FRASER RIVER ACTION PLAN

Fraser Pollution Abatement Office

Progress Report 1994-1995

DOE FRAP 1997-01

Environment Canada Environnement Canada

FRASER POLLUTION ABATEMENT OFFICE

PROGRESS REPORT 1994-95

Prepared By

Maggie M. Paquet
MAIA Publishing Ltd.
Vancouver, BC

For

Technology and Pollution Prevention Section
Fraser River Action Plan
Environment Canada
224 West Esplanade
North Vancouver, BC V7M 3H7

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> Fisheries and Oceans Canada; BC Ministry of Environment, Lands and Parks; Agriculture Canada; Health and Welfare Canada; Indian and Northern Affairs; Industry Canada; BC Ministry of Agriculture, Fisheries, and Food; BC Ministry of Health; regional districts and municipalities along the Fraser River; industry associations; and community organisations.

All these, along with numerous working groups, technical committees, and scientific advisors, some of them in a volunteer capacity, have been and continue to be active partners with FPAO to achieve common goals for pollution abatement in the Fraser River basin.

DISCLAIMER

This consultant's report was funded by Environment Canada under the Fraser River Action Plan through its Fraser Pollution Abatement Office. Environment Canada is not responsible for the content of this report but has made it available for public distribution.

Any comments regarding this report should be forwarded to:

Fraser Pollution Abatement Office
Environment Canada
224 West Esplanade
North Vancouver, B.C.
V7M 3H7

EXECUTIVE SUMMARY

The Fraser River basin is one of Canada's richest ecosystems. It is also a focus for human settlement and industrial growth. Two-thirds of British Columbia's population currently lives in the basin, and the numbers are expected to increase by 50 percent in the next 25 years. With this increased growth there is a concomitant increase in the demands on its natural resources, particularly water. The sustainability of the Fraser basin's fish, wildlife, and human populations is dependent upon the environmental quality of its ecosystems. The environmental integrity of the basin must be protected and improved in order to safeguard the health of its people and the conservation of its biodiversity. This is why the federal government, working in partnership with other government agencies, industries, First Nations, and community groups, is taking action with the Fraser River Action Plan (FRAP).

Announced in June 1991, FRAP's primary objectives are to build partnerships, clean up pollution, and renew the productivity of the natural environment. The Fraser Pollution Abatement Office (FPAO), established as a program of FRAP, has the responsibility to lead the pollution abatement component of FRAP. FPAO's legislative authority comes from the *Canadian Environmental Protection Act* and the pollution prevention provisions of the *Fisheries Act*. The pollution clean-up and prevention strategy of FPAO includes the development of inventories and databases of pollution sources, Best Management Practices (BMPs) and Codes of Practice, wastewater characterizations and pollutant loading evaluations, and the development and demonstration of technologies to prevent or reduce pollution.

Part of FPAO's strategy is to engage partners from across the spectrum of government agencies and stakeholders. This strategy serves not only to help reduce the cost of pollution clean up and prevention, it also increases the levels of understanding and acceptance of the benefits of pollution abatement measures.

This strategic approach has enabled FPAO to initiate, support, or participate in a wide range of projects (over 40) for the 1994-95 fiscal year. In this third year of operation, FPAO shifted its focus from pollution control type approaches to pollution prevention, particularly the development of BMPs.

The work of FPAO has been organised into six main program areas: Industrial Discharges; Municipal Discharges, Combined Sewer Overflows (CSOs), and Urban Runoff; Agricultural Runoff; Groundwater; Contaminated Sites; and Airborne Contaminants. The first five of these made up the work of FPAO for this reporting period. The profiles in this report show that most of the over 40 projects carried out were done at some level of partnership with other agencies and organisations. All of them contribute to the achievement of FPAO goals to reduce contaminant loading to the Fraser River basin and develop practices for its sustainability.

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RÉSUMÉ

Les objectifs principaux du Fraser River Action Plan (FRAP) sont de former des partenariats pour restaurer, protéger et conserver le fleuve Fraser. Sous le FRAP, le Fraser Pollution Abatement Office (FPAO) a la responsabilité de superviser les programmes de réduction de la pollution dans le fleuve. Cet objectifa mené au développement d'inventaires et de banques de données des sources de pollution, de meilleures pratiques environnementales, de codes de pratiques environnementales, d'évaluation d'effluents contaminés, et de technologies pour prévenir ou réduire la pollution.

Une facette importante du mandat du FPAO est de participer en partenariat avec d'autres agences govememmentales et intervenants à des projets réduisant la pollution du fleuve. Cette participation mutuelle à des projets aide d'une part à réduire les coûts de prevention et de remédiation, et d'autre part à augmenter et partager le degré de connaissance relié aux mesures de réduction de la pollution développées et utilisées.

Durant l'année fiscale 1994-95, le FPAO a initié, supporté, et participé à plus de quarante projets qui sont présentés dans ce document. Pendant cette troisième année d'opération, le focus du FPAO est passé d'une approche de contrôle de la pollution à une approche de prévention de la pollution, particulièrement au développement de meilleures pratiques environnementales.

Les projets présentés sont organisés par secteurs: Décharges Industrielles, Décharges Municipales, Agriculture, Eau souterraine, et Sites Contaminés. La majorité des projets ont été réalisés en partenariat avec d'autre agences gouvernementales et organizations. Tous les projets ont contribué à la réalisation du mandat du FPAO qui est de reduire la contribution des contaminants à l'écosystème du fleuve Fraser et de développer des pratiques environnementales pour sa durabilité.

TABLE OF CONTENTS

Acknowledgements ..... *ii*
Executive Summary ..... *iii*

PART ONE—INTRODUCTION

Figure 1. Map: British Columbia, Fraser River drainage basin 1
Figure 2. Map: Detail of Fraser River drainage basin 2

THE FRASER BASIN 3

Fraser River Action Plan 5
FRAP Origins 5
FRAP Strategy 5
FRAP 48 Deliverables 6

Fraser Pollution Abatement Office 6
FPAO Mandate 6
FPAO Objectives (10 Deliverables) 6
FPAO Organisation and Strategic Approach 7

Purpose of this Progress Report 8

PART TWO—PROJECT PROFILES

HIGHLIGHTS OF THE 1994-95 PROJECT YEAR 9

Industrial Discharges 10
Reference Workbook: Pollution Prevention Plans 10
Technical Guide for the Development of Pollution Prevention Plans for Fish Processing Operations in the Lower Fraser Basin 12
Best Management Practices for the Ship and Boat Building and Repair Industry in British Columbia: Background Document 13
BMPs for the Ship and Boat Building and Repair Industry in British Columbia 15
BMPs for Marinas and Small Boatyards in British Columbia 16
Fraser River Pulp and Paper Data Analysis 17
Effluent Point Source Inventory and Database for the Fraser River Basin/Fraser Point Source Inventory: User's Manual 18
Aerobic Biotransformation of Toxic Organics in Wastewater 20
Effluent Characterization Study 22
Evaluation of Leachate Quality from Pentachlorophenol, Creosote, and ACA Preserved Wood Products 24
Plume Delineation of a Pulp and Paper Mill Outfall Using Airborne Multispectral Imagery and Rhodamine Dye 26

Municipal Discharges, Urban Runoff, and CSOs 27
Aerial Foreshore Reconnaissance of the Fraser River Basin 27
Protection of Aquatic and Riparian Habitat by Local Governments: An Inventory of Measures Adopted in the Lower Fraser Valley, 1995 28
Optimization of Biological Phosphorus and Ammonia Removal in a Combined Fixed and Suspended Growth Wastewater Treatment System - Final Report 30

Sewage Lagoon Design Using Wetlands & Other Upgrading Technologies to Achieve Non-acutely Toxic Effluent....32
Stormwater Retention and Treatment Facility - District of 100 Mile House: Preliminary Design Report....33
CSO and Urban Runoff Investigative Assessment Guidelines....35
Westridge Combined Sewer System Spring/Summer 1994 Overflow Characterization Study - Final Report....36
Characterization of the Clark Drive CSO & Stormwater From a Residential and an Industrial Catchment: Spring 1994....38
Crowe Street CSO Spring 1994 Overflow Characterization Study....40
Glenbrook CSO Spring 1994/Winter 1995 Characterization Study....41
Effluent Dispersion in the Fraser River from the Glenbrook CSO at New Westminster, BC....43
GVRD Solid Waste Management Plan Review-Stage 2 Report....44

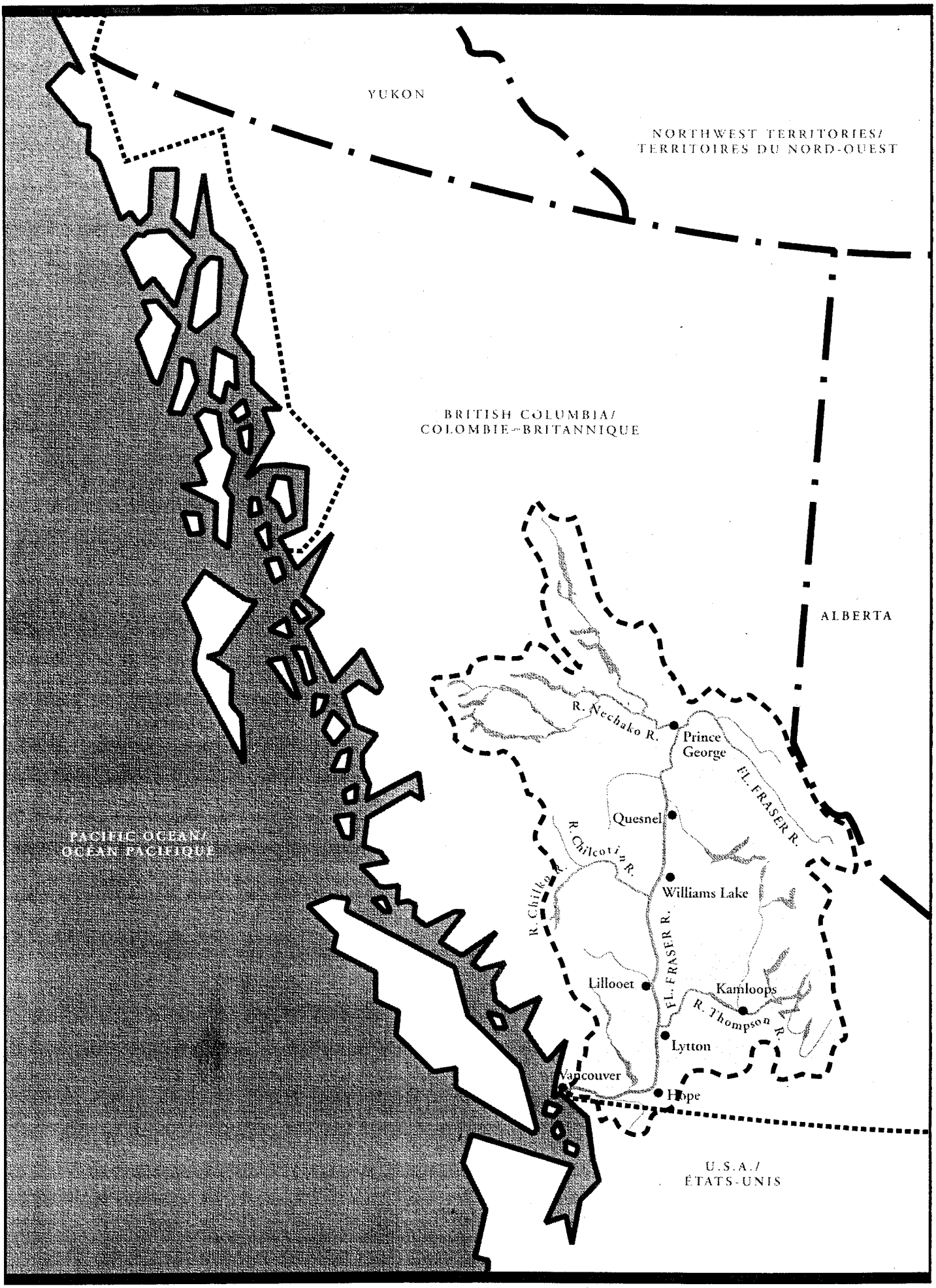
Agricultural Runoff....47
Agricultural Inventory of the Lower Fraser Valley: Data Summary Report....47
Lower Fraser Valley Agricultural Practices (3 Reports)....48
Rural-Urban Connections....49
Bridge Creek Watershed Project....50
Cranberry Database for IPM Information System....51
Pre-sidedress Soil Nitrate Test for Silage Corn: 1994 & 1995 Results....52
Improved Use of Poultry Manure for Raspberry Production....53
Qualifying and Quantifying Ammonia Emissions from Poultry on Different Dietary Regimes....55
Status Report of Projects in Waste Management in the Livestock Industry in the Interior of BC....56
Environmental Guidelines for Field Vegetable Producers....57

Groundwater....59
Groundwater Quality Protection Practices....59
Septic System Maintenance: Pure and Simple....60
Groundwater Denitrification Research....61
Evaluating Methods of Aquifer Vulnerability Mapping for the Prevention of Groundwater Contamination in British Columbia....62
A Groundwater Quality Assessment in the Hopington (Langley) Aquifer....64

Contaminated Sites....66
Fraser Basin Contaminated Sites Inventory - SITE Database....66
Impact Assessment of the Old Quesnel Landfill: Final Report....67

REFERENCES....68

APPENDICES....69
A List of FPAO Reports Published Under FRAP....70
B Glossary....75
C FRAP 48 Deliverables....77
D FPAO Contacts....80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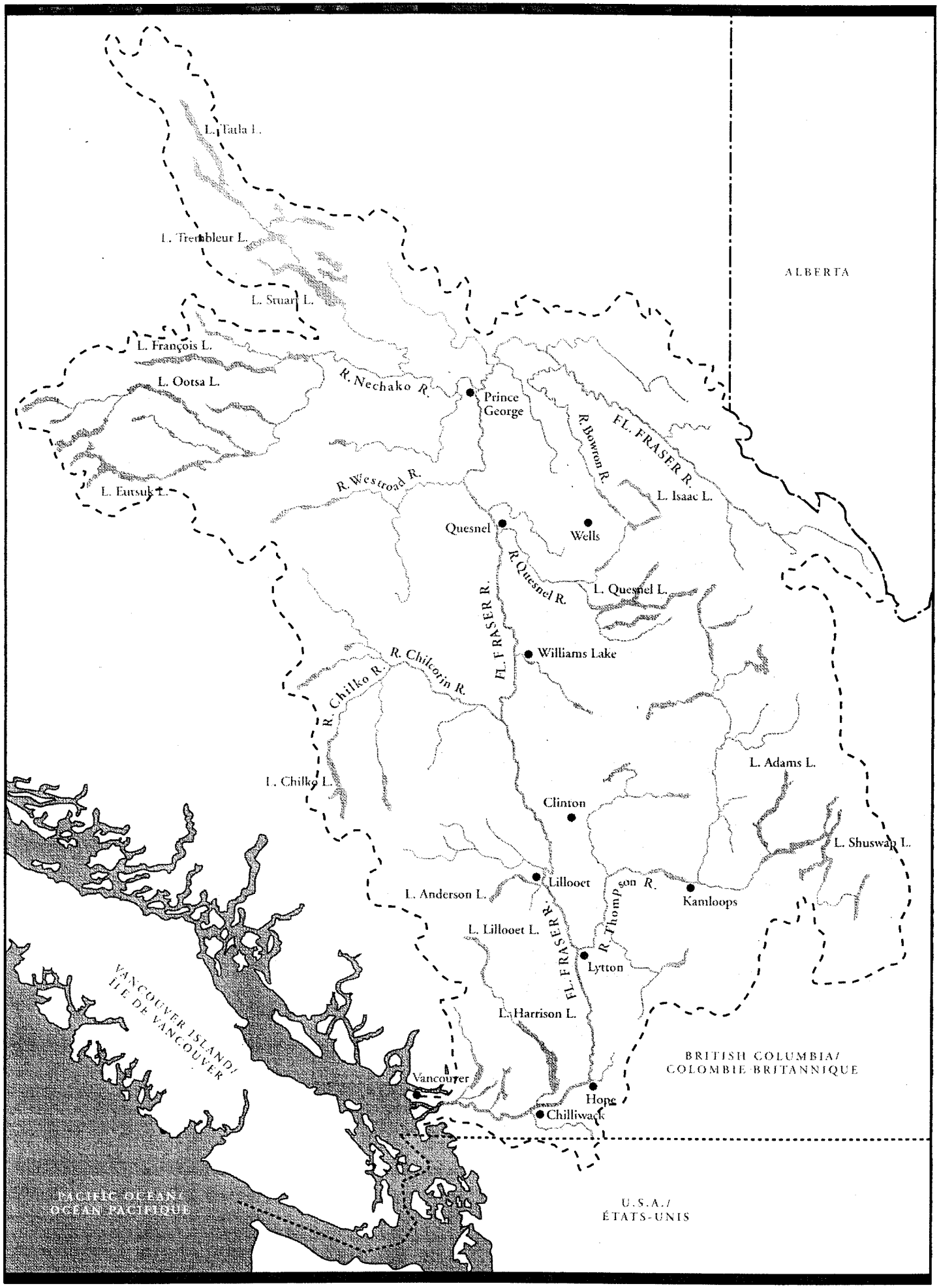
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FRASER POLLUTION ABATEMENT OFFICE

Progress Report 1994-95

PART ONE—INTRODUCTION

THE FRASER BASIN

The Fraser River is the fourth largest river in Canada and is British Columbia's largest river. Flowing for nearly 1,400 km from headwaters in the Rocky Mountains to its mouth in the Strait of Georgia and taking in the watersheds of dozens of tributaries—Nechako, Quesnel, Chilcotin, Thompson—its drainage basin covers nearly 25 percent of the province and encompasses all but one of the 14 major ecoregions and climatic zones in British Columbia.

The richness of the Fraser River basin is evident in its diversity. Its landscapes range from alpine wildernesses to forested plateaus, arid canyons, rolling uplands, verdant valleys, fragile wetlands, and the immense delta at its estuary. Magnificent wildflower meadows, grasslands, and forests are habitat for an incredible variety of plants and animals, from goosefoot to grizzly bears, mountain heather to moose, and orchids to owls.

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

Forty-one 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 most ancient living species of fish. Another 52 fish species are supported by the Fraser's vast network of lakes and tributaries and its estuary. 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, sport, and aboriginal food catches.

Over 60 percent of British Columbia's population lives and works in the Fraser basin; a population expected to grow by 50 percent in the next 25 years. The history of many of the province's people can be traced throughout the Fraser River system, from the earliest activities of First Nations through European contact to today's cultural mosaic. The Fraser has been a vital transportation link for trade and exploration thoughout the human history of the province; it brought the fur traders and provided access to overland trails. It was both the site and access route of many gold rushes and has provided for a multicultural influx across BC.

Today it remains a focus for human settlement and industrial growth. The Fraser River basin supports 48 percent of our commercial forests, 60 percent of metal mining operations, and nearly 45 percent of BC's precious farmland. The lower portion of the basin is one of the most productive agricultural areas in Canada. Tourism and outdoor recreation are also significant contributors to the economy of the basin. The Fraser River basin accounts for 80 percent of the gross provincial product and 66 percent of total household income.

The water of the river connects the land to the plants, animals, and people. But the same water also transports environmental contaminants throughout the basin. Millions of tons of wastewater from industrial and municipal activities are pumped into the Fraser. Drainage from agricultural activities has also been a significant source of pollution. Metals and other contaminants from human activities have been detected in fish and sediments. Wetlands and riparian habitats have been destroyed, polluted, or otherwise alienated for use by fish, waterfowl, and other wildlife. Groundwater has been contaminated in local areas. Conflicting demands for water use (e.g., irrigation, instream fisheries, and water quality requirements) have resulted in local shortages during summer periods on certain streams.

While the overall health of the Fraser basin's ecosystems is robust, a burgeoning human population—with its urban sprawl, expanding industrial development, and increased resource extraction—is placing it under tremendous and increasing stress.

The sustainability of the Fraser basin's fish, wildlife, and human populations is dependent upon the environmental quality of its ecosystems, including the places where we live. Municipal and industrial waste discharges, air and groundwater pollution, agriculture and other human activities can all have impacts on environmental quality.

It is evident that the environmental integrity of the Fraser River basin must be protected and improved in order to safeguard the health of its people and the conservation of its biodiversity. That is why the federal government, working in partnership with other stakeholders, is taking action with the Fraser River Action Plan.

FRASER RIVER ACTION PLAN

FRAP Origins

The government of Canada acknowledges the Fraser River is under stress and is striving to improve its long-term health and productivity. In recognition of its tremendous environmental and economic importance, clean-up of the Fraser River basin was targeted as a priority in 1991, and the Fraser River Action Plan (FRAP) was launched by Environment Canada and Fisheries and Oceans Canada. Initially a five-year program, Environment Canada reprofiled its FRAP resources in 1994 to institute a seven-year program.

The mission of FRAP is to:

1. build partnerships
2. clean up pollution
3. renew the productivity of the natural environment

FRAP Strategy

Since inception, the Fraser River Action Plan has been working on many different fronts toward its goals.

Strengthened partnerships are the key to the future of the Fraser. Only through cooperative efforts will the goal of a healthy and viable river be realised. FRAP is actively working with provincial and municipal governments, industry associations, community groups, and First Nations to take steps to clean up pollution, improve environmental quality, and resolve difficult environmental management issues in the Fraser basin. FRAP helped create the Fraser Basin Management Board, which facilitates the cooperation necessary to restore and maintain the health of the Fraser River basin.

A major thrust of cleaning up pollution is identifying and reversing the existing sources of environmental contamination and implementing measures to prevent pollution from being created in the first place. The Fraser Pollution Abatement Office is adding to the store of tools and knowledge needed to achieve this objective.

FRAP 48 Deliverables

To meet the broad goals of FRAP, Environment Canada further described its FRAP commitment in 48 “deliverables,” or program objectives. The FRAP 48 deliverables, listed in full in Appendix C, are defined under three main headings. These are:

- **Sustainability**—Develop a management program for sustainable development in the Fraser River basin in partnership with the provincial and local governments and other basin stakeholders.
- **Pollution Prevention**—Arrest and reverse the existing environmental contamination and degradation of the Fraser River ecosystem by developing targets and strategies to reduce pollution and by virtually eliminating the discharge of persistent toxic substances into the Fraser River.
- **Habitat Restoration and Conservation**—Restore the productivity of the natural environment by restoring and enhancing environmental quality and the natural productive capacity of Fraser River ecosystems.

FRASER POLLUTION ABATEMENT OFFICE

FPAO Mandate

The Fraser Pollution Abatement Office (FPAO) was established in 1991 to lead the pollution abatement component of FRAP. Working closely with the Environmental Quality and Enforcement components, the mandate of FPAO is to address the FRAP goal of cleaning up pollution in the Fraser River basin.

The legislative authorities for the clean-up part of FRAP are the *Canadian Environmental Protection Act* and the pollution prevention provisions of the *Fisheries Act*, for which Environment Canada has responsibility. FPAO also encourages stewardship and voluntary actions by industry and government operations wishing to move beyond compliance.

FPAO Objectives (10 FPAO Deliverables)

Of the 48 FRAP deliverables, ten (numbers 8 through 17 under the Pollution Prevention heading) apply specifically to FPAO:

8. Develop and maintain an inventory of major pollution sources and loadings in the basin.
9. Reduce environmentally disruptive industrial effluent discharges by 30% to meet environmental quality objectives.
10. Reduce contaminant loadings from combined sewer overflows and untreated sewage discharges by 30% to meet environmental quality objectives.

11. Reduce the contaminant load from inadequately treated sewage discharges by 30% to meet environmental quality objectives.
12. Implement a strategy to reduce the loading of nutrients, bacteria, and agrochemicals from agricultural operations to ground and surface waters by 30% to meet environmental quality objectives.
13. Implement a strategy to reduce the contaminant loading from urban runoff by 30% to meet environmental quality objectives.
14. Establish a Groundwater Protection Strategy that includes the remediation of high priority sites.
15. Clean up 70% of contaminated federal waste sites to CCME (Canadian Council for Ministers of the Environment) standards.
16. Develop and maintain a toxic air emissions inventory for major industrial sectors.
17. Reduce the release of persistent toxic substances pursuant to the *Canadian Environmental Protection Act* and identified as priority from inventories and environmental data to the extent allowed by best practicable technology.

Of the projects reported on for this reporting period, many addressed one or two of the above, some three or more, and some of them addressed others from FRAP's list of 48 Deliverables (see Appendix C).

FPAO Organisation and Strategic Approach

The work of the Fraser Pollution Abatement Office is carried out in the following sectors: industrial discharges, municipal discharges and combined sewer overflows, urban runoff, agricultural runoff, groundwater, contaminated sites, and airborne contaminants.

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. Joint project agreements provide for the participation by other government agencies, First Nations, industry associations, non-government organisations, and academic and private sector groups through work- and cost-sharing arrangements.

The strategic approach includes:

- development of databases for use in inventories, research, and trend assessments
- inventories of point and non-point sources of contaminants
- wastewater characterisation (sampling and analysis for chemical and physical parameters) and pollutant loading evaluations
- site-specific effluent dispersion assessments
- development and demonstration of technologies and techniques to prevent or reduce pollution, and evaluation of their effectiveness

- identification of best management practices (BMPs) to conduct industrial and commercial activities in a manner that protects the environment and is also cost-effective
- support for industry and public education programs to foster understanding of the methods and benefits of abating pollution
- development and promotion of codes of practice and pollution prevention technical guidelines to help industrial and commercial operations improve their environmental performance
- provide technical advice to other government agencies, industry, and community groups engaged in pollution abatement to advance progress in eliminating toxic substance and environmentally disruptive effluent discharges

Since FRAP started, there has been a shift in activity from pollution control type approaches to pollution prevention. Pollution prevention means changing production processes and reducing the amount of waste we create in the first place in order to eliminate the causes of pollution rather than treat its symptoms. The development of Best Management Practices (BMPs) is particularly useful in this regard, not only because they are generally developed cooperatively with industry associations, but because they are cost-effective and contribute to raising awareness of how to move from the concept to the implementation of pollution prevention.

The strategic approach outlined above has enabled FPAO to initiate, support, or participate in a wide range of projects —over 40—for the 1994-95 fiscal year. FPAO's task for the remaining three years of FRAP is to continue to work with our partners to translate the objectives stated in FRAP deliverables number 8 through 17 into practical results and actions in the Fraser basin. One of the key priorities will be to conduct demonstrations and outreach to assist all of us to implement pollution abatement actions in our day-to-day activities.

Purpose of this Progress Report

This report summarises progress on projects led or supported by the Fraser Pollution Abatement Office in 1994-95. The report presents numerous examples of the collaboration and partnerships that are integral to accomplishing the pollution prevention objectives of FRAP. A list of FPAO reports published under FRAP or by partners is given in Appendix A.

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PART TWO

PROJECT PROFILES

HIGHLIGHTS OF THE 1994-95 PROJECT YEAR

Characterising contaminant loadings and developing control or prevention strategies for point and non-point sources of pollutants continue to be major objectives of the Fraser Pollution Abatement Office. For the 1994-95 reporting period, many projects addressed the development of Best Management Practices and Pollution Prevention (P2) plans, usually in partnership with other federal and provincial government agencies: Fisheries and Oceans Canada, Industry Canada, Agriculture Canada, Health and Welfare Canada, BC Environment, BC Agriculture, Food and Fish, BC Ministry of Health; regional district and municipal governments; and industry or sector associations, such as the shipyard, fish processing, agriculture, food production, construction, and forest products industries.

FPAO led, participated in, or supported upwards of 42 projects for the 1994-1995 fiscal year. Some of the projects described in this report build on the work of previous years and may be updates on results or continuing activities in the development of methodologies to reduce or eliminate pollution in the Fraser River Basin; others require additional time to complete.

Five main program areas are profiled in this report: Industrial Discharges; Municipal Discharges, Combined Sewer Overflows (CSOs), and Urban Runoff; Agricultural Runoff; Groundwater; and Contaminated Sites. Projects are described according to the following formula:

- name of project;
- partnerships;
- funding arrangements;
- relevance to FPAO deliverables (see pp. 6-7);
- who prepared the project report or participated in its activities;
- FPAO (or partner) contact person for communication related to the project;
- a brief profile of the project, its goals and objectives, and project results (if applicable).

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INDUSTRIAL DISCHARGES

PROJECT: Reference Workbook: Pollution Prevention Plans

Partnerships: FPAO, EC-Industrial Programs
Funded By: **Total Cost: $5K**;
EC-Industrial Programs $5K
FPAO Deliverables: #9, #13, #17
Prepared By: PCA Consultants Ltd.
Publication/Product #: DOE FRAP 1994-35
FPAO Contacts: Lisa Walls, David Poon, Vivian Au

A growing awareness among governments, industries, and the public that the prevention of pollution can be more effective and efficient than treatment or remediation has prompted the need for the development of sector-wide or industry-specific pollution prevention plans.

Pollution prevention (P2) is defined by Environment Canada as:

> *the use of processes, practices, materials, or energy that avoid or minimise the creation of pollutants and wastes without creating or shifting new risks to communities, workers, consumers, or the environment.*

Pollution prevention emphasises source reduction measures for the generation of all wastes at production areas using a multi-faceted approach that encompasses reduction in:

- air emissions
- wastewater discharges
- solid wastes

Pollution prevention involves the application of Best Management Practices (BMPs), product changes, and modifications of manufacturing processes and other activities that eliminate or reduce the use or production of hazardous and non-hazardous materials, energy, water, or other substances.

This project is an important initial step to guide the development of industry-specific pollution prevention plans. The reference workbook that was produced introduces the concept of industrial pollution prevention, relates it to the traditional “react and control” approach, and details the elements needed to develop pollution prevention plans that can be tailored to a specific industrial process or activity. Industry-specific guides will be designed to provide background information on the processes, waste characteristics, and recommended pollution prevention measures to be used by individual companies to develop facility-specific pollution prevention plans.

Sections of the workbook detail the tasks of preparing an industry-specific profile, preliminary environmental site audits, detailed environmental site audits, pollution prevention progress assessments, and a series of worksheets with step-by-step instructions on the development of pollution prevention plans. In the absence of an industry-specific guide, the *Reference Workbook* may be used to provide a model for pollution prevention.

In British Columbia, some of the industrial sectors that could benefit from the development of guides to preparing pollution prevention plans are listed in the following table.

Proposed Industries for Guides for the Preparation of Pollution Prevention Plans

Industries With Site Contamination	Industries With Foreshore Operations	Industries Related to Food
Sawmills	Dry Bulk Terminals	Fish Processing
Wood Preservative	Shipyards	Meat Processing
Auto Recycle	Petroleum Terminals	Fruit and Vegetable
Foundry	Chlor-alkali	Feed Mills
Sand and Gravel	Sodium chlorate	Abattoirs
Metal Smelters	Chemical	Dairy
Scrap Metal	Sugar	Winery
Mining	Pulp Mills	Agricultural Operations
Cement	Ready-Mix	Brewery

This project recognises that the shift in emphasis towards adopting pollution prevention measures has been prompted by the continuing increases of waste treatment and disposal costs, the promulgation of laws and regulations that limit waste disposal options, and the need to reduce potential threats to human health and the environment. At the federal and provincial levels, strategies are being developed to promote the implementation of pollution prevention practices.

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PROJECT: Technical Guide for the Development of Pollution Prevention Plans for Fish Processing Operations in the Lower Fraser Basin

Partnerships: EC-Industrial Programs, DFO, BC Environment, FRAP, GVRD, Industry Canada, Task Force on Fish Processing Wastewater Management

Funded By: **Total Cost: $20K**; FRAP $7K; EC-Industrial Programs $7K; Marine & Atmospheric Service $6 K; all other partners provided in-kind support

FPAO Deliverables: #9, #17

Prepared By: NovaTec Consultants Inc.

Publication/Product #: DOE FRAP 1995-23

FPAO Contacts: David Poon, Vivian Au

The goal of this project was to develop pollution prevention (P2) plans for the fish processing industry in the Lower Fraser Basin. A guide was produced that is designed to provide the industry with step-by-step procedures to develop facility-specific pollution prevention plans. It includes worksheets to use in evaluating the P2 potential at a particular facility specifically for fish processing operations and suggests pollution prevention options appropriate to the industry. The guide also describes the economic benefits of P2 planning.

The guide is based on two Environment Canada publications: *Guide for Best Management Practices for Process Water Management at Fish Processing Plants in BC* (1994), which was reported on in the *FPAO Progress Report 1993-1994*, and *Reference Workbook: Pollution Prevention Plans* (1994), reported in this Progress Report.

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 Strait of Georgia). Many 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.

Liquid wastes from this activity constitute a significant load either to municipal sewage collection and treatment systems or to surface waters. Overall, high biochemical oxygen demand (BOD), chemical oxygen demand (COD), oil and grease, residual chlorine, solids and suspended solids, and ammonia nitrogen content can be expected in effluents from fish processing facilities.

In addition to the pollution potential of substances entering the Fraser basin, water consumption is also a concern. Water conservation techniques and processing technology modifications can reduce water consumption significantly.

This guide was produced in partnership with federal, provincial, and municipal agencies and the fish processing industry, and is designed for use by plant operators, regulatory agencies, industry suppliers, and consultants. It will be distributed to libraries and made available to consultants and members of the industry and industry associations.

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PROJECT: Best Management Practices (BMPs) for the Ship and Boat Building and Repair Industry in British Columbia: *Background Document*

Partnerships: EC-Commercial Chemicals, EC-Industrial Programs, BIEAP, BC Environment, VPC, GVRD, DFO, FRAP

Funded By: **Total Cost:* $30K**; FRAP $17K; EC-Commercial Chemicals $13K
**Total cost is for this and the following two BMP projects for the Ship and Boat Building Industry*

FPAO Deliverables: #9, #17

Prepared By: PCA Consultants Ltd.

Publication/Product #: DOE FRAP 1995-15

FPAO Contacts: Stanley Liu, Vivian Au

The purpose of this project was to develop a BMP reference document and technical report examining Best Management Practices in the ship and boat building and repair industry in British Columbia. A number of BMP guiding documents (companion reports) for this industry were subsequently developed and are profiled in this Progress Report. The companion BMP documents set out industrial techniques and good housekeeping principles for reducing the volume of contaminants from shipyards and boatyards in British Columbia. Both the Background Document and the companion BMP documents were developed by updating and expanding on the *Draft Recommended Environmental Management Practices for the Ship and Boat Building and Repair Industry* that was prepared by Environment Canada in 1989 and on a study of existing practices at shipbuilding facilities in British Columbia.

This background document summarises the state of knowledge on the impacts of different contaminants on the receiving environment; the relevant legislation governing handling, control, and disposal of contaminants generated during ship-

building and repair activities; and the environmental practices employed in other Canadian and US jurisdictions.

Activities at ship and boat yards that have environmental impacts were identified; some of these are pressure-washing, surface preparations, paint removal, sanding, painting, engine repair, waste disposal, liquid storage, and shipboard process discharges. The contaminants of concern associated with these activities include copper, lead, zinc, chromium, total suspended solids (TSS), oil and grease, pH, and organotin.

This current study examined practices used in Washington and other west coast US states in order to learn as much as possible from their experiences and to extract useful guidelines and practices that have proven workable in the Pacific Northwest.

The legislation and environmental practices reviewed in this Background Document are intended to apply to all sizes of ship or boat building and repair facilities working on commercial or recreational vessels, including marinas with lifts, marine ways and/or tidal grids, and to government facilities involved in maintaining their own vessels (Fisheries and Oceans Canada, DND, RCMP, BC Ferries). These reports are applicable to any facility in BC, whether in a freshwater or saltwater environment.

The information presented in this Background Document was used to develop the documents described in the next-listed projects: *Best Management Practices (BMPs) for the Ship and Boat Building and Repair Industry in British Columbia* (DOE FRAP 1995-14) and *Best Management Practices (BMPs) for Marinas and Small Boatyards in British Columbia* (DOE FRAP 1995-16).

As well, the steering committee for this project identified that a simplified version of the BMPs should be developed for smaller boatyards and marinas because these smaller facilities do not provide all of the servicing activities normally available at the larger operations. Based on this intent, two additional documents were developed for these smaller facilities: *Best Management Practices (BMPs) for Marinas and Small Boatyards in British Columbia* and a pamphlet titled *Best Management Practices (BMPs) for Boat Building and Repair*.

Finally, the implementation of BMPs will be subject to economic factors in this industry, which for some time has been in a state of recession and is facing stiff competition from other Pacific Rim yards. In spite of this, there is an opportunity to affect significant improvements in local aquatic and air pollution by applying relatively simple modifications to existing operations and activities.

Ω

PROJECT: Best Management Practices (BMPs) for the Ship and Boat Building and Repair Industry in British Columbia

Partnerships: EC-Commercial Chemicals, EC-Industrial Programs, FRAP, BIEAP, BCE, GVRD, DFO

Funded By: **Total Cost:** (See p. 13)

FPAO Deliverables: #9, #17

Prepared By: PCA Consultants Ltd.

Publication/Product #: DOE FRAP 1995-14

FPAO Contacts: Stanley Liu, Lisa Walls, Vivian Au

This document was developed from the BMP background document described in the previous profile. The partners agreed that recommendations for improved practices need to be applied not only to large shipyards, but also to government facilities, smaller commercial boat construction and repair yards, and any other facility offering repair facilities and services, including marinas, yacht clubs, and small-craft harbours. The Best Management Practices (BMPs) discussed in this report are intended for implementation by all facilities in British Columbia where ship or boat building and repair activities are conducted in proximity to aquatic environments. This includes building and repair of pleasure boats and commercial vessels.

The philosophy behind BMPs is to conduct activities in a more ecologically sound manner, keeping pollutants out of surface and ground waters but recognising that total containment and recovery are not always practical. In addition to environmental benefits, BMPs are cost-effective; their implementation can usually be achieved by using in-house materials and techniques not requiring any capital outlay and there is frequently a training component that benefits workers.

BMPs for ship and boatyards fall into two general groups: source-control (vessel shrouding, sweeping, covering waste piles, bermed storage for oils and paints) and treatment (hull washwater settling tanks and filters). BMPs will help shipyards, boatyards, and marinas comply with federal and provincial laws and municipal bylaws, including the *Canadian Environmental Protection Act*, *Fisheries Act*, *Workers' Compensation Act*, BC *Waste Management Act* and contaminated sites legislation, and municipal air quality, noise, sewer, and fire safety bylaws.

The BMP document produced is clearly detailed and includes diagrams, photos, contingency plans, checklists, a complete reference section, and employee training instructions to enable the effective implementation of a BMP plan at ship and boatyard facilities. This report, as is the case with the other BMP documents, will be distributed to libraries and made available to consultants and members of the industry.

Environment Canada will work cooperatively to find cost-effective solutions to the environmental issues in this report. Facilities are encouraged to tailor the BMPs to their operations and locations, and to develop their own solutions for pollution control. The

extent to which industry is able to follow the recommended practices will be determined by audits. These BMPs do not preclude government from introducing or taking regulatory steps in the future to ensure that the environment is adequately protected.

Ω

PROJECT: Best Management Practices (BMPs) for Marinas and Small Boatyards in British Columbia

Partnerships: EC-Commercial Chemicals, EC-Industrial Programs, FRAP, DFO, VPC, BIEAP, BCE, GVRD

Funded By: **Total Cost:** (see p. 13)

FPAO Deliverables: #9, #17

Prepared By: PCA Consultants Ltd.

Publication/Product #: DOE FRAP 1995-16

FPAO Contacts: Stanley Liu, Lisa Walls, Vivian Au

As previously described, this project was a recommendation of the Project Team steering committee that developed the Background Document for *BMPs for the Ship and Boat Building and Repair Industry in British Columbia*. It was thought that this simplified version of the BMPs will better serve the smaller boatyards and marinas, which do not offer the large variety of servicing activities normally available at the larger ship and boat building and repair facilities.

These BMPs focus on practices for small boatyards, marinas, yacht clubs, and other facilities that primarily maintain and repair pleasure craft. Practices outlined in this report include processes or operations necessary to clean, prepare, and coat boat hulls (including storing and disposing of paints, solvents, oils, and cleaners).

The BMPs are divided into eight categories, each covering a specific operation or management task. In each case, the general intent behind them is stated and guidelines for achieving improvements to existing practices are listed. As with the previous BMP documents, a strong emphasis is put on waste minimisation and the three Rs: recovery, recycle, and re-use.

There is no expectation that facilities will undertake any costly installations or improvements without weighing the alternatives that may be available to reduce contaminant discharges. Facilities should, nonetheless, implement as many simple practices as possible in the short term while continuing to pursue other options or approaches to the most costly problems. All practices need to be implemented and

judged on a case-by-case basis, taking into account the conditions, operations, and natural limitations at each facility. Environment Canada will work cooperatively with facilities to find practical and cost-effective solutions to the environmental issues addressed in these BMPs.

Ω

PROJECT: Fraser River Pulp and Paper Data Analysis

Partnerships: None
Funded By: **Total Cost: $5K**; FRAP $5K
FPAO Deliverables: #8, #17, [FRAP #18, #20, #33]
Prepared By: HBT AGRA Limited, Water Resources Division
Publication/Product #: No DOE FRAP Report
FPAO Contacts: Snehal Lakhani, Lisa Walls, Vivian Au

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. This project was initially reported on in the *FPAO Progress Report for 1992-93* (p. 10) as "Fraser River Basin Pulp Mill Database Project," and again in the *FPAO Progress Report for 1993-94* (p. 7). In its current form, it is the logical expansion of that project as part of FPAO's wastewater characterisation program. For the purpose of the current FPAO progress report, this profile reports on the project's completion.

A primary objective of the initial project was to assemble all the effluent monitoring data in the EC Envirodat database from seven pulp mills in the Fraser basin using 1990 as a baseline year. The seven participating pulp mills were Northwood Pulp and Paper (Prince George), Cariboo Pulp and Paper (Quesnel), Canadian Forest Products (Prince George), Quesnel River Pulp and Paper (Quesnel), Weyerhaeuser (Kamloops), Paperboard Industries (Burnaby), Scott Paper (New Westminster).

Envirodat is a national Environment Canada database residing on VAX Oracle. It contains monitoring data information, including the geographic locations of the sampling sites, sampling dates and times, method of analysis and test results for water quality, effluent, sediment, and biota analysis data. For the purpose of this study, a range of daily, weekly, and monthly measurements of the following parameters, submitted by the pulp and paper mills under the federal pulp and paper regulations, were used:

- effluent flow
- biochemical oxygen demand (BOD)

- total suspended solids (TSS)
- acute toxicity
- adsorbable organic halides (AOX)
- dioxins/furans
- nutrients

The objectives of the data analysis were:

1. summarise the data (concentrations, flow, loadings, and production
2. conduct statistical analyses
3. identify significant temporal trends

The final report documents the results of the data analysis, contrasting the concentrations, loadings of TSS, dioxins and furans, including flow and production methods from the seven participating pulp mills, statistical summaries, graphs, interpretations, and literature references.

Among the results, it was noted that TSS went down over time and production went up, and that there was a decrease in dioxins and furans.

Ω

PROJECT: Effluent Point Source Inventory and Database for the Fraser River Basin/ Fraser Point Source Inventory: User's Manual

Partnerships:	FRAP, EC-EP, BCE, DIAND
Funded By:	**Total Cost: $55K**; FRAP $55K
FPAO Deliverables:	#8, #9, #17
Prepared By:	Westwater Research Centre, UBC Revised by FPAO in 1994
Publication/Product #:	DOE FRAP 1993-05 and DOE FRAP 1993-06
FPAO Contacts:	Vivian Au, Lisa Walls

One of the principal goals of FPAO—identify and reduce contaminants entering the Fraser basin—is directly addressed by the two main objectives of this project:

1. Conduct an inventory of industrial and municipal point sources of wastewater discharges to the Fraser River basin, including basic administrative, geographic, and regulatory data on each source.
2. Design a personal computer database system to maintain, examine, and report the information collection in the inventory.

This project was initially profiled in the *FPAO Progress Report 1992-93* (p. 5). A database (using FoxPro) was developed that lists the point sources of industrial and municipal wastewater discharges entering the Fraser River basin. Geo-referenced information on the discharges is compiled in a PC-based system designed to allow flexible querying and reporting of inventory data. The scope of effluent data collection is limited to BC Waste Management Permit provisions and, for non-permitted federal facilities, typical flow estimates.

Data was collected from BC Waste Management permits (using BC Environment's WASTE data management system) and site visits to BC Environment regional offices. Data on federal non-permitted installations was obtained from FFEAD, the Federal Facilities Environmental Activities Database of Environment Canada. FFEAD data was supplemented with site information for federal facilities obtained from Environment Canada files, DIAND, federal institutions, and Transport Canada.

The ability to transfer data from one database type to another was an important criterion of this project in order to maximize information exchange and avoid duplication of effort. The database model was, therefore, designed to conform to the Spatial Archive and Interchange Format (SAIF) developed by BC Environment. The resulting program is called the Fraser Point Source Inventory, or FR_PSI.

The database is designed to be updated periodically by FPAO as changes in permits occur. As of this reporting period, the point source inventory contains records for 458 sites and 1207 parameters. Data summaries are comprised by sub-basin, region, key parameters, and major SIC groups. Actual wastewater monitoring data are not included in this database. Copies of the data base are available from Environment Canada on request.

The User's Manual describes the use of the program, including giving background information, installing the system, running the program, the database structure, importing and exporting data, reporting, and maintaining updates.

Ω

PROJECT: Aerobic Biotransformation of Toxic Organics in Wastewater

Partnerships: **FRAP**
Funded By: **Total Cost: $20K** ($10K 1993/94; $10K 1994/95)
FPAO Deliverables: #17
Prepared By: Burlington Environmental Technology Office
Enviromega Ltd., Flamborough, Ontario
Publication/Product #: KE405-3-0173/01-XSE
FPAO Contacts: Vivian Au

CEPA states that toxic compounds will be controlled from development to disposal, and defines three groups of priority substances. A number of chemicals from each of these groups are typically found in wastewater, including benzene, tetrachloroethylene, hexachlorobenzene, and toluene. These are also referred to as volatile organic compounds (VOCs) and they are commonly detected in both domestic and industrial wastewater. The release of these compounds during wastewater treatment is an increasing public concern. Problems may arise when some of these compounds biodegrade; there is a possibility that a compound more toxic than the original may be formed. An example of this is the production of vinyl chloride in the biotransformation of carbon tetrachloride; vinyl chloride has been shown to be carcinogenic, while carbon tetrachloride is only a suspected carcinogen.

In response to these concerns, computer models, such as Toxchem, have been developed to predict the mass of VOCs in wastewater treated by biotransformation and the mass stripped to the atmosphere and released in the treated effluent. Such models require the input of a biotransformation rate coefficient for each VOC or concern. However, there is considerable uncertainty in the prediction of specific biotransformation rates. The impact of bioreactor operating conditions on biotransformation rates is not well understood. At the current time, there is no universally accepted bench scale method for measuring biotransformation rates. This limitation has constrained the investigation of VOC biotransformation rates. The objectives of this study were to:

1. develop a protocol that can measure the rate of biotransformation of VOCs
2. use the protocol to investigate factors influencing biotransformation rates
3. improve model capabilities of predicting the biotransformation of candidate VOCs during wastewater treatment

The report details the development of this protocol and investigates the effects of operating conditions on VOC biotransformation rates (operating conditions include anaerobic and anoxic denitrifying conditions, and aerobic conditions).

Some of the findings reported include:

1. Results in side-by-side experiments, employing the same biological seed, were similar, confirming that protocol results were reproducible.
2. A mixed second-order model was practical for quantifying biotransformation rates measured using the protocol.
3. Minimal biotransformation of all target VOCs was observed under anaerobic and anoxic denitrifying conditions.
4. There was no evidence that biotransformation rates changed over the length of a protocol experiment, suggesting that the decline in COD concentration over an experiment had minimal impact on biotransformation rates.
5. It was postulated that biotransformation rates were dependent on the biological seed characteristics used in the protocol reactor and that these characteristics changed during the study.

Three recommendations emerged:

At this time, it is recommended that predictive fate models, such as Toxchem, not be modified to account for the effect of operating conditions until further understanding of these effects is obtained. In this study, there was no conclusive evidence of an effect of either dissolved oxygen or COD concentrations on VOC biotransformation rates within the ranges examined.

In practical terms, the protocol developed provides a simple method for determining VOC biotransformation rates with reproducible results. However, the protocol consistently predicted lower than anticipated biotransformation rates, particularly for the non-chlorinated compounds. Further investigation of this discrepancy is recommended before widespread application of the protocol.

Once the above-mentioned discrepancy is resolved, it is recommended that the protocol be applied to further investigate the impact of bioreactor operating conditions on VOC biotransformation rates. The experiments should be planned to minimise the potentially confounding variable of changes to the biological seed. The impact of the biological seed characteristics and the acclimatory/inhibitory effects of both the primary substrate and the VOCs should be examined in a parallel study.

Ω

Project Name: Effluent Characterization Study

Partnerships: EC-FRAP, FREMP, BCE, DFO, GVRD, FRHC, NFHC

Funded By: **Total Cost:** information not available
In kind: coordination by FREMP

FPAO Deliverables: #8, #9

Prepared By: Technology Resource Inc. & McLeay Assoc. Ltd.

Product/Publication #: Technical Report DOE FRAP 1993-13

FPAO Contacts: Lisa Walls

This project, initially profiled in the *FPAO Progress Report 1992-1993*, was an effluent characterization project for industries that discharge into the Fraser River Estuary. Eleven industries participated: Domtar, Fraser Wharves, Hilinex Packaging, International Forest Products (Hammond Cedar and Fraser Mills divisions), Lafarge Canada, MacMillan Bloedel (New Westminster) Scott Paper, Tilbury Cement, Tree Island Steel, and Westshore Terminals. Assessments showed that most discharges were under permit by BC Environment.

This project is part of a three-year monitoring cycle to generate environmental trend data on the fate and effects of contaminants in the Fraser River Estuary. The data will be used as a basis for establishing priorities for the subsequent monitoring of contaminants and toxicity in water, sediments, and biota, and to recommend priorities for pollution abatement.

Discharges were sampled for general parameters, such as pH, suspended solids, chemical contaminants, acute and chronic toxicity, and bioavailability (bio-uptake). Acute toxicity was measured using water fleas (*Daphnia magna*) and rainbow trout (*Oncorhynchus mykiss*). The samples were also tested for effects on reproduction and survival of the daphnid *Ceriodaphnia dubia*. Eight-day tests to measure muscle bio-uptake of heavy metals, polycyclic aromatic hydrocarbons (PAHs), and chlorinated phenolic compounds were performed using rainbow trout. The bio-uptake test was included for continuity with an earlier effluent characterization study for FREMP.

The acute and chronic toxicity data were appraised with respect to the chemical analyses for the same samples, current provincial water quality criteria for the protection of sensitive freshwater life, and to the literature on lethal and sublethal toxic effects of each chemical on sensitive species of salmonid fish or freshwater invertebrates. Chemical constituents in the samples were identified which, alone or together, were present at concentrations that could account for the toxic effects observed. Depending on sample type and source, these included copper, zinc, iron, manganese, aluminum, resin and fatty acids, total suspended solids, and specific PAHs. One effluent source had a pH adverse to sensitive freshwater life. Future studies designed specifically to identify the causes of observed toxicity should ensure that analytical detection limits are employed that are significantly lower than

concentrations known to be toxic. For all primary effluent samples studied, the extent of accumulation of contaminants in fish muscle tissue was only at trace amounts or was non-detectable.

Conclusions of this characterisation study include:

- In general, most discharges were found to be in compliance with their Waste Management permit.
- The limits of detection for dissolved aluminum, cadmium, chromium, copper, nickel, silver, chlorinated phenolics, and resin and fatty acids were not sufficiently low to ensure these chemicals were not present at concentrations that could contribute to sample toxicity.
- Some heavy metals, particularly copper, iron, lead, and zinc were found in effluent samples at concentrations that might have an adverse effect on test organisms in bioassay analyses. These materials are recommended for future study.
- Bio-uptake tests revealed some specific chlorinated phenolic compounds, PAHs, and chromium and nickel in the muscle tissue of certain fish., but provincial water quality objectives were not exceeded.
- The chronic toxicity test using *Ceriodaphnia dubia* was more sensitive than the acute lethality test with *Daphnia magna* or rainbow trout.
- Operational assessments at the discharges sampled indicated that flow measure-ment is generally estimated by facility personnel. It was concluded that reported discharge flow rates do not necessarily reflect actual rates.

Principal recommendations included:

1. Future chemical characterization of effluent discharges in the FREMP area should focus on heavy metal concentrations. Concentrations of anti-sapstain chemicals, resin and fatty acids, PAHs, dioxins, and furans were found only at trace levels.
2. To assist in the interpretation of data for chronic toxicity tests, information should be compiled regarding the influence of total suspended solids, salinity, pH, and water hardness on test results.
3. Any comparison of the potential toxic loadings of multiple point-source discharges to the lower Fraser River should take into account data regarding daily effluent flow for each discharge rather than restricting the appraisal to a simple comparison of sample toxicity.
4. For future studies, the limits of detection for all chemical constituents analysed should be adequately low to ensure measured concentrations are below those known to cause chronic toxic effects on sensitive freshwater life (detection limits were given for a number of parameters).

Ω

Project Name: Evaluation of Leachate Quality from Pentachlorophenol, Creosote, and ACA Preserved Wood Products

Partnerships: FRAP
Funded By: **Total Cost: $60K**
FPAO Deliverables: #8, #9, #17
Prepared By: DM Whiticar, L Letourneau, D Konasewich, Envirochem Special Projects Inc.
Product/Publication #: DOE FRAP 1993-36
FPAO Contacts: Doug Wilson

The wood preservation industry in British Columbia uses approximately 4,500 metric tonnes of wood preservation chemicals annually to protect wood products from attack by fungi, insects, and marine borers. The principal chemicals used include creosote, pentachlorophenol (PCP), and aqueous formulations of arsenic, copper, and chromium or ammonia. Discharges from wood preservation plants have been shown to be acutely toxic to fish.

The current project is the second of two studies to evaluate wood preservation leachates into the Fraser River Basin. The first study, profiled in the *FPAO Progress Report 1992-1993* (p. 13), evaluated Chromated Copper Arsenate (CCA) treated wood products.

This project was initiated to evaluate the leachability characteristics of pentachlorophenol (PCP), creosote, and ammoniacal chromium arsenate (ACA) wood preservatives from freshly treated wood products. The study was designed to reproduce the conditions found in a typical treated product storage yard and to determine the potential chemical concentrations that may be found in rainfall-generated leachate. The purpose of this study was to provide preliminary data for both industry and regulatory agencies to assess the quality and potential significance of leachate releases from wood preservative-treated products in a storage yard.

The test products included pentachlorophenol-treated utility poles, creosote-treated timbers, creosote-treated marine pilings, and ACA-treated utility poles. Analyses included pH, oil and grease, total organic carbon, ammonia, metals, polynuclear aromatic hydrocarbons (PAHs), chlorinated and non-chlorinated phenols, resin acids, and fish toxicity. A quality assurance and quality control (QA/QC) program was included to verify the validity of the analyses.

Ammonia (from ACA-treated poles) releases to the environment did not show a trend because values fluctuated throughout the course of the study. However, a decreasing trend was noted in both the arsenic and copper releases as cumulative precipitation increased. Comparisons of releases with reported LC_{50} values for individual constituents suggest that copper would be of greatest concern with respect

to fish toxicity. Overall, bioassay results indicated that the toxicity of ACA leachate slightly decreased as cumulative precipitation increased.

PCP releases remained constant over the course of the study, whereas PAH releases (from the carrier oil) showed no significant trend. Total PAH showed no overall trend with respect to chemical concentration over time. Phenanthrene was found to be the main component in releases, although naphthalene has a higher solubility in water and is present in greater proportion in creosote. A sample of the pole leachate obtained approximately four months after the end of the study showed that creosote and PCP releases remained in the same range as those found during the original study period. Bioassay results from creosote-treated products indicated that toxicity slightly decreased over the study period, although the toxicity evaluated by these tests was slightly higher than that predicted by comparison of actual concentrations found in releases and reported LC_{50} values for creosote.

Results of the study showed that wood products treated with these chemicals have potential for aquatic toxicity if released to the environment. However, the actual impacts of releases on site contamination and on the aquatic environment would have to be assessed on a site-specific basis because many factors (e.g., composition of the storage yard surface, inventory and length of time in storage yard, storage practices, treatment conditions, amount of rainfall and dilution effects during collection of precipitation by the stormwater system) contribute to variability of the runoff quality from one site to another. Also, the study represented a worst-case scenario of releases; there are significant differences between the experimental setup and actual conditions at treatment facilities. Assessments of the actual environmental risk presented by the discharge of these leachates requires further study.

Ω

Project Name: Plume Delineation of a Pulp and Paper Mill Outfall Using Airborne Multispectral Imagery and Rhodamine Dye

Partnerships: Environmental Innovation Program, Supply & Services Canada
Funded By: **Total Cost: $15K**
FPAO Deliverables: #8, #9, #10, #11, #17
Prepared By: **GA Borstad Associates Ltd.**
Product/Publication #: DOE FRAP 1994-23
FPAO Contacts: George Derksen

Using a Compact Airborne Spectrographic Imager (CASI), remote sensing data was acquired over the Scott Paper Pulp and Paper Mill on the Fraser River (New Westminster, BC). This project reports on the Scott Paper study area and the Northwood and Canadian Forest Product pulp mills in Prince George, and coincided with a conventional river-based *in situ* dye dispersion study conducted independently by Seaconsult Marine Research Ltd. (See the project, *Effluent Dispersion in the Fraser River from the Glenbrook CSO at New Westminster, BC,* profiled on p.43 of this report.) During airborne data acquisition, rhodamine WT tracer dye was pumped into the pulp mill effluent discharge at a continuous rate for 29 hours. An *in situ* towed fluorometer measured dye concentrations throughout the injection period while simultaneously collecting salinity, temperature, and density measurements at various depths.

Although aerial data acquisition took place under very poor winter conditions, results indicate that the CASI imagery can be used to map dispersal of near-surface mill effluent with a spatial resolution of 1 m and at concentrations down to the 0.2% dilution level. This concentration is a higher limit of detection than *in situ* fluorometer measurements made at the same time, but the synoptic and complete surface picture of effluent dispersion provided by the imaging may offset this disadvantage. The technology was demonstrated to be feasible and have the potential to map and monitor the dispersal of dyed effluent discharged from pulp and paper mills.

Ω

MUNICIPAL DISCHARGES, URBAN RUNOFF, AND CSOs

PROJECT: Aerial Foreshore Reconnaissance of the Fraser River Basin

Partnerships: EC-FPAO
Funded By: **Total Cost: $10K**
FPAO Deliverables: #8, #12, #13
Prepared By: Terra Pacific Information Systems
Product/Publication #: AVIMS Field Survey Report; AVIMS and MAPINFO data disks
FPAO Contacts: Marielou Verge, Bert Kooi

This project was initially profiled in the *FPAO Progress Report 1993-1994* (p. 8). At that time, the contractor compiled and summarised information from an aerial reconnaissance of the foreshores of the Fraser and major tributaries looking at urban, industrial, and rural activities from Vancouver to Hope, and at Lytton, Lillooet, Kamloops, and some smaller centres. Completion of this project expands its focus to agricultural areas in Chilliwack, Salmon Arm, Sumas, and Langley.

Aerial Video Imaging and Mapping System (AVIMS) data was collected and an aerial video Geographic Information System (GIS) shoreline inventory was constructed. Methods were optimised to detect shoreline pollution sources and general shoreline characteristics. AVIMS data tapes were processed using data processing software and GIS databases showing the Global Positioning System (GPS) positions and flight paths. The GIS databases allow detailed AVIMS tape management through the cross-referencing of the GPS position and the tape counter in real time.

This project adds to knowledge of the state of the environment of the Fraser River basin. The type of information it can provide will facilitate better-informed decision making.

Ω

PROJECT: Protection of Aquatic and Riparian Habitat by Local Governments: An Inventory of Measures Adopted in the Lower Fraser Valley, 1995

Partnerships: DFO, FPAO
Funded By: **Total Cost: $24K**; DFO $12K; FPAO $12K
FPAO Deliverables: [FRAP #7, #25, #38, #40]
Prepared By: Quadra Planning Consultants Ltd.
Publication/Product #: Report named above
FPAO Contacts: Phil Wong [DFO Contact: Otto Langer]

The purpose of this project was to inventory environmental protection measures used by local governments (regional districts and municipalities) in the Lower Fraser Valley to protect aquatic and riparian habitats. This project contributes to the Stewardship Series promoted by FRAP and DFO to encourage senior and local governments to work collectively and more effectively to protect streams in urban areas. Other stewardship products include: *Stream Stewardship: A Guide For Planners And Developers*, *Partners In Protecting Aquatic And Riparian Resources*, and *Community Stewardship: A Guide to Establishing Your Own Group*.

Three primary objectives of this project were:

1. to inventory existing environmental protection measures adopted by local governments that may assist in protecting aquatic and riparian habitats
2. to assess the adequacy of these measures to protect these habitat types
3. to suggest improvements to these measures, including improved ways to protect habitats, training needs, and support requirements from senior governments (federal and provincial)

The report provides a synopsis of policies, bylaws, and other tools used by local governments to protect aquatic and riparian habitats and serves as an inventory of these policies and bylaws and provides information on the use of other tools, such as development permits, covenants, density bonusing, parkland dedications, and land tenures, among others.

The consultants gathered information from staff and reports from four regional districts and 25 municipalities in the Lower Fraser Valley. Information was based on two primary sources: interviews and review of planning documents (such as official community plans [OCP] and environmentally sensitive area [ESA] studies). The study area extends from the mouth of the Fraser River upstream to Hope, and from the North Shore Mountains south to the US border.

The report consists of the following components:

- **Report**: Provides a full background to study. Consists of the study methodology, overview of findings, and conclusions and suggestions.
- **Database**: Provides the inventory of environmental protection information in detail and is presented according to each local government.
- **Bylaws Respecting Aquatic/Riparian Protection**: Lists, by local government, the bylaws adopted that in some way take into account aquatic and riparian habitat protection.
- **OCP Summary**: Provides a listing of all master and sub-area community plans for each local government, with associated information, such as the term, revision status, etc.
- **Mapping Systems**: Provides information on each local government's mapping systems in use, such as the type (manual or digital), scale, software type, database, etc.
- **Contact List**: Provides a list of key contacts within each local government, including telephone and fax numbers.

It is recommended that this report should be treated as an initial source of information for general reference purposes for the following reasons:

a) The information is bound to change over time.
b) The information is of a limited level of detail.
c) The reports presents policies and regulations that have been adopted by local governments but does not address the implementation or effectiveness of these measures.
d) If further information is required, it should be obtained directly from the source, i.e., the local government in question.

Ω

PROJECT: Optimization of Biological Phosphorus and Ammonia Removal in a Combined Fixed and Suspended Growth Wastewater Treatment System - Final Report

Partnerships: FPAO, EC-EIP, BC Research, UBC, BC Science Council, Dayton & Knight, BCIT

Funded By: **Total Cost: $378K**; FPAO $40K

FPAO Deliverables: #7, #10, #11

Prepared By: BC Research Institute

Publication/Product #: DOE FRAP 1994-24

FPAO Contacts: Phil Wong

The discharge of nutrient-rich sewage effluents into environmentally sensitive surface waters can cause serious deterioration in water quality. Nutrient enrichment of these 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 (discharges to marine waters). In addition to eutrophication, ammonia nitrogen is toxic to fish.

Processes for the chemical removal of nutrients often increase treatment plant operating costs and generate larger solids disposal volumes than biological removal processes. This project set out to optimise a biological nutrient-removal technology.

This three-year project was initially profiled in the *FPAO 1993-1994 Progress Report* (p. 29). At that time, the Interim Report summarised the plant design and operating parameters during the hydraulic retention time (HRT) optimization investigation.

The pilot-scale study utilised was a combined trickling filter-activated sludge process. The system is called the FGR-SGR (fixed growth reactor-suspended growth reactor) process. The innovative aspect of the FGR-SGR process is the incorporation of a fixed growth (trickling filter) component into the conventional suspended growth (activated sludge) biological nutrient removal treatment train.

In this process, nitrification is mainly accomplished by the fixed growth biomass attached to the FGR (trickling filter) media. The long aeration basin hydraulic retention times required for nitrification in activated sludge systems are, therefore, unnecessary in the FGR-SGR process, and the aeration basin size may be reduced to that required for bacterial phosphorus uptake only. Other advantages of this process include:

- the option of retro-fitting existing FGR facilities for biological phosphorus and nitrogen removal
- low energy cascade aeration (and hence, lower costs) of the process mixed liquor

- process stability added by the fixed growth biomass
- reduced competition among the specific microorganisms responsible for uptake-storage of phosphorus and nitrification due to separation of the respective unit processes into distinct microbial communities
- reduction of the land area required for full-scale biological phosphorus removal facilities

The objectives of the pilot-scale study were to investigate the optimum hydraulic retention times in the activated sludge reactors, the optimum internal recycle flow rates within the process, and the optimum solids retention time for the suspended growth treatment train.

The study results confirmed the capacity of the FGR-SGR process for effective biological phosphorus removal and nitrification-denitrification. Under optimum conditions, the process produced an effluent with non-detectable ammonia concentrations and mean orthophosphate concentrations of 0.10 to 0.27 mg P/L. The FGR-SGR process can operate effectively for biological nutrient removal with a total nominal hydraulic retention time (i.e., total process volume divided by process influent flow rate) of eight hours or less.

The results show that trickling filter plants can be retro-fitted to include biological phosphorus removal, eliminating or reducing the requirement for chemical additions, and maximizing the use of existing facilities. The study data are currently being applied to the design of full-scale plants.

Ω

PROJECT: Sewage Lagoon Design Using Wetlands & Other Upgrading Technologies to Achieve Non-acutely Toxic Effluent (2nd Revised Edition)

Partnerships: FPAO, BCE
Funded By: **Total Cost: $40K**; FPAO $40K
FPAO Deliverables: #7, #11
Prepared By: NovaTec Consultants Inc.
Publication/Product #: DOE FRAP 1994-34
FPAO Contacts: Phil Wong

This project was initially profiled in the *FPAO Progress Report 1993-1994* (p. 37). The purpose of this project is to review performance data and present design guidelines for lagoon and constructed wetland systems to achieve non-acutely toxic effluent in temperate and cold climate conditions.

Many effluents from sewage lagoons are acutely toxic to fish. This toxicity is believed to be most often the result of elevated concentrations of total ammonia or free ammonia (or both), chlorine residuals (where chlorination is used), or hydrogen sulphide resulting from anaerobic sludge decomposition. The ability of lagoon systems to remove ammonia primarily depends on pH, detention time, season, and liquid temperatures. The major removal pathway is volatilization at the water surface during warm weather; this pathway is greatly diminished during cold weather, particularly where there are conditions of ice cover.

The report reviews historical lagoon performance data on effluent ammonia concentrations and toxicity to fish. The data suggests that a total ammonia concentration of 10 to 11 mg/L-N is a critical level, above which effluents are typically toxic, and below which effluents are typically non-toxic. Using an arbitrary safety factor of 2, it is recommended that a total ammonia concentration of 5 mg/L-N be used as a design criteria.

In addition to presenting design guidelines for lagoon systems, the report presents guidelines for upgrading technologies to reduce effluent ammonia levels. Wetland systems are one of the upgrading technologies that have received attention in recent years because of their ability to further treat lagoon effluents prior to discharge, thus reducing toxicity to fish.

The other technologies described include storage basins, rapid infiltration, overland flow, and fixed-film processes. Upgrading technologies have limited abilities to remove ammonia during cold weather and should be considered in conjunction with winter storage basins.

This document focuses on factors to enhance the removal of ammonia, but includes recommendations that will result in overall design and operational improvements (i.e., pre-treatment, size, configuration, baffles, aeration, diffused inlets/outlets structures, liners, operating depth, hydraulic retention time, sludge management, maintenance). Capital and operating costs are also presented to enable comparisons with alternative treatment technologies described.

Ω

PROJECT: Stormwater Retention and Treatment Facility - District of 100 Mile House: Preliminary Design Report

Partnerships: FPAO, District of 100 Mile House, BCE
Funded By: **Total Cost: $40K**; FPAO $40K; 100 Mile House: in kind; BCE: in kind
FPAO Deliverables: #8, #9, #11, #13
Prepared By: TR Underwood Engineering
Publication/Product #: Report named above
FPAO Contacts: Bruce Galbraith, Marielou Verge

In the Bridge Creek/100 Mile House area, increasing awareness of the potential for contaminated urban and agricultural stormwater runoff to cause deterioration in the qualify of surface waters led to an increased need to characterize the runoff and its potential impacts to water quality. Some of the water quality issues raised by residents include impacts 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.

This two-year project provided for stormwater monitoring and sampling of Little Bridge Creek in the District of 100 Mile House with a view to designing and constructing stormwater retention and treatment facilities. Objectives of the project were to ascertain the effectiveness of a proposed wetland treatment system.

The District proposed wetland treatment of stormwaters at the existing decommissioned sewage lagoon cell #3 at the confluence of Little Bridge Creek and Bridge Creek prior to construction of the wetlands treatment project. The proposal also required construction of a diversion dam on Little Bridge Creek and associated piping and control structures.

This report provides a discussion of the urban runoff characteristics and sources, as well as general design recommendations for stormwater conveyance, detention, and treatment facilities. The information provided in the document emphasises the fact

that urban stormwater runoff cannot be generalised, particularly since Little Bridge Creek meanders through industrial and agricultural lands and receives both point and non-point source runoff. The types of pollutants, pollutant concentrations, and loadings vary over a wide range. In addition, the runoff quality varies with the intensity, duration, and characteristics of rainfall events according to season, phase of the runoff event, and length of time between events.

A review of the constituents of general urban runoff indicates that the following contaminants routinely exceeded the maximum acceptable levels in surface waters:

- suspended solids
- oxygen-demanding substances (chemical and biochemical oxygen demand)
- metals and trace elements (e.g., lead, zinc, copper)
- organic contaminants (hydrocarbons)
- nutrients (phosphorus, nitrogen)

The resulting effects of urban runoff on ecosystems include increased turbidity, decreased dissolved oxygen, decreased species diversity due to toxic levels of metals, and increased rates of eutrophication due to high nutrient loads.

To provide treatment of the runoff at a controlled rate, the peak runoff flows must be stored and discharged into the treatment cell gradually. The design proposes converting the former storage lagoon into a wetlands treatment system utilising a combination of subsurface and surface flow, to be vegetated with wetland plants native to the Cariboo region. The control structure includes an emergency bypass weir to operate only if the combination of retention storage and peak flow exceed the capability of the treatment facility. Also, an emergency spillway is provided in the dam embankment to ensure that the dam is not overtopped.

Ω

PROJECT: CSO and Urban Runoff Investigative Assessment Guidelines

Partnerships: FPAO, GVRD
Funded By: **Total Cost: $48K**; FPAO $48K
FPAO Deliverables: #9, #10, #11, #13, #17, #18
Prepared By: NovaTec Consultants Inc., UMA Engineering Ltd., W_2O Inc.
Publication/Product #: DOE FRAP 1993-37
FPAO Contacts: Phil Wong, Marielou Verge

A combined sewer overflow (CSO) inventory for the Fraser River and Burrard Inlet, profiled in the *FPAO Progress Report 1992-1993* (p. 16), identified 53 CSOs in the GVRD. CSO discharges occur during heavy rainfall events when the volume of sewage entering the combined sewage/stormwater pipe becomes too large for the system to handle. Sixteen percent of the Greater Vancouver Regional District (GVRD) is served by CSOs that are subject to overflows; the remainder have separate systems for carrying stormwater and sewage.

The current Guidelines project, initially profiled in the *FPAO Progress Report 1993-1994*, presents a methodology for investigative and detailed contaminant loading assessment of CSO and UR discharges into receiving waters of the Fraser River and Burrard Inlet. The overall purpose of these Guidelines is to provide agencies with information on procedures for planning and implementing monitoring programs for these two types of wastewater discharges; elements to be considered include monitoring objectives, physical constraints, resource requirements, and monitoring schedule.

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 discharges.

There are many sources and pathways of contaminants carried to the receiving waters, some of which are:

- surface wash-off by rainfall or snowmelt (which may already be contaminated from atmospheric pollutants)
- street refuse (including litter, street dirt, vegetation and organic residues)
- traffic emissions and debris (rust, paint, exhaust, brake lining, etc.)
- industrial and commercial land use activities
- spills
- road de-icing products (salt, sand, etc.)

Some contaminants typically found are: phosphorus, biodegradable organic matter, bacteria, pesticides, halogenated and non-halogenated hydrocarbons, metals, and some organic toxic contaminants.

The investigative assessment provides qualitative information that allows investigators to prioritize 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 are presented in a format that allows easy extraction and replacement of sections updated on a periodic basis. The methodology is presented in a step-by-step fashion to be used as a guidance document for investigators and field-sampling crews. Information is also provided on local laboratory capabilities and on safety procedures to use in field sampling.

(To better understand the potential impacts of CSO discharges on the receiving environment, a series of four characterization studies (Clark Drive, Crowe Street, Glenbrook, and Westbridge) was commissioned as a collaborative project of the FPAO and the GVRD; these were initially profiled in the *FPAO Progress Report 1993-1994*. The information obtained will provide a basis for future studies and policy-making for liquid waste management in the GVRD. These characterisation studies are profiled in the following pages.)

Ω

PROJECT: Westridge Combined Sewer System Spring/Summer 1994 Overflow Characterization Study - Final Report

Partnerships:	FPAO, BIEAP, GVRD
Funded By:	**Total Cost: $30K**; FPAO $10K; BIEAP $5 K; GVRD $15K
FPAO Deliverables:	#8, #9, #10, #11, #13, #17
Prepared By:	Liquid Waste Management Planning GVRD
Publication/Product #:	Report named above
FPAO Contacts:	Phil Wong, Bert Kooi

The Westridge CSO outfall is located in Burnaby, 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. In the initial phase of this project, profiled in the FPAO Progress Report 1993-1994, Westridge CSO was identified as a location where high rate CSO treatment has the potential to become part of the integrated CSO control program.

In the current characterization study, wastewater samples from the Westridge CSO were analysed with respect to chemistry, bacteriology, and toxicity. The second major focus involved monitoring CSO discharges throughout the project to quantify total wastewater discharges and identify the frequency of overflow occurrences in relation to storm events. Data collected from this study will serve to increase the knowledge base on CSOs and provide information to assess the impacts of CSO discharges and develop effective management strategies.

Some of the key findings from the Westridge CSO characterization study are:

- The average concentration of general constituents, heavy metals, and organic compounds were either similar or less than the GVRD's Stage 1 Liquid Waste Management Plan (LWMP) Report estimates except for copper, which was detected at higher concentrations.
- Concentrations of cadmium, chromium, nickel, and lead were well below the Stage 1 LWMP estimates. The lower lead levels are likely a result of the ban on leaded gasoline several years ago.
- Polychlorinated biphenyls (PCBs) were not detected in any of the samples.
- Naphthalene, phenanthrene, benzo(b)fluoranthene, di- and tri-methylnaphthalenes, chloroform, and tetrachloroethylene were detected at relatively low concentrations in all CSO samples.
- The concentrations of nutrients, suspended solids, and BOD_5 were two to four times less than those typically measured in GVRD domestic sewage. The concentration of these constituents gives a relative indication of the proportions of sewage and stormwater contributing to the combined overflows.
- Wastewater sampled for events 2 and 4 exhibited mild levels of toxicity based on the Microtox bacterial bioluminescence bioassays.
- Wastewater for event 2 was not acutely toxic to rainbow trout and had no measured toxic effect on *Ceriodaphnia* reproduction and growth. There was no inhibition of algal growth in the *Selenastrum capricornutum* chronic bioassay.
- Settling column tests revealed that the vast majority of the solids were light in nature and that conventional sedimentation technology could be an effective method of solids removal. The vortex separator technology would not be effective for this application due to the light nature of the solids.
- UV disinfection experiments revealed that UV dosages required to treat the wastewater samples were similar to those used in the disinfection of secondary treatment plant effluents; UV would be an effective disinfection method for treatment of Westridge CSO discharges.

This study was successful in characterizing CSO discharges at the Westridge site. Characterization study findings confirm the variability in wastewater quality and provide information on the suitability of sampling procedures and protocols for future programs.

Ω

PROJECT: Characterization of the Clark Drive Combined Sewer Overflow and Stormwater From a Residential and an Industrial Catchment: Spring 1994

Partnerships: FPAO, GVRD
Funded By: **Total Cost: $160K**; FPAO $80K; GVRD $80K
FPAO Deliverables: #8, #9, #10, #11, #13, #17
Prepared By: Norecol, Dames & Moore Inc.
Publication/Product #: Report named above (final draft)
FPAO Contacts: Phil Wong, Bert Kooi

The Clark Drive CSO, which is a group of three closely associated outfalls, discharges directly to Burrard Inlet in the Vancouver Harbour area and is the largest single volume CSO in the region, accounting for about 56 percent of the GVRD's total annual CSO discharge volume. A sediment monitoring program by Environment Canada identified the Clark Drive CSO as a probable source of mercury, lead, and PAH contamination.

The characterization sampling program conducted in 1993 and profiled in the previous FPAO progress report, was continued in 1994 and expanded to include sampling of urban stormwater from both an industrial and a residential catchment. This report presents the final data and analyses of this study.

The two principal objectives were:

- to monitor the quality and quantity of the Clark Drive CSO discharge over seven storm events (in a manner consistent with the monitoring done in the previous year), and
- to monitor the quality and quantity of stormwater from two separated stormwater catchments adjacent to the Clark Drive catchment area to estimate the contribution of contaminants from stormwater to the CSO discharge.

In the 1993 monitoring program, most of the monitoring was done through a manhole near the China Creek gauge, whereas in 1994, all monitoring was done at the Harbour Pump Station 2.4 km downstream of the China Creek gauge. It appears that under some storm and/or sanitary discharge conditions there are significant flow differences between the two sites due to contributions from branches of the combined sewer system not captured at the China Creek gauging station. However, the 1994 program generally confirmed the 1993 observations about CSO quality. Specifically, the current study showed that:

- Average concentrations of most inorganic parameters were similar to levels measured in 1993, although the concentration ranges measured were wider.
- As in 1993, the most frequently detected organic parameters were PAHs and phthalate esters, particularly benz(a)anthracene, chrysene, benzo(b+k)fluor-

anthene, pyrene, acenaphthene, fluoranthene, fluorene, naphthalene, and the six methylated naphthalenes and phenanthrenes.

- Tetrachloroethylene was the volatile organic compound (VOC) most commonly found in this CSO.
- Chloroform, toluene, and meta- and para-xylenes, which were detected in all of the 1993 samples, occurred in only 37.5 percent (xylenes) to 62.5 percent (chloroform, toluene) of the 1994 samples.
- Nonyl phenol, which was not detected in 1993, was found in 50 percent of the 1994 samples.

There were significant differences found between the stormwater samples and the CSO samples, some of which are:

- Based on liquid effluent quality, stormwater from industrial catchments appears to be a significant source of lead and zinc.
- A greater diversity of dioxins and furans occurred in sediments from the stormwater sites compared with sediments from the combined sewer.
- The liquid component of the industrial stormwater also contained several furans that were not found in the CSO.
- The CSO was more toxic to Microtox bacteria that were the stormwater samples. The greater toxicity is likely related to ammonia or organic compounds, or the combination of a greater number of toxicants in the CSO compared to the stormwater.
- The residential stormwater had the lowest Microtox toxicity and the lowest contaminant concentrations of the three wastewaters tested.

Despite some problems, the study was generally successful in characterizing the quality of CSO and stormwater at this site, although it was less successful in characterizing the quantity of stormwater. Quality control samples indicated that overall quality of the chemistry and toxicity data was good. Recommendations were made for future CSO and stormwater characterization studies that take into account the problems encountered with this study and seasonal differences in flow quantities.

Ω

PROJECT: Crowe Street Combined Sewer System Spring 1994 Overflow Characterization Study

Partnerships: FPAO, BIEAP, GVRD
Funded By: **Total Cost: $30K**; FPAO $10K; BIEAP $5K; GVRD $15K
FPAO Deliverables: #8, #9, #10, #11, #13, #17
Prepared By: Liquid Waste Management Planning GVRD
Publication/Product #: Report named above (final draft)
FPAO Contacts: Phil Wong, Bert Kooi, Marielou Verge

The Crowe Street CSO is located on the south shore of False Creek approximately 0.2 km east of Cambie Street. It discharges into the False Creek area of Burrard Inlet. While the Crowe Street site was initially chosen because it had been identified for possible pilot scale treatability testing (see profile in *FPAO Progress Report 1993-1994*, p. 23), the objectives and focus of this study are the same as those for the Clark Drive CSO characterization study: water quality, toxicity effects, and flow monitoring and variability. Key findings from the Crowe Street CSO study include:

- The level of inorganic and physical parameters detected in the wastewater samples were typical of weak to medium strength domestic sewage. Average concentrations of total suspended solids and COD, however, exceeded the GVRD's Stage 1 LWMP Report estimates.
- Heavy metal concentrations varied considerably for all three sampling events. Average concentrations of eight metals exceeded Stage 1 LWMP Report projections by a factor of two to nine times (for aluminum, cadmium, chromium, copper, iron, manganese, nickel, and zinc).
- Forty-four organic compounds were detected in the CSO wastewater samples. Of these, 23 were common to all three sampling events. The following were measured at relatively high levels: nonylphenol, dichloromethane, and tetrachloroethylene for event 1; bis(2-ethylhexyl) phthalate and tetrachloroethylene for event 2; and toluene and xylenes meta-, para-, ortho- for event 3.
- PCBs were only detected in the wastewater for event 3. The elevated level of dioxins and furans measured in the wastewater for event 1 was significantly higher than detected during the Clark Drive and Westridge CSO studies or as measured in wastewater samples from GVRD treatment plants.
- The wastewater for event 3 was not acutely toxic to rainbow trout, however, low levels of chronic toxicity were observed in the Microtox bioassay.

The study was successful in characterising the CSO discharges at the Crowe Street site. Chemistry and toxicity data collected were considered reliable based on the quality assurance and control programs set up in the field and labs. Recommendations similar to those made for the Clark Drive CSO characterization were made for future CSO and stormwater characterisation studies at this site.

Ω

PROJECT: Glenbrook Combined Sewer System Spring 1994/Winter 1995 Overflow Characterization Study

Partnerships: FPAO, GVRD
Funded By: **Total Cost: $80K**; FPAO $40K; GVRD $40K
FPAO Deliverables: #8, #9, #10, #11, #13, #17
Prepared By: Liquid Waste Management Planning GVRD
Publication/Product #: Report named above (final draft)
FPAO Contacts: Phil Wong, Bert Kooi, Marielou Verge

The Glenbrook 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 on the Fraser, with an estimated annual effluent volume of 1.2 million cubic metres discharge during an average year of rainfall.

The initial phase of this characterisation study, profiled in the *FPAO Progress Report 1993-1994* (p. 24), had two principal objectives:

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

Quality of composite wastewater samples and sediment deposits were analysed with respect to chemistry, bacteriology, and toxicity. A second major focus was to quantify total wastewater flow and identify the frequency of overflow occurrences in relation to storm events. Data collected from this study will increase the knowledge base of CSOs in the region and provide information needed to assess discharge impacts and develop effective strategies to manage them.

For each sampling event, wastewater quality characterisation parameters monitored included conventional parameters, metals, toxic organics, bacteriological (fecal coliforms and enterococci), and Microtox toxicity. A suite of toxicity tests was conducted on samples from four CSO events, including rainbow trout lethality, *Ceriodaphnia dubia* survival and reproduction, and algal (*Selenastrum*) growth stimulation and inhibition. Dioxins and furans were sampled from two CSO events. This report presents results of analyses on the data collected during 1994/95.

Some of the key findings include:

- The average concentration of general constituents, heavy metals, and organic compounds were either similar or less than the estimates developed as part of the GVRD's Stage 1 Liquid Waste Management Plan (LWMP) Report.
- Levels of cadmium, chromium, lead, and nickel were well below Stage 1 LWMP estimates.
- Polychlorinated biphenyls (PCBs) were not detected in any of the wastewater samples. The levels of dioxins and furans detected for events 1 and 2 (in 1994) were considered low.

- Twenty-six organic compounds were detected in the 1994 CSO wastewater samples. Of these, four were common to both sampling events 1 and 2; these included benzo(a)pyrene and pyrene (high molecular weight PAHs), methylnaphthalenes, and dioxins.
- Twenty-six organic compounds were also detected in the 1995 CSO wastewater samples. Of these 26 compounds, 10 were found to be common to all sampling events. They included benzo(b) fluoranthene and fluoranthene (high molecular weight PAHs), methylnaphthalenes, dimethylnaphthalenes, trimethylnaphthalenes, methylphenanthrenes, and dimethylphenanthrenes (methylated naphthalenes and phenanthrenes), chloroform (halogenated VOC), toluene, and xylenes: meta- and para-(non-halogenated VOCs).
- The CSOs exhibited concentrations of suspended solids, BOD_5, and nutrients (ammonia and phosphorus) four to 14 times below typical GVRD domestic sewage levels, indicating relative rates of stormwater dilution.
- Wastewater samples for events 2 through 6 exhibited mild levels of sub-lethal toxicity in the Microtox bacterial luminescence inhibition bioassay. The samples for events 2 and 6 also exhibited low levels of chronic toxicity in the *Ceriodaphnia* reproduction and growth bioassay.
- The deposited sediment sample collected on March 29, 1994 from the Glenbrook CSO sewer line exhibited low levels of contaminants, similar to those detected in the wastewater samples. Metals were below the threshold effects level provided in Environment Canada's interim freshwater sediment quality guidelines. Of the 23 organic compounds detected, 21 were polynuclear aromatic hydrocarbons (PAHs): low and high molecular weight PAHs and phenanthrenes. Five of these were above the threshold effects level, but below the probable effects level provided by the interim freshwater sediment quality guidelines.

On the whole, the study was generally successful in characterising the CSO discharges at the Glenbrook site. Difficulties with flow monitoring and sampling that arose during 1994 due to site constraints did not adversely affect the program. Findings confirm the variability in wastewater quality during CSO events as well as provide information on the suitability of sampling procedures and protocols for future monitoring programs. The following are some of the recommendations that should be considered in the design of future programs to characterise discharges from Glenbrook and other CSO outfalls.

- Conduct further studies over all seasons of the year to more thoroughly characterise CSO discharges.
- Look at modifying the wastewater target parameter list so that those contaminants consistently found in trace amounts are not routinely monitored. A list of priority pollutants could be developed that represents key monitoring parameters representative of target groups; this would enable significant cost savings.
- Toxicity testing should use a minimum of two bioassays in order to better interpret results.

Ω

PROJECT: Effluent Dispersion in the Fraser River from the Glenbrook CSO at New Westminster, BC

Partnerships: FPAO, GVRD

Funded By: **Total Cost: $58K**; FPAO $58K;
in kind (drawings, flow data) assistance of GVRD

FPAO Deliverables: #8, #9, #10, #11, #13, #17

Prepared By: Seaconsult Marine Research Ltd.

Publication/Product #: DOE FRAP 1995-22

FPAO Contacts: Phil Wong

A wastewater plume delineation study for the Glenbrook CSO was conducted in February 1995 to assist in setting priorities for contaminant monitoring in the Fraser River estuary. The work was undertaken as part of the component of the FRAP mandate and concerned with identifying point and non-point sources of contaminants entering the Fraser River. One aspect of this component centers on delineating wastewater dispersion from the Glenbrook CSO. These dispersion results will be used, in conjunction with results from the Glenbrook CSO characterisation study, to establish priorities for subsequent monitoring of contaminants and toxicity in water, sediments, and biota, and for assisting in setting priorities for pollution abatement measures.

The Glenbrook CSO discharges into Sapperton Channel, which is part of the Main Arm of the Fraser River, separated from the main channel by a series of flooding banks called City Bank. These banks are submerged at higher high tide and are effective in creating a flow regime in the channel that is distinct from the main channel to the south. During winter months (November-March), flood tides reverse the flow in the channel so the dispersion pattern extends upstream of the outfall as well as downstream.

This plume delineation study was carried out with the following specific objectives:

- map the regions of the river that are exposed to the effluent on both flood and ebb tides
- assess the effective dilution rate under winter low flow conditions

The wastewater plume from the Glenbrook CSO was measured in the receiving water using a rhodamine dye tracer and a towed *in situ* fluorometer. Two injections of dye were made over two days for different stages of the tide. The dye plume was also observed on February 17 using the CASI multispectral imager, flown on a small airplane (see profile for project *Plume Delineation of a Pulp and Paper Mill Outfall Using Airborne Multispectral Imagery and Rhodamine Dye* on p. 29 of this report). Three separate images were obtained.

The survey methods were successful in accurately delineating the plume, particularly the areas of shore contact and the cross-channel width and depth of the plume. Estimates of secondary dilution were obtained.

In general, it was found that the plume was confined to the north shore of the river, forming a narrow streak less than 100 to 150 m in width downstream of the outfall. The highest concentrations were observed next to the shore and the plume remained in continuous contact with the shore from the outfall to the North Arm of the estuary. The plume was carried upstream on the flood tide for a distance of 2,600 m near the end of Sapperton Channel. Plume width was approximately 150 m wide in Sapperton Channel.

Mixing was found to be most effective within 300 m of the outfall, producing a minimum dilution of about 60:1. Dilutions of 100:1 were observed at a distance of 850 m on ebb flows and reached approximately 400:1 at the junction to the North Arm. Vertical mixing was found to be rapid, producing nearly uniform concentrations over the water column within 200 m of the outfall.

Ω

PROJECT: GVRD Solid Waste Management Plan Review - Stage 2 Report

Partnerships: EC-Environmental Protection, BCE, GVRD

Funded By: **Total Cost: $2.6 M** (stages 1-3); EC $200 K, BCE and GVRD did not break out their funding into specific stages

FPAO Deliverables: #9, #17 [FRAP #4, #5, #6]

Prepared By: GVRD, CH2M Hill Engineering

Publication/Product #: Report

FPAO Contacts: Phil Wong

The Greater Vancouver Regional District (GVRD) undertook a comprehensive review of their solid waste management plan. Stage 2 of the review includes a detailed study of solid waste management options. As partners, Environment Canada-Environmental Protection and BC Environment Waste Management Branch shared in the work and funding of this major undertaking.

In 1993, over 2 million tonnes of solid waste were generated in the GVRD—enough to fill BC Place Stadium two times. With the projected growth in the region's population over the next five years, the volume of garbage generated will increase to over 3 million tonnes. Studies show that not only would we be unable to handle this

amount of garbage at the region's waste management facilities, we would be faced with enormous economic costs and environmental impacts.

The GVRD initiated the Solid Waste Management Plan (SWMP) Review to develop realistic, environmentally sound ways of reducing and managing the region's waste. The new plan aims to show how the region can meet the requirements of provincial legislation (*Waste Management Amendment Act* 1989) and achieve a 50 percent per capita reduction in waste requiring disposal by the year 2000.

Stage 1 of the SWMP was initiated in 1991. During this phase, a waste flow and recycling audit was conducted and waste management options were identified. Two advisory committees were formed to provide on-going input from a range of stakeholder groups and interested members of the public: the Local Solid Waste Advisory Committee (LSWAC) and the Technical Solid Waste Advisory Committee (TSWAC).

Stage 2 also began in 1991, when the GVRD hired a team of consultants to carry out the required technical studies, develop a recommended strategy, and implement a public consultation program. During Stage 2, the consultants identified alternative waste management systems that were reviewed by the public and technical advisory committees. Based on this input and on further evaluations, the consultants prepared a recommended comprehensive waste management strategy. This strategy was reviewed by both advisory committees and further revised.

Of the nearly 2 million tonnes of solid wastes generated in the GVRD, 46 percent is generated by the residential sector and 54 percent is generated by the industrial, commercial, and institutional sectors. Numerous solid waste disposal facilities, including landfills, incinerators, recovery plants, and transfer stations are located throughout the lower mainland region.

Based on detailed technical studies and on input received from advisory committees and the public, three major criteria and 24 sub-criteria were used to develop a comprehensive waste management strategy. The three major criteria are:

1. promotion of waste reduction, reuse, and recycling (the three Rs)
2. cost-effectiveness
3. minimizing environmental and social impacts

The 24 sub-criteria provided a framework for considering environmental, social, and other factors that were important but difficult to measure, such as water and air impacts, ease of implementation, public acceptability, reliability, and financial risk.

Additionally, four major principles underlie the strategy:

1. Fundamental changes are needed to meet the 50% waste reduction goal. The emphasis should be on waste reduction.
2. The use of revenues from one sector to finance another should be eliminated where possible. Funds raised from fees or levies on particular products or materials should be dedicated entirely to the management of those products or materials.

3. The strategy should be flexible enough to meet diverse waste generation demands, changing waste characteristics, and evolving technologies.
4. In order to pay for waste management, producers must be responsible (possibly through manufacturer responsibility initiatives) and accountable for their products "from cradle to grave" and consumers must be responsible and accountable for the wastes they generate (including the ability to stop delivery of junk mail by residents). Funding, legislation, and market development measures in the strategy support the internalization of waste management costs in pricing policies. The strategy also promotes the increased visibility of waste management costs to consumers.

Among the key recommendations for reducing source waste are:

1. institute an expanded deposit/refund system for all beverage containers (plastic, glass, metal, gable-top, and aseptic)
2. remove subsidies on the use of virgin materials
3. phase-in user-pay programs for garbage collection while continuing to subsidize (temporarily) curbside collection for recyclables and yard waste
4. expand education programs to all sectors

Because of the interdependence of many of the components of the recommended strategy, the success of the plan would depend on all levels of government fulfilling the roles and responsibilities described in the report. Another key fundamental requirement is appropriate action to stop the uncontrolled flow of waste (where waste generated in the plan area is transferred to and disposed of at facilities that are not included in the proposed strategy).

Provincial legislation requirements are met when Stage 3 has been completed. This stage describes the final revised solid waste plan for the region, incorporates the recommendations approved as part of this Stage 2 report, and involves the development of implementation plans for those recommendations.

Ω

AGRICULTURAL RUNOFF

PROJECT: Agricultural Inventory of the Lower Fraser Valley: Data Summary Report

Partnerships: FRAP, BCE, BCMAFF, DFO, AAFC, BCFA

Funded By: **Total Cost: $87.5K**; FRAP $37.5K; BCE $39K; DFO $11K; BCMAFF: in kind

FPAO Deliverables: #8, #12, #14, #17

Prepared By: Charcoal Creek Projects Inc.

Publication/Product #: DOE FRAP 1994-28

FPAO Contacts: George Derksen

The lower Fraser Valley is an area of intensive agricultural activity; annual gross farm receipts in 1991 were over $700 million. Agricultural waste management and protection of ground and surface water quality have been identified as major concerns in the region.

The BC Ministry of Environment, Lands and Parks (BCE) undertook an initiative (*Management of Livestock and Poultry Manures in the Lower Fraser Valley* project) to assess agricultural waste management in the lower Fraser Valley with the broad objectives of evaluating the production, management, and use of agricultural wastes and then using this information to develop strategies for improving nutrient (manure and inorganic fertilisers) management.

These objectives are consistent with the broad goals of FRAP, which include reducing the loading of agriculturally related chemicals and wastes to the environment. In addition, one of the principal tasks of FRAP is to report on the state of agriculture in the different regions of the Fraser basin. This inventory report, the first in a series of nine reports, is a result of the first phase in these two federal and provincial government initiatives.

The objective of this report was to establish an inventory of agricultural livestock and poultry, and an inventory of the agricultural land base within 20 geographic areas (Agricultural Waste Management Zones) of the lower Fraser Valley. For each of the zones, 1991 Census of Agriculture information on the number and type of livestock and poultry, the area farmed by crop, and the application of manure and commercial fertilisers was tabulated and summarised. Data was further subdivided into large and small farms and livestock and non-livestock farms categories. Other readily available data sources were collected and compared with Census summaries.

Ω

PROJECT: Lower Fraser Valley Agricultural Practices (3 Reports)

Partnerships:	FRAP, BCE, BCMAFF, DFO, AAFC, BCFA
Funded By:	**Total Cost: $87.5K**; FRAP $37.5K; BCE $39K; DFO $11K; BCMAFF: in kind
FPAO Deliverables:	#8, #12, #14, #17 [FRAP #4, #5, #7, #19]
Prepared By:	Charcoal Creek Projects Inc. & Land Sense Ltd.
Publication/Product #:	DOE FRAP 1995-31, -28, -26
FPAO Contacts:	George Derksen

These reports are numbers two, three, and five of a series of nine reports under the *Management of Livestock and Poultry Manures in the Lower Fraser Valley* project.

Program objectives are to evaluate the production, treatment, disposal, and impacts of agricultural wastes to develop strategies for improving nutrient management. The project has a number of components, covered by three reports for this period:

- *Application of Inorganic Fertilisers in the Lower Fraser Valley: Data Summary Report* - Report 2 (DOE FRAP 1995-31
- *Agricultural Nutrient Pathways* - Report 3 (DOE FRAP 1995-28)
- *Livestock Waste Management Practices and Legislation Outside British Columbia July 1995* - Report 5 (DOE FRAP 1995-26)

The objective of the first component project was to estimate the use of inorganic fertilisers in different geographic zones of the lower Fraser valley in order to develop an inventory of the livestock, poultry, and commercial fertilisers used in the lower Fraser basin. Twenty Agricultural Waste Management Zones (AWMZ) in the lower Fraser basin were considered in this study, which addressed the major plant nutrients of nitrogen (N), phosphorus (P), and potassium (K). 1991 Census of Agriculture information on land areas to which manure and fertilisers were applied, total expenditures on fertilizer and lime, and area farmed by crop was summarised for each of the AWMZs. Data on retail fertilizer sales was obtained from the Western Canada Fertilizer Association and summarised, and estimates of the average N, P, and K application for a variety of crops was solicited from people in the agriculture industry and a consensus value of N-P-K application by crop was developed. This information was used to generate an estimate of the total mass of inorganic fertilizer applied in each AWMZ. This information will be used in subsequent nutrient modelling.

The objective of the second component project was to elucidate a general discussion of the environmental impacts of agricultural nutrients and pathways along which these nutrients flow. The application of agricultural wastes to the land can have environmental and health effects on water, soil, and air. The proper management of these nutrients can enhance the beneficial impacts and minimize harmful effects.

Each nutrient was discussed in the context of its beneficial and harmful effects on the environment and human health.

This component provided a review of legislation, regulation, and policy from other jurisdictions (Canada, USA, and Europe), and examined key problems identified from experience in these jurisdictions. The various approaches to livestock waste management are extremely dynamic at this time and, while we cannot expect to extrapolate directly from the experiences of other jurisdictions, the combination of this review of approaches and experiences is helpful to provide guidance for developing a livestock waste management plan that is optimal for conditions in the lower Fraser Valley.

Ω

PROJECT: Rural-Urban Connections

Partnerships:	FRAP, BCMAFF, AAFC, BC 4-H Council sponsors
Funded By:	**Total Cost: $35K**; FRAP $3K; BCMAFF & AAFC $17K; 4H sponsors $15K
FPAO Deliverables:	#12 [FRAP #5]
Prepared By:	advanced image communications and BC 4-H Council
Publication/Product #:	video/seminar
FPAO Contacts:	George Derksen

As part of the overall effort to promote environmental awareness and stewardship, the concept “rural-urban connections” was presented at a 4-H conference held at Trinity Western University in Langley in August 1994. FPAO personnel participated in this conference. Among the topics discussed were:

- loss of fertile agricultural land due to urban expansion, erosion, salinity
- effects of migratory birds on agricultural land
- soil and water conservation
- importance and composition of soil
- use and management of manure as fertilizer
- public support for agriculture
- conservation of fish and wildlife in agricultural areas
- producing safe food (pesticides, animal health, use of antibiotics and hormones, inspection of processing plants, food handling)

- complexity of watershed planning (industry, urban development, and agriculture all want the same lands)
- federal and provincial legislation and the development of environmental guidelines

In addition to talks and presentations, 4-H delegates participated in field trips focusing on environmental waste management, food safety, conservation, forestry, intensive livestock production, and fish and wildlife management. The closing speaker reminded delegates to think globally and act locally by getting involved in community-based urban-rural activities, learning more about the issues, and helping educate the public about the challenges to agricultural and environmental sustainability.

Environment Canada helped pay for production of the video.

Ω

PROJECT: Bridge Creek Watershed Project

Partnerships: FRAP, BCE
Funded By: **Total Cost: $5K**; FRAP $5K, BCE: in kind
FPAO Deliverables: #12 [FRAP #5]
Prepared By: BC Environment, Cariboo Region
Publication/Product #: Brochure
FPAO Contacts: George Derksen

This project fulfills part of the FPAO mandate by promoting environmental awareness and stewardship. As a summary of the work funded over 1993-94 and 1994-95, a three-panel brochure was produced outlining the importance and characteristics of watersheds (surface and ground waters, including lakes, streams, wetlands, etc.), in this case, the Bridge Creek watershed in the southern Cariboo region of BC.

The Bridge Creek watershed drains 1,550 km^2 of the Fraser Basin and is the source of drinking water for 100 Mile House and other nearby communities. Surface waters in this watershed are used extensively for recreational purposes in summer and winter, and the lakes and streams support important populations of rainbow trout, kokanee, and lake char.

The brochure describes a healthy watershed, what impacts humans and various land uses exert on ecosystems in this watershed, and suggests ways local citizens can

become involved in environmental stewardship. A brief description of the report, *Land Use and Water Quality Management in the Bridge Creek Basin* was given, along with information on the Cariboo-Chilcotin Land Use Plan.

Initially profiled in the 1993-94 Progress Report, the final report on this project is FRAP publication DOE FRAP #1994-25.

Ω

PROJECT: Cranberry Database for IPM Information System

Partnerships:	EC-CCD and FRAP, BCE, AAFC (Canada-BC Agriculture GP)
Funded By:	**Total Cost: $213K**; FPAO & CCD $15K; BCE $163K; AAFC & Canada-BC Agri GP $35K
FPAO Deliverables:	#12, #8
Prepared By:	ES CropConsult
Publication/Product #:	database
FPAO Contacts:	George Derksen

This was a component of the overall development of an Integrated Pest Management (IPM) Information System project. The funding information above reflects the complete development of the overall system and input to date, and not simply this component.

In this work, the contractor located information on cranberry pest research and management for entry into this database. Over 75 records on cranberries, cranberry pests, and related topics were submitted and reviewed.

Further information on this can be found on the Internet at:

http://www.pupux1.env.gov.bc.ca.

Ω

PROJECT: Pre-sidedress Soil Nitrate Test for Silage Corn: 1994 & 1995 Results

Partnerships: FRAP, AAFC, BC MAFF, East Chilliwack Agricultural Co-op

Funded By: **Total Cost: $184K**; FRAP $32K, AAFC $31K; BC-Canada Agric. GP $98K; E. Chilliwack Agric. Coop $23K; BCMAFF: in kind

FPAO Deliverables: #8, #12

Prepared By: Pacific Agriculture Research Centre

Publication/Product #: AAFC Technical Reports (2)

FPAO Contacts: George Derksen

The application of manure and nitrogen fertilizer to soil has effects on ground and surface waters and on the atmosphere, depending on climatic conditions. The pre-sidedress soil nitrate test (PSNT) can provide better estimates of the amount of nitrogen (or crop fertilizer) that needs to be provided for optimal use by the crop (in this case, corn). Results (to date) from this project show that 37 farm fields in 1994 revealed that only about one field in three required additional fertilizer nitrogen at sidedress to obtain maximum yield. Approximately 85 percent of the 62 farm fields sampled in 1995 required no additional fertilizer.

The PSNT should be used as part of a nitrogen-management system. By using this test, a farm with 20 ha of corn could save over $1,700 per year in fertilizer costs. In south coastal BC, over $550,000 in fertilizer costs could have been saved in 1995. In addition, local ground and surface waters were less subject to nitrate leaching (nutrient-loading).

This is an ongoing project. The final report will be available in 1997-98.

Ω

PROJECT: Improved Use of Poultry Manure for Raspberry Production

Partnerships: FRAP, AAFC, Fraser Valley Egg Producers Association

Funded By: **Total Cost: $119.5K**; FRAP $63.8K; AAFC $47.3K; FVEPA $8.4K

FPAO Deliverables: #12, #8

Prepared By: Coast Agri Ltd., Pacific Agriculture Research Centre

Publication/Product #: Technical Report

FPAO Contacts: George Derksen

Currently, poultry manure is applied to raspberry fields as a broadcast application using a solid manure spreader, a method in which the rate and uniformity of application is difficult to control. To be effective as a source of nitrogen or other nutrients, manure needs to be applied to the crop in a uniform manner and at a controlled rate. In this project, a mulch spreader, rather than a solid manure spreader, was tested for its ability to apply a uniform band of manure to the soil in a band close to the crop row, where the raspberry roots are most likely to be. In addition, trials were run using broiler, wet layer, and dry layer manure.

Evaluation showed the mulch spreader was able to supply a sufficiently uniform band of manure to the raspberry crop. Variation in the rate of manure application was observed, particularly for the wet layer manure.

The usefulness of this project relates to efficiency in the volume of manure used for raspberry production. It is possible that with optimal use of this technology, the risk of nutrient leaching into ground and surface waters of the Fraser basin can be minimized.

The final report on this project is expected in 1997-98.

Ω

PROJECT: Hydrolysis of Azadirachtin in Water

Partnerships: EC (FRAP & CCD), AAFC, UBC, PheroTech
Funded By: **Total Cost: $30K**; FRAP $9K; CCD $6K; AAFC $5K; UBC $5K; PheroTech $5K
FPAO Deliverables: #8, #12
Prepared By: SY Szeto (AAFC) and MT Wan (EC)
Publication/Product #: *J Agric Food Chem* (*44:4,* 1996*, pp. 1160-3*)
FPAO Contacts: George Derksen

This project was undertaken to examine the efficacy of the natural insecticide, azadirachtin (AZA). AZA is a botanical bioactive agent found only in the seed kernel of the neem tree (*Azadirachta indica* A. Juss). Unlike synthetic chemical insecticides, which are mostly contact neurotoxins, AZA is a selective compound that affects the endocrine system of insects, and is an antifeedant. Because of this selectivity and its rapid degradation, it is considered to be less environmentally damaging than synthetic insecticides and to pose a much smaller threat to nontarget organisms, including humans, via food residues, surface and ground water contamination, or accidental exposure.

In their article, *Hydrolysis of Azadirachtin in Buffered and Natural Waters*, Szeto and Wan report their findings on the kinetics of AZA hydrolysis over normal pH ranges (and temperatures and water types) in the aquatic environment to predict the stability of a water-based spray mix and the fate of this compound in wetland areas. Results of this work indicate that AZA appears to be more susceptible to hydrolysis than synthetic organophosphates (e.g., chlorpyrifos, diazinon, malathion, parathion), Ronnel (an animal systemic and contact insecticide), or carbamates (e.g., carbaryl, propoxur). All of these insecticides are currently used extensively for pest control. Accordingly, AZA is expected to be nonpersistent in water.

Ω

PROJECT: Qualifying and Quantifying Ammonia Emissions from Poultry on Different Dietary Regimes

Partnerships: FRAP, AAFC, BC Chicken Marketing Board

Funded By: **Total Cost: $112K**; FRAP $20K, BCCMB $7K; other sponsors $85K (multi-year)

FPAO Deliverables: #8, #12

Prepared By: JW Paul, TA Scott, PK Barton, RC Newberry

Publication/Product #: 2 AAFC Tech Reports July 1996: #127 and #128

FPAO Contacts: George Derksen

There were two technical reports relating to this project. Ammonia emissions from poultry litter may negatively affect workers and birds, cause environmental distresses outside of the barn, and depress nitrogen fertilizer potential of the manure. Environmental concerns from ammonia exhaust are valid; in Denmark the ammonia from swine and poultry barns is a major contributor to acid rain.

This project assessed management changes affecting ammonia emission on bird health and performance, as well as ammonia emissions to the atmosphere. Atmospheric ammonia emissions have the potential to form fine aerosol particulate matter from reactions of ammonia with nitrogen and sulphur oxides from auto and industrial emissions. These particulates lead to visibility impairment and cause human health concerns because they circumvent the body's defence mechanisms and can penetrate deep into the lungs, where they react with water in the alveoli to form ammonium hydroxide, a corrosive alkali.

Ammonia emissions also represent a loss of potential nitrogen for crop production. If ammonia emissions can be captured or reduced, this can increase the potential of the manure as a fertilizer source.

The first technical report, *A Research Barn for Measuring Ammonia Emissions During Poultry Broiler Production*, discussed measuring ammonia emissions and analysing the design of the research barns and the ammonia system for accurately identifying differences in ammonia concentration in the air.

The second technical report, *Balanced Amino Acid Diets Increase Bird Health and Reduce Ammonia Emissions*, discussed altering dietary regimes (feeding a lower crude protein diet and balancing for amino acids) for poultry in order to achieve a reduction in ammonia emissions to increase bird and worker health, and to maintain the maximum value of the manure as a nitrogen fertilizer.

Ω

PROJECT: Status Report of Projects in Waste Management in the Livestock Industry in the Interior of BC

Partnerships: FRAP, AAFC, Univ. College of Cariboo

Funded By: **Total Cost: $12.5K**; FRAP $8.5K; AAFC $2K (in kind); BCCC $2K (in kind)

FPAO Deliverables: #8, #12

Prepared By: K Broersma, P Webb, B Roddan, K Wallach

Publication/Product #: DOE FRAP 1995-30

FPAO Contacts: George Derksen

This status report summarizes current activities undertaken by various BC government agencies and other user groups in the Thompson-Nicola, southern Cariboo-Chilcotin, and northern Okanagan-Shuswap regions of the Fraser River Basin that involve research, demonstration, and monitoring projects in the area of pollution prevention and waste minimization in the livestock industry. The projects are largely concerned with identification of non-point source pollution, minimizing impacts of livestock waste on the environment, improving or maintaining water quality, and restoring riparian zones, streams, and surface water habitats for fish and wildlife through fencing. The report discusses agricultural operations in the context of local, provincial, and federal environmental legislation, regulations, and bylaws, and provides information on cattle numbers and feedlots by region and on potential manure production by cattle. It appends a list of selected projects and makes conclusions and recommendations, some of which are:

1. Direct contact of water courses by livestock should be eliminated in confined holding, feeding, and feedlot areas, and alternate remote watering methods be used.
2. Feedlots should have adequate land available to dispose of manure without polluting the soil and watercourses with nutrients.
3. The BC Environment program to survey agricultural practices in the Thompson Basin for monitoring and enforcing pollution prevention and waste minimisation measures should be continued and enhanced in other regions because it is an effective tool to identify and reduce non-point source pollution.
4. Further research is required on the effects of various land use activities, including livestock grazing on rangeland on water quality and to identify cause and effect relationships.
5. Most available information is highly industry-specific. Further studies may benefit from a more integrated watershed approach to pollution identification and prevention.

The study addresses the FRAP goal of identifying sources of pollution and developing and implementing suitable prevention and management measures.

Ω

PROJECT: Environmental Guidelines for Field Vegetable Producers

Partnerships: FRAP, BCMAFF, BCFA
Funded By: **Total Cost: $45K**; FRAP $25K; BCMAFF $10K; BCFA $10K
FPAO Deliverables: #8, #12
Prepared By: BCMAFF, BCFA
Publication/Product #: Guidelines Document
FPAO Contacts: George Derksen

The development and implementation of acceptable environmental practices is needed as a first step towards improving individual operations and those of commodity groups as a whole. This project was a component of a number of activities addressing needs for agricultural guidelines and educational materials.

In partnership with the BC Ministry of Agriculture, Food, and Fisheries (BCMAFF), the BC Federation of Agriculture (BCFA), and the vegetable-producing industry of BC (five industry organisations), the *Environmental Guidelines for Field Vegetable Producers* reviews federal, provincial, and municipal legislation, regulations, and bylaws, existing codes of practice, and includes information on nutrient management, preservation of soil and water resources, pesticide application, waste handling, and other considerations (e.g., noise, use of petroleum products, on-farm processing and refrigeration facilities, and keeping farm animals). It gives a detailed explanation of the source of pollutants and their impacts that may result from agricultural activities, such as:

- **air emissions**
    - from open burning and the operation of farm vehicles
    - impacts on animal and human health from ammonia (from manure)
    - pesticides when sprayed
- **impacts on soil**
    - metals, from application of manure and loss of vehicle fluids (oil, etc.)
    - excessive nutrients (spills, improper storage, over-application)
    - pesticides, especially build-up
    - petroleum products, especially from improper or leaking storage containers
    - plant disease transfer
    - salts
    - soil compaction and erosion
- **impacts on water**
    - ammonia, especially as runoff to surface and ground waters
    - metals, from manure, woodwaste, waste oil, etc.

- nitrates, from manure and chemical fertilisers
- elevated nutrients
- pathogens
- volume of water used
- woodwaste leachate

The guidelines discuss in detail the importance of planning site location, layout, buildings, pest management and waste handling practices, and other activities and considerations in order to minimise environmental effects and potential to cause problems with neighbouring residential developments.

The authors recommend that vegetable producers use these Guidelines to evaluate their current management practices and cautions against “extracting portions of the publication without considering the entire environmental context” of their operation.

Finally, the useful appendices give information on various government programs, industry associations, references, and a glossary.

Ω

GROUNDWATER

PROJECT: Groundwater Quality Protection Practices

Partnerships: FRAP
Funded By: **Total Cost: $40K**
FPAO Deliverables: #12, #14 [FRAP #5, #18]
Prepared By: Golder Associates Ltd.
Publication/Product #: FRAP Report [*early 1995*]
FPAO Contacts: Larry Adamache

Groundwater is the sole source of drinking water for 22 percent of BC's population and 40 percent of the province's rural population. In many areas, it is the only viable and economic source of water. In addition to providing a vital source of public water supply, groundwater plays an essential role in the maintenance of ecosystems by providing a source of recharge to wetlands, streams, and lakes.

The province's groundwater resources have come under increasing threats from contamination in recent years. Once contaminated, remediation of groundwater is a very costly and lengthy process; often by the time pollution is identified, the aquifer is damaged beyond repair. Furthermore, the effects of groundwater contamination do not end with the loss of well-water supplies. Surface waters in wetlands, streams, and lakes that are receptors of groundwater discharge are subject to pollution by the contaminated groundwater.

The most cost-effective means of ensuring a safe groundwater supply is to prevent contamination from occurring in the first place. This can be accomplished by implementing groundwater quality protection measures. These measures offer a means of managing a land area around an individual well field or above an entire aquifer in order to prevent groundwater contamination.

The objective of this project is to provide guidance to municipalities for the implementation of groundwater protection plans. Although federal and provincial initiatives can provide a level of protection for groundwater resources, the most effective means of protection occur at municipal levels through the implementation of site-specific groundwater quality protection plans based on local hydrogeological conditions, land uses, and political and economic conditions.

Groundwater protection measures can be implemented through regulatory (zoning) or non-regulatory (guidelines, public education) means, or through a combination of both these mechanisms (see table below). This project presented various measures and provided an evaluation for these measures based on numerous criteria, including: the extent to which the practice is pro-active versus reactive, the degree of groundwater protection offered, the effort required for implementation, relative cost to implement, public acceptability, and flexibility (for site-specific parameters).

Some Groundwater Protection Measures

Non-Regulatory	Non-Regulatory or Regulatory	Regulatory
vulnerability mapping	stormwater and sewage controls	zoning
aquifer classification	septic system controls	facility siting, design, operation
contaminant inventory	agricultural controls	hazardous materials restrictions
groundwater monitoring	road salt controls	above-ground storage tanks
contingency planning	forest management	permitting
hazardous waste collection	groundwater guidelines	inspection and compliance

The process of developing and implementing a groundwater protection plan can provide a range of benefits to a municipality (or regional district), including gaining more knowledge about local aquifers, identifying priorities for groundwater management, and raising public awareness about the need for groundwater protection.

Ω

PROJECT: Septic System Maintenance: Pure and Simple

Partnerships: EC-Science Division; FRAP; Health Canada, CIPHI, BC Ministry of Health

Funded By: **Total Cost: $68 K***; EC-Science Division $37K; Health Canada $11K; CFVUBH $10K; BC Ministry of Health $10K; in kind contribution from the Canadian Institute of Public Health Inspectors

FPAO Deliverables: #11, #12, #14 [FRAP: #4, #5]

Prepared By: Verna Hall Productions

Publication/Product #: Video, Brochure, Poster

FPAO Contacts: Hugh Liebscher

Three products—a 19-minute video, brochure, and poster—introduce homeowners, contractors, health agencies, and the general public to the workings and care of on-site sewage disposal (septic) systems. Produced in partnership with the BC Ministry of Health, the Central Fraser Valley Union Board of Health, and the Canadian Institute of Public Health Inspectors, the video, brochure, and poster shows the

importance of properly functioning septic systems and the relationship to ground and surface waters, public health, and overall ecosystem health. The conventional gravity-flow system is described, including tank maintenance and explanations of how to prevent septic system problems are explicitly set out. Information is given on warning signs of system failure.

*After production of the video, Health Canada contributed $11K to produce a national version for distribution across the country. Recent initiatives have resulted in video, brochure, and poster translations into Punjabi, Cantonese, and French for use in other jurisdictions within Canada and around the world.

Ω

PROJECT: Groundwater Denitrification Research

Partnerships: EC-Science Division, UBC Civ Eng Dept.
Funded By: **Total Cost: $7.5K**; FRAP $7.5K; UBC: in kind
FPAO Deliverables: #12, #14 [FRAP #5, #18]
Prepared By: RK Dasika and RK Dasika & J Atwater
Publication/Product #: PhD Thesis, 5 scientific papers
FPAO Contacts: Hugh Liebscher

Groundwater resources in unconfined aquifers in the lower Fraser valley have been identified as being highly susceptible to nitrate contamination. Extensive use of fertilisers (both inorganic and manure-based) in this largely agricultural region, along with numerous septic drain fields in rural areas, are believed to be the major sources of nitrate to underlying unconfined aquifers. Water well monitoring within the region has shown that selected areas of several aquifers are contaminated with nitrate levels well above the drinking water quality standards.

This project was initially profiled in the *FPAO Progress Report for 1993-1994* (p. 42) and was part of a Ph.D. thesis and additional research carried out under the Department of Civil Engineering at the University of British Columbia. The purpose of the project was to obtain a detailed understanding of the temporal and spatial distribution of groundwater nitrate and how this may be influenced by surface land use and subsurface geology. Five scientific papers (peer reviewed) and the thesis have been completed and the thesis successfully defended.

The thesis, titled *Investigations into the Distribution of Non-point Source Nitrate in Two Unconfined Aquifers and the Role for Carbon Addition in the Control of Nitrate Concentrations in Groundwater*, by RK Dasika, examined how shallow, unconfined aquifers are prone to contamination by non-point source nitrate as a result of

agricultural and other land use practices. The study involved a detailed monitoring of the changing groundwater chemistry profiles of two subject aquifers, combined with laboratory tests. The research included the first known detailed measurement of the seasonal arrival of leached non-point source nitrate to the water table beneath agricultural lands and has provided definitive evidence of the pulsed nature of this arrival. A conceptual model was developed to describe the observed distribution of nitrate below the water table.

Groundwater contamination by nitrate continues to be a subject of much concern, investigation, and debate. The characteristic that makes leached nitrate a particularly persistent and ubiquitous contaminant in the subsurface environment is the relatively non-reactive nature of the nitrate ion (NO_3^-). There are some processes that can lead to the removal or reduction in concentration of the leached nitrate in the unsaturated zone and groundwater.

The study results suggest that the role for carbon additions within aquifers for promoting *in-situ* denitrification on an aquifer-wide basis may be limited due to the seasonally dynamic nature of the nitrate loading and subsequent distribution through unconfined aquifers, as well as uncertainty associated with the efficacy of heterotrophic denitrifying microbial populations within the aquifers.

Ω

PROJECT: Evaluating Methods of Aquifer Vulnerability Mapping for the Prevention of Groundwater Contamination in British Columbia

Partnerships: FRAP, BCE-Water Management Division
Funded By: **Total Cost: $52K**; FRAP $52K, BCE: in kind
FPAO Deliverables: #14
Prepared By: BCE Groundwater Section, Hydrology Branch
Publication/Product #: Report
FPAO Contacts: Larry Adamache

A significant portion of British Colombia's groundwater supply comes from shallow, unconfined aquifers that receive recharge directly from infiltration of precipitation or from surface water bodies, such as rivers and lakes. These unconfined aquifers are prone to impacts from human activities. A cost-effective approach to protecting groundwater quality is to map the vulnerability of aquifers; this will enable better planning for development and other land uses in order to minimize potential impacts to water quality. This project is the beginning of a three-year initiative.

Aquifer vulnerability can be defined as the intrinsic susceptibility of an aquifer to contamination solely as a function of hydrogeological factors, both the hydrogeologic characteristics of the aquifer itself and the overlying soil and sediments. The type and intensity of human activities above an aquifer are not criteria in determining aquifer vulnerability, but are factors in the overall assessment of an aquifer's risk to contamination.

Two aquifer vulnerability mapping methods were evaluated for use in British Columbia: AVI (Aquifer Vulnerability Index, developed by the Prairie Provinces Water Board) and DRASTIC (which represents composite representations of Depth, Recharge, Aquifer, Soil, Topography, Impact, and Conductivity, a method developed by the US Environmental Protection Agency). This project reports on the evaluation of these two methods as they can be applied to the shallow, unconsolidated, glaciated aquifer terrain in southwestern British Columbia, most notably in the Lower Fraser River valley. The specific study area encompassed both the Abbotsford-Sumas Aquifer and the Aldergrove Aquifer on the south side of the Fraser River and southeast of Vancouver.

While the reviewers documented merits and drawbacks for both vulnerability mapping methods, other conclusions of this evaluation include:

a) The strongest merits in favour of the AVI method are its ease of use and its objectivity.
b) DRASTIC was better able to delineate a boundary between two different hydrogeologic environments and may be more valuable where there is a paucity of well lithology and aquifer data.
c) Where sufficient well log data is available, the AVI method, in conjunction with the more readily available data on surficial geology and aquifer boundaries for fine-tuning vulnerability boundaries, is recommended.
d) To successfully apply either of these methods, it is imperative to have:
    - good, accurate, large-scale surficial geological mapping
    - maps showing delineated aquifer boundaries
    - the most current and widest possible coverage of accurately located water wells with accompanying lithologic and water level information

The principal value of vulnerability maps is as a screening tool for management and protection of groundwater, including land use planning, identifying areas that need protection, and as an educational tool to inform the public and policy-makers about the vulnerability of the groundwater resource in specific areas and the need to limit the impacts of human activities in these areas. For British Columbia, aquifer vulnerability mapping would be useful to a number of planning initiatives currently underway, such as the Protected Areas Strategy, Ground Water Management Areas, regional and municipal planning, and for local health units in their mandate to protect public drinking water supplies.

Ω

PROJECT: A Groundwater Quality Assessment in the Hopington (Langley) Aquifer

Partnerships: FRAP, EC, DFO, Township of Langley, UBC, Salmon River Enhancement Society

Funded By: **Total Cost: $10K**; FRAP, DFO, Langley, UBC: no information

FPAO Deliverables: #12, #14

Prepared By: Schreier, Scales, Hall, *et al*.; UBC, and Langley Township Engineering Section

Publication/Product #: Report

FPAO Contacts: Bert Kooi

The Hopington aquifer, located in the central Langley area, provides drinking water to the local community and maintains the base flow of the Salmon River (an important salmon stream in the lower Fraser Valley). The aquifer has an estimated 1,900 groundwater wells that provide drinking water to more than 6,600 people and a large number of permits exist for using the streamwater for irrigation during the summer. The aquifer is located at the urban-rural fringe and is dominated by commercial and hobby farms.

Because this is an unconfined aquifer, it is highly vulnerable to contamination. The aquifer is a key water resource for people, fish, stream flow, and aquatic biota, and considerations should be given to protect and sustain this valuable resource because continued over-utilisation and contamination would have further longterm impacts on human health, land use, and fish. Nitrate problems have been identified, particularly in late summer, when demand is highest and recharge sources are at an annual minimum.

In response to concerns about contamination, this project included a detailed groundwater survey, conducted between November 1994 and March 1996. The study examined the Hopington aquifer to determine the extent of nitrogen contamination and to identify possible sources of the contamination. The issues of concern were overall water quality in the aquifer, the impacts of land use on groundwater quality, and streamflow and stream water (particularly the Salmon River and Coghlan Creek) quality.

The study was designed to address the spatial, temporal, and depth variability of the entire watershed. Seventy well-owners were involved in the monitoring program, and the water quality analyses focused on the nitrate problem. Land use types and intensity of uses were expressed in terms of animal stocking density, area under arable farming, density of septic systems, and hobby farm densities. All of these were thought to be contributors to the nitrogen problem in the aquifer. The study results were produced in two formats: a written “paper” report and a hypertext multimedia computer display program.

The report details the methods used to examine the Hopington aquifer, describes the groundwater quality of the aquifer, discusses the land uses and possible sources of contamination and the relationships between land uses and water quality. It also examined the perception of the local citizens about groundwater issues through the use of a survey/questionnaire. Finally, the report presented the conclusions and recommendations arising from the investigation. Some of these include:

♦ **Findings:**

a) About one-third of the aquifer is affected by nitrogen contamination; between 30% and 40% of all samples were affected by pollution, and, depending on the time of year, between 3% and 13% of all samples showed nitrate values above drinking water health standards (including high levels of phosphorus, but there are no health standards listed for phosphorus).

b) There was a general trend towards lower nitrate levels at depth and both pH and conductivity increased with depth.

c) Animal and septic system densities showed values exceeding the carrying capacity in a number of areas within the aquifer.

d) Nitrogen originating from commercial agriculture, hobby farms, and septic systems are the main sources of contamination; 48% of nitrate sources came from commercial farms; 34% from septic systems, and 18% from hobby farms.

e) Relationships between groundwater contamination, surface texture, and surplus nitrogen applied, while weak due to the complex nature of water movement within the watershed, showed that groundwater quality has a direct impact on the stream quality in the Salmon River.

f) There was a general perception that chemicals and chemical fertilisers were the main sources of pollution and that septic systems and manure were only partially identified as serious problems for the aquifer.

♦ **Recommendations:**

g) Source control:
- service septic systems regularly
- reduce the use of chemical fertilisers
- reduce application rates of manure and reduce animal stocking density in some parts of the aquifer

h) Best Management Practices
- improve the storage, management, and application of manure

i) Restrict land uses
- discourage expansion of livestock units on the aquifer
- regulate agriculture
- discourage hobby farm expansion
- regulate proximity to streams of commercial and “hobby” agricultural operations

j) Education
- carry out public education activities directed at the media, developers, politicians, schools, and the rural/urban public on the role of the aquifer, its vulnerability, and the longterm consequences of groundwater contamination

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CONTAMINATED SITES

PROJECT: Fraser Basin Contaminated Sites Inventory - SITE Database

Partnerships: EC-Environmental Assessment and Waste Prevention Section, BCE-Contaminated Sites Remediation and Assessment Section

Funded By: **Total Cost: $306K** (estimate); FRAP $56K; BCE $250K (estimate - for installing database)

FPAO Deliverables: #15

Prepared By: EC-EAWPS

Publication/Product #: database

FPAO Contacts: Richard Glue

FPAO and BC Environment collaborated on the development and completion of the BC Environment Site Information System (SITE), designed to assist, monitor, and manage contaminated sites data, prioritize remedial actions, and form the basis of a Site Registry pursuant to proposed regulations of the BC *Waste Management Act* (Bill 26).

SITE enables contaminated sites information, (such as status, site participants, description, and exact location of contamination) to be retrieved and reviewed for assessment and remediation. This ongoing process is being updated continuously by BC Environment and Environment Canada.

SITE contains information useful to FRAP's overall objective of inventorying contaminant sources having potential impacts on the Fraser River basin. The *1994-95 Contaminated Sites Progress Report*, by the Environmental Assessment and Waste Prevention sections of Environment Canada, represents the inventory development stage of this activity and is based on data provided by BC Environment on contaminated sites in the province of British Columbia that have been entered into the SITE database as of October 4, 1995.

Based on data reviewed by Environment Canada in October 1995, there were 2866 non-federal and 342 federal contaminated sites (known) in British Columbia. Of the 2866 contaminated provincial sites, 2699 were located in the Fraser basin system, mostly in the lower mainland (2568, or 89.6 percent, in Surrey alone). About 41 percent (1173) of provincial contaminated sites have developed and implemented a site remediation plan.

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PROJECT: Impact Assessment of the Old Quesnel Landfill: Final Report

Partnerships: EC-Environmental Protection, Cariboo Reg. Dist.
Funded By: **Total Cost: $9.7K**; EC $9.7K
FPAO Deliverables: #8, #14, #18
Prepared By: Gartner Lee Ltd.
Publication/Product #: Report DOE FRAP 1995-05
FPAO Contacts: Phil Wong

The old Quesnel Landfill, operated between 1955 and 1972, is located on the south bank of the Fraser River, west of the Quesnel municipal boundary. In addition to geotechnical concerns, the focus of this assessment was to address current and potential future impacts from leachate and for direct damage from landfill waste if it were to slide into the Fraser River. This study was initiated as a first step in determining the potential for and severity of impacts on the Fraser River.

The assessment approach applied should also be applicable to other similar situations elsewhere in the Fraser River basin. Interpretation of the results is based on a "source→pathway→receptor" model. The "source" is the garbage plus leachate; the "pathway" is the groundwater/surface water route of contaminants moving to the water table or to the Fraser River; the "receptor" is the aquifer, surface water body, or those organisms or water users that may be affected by the contaminants that have moved through the pathway. Receptors may include nearshore benthic macroinvertebrates (e.g., aquatic insect larvae, snails, clams) and fish. Downstream water intakes could be affected physically, and water for human consumption could pose a public health risk. As well, water wells downgradient from the pathway could become receptors of contamination.

The study team reviewed the history of the site, geological, hydrological, climatological, and water use information. A geologist, fisheries biologist, and water pollution biologist conducted a site visit and relevant field activities. Results were interpreted in the context of federal and provincial water quality guidelines and the above-stated model.

Conclusions included that leachate impact on nearby water wells is highly unlikely, sampling program failed to detect an impact on the Fraser River, and there are a number of potential public safety issues related to the site, including potential slope failure, cuts and punctures from sharp pieces of scrap, and accidental confinement.

Recommendations included constructing a ditch to intercept surface water runoff to minimize leachate generation, discouraging continued use of the site for dumping waste, developing options for dealing with the scrap metal and old cars at the site, further testing to determine the full extent of the area of the landfill.

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APPENDICES

APPENDIX A
LIST OF REPORTS PUBLISHED UNDER FPAO REPORT SERIES

APPENDIX B
GLOSSARY

APPENDIX C
FRAP 48 DELIVERABLES

APPENDIX D
FPAO CONTACTS

APPENDIX A
LIST OF FPAO REPORTS PUBLISHED UNDER FPAO REPORT SERIES

The following reports are arranged alphabetically, with the year reported on and the FRAP program area indicated in the second and third columns, respectively. Please contact Environment Canada (FPAO or FRAP offices) for information on their availability.

Report Title, FRAP #, Prepared By, Date, FPAO Contact, Availability Status/Electronic Copy	**Year Reported** (FPAO Annual Rep.)	**Program Area**
A Comprehensive Survey of Pesticide Use In British Columbia: 1991, DOE FRAP 1993-35, Norecol Consultants, November 1993	1992-93	Agricultural Runoff
Aerial Reconnaissance of the Fraser River Basin, Terra Pacific Info Systems; Bert Kooi	1993-94	Industrial Discharges
Agricultural Inventory of the Lower Fraser Valley - Data Summary Report, DOE FRAP 1994-28, George Derksen	1993-94	Agricultural Runoff
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Agricultural Nutrient Management in the Lower Fraser Valley, DOE FRAP 1995-27, Charcoal Creek Projects, December 1995, George Derksen, April 1996	1994-95	Agricultural Runoff
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Crowe Street CSO and Stormwater Characterisation, GVRD; Bert Kooi	1993-94	Municipal, Urban, CSOs
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APPENDIX B
GLOSSARY OF ABBREVIATIONS, ACRONYMS, TECHNICAL TERMS

AAFC	Agriculture and AgriFood Canada (previously Agriculture Canada)
ACA	Ammoniacal Chromium Arsenate
BCE	British Columbia Environment (BC Ministry of Environment, Lands and Parks)
BCFA	British Columbia Federation of Agriculture
BCMAFF	BC Ministry of Agriculture, Fish, and Food
BIEAP	Burrard Inlet Environmental Action Program
BMPs	Best Management Practices
CCD	Commercial Chemicals Division (Environment Canada)
CCME	Canadian Council of Ministers of the Environment
CIPHI	Canadian Institute of Public Health Inspectors
CORE	Commission on Resources and the Environment (a BC initiative)
CSO	Combined sewer overflow
DFO	Department of Fisheries and Oceans; also Fisheries and Oceans Canada
DIAND	Department of Indian Affairs and Northern Development
EC	Environment Canada
EC-EIP	Environmental Innovation Program (Environment Canada)
EP	Environmental Protection (Environment Canada)
FPAO	Fraser Pollution Abatement Office
FRAP	Fraser River Action Plan
FREMP	Fraser River Estuary Management Plan
FRHC	Fraser River Harbour Commission
GVRD	Greater Vancouver Regional District
IPM	An ecological approach to the control of pests that combines and integrates chemical methods with natural and biological control. Chemical control is applied as necessary and in whatever manner is least disruptive to natural and biological control. Also: IPM is a system that, in consideration of the associated environment and population dynamics of the pest species, uses all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury.

NFHC	North Fraser Harbour Commission
P2	Pollution Prevention (Environment Canada)
PAS	Protected Areas Strategy (an initiative of the BC government)
PCB	Polychlorinated biphenyl
PCP	Pentachlorophenol
RIC	Resources Inventory Committee (an initiative of the BC government)
UBC	University of British Columbia
VPC	Vancouver Port Corporation

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APPENDIX C
FRAP 48 DELIVERABLES

Sustainability

Develop a management program for sustainable development in the Fraser River basin in partnership with the provincial and local governments and other basin stakeholders.

1. Prepare a "blueprint" for sustainable development.
2. Involve 5% of the basin's population in the planning and decision making process to create the Blueprint for Sustainability.
3. Expose 40% of the basin's population to the principles of sustainable development.

Pollution Prevention

Arrest and reverse the existing environmental contamination and degradation of the Fraser River ecosystem by developing targets and strategies to reduce pollution and by virtually eliminating the discharge of persistent toxic substances in the Fraser River.

4. Provide decision makers with a knowledge of non-market values produced by a healthy environment/ ecosystem.
5. For both public and private sectors, integrate environmental concerns in the planning and decision making process.
6. Through our partners, initiate the use of economic instruments in the basin.
7. Provide decision makers with knowledge of the cost effectiveness of various pollution abatement and habitat enhancement alternatives.
8. Develop and maintain an inventory of major pollution sources and loadings in the basin.
9. Reduce environmentally disruptive industrial effluent discharges by 30% to meet environmental quality objectives.
10. Reduce contaminant loadings from combined sewer overflows and untreated sewage discharges by 30% to meet environmental quality objectives.
11. Reduce the contaminant load from inadequately treated sewage discharges by 30% to meet environmental quality objectives.
12. Implement a strategy to reduce the loading of nutrients, bacteria and agrochemicals from agricultural operations to ground and surface waters by 30% to meet environmental quality objectives.
13. Implement a strategy to reduce the contaminant loading from urban runoff by 30% to meet environmental quality objectives.
14. Establish a Groundwater Protection Strategy which includes the remediation of high priority sites.
15. Clean up 70% of contaminated federal waste sites to CCME standards.
16. Develop and maintain a toxics air emission inventory for major industrial sectors.

17. Reduce the release of persistent toxic substances pursuant to the Canadian Environmental Protection Act and identified as priority from inventories and environmental data to the extent allowed by best practicable technology.
18. Provide new knowledge for environmental quality assessments and the development of objectives.
19. Measure and report on the condition of the basin.
20. Develop water quality objectives and criteria for contaminants of concern in the four main sub-regions of the basin.
21. Provide a provisional framework for developing ecosystem objectives.
22. Initiate a pilot project for ecosystem objectives.
23. Assess water quality relative to water quality objectives.
24. Assess contamination from major pollution sources.
25. Assess and report on the effectiveness of selected pollution abatements relative to the environment.
26. Achieve 90% compliance with environmental legislation in cooperation with provincial and federal enforcement agencies
    - Annually conduct approximately 180 inspections at federally regulated sectors discharging/ impacting in the basin, and initiate 8 - 10 investigations per year;
    - Prosecute violators having continuous or significant non-compliance;
    - Participate in the development of compliance strategies, which include punitive and other instruments (e.g. economic incentives).
27. Target enforcement programs to assist in achieving the pollution abatement goals and environmental quality objectives of the program.
28. Establish an enforcement field office in Prince George and implement a pilot project for delivery of coordinated, effective and efficient enforcement programs in the basin.

In partnership with the other four parties to the Burrard Inlet Environmental Action Program Agreement (BIEAP):

29. Establish a sustainable development plan for the Inlet.
30. Develop and implement a long term, integrated, focused monitoring program to identify existing and emerging environmental problems and evaluate the effectiveness of abatement actions.
31. Establish water quality objectives for contaminants of concern as a guide for abatement actions.
32. Develop and maintain an inventory of all contaminant sources and loadings in the inlet.
33. Reduce environmentally disruptive industrial discharges by 30% to meet environmental quality objectives.
34. Reduce contaminant loadings from combined sewer overflows by 30% to meet environmental quality objectives.
35. Reduce contaminant load from urban runoff by 30% to meet environmental quality objectives.
36. Develop and implement a dredge material management plan and sediment remediation strategy for dredging and disposal of contaminated sediments as part of site remediation and maintenance programs.

37. Develop and implement land use classification criteria and strategy to protect existing habitats.
38. Develop and maintain an environmental review process for expanded and new development projects proposed for the Inlet.

Habitat Restoration and Conservation

Restore the productivity of the natural environment by restoring and enhancing environmental quality and the natural productive capacity of the Fraser River ecosystem.

39. Directly protect 15 ha. of estuary land.
40. Track and protect additional habitat in the lower Fraser uplands through cooperative stewardship initiatives and publish two maps and two technical reports.
41. Retain 1200 ha. of farmland, annually, as seasonal bird habitat, and control crop damage.
42. Complete (at least) six interior wetlands demonstration projects
    - Protect 100 hectares at Salmon Arm in Year Two.
43. Deliver annually, and report on, coordination/ extension liaison function with ranchers to
    - Improve ranchers' understanding of wetland values;
    - Reduce the impact of grazing on wetlands;
    - Increase wetland productivity for wildlife on private lands.
44. Map and analyze critical interior habitats and report on forest fragmentation/ biodiversity.
45. Develop procedures to protect critical forest habitats
    - Produce (up to) four operational level pamphlets on selected forest habitat management issues;
    - Produce a technical report on managing for cavity-nesters.
46. Jointly develop guidelines for the protection of riparian zones after holding a workshop and publishing proceedings.
47. Integrate wildlife values into forest management policies through participation on PAS, CORE, IRPC, Inter-Ministry Biodiversity Group, and RIC.
48. Demonstrate methods to maintain forest bird diversity
    - Produce a report on integration of Shuswap bird data with other biodiversity attributes;
    - Complete identification of bird groups with common habitat dependency.

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APPENDIX D
FRASER POLLUTION ABATEMENT OFFICE CONTACTS

224 West Esplanade, North Vancouver, V7M 3H7

Name	Program	Telephone	E-mail (...@ec.gc.ca)
Lisa Walls	Section Head	604-666-6262	lisa.walls@
George Derksen	Agricultural	604-666-3220	george.derksen@
Marielou Verge	Urban	604-666-2399	marielou.verge@
Vivian Au	Industrial	604-666-5712	
Phil Wong	Municipal/CSOs	604-666-2699	phil.wong@
Richard Glue	Contaminated Sites	604-666-5566	richard.glue@
Tim Wilde	GIS/Data Management	604-666-3487	tim.wilde@
Stan Lui	BMPs/Industrial	604-666-2104	stan.lui@
Hugh Liebscher	Groundwater	604-664-4050	hugh.liebscher@
Larry Adamache	Groundwater	604-664-4004	larry.adamache@
Doug Wilson	Wood Preservation	604-666-3197	doug.wilson@
David Poon	BMPs/Pollution Prevention	604-666-2862	david.poon@
Snehal Lakhani	Pulp and Paper	604-666-2037	snehal.lakhani@

Fax for everybody: 604-666-7294

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