to the sea. Here, the silt-laden fresh water meets the Strait of Georgia and forms an immense delta that pushes well past the margin of salt water.

The Fraser River flows through a diverse range of landscapes, from alpine wilderness to plateaus and canyons, rolling uplands, wetlands, and estuaries. This mosaic provides habitats for an incredible variety of plant and animal species. The Fraser River basin supports internationally significant populations of fish and wildlife. Magnificent wildflower meadows, grasslands, and forests are all found here. It is home to wolves, black and grizzly bears, mountain goats, bighorn sheep, caribou, moose, and countless small mammals; and reptiles and amphibians (important environmental quality indicator species). Throughout its length, the Fraser River provides critical nesting, feeding, and staging habitats for hundreds of thousands of migratory birds and waterfowl. The delta is a vital staging area on the Pacific Flyway (one of the world's major migratory routes that extends from the Bering Sea to South America) and supports the highest density of wintering waterfowl, shorebirds, and birds of prey (raptors) in Canada.

At least 40 species of fish inhabit the Fraser River, including all five species of Pacific salmon, cutthroat, steelhead, and rainbow trout, Dolly Varden char, and sturgeon, one of the world's oldest extant species of fish. The Fraser River system produces more salmon than any other river system in the world. It provides over 65 percent of BC's sockeye, 60 percent of the pinks, and 16 percent of the chinook salmon catches, and gives an average return of about $300 million from the combined commercial, recreational, and aboriginal food catches.

Nearly two million people - over 60 percent of BC's population - live, work, and play in this vast and diverse watershed. The cultural history of many of the province's peoples can be traced throughout the Fraser River system, from the earliest activities of First Nations peoples through European contact. The Fraser River has been a vital transportation link for trade and exploration throughout the human history of the province;

British and Spanish naval vessels surveyed its opening to the sea, it brought the fur traders and provided access to overland trails; it was both the site and access route of many gold rushes; and it eventually provided for a multicultural influx across the province. Today, it remains a focus for human settlement and industrial growth. The Fraser River basin supports 48 percent of BC's commercial forest area, 60 percent of its metal mining operations, and nearly 45 percent of the province's precious farmland. The lower portion of the basin is one of the most productive agricultural areas in Canada and in 1990, supported over 5,500 farms. Tourism and outdoor recreation are also significant contributors to the economy of the basin. The Fraser River basin accounts for 80% of the gross provincial product and 66% of total household income.

The waters of the river connect the land to the plants, animals, and people. But the same water also transports environmental contaminants throughout the basin. Millions of tons of contaminants are pumped into the Fraser. Wetlands and other habitats have been destroyed or polluted. Groundwater and lakes have been contaminated, and high demands for water have meant local shortages. The health of the Fraser's ecosystems is critical. A burgeoning population, expected to increase 50% in the next 20 years, urban sprawl, and expanding resource development threaten the environmental balance of the basin.

The sustainability of the basin's fish and wildlife populations is dependent upon the condition of their habitat. Over 50 percent of industrial discharge volumes in the watershed come from pulp mills in its northern interior, and about 95 percent of municipal waste discharge volumes come from the cities and towns in its lower reaches. Airborne pollutants also find their way into the rivers and streams of the Fraser basin.

It is evident that the environmental integrity of the Fraser River basin must be protected and improved in order to sustain its immense importance to the people of British Columbia.

1.2 The Green Plan and The Fraser River Action Plan

In summer 1990, Canadians across the country participated in public meetings to voice their concerns and suggestions for cleaning up and protecting the environment. Canada's Green Plan was developed in response to the ideas expressed at those meetings. In recognition of its tremendous environmental and economic importance, clean-up and sustainable management of the Fraser River basin was targeted as a priority. The resulting six-year, $100 million Fraser River Action Plan (FRAP), one of over 100 programs contained in the Green Plan, is the largest single Green Plan initiative in British Columbia.

The mission of FRAP is to clean up pollution, restore the productivity of the natural environment of the Fraser River basin, and implement a management program to ensure its long-term sustainability.

This is a huge responsibility. The government of Canada is working in partnerships with the government of British Columbia, First Nations, communities, industries, colleges and research institutions, and other stakeholder groups along the Fraser River in its efforts to clean up pollution and achieve environmental and socioeconomic sustainability in the Fraser basin.

FRAP is administered jointly by the Department of Environment (DOE) and the Department of Fisheries and Oceans (DFO). The legislative authority for the work of these two departments are the *Canadian Environmental Protection Act* (CEPA) and the *Fisheries Act*; Environment Canada has responsibility for pollution provisions of the *Fisheries Act*. Environment Canada's approach is to lead (carry a project or study through to completion on its own), participate (where partnerships are essential to the completion of a project or where DOE doesn't have the primary mandate), and support (where DOE's role is to provide financial or limited technical input) studies and projects that will help accomplish the goals of the Fraser River Action Plan.

A key component of FRAP, operated by Environment Canada, is pollution abatement. The pollution abatement component is charged with the tasks of identifying contaminants entering the waters of the Fraser River basin, and preventing and cleaning up point and non-point sources of pollution. Of FRAP's total funds, $6.5 million over six years is directly allocated for pollution abatement.

1.3 Fraser Pollution Abatement Office

Key objectives of the Fraser River Action Plan are to arrest and reverse pollution and degradation of the Fraser River basin and to reduce the discharge of persistent toxic substances into the river. A primary component of these objectives is pollution abatement and prevention. In 1991, the Fraser Pollution Abatement Office (FPAO) was established specifically to coordinate activities toward identifying, preventing, and cleaning up pollution in the Fraser River basin.

The goal of FPAO is to ensure healthy ecosystems in the Fraser basin by working with others to identify contaminants and to prevent and clean up point and non-point sources of pollution.

Specific pollution abatement targets are as follows:

- to reduce by 30% the total discharge of environmentally disruptive effluents entering the waters of the Fraser basin by 1997
- to significantly reduce the release of persistent toxic substances entering the waters of the Fraser basin by the year 2000

Persistent toxic substances are defined by the Priority Substances List (PSL) and the Toxic Substances List (TSL) of CEPA.

The chief federal legislation from which FRAP and FPAO obtain their mandate to act are CEPA and the Fisheries Act. Both of these are broad-based to enable a wide range of actions, and both are currently under extensive nation-wide review processes to ensure they are able to provide the legislative clout to get the job done. FPAO's success in achieving its goals will also depend in large part on voluntary pollution prevention measures by individuals, communities, and industries throughout the Fraser River basin.

1.4 FPAO Strategic Approach

The work of the Fraser Pollution Abatement Office is necessarily complex. In order to achieve its goals, FPAO has developed a multilateral and cooperative strategy to identify and reduce or eliminate contaminants entering the Fraser River basin in seven main program areas: Industrial Discharges, Municipal Discharges/Urban Runoff, Agricultural Runoff, Groundwater Contamination, Contaminated Waste, Airborne Contaminants, and Technology Transfer.

The strategic approach includes:

- development of databases for use in inventories and research
- inventories of point and non-point sources of contaminants
- wastewater characterization and pollutant loading evaluations
- site-specific effluent dispersion assessments
- identification of control technologies and cost-effectiveness
- reviews of best available technology (BAT) and best management practices (BMP)
- priorization of discharges for abatement
- support for industry and public education programs
- development of specific partnerships based on problem, expertise required, and mandates
- development of codes of practice for voluntary pollution prevention
- regulatory instrument compliance reviews
- promotion of economic and non-economic incentives, such as user-pay systems, deposits/refunds, government procurement policies, environmental citizenship, and alternative uses of wastes
- implementation of detailed abatement plans in consultation with other government agen-

cies and dischargers, and in accordance with the polluter-pays principle

This strategic approach has enabled FPAO to initiate, support, or participate in a wide range of projects - over 42 - for the 1993-94 fiscal year.

1.5 Partnerships

The costs associated with pollution abatement are enormous. The chief means by which FPAO can significantly reduce costs is by entering into partnerships.

FPAO's roles include leading, participating, and supporting a wide array of projects with the primary objective of pollution abatement in the Fraser River basin. Building on existing programs in partnerships with other government and industry organizations can accelerate or expand the levels of accomplishment and save financial resources by avoiding duplication of effort.

One of the foremost partnerships is between the Department of Environment and the Department of Fisheries and Oceans, each of which is responsible for half of FRAP core funding ($50 million DOE and $50 million DFO). While each department focuses on its own areas of expertise and responsibility, their activities are coordinated by a senior level joint committee. A number of working groups, technical committees, and scientific advisors cooperate in a formal and informal way to share knowledge and resources.

FPAO also initiates new projects in partnership with other federal government departments and initiatives, notably Agriculture, Health and Welfare, Indian and Northern Affairs, Geological Survey of Canada, Atmospheric Environment Service, and the Fraser River Estuary Management Plan.

Provincial government ministries and agencies, particularly branches of BC Environment, namely Environmental Protection, Waste Management, and Pesticide Management branches, and the ministries of Agriculture, Fisheries and Food, and Health have been active partners with FPAO to achieve both federal and provincial goals for pollution abatement and waste management in the Fraser basin.

FPAO also works in collaboration with municipal and regional governments, industry associations, and research institutes.

Some of FPAO's current partners include the Greater Vancouver Regional District (GVRD), Municipality of Surrey, City of Prince George, Fraser Valley Health Unit, BC Federation of Agriculture, Greenhouse Growers Association, Nursery Growers Association, Mushroom and Berry Producers Association, BC Water and Waste Association, BC Research Corporation, University of British Columbia, and the National Water Research Institute.

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2.0 PROJECT PROFILES

2.1 Highlights of 1993-94 Project Year

The Fraser Pollution Abatement Office led, participated in, or supported upwards of 40 projects for the 1993-94 fiscal year. Some of these were completed by April 1 1994, but many were designed to be ongoing projects; others require additional time to complete.

A large number of projects addressed the lack of data - and a database for the entire Fraser River basin - on the locations and types of discharge sites and wastewater characterization and loadings. Linking databases to Geographic Information Systems (GIS) and other computerized software programs to enable widespread use and more rapid analysis is another important component of some of FPAO's projects. A number of this year's projects were also continuations of last year's characterization projects, and serve to increase the knowledge base of discharges under varying climatic conditions.

Characterization means a detailed analysis for chemical and biological variables. Loading is a mathematical term (concentration x flow = mass) that essentially means the amount of a substance being discharged to a receiving environment.

The design of sampling techniques and field protocols is a critical area. Uniform, valid, and consistently utilized techniques are required if the data collected is to have any degree of comparability. Some projects addressed this need.

Inventories and characterizations of point and non-point sources of pollution have continued to be a focus of FPAO during 1993-94. These included:

- industrial discharges
- municipal discharges, including combined sewer overflows (CSOs) and urban runoff
- agricultural runoff
- groundwater mapping, classification of aquifers, and determination of contaminant loading in aquifers

Point source discharges are those that enter the receiving environment from a single, distinct point, such as a pipe. They are concentrated points where samples can be taken directly from the discharge under study. Examples of point source discharges include sewage treatment plants and industrial wastewater discharge systems.

Non-point source discharges are dispersed over a large area where there is widespread opportunity for contaminants to enter the receiving environment. They may be accumulated discharges that result from a number of individual sources. Examples include agricultural runoff, urban runoff, combined sewage overflows during storm events, or areas affected by airborne contaminants.

Producing codes of practice and operations guidelines, usually in partnership with industry associations, is a major component of FPAO's strategy to reduce contaminant loadings to the Fraser River basin, particularly with the agriculture, food production, mining, and forest products industries. Another aspect of this strategy is to target a group of industries for each year, thereby moving successively through the range of industrial activities that are carried out within the basin.

A number of this year's projects focused on surveys of land uses within certain areas of the basin, and how these land uses affect water quality on local scales. These types of studies can assist in proactive planning and decision making that will result in a lower rate of degradation of local habitats.

Wastewater treatment systems throughout the basin have received a lot of FPAO's attention in the past reporting period. Some of the projects were designed to characterize wastewater and assess loadings, others focused on ways to increase treatment plant efficiency and cost-effectiveness. Another program implemented a pilot-scale project for toxicant control in industrial waste sludges.

To enable the mining industry to be more environmentally responsible, FPAO supported an acid mine drainage (AMD) pollution prevention project to develop standard reference material for AMD prediction.

Federal sites within the Fraser River basin were inventoried and a report on federal sources of pollution in the basin was prepared.

Ongoing activities in the Agriculture Runoff program include a manure production database, a manure stockpile survey, and an assessment of industry practices.

An agreement between the Waste Management Division and BC Environment was developed for a contaminated sites inventory for the Fraser River basin, and a number of technical and regulatory meetings were held to discuss remediation alternatives for a number of contaminated sites in the basin.

A toxics emission inventory report was prepared, including a GIS component, for airborne contaminants.

Pollution prevention and treatment depends on sharing knowledge and technological innovation. Technology transfer is an important component of FPAO's activities and there are aspects of it in many of the current projects. IPM workshops for the agricultural industry were held, as were seminars on alternative uses and disposal methods of domestic sludge (biosolids) and water conservation strategies.

The following project profiles give more detailed information on the activities of the Fraser Pollution Abatement Office for 1993-94. In these profiles, information is provided on funding, partnerships, and FPAO contact people. In many cases, in-kind funding has been provided, particularly by BC provincial ministries, which often have expended considerable staff time, expertise, and facilities, and given other kinds of support, including datasharing and file searches.

In other cases, industry groups or producers' associations have participated in a project, often by producing initial surveys or final reports.

These profiles give details about each of the projects conducted in the 1993-94 fiscal period. FPAO staff and DOE advisory contact information is provided in the chart in section 4.0 of this report.

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2.2 Project Area: Industrial Discharges

2.2.1 Fraser River Pulp and Paper Data Analysis

Performed by: *HBT AGRA Limited, Engineering & Environmental Services*
Partner: *FPAO*
Funded by: *FPAO ($17K)*
FPAO Contact: *Lisa Walls, Snehal Lakhani*

In order to reduce pollution input, restore natural productivity, and promote sustainable industrial activity in the Fraser River basin, it is necessary to identify contaminant loadings to the basin and analyse existing effluent quality data. Over the past few years, FPAO has compiled daily compliance monitoring data submitted by seven pulp and paper mills located on the Fraser River (Northwood Pulp & Paper and Canadian Forest Products, Prince George; Cariboo Pulp & Paper and Quesnel River Pulp & Paper, Quesnel; Weyerhaeuser, Kamloops; Paperboard Industries, Burnaby; Scott Paper, New Westminster).

The monitoring data collected for analysis during this project is for a range of daily, weekly, and monthly measurements, which were entered into Environment Canada's Envirodat database on VAX Oracle. The data include measurements of effluent flow, biochemical oxygen demand (BOD), total suspended solids, acute toxicity, adsorbable organic halides (AOX), dioxins, furans, nutrients, the geographic locations of sampling sites, sampling dates and times, method of analysis and test results for water quality. The data set for this project covers the period from January 1990 to August 1993.

The objective of this data analysis project was to summarize the data (concentrations, flow, loadings, and production), conduct statistical analyses, and identify significant temporal trends. The trend statistics for all of the mills were designed to define a linear trend for the available data, although step trends may have occurred in some data as a result of mill process or treatment system changes that affect the effluent quality.

The report documents the results of the data analysis, including methods, statistical summaries (*e.g.*, monthly and annual summary statistics of physical and chemical parameters for the mills), graphs (*e.g.*, monthly and annual loadings for BOD, total suspended solids, AOX, etc.), interpretations, and literature references.

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2.2.2 Aerial Reconnaissance Of Fraser River Basin

Performed by: *Terra Pacific Information Systems*
Partner: *FPAO*
Funded by: *FPAO*
FPAO Contact: *Bert Kooi*

The contractor, in consultation with FPAO, was to compile and summarise an aerial reconnaissance of the Fraser River Basin, including the foreshores of major rivers and tributaries, for areas showing urban, industrial, and rural activities. The urban areas covered to date are Vancouver to Hope, Lytton, Lillooet, Kamloops, and some smaller centres.

The aerial reconnaissance information would be on S-VHS videotape and a GIS database compatible with that used by FPAO. Global Positioning System (GPS) data will be correlated with real time positional tracking on a GIS mapping system. All data would be integrated into a GIS to allow queries from the GIS to the exact place or count on the videotape (VHS). Two sets of S-VHS tapes would be supplied, along with all necessary MAP Info maps and associated databases indicating flight path and other appropriate data.

FPAO provided MAP Info maps for downloading, but no access to any databases. Environment Canada provided the aircraft and camera for the aerial reconnaissance, and the necessary computer and software for the contractor to download all processed videotape.

This project will increase the current knowledge of the state of the environment of the Fraser River basin. The type of information it can provide will help make possible better-informed decision making to achieve the overall goals of the Fraser River Action Plan.

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2.2.3 Guide For Best Management Practices For Process Water Management At Fish Processing Plants In British Columbia

Performed by: *NovaTec Consultants Inc. and British Columbia Packers Limited*
Partner: *FPAO, Environmental Protection, Environmental Conservation*
Funded by: *FPAO ($25K), EP ($3K), EC ($12K)*
FPAO Contact: *Bert Kooi, David Poon*

Fish processing is one of British Columbia's major industries. In 1990, fish processing in British Columbia accounted for 12 percent of the total number of Canadian fish processing plants, 16 percent of total industry employment, and 32 percent of the landed value, making it the largest fishing province in Canada. In 1993, there were 173 licensed (by BC Ministry of Agriculture, Fisheries and Food [MAFF]) fish processing facilities in BC (including small enterprises), including salmon canneries and small stores selling fresh fish. Approximately 70 percent of the total value of fish products originates from the Lower Mainland region, putting the bulk of this industry squarely in the lower Fraser River basin.

Fish processing plants in BC discharge either to municipal or regional sewer systems, or directly to the environment (mainly the Fraser River, Pacific Ocean, and Straight of Georgia). Most facilities are under permit and discharge to sewer systems, but several of the largest processing plants (BC Packers Limited and Ocean Fisheries Ltd.) discharge directly to the environment.

The liquid wastes from this activity constitute a significant load either to municipal sewage collection and treatment systems or to surface waters into which plants may discharge their wastes. Overall, high biochemical oxygen demand (BOD), chemical oxygen demand (COD), oil and grease, solids and suspended solids, and ammonia nitrogen content can be expected in effluents from fish processing facilities. While information about plant capacities was not obtained because of confidentiality, their maximum permitted discharge flows may be considered as an estimate of the plants' capacities. Determining the amount of contaminants discharged per unit weight of fish processed (contaminant mass loadings) allows a more accurate evaluation of plant performance with respect to generating wastewater, because low contaminant concentrations are not necessarily due to "clean" processing but may be the result of high water use. Those plants operating with a permit to discharge to the environment or to the Greater Vancouver Sewerage and Drainage District had an average discharge flow rate of 500 m^3/day.

The federal *Fisheries Act* regulates the discharge and disposal of deleterious substances to waters that harbour fish, but does not set limits for any of the possible pollutants that fall under the definition of a deleterious substance. Provincially, the BC *Pollution Control Objectives for Food-processing, Agriculturally Oriented, and Other Miscellaneous Industries of British Columbia* establishes objectives for wastewater discharge and waste disposal. These objectives apply to effluents discharged to fresh and marine waters other than groundwater and are expressed as a weight of contaminant per unit weight of production. There are also various Regional District and Municipal by-laws that regulate the discharge of wastewater from fish processing plants to municipal sewer systems and that have general restrictions on particle size, total suspended solids, oil and grease, and biochemical oxygen demand.

In addition to possible pollutants entering the basin, water consumption is also of concern. Water conservation techniques and processing technology modifications can reduce water consumption significantly.

The purpose of this project is to provide a technical guide and reference source to enable plants to effectively minimize cost and environmental impacts. The scope of the project included the following:

» collect and summarise available literature and case information on fish processing technology, wastewater treatment, and waste disposal practices at fish processing facilities throughout the world, specifically in BC;

» summarise available information on wastewater treatment technology in the context of Best Available Technology (BAT) appropriate to fish processing;

» summarise and analyse current practises in the lower Fraser River basin and assess the applicability of different components at other fish processing facilities in this region and elsewhere in BC;

» summarise the size, economic value, diversity, profitability, and trends in the BC fish processing industry and assess the probably impacts of various investments and present case studies;

» provide a guide for regulatory bodies, for use by the industry, and for those concerned with building new facilities or upgrading existing facilities.

The objectives of this *Guide for Best Management Practices for Process Water Management at Fish Processing Plants in BC* are:

» to give a comprehensive review of the best processing and treatment technologies and best wastewater management options, and

» to outline in a comprehensive manner the feasibility of process improvements, water conservation, byproduct recovery, and wastewater treatment.

The findings of the study, relative to pollution reduction in the lower Fraser River basin, include the following:

» Although the contaminant contribution to local sewer systems and receiving waters can be high, particularly during peak processing months, the contaminant load is believed to be minor compared to other sources. On an annual basis, the contaminant load from all fish processing in BC is estimated to have a population equivalent of 50,000 people.

» Even with limited data on the toxicity of fish processing plant effluent, the findings suggest that these effluents may fail toxicity tests because of elevated ammonia concentrations and BOD.

» Water and wastewater minimization procedures should be implemented prior to upgrading existing wastewater treatment facilities.

» Best Management Practices for fish processing plant effluents include dry processing and transport, and prevention of mixing solid waste material with water.

» A detailed water and wastewater audit should be carried out prior to implementing major process modifications.

» Currently, fine-mesh screening is generally considered to be the best economically achievable technology for treating fish processing effluents. More advanced forms of treatment, such as dissolved air flotation and enhanced gravity settling, should only be considered for specific receiving environment conditions and after acceptable options for disposing solid wastes have been developed.

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2.2.4 WASTEWATER CHARACTERIZATION OF FISH PROCESSING PLANT EFFLUENTS

Performed by: *NovaTec Consultants Inc. and EVS Environment Consultants*
Partner: *Fraser River Estuary Management Program (FREMP)*
Funded by: *FPAO ($50K)*
FPAO Contact: *Bert Kooi*

As part of FPAO's and FREMP's objectives to determine contaminant loadings from all origins in the Fraser River basin, this project's objectives included the following components:

- to compile and summarize recent available information on the physical and chemical characteristics, toxicity, volume of discharge, and discharge frequency of permitted effluents and other discharges entering the Fraser River and Burrard Inlet from the subject fish processing facilities; and
- to conduct a one to two-day site assessment of the operational practices at all processing facilities listed below on the basis of the information gathered.

The scope of the study was to describe a preliminary effluent sampling program carried out at four fish processing plants that discharge to the Fraser River. The overall purpose of the study was to evaluate existing data and new, site-specific data on effluent characterization. In addition to the four plants from which samples for effluent chemistry and toxicity were collected, four other fish processing plants were assessed based upon existing in-house data. The study period was limited to the salmon processing period, but was to include all processing that took place during that period, including the processing of other fish that took place during that time.

The four facilities at which field sampling was carried out were BC Packers (Richmond), Bella Coola (Delta), Lions Gate (Delta), and Ocean Fisheries (Richmond). The additional four fish processors were Great Northern (North Vancouver), New West Net (New Westminster), Shearer (Delta), and SM Products (Delta).

Considerable variation was found both within and between processing plants in terms of water consumption and effluent characteristics. Contaminant concentrations ranged from 128 to 2680 mg/L BOD, 316 to 3460 mg/L COD, 74 to 3640 mg/L TSS, and 0.7 to 70 mg/L ammonia. The estimated annual contaminant loadings for 1993 from all fish processing facilities to the Fraser River Estuary are 216 tonnes of biochemical oxygen demand (BOD), 380 tonnes of chemical oxygen demand (COD), 121 tonnes of total suspended solids (TSS), and 13 tonnes of ammonia. The annual contaminant loading from these facilities is approximately equivalent to a population of 6,000.

The fish processing and waste management practices encountered during the study are typical for similar processing plants located in other parts of North America. Areas for improvement at all facilities were identified and a number of operating and equipment changes were described that would lower the existing contaminant concentrations and reduce loads to the environment. However, in the absence of site-specific receiving environment information, it is not possible to predict whether such changes would reduce potential impacts in the receiving waters.

Effluent toxicity was demonstrated at all sites and the range of toxicity observed at each site varied between processing days. Only four of the nine toxicity samples collected passed the 96h-LC50 100% criteria for rainbow trout. Of the four toxicity tests carried out, the Microtox *Photobacterium* test was generally found to be the most sensitive to effluent samples. The wide variation in toxic responses by several organisms

to a single sample illustrates that the use of a single toxicity test is not recommended. Rather, the use of a number of tests with both chronic and acute endpoints is more predictive of the toxicity of the effluent from fish processing facilities. Continued use of the algal bioassay *Selenasrum* test for fish processing effluent testing is not recommended because nutrients contained in the effluent stimulated algal growth, interfering with the test endpoint.

A summary of water consumption for the 1993 season is presented in the project report. Effluent solids (TSS) concentrations were generally high, BOD and COD varied widely, nitrate and nitrite (mostly ammonia) concentrations were low at all facilities, and total and dissolved metal concentrations were generally low. With the exception of BC Packers, concentrations of fecal coliforms in fish processing effluent were generally low. These may be partly due to bird droppings in areas from which runoff is discharged, together with process effluent (containment around wet pumps, yard drains, etc.).

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2.2.5 Wastewater Characterization of Four Industrial Discharges in the Fraser River Basin, Parts 1 and 2

Performed by: *IRC Integrated Resources Consultants Inc.*
Partner: *FPAO, BC Ministry of Environment, Lands & Parks (BC MOELP)*
Funded by: *FPAO ($104K)*
FPAO Contact: *Lisa Walls, Snehal Lakhani*

This project was carried out in support of the Fraser River Action Plan/Fraser Pollution Abatement Office's objectives of reducing contaminant loadings to the Fraser River. In order to do this, loadings to the river must be identified and quantified. Sampling programs were developed to characterize the wastewater discharges of four industrial facilities:

- Canadian Forest Products Limited, Prince George
- FMC of Canada (a chemical company), Prince George
- Quesnel River Pulp Company, Quesnel
- Weyerhaeuser Canada Limited, Kamloops

Each industrial site was visited before the sampling program was developed. These visits were used to familiarize the personnel responsible for the collection of the samples with each site. During the site visits, project personnel reviewed the treatment and piping systems, outfall systems, mill procedures and operations. The sampling locations at each site were selected and equipment required for sampling was determined.

At each facility, the effluent was sampled over a 24-hour period using the procedures for wastewater characterization studies recommended by Environment Canada for the Fraser River basin. The collected samples were analysed for the chemical parameters listed in Environment Canada's report titled *Recommended Guidelines for Wastewater Characterization in the Fraser River Basin, 1993*. The parameters for wastewater characterization include: BOD, TSS, COD, AOX, dioxins and furans, resin acids, ammonia, nitrite, dissolved phosphorus, cyanide, metals, chlorophenols, trichlorobenzenes and tetrachlorobenzenes, dichloromethane, toluene, hydrogen peroxide, chlorine, pH, alkalinity, temperature, and dissolved oxygen. This is an industry-specific list. Bioassay tests recommended in the Guidelines were also carried out on the effluent samples. The quality assurance and control procedures specified in the Guidelines for sampling and analyses were followed.

Using the data generated, the loadings for the four facilities were computed and compared to loadings measured in the 1993 routine monitoring programs. The loadings calculated from the 24-hour composite samples were generally within the normal variation of loadings measured from the 1993 monitoring data. However, when the suspended solids concentration in the effluent was high, the wastewater loadings for parameters associated with the solids could differ by nearly two standard deviations.

The annual and monthly means, standard deviation, maximum and minimum loadings for the four facilities for the period 1990 to 1993 were computed from the Environment Canada database. In general, the loadings of specific parameters decreased at all four facilities in this period. There were significant reductions in AOX (adsorbable organic halogens) loadings from Canadian Forest Products and Weyerhaeuser, in hydrogen peroxide from FMC, in TSS (total suspended solids from Weyerhaeuser, and in BOD (biochemical oxygen demand) from Quesnel River Pulp. The reductions in loadings were reflected by similar decreases in the annual mean concentrations of the various parameters in the effluent.

The acute, sub-acute, and chronic toxicity, as well as the inhibition of algal growth bioassay, were determined for each sample. In addition, some of the bioassay procedures were carried out on duplicate samples as an additional quality control procedure in the testing. With the exception of one toxicity test, all effluents were not acutely toxic. Two of the mills' effluents tested positive in the chronic reproduction test. The same two mills had effluents that inhibited algal growth.

The report of this project describes the site descriptions, sampling and testing methods and procedures, discusses the operating conditions during sampling, and interprets the project results. Some of the conclusions and recommendations put forward include:

» The one-day procedures for characterizing effluent loadings as specified in the draft Methods Manual were found to be effective in quantifying loadings when the facilities were operating normally.

» The QA/QC procedures specified in the manual were found to be an important component of the characterization procedure, particularly for parameters near the detection limits or within 10 times the minimum detection limit.

» The parameter list for the various industries in the manual is intended to be comprehensive. In this project, this parameter list was used. Although many of the measured parameters were less than detection limits, the list should still be used in the initial characterization and can be amended, if necessary, for subsequent measurements.

» The sampling program must be site-specific, therefore, pre-sampling site visits are necessary.

» The results for both acute and chronic toxicity procedures were the same for both grab or composite samples.

» The QC program should include some comparisons of grab and composite sample results to quantify the representativeness of the composite sample and review procedure.

» A method for interpreting the suite of bioassay results should be developed and a toxicity loading parameter developed to determine acute and chronic toxicity loading units.

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2.2.6 Preparation of Guide For Stormwater Best Management Practices For Selected Industrial Sectors in the Lower Fraser River Basin, Phase 1

Prepared by: *CJ Anderson Consultants*
Partner: *FPAO, Environmental Protection, Environmental Conservation*
Funded by: *FPAO ($50K), EP ($3K), EC ($12K)*
FPAO Contacts: *Bert Kooi, David Poon*

The characterization of contaminant loadings and development of control strategies for point and non-point sources of pollutants to the Fraser River basin are an integral part of the Fraser River Action Plan objectives for reducing contaminants to the basin. Non-point sources were identified in the United States as the largest source of water pollution, contributing 65 percent of the contamination in impaired rivers, 76 percent in impaired lakes, and 45 percent in impaired estuaries. For Canada, because of a smaller population, these statistics may be lower. However, the climatic and geophysical conditions and human-related activities in British Columbia are unique. Stormwater runoff is a major non-point discharge in the densely populated lower Fraser River basin.

Depending on local geographical and land use conditions, major pollutants from non-point sources include sediments/solids, petroleum-based products, PAHs, agricultural chemicals, nutrients, heavy metals, pH/alkalinity regimes, bacteria, viruses, and oxygen-demanding compounds. Among non-point sources of water pollution, agricultural runoff is the major source, followed by urban surface runoff, which also includes stormwater discharges associated with industrial activities. Airborne contaminants are also considered non-point sources of pollution in the lower Fraser River basin, but were not focused on in this project.

The overall goals of this project were to develop a background knowledge database and a guide for best management practices for stormwater from selected industrial sectors, namely the following:

Aluminum	Fruit
Asphalt	Industrial Park
Brewery	Meat
Cement	Metal
Chemical	Metal Smelters
Chlor-alkali	Petroleum
Concrete Products	Poultry
Dairy	Refinery
Dry Bulk Terminals	Sand and Gravel
Fertilizer	Steel
Fish	Sugar
Food	Vegetable Processing

Pulp and paper mills, forest product operations, and mining operations have their unique operation and stormwater handling characteristics and, while they may be major contributors to non-point source contaminant loading in the Fraser River basin, were not included in this project.

This study is to be conducted in two phases (of which Phase 1 is completed): Phase 1 determined characterization of stormwater at typical industrial sites; Phase 2 completes the preparation of a Code of Practice document.

The sequence of tasks for Phase 1 were as follows:

» List and survey industrial stormwater generators in the lower Fraser Valley.

» Perform a literature survey on stormwater characteristics and control technologies.

» Characterize and assess stormwater control practices at five selected industrial sites (from four industrial sectors: wire and wire products, ready-mix concrete, asphalt manufacturing, and light industrial parks).

» Characterize and assess stormwater quality from the selected industrial sites.

» Perform an economic evaluation of stormwater management and control practices for one of the selected industrial facilities.

The intended objectives for Phase 2 are:

» Characterize and assess stormwater control practices at selected sites for the remaining industrial sectors.

» Characterize and assess stormwater quality from the above selected industrial sites.

» Perform an economic evaluation of stormwater management and control practices for the remaining industrial sectors not performed in Phase 1.

» Report the recommended practices for stormwater management.

The project is also intended to provide information to the selected industrial sectors for the development of stormwater control and management plans at their operating facilities.

An important product of this project will be the preparation of an Industrial Facility Stormwater Inspection Checklist. The nature of the checklist will be generic and is intended to be used only by regulatory inspectors to conduct stormwater inspections at a facility or development. The checklist will not contain specific site and industrial activity questions. FPAO intends to develop an industry-specific checklist for each of the selected industrial sectors in the future. The products of this project will go towards that goal.

Some of the findings of Phase 1 include:

» Of the 19 industrial installations that responded to the survey, 79 percent are permitted facilities.

» Most permitted facilities had already implemented some form of best management practices to control stormwater runoff at their facilities, including a closed-loop system at one.

» The fish processing, canned fruit and vegetables, and asphalt manufacturing industries do not normally operate during months of heavy rainfall. Therefore, the impact of runoff is generally minimal for these industrial sectors. It is recommended that these be evaluated during summer while they are full operating mode in order to evaluate the potential surface runoff from their land disposal fields or on-site wastewater treatment systems. This would enable assessment of impacts should they operate during an unusually rainy season.

» Stormwater sampling and water quality characterization at light industrial parks revealed that concentrations of contaminants in the stormwater from the industrial parks are lower than those in the municipal storm sewers (were higher in up-gradient samples than in samples down-gradient from the sites). This implies that a properly designed and operated industrial park can reduce wastewater loading to the receiving environment.

Results of the economic evaluation revealed the following findings and observations:

» To minimize stormwater pollution program costs, various best management practices should be integrated into initial phases of site development and plant construction.

» Retrofitting an existing industrial facility may be costly.

This project will continue into the next fiscal period in order to complete Phase 2.

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2.2.7 Background Report on Recommended Best Management Practices for Ship & Boat Building and Repair Facilities in BC

Prepared by: *DF Dickins Associates Ltd. and Westmar Environmental Consultants Inc.*
Partners: *FRAP, CCD, BIEAP, GVRD, DFO, BC MOELP*
Funded by: *FRAP ($29.7K); CCD ($28.9K)*
DOE Contact: *Stan Liu (Commercial Chemicals Division)*

This Ship and Boat Building Best Management Practices project was initiated to build on the draft guidelines that were developed in 1989 for use by large shipyards (11 facilities in BC), but that dealt only with hull cleaning (abrasives) and coating (painting). The current project applies to all aspects of commercial and government ship and boat building and repair facilities. It includes recommended practices beyond just hull cleaning and coating (i.e., spill contingency, housekeeping, waste minimization).

The project surveyed the relevant federal, provincial, and regional legislation, bylaws, and project review processes; performed an overview of current environmental management practices in British Columbia, other Canadian jurisdictions, the United States, and internationally, and made a comparison of these. The report also contains a contact list of applicable government agencies, definitions of shipbuilding and repair terminology, stakeholders' comments, a list of the types of facilities available at ship and boatyards in BC, a summary of the pollutants associated with this industrial sector, references to the Ocean Dumping Regulations (federal), and lists the leachable quality standards for selected contaminants under the (BC) Provincial Special Waste Management Regulations.

There are about 60 companies of various types active in the commercial ship and boat building and repair industry in British Columbia. Many are small operations dealing almost exclusively with the pleasure boat market. Eleven are listed as shipbuilding and repair companies and 41 as boat building and repair. While many of these are located in the marine environment, some are along the Fraser River downstream of Mission and others build vessels small enough to be transported by road. Of the at least six government-owned and -operated ship repair facilities, one (the Deas Dock Refit Complex of BC Ferries) is located on the Fraser River.

Common industrial activities include: sanding, blasting, welding, refinishing, painting, vessel and equipment cleaning fluid change, mechanical repairs, part cleaning, fueling, dockside repair services, storage of materials and wastes (e.g., oil, fuel, batteries, hydraulic components, oil filters). Any of these can affect receiving environments by directly discharging process wastewater or contaminated surface runoff to receiving water bodies, or through entrainment or dispersion of airborne particulates to the local air-shed. Some of the specific contaminants associated with the ship and boat building and repair industry are paint solids, detergents, heavy metals (including lead, copper, zinc, chromium, cadmium, mercury), suspended solids, spent abrasives, solvents, dust, ethylene glycol, acid/alkaline wastes, fuel oils, bacteria, oil and grease, spent solvents, and wastes that have biochemical oxygen demand.

In addition to the possibility of introducing contaminants to aquatic environments, under the Fisheries Act, there are concerns about spent abrasives because of their potential to foul fish gills, leach heavy metals, and smother fish habitat.

During the course of this study, it was noted that shipyards typically have more formal procedures in place than do smaller boatyards for conducting activities and managing wastes be-

cause of the comparatively larger quantities of materials used and because of the presence of a dedicated administrative staff. However, the cumulative volume of toxic substances handled by even a medium to small sized boatyard can be significant.

BC's shipbuilding and repair industry has been in a state of recession for some time and faces stiff competition from other Pacific Rim yards. It was recognized at the outset of this study that economic realities will be a constraining factor controlling the rate and extent to which new guidelines can be put into practice. However, there is opportunity to affect significant improvements in local aquatic and air pollution by applying relatively simple and sensible modifications to existing routine operating activities.

The report summarizes the state of knowledge on the impact of several different contaminants on the receiving environment, and gives BMPs for the handling, control, and disposal of contaminants generated during shipbuilding and repair activities. Although they are intended to apply only to commercial vessels and government facilities, the report makes recommendations for practical measures that can be employed by both large and small shipbuilding and repair facilities (from the largest drydock to the smallest marina travel lift) to reduce the volume of contaminants entering aquatic environments, thus helping meet the objectives of the programs of the Fraser Pollution Abatement Office.

This project is being expanded to include facilities servicing the recreational and pleasure boat sector. Total project completion is expected in early 1995. A compliance checklist will also be developed, based on BMPs.

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2.2.8 Processing and Homogeneity Testing of a Standard Reference Material for Acidic Rock Prediction Technologies

Performed by: *Canada Centre for Mineral and Energy Technology (CANMET), Mineral Sciences Laboratories*

Partners: *FPAO; Mine Environment Neutral Drainage (MEND) Prediction Committee*

Funded by: *FPAO ($25K)*

DOE Contact: *Benoit Godin*

There are a number of mines within the Fraser River basin that have the potential to generate acid rock, thus altering the chemistry of waters that are used for a number of sensitive purposes, including drinking water, industrial processing water, and, probably most importantly, as habitat for aquatic organisms including fish.

The processing and homogeneity testing of a standard reference material for acidic rock prediction technologies is becoming increasingly important to industries worldwide as they endeavour to diminish the environmental impacts of acidic rock drainage (ARD). A standard enables a reliable comparison of results obtained by different laboratories performing the tests. Much time and resources have been expended on the development of methods and the analysis of materials in the evaluation of the acid generating potential of rock samples. Currently, ARD methods are still in the developmental stages and no reference material exists to enable a comparison of results obtained by different laboratories. In order to advance the technology further, a standard material with well-characterized values for ARD parameters is required.

For use in this study, Noranda supplied CANMET with 540 kg of non-ore grade pit rock from the Bell Mine at Granisle, BC. This material was processed according to the CANMET protocol for certified reference materials. A total of 3,429 bottles containing 100 g of the material (NBM-1) with a particle size of minus 74 mm were prepared. The bottles were sealed under nitrogen in laminated foil pouches to provide long term protection from oxidation.

Although it would have been most useful to test the homogeneity of NBM-1 with respect to the static ARD prediction parameters (i.e., standard or modified acid-base accounting), these analyses are not sufficiently precise to detect the small differences between the results that are required. Instead, the homogeneity was tested with respect to iron and sulphur, for which extremely accurate and precise analytical methods exist. On the basis of the CANMET homogeneity test, it was concluded that no evidence of inhomogeniety with respect to iron and sulphur could be detected.

The equilibrium of carbon species in rocks also plays a highly critical role in the generation of acid (calcites will dissolve at low temperatures in acidic solutions, whereas dolomite and siderite are only slightly soluble). At the request of the MEND Prediction Committee, CANMET analysed the determination of carbonate. From the results of carbonate analysis, it was calculated that the material contains 0.78% carbon in the form of siderite and ankerite, based on the results of mineralogical analysis performed under another project contract.

This project has provided the relevant agencies with a standard reference material, NBM-1, that is ready for an interlaboratory measurement program for characterization according to specific methods. The projects represents the first stage in the preparation of a standard material characterized for ARD parameters. NBM-1 can serve the dual purposes of a standard material for method development and for quality control.

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2.2.9 Evaluation of CASI* Imagery for the Lower Fraser River (Scott Paper, New Westminster) and Upper Fraser River (Prince George Area) Pulp Mills

Prepared by: *GA Borstad Associates Ltd.*
Partner: *FPAO*
Funded by: *FPAO ($15K)*
FPAO Contact: *George Derksen*
**CASI = Compact Airborne Spectrographic Imager*

The application of remote sensing technology for aquatic ecosystems management has tremendous potential for detailed analysis. In the 1993/94 fiscal year, two CASI flights were flown as part of an Environmental Innovation Program: April 6 over Scott paper in New Westminster, and September 15 on flight paths over the Prince George region. This project undertook to evaluate the CASI data collected for integration with roll, pitch, and yaw measurement systems and Global Positioning Systems (GPS) for use with GIS for digitized imagery.

The two components of this project targeted one specific site in the lower Fraser River basin (Scott Paper) and a general target in the north central portion of the basin (Prince George area pulp and paper mills). The reports of this data evaluation project present the calibrated imagery to define effluent plumes and imagery

classification of various urban outfalls in the Lower Fraser River and Burrard Inlet, and discuss the concurrent use of airborne imaging and *in situ* fluorometry.

The focus of this year's project was to complete the work begun in fiscal year 1992/93. Specific areas of interest for this study included nearshore zones adjacent to rivers and streams. These "edge environments" are transitional areas that provide a diverse range of habitats and generally provide critical spawning, feeding, and nursery habitats for many species of fish, birds, mammals, and other wildlife. The overall goals of the project are to:

- streamline methods of collecting remote sensing data and the production of accurate digital databases
- review and assess ground truthing data (*in situ* fluorometer) for select flight paths to determine if this is an adequate method for classifying CASI images to estimate effluent dilution
- classify images to define pulp mill effluent plumes and estimate effluent dilution when dye was being injected and when dye was not being injected and, in the case of the flight paths over Scott Paper on the lower Fraser River, relate the imagery to stages of the tide cycle
- calculate the overall area of the effluent plume and, where possible, draw isopleths of four approximate effluent concentrations for each of the flight lines
- prepare classified raster images for use in GIS
- provide colour prints, negatives, and slides for each of the above flight lines
- provide a report outlining the methods and procedures used, along with a limited interpretation of the results and any benefits of concurrent use of the two technologies (CASI and traditional *in situ* fluorometry) to assess effluent dispersion

The project includes a study of the multispectral characteristics of discharges from municipal and industrial sources. The changing horizontal patterns through time of effluents near the surface can be mapped accurately with CASI and may be a valuable assessment tool in conjunction with data collected by more traditional effluent dispersion techniques.

The final reports for this project are not yet completed.

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2.3 Project Areas: Municipal Discharges and Urban Runoff

2.3.1 Inventory of Municipal Stormwater Discharges Within the Fraser River Estuary

Prepared by: *UMA Engineering Ltd.*
Funding: *FPAO ($30K)*
FPAO Contact: *Bert Kooi*

Municipal stormwater discharges are a major point source of contaminant loading to the Fraser River. An inventory of point sources of this type of discharge from the mouth of the Fraser upstream to Kanaka Creek (not including tributaries) is required as an important first step in assessing the contaminant loading to this highly urbanized and developed portion of the Fraser.

The consultant compiled and summarized information on the location of 252 stormwater discharges downstream of Kanaka Creek, including visual verification of the locations. This stormwater discharge inventory will be used as a basis for establishing priorities for subsequent monitoring of contaminants and toxicity in water, sediments, and biota, and to recommend priorities for pollution abatement measures. No sampling was required for this project.

In addition, an environmental assessment matrix was used to evaluate the overall environmental risk and provide a "sensitivity" ranking of storm drains based on the following five criteria:

1. flushing characteristics
2. discharge flow
3. habitat sensitivity
4. drainage area/land use characteristics
5. public use

Three levels of environmental concern were considered for the environmental assessment matrix:

1. **High**: Associated with any shoreline or any site known to be an endangered or protected habitat or a fish spawning or rearing area for recreational or commercially utilized species, or any site that is used for primary contact water activities
2. **Moderate**: Any site generally with moderate river flow, secondary water contact (surface water sports), and moderate fishery resources
3. **Low**: Any site generally with good river flow and low public use, and minimal fishery resources

A list of the storm drains discharging into the Fraser River Estuary, along with site, drainage, and outfall data, was compiled from existing reports and as-built information received from all the government agencies and municipalities within the region of concern for this project. Determinations were made for each discharge point for the above-listed five criteria for environmental sensitivity. Photographs were taken of each discharge site.

All the information gathered during this project was compiled into a database designed for easy review and retrieval. One hundred and sixteen sites were classified as having low environmental sensitivity; 96 were classified as moderately sensitive; and 40 were classified as having high environmental sensitivity. The final report for this project also includes information and references, such as personal communications and pump station information.

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2.3.2 CLARK DRIVE CSO AND STORMWATER CHARACTERIZATION

Prepared by: *GVRD Sewerage and Drainage Department*
Partners: *FPAO and GVRD*
Funded by: *FPAO ($80K), GVRD ($80K)*
FPAO Contact: *Bert Kooi*

The Clark Drive combined stormwater and sewer overflow (CSO), which discharges directly to Burrard Inlet, is the largest single volume CSO in the Greater Vancouver Region and accounts for about 60% of the GVRD's total annual CSO discharge volume. Monitoring of this CSO by Environment Canada and the BC Ministry of Environment has found sediment contaminant levels in excess of Provisional Water Quality Objectives. This project builds on the characterization study of the Clark Drive CSO begun in the 1992/93 fiscal period and will require a joint sampling program for the 1993/94 winter season.

Data collected for this discharge is a necessary step in assessing its impacts and for developing a cost-effective strategy to manage it. Data collected will include measurement of discharge quantity and toxicity for this catchment area, and will also serve to increase our knowledge of the characteristics of CSO and stormwater within the region and provide information to be used in the development of the Liquid Waste Management Plan.

It should be noted that below normal precipitation was experienced during this study and may have had an effect on the data collected.

The specific objectives of this phase of the study are as follows:

- to monitor the quality and quantity of the Clark Drive CSO discharge over seven storm events
- to monitor the quality and quantity of stormwater from selected separated stormwater catchments tributary to the Clark Drive CSO over seven storm events in order to estimate the contribution of contaminants from stormwater to the CSO discharge

Concurrent characterization of stormwater from separated catchments tributary to the Clark Drive CSO will help distinguish between the sanitary sewage and stormwater contributions to the CSO. The stormwater quality data will also be compared to the quality of stormwater from the residential Fraser Glen catchment sampled in spring 1993. This will allow comparisons between stormwater quality from catchments with different land uses.

For each storm event sampled, wastewater quality characterization parameters monitored will include conventional parameters, metals, toxic organics (including phenols, chlorinated phenols, PAHs, chlorinated hydrocarbons, phthalate esters, PCBs, volatile organic compounds, and napthlenes), bacteriological (fecal coliforms and enterococci), and toxicity, including bacterial luminescence inhibition (Microtox), Rainbow trout lethality, *Ceriodaphnia dubia* survival and reproduction, and algal (*Selenastrum*) growth stimulation/inhibition. Dioxins and furans were sampled for only two events for both CSO and stormwater. Wastewater discharge rate data were collected on a continuous basis.

A final report is expected pending results of analyses in 1994/95.

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2.3.3 WESTRIDGE CSO AND STORMWATER CHARACTERIZATION

Prepared by: *GVRD Sewerage and Drainage Department*
Partners: *FPAO, BIEAP, and GVRD*
Funded by: *FPAO ($10K), BIEAP ($5K), GVRD ($15K)*
FPAO Contact: *Bert Kooi*

Westridge combined sewer overflow (CSO) outfall is located on the south shore of Vancouver Harbour, approximately 5 km east of the Second Narrows Bridge. About 0.6 million cubic metres of wastewater is discharged through this outfall annually from a combined industrial and residential catchment area.

Westridge CSO has been identified by the GVRD as a location where high rate CSO treatment has the potential to become part of the integrated CSO control program.

Characterization monitoring will help evaluate the feasibility of a range of high rate technologies. Potentially, one of these technologies will be selected for a future pilot project at the Westridge site.

This CSO characterization is part of Environment Canada's and the Fraser Pollution Abatement Office's effort to reduce contaminant loading from municipal sources to the Fraser River.

There are 53 CSOs that discharge intermittently to the receiving environment within the Greater Vancouver Region. Only the Clark Drive CSO has been monitored for the quality and quantity of its discharge. The data collected from the Westridge CSO characterization will be added to that of the Clark Drive monitoring and characterization project to increase our knowledge and understanding of the variability among CSO discharges from different locations within the region. It will also provide information to help assess the feasibility of a high rate CSO treatment technology for managing the Westridge CSO.

Three CSO events will be monitored at Westridge for information on the quality and quantity of discharge. One event will be monitored to assess the toxicity of Westridge discharge. The parameters monitored are the same as those given in the Clark Drive CSO project synopsis preceding this section.

The final report is pending results of analyses in 1994/95.

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2.3.4 CROWE STREET CSO AND STORMWATER CHARACTERIZATION

Prepared by: *GVRD Sewerage and Drainage Department*
Partners: *FPAO, BIEAP, and GVRD*
Funded by: *FPAO ($10K), BIEAP ($5K), GVRD ($15K)*
FPAO Contact: *Bert Kooi*

The Crowe Street combined sewer overflow (CSO) is located on the south shore of False Creek, approximately 0.2 km east of Cambie Street, and discharges into the False Creek area of Burrard Inlet. The GVRD and Environment Canada require data on the quality, quantity, and toxicity of wastewater and sediment being discharged through this CSO as part of its studies to assess impacts from this and other CSO discharges, and as part of the ongoing effort to characterize and reduce contaminant loadings into the Fraser River basin from point sources.

The Crowe Street outfall is also the site of a pilot study to investigate the effectiveness of a CSO treatment technology, a high-rate clarifier with the trade name "Microsep." The CSO characterization at this site includes selected monitoring of effluent from the pilot project in order to provide preliminary information for evaluation of the pilot treatment process.

This project provides information on variability among CSO discharges from different locations within the GVRD, when compared to data collected from the Clark Drive, Westridge, and Glenbrook CSO characterization programs. In addition, this study provides some initial information on the effectiveness of Microsep technology for treating CSO effluent.

In particular, the Crowe Street CSO characterization monitored the quality and quantity of discharge during two CSO events and assessed the toxicity during one CSO event. Samples were collected from both the CSO system at the pilot treatment unit's intake point and from the effluent of the pilot treatment unit.

The parameters monitored included conventional parameters (metals, toxic organics, bacteriological) and a suite of toxicity tests, including bacterial luminescence inhibition (Microtox), Rainbow trout lethality, *Ceriodaphnia dubia* survival and reproduction, and algal growth stimulation/inhibition.

Effluent from the pilot Microsep treatment unit was analysed to assess the effectiveness of this treatment using a limited number of parameters, including the conventional parameters, heavy metals, and bacteriological.

Wastewater discharge rate data were collected on a continuous basis over the sampling period for information on the quantity of CSO discharge and to allow samples to be flow-composited.

The final report for this project is pending results of analyses in 1994/95.

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2.3.5 GLENBROOK CSO AND STORMWATER CHARACTERIZATION

Prepared by: *GVRD Sewerage and Drainage Department*
Partners: *FPAO and GVRD*
Funded by: *FPAO ($40K), GVRD ($40K)*
FPAO Contact: *Bert Kooi*

The Glenbrook combined sewer overflow (CSO) outfall is located in New Westminster and discharges directly to the Main Arm of the Fraser River. Glenbrook is one of the larger volume CSOs located on the Fraser, with an estimated annual effluent volume of 1.2 million cubic metres discharge during a year of average rainfall.

As part of its goal of reducing contaminant loadings to the Fraser River, FPAO co-funded this study to obtain data on the quality, quantity, and toxicity of wastewater and sediment discharged through the Glenbrook CSO. Collection of this information is a necessary step in assessing the impacts from this discharge and for developing a cost-effective strategy to manage it and other CSOs in the region. The data collected will also serve to increase our knowledge of the characteristics of CSOs and will be used in the development of a Liquid Waste Management Plan for the GVRD.

The FPAO/GVRD study initiated in early 1993 of the Clark Drive CSO, the largest in the region, provided much information on the types and levels of contaminants found in the Clark Drive CSO effluent, however, additional information is required from other CSOs in order to build a body of knowledge on the quality, quantity, toxicity of effluents discharged to the Fraser River, and on the variability between different outfalls and over time.

This Glenbrook CSO characterization project will provide important information on variability among CSO discharges from different locations within the region when compared to data collected from other characterization studies, such as the Clark Drive, Westridge, and Crowe Street CSO studies.

The objectives of this study are:

- to monitor the quality and quantity of the Glenbrook CSO discharge during seven CSO events, and
- to assess the toxicity of this CSO discharge during four CSO events.

Sampling of the Glenbrook CSO will be conducted at one site within the collection system. Site selection criteria will include proximity to the outfall, suitability for flow monitoring, and security of sampling personnel and equipment. For each sampling event, wastewater quality characterization parameters monitored will include conventional parameters, metals, toxic organics, bacteriological parameters (fecal coliforms and enterococci), and Microtox toxicity. A suite of toxicity tests will be conducted on wastewater samples collected from four CSO events. This suite of tests includes Rainbow trout lethality, *Ceriodaphnia dubia* survival and reproduction, and algal (*Selenastrum*) growth stimulation/inhibition. Dioxins and furans will be sampled in wastewater from two CSO events.

Wastewater discharge rate data will be collected on a continuous basis for the duration of the sampling program.

The final report of this study is pending results of analyses in 1994/95.

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2.3.6 BC Ministry of Health Sewage Disposal System Report

Prepared by: *Dayton & Knight Ltd. and Piteau & Associates*
Partners: *FPAO and BC Ministry of Health*
Funded by: *FPAO ($25K), BC MOH ($50K)*
FPAO Contact: *Bert Kooi*

This project was begun in the previous fiscal period and relates to the BC Ministry of Health's (MOH) concern with existing on-site sewage disposal practices in the Fraser Valley, specifically in the Simon Fraser, Central Fraser Valley, Upper Fraser Valley, and Boundary Health Units. The concern comes from two sources: the number of failures observed of on-site disposal systems and the increase in general knowledge about how to develop sewage disposal systems that function properly to allow protection of human and environmental health. Both Environment Canada and the Ministry of Health want to ensure that the on-site sewage disposal systems being developed in the Fraser Valley are designed, installed, and maintained in a manner that will prevent the discharge of inadequately treated effluent to the land, surface water, or groundwater.

The area of study is bounded on the west by the Pitt and Fraser rivers, on the east by the town of Hope, on the south by the Canada/US border, and on the north by the developed areas on the north side of the Fraser River. The study area lies within the coast trough and enjoys a modified maritime climate. Maximum precipitation occurs in the winter months. Total annual rainfall is variable throughout the region, with the lowest in the south end of the study area and the highest in the north, around Maple Ridge and Chilliwack (average 75 inches (1900 mm) annually). Almost 70% of annual precipitation occurs between October and March.

The primary objective of this project was to review current on-site sewage disposal system practices in the Fraser Valley and make recommendations for improvement. In addition, an extensive review of relevant on-site sewage treatment and disposal technical reports and government regulations and guidelines was undertaken, with particular emphasis on Washington and Oregon, which have similar physiographic conditions as those in the Lower Mainland of BC.

It is estimated that there are about 132,700 dwelling units within the study area, of which about 68% (89,800) are on a community sewerage system and about 32% (42,900) are on individual on-site (septic) systems. Of these latter, about 39% (16,623) are older than 20 years, 15% (6,263) are between 16 and 20 years old, and 12% (5,321) are between 11 and 15 years old.

Monitoring was conducted at eleven existing drainfields located in high water table areas of the lower Fraser Valley. Sites were selected on the basis of representativeness of age, type of construction, and location in diverse climatic and soil conditions. As well, eight holes were installed within the road allowances throughout the Country Woods Estates subdivision in south Surrey. This subdivision was developed in the early 1980s and has a high percentage of alternative types of drainfields.

The Ministry considers an on-site sewage disposal system failure to have occurred when the effluent moves directly to the ground surface with minimal treatment, when sewage odours are detected, or when flows within the household plumbing system are sluggish. Failures are generally recognized on a complaint basis only. Health hazards from septic system failures include microbial, viral, and nitrate contamination of groundwater. These can have serious health consequences given the number of groundwater

wells used as sources of drinking water in the Fraser Valley. In recent years, residents of the Valley have been instructed to boil or buy drinking water from time to time. The problem, while intermittent, is considered serious and remedial action is being taken, this study being part of that action. Environment Canada was also concerned with the possibility of contaminants entering the water table and ultimate leaching of pollutants into the Fraser River.

Site evaluations typically involved a review of the development history. After drilling boreholes and installing monitoring tubes, the water levels were monitored over a two-month period and samples were collected and submitted for chemical and biological analyses.

As part of FPAO's contribution to the study, an evaluation of the impact of septic effluent on unconfined permeable aquifers with relatively shallow water tables was carried out. The principal objective of this aspect of the project was to measure distance of travel of nitrates, coliform bacteria, and possible other pathogens at a selected site in the Fraser Lowland. There is limited information on groundwater quality in the lower Fraser Valley. Only a small part of it has been compiled in a manner that can be interpreted for its usefulness in locating potential sources of contamination and aquifer type. Projects of this sort will help increase the base of knowledge.

Key conclusions drawn from the field studies included:

» Water levels in most of the drainfield mounds studied were high, and vertical separations were either virtually nonexistent or were less than the required 0.6 m minimum over extensive areas of these drainfields.

» Both bacteriological and chemical testing did not provide much evidence of significant migration of pollutants from the drainfields. However, it is believed that if the sampling had been carried out in wetter conditions, some migration would have been detected.

» Rainfall had a significant impact on the operation of the drainfields. However, February 1993 was a record dry month and water levels were considered to be better than normal for the late winter season.

» The soils used to construct the drainfields were generally not homogeneous (and in some cases was imported soil) and as-built conditions for the fields often did not match those specified in the approved plans.

This project came up with a considerable number of recommendations for the design, construction, operation, maintenance, inspection, monitoring, and future research on on-site sewage disposal systems tailored for use in the lower Fraser Valley. Based on the literature review and on the field studies, it is clear that there are a number of problems with the existing regulatory framework and the current guidelines. Many of these issues can be solved by a combination of changing current guidelines, and education and registration of personnel designing and constructing the on-site facilities. Education of the public about the necessity to maintain minimum maintenance standards was another important recommendation.

Suggested changes in the guidelines include:

» restricting the fill by providing a standardized specification,

» ensuring a minimum vertical separation of 0.6 m between the floor of the drainfield and the top of the highest level of the water table, and

» providing more detailed evaluations of water levels and the hydraulics of drainfields.

It was also recommended that the Ministry of Health establish a working committee consisting of representatives from industry, consultants, and regulatory agencies to develop standardized guidelines for investigations and construction standards, as well as develop a training program leading to registration of design professionals and contractors. It is hoped this type of cooperation will result in better quality control for all on-site systems.

Another conclusion coming out of this project is the recognition of a need to evaluate the synergistic impact of groups of on-site systems before large subdivisions are approved. Of particular concern is the need for an assessment of the impact on subsurface drainage in areas with high

water tables and on groundwater quality in areas that overlie high risk aquifers. For example, if a proposed subdivision has more than five housing units with an average lot density greater than 2.5 residences (discharging about 1.6 cubic metres per day, or 300 lgpd) per hectare, then an assessment would be required to ensure that the discharged effluent will not affect the aquifer water quality. If necessary, mitigative measures may have to be incorporated into the on-site systems. These measures may include restricting approvals to those areas where perc times are greater than 2 minutes per inch, incorporating sand or other filter material into the trenches, or pre-treating the effluent in a sand filter. Increasing the vertical separation to a minimum of 2 metres could also be considered.

The study concluded with recommendations on the roles for municipalities in the management of on-site treatment and disposal systems and the need for ongoing research programs to improve their design.

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2.3.7 District of Hope: Sewage Treatment Study

Performed by: *Dayton & Knight*
Partners: *FPAO and District of Hope*
Funded by: *FPAO ($7.5K); District of Hope ($7.5K)*
FPAO Contact: *Phil Wong*

The sewage treatment plant at the confluence of the Fraser River and Silverhope Creek in the District of Hope is overloaded and has exceeded the provincial permit limits for various parameters (including BOD and TSS) on several occasions over the past few years. In addition, two out of four effluent samples monitored by Environment Canada in 1992 and 1993 did not meet the non-acutely toxic requirements of the *Fisheries Act.*

The works consist of two aerated lagoons, two 75 HP blowers, an effluent metering manhole, and an outfall to the Fraser River. The lagoons are now 15 years old. The combination of increased loading (because of regional population increase) and more stringent criteria for sewage discharges proposed by the province of BC requires that this facility be upgraded.

This study is a preliminary step to determine short term improvements and to develop a long term plan for growth to enable this facility to be in compliance with federal and provincial standards and regulations. Components of the study included the following:

1. Short term improvements to meet current permit requirements

- Assess loading and impacts of septage discharge to lagoon.
- Outline systems for monitoring and make recommendations for controlling septage discharges.
- Recommend improvements to septage receiving facilities and possible pre-treatment.
- Assist District with measurement and assessment of sludge levels in both lagoons.
- Develop recommendations for sludge removal and disposal.
- Review options and make recommendations for increasing lagoon aeration capacity.
- Review options and make recommendations for improving effluent clarification.
- Review and recommend upgrading of instrumentation and monitoring facilities.

» Sealing requirements if lagoon operating level is raised.

The cost estimate for these recommended short term improvements is $150,000.

2. Long term improvements to meet future discharge criteria

» Outline expected future discharge criteria

» Outline upgrading required to meet new discharge criteria.

» Outline most economic staging of work and provide cost estimates for upgrading.

» Outline additional testing and monitoring required to determine staging requirements and timing.

The cost estimate for these recommended long term improvements is $1,680,000.

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2.3.8 Land Use Effects on Water Quality in the Bridge Creek Basin

Performed by: *Sandy Hart, P. Geo., J. S. Hart & Associates Ltd.*
Partners: *FPAO; BC MOELP*
Funded by: *FPAO ($20K)*
FPAO Contact: *George Derksen*

Bridge Creek drains a 1,550 km^2 area of the Fraser River basin upstream of Canim Lake. The largest community within the basin is the District of 100 Mile House, located 80 km southeast of Williams Lake. This project was initiated as a result of long-standing public health and environmental concerns about the quality of water in the Bridge Creek basin. Bridge Creek is the principal water source for the District of 100 Mile House. As well, there are many highly valued recreational lakes throughout the basin and the watercourses provide critical fish habitat and domestic and irrigation water supplies. The field work for this study was carried out between October 1993 and April 1994.

The quality of Bridge Creek water has been a long-standing concern for residents. A 1981 outbreak of giardiasis ("beaver fever"), attributed to waterborne *Giardia lamblia* cysts, as well as other public health concerns resulted in construction of a slow sand water filtration plant in 1985. Leakage and accidental spillages from the municipal sewage lagoons adjacent to Bridge Creek also threatened water quality until the 1993 opening of new lagoons at Stephenson Lake.

Other water quality issues raised by residents included the impact of contaminated runoff from livestock wintering areas, leakage of lakeside septic systems, and impacts of urban runoff and forestry activities on water quality and quantity. There is particular concern for the quality of the numerous highly valued recreational lakes in the basin. The shorelines of many of the larger lakes are occupied by cottages and resorts, and their drainage areas are in use for logging and ranching.

This study was designed to identify the basin land uses that may affect water quality. It is the second phase of a project for which the goal is to develop a watershed management plan to sustain high water quality for both environmental and public health. Due to budget and time constraints, many of the land use impacts were examined in a general way. A more detailed inventory was carried out on the livestock wintering sites. Where possible, recommenda-

tions were made for measures to mitigate water quality impacts.

The effects of a range of basin land uses on water quality were evaluated, including roads, agriculture, forestry, rural residences, cottages and resorts, and urban and industrial development. The most detailed evaluations were of the impact of snowmelt runoff from livestock wintering areas to receiving waters, a source of phosphorus that has had an impact on lakes elsewhere in the Cariboo region.

The most significant land use impacts on water quality were considered to be:

- urban and industrial development in the vicinity of 100 Mile House
- residential and cottage development along lakeshores
- agricultural land development, including livestock wintering, grazing
- forestry in the lake drainage basins, particularly along the Bridge Creek floodplain from Deka Creek confluence to Canim Lake

Water quality problems are believed to be produced by many individually minor sources dispersed throughout the watershed. Therefore, they do not lend themselves to easy identification or control. To maintain water quality, comprehensive planning with active public participation is required.

The central recommendations for water quality management as a result of this study are:

- develop a Watershed Management Plan for the entire Bridge Creek basin in consultation with the public to plan land use for the protection of water quality and other resource values
- conduct monitoring to determine the trophic status of the most developed lands and to characterize 100 Mile House runoff water quality
- implement programs to minimize the impacts of urban and industrial zone runoff, livestock wintering area runoff, riparian zone disturbance by agriculture, forestry, and lakeshore development
- plan land use in individual lake basins in the upper watershed based on lake sensitivity, terrain suitability for development, and the water quality impacts of alternative development strategies

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2.3.9 Optimization of Biological Phosphorus and Ammonia Removal in a Combined Fixed and Suspended Growth Wastewater Treatment System - Interim Report

Prepared by: *BC Research Inc.*

Partners: *Environment Canada Environmental Innovation Program, BC Research, UBC, BC Science Council, Dayton & Knight Ltd.*

Funded by: *FPAO ($20K); UBC ($166K); BC Science Council ($54K); Dayton & Knight ($3.12K)*

FPAO Contact: *Phil Wong*

The discharge of nutrient-rich wastes, such as domestic sewage, into environmentally sensitive surface waters can cause serious deteriorations in water quality. Nutrient enrichment of surface waters (eutrophication) can cause algal blooms and promote the growth of aquatic vegetation. These conditions degrade water quality and deleteriously affect fish, wildlife, and human use of the water body. The nutrients of primary concern are phosphorus, in the case of discharges to fresh water, and nitrogen, in the case of marine discharges. In addition to the problems

caused by eutrophication, ammonia nitrogen is toxic to fish. This toxicity is regulated by the federal *Fisheries Act.* Environment Canada is responsible for the pollution provision of this Act, and the Fraser Pollution Abatement Office has a mandate to reduce contaminant loadings to the Fraser River basin under Environment Canada's Green Plan programs.

Chemical removal of nutrients is currently practised, but these processes often increase treatment plant operating costs and generate larger solids disposal volumes than biological removal processes. Biological phosphorus removal is preferred in many situations. Current technology for this is generally based on activated sludge systems only; existing trickling filters are usually decommissioned and demolished, or converted to other uses when activated sludge systems are installed.

A biological phosphorus removal process combining both trickling filter and activated sludge technologies was pioneered by Dayton & Knight Ltd. at a full-scale domestic wastewater treatment facility at Salmon Arm on Shuswap Lake, which is in the Fraser River basin (Thompson River system). The process is called the FGR-SGR (fixed growth reactor-suspended growth reactor) process. Advantages of incorporating trickling filters into biological nutrient removal technology include the option of retrofitting existing trickling filter plants, relatively low energy consumption, process stability added by the fixed growth bacteria in the trickling filters, increased process efficiency, relatively low land use, and improved sludge settling qualities.

Feasibility studies carried out at the Salmon Arm facility during 1988-89 showed that the FGR-SGR process has the capacity for effective biological phosphorus removal, but difficulties associated with full-scale research prevented development of the next generation of design. Consequently, it was decided that pilot-scale research was the best alternative to develop the needed design and operating data.

This three-year project, which is partially completed, involves pilot-scale research and development of the FGR-SGR process for biological removal of phosphorus and ammonia nitrogen from sewage. The purpose of the study is to optimize process reactor sizes, internal recycle flow rates, and system solids retention time. The project is directly applicable to the goals of the FPAO because its successful completion will promote the use of effective, energy- and cost-efficient nutrient removal systems and contribute to the long-term sustainability of environmentally sensitive surface waters in the Fraser River basin. Protecting recreational, tourism, and fisheries resources contributes to a locally healthy economy within the basin.

The Interim Report for this project (dated July 15, 1994) summarizes plant design and operating parameters during the hydraulic retention time (HRT) optimization investigation. Mean removals of total suspended solids (TSS) and five-day biochemical oxygen demand from the process influent (primary clarifier overflow) were typically in the range of 80-90% and 92-97%, respectively. Removal of ammonia was typically greater than 99%. Concentrations of ammonia in the plant effluent were consistently less than the detection limit of 0.01 mg N/L. Nitrogen mass balances conducted on the individual bioreactors showed that most of the ammonia was nitrified and that nitrification occurred predominantly in the FGRs. Statistical analysis showed that the progressive reductions in reactor HRTs did not result in a significant deterioration in process removal of any of the design parameters.

Process removal of total phosphorus and plant effluent orthophosphate concentration ranged through Phases 1, 2, and 3 and on both sides of the reactor trains (A and B sides) from 59-71%, 77-97%, and 91-94%, respectively. Following a period of good to excellent phosphorus removal from January through July 1993 (Phases 1 and 2), plant effluent PO_4 concentration rose from values typically less that 0.1 mg P/L to greater than 1 mg P/L. The increase in PO_4 was not associated with equipment failures, and effluent parameters other than phosphorus did not increase.

Investigations into the cause of the deterioration in biological phosphorus removal revealed an

excessive buildup of biosolids on the FGR media, probably caused by suspended organisms in the mixed liquor adhering to the biofilm on the media. Accordingly, a hydraulic pulse loading regime was introduced on both the A and B sides of the pilot plant, whereby the FGR irrigation rate was periodically increased for a short period to flush accumulated solids. Regular pulse loading resulted in an immediate and consistent improvement in both process trains to mean effluent PO4 concentrations of 0.27 mg P/L on the A side and 0.10 mg P/L on the B side. This pulse loading also eliminated an early fluctuation in process MLSS concentration.

This project is anticipated to complete in fall 1994. The final report will present in-depth analysis and results.

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2.3.10 Effluent Dispersion From the Lansdowne Road (Prince George) Wastewater Treatment Centre

Performed by: *SEACONSULT Marine Research Ltd.*
Partners: *FPAO; City of Prince George*
Funded by: *FPAO ($11K); City of Prince George (#11K)*
FPAO Contact: *Phil Wong*

An effluent plume delineation study was carried out at the Prince George Lansdowne Road Wastewater Treatment Centre on October 13, 1993. This study evaluated performance of the outfall for dilution rate and distribution of the effluent downriver. The specific objectives of the study were as follows:

- assess the effective dilution rate under low flow conditions
- map the regions of the river that are exposed to the effluent
- confirm the integrity of the outfall

A new diffuser outfall was installed at the Lansdowne Road Wastewater Treatment Centre in 1990. The city of Prince George discharges treated effluent at approximately 300 to 400 l/s through the diffuser, which is located on the river bottom about 50 m from shore. The Lansdowne outfall discharges about 0.1% of the Fraser River's volumetric discharge at low flow.

A fluorescent red dye was added to the effluent stream to act as a measurable tracer of the effluent. This allowed mapping of the plume from the diffuser to 12 km downstream. During the survey, the discharge to the Fraser River at Prince George was approximately 400 m^3/s, which was roughly 1000 times the Lansdowne outfall discharge. Surveying with an in situ fluorometer successfully traced the dyed effluent to concentrations of less than 0.05%, with positional accuracy of plus or minus 5 m in the horizontal.

Initial dilution was rapid, from 100% effluent concentration at the diffuser to 0.65% or less within 250 m of the outfall. Vertical mixing was complete at 1 km. Beyond about 8 km, no concentrations were observed anywhere in the river that exceeded 0.1% effluent. North of the 8-km section there was no observed contact with the eastern shore.

Lateral mixing appeared to be inhibited by current shear zones separating the central fast-moving core of the river (which contained most of the freshly discharged effluent) and relatively quiescent areas along some sections of the shorelines. Because mixing across the shear zones is slow, effluent in the quiescent waters will tend to be of older origin (discharged earlier) than the effluent in the main river core.

The diffuser discharged effluent in two persistent jets that were separated by roughly 10 m. This characteristic appears to be indicative of the diffuser performance. No leaks were detected.

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2.3.11 Prince George Wastewater Treatment Centre, Wastewater Characterization Study

Performed by: *Dayton & Knight*
Partners: *FPAO; City of Prince George*
Funded by: *FPAO ($15K); City of Prince George ($15K)*
FPAO Contact: *Phil Wong*

During the late 1980s, there were toxic discharges received at the Prince George Wastewater Treatment Centre that affected the sludge digestion process (low digester gas production and resulted in plant upsets (sludge bulking in secondary clarifier), on average five to six times per year. Belt filter press sludge was sampled each day the presses were used and the samples were composited and analysed on a monthly basis. Relatively high concentrations were measured in cadmium, copper, lead, mercury, molybdenum, and zinc. There has been a subsequent trend in reducing the concentrations of these metals, although copper and mercury continued in relatively high concentrations. A general database exists on this toxic discharge problem.

This project initiated a characterization of the wastewater at this treatment centre. The scope of work for this study included examining the toxic metal concentrations in the sludge train, sampling of influent and effluent, and some water sampling at different areas in Prince George to help determine if any one area contained relatively high copper concentrations.

As part of the sampling plan for this project, an industry survey was proposed involving the following components:

- identification of industrial users
- pre-screening of industrial users to identify those most likely to contribute toxic metals
- detailed survey of materials used at targeted industries
- development of a proposal for a detailed sampling program of those industries suspected to be discharging elevated concentrations of toxic metals

This study investigated the causes of several plant upsets, including diesel and solvent discharges from a bus-washing facility, a borate discharge from a now discontinued CNR activity, and a chromium discharge problem (the source of which is still unknown).

The results and recommendations from this study can be summarised as follows:

- The Prince George Wastewater Treatment Centre generally operates satisfactorily. Some specific toxic discharges have been observed, traced, and the sources established, such as

diesel from an overflowing containment tank at the transit depot.

» Concentrations of the following parameters were analysed:

For mercury, all samples were below the maximum allowance of 10 mg/kg. All the influent and effluent samples were below the high grade agricultural concentration of 5 mg/kg, and only four of the 28 dewatered sludge samples exceeded this concentration.

For copper, there was found to be a relatively high concentration in the dewatered sludge. This is directly related to the influent concentration, most of which appears to be coming from leaching of plumbing fixtures, particularly in the older areas of the city.

BOD5 exceeded the permit requirements only once. TSS was above the permit requirements on occasion, and the frequency of exceedance is increasing.

Total ammonia values were consistently higher in the effluent than in the influent; nitrates showed a general increase between influent and effluent.

Phosphorus readings showed a general reduction between influent and effluent.

PCB values compared favourably with maximum allowed.

PAHs, while no current guidelines for comparison exist, compared favourably with Vancouver harbour marine sediment.

Dioxin and furan values were low.

» The duration of plant upsets from toxicity effects has declined, particularly since staff implemented a series of gradual operational improvements.

» Various methods of alerting treatment centre staff to incoming toxic effluent have been reviewed. A pH meter, with an alarm connection to the operations building, has been considered and budgeted for installation.

» Increasing public awareness of toxicity effects is likely helping reduce the frequency of toxic discharges to sewers. However, adoption of upcoming Special Waste Regulations will likely increase toxicity effects as industries will be tempted to discharge toxic liquids into sewers instead of paying for transportation and disposal. This was the experience in Alberta.

» The public should be further informed of the need to minimize the discharge of toxic substances into sewers. This could effectively be accomplished through local newspapers and by public open houses and other forums.

» The development of a revised sewer use bylaw would provide the city with a means of minimizing potential hazards from wastewater contaminants.

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2.3.12 Preliminary Assessment of Snow Disposal: City of Prince George

Performed by: *Stanley Associates Engineering Ltd.*
Partners: *FPAO; City of Prince George*
Funding: *FPAO ($6K); City of Prince George ($6K)*
FPAO Contact: *Phil Wong*

This project was instituted to assess the current practice of snow disposal at Prince George and to evaluate and provide direction for future options for snow disposal as existing land disposal sites are removed from service. Currently, the program involves ploughing accumulated snow, sanding and salting streets, and, in certain areas, removing snow from ploughed streets and sidewalks. The system is built around several sites where collected snow is dumped and the piles melt and drain off during warm weather. At least two of the land disposal sites will be removed from use in the near future. The options under consideration are the retention of the land disposal site system or the installation of snow-melters where snow is disposed of on a daily basis throughout the winter.

In the second part of this study, the environmental impacts of the snow disposal options were screened and conceptual engineering requirements identified.

Environmental considerations of the two primary options - use of snow-melters for immediate melting, or land disposal and natural melting in spring - centred on the ultimate fate of the meltwater. For the land disposal and natural melting option, the choices are between natural percolation and evaporation, and natural drainage and river discharge. For the snow-melter option, the choices are between sewer discharge, river discharge, or well injection and groundwater recharge. Both sets of options entail environmental impacts.

Both options may affect the groundwater resource of the Prince George region. The land disposal option may affect groundwater by percolation of collected snow-melt through the soil into the groundwater reservoirs. Snow-melt contains high levels of sodium chloride, some dissolved heavy metals, organic hydrocarbons, and inorganic nitrates and sulphates. Even with the widespread use of unleaded fuels, the melt would also contain some concentration of lead. It is expected that passage of meltwater through soil would effectively filter and adsorb contaminants. The snow-melter option would affect groundwater by direct injection of collected snow-melt into groundwater reservoirs. However, a well-injection location could be selected where well water is not extracted, so the meltwater may not become an environmental concern.

Both options also have an affect on surface waters. The land disposal option results in surface runoff during spring melt that will enter the Nechako River system if it does not have an opportunity to percolate or evaporate. This melt may also contain sediment from drainage that could affect the turbidity of the receiving waters and affect aquatic flora and fauna. DFO has concerns that the current snow disposal sites appear to influence surface vegetation and, presumably, water quality. Concern was also expressed about meltwater salinity affecting the micro-environment within the Nechako River system. Elevated sodium chloride is toxic to vegetation and aquatic life and may affect the local ecosystems. Heavy metal concentrations and salinity and turbidity levels would need to be established in a pre-design study if the snow-melter option is selected.

All alternatives affect the soils in the immediate area of operation. The land disposal option has a large impact because the sites occupy a greater surface area and there is no provision for containment of pollutants in a melt basin, as there is in the snow-melter option. In the land disposal option, the major pollutants and residual trash will accumulate in the surface soil layer.

The snow-melt option is expected to have some environmental impact on air quality because of exhaust emissions from the combustion of natural gas. Contaminants of concern include nitrous oxides, sulphides, and carbon monoxide. There will also be condensing water vapour clouds in the immediate vicinity of the snow-melters. This affect is expected to be insignificant.

Both options also affect the visual quality of the local landscape and have public safety considerations. The land disposal sites present a winter-long high pile of snow, but do not exist in summer. Snow-melters are permanent installations and, therefore, are permanent landscape features. During operation, these also present public safety concerns and will require enclosure within security fences and the use of security personnel. During summer, the melt baths would be drained and pose a lower risk to the public.

Snow-melters require large capacity air blowers for combustion, which generate some noise pollution. Even with silencers and enclosure within a building, the noise of air suction through the filters will be audible to nearby residents.

The snow-melter option with discharge to the sanitary sewer system would likely affect the wastewater effluent quality and volume.

An economic computer simulation model of Prince George snow disposal was developed based on historic snowfall data and collection areas. Two potential new land disposal sites and two potential snow-melters were located in the Prince George environs and a number of alternative iterations were calculated. The economic model predicted operating and fixed costs for road-clearing, snow-loading, transport, and disposal at the sites.

Based on the use of the computer model, the following economic findings were made:

1. The "status quo" is the most cost-efficient disposal method for reasonable, expected annual snowfalls, excluding environmental or possible land development issues.

2. If any site is taken out of service, "doing nothing" is only possible if the assumption is made that annual snowfall will not exceed approximately 220 cm/year and that relatively high temperatures will prevail to encourage snow-melt. This is not considered a reasonable approach.

3. The City of Prince George has three basic options:

   a) installation of a 300 tonne/hr downtown snow-melter
   b) expansion of existing land disposal sites, particularly the Exhibition grounds
   c) development of a new land disposal site approximately 4.5 km from downtown

4. The costs for collection and disposal of snow for the 1992/93 year were approximately $2.70 per compacted cubic metre, or $0.67 per cubic metre of fresh snowfall. The total costs for the snow program for 1992/93 were $7.60 per compacted cubic metre, or $1.90 for fresh snowfall.

It is recommended that after the 1993/94 season the economic model be recalibrated and the 30% factor for melt and drift checked and adjusted if necessary.

This preliminary study was designed to provide insights into the economic, environmental, and engineering factors that must be considered when evaluating the snow disposal options.

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2.3.13 Assessment of Federal Sources of Pollution in the Fraser River Basin

Prepared by: *FPAO*
FPAO Contact: *Bert Kooi*

This report outlines an inventory and discussion of potential pollution sources at federal facilities within the Fraser River basin. Federal facilities may include: inhabited Indian reserves, airports, prisons, small craft harbours, military bases, and research stations. Inhabited Indian reserves account for 88.5% of the estimated total number of federal sites in the Fraser River basin.

The type of pollution sources that may be of concern include: sewage, fuel storage, landfills, contaminated sites, industrial and commercial activity, and agriculture. Discharge factors from the literature are used to estimate some conventional pollutant releases in effluent discharges. Effluent permits are also identified.

FPAO is the lead agency for assessing federal sources of pollution in the Fraser River basin. This report is a first step to identify such sources and will be used to help set priorities and establish strategies for abatement activities at these facilities. Information was gathered by direct communication with the various federal agencies and through the Federal Facilities Environmental Activities Database (FFEAD). Contact lists for district offices within the Fraser basin were acquired and personnel were faxed a list of questions related to their own inventories. Generally, the inventory information requested was specific for a pollution source type. All information has been summarised in spreadsheet format.

An overview of this inventory indicates that the number of federal sites with potential to contaminate waterways within the Fraser River basin is relatively low. Of the few contaminant concerns identified, information on estimated loadings, other than for sewage, was difficult to obtain. Indian reserves account for 85% of sewage generation on federal sites. Of these, the Kamloops reserve at the confluence of the Thompson and North Thompson rivers has more than 100 industrial activities, including two asphalt plants, which may contribute to PAH loadings to the Fraser River basin. The PCB-contaminated oil stored at this site is currently being cleaned up. Transport Canada is responsible for the largest amount of petroleum product storage in the basin, with airports accounting for most underground fuel storage sites. Underground storage tanks at these sites have been leak-tested and a replacement program is underway.

There are 62 landfills on federal lands within the Fraser River basin. Several are located less than 30 m from the nearest watercourse. A range of potential contaminants, including hog fuel leachate, general and construction refuse, chemical and foam containers, metal wastes, acid and alkaline solutions, pesticides, paint and lead sludge, solvents, and oils, is found at a number of these locations.

The inventory of contaminated sites at federal locations is documented from Environmental Site Assessments (ESAs). The majority of ESAs were conducted under the National Contaminated Sites Remediation Program. Soil and groundwater contamination, commonly by hydrocarbons, was encountered at several sites. However, contaminant discharges to surface water bodies were generally not found or anticipated for a number of reasons. An exception is the DFO Marine Ways station in New Westminster, where historic ship repair activities have contaminated river bottom sediments with metals, oil, and grease. Sampling results indicate some contamination of foreshore sediments as well, but no groundwater contamination. This

site is undergoing remediation. There may also be hydrocarbon (jet fuel) contamination discharging to the Fraser River from the Canadian Coast Guard Hovercraft Base on Sea Island at Vancouver International Airport. Underground storage tanks, piping, and some hydrocarbon-contaminated soils have been removed. Small amounts of contaminants may be entering the river from areas below the access ramps, which are inaccessible to remediation efforts.

The Agriculture Canada research facility at Agassiz has undergone extensive ESAs. Thirteen sites were investigated there, including solid waste landfills, manure storage, compost facilities, and in-ground wastewater disposal systems. The three compost sites were reported to be leaching nitrates to groundwater, which ultimately discharges into nearby sloughs. Minor pesticide components were also reported at one of the six in-ground wastewater disposal sites.

Parks Canada owns the Gulf of Georgia Cannery National Historic Site on the Fraser River at Steveston. This site has soil contaminated with bunker C oil and lead. However, there appears to be no apparent impact on the river. The area is currently undergoing remediation.

Federal sites in the middle and upper Fraser regions, notably at Williams Lake and Quesnel airports, an Agriculture Canada research station at Kamloops, the Kamloops airport and Enderby VORTAC station, and three sites being investigated in Prince George, are all being assessed. Further inventory and clean-up assessment is expected to continue into the 1994/95 fiscal period.

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2.3.14 Guideline Manual: Sewage Lagoon Design, Optimization, and Operation to Achieve Non-acutely Toxic Effluent

Prepared by: *NovaTec Consultants Inc.*
Partners: *FPAO; BC MOELP*
Funded by: *FPAO ($20K)*
FPAO Contact: *Phil Wong*

The Fraser Pollution Abatement Office, under the Green Plan, directs that action be taken to identify and control contaminants entering the Fraser River basin from both point and non-point sources. One of the key issues to both the federal and provincial governments is to identify whether such sources are acutely toxic and to identify remedial actions that can be taken to reduce any identified toxicity.

The purpose of this project is to review performance data and present design guidelines for lagoon and constructed wetland systems to achieve a non-acutely toxic effluent in temperate and cold climate conditions. The report presents information on alternative upgrading technologies for consideration in reducing lagoon effluent toxicity, including storage basins, rapid infiltration, overland flow, and fixed-film processes.

Recommendations are provided for minimum standards for the design of lagoon and constructed wetland systems and key design considerations are presented for the alternative upgrading technologies. The guideline focuses on factors to enhance the removal of ammonia, but includes recommendations that will result in overall operational and design improvements (i.e., pre-treatment, size, configuration, baffles, aeration, diffused inlet/outlet structures, liners, operating depth, hydraulic retention time, sludge management, maintenance, etc.). Capital and operating costs are also presented for use in comparing the alternative treatment technologies described.

In the absence of a high proportion of industrial discharges to the wastewater entering a lagoon system (pond), the toxicity of lagoon effluents treating primarily domestic wastewater is believed to be most often the result of elevated concentrations of free ammonia, the relative concentrations of ionized and un-ionized ammonia present in the effluent, and chlorine residuals or hydrogen sulphide resulting from anaerobic sludge decomposition.

Of these, ammonia is the most common potentially toxic component of domestic sewage. The ability of lagoon systems to remove ammonia depends primarily on pH, detention time, season, and liquid temperatures. The pH fluctuates as a result of algal-carbonate interactions, mitigated by the amount of alkalinity in the water. The major removal pathway is volatilization at the water surface during warm weather, In cold weather climates, particularly where there is ice cover on the lagoons during winter months, ammonia removal is not consistent throughout the year. British Columbia's proposed Municipal Sewage Discharge Criteria allow for ammonia to be removed from the sample tested for acute toxicity, or alternatively allows the pH to be lowered to reduce the proportion of free ammonia to reduce ammonia toxicity. Existing sewage lagoons that discharge into the Fraser River are expected to consistently (on a year-round basis) achieve sufficiently low ammonia concentrations to ensure the effluent is not acutely toxic.

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2.3.15 CSO AND URBAN RUNOFF INVESTIGATIVE ASSESSMENT GUIDELINES

Prepared by: *NovaTec Consultantss Inc., UMA Engineering Ltd., W20 Inc.*
Funded by: *FPAO in fiscal 1992/93*
FPAO Contact: *Phil Wong*

The Greater Vancouver Sewerage and Drainage District (GVS&DD) discharges into the lower Fraser River basin and Burrard Inlet over 700,000 m^3/yr of liquids, made up of 50% urban stormwater runoff (UR), 41% wastewater, and 9% combined sewer overflow (CSO). This project presents a methodology for investigative and detailed contaminant loading assessment of CSO and UR discharges into the Fraser River. The overall purpose of the Guidelines is to provide agencies with procedural documentation to plan and implement monitoring programs for these two types of wastewater discharges.

The recommended approach is to first carry out an investigative assessment to determine whether specific contaminants of concern are present or are being discharged into the sewer system, and whether these key contaminants are also identifiable in sediment of the receiving environment or in tissue samples of organisms collected in the vicinity of the discharge. The investigative assessment provides qualitative information that allows investigators to priorize outfall discharges for detailed assessment. Depending on the findings of the investigative program, a detailed assessment program may be carried out to obtain information that will enable investigators to estimate the contaminant loading characteristics for each discharge. Finally, a process assessment may be carried out to determine remedial measures to reduce contaminant discharges.

The Guidelines were presented in a format to allow easy extraction and replacement of sections updated on a periodic basis. The methodology was presented in a step-by-step fashion to be used as a guidance document for investigators and field sampling crews. Information was also provided on local laboratory capabilities and on safety procedures for use in field sampling.

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2.3.16 Solid Waste Management Plan Review - Stage 2

Prepared by: *CH2M Hill Engineering Ltd.*
Partners: *GVRD; BC MOELP*
Funded (1993/94) by: *FPAO ($35K); Environment Canada - Federal Waste Reduction Plan ($60K)*
FPAO Contact: *Phil Wong*

The 1989 BC Waste Management Amendment Act required regional districts to submit solid waste management plans by the end of 1995. The plans are to provide for the management of all types of wastes generated, with the exception of biomedical and special wastes, within the regional district. The plans are to include strategies for reducing the per capita disposal of solid waste by 50 percent by the year 2000 through application of the first 3-R hierarchy of Reduce, Reuse, and Recycle. The remaining waste is to be managed in an environmentally sound manner through the second two Rs: Recovery and Residuals management.

Within the Greater Vancouver Regional District (GVRD), the total municipal type waste generated in 1990 was estimated at 1,423,000 tonnes. Additional waste from demolition, land-clearing, and construction (DLC) is estimated at 830,000 tonnes for 1991. In the absence of efforts to reduce waste generation at source, the municipal type waste generated is projected to grow to 1,964,000 tonnes and DLC waste is estimated to increase to 1,116,000 tones by the year 2000.

The 1990 per capital generation of municipal type waste was about 0.86 tonnes. The plan review objective is to develop a strategy that would reduce the per capita disposal rate to 0.43 tonnes (50% of the 1990 generation rate) by the year 2000 in a cost-effective and environmentally sound manner.

The Stage 2 report, completed in May 1994, summarizes the recommended solid waste management strategy for the GVRD to achieve the plan objectives. Some of the key recommendations identified for implementation by the GVRD and member municipalities, and which may be suitable for adoption by other regional districts, include the following:

- The GVRD would set performance standards for mandatory residential 3Rs programs to be delivered by municipalities while ensuring flexibility to allow municipalities to decide how to meet the standards.
- The GVRD would require the preparation of waste inventories for all industrial, commercial, and institutional (IC&I) generators and require waste audits and reduction plans for all waste generators in the IC&I and DLC sectors (with exemptions).
- The GVRD would require source separation of designated recyclable materials by all IC&I and DLC waste generators (with approved exemptions). Off-site processing of mixed recyclables would be an acceptable option for IC&I generators.
- The GVRD (or other appropriate government body) would develop and apply a system of operational certificates or waste management stream licenses for all waste processing (recycling and composting) facilities and all DLC disposal facilities. For processing facilities, the GVRD would set standards and ensure a level playing field while using existing private sector/municipality processing and marketing capabilities and capacities in a flexible and competitive manner.
- The GVRD (or other appropriate government body) would implement a system of permits or licenses for waste hauling companies operating within the GVRD.
- The GVRD would coordinate with member municipalities to procure additional in-vessel composting capacity.
- As soon as viable alternatives to disposal are operational, phase in disposal bans of recycla-

ble and compostable materials generated by the residential, IC&I, and DLC sectors at all disposal facilities.

» Maintain the current system of standardized tipping fees at GVRD/municipal disposal facilities and use differential tipping fees and tipping fee surcharges to support program implementation at all disposal facilities (including DLC) to support 3Rs program implementation.

» If practical on a site-specific basis, maintain staffed recycling depots at all transfer, disposal, centralized composting, and multimaterial recyclables processing facilities in the region.

» The GVRD and municipalities would expand public information/education programs targeted at residential, IC&I, and DLC generators. The GVRD and all municipalities would develop formal communications plans and ongoing programs of audience research to support overall educational promotional campaigns.

» The private sector would continue its role in providing processing capacity for residential and IC&I recyclables under competitive conditions. The GVRD could assist in the development of cooperative arrangements among local municipalities.

» The GVRD and municipalities would increase government procurement of reusables and products containing post-consumer recyclable secondary materials.

» The GVRD would develop a waste exchange database for all materials.

» Market development (i.e., technical advice, grants, loans) would become an integral part of municipalities' economic development function and be viewed as a local strategy for both waste reduction and job creation.

» Municipalities would support the establishment of local reuse and repair centres.

In addition, 14 other recommendations in the report were directed at the provincial and federal governments, where jurisdictional authority exists, as these issues are outside of the control of local governments. The report notes that the solid waste management system recommended is a combination of many interdependent and interrelated activities and initiatives, and that the success of the strategy requires the implementation of all activities and initiatives by all levels of government.

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2.4 Project Area: Groundwater

2.4.1 Groundwater Resources of British Columbia

Prepared by: *J. W. Atwater, Water Management Division, BC Environment*
Partners: *Co-published by BC Environment and Environment Canada*
Funded by: *Environment Canada ($4K); BC MOELP ($34K)*
FPAO Contact: *Larry Adamache*

Groundwater is one of the province's most important resources. In some areas, it is the only viable and economic source of water supply for individual and community systems, as well as for agricultural and industrial uses. Agriculture and industry - including irrigation, pulp and paper, fish hatcheries, food processing, mining, chemical, petrochemical industries, parks, and airports - are the major users of groundwater in BC.

Currently, a water license under the Water Act is not required to use groundwater. The depletion of groundwater supplies, conflicts between groundwater and surface water users, and the potential for groundwater contamination are concerns of increasing importance as use and development of groundwater resources continues to grow.

Some measure of groundwater resource protection is provided by existing acts, regulations, guidelines, and standards and objectives formulated over the years by the various levels of government. However, to effectively manage this critical resource, it will require legislation that is integrated with the various levels of government and interest groups involved with its management, protection, development, and use.

This project produced an authoritative, detailed, and informative document on the entire groundwater resource of British Columbia. It makes information readily available to individuals, communities, and organizations that have an interest in groundwater now and in the future. A principal aim of this publication is to assist in future groundwater resource planning for the public and private sectors.

The publication provides an overview of the groundwater resources of the province, how groundwater occurs, where it is found and what conditions favour its development. Because it cannot be readily seen, the scientific and technical understanding of this hidden resource has developed slowly. Given greater knowledge and understanding about groundwater, it is hoped that planning initiatives at all levels of government will govern its use and development, and thereby minimize potential negative impacts of human and land use activities and sustain available quantities at a high degree of quality for future generations.

The Fraser River basin is one-quarter of the province and home to over 60% of its population. It is the most highly developed - in the industrial, agricultural, and urban senses - portion of the province. Groundwater resources in some areas of the basin have already been seriously affected by these land uses. Environment Canada, through the Fraser River Action Plan and FPAO, contributed to this major groundwater study as part of their mandate to establish sustainable use of the Fraser River and its drainage basin.

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2.4.2 Enhanced Denitrification of Groundwater Nitrate: Interim Findings of Laboratory Investigations (Draft Report)

Prepared by: *University of British Columbia Department of Civil Engineering*
DOE Contact: *Hugh Liebscher*

The document, *Enhanced Denitrification During Saturated Flow Through Sand*, is PhD research of R. Dasika, UBC Dept. of Civil Engineering, and represents Progress Report #3 for this project. The overall objectives of the research are:

- to investigate in detail the enhancement of the natural denitrification potential within aquifer environments;
- to develop an understanding on how the natural denitrification potential within aquifers can be used towards the management of nitrate in the subsurface environment;
- to determine where and how the enhancement of this denitrification potential may be appropriate as a management strategy.

The specific objectives are to obtain a more complete understanding of the following:

- the role of individual and mixed carbon sources on the extent of denitrification during saturated flow through sands and gravels;
- the significance of initial pore velocity and the total residence time within the sands and gravels;
- the temporal variation in any accumulations of intermediate products of denitrification;
- the generation, fate, and impact of the evolved dinitrogen within the flow regime;
- the effects of enhanced denitrification on flow characteristics within the sands and gravels;
- the applicability of the laboratory-scale findings to the field.

Results are evaluated in light of recent findings of related research being performed around the world. Findings related to the distribution of nitrate in unconfined aquifers show that the nitrate tends to be highly stratified in an upper oxidised layer, with a relatively steep chemical gradient into the underlying uncontaminated and generally anaerobic groundwater. Naturally occurring denitrification has been found to occur within this chemical gradient, also referred to as the "redox line." The extent of stratification, steepness of chemical gradient, and the extent of denitrification all appear to be highly dependent upon site-specific conditions, such as the aquifer geochemistry, groundwater flow regime, and surface land use.

On the basis of the findings to date, it is proposed that the column flow-through testing be modified to a series of short term tests in order to minimize the impact of excessive biomass development. Additionally, it is proposed that attention be focused on detailed sampling of the groundwater in the vicinity of the groundwater table underlying agricultural lands and in the vicinity of septic tank drainfields. Three fully screened monitoring wells have been installed in the lower Fraser Valley for the purpose of obtaining detailed site-specific vertical profiles of groundwater chemistry. Monitoring of these wells occurred between April and September 1994 (and will be reported on in the next fiscal reporting period).

The evaluations and testing performed to date have provided an increased understanding of the fate of nitrate during saturated flow through sands and gravels, and the role of denitrification in this process. The findings from the proposed laboratory investigations to be performed over the remainder of the project duration will provide further fundamental information on the role of different carbon sources on denitrification during saturated flow through sands and gravels. The results of the field investigations are expected to provide site-specific details of the distribution and fate of nitrate within the lower Fraser Valley area.

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2.4.3 Draft Classification of Aquifers in the Fraser River Basin

Performed by: *BC Environment, Groundwater Section, Hydrology Branch*
Partner: *RIC/BC Environment Groundwater Section*
Funded by: *BC MOELP ($11K); BC Surveys & Mapping ($30K); FRAP ($35K); EC ($50K)*
DOE Contact: *Hugh Liebscher*

An aquifer classification system was proposed by Kreye and Wei (1994) to provide a systematic method for identifying, describing, and priorizing aquifers for groundwater mapping, management, and protection. A pilot study to test this system was applied to the lower Fraser Valley in 1993. For that study, using a 1:50 000 mapping scale, 73 aquifers were identified, classified, and delineated based on existing information in the Groundwater Section (of BC Environment) files.

In fall 1993, project funding from Environment Canada through the Fraser River Action Plan (FRAP) and FPAO was used to extend the classification of aquifers into the rest of the Fraser River basin. In winter 1994, additional funding from the Resource Inventory Committee (RIC) was used for development of methodology. The results of this funding include:

- the identification and classification of vulnerable, highly productive, and other aquifers within the Fraser River basin
- a means of rigorously assessing and refining the methodologies for delineating and classifying aquifers
- an increased inventory of aquifers (current total 123) that provides a framework for planning groundwater management activities under FRAP and the BC Environment ministry's Water Management Program

Four regions of the Fraser River basin were selected to review and implement this aquifer classification system: Merritt, Prince George, Salmon Arm, and Quesnel. The classification system was found to be comprehensive enough to assess and classify aquifers for levels of development (productivity *vs* demand) and vulnerability to contamination in the geographic regions selected for this study.

A total of 50 aquifers were identified, classified, and mapped at a 1:50 000 scale, based on existing information in Groundwater Section (BC Environment) files. There were 17 confined and 16 unconfined unconsolidated aquifers, and 17 bedrock aquifers. Results showed there were five heavily developed, 16 moderately developed, and 29 lightly developed aquifers; 12 aquifers were highly vulnerable, 8 moderately vulnerable, and 30 had low vulnerability to contamination. Aquifers were ranked or priorized based on the aquifer's productivity, vulnerability, size, demand, type of use, and known quality/quantity concerns. Ranking values for the 50 aquifers ranged from a low of 6 to a high of 16 (out of a maximum 21). The ranking values in these four regions are probably lower than the ranking values of the aquifers originally used to develop the classification system in the lower Fraser Valley because there were so few documented water quality and quantity concerns.

Results showed that the classification and ranking components were generally consistent; aquifers with greater level of development and higher vulnerability generally had a higher ranking value. Ranking values for fractured bedrock aquifers were generally lower than ranking values for unconsolidated aquifers. No highly vulnerable or heavily developed fractured bedrock aquifers were found. Also, there were no heavily developed, moderately vulnerable unconsolidated aquifers found. Review and implementation of the classification system in others areas of the Fraser basin and the province is recommended, along with further refinement of the moderately vulnerable component of the classification system.

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2.4.4 Evaluation of the Origin and Fate of Nitrate in the Abbotsford Aquifer Using Isotopes of ^{15}N and ^{18}O in NO_3

Performed by: *National Hydrology Research Institute*
Partners: *FPAO; BC MOELP*
Funded by: *FPAO ($20K); BC MOELP ($50K)*
FPAO Contacts: *Bert Kooi; George Derksen*

This project began in the 1992/93 reporting period and the final report has now been submitted to FPAO. The purpose of this project was to distinguish between various nitrate sources detectable in the Abbotsford aquifer. These include septic seepage and runoff from manure and fertilizers. The project also sought to develop methods to distinguish contaminant sources in aquifers in general.

The Abbotsford aquifer (known as the Sumas aquifer in Washington State) is one of the largest groundwater reserves in the Fraser Lowlands, occurring in BC and in northern Washington. It is extremely susceptible to surface-derived contamination because of its largely unconfined nature and highly permeable sands and gravels. In the past decade, it has become the focus of public concern resulting from widespread nitrate contamination, from the detection of agricultural pesticides, and from increased pressures for urban development above the aquifer. Flow of groundwater in the aquifer is southerly from BC into the US, thereby raising the possibility of cross-border groundwater contamination.

Nitrate contamination of groundwater in the Abbotsford aquifer to levels well above national drinking water standards is a major problem in BC and in Washington. Many wells in the aquifer show marked seasonal variations in water table nitrate concentration, with the highest concentrations occurring during the fall and winter recharge period.

The source(s) of nitrate contamination in the Abbotsford aquifer are not unequivocally known, but are generally attributed to long term agricultural land use practices, such as poultry and raspberry farming, and stockpiling and spreading poultry manure directly above the permeable sands and gravels of the aquifer.

Stable isotope ratios of nitrogen ($^{15}N/^{14}N$)^2 in NO_3^- are often used to aid in distinguishing various sources of nitrate in groundwater. $\delta^{15}N$ values can be used to distinguish between inorganic fertilizer-derived nitrate and animal waste sources or sewage-derived nitrate.

Nitrate concentrations in the aquifer ranged from 0 to 151 mg/L NO_3, with a median concentration of 46 mg/L NO_3. Of 117 wells sampled, 54% had nitrate concentrations exceeding the drinking water limit. Approximately 80% of the study area had groundwater nitrate concentrations exceeding 40 mg/L NO_3.

Potential nitrate source materials were poultry manure N and ammonium-based fertilizers. The $\delta^{15}N$ of solid poultry manure samples ranged between +7.9 and +8.6 0/00. Four brands of synthetic fertilizers commonly used had $\delta^{15}N$ values between -1.5 and -0.5 0/00. Ammonia volatilization caused the $\delta^{15}N$ of groundwater nitrate produced from poultry manure N to range between +8 and +16 0/00.

The $\delta^{18}O$ values of groundwater nitrate, by contrast, mostly ranged between +2 and +5 0/00. This narrow range of $\delta^{18}O$ values fell within the expected range of nitrate produced by nitrification of reduced nitrogen forms, such as poultry manure N and ammonium fertilizers, and had a similar range of $\delta^{18}O$ values as nitrate in the upper part of the unsaturated zone below raspberry fields and beneath former manure piles.

The $\delta^{15}N\text{-}NO_3^-$ and $\delta^{18}O\text{-}NO_3^-$ data indicated nitrate in the aquifer was predominantly derived from poultry manure and, to a lesser extent, from ammonium-based fertilizers. The $\delta^{18}O\text{-}NO_3^-$ data suggested the nitrification process occurred mainly in the summer months, with the soil nitrate produced subsequently flushed into the aquifer during fall recharge. The $\delta^{15}N\text{-}NO_3^-$ and $\delta^{18}O\text{-}NO_3^-$ data further indicated that no significant bacterial denitrification is taking place in the Abbotsford aquifer. Because the aquifer does not sustain denitrification, the only viable form of cleanup is the elimination of nitrate at the sources and continual flushing from natural recharge. However, because the residence time of groundwater in the Abbotsford aquifer is on the order of decades, high levels of nitrate will persist for many years even if the nitrate sources were eliminated.

As part of the Fraser River Action Plan (Green Plan), Environment Canada and the BC Ministry of Environment are working to develop methods for better manure management for raspberry growers and to address livestock waste management issues in the Lower Fraser Valley.

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2.5 Project Area: Agricultural Runoff

2.5.1 Environmental Guidelines for Berry Producers in British Columbia and Environmental Guidelines for Mushroom Producers in British Columbia

Prepared by: *BC Ministry of Agriculture, Fisheries and Food*

Partners: *FRAP, BC Federation of Agriculture, Berry and Mushroom Producers; BC Ministry of Agriculture, Fisheries and Food*

Funded by: *FPAO ($30K)*

FPAO Contact: *George Derksen*

These two projects reflect concerns for healthy land and water resources in the Fraser River basin, upon which all agricultural commodities, including animal and crop production, depend. Agricultural activities need to be carried out in a manner that will protect the resources it relies on by adopting environmentally sound farming practices. Our future ability to feed people will require higher density farming on a decreasing agricultural land base. These guidelines outline acceptable farming practices for the berry and mushroom producing industries that will support the long-term sustainability of agriculture.

The environmental issues discussed in these guidelines include fertilizer and manure handling, pesticide storage and application, and the use of woodwastes. Both documents give information on the federal, provincial legislation, including the *BC Code of Agricultural Practice for Waste Management*, and local bylaws affecting their operations. Each also discusses the regulations accompanying the legislation.

The Berry Producers guidelines deals specifically with blueberry, cranberry, raspberry, and strawberry crops, but applies to all berry producers in British Columbia. The manual covers fertilizer and manure management; water management, including appropriate irrigation methods, understanding drainage, and construction of wells; soil management and erosion control; use of woodwaste; the use of pesticides, including management practices, controlling pesticide runoff and drift, soil fumigation, and storage and disposal of pesticides; controlling vertebrate pests, such as birds and rodents; and other considerations, such as dealing with waste plastics, burning, and on-farm processing facilities. The Mushroom Producers guidelines discusses similar practices specific to mushroom producing, and emphasizes the environmentally sound handling of manure wastes.

Sources of contaminants, their impacts on air, soil, water, and surrounding communities are discussed. Site selection and planning, water use and management, storage of supplies, and recycling and composting options are presented in clear language. Each also has a glossary of terms.

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2.5.2 GREEN/YELLOW/RED PESTICIDE CLASSIFICATION FEASIBILITY STUDY

Prepared by: *Windwalker Consulting Services*
Partners: *FRAP; BC MOELP*
Funded by: *FRAP ($3K); BC MOELP ($3K)*
FPAO Contact: *George Derksen*

This project examined the feasibility of a pesticide classification system. With the increasing threat to the environment and to human health posed by synthetic chemicals , it has become essential to encourage low risk, environmentally friendly pesticide use. Some semi-quantitative means of ranking pesticides based on their effects on the environment could provide the basis for target pesticide reduction programs ranging from information brochures for the general public to certification programs for Integrated Pest Management (IPM) practitioners and growers.

Choosing the criteria and models on which such a classification system should be based requires a critical assessment of currently existing schemes. The BC Ministry of Environment, Lands and Parks (MOELP) has set the following objectives on pesticide use that a pesticide classification model would need to address:

- guiding efforts to reduce pesticide use and determine which activities or uses to target for reduction
- assessment of the relative effects of different management systems, with particular consideration for those used in IPM certification of standards programs
- guiding municipalities with posting or pesticide use policies now being based on the Exempt Schedule
- assisting growers and the general public to make environmentally sound pesticide choices
- defining a class of pesticides that might be subject to a tax for funding pesticide reduction projects through the Sustainable Environment Fund
- formalizing justifications for the Exempt Schedule and assist consumers in making product choices, such as "green labelling" possibilities
- providing potential for basing future pesticide reduction estimates on using environmental impact targets for specific commodity groups

A number of databases were searched, a list of which, along with a review of the resulting models, is included in the report of this project. Each model was examined to determine its purpose, strengths and weaknesses, and to assess whether it could meet MOELP's objectives. It was determined that the model produced by Kovach et al (1992), referred to as the "NY Model," was the most comprehensive in its assessment of environmental impacts. A detailed review of this model is included in the project report.

Efforts then focused on determining what programs currently exist in other regions. Ontario has an Environmental Choice Program that examines products on a voluntary basis and rewards those that meet environmental standards with an "EcoLogo," which is then used as a marketing alert for consumers. A similar program exists in California, but US federal legislation protects the chemical industry from discrimination, which has been interpreted as a reason for not allowing environmentally unfriendly pesticides to be labelled as such. However, California does have certification and regulatory programs for organic growers that, in addition to Canadian organic standards, may serve as a model should BC choose the regulatory route. It became clear that no model program currently exists that could be directly adopted as a template for developing a pesticide reduction plan for British Columbia. A list of contact individuals is also provided in the project report.

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2.5.3 Agricultural Land Use Survey in the Matsqui Slough Watershed

Prepared by: *IRC Integrated Resource Consultants Inc.*
Partners: *FPAO; BC MOELP; DFO*
Funded by: *FPAO ($30K)*
FPAO Contact: *George Derksen*

The Fraser River Action Plan (FRAP) was established to reduce pollution inputs to the Fraser River and restore the natural productivity of the Fraser River basin. The primary goal of the agricultural component of FRAP is to implement a strategy to reduce the loading of nutrients, bacteria, and agrochemicals from agricultural operations to ground and surface waters. Targets and strategies for the reduction are to be developed in consultation with stakeholders, such as producer groups, the BC Ministry of Agriculture, Fisheries and Food, BC Environment, Agriculture Canada, Environment Canada, Department of Fisheries and Oceans, and the BC Federation of Agriculture. The first step toward devising a strategy to achieve this goal is to identify the contaminant sources and to determine the loadings of specific contaminants. The major nonpoint sources of potential contamination in rural areas are from agricultural operations.

The primary objective of this study was to develop an information base from which to assess whether the Code of Practice and the Guidelines are sufficient to sustain the surface and subsurface water quality in the lower Fraser River basin, which receives a greater amount of precipitation on an annual basis that other agricultural areas in BC.

Specifically, the goals of the study were to (1) identify farms that followed the *Code of Agricultural Practice for Waste Management* and the *Agricultural Environmental Guidelines*, and (2) identify possible contaminant sources that could affect water quality. An inventory of the agrowaste facilities and management in the Matsqui Slough basin was carried out. This inventory included completing a telephone questionnaire, followed by a site visit to each farm, a process that the report recommends be updated within five years. The quality of the surface and subsurface waters in the basin were studied over a five-month period and five fish species composition and relative abundance studies were carried out.

Unlike some agricultural studies that make extensive use of runoff estimates to estimate loadings, this project developed an initial detailed inventory of the manure handling and agrowaste practices on each individual farm. Nearly all (80%) of the individual farms were visited in the Matsqui Slough watershed with the only exceptions being individual farmers who chose not to participate or could not be contacted. In addition, this project documented in a limited way, the quality of the surface and subsurface waters and the fisheries resource in an extensively agricultural watershed.

The project summary report discusses the studies undertaken in the Matsqui Slough watershed, which is intensively used by dairy, hog, and poultry producers, as well as commercial crop producers. Irrigation is extensive throughout the watershed. The report describes the methods used in the project and presents and discusses the data collected on agricultural operations in the watershed.

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2.5.4 AGRICULTURAL LAND USE SURVEY IN THE SUMAS RIVER WATERSHED

Prepared by: *IRC Integrated Resource Consultants Inc.*
Partners: *FPAO; BC MOELP; DFO*
Funded by: *FPAO ($30K)*
FPAO Contact: *George Derksen*

This project is complementary to the previously listed project in the Matsqui Slough watershed. The Sumas River watershed is an economically important agricultural area located in the lower mainland area of the Fraser River basin. In 1991, the gross farm revenues were greater than $68 million, with expenses greater than $53.5 million. The goals of this study were to (1) identify farms that followed the BC *Code of Agricultural Practise for Waste Management* and the Agricultural Environmental Guidelines, and (2) identify possible contaminant sources that could affect water quality. An inventory of the agrowaste facilities and management in the Sumas River watershed was carried out. The inventory included completing a telephone questionnaire, followed by a farm visit. The consultants recommend this process should be updated within five years in order to document changes within this important agricultural watershed. The surface water quality was studied over a five-month period, and five fish species composition and relative abundance studies were conducted.

Of the 5,693 ha in the Sumas Prairie used for agricultural purposes, about 79% is dairy, 4.4% hog, 2.9% poultry, and 17% produce and nursery farms. There was also one small goat dairy farm. There is an overall manure loading rate of 262L/ha/day on the 4,728 ha of land used by livestock farms. Dairy producers generated 65% of the manure, hog producers 31%, and poultry producers 4%.

For dairy producers, the average manure storage time was 3.05 months, with 51% of storage facilities of concrete, and 19% of these covered. Ninety percent of the producers spread manure on their own property. An Environmental Sustainability Parameter (ESP) was developed that quantified the potential for contamination of the surface and subsurface waters from a farming operation based on the *Code of Agricultural Practice for Waste Management* and the *Agricultural Environmental Guidelines* for the dairy producers. Farms with an ESP greater than 80% were considered in this study to have a low potential for degrading water quality. Seven percent of the dairy producers had an ESP value of greater than 80%, and 88% were between 40% and 80%, which 4% had an ESP value less than 40%.

Twelve of the 14 hog producers identified were surveyed (86%). The average number of sow equivalents per farm was 446. Fifty percent of the hog producers have greater than 6 months manure storage, with 75% of storage concrete and covered. Eighty-three percent of the hog producers spread manure on their own land. Twenty-five percent had ESP values greater than 80% and twenty-five percent less than 40%.

Seventy percent (21 of 30) of the poultry producers identified were contacted, with 16 participating in the study. The average number of broiler equivalents per farm was 446,100. Thirty-one percent exported their manure. Nine-four percent of poultry producers have concrete manure storage facilities. Thirty percent had ESP values greater than 80% and a similar percentage less than 40%.

Fecal coliform densities in some reaches of the Sumas River and Stewart Slough indicate that this water is not suitable for irrigating vegetables. Throughout the watershed, alkalinity exceeded the provincial criteria. Individual pH readings ranged from 6.1 at the upper reach of the Sumas River, to 7.6 downstream. Two metal

concentrations were measured twice during winter 1994. Total aluminum concentrations exceeded Canadian guidelines for the protection of aquatic life at all sites, except Stewart Slough, on both sampling occasions. The criteria for total chromium for the protection of phyto- and zooplankton was exceeded at all except one site. Total copper criteria were exceeded at all nine sampling locations on one day, and at five sampling locations on both sampling days. Total iron concentrations exceeded the criteria for the protection of freshwater aquatic life throughout the watershed. The criteria for the protection of freshwater aquatic life for total nickel concentrations were exceeded at three sites after one week of steady rain. The surface waters are nutrient-enriched. All reaches of the Sumas River support fish life and salmonids were found throughout the watershed except at the mid-reach on the Sumas River, the Sumas Drainage Canal at Barrowtown and Arnold Slough. The water quality in Saar Creek and the Arnold Slough in fall was degraded and not considered suitable fish habitat for the identified fish species.

Among the recommendations coming out of this study, it was specifically recommended that an on-going water quality program should be conducted for this watershed. Parameters studied should include dissolved oxygen water quality, measurements of dissolved oxygen, measurements of runoff and dry weather concentrations of aluminum, chromium, copper, iron, nickel, and indicator bacterial densities.

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2.5.5 Survey of Agricultural Practices in the Thompson River Basin

Performed by: *BC Environment, Regional Environmental Protection Office, Kamloops*
Partners: *FPAO; BC MOELP*
Funded by: *FPAO ($17K)*
FPAO Contact: *George Derksen*

The Thompson River is the major tributary of the Fraser River, and includes the Shuswap and Kamloops lakes and rivers systems, the North Thompson and Clearwater rivers, and the numerous lakes and rivers in the Nicola area. The primary agricultural activity in this large region is ranching, specifically cattle ranching and feedlots. An aerial survey of cattle ranches was undertaken that covered the entire area, to determine apparent compliance or non-compliance with the provisions of the *Environmental Guidelines for Beef Producers in British Columbia.*

The final report for this project has not yet been completed, but initial results indicate the following for the four main circuits of the surveillance:

1. Eastern area (Kamloops, Chase, Shuswap Lakes, including Douglas Lake, Nicola Lake, Stump Lake to Shumway Lake and Campbell Creek to the South Thompson River east of Kamloops): approximately 35 ranches were felt to be in one way or another in violation of the guidelines. Photos were taken, along with locations documented on topographic maps.

2. Southern area (west from Kamloops to Kamloops Lake, to Ashcroft, Spences Bridge, Nicola River to Merritt, Lower Nicola to Guichon Creek north to Logan Lake, then Tunkwa Lake to Durrand Creek north to Kamloops Lake near Savona): approximately 24 ranches in violation of the environmental guidelines. Again, photos and map documentation were taken.

3. Northern area (north from Kamloops past Heffley Creek, McLure, Barriere to Little Fort, then Lemieux Creek north to its origin, then back to Little Fort to follow the Clearwater River well into Wells Gray Provincial Park, then to Vavenby, Adams Lake, Sinmax Creek to Louis

Creek, then south to just west of Niskonlith Lake): approximately 21 ranches in violation of the environmental guidelines. Photos and map locations were taken.

4. Western area (from Ashcroft, Bonaparte River to Thompson River, north to Cache Creek, Loon Lake, then back north and east to Bonaparte Lake, then south to Deadman River when it meets the Thompson just west of Savona): approximately 28 ranches in violation of the guidelines, and photos and map locations were taken.

About 108 ranches seemed to be in some form of contravention of *the Environmental Guidelines for Beef Producers in British Columbia*, although problems varied between the ranches. Some problems will require considerable works to achieve satisfactory compliance. It was apparent that the majority of the problems were found with reference to feedlots having direct access to surface waters. Some ranches seemed to do absolutely nothing to restrict access, while others had actually constructed fencing to allow for direct access to water by livestock. In a number of situations, creeks ran directly through the middle of confined feedlots. Another problem was where livestock were being fed within 30 metres of surface waters in confined feedlot situations. Here, access to water was being restricted, but it was obvious that surface runoff from the feeding area was entering the local water source.

Once ranch ownership has been confirmed, formal complainant forms will be forwarded to AEPC to enable follow-up by peer inspectors. The Cattlemen's Association will also be contacted to try and come to a workable solution on the majority of problems encountered. If funds are available, a follow-up aerial survey will be conducted. The final report will be released in fall 1994.

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2.5.6 Reduced Risk of Groundwater Contamination Through Development of a Pre-sidedress Soil Nitrate Test for Silage Corn in South Coastal BC

Prepared by: *Coast Agri Ltd. and Agassiz Research Station Agriculture Canada*
Partners: *FPAO; Canada-BC Green Plan for Agriculture; FRAP*
Funded by: *Green Plan ($152K over 4 years); FPAO ($32K over 4 years)*
FPAO Contact: *George Derksen*

Silage corn production in south coastal BC receives large fertilizer nitrogen applications in addition to manure applications. These fields have a high risk for groundwater contamination by nitrate leaching. There is no technology currently available for use by farmers to address this concern. No method is available for providing an accurate estimate of the crop nitrogen requirement. Improved cropping systems, such as use of winter cover crops, usually reduce the potential for nitrate leaching by less than 20%.

The solution is to develop a method of matching nitrogen inputs to meet the crop nitrogen requirement. This method could reduce the potential for nitrate leaching without sacrificing crop yield. A spring soil nitrate test developed for this purpose has gained wide acceptance in the US midwest and eastern seaboard. Preliminary research conducted at Agassiz Research Station suggests that such a soil test should work under local soil and climatic conditions. As well, development of a leaf chlorophyll index-based nitrogen test, which can be used quickly and easily in the field, could provide a more rapid means of assessment.

The purpose of this project is to develop the tools required to produce silage corn in south coastal BC in a more environmentally and economically sustainable manner. This will be achieved by the following specific objectives:

1. Develop and calibrate a pre-sidedress soil nitrate test for silage corn.

2. Evaluate the leaf chlorophyll-based N test as a replacement for the soil nitrate quick test.

3. Use the results from the field trials to improve the ability of the SOILCHEK software package used by Coast Agri Ltd. to predict the nitrogen requirement of silage corn.

4. Encourage more efficient use of nitrogen by farmers through participation in field trials, and through field days and workshops, thereby reducing the potential for nitrate leaching.

The technology developed by the field calibration and research trials will be transferred to producers and to professionals in agriculture and environment. Technology transfer will be accomplished through field days, workshops, technical reports, and articles in industry publications. The logic used in the upgrade of the SOILCHEK software model will be made freely available in written form.

This project began in February 1994, and will continue to March 31, 1997. Reports will be made available from time to time.

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2.5.7 Control of Agricultural Runoff - Integrated Pest Management Workshops for Growers of Vegetables and Small Fruits, and Greenhouse Growers

Prepared by: *BC Federation of Agriculture*
Partners: *FPAO, BC Federation of Agriculture*
Funded by: *FPAO ($2K); BC Federation of Agriculture ($3K)*
FPAO Contact: *George Derksen*

An objective of the Fraser River Action Plan is to reducing loading of nutrients and other contaminants from agricultural runoff to the Fraser River basin. It can accomplish this, in part, through the identification of point and non-point sources of contamination and by the development and implementation of suitable control and treatment measures. One area that has been targeted is the use of pesticides. Optimal pest control practices are being developed as Integrated Pest Management (IPM) practices.

Environment Canada, the BC Federation of Agriculture (BCFA), and other government agencies have identified a need for promoting grower education and awareness of IPM. All recognize the importance of development of training and education programs for the various producer groups in the Fraser River basin and in BC overall. The BCFA sponsors one-day workshops on IPM for use with various commodities, including small fruit (strawberry, raspberry, blueberry, currant, cranberry), greenhouse (cucumber, bell pepper, tomato), and vegetable (potato, carrot, onion, brassicae, etc.) producers. Information on pests and diseases is available, along with the integrated tools and practices to manage them. Participants will receive a handbook containing valuable management information and colour photos of the pests and diseases of each crop covered in the workshop. The workshops will explain programs being used and developed specifically for the Fraser Valley. Through these programs, it is hoped that farmers and producers can reduce the economic and environmental costs of pest management.

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2.5.8 Development of Educational Materials and Training Courses for AEPC Advisors in the Swine and Nursery Agricultural Industries

Performed by: *BC Federation of Agriculture; BC Ministry of Agriculture, Fisheries & Food*
Partners: *FPAO, BCFA, BC MAFF*
Funded by: *FPAO ($14K); Other partners provided in-kind support and/or matching funds.*
FPAO Contact: *George Derksen*

A major goal of FPAO is to reduce the loading of nutrients and other contaminants from agricultural runoff to the Fraser River basin. This entails the identification of sources and contaminants and the development and implementation of suitable control and treatment measures. A cooperative program to develop environmental guidelines to meet the Code of Agricultural Practice for Waste Management under the (BC) *Provincial Waste Management Act* and the federal *Fisheries Act* is underway.

To this end, the BC Federation of Agriculture (BCFA) and the BC Ministry of Agriculture, Fisheries & Food (BC MAFF) developed and conducted a number of training courses for AEPC advisors (Agricultural Environmental Protection Council Peer Group Inspectors/Advisors) in the Swine and Nursery industries.

A series of educational and resource materials, including visual aid materials and brochures, have also been produced and are available from BCFA outlets and the BC ministries of Environment and MAFF. The following brochures are currently in print:

- Environmentally Safe Handling of Pesticides
- The BC Agricultural Environmental Protection Council
- Agricultural Environmental Protection Program
- Environmentally Acceptable Management of Manure
- Environmentally Acceptable Management of Wood Waste
- Environmental Guidelines for Pork Producers in BC (brochure about)
- Environmental Guidelines for the Nursery & Turf Industries (brochure about)
- Environmental Guidelines for Berry Producers (brochure about)
- Environmental Guidelines for Mushroom Producers (brochure about)
- Environmental Guidelines for the Greenhouse Industry in BC (brochure about)

Each of these brochures introduces the concerns and considerations for the subject matter and explains the differences between codes of practice, legislation, guidelines, and the level of compliance and cooperation that is required. The brochures give basic and general information on the preparation, use and storage of, or safety procedures for the substance in question, and provide a glossary of terms. Each also gives information on how or where to obtain further assistance or information.

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2.6 Project Area: Contaminated Sites

A number of work activities were carried out by the Waste Management Section (WMS) of Environment Canada during the 1993/94 fiscal reporting period. WMS operates under the authority of the Canadian Environmental Protection Act (CEPA) and section 36(3) of the *Fisheries Act*. The BC Ministry of Environment, Lands and Parks is the lead agency responsible for ensuring appropriate clean-up of private lands, WMS actively participates in the review of site actions and in setting remedial objectives and requirements for sites where there is a fisheries concern.

2.6.1 Federal Contaminated Sites and Landfills Inventory

Performed by: *Waste Management Section*
Partners: *Other government departments*
DOE Contacts: *Bob Shepherd, Peggy Evans*

As part of the effort to establish baseline conditions within the Fraser River basin and to identify and priorize contaminant sources, WMS prepared an inventory summarizing all available in-house databases and non-database information on contaminated sites and landfills on federal lands within the basin.

The inventory was augmented wherever possible with information from various OGDs. Gaps in information and future needs will be determined in order to carry out a realistic assessment of contaminant contributions from these sources.

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2.6.2 BC Contaminated Sites Inventory Development

Performed by: *Waste Management Section*
Partners: *FPAO; EP (Environmental Protection-Environment Canada); BC MOELP*
DOE Contact: *Bob Shepherd*

During the 1993-94 reporting period, WMS engaged in negotiations with BC Environment to assist in the development of a provincial Contaminated Site Inventory.

BC Environment is currently in the process of developing a database of contaminated private sites within the province (referred to as the "Site Registry") to fulfill their obligations under the new Bill 26 legislation of the *Waste Management Act* (proclaimed in fall 1994). Rather than carry out parallel database development for the Fraser River basin, WMS has elected to assist in the development of the province's database.

In the 1993-94 period, WMS reviewed the various stages of database development and conveyed to the province specific information that would permit the evaluation of contaminant loadings to the Fraser River system. An agreement, whereby WMS would provide financial assistance to expedite database seeding from provincial files, was presented to the province, but never finalized. Negotiations with the province are ongoing and it is anticipated that an agreement will be signed for the 1994-95 fiscal period.

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2.7 Project Area: Airborne Contaminants

Atmospheric contamination deposition is one of the sources of toxic contamination in the Fraser River basin. The identification, inventory, and characterization of airborne contaminants is one of the program areas of the Fraser Pollution Abatement Office.

2.7.1 Inventory of Sources and Emissions of Toxic Air Contaminants for British Columbia

Performed by: *B. H. Levelton & Associates Ltd.*
Partners: *FPAO, CCD; BC MOELP; GVRD*
Funded by: *FPAO ($50K); CCD ($20K)*
DOE Contacts: *Ed Wituschek, Michael DeAbreu*

This project is a continuation of work begun in the previous reporting period. The design of a system for completing an air toxics inventory has been completed as Phase I of this project. This system uses software and a database compatible with the Residual Discharge Information System (RDIS) of Environment Canada and employs a large file of air toxic emission factors. In addition, a separate facility is available for speciating particulate and VOC emissions where no suitable emissions factors are available. It is also possible to manually enter air toxic emission estimates based upon monitoring data or engineering calculations, where these are available.

The overall objective of the project is to produce an inventory of sources and emissions of toxic air contaminants for BC for 1990. This inventory will include the source categories and sectors covered by the BC 1990 inventory for common air pollutants. In order to achieve this objective, the project has two main goals:

1. For each source that is to be included in the inventory, identify which of the available emission factors for that type of source is appropriate and can reasonably be used to calculate emission estimates. Where no or insufficient emission factors are available, then the most suitable speciation profiles for known VOC and particulate emissions estimates will be assigned. These speciation profiles will include $PM_{2.5}$ and PM_{10} partitioning wherever possible.

2. Produce emission estimates of toxic air pollutants for anthropogenic and natural sources, based on the source categories and sectors covered in the BC 1990 emission inventory of common pollutants. These emission estimates will use the identified emission factors wherever possible and be supplemented by the use of VOC and particulate speciation profiles where appropriate.

The project also has a component to refine the TOXS database and perform updates to both the emission factor file in TOXS and the speciation files in the reporting option. These updates will allow corrections for errors identified by the US EPA and for the inclusion of additional data only recently made available. It will also be necessary to produce a slightly modified version of the TOXS program coding.

In the 1992-93 reporting period, the consultants developed a design for an inventory of sources and emissions of toxic air contaminants for BC. The data system described in the report, *Devel-*

opment of the Design Basis for an Inventory of Sources and Emissions of Toxic Air Contaminants for BC was modified and the program used to compile an inventory of sources and emissions from point, area, and mobile sources. Environment Canada (Commercial Chemicals Division) staff have been able to map the data on point sources using the MapInfo GIS and 1:2 000 000 map of BC. This is compatible for mapping discharges to streams and rivers using 1: 20 000 scale maps. The data is capable of being moved into an ArcInfo GIS for further analysis.

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2.8 Project Area: Technology Transfer

Research performed under the auspices of government agencies and universities must eventually be made usable for a wider audience. Publications, media events, workshops, and seminars are some of the ways new technologies reach a more generalized use and understanding. As well, when public money is spent, these are a form of accountability to the public. The exchange of ideas, information, and technologies is an ongoing function of Environment Canada's mandate to increase the general well-being of the public and the environment.

2.8.1 Seminar: Water Conservation Strategies and Experiences

Performed by: *British Columbia Water and Waste Association*
Partners: *Environment Canada and BC MOELP*
DOE Contact: *Fred Claggett*

The public is beginning to realize that clean water is a somewhat finite resource, particularly in highly urbanized and industrial regions such as the Fraser River basin. Increased public education on how to protect and conserve water resources in the basin is one of the mandates of the federal Green Plan. In April 1993, a seminar was held in Kelowna on the topic of water conservation strategies. Participants from a wide spectrum of public and private agencies were presented with a range of information. One of the goals of the seminar was to discuss environmentally oriented approaches to water resource management.

Sponsored by the BC Water and Waste Association, with technical and financial assistance from Environment Canada and the BC Ministry of Environment, Lands and Parks, plenaries and workshops covered experiences in communities throughout Canada, compared water conservation rate structures in North America, alternative sources of irrigation for municipal golf courses, BC Hydro's PowerSmart program and water-saving devices for home use, metering programs, and BC government water policies related to conservation.

The focus for water conservation has shifted from supply-side management to demand-side management, that is, stretching the capacity of existing sources and delivery systems to support population growth and industrial development rather than in major capital investments for new waterworks facilities.

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2.8.2 SEMINAR: SLUDGE (BIOSOLIDS) RECYCLING

Performed by: *British Columbia Water and Waste Association*
Partners: *Environment Canada; BC MOELP*
DOE Contact: *Fred Claggett*

This technology transfer seminar, sponsored in part by Environment Canada and the BC Ministry of Environment, Lands and Parks, focused on the uses and disposal methods of domestic sludge (biosolids). Municipal Liquid Waste Discharge Criteria are currently being developed for British Columbia. Six sets of criteria will directly affect the application of biosolids to land. One is an Agriculture Canada document, another has been produced by the Canadian Council of Ministers of the Environment, one has recently been released by the US EPA, and the remaining three are provincial. This profusion of regulations is a result of the complex physical, social, and legal issues involved in converting this type of waste product into a useful resource.

Several communities are being encouraged to install secondary sewage treatment. It is anticipated that the volumes of biosolids to be applied to land will increase significantly in the future, while the available land will decrease. In addition to the probably shortage of land, it is of utmost importance that surface water and groundwater resources not be contaminated by this material.

Standards for its use, fundamentals of land application of biosolids, use of biosolids in other parts of Canada, development of a sludge management program, silvicultural land application programs, successful biosolids reuse practices, and reclamation and revegetation of mine spoils using biosolids were some of the topics discussed at this seminar.

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3.0 How 1993-94 FPAO Projects Help Achieve Key Objectives of the Fraser River Action Plan

In order to achieve the objectives of the Fraser River Action Plan, a clear strategic approach to pollution abatement is required. First and foremost is the need to identify sources of pollution entering the Fraser River basin. A significant number of projects have addressed this, but many more are still required. These may be point or non-point sources related to a wide variety of industrial, municipal/urban, domestic, agricultural, airborne, groundwater, and contaminated sites activities or causes.

Once these have been identified and inventoried, information needs to be entered into a user-friendly and widely available computer database program. Some projects deal specifically with this requirement.

The next critical phase is the characterization and quantification of the effluents and contaminants entering the basin. This information also needs to go into the database.

Eventually, all this data will be linked in one GIS to present basin-wide information in a concise and uniformly available form.

A major contribution to reducing pollution is the development of codes of practice and guidelines for a number of industries. Protection of the environment is more easily achieved through the cooperative efforts of government and industry working together, using the information gained from characterization studies and surveys of control technologies to develop industry-wide policies and procedures that can control pollution at the source.

Land use has a major influence on how contaminants enter the basin. Surveying land uses and assessing the needs of local communities can lead to better planning, which in turn can lead to a reduction in pollution and better protection of existing resources, thus increasing the potential for sustainable development within the basin.

All these activities help FPAO achieve its objectives and enable planning to proceed in a manner that will allow for sustainable land and resource use decisions for the Fraser River basin.

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4.0 FPAO Location and Personnel

Fraser Pollution Abatement Office, Environment Canada 224 West Esplanade, North Vancouver, BC V7M 3H7		
Name	**Program**	**Phone/Fax**
Dr. Martin Pomeroy, Biologist	FPAO Head	666-5193/9107
Sandra Lum, P. Eng.	Industrial	666-3487/7294
Lisa Walls, P. Eng.	Industrial	666-3487/7294
Bert Kooi, Biologist	Municipal/Urban, Industrial	666-2790/7294
Phil Wong, P. Eng.	Municipal/Urban	666-2699/7294
George Derksen, Biologist	Agriculture, Municipal/Urban	666-5712/7294
David Ellis, P. Eng.	Municipal/Urban	666-2690/7294
Bruce Galbraith, Technologist	Field Sampling, Data Management	666-5265/7294

DOE Advisors - Environment Canada 224 West Esplanade, North Vancouver, BC V7M 3H7		
Name	**Program**	**Phone/Fax**
Fred Claggett, P. Eng.	Technology Transfer	666-6262/7294
Ed Wituschek, P. Eng.	Toxic Air Contaminants	666-2815/6800
David Poon, Engineer	Advisory	666-2862/7294
Bob Shepherd, P. Eng.	Contaminated Sites	666-3055/7294
Hugh Liebscher, Hydrogeologist	Groundwater	666-0807/6713
Snehal Lakhani, P. Eng.	Advisory	666-2037/9107

5.0 FPAO Projects Planned or Ongoing for 1994-95

The project forecast and work plan for FPAO for 1994-95 has been completed. Due to fiscal restraint and budget cutbacks, increased emphasis has been placed on co-funding with other entities, whether government agencies, industry associations, research institutions, or non-profit organizations. Upcoming projects listed below have been tailored to meet realigned goals and objectives. Some of these projects were initiated in the 1993-94 fiscal year and are ongoing or will complete in 1994-95.

Industrial Discharges:

- Final guidelines document for wastewater characterization
- Wastewater characterization and effects on salmon production assessed at one industrial site
- Suspended solids characterization to evaluate carcinogen loadings
- Best Management Practices seminar held at two locations
- Pollution prevention audit manual
- Report on best practicable control technology for pulp and paper discharges
- Industrial stormwater characterization and BMP guides
- Decision support tool for eliminating toxic organics in wastewater
- BMP review for food, dairy, meat processing sectors
- ATAD pilot project for reducing toxic organics in industrial wastewater
- Anaerobic treatment resin acids audit at one pulp mill
- Advanced pollution abatement technology pilot studies at two industrial discharges
- Code of Practice checklists developed and industry conformance evaluated for two sectors (e.g., fish, ready-mix)
- Redesign and update Fraser Point Source Inventory database and GIS applications already completed
- Summary report on reduction of pollutants loading from industrial point sources discharging to the basin

Municipal Discharges:

- Clark Drive and Glenbrook CSO characterizations completed
- 3D dilution modelling completed for one CSO
- Site-specific impacts of one abandoned landfill assessed
- Solid Waste Management Plan Review, Phase 2 completed
- Inventory of environmental guidelines for municipal land development in the Fraser River basin
- Demonstration watershed project to measure effectiveness of land development guidelines initiated
- Video on septic tank and tile field maintenance for Fraser basin communities
- Design manual for cold climate sewage lagoons completed
- Phase 2 of wastewater treatment plant nutrient removal optimization
- Technical advice to support technology development project for reducing CSO loadings
- Abatement plan developed to address FRAP 30% reduction target
- Summary report on baseline contaminant loadings and progress toward 30% reduction (1990-93) from municipal sewage and CSO discharges

Urban Runoff:

- Golf course pesticide use inventory completed and toxicity and chemical/pesticide loadings in golf course runoff estimated

- Aerial reconnaissance of Fraser River basin, Hope to Prince George segment, to priorize urban runoff sources for abatement
- Field verification of urban runoff loading estimates
- Review of environmental guidelines applicable to chemical/pesticide use on golf courses in Fraser basin to identify practices to minimize contamination from this source activity
- Car wash chemical use and runoff characterization, and fact sheet to identify best operating practices
- Abatement plan developed and summary report on baseline contaminant loadings and progress (1990-94) toward 30% reduction in urban runoff contaminant loadings

Agricultural Runoff:

- Develop agriculture environmental guidelines for one producer group
- Report baseline level of adoption and develop/implement performance evaluation process for agriculture environmental guidelines
- Farm pesticide inventory for select geographic areas in lower Fraser Valley
- Silage corn nitrogen test and management model development to develop N application guidelines and reduce manure and fertilizer use
- Agriculture workshops and training programs to increase environmental awareness and improve agricultural practices
- Bridge Creek project to identify agriculture issues and develop watershed management plan
- Agriculture runoff characterization and GIS predictive impact model development
- Identify agriculture issues and address agriculture problems through prevention and abatement demonstrations
- Progress report and measurement of agricultural loadings (1990-94) to address FRAP 30% reduction target

Groundwater:

- GIS database and preliminary analysis of high risk contaminant sources likely to affect unconfined aquifers and surface water
- Preliminary hydrogeological assessments completed at three high priority sites
- Inventory and development of non-regulatory and regulatory options for groundwater protection
- Video on groundwater protection strategies to promote methods to prevent groundwater contamination
- Denitrification research, Phase 2
- BC Environment agreement for inventory and ranking of developed aquifers and vulnerability mapping of major Fraser basin aquifers
- Status report on development and implementation of a Groundwater Protection Strategy for the Fraser River Basin

Airborne Contaminants:

- Complete air toxics inventory data system, operating manual, and final report

Contaminated Waste Sites:

- Develop inventory of contaminated sites with BC MOELP for the Fraser River Basin
- Develop inventory of federal contaminated sites

Technology Transfer:

- Negotiate funding support for two technology development projects that assist in Fraser basin clean-up
- Coordinate and co-sponsor BMP seminar at two Fraser locations
- Co-sponsor one BC Water and Waste Association seminar

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7.0 GLOSSARY OF ACRONYMS

AMD	acid mine drainage
AEPC	Agricultural Environmental Protection Council
AOX	adsorbable organic halides
ARD	acidic rock drainage
BAT	Best Available Technology
BC MOELP	BC Ministry of Environment, Lands and Parks
BC MOH	BC Ministry of Health
BCFA	BC Federation of Agriculture
BIEAP	Burrard Inlet Environmental Action Plan
BOD	biochemical oxygen demand
CANMET	Canada Centre for Mineral and Energy Technology
CASI	compact airborne spectrographic imager
CCD	Commercial Chemicals Division (Environment Canada)
CEPA	*Canadian Environmental Protection Act*
COD	chemical oxygen demand
CSO	combined sewer overflows
DFO	Department of Fisheries and Oceans
DOE	Department of Environment (Environment Canada)
EC	Environmental Conservation (Environment Canada)
EP	Environmental Protection (Environment Canada)
ESA	environmental site assessments
ESP	environmental sustainability parameter
FFEAD	Federal Facilities Environmental Activities Database
FGR-SGR	fixed growth reactor-suspended growth reactor
FPAO	Fraser Pollution Abatement Office
FRAP	Fraser River Action Plan
FREMP	Fraser River Estuary Management Program
GIS	geographic information systems
GPS	global positioning system
GVRD	Greater Vancouver Regional District
GVS&DD	Greater Vancouver Sewerage and Drainage District
HRT	hydraulic retention time
IPM	integrated pest management
MAFF	BC Ministry of Agriculture, Fisheries and Food
MEND	mine environment neutral drainage
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PSL	Priority Substances List

RDIS	residual discharge information system
RIC	Resource Inventory Committee (BC)
TKN	total Kjeldahl nitrogen
TSL	Toxic Substances List
TSS	total suspended solids
UR	urban (stormwater) runoff
WMS	Waste Management Section (Environment Canada)

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