B3029

TECHNICAL AND MANAGEMENT PROPOSAL: IMPACT OF COAL DUST ON THE MARINE ENVIRONMENT - PHASE II

Prepared for:
Environmental Protection
Environment Canada
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1 TECHNICAL PROPOSAL

BCRI is pleased to submit this proposal to Environmental Protection, Environment Canada, in response to positive findings reported in the "*Draft* Impact of Coal Dust on the Marine Environment" study , recently submitted to Environment Canada.

1.1 Background

There are three coal terminals on the Canadian west coast. Coal dust spillage and drainage generated during these operations may effect the environment of the foreshore adjacent to these terminals. Both the coal industry and fisheries are vital to the economy of British Columbia and hence any legislation to protect the environment would impact on either one of these industries. Therefore it is imperative to ensure that any measures taken to prevent environmental impacts, do not impose unnecessary burdens on either industry.

Coal terminals are required by provincial regulations not to exceed total suspended solids to 50 mg/L in wastewater streams and have requested that this level be increased to 200 mg/L. This may result in a possible increase of organic chemicals in the adjacent sea water and foreshore sediment which could effect the marine environment.

Preliminary results from the recently completed Phase I study indicate that coal dust may have a detrimental effect on biota. An inhibition effect on fertilization was observed in sand dollars (*Dendraster excentricus*) at levels of 100 mg/L. The study also demonstrated that juvenile chinook salmon (*Oncorhynchus tschawytscha*) exposed to coal fines showed a cellular chemical response at levels of 60 mg/L, althought the impact of this exposure on fish health and reproduction remains unclear.

The knowledge of the impact of coal and coal run-off is sparse and other studies have shown that up to 75% (coal to sand by volume) has no measurable effect on the oxygen consumption or gill ventilation of crabs over an exposure of 21 days.

Compounds associated with coal include inorganic compounds such as heavy metals, and organic compounds such as phenols, arylamines, alkanes, mono- and polycyclic aromatic hydrocarbons and their sulphur and nitrogen heterocyclic analogs.

From a brief literature review (1-8) it has been determined that phenols generally have a high acute toxicity, a low potential for bioaccumulation and are readily

degraded by microbes. Arylamines have been found to be toxic to blue-green algae and other aquatic organisms. Alkanes undergo microbial degradation, are relatively non-toxic and may be accumulated in aquatic organisms.

The aromatic hydrocarbons and their heterocyclic analogs have caused the most concern. Mutagenicity and carcinogenicity are associated with many members of this group of compounds including benzo(a)pyrene, benzo(a)anthracenes and chrysenes. Toxicity has also been reported for some members such as 6-methylquinoline and phenanthrenes.

Scientific data regarding leaching of organic chemicals from coal by sea water has been collected in Phase I. Results indicated that PAHs are bound to the coal dust particle and not readily transferred to coal dust leachate (insoluble).

The information obtained is relevant in that results indicate that there is a potential for an adverse effect from coal dust discharge into the marine environment. What the fate of this material is, and how it impacts the biota in the environment is presently unknown.

Field sampling of sediments and biota is now required to determine the actual effect of settled coal fines on marine life near coal terminals, and bioaccumulation potential of the coal dust constituents of interest (i.e. PAHs), before a decision can be made on permitting higher effluent discharge limits for total suspended solids from terminal operations.

BCRI proposes to support of the decision making process and assist Environment Canada, by conducting a series of tests to obtain the required information.

1.2 Objectives

- To assess the toxicity of sediments in the vicinity of coal terminal effluents to benthic marine life. Assess and quantify the toxicity of the sediments to an indicator species of benthic invertebrates.

- To assess the bioaccumulation propensity of coal dust constituents in the vicinity of the effluent discharge points. Examine a sedentary invertebrate indicator species residing in the vicinity of a chosen coal terminal discharge point. Examine for presence of an indicator chemicals (i.e. PAHs) to determine to what degree coal dust constituents bioaccumulate in the marine environment.

- Establish if the 50 mg/L total suspended solids (coal) permit requirement can be increased to 200 mg/L.

1.3 Scope

The tasks listed in this proposal represent the chronological sequence for a study to determine the potential impact of coal and coal contaminated sediments on marine life.

The scope of the study will involve five unique tasks. The first task will be to design the detailed study protocol with the input of the Scientific Authority.

Task (2) will is designed to expand testing on Echinoderms (sand dollars) to verify results obtained in the Phase I fertilization inhibition study, which reported fertilization inhibition in sand dollars based on a limited sample size. The preliminary results will be verified through further, statistically defensible replicate testing for echinoderm fertilization assay using sand dollars (*Dendraster excentricus*).

Task (3) is designed to identify the bioaccumulation of PAHs from a coal terminal effluent source. The tests in the Phase I study focused on short-term lethal and sub-lethal exposure to coal fines. Valuable information could be gained by conducting a bioaccumulation study. One of the more cost-effective and true-life methods is to assess the level of PAH or other compounds in an indigenous, sedentary indicator invertebrate (e.g. blue mussels, *Mytilus edulis*), near a coal terminal outfall (Young, D.R. et al, 1995).

This information may provide insight into the sensitivity of the indicator species to bioaccumulation, and also indirectly to the effectiveness of the effluent flushing action in the outfall area. Shellfish will be collected and analyzed for indicator PAHs.

In Task (4), we will undertake an investigation into the sediments found in the marine environment in the vicinity of coastal coal terminals. This information may provide an indication as to whether discharged materials which settle are deleterious to benthic life, and whether any deleterious substances have already accumulated in the sediments. We recommend that a series of acute sediment toxicity bioassays be conducted with the marine amphipod, *Rhepoxynius abronius.*, and solid -phase Microtox™ using the luminescent bacteria, *Photobacterium phosphoreum.*

All tests will be conducted according to the appropriate Environmental Protection Series biological test methods (10-13). Details of the specific tests are listed in the following work plan.

Task (5) will culminate with the preparation and submission of a concise summary report.

1.4 Deliverables

The deliverables of this study will include:

- A concise summary report outlining the findings of this study.
- Optional in-house-quality video documentation of the field collection areas and overview of the testing procedures.

1.5 Work Plan

1.5.1 Task 1: Detailed Study Design and Alignment Meeting

An alignment meeting with all participants will be held upon contract award, and will be valuable in assuring that the work plan is clearly defined and satisfactory to Environment Canada. A detailed study design will be presented to the Scientific Authority during an initial meeting. Suggestions arising from this meeting will be incorporated through mutual agreement of BCRI and the Scientific Authority (Any major scope changes will be agreed to by both BCRI and the Scientific Authority, and may change the level of effort and study costing).

1.5.2 Task 2: Echinoderm Fertilization Test

We propose to conduct a series of fertilization inhibition tests with the sand dollar (*Dendraster excentricus*) exposed to coal fine leachate, in order to confirm the inhibition effect observed in the Phase I study. Three replicate sets of tests will be performed, with each test exposing sand dollars to five (5) coal dust concentrations between 100-200 mg/L. This will establish the IC_{50} inhibition concentration. It may also determine whether there is a threshold effect by measuring the LOEC (lowest observable effective concentration) & NOEC (no observable effective concentration), and if so, at what concentration. (In Phase I, fertilization inhibition in sand dollars was observed at coal dust concentration of 200 mg/L, while no inhibition was noted at 100 mg/L, suggesting that the threshold concentration for fertilization inhibition in sand dollars is somewhere between these values.).

We propose to use coal collected from Ridley Terminal. Ridley Terminal has no treatment system, while the PAH content is the highest of the three terminals tested. Previous studies conducted at BCRI and the information in the literature have indicated that the compounds derived from coal most likely to have an impact on marine life are polycyclic aromatic hydrocarbons (PAHs) and nitrogen heterocyclic compounds (azaarenes).

Optionally, we could perform a similar PAH testing on Westshore and Neptune Terminals.

Option #2 is to assess the fertilization inhibition potential of sediment leachate samples collected from the vicinity of a coal terminal outfall. This bioassay procedure was included in the tests used in the 1993 Survey of Sediments and Tissues From Boundary Bay and Roberts Bank (Fraser River Estuary Monitoring,

Report B.C. Ministry of Environment, Lands & Parks, March 1994)[2]. The results of this study indicated variable fertilization inhibition of sand dollar gametes among the sediment samples tested although some sites demonstrated considerably low percent fertilization values.

We propose to conduct 3 replicate tests for each of two sediment sampling sites: 1) the intertidal vicinity of the Westshore Terminal outfall, and 2) from an intertidal control area within the same bay (site yet to be established). The results from each area could be compared to the results of testing only coal fines. This comparison may enable us to determine whether the effect of fertilization inhibition is a physical one (i.e. all samples exhibit similar results), or whether the inhibition could be due to some chemical effect of the coal (coal and outfall sediment samples would exhibit higher fertilization inhibition than the control samples). This would determine whether coal fines specifically inhibit sand dollar fertilization.

Test Protocol: Echinoid Fertilization Inhibition Test

Tests will be conducted in accordance with EPS Biological Test Method:" Fertilization Assay Using Echinoids (Sea Urchins and Sand Dollars)" Report EPS 1/RM/27 December 1992. Sand dollars (*Dendraster excentricus*) will furnish gametes for the test since they are relatively easy to collect in shallow water, they are readily held in the laboratory and conditions can be manipulated to extend their gravid period. This particular fertilization assay is rapid and economical using small sample volumes and ordinary bioassay facilities and supplies.

Three replicates of 10 mL sediment leachate sub-sample will be exposed to sand dollar sperm for 10 minutes. Fertilization will be stopped after a further 10 minute exposure following introduction of eggs to the solutions. The pH, dissolved oxygen and salinity will be measured prior to analysis. Filtered natural sea water will be used as control/dilution water. This fertilization assay will be performed at determined intervals during favorable seasonal condition to ensure test organisms in gravid condition.

The biological endpoint of the test is the adverse effect on fertilization success of echinoid gametes as determined by comparison with the controls. The percent fertilization in each of the leachate dilutions and the controls will determine the end points of the test. The No Observed Effective Concentration (NOEC) and Lowest Observed Effect Concentration (LOEC) will be statistically derived by hypothesis testing.

1.5.3 Task 3: Bioaccumulation Study

The bioaccumulation study will consist of collecting the indicator species blue mussels, *Mytilus edulis*), from the vicinity of a coal terminal outfall, and analyze the tissues for PAH compounds. These results will be compared with control mussel samples collected from a control zone, and from other possible sources of PAH contamination (e.g. other terminals and foreshore industries, and effluent point sources). The PAH results from potential alternate PAH contributors (from past or

present industrial operations in the vicinity of the coal terminal) are designed to eliminate the uncertainty of the PAH source if PAHs are found.

Blue mussel samples will be collected from the vicinity of the Westshore Terminal. This terminal is chosen due to good access, and greater wave exposure than Neptune Terminal. Note that if mussels are not available from Westshore Terminal, Ridley Terminal will be the alternative collection site. The Ridley Terminal foreshore is more conducive to mussel production, as the shoreline is of higher energy and the foreshore is more rocky that at Westshore Terminal. Three replicate analyses will be conducted for the test and control site.

Test Protocol: Analysis of Shellfish Tissues for PAHs

A comprehensive review of the literature relevant to the detection of polycyclic aromatic hydrocarbons and azaarenes in leachates and sediments and their toxic effects on marine life was undertaken in Phase I of the study. B.C. Research has developed analysis methods for most of the compounds in coal which are known to be of concern.

Shellfish tissue will be prepared for testing by blending whole body tissue. The mixture will then be analyzed for PAH compounds by extracting the tissues with dichloromethane. If necessary the dichloromethane extract will be cleaned with alumina column chromatography and then analyzed by GC/Mass spectroscopy for PAHs. The GC/MS scan will quantify 16 indicator PAH species.

Determination of Polynuclear Aromatic Hydrocarbons (PAHs)

Air dried sediment samples or biota samples are solvent extracted with a 15% acetone in dichloromethane solvent or tetrahydrofuran. A surrogate mixture of five deuterated PAHs is added to the samples prior to extraction to determine analytical recoveries. The organic extract is concentrated on a rotary evaporator at 35°C. For those samples requiring clean up, alumina chromatography is used to isolate the PAH fraction. The final sample extract is adjusted to 2 mL of toluene for analysis.

Each sample set is analyzed using a method blank and a range of calibration standards on a Hewlett-Packard Model 5988A gas chromatograph/mass spectrometer (GC/MS) operated in selected ion mode (GC/MS-SIM). The GC/MS is equipped with a 30 m x 0.25 mm fused silica DB-5 capillary column and a split/splitless injection port. The method used for analysis of PAHs is based on the EPA Method 8270 as described in "Test Methods for Evaluating Solid Wastes", SW-846.

The PAHs analyzed are as follows:

Naphthalene
Acenaphthylene
Acenaphthene
Fluorene

Phenanthrene
Anthracene
Floranthene
Pyrene
Benzo(a)Anthracene
Chrysene/Triphenylene
Benzo(b/k)Fluoranthene
Benzo(a)Pyrene
Indeno(1,2,3-cd)Pyrene
Dobenzo(a,h)Anthracene
Benzo(g,h,i)Perylene

1.5.4 Task 4: Sediment Toxicity Study

Consistent with the toxicity tests used in the Fraser River Estuary Monitoring Program[1], the marine amphipod, *Rhepoxynius abronius*, will be used to assess acute toxicity of sediments from the vicinity of Westshore Terminals outfall.

A 10-day LC_{50} amphipod bioassay will be conducted on three (3) replicates of 200 g of sediment, for one test and one control location. Sample locations will be the same as those described in Task 3. The percent survival at the conclusion of 10 day period will establish the toxicity endpoint.

The PAH levels in the sediments will be analyzed in support of the sediment bioassay work.

Solid-phase Microtox™ is a rapid screening test for sediment toxicity. The Solid-phase Microtox™ bioassay procedure is an acute toxicity test requiring only 25 minute exposure of a saltwater bioluminescent bacteria, (*Photobacterium phosphoreum)* to a leachate obtained from the solid sample. Any toxic materials present in the sample will interfere with metabolism of the bacteria and inhibit light production.

BCRI is a leader in Microtox™ bioassays, and we are presently developing new solid-phase tests. The Microtox™ test is inexpensive and has been used in other Environment Canada studies of coal terminals. Solid-phase Microtox™ testing is recommended as the bioluminescent saltwater bacteria species used in this test may have a different sensitivity to toxic sediments, and represent a different trophic level in the marine environment.

Microtox™ bioassays will be performed by the Standard Microtox™ method as outlined in the EPS Biological Test Method: "Toxicity Test Using the Luminescent Bacteria (*Photobacterium phosporeum*)" Report EPS 1/RM/24 November 1992.

We propose to conduct 3 replicate bioassays for each of the two sample locations described in Tasks 3 & 4.

An appropriate range of serial dilutions plus three controls will be tested. The light output of the cuvettes of reconstituted bioluminescent bacteria is measured before the sample is introduced and then again after 5 and 15 minutes of exposure. Readings are corrected according to the light intensity changes of control solution (non toxic diluent only), to allow for drifts in light output over time and the minimal effects from dilution of the bacteria following sample addition. From the resulting dose-effect curve, the sample concentration causing 50% inhibition of light production is estimated mathematically.

Standard QA/QC measures will be taken throughout the analyses and reference toxicants will be run concurrently with the analyses at each specified time interval. The pH, dissolved oxygen, and salinity will be measured prior to Microtox™ analyses. Clean sea water will be used in place of Microtox™ diluent of fixed 2% salinity since bacteria will generally produce significantly more light in natural sea water.

1.5.5 Task 5: Reporting

The final report will summarize the findings of the Phase II study. Particular attention will be paid to quantifying effects and establishing threshold levels where possible. Discussion and conclusion will focus on the potential impact of coal on the marine environment to assist in decisions relating to coal terminal effluent and protection of the marine environment in the vicinity of coal terminals. The report will include:

- Fertilization inhibition results, bioassay results.
- Bioassay results.
- Mussel tissues PAH results.
- Report interpretation and summary.

1.6 References

1. Carbon, R. et al. Implications to the Aquatic Environment of Polynuclear aromatic Hydrocarbons liberated from Northern Great Plains Cal. NTIS Report EPA-600/3-79-093 August 1979.
2. Barrick, R.C. et al. Hydrocarbon and Azaarene Markers of Coal Transport to Aquatic Sediments. Environ. Sci. Technol., Vol. 18, No. 11, 1984. 846-854.
3. Merrill, E.G. & T.L. Wade. Carbonized Coal Products as a Source of Aromatic Hydrocarbons to Sediments from a Highly Industrialized Estuary. Environ. Sci. Technol., Vol. 19, No. 7, 1985, 597-603.
4. Krone, C.A. et al. Nitrogen-Containing Aromatic Compounds in Sediments from a Polluted Harbor in Puget Sound. Environ. Sci. Technol., Vol. 120, No. 11, 1986, 1144-1150.

5. Eiceman, G.A. et al. Depth Profiles for Hydrocarbons and Polycyclic Aromatic Hydrocarbons in Soil beneath Waste Disposal Pits from Natural Gas Production. Environ. Sci. Technol., Vol. 20, No. 5, 1986, 508-514.

6. Soltys, P.A. et al. Time-Resolved Solvent Extraction of Coal Fly Ash: Retention of Benzo(a)pyrene by Carbonaceous Components and Solvent Effects. Environ. Sci. Technol., Vol. 20, No. 2, 1986, 175-180.

7. Vogt, N.B. et al. Polycyclic Aromatic Hydrocarbons in Soil and Air: Statistical Analysis and Classification by the SIMCA Method. Environ. Sci. Technol., Vol. 21, No. 1, 1987, 35-44.

8. Fendinger, N. et al. Characterization of Organic Material Leached from Coal by Simulated Rainfall. Environ. Sci. Technol., Vol. 23, No. 2, 1989, 170-177.

9. B.C. Ministry Environment, Lands and Parks: 1993 Survey of Sediments and Tissues From Boundary Bay and Roberts Bank, Fraser River Estuary Monitoring Program Report, March 1993.

10. Environmental Protection Series. Biological Test Method: Acute Test for Sediment Toxicity Using Marine or Estuarine Amphipods Report EPS 1/RM/26

11. Environmental Protection Series. Biological Test Method: Fertilization Assay Using Echinoids (Sea Urchins and Sand Dollars). Report EPS 1/RM/27.

12. Environmental Protection Series. Biological Test Method: Toxicity Test Using Luminescent Bacteria (*Photobacterium phosphoreum*). Report EPS 1/RM/24.

13. Environmental Protection Series. Biological Test Method: Acute Lethality Test Using Three spine Stickleback (*Gasterosteus aculeatus*). Report EPS 1/RM/10.

1.7 Personnel and Level of Effort

The project team is essentially divided into personnel with biological and chemical experience. The project leader is Mr. Pasek, with Dr. McKinley as backup. The organic chemists are Mr. Barrass and Mr. Masson and the biological aspects of the project will be handled by Ms. Keen and Ms. Pickard.

1.7.1 Project Leader

George J. Pasek, P. Biol., R.P. Biol.
B.Sc. (Environmental Biology), University of Calgary
M.Sc. (Marine Biology), University of Victoria

Mr. George Pasek is program leader of the Aquatic Toxicity & Water Quality Group. Before joining BCRI he held the positions of pulp & paper specialist with Chemex Labs Inc. (Alberta), head of Bovar Environmental Services' British Columbia operations and Environmental Coordinator for Eurocan Pulp and Paper Co. He has extensive background in the environmental industry with experience working with all facets of government, consulting, laboratory support services, and regulatory affairs. Mr. Pasek has particular experience in environmental

assessments, regulatory permit applications, environmental impact minimization and the control of industrial toxicity discharges. He had set up the toxicity testing program and bioassay labs for Chemex Labs Inc. (Alberta). Mr. Pasek has supplemented his experience in the pulp industry with the completion of a Pulp & Paper Program Certificate.

1.7.2 Key Personnel

Jim McKinley
B.Sc. Chemistry, M.Sc., Ph.D. Physical Organic Chemistry, University of B.C.

Dr. Jim McKinley will assist Mr. Pasek in assessing all aspects of this study. Dr. McKinley is Program Leader, Organic Analysis. Prior to this he was Senior Project Coordinator of organic analytical chemistry at the B.C. Ministry of Environment Laboratory, and head of the organic section at the Water Quality Branch of Environment Canada in Vancouver. His expertise is in trace organic chemistry, pesticide residue analysis, method development, industrial chemistry, dioxin analysis and biomass liquefaction. Dr. McKinley has been with B.C. Research since 1986.

Graeme Masson
B.Sc. Biology/Chemistry, University of British Columbia

Mr. Graeme Masson will analyze material obtained from the coal and sediments using the GC/MS. Mr. Masson is a Research Chemist, organic analysis. He supervises projects that deal with analysis of pesticide residues and other environmental trace pollutants. He is also responsible for mass spectrometry analyses. Prior to joining B.C. Research he was a scientist at the B.C. Ministry of Environment laboratory working on trace organic and trace metal analyses. Mr. Masson has been at BCRI since 1988.

Patricia Lynn Keen
B.Sc. (Chemistry), University of British Columbia 1986
Dipl. Technology (Chemistry & Metallurgy), B.C.I.T.

Ms. Patricia Keen's academic background has focused on environmental chemistry and toxicology, including graduate level studies in pulp and paper science and environmental engineering. With a total of seven years experience in the chemistry laboratories of MacMillan Bloedel Research and the British Columbia Ministry of Environment, Ms. Keen developed strong skills in analytical chemistry related to environmental monitoring of air and water contamination. She has over five years experience in routine and non-routine bioassays of various species and methodologies. She has extensive experience with the routine lethal and sub lethal bioassay procedures required by Federal and Provincial government environmental monitoring. She is involved in method development of aquatic and marine bioassay procedures, promotion and marketing of the Aquatic Toxicity group and plays a key role in maintaining BCRI's strict QA/QC standards. Ms. Keen joined B.C. Research in 1988.

Janet S. Pickard
B.Sc., (Natural Resources) Cornell University, Ithaca, N.Y.

Ms. Janet Pickard will assist Ms. Patricia Keen with bioassays. Ms. Janet Pickard is Manager of the Aquatic Toxicity program and is familiar with acute and chronic tests using Rainbow Trout and daphnids, algal growth inhibition test, and marine stickleback. Ms. Pickard has over 5 years experience of helping clients in the pulp and paper industry, mining operations, and municipalities identify their toxicity problems. She has attended the various aquatic toxicity workshops. Ms. Pickard has also worked on method development of acute and chronic daphnid bioassays, toxicity tests using early life stages of salmonids and bioaccumulation and enzyme activation tests with salmonids. She is experienced in field sampling of waters and soils for permit compliance. She has also worked for Cornell University and N.O.A.A. on a study of fish health in New York State. Ms. Pickard has been with B.C. Research since 1989.

Michael McLeay
B.Sc. (Biology/Oceanography), University of British Columbia B. of Commerce and Business Administration, U.B.C.

Mr. Michael McLeay has experience in organism, sediment, and water collections. He has been performing acute lethality bioassays using *Daphnia magna*, and *Oncorhynchus mykiss* (rainbow trout). In addition he has been performing acute sublethal toxicity tests using *Ceriodaphnia dubia*, Echinoderms (sand dollars), and seawater acclimated juvenile Chinook (biomarker/detoxification enzyme test).

1.8 Corporate Background and Experience

1.8.1 General Corporate Information

B.C. Research, Inc. is an environment/ecology focused company providing test, analysis and monitoring services, applied research and development, the development of new technologies, and international new business development. The key areas of specialization are:

- systems engineering, product development and ocean engineering
- remediation and control of air emissions, wastewater and solid waste
- quality control, environmental chemistry and environmental monitoring
- occupational health and ergonomics
- forest biotechnology
- clean fuels for transportation
- information systems and services

Our mission is to provide the highest quality solutions to customer needs, and display an innovative approach utilizing our unique laboratory facilities and blend

of scientific skills. BCRI continues the proud tradition of the former provincial research organization.

Technical, scientific, engineering and support staff at BCRI total approximately 90 with expertise in a wide range of technologies and the applied sciences. Facilities occupy 16,000 square meters on a 3.6 hectare site in Discovery Park just south of the University of British Columbia. There are four laboratory wings ranging in size from 550 to 1250 sq. m., an 800 sq. m. pilot plant, an Ocean Engineering Centre occupying 4500 sq. m., a scientific library (530 sq. m.), offices and a full basement with workshops, storage and additional laboratory space.

1.8.2 Project Experience

BCRI has recently been involved in a program of work sponsored jointly by Environment Canada, Energy Mines and Resources Canada and B.C. Ministry of Environment, to successfully determine coal and diesel soot in dust samples. A procedure was established in which polycyclic aromatic hydrocarbons (PAHs) extracted with different solvents and temperatures, were used to separate and quantify the above two components in dust samples. Nitrogen containing aromatics derived from coal and diesel soot were also investigated.

The experience gained in these previous investigations will be extremely useful in analytical work required in this study of potential toxic compounds derived from coal and sediments.

BCRI has more than thirty years experience in conducting acute and chronic bioassay tests for clients in industry and government throughout North America. Over the years, we have conducted both acute lethal and chronic life cycle studies using a range of freshwater and saltwater organisms. Personnel at BCRI have extensive experience in rearing and maintaining both sea water and freshwater invertebrate and vertebrate test organisms.

BCRI has a large environmentally controlled 15°C bioassay laboratory devoted entirely to trout bioassays (600 sq. ft.) along with six temperature and photoperiod rooms which can control temperatures within the range of 4 to 35°C. Also, BCRI maintains a top quality analytical facility and has the equipment necessary to conduct the tests required in support of bioassays. Our staff has the expertise and experience in handling water quality samples. Our shipping and receiving department is capable of quickly handling large volume consignments.

Also, our staff has worked with, and visited, federal, provincial, and state laboratories across Canada and the US. to confirm that our practices meet current standards. We are participating in the Canadian Association for Environmental Analytical Laboratory testing program. Recent projects include bioassays for the Fraser River Estuary Management Program, Toxicity Identification and Remedial Evaluations (TIRE) for a number of industrial clients and permit bioassays for industry in British Columbia and the United States.

2 MANAGEMENT PROPOSAL

2.1 Project Management

The work will be performed by a team made up of the personnel listed in Section 1.6. BCRI will be responsible for contract management and administration, timely completion of deliverable items, control of costs, preparation of reports and invoicing for payment.

The personnel loading by Task and Level of Effort, and the total work load for each task has been estimated and is summarized in Table 1 and 2 in the Price Proposal. The project manager with responsibility for all deliverables will be Mr. George Pasek. He will also be responsible for coordination of the work, liaison amongst the BCRI project team, and liaison with between BCRI and the Scientific Authority. The Scientific Authority will be informed immediately of any circumstances that may lead to delays or a change in the proposed work schedule.

2.2 Contract Deliverables

Deliverables are as follows.

- Letter style progress reports shall be submitted to the Scientific Authority once a month.
- A draft report (1 unbound original), including the analytical results, shall be submitted to the Scientific Authority by no later than March 30, 1995 for Phase I.
- The complete and final report (1 camera ready, 20 bound and one diskette copy) shall be delivered to the Scientific Authority no later than February 28, 1994. Reports will be prepared as per the Instructions specified in the RFP.

2.3 Sub-Contracts

As BCRI has a full in-house complement of expertise to complete this study, it will not be necessary to sub-contract any portion of this work.

APPENDIX 1

Resumes

GEORGE J. PASEK

Education

B.Sc. (Environmental Biology)
University of Calgary, Alberta 1983.

M.Sc. (Marine Biology)
University of Victoria, British Columbia 1986.

Pulp and Paper Program Certificate,
BC Institute of Technology (1992).

Experience

March 1995
Aquatic Toxicity & Water Quality, BC Research Inc.

1993 to February 1994
Senior Project Manager, Fluor Daniel Inc., Vancouver Branch

Senior project manager responsible for marketing, securing and completing a diverse variety of projects, including; site assessments, remediation, auditing, emergency env. response planning, sampling, quality assurance/quality control services, feasibility studies, and regulatory permitting and permit negotiations.

- Faced with an ineffective business development plant, designed and set up a networked computer client tracking system, resulting in more efficient client marketing.
- Directed a comprehensive licensing requirements study for a green field ethanol plant in central BC, to ensure environmental compliance during construction and start-up operations (confidential client).
- Conducted an environmental feasibility study for a proposed $800 Million northern BC copper mine project, and a proposal for a Soviet mine expansion project (confidential clients).

1993
Senior Manager, Bovar Environmental Services

Senior manager responsible for all aspects of Bovar's BC operations, including administrative and technical affairs. Provide leadership in BC market development and company expansion through increased revenue, restructuring, and corporate acquisitions of complimentary businesses. Fully accountable for two regional branches and their profitability. Technically active in project management and review of air monitoring and hazardous waste work performed by 12 staff.

- Managed an $800,000 comprehensive multi-site, low-level on-site PCP liquid waste treatment, consolidation, compaction and final disposal of 800+ drums of PCP contaminated wastes, Canadian Pacific Forest Products on Vancouver Island.
- Sourced, designed, and managed the construction of a new $70,000 office, service lab for air monitoring equipment, and warehouse facility for the main BC branch, which was fully operational in 6 weeks from the start of construction.
- Completed a financial turn-around in a historically (5 years) unprofitable region for the company in only 8 months. Streamlined operations and reduced expenses, while increasing revenues by $20,000 per month.

1991 to 1993
Eurocan Pulp and Paper Co.

Responsible for all env. activities in the pulp and paper mills, including water, air quality, and waste management. Managed the on-site analytical laboratory. Supervised, motivated and trained 3 staff, and guided activities of external consultants, and contractors.

Liaised with regulatory agencies, and developed and implemented new env. programs and guidance manuals. Active role in public relations and negotiations with special interest groups.

- Teamed up with Beak Consultants to design, initiate, and pioneer an innovative analytical investigative procedure to isolate fish tainting compounds in mill effluent (Toxicity Reduction Evaluation).
- Effectively administered a $2.4 million operations budget, resulting in an annual cost savings to the company of $55,000.

1990 to 1991
Chemex Labs (Alberta) Inc.

Consulted to key accounts regarding environmental laboratory services: including water, sludge, soil, PCB, and air quality monitoring, pulp & paper industry analyses, bioassays, environmental impact assessment related to engineering projects, and hazardous waste management. Initiated joint-venture projects with suppliers of laboratory equipment to provide laboratory equipment to clients' in-house production laboratories.

- Contracted out 8 Chemed staff on long-term contract to client facilities, resulting in 100% bilabial staff for periods of up to 2 years.
- Doubled the previous year's sales volume, resulting in an 85% expansion of the company's existing environmental division.
- Engineered and constructed a state-of-the-art trout and *Daphnia* toxicity (bioassay) testing facility for Chemed. Capital pay-back was achieved within only 6 months, while securing a 30% market share.

1986-1989
General Manager, Canadian Oceanic Research

As the general manager and consultant, set up and operated an environmental research laboratory/consulting firm. Directed general company activities, in both technical and administrative roles. Hired and supervised 6 employees.

- Secured a $90,000 contract to conduct marine underwater research for the federal Dept. of Fisheries. Conducted marine habitat evaluation and environmental impact assessment studies.

Pre-University Employment
Environmental Biologist, Alberta Environment (University summer job).

Environmental Lab Technician, Shell Canada Resources Ltd. (2 years).

Representative Project Experience

Fluor Daniel Inc.

Conducted an environmental feasibility study for a proposed $800 Million northern B.C. copper mine project (Kennecott Corporation), and a proposal for a Soviet coal mine expansion (Yakutugol).

Provided expert testimony for a compliance defense for a confidential pulp and paper client.

Managed a complex underground storage tank decommissioning project for Albert Wheat Pool, Vancouver.

Secured a special water discharge permit for Pacific Coast Terminals Co. Ltd., Port of Vancouver, to allow for marine discharge of hydrostatic test waters.

Directed a comprehensive licensing requirements study for a greenfield ethanol plant in central B.C., to ensure environmental compliance during construction and start-up operations (confidential client).

Bovar Environmental Services

Managed an $800,000 comprehensive multi-site, low-level on-site PCP liquid waste

treatment, consolidation, compaction and final disposal of 800+ drums of PCP contaminated wastes, Canadian Pacific Forest Products on Vancouver Island.

Sourced, designed, and managed the construction of a new office, lab, and warehouse facility for the main B.C. branch.

Successfully completed a financial turn-around in a historically unprofitable region for the company in only 8 months.

Designed closure plans for a foundry on-site slag landfill, based on ecological and human health risk assessment, and negotiated the acceptance of these plans by regulators, Mainland Manufacturing in Richmond, B.C.

Senior manager on numerous hazardous waste transportation and disposal project.

Stakeholder participation in developing a strategic plan for removal of PCBs from B.C. to Chem-Security Co.'s hazardous waste treatment facility in Swan Hills, AB.

Volunteered to design an environmental program for the 1993 Pulp and Paper Expo. Chaired environmental sessions.

Eurocan Pulp and Paper Co.

Teamed up with Beak Consultants to pioneer an innovative analytical and investigative procedure for identifying and isolating fish tainting compounds in mill effluent. Project design, implementation, and management.

Overall project management of a compliance audit of 23 emission source structures to the source emission testing code.

Reduced the mill's environmental liability by conducting a permit compliance audit, and developed a guidance manual for proper permit excursion notification and reporting.

Initiated an environmental impact study associated with a proposed replacement of an underground, river effluent outfall, to gain regulatory approval.

Formulated a permit application for increased hog fuel burning emissions, as trade for minimizing hog pile (bark) leachate runoff.

Project manager for a power boiler emissions performance study, based on hog fuel feed rates and other burning control variables, resulting in license approval to burn more hog fuel.

Developed and implemented a spill contingency plan, and trained a mill management staff of 80+, as part of an environmental liability reduction strategy.

Formulated an impact statement and license applications for a chip-pile runoff stream dredging and channeling project.

Conducted periodic permit amendments and inspections of a licensed PCB storage site.

Successfully negotiated with B.C. Environment for a reduction of monitoring breadth and frequency of effluent permit parameters. saving the company at least $200,000 annually.

Participated as a stakeholder's representative on an open forum on increasing user fees for permit holders.

Negotiated with B.C. First Nations with respect to environmental impairment issues, resulting in conflict resolution between Eurocan and the Haisla band.

Design and project management of a landfill leachate collection system consisting of ditches, piping, pumping station and monitoring. project was initiated to reduce leachate loading on adjacent fish-bearing streams.

Member of the Council of Forest Industries Environmental Committee (industry technical and lobby group).

Chemex Labs (Alberta) Inc.

Responsible for project work involving laboratory services: including water, sludge, soil, PCB, and air quality monitoring; pulp & paper industry analyses; bioassays; support for environmental impact assessment related to engineering projects, and hazardous waste management.

Provided short- and long-term contract/laboratory personnel to in-house environmental labs at clients' facilities (e.g. Dupont, Slave Lake Pulp & Paper Co., Alberta Envirofuels).

Engineered and constructed a state-of-the-art trout and *Daphnia* toxicity (bioassay) testing facility for Chemex.

Participated in successful negotiations of a landfilling permit for waste burner ash for Slave Lake Pulp & Paper Co., resulting in a large savings of landfill tipping fees.

Guided above client in rigorous effluent quality monitoring based on a temporary permit to operate during startup operations, to ensure successfully securing a regular permit.

Performed a facility audit of Ritchie Bros. heavy equipment auction grounds, Edmonton, AB.

Canadian Oceanic Research

Conducted an environmental impact assessment, biota inventory, and marine habitat evaluation of a foreshore area near Port Hardy, B.C., which was subject to

industry pressure for kelp bed harvesting, for the Department of Fisheries & Oceans.

Set up a laboratory to facilitate the identification of benthic invertebrates.

Management of a project dealing with underwater data collection, transect demarkation, and photographic documentation via SCUBA diving and boat work.

Other Projects

Environmental Impact Assessment of a proposed ungulate grazing area in the National Parks System.

Conducted saline soil remediation test project for wellhead spills, for Shell Oil Company, Calgary, AB.

Researcher for a pesticide application research project for Alberta Environment, for mosquito control in urban areas.

Chief analyst for a gamma radiation tracer study to determine hydrogeological conditions associated with oil production, Shell Oil Co., Calgary, AB.

JIM McKINLEY

Education

Ph.D.
Doctoral Thesis in Physical Organic Chemistry in the Area of Reaction Mechanisms and Synthesis of Small Ring Compounds
University of British Columbia, 1972.

M.Sc.
University of British Columbia, 1969.

B.Sc.
University of British Columbia, 1967.

Experience

June 23, 1993 - Present
Program Leader, Industrial Chemistry and Engineering
B.C. Research Inc.

1986 – 1993
Program Leader, Organic Chemistry Group, Industrial Chemistry Division
British Columbia Research Corporation

- Responsible for research and development in areas of organic chemistry.
- Leads projects relating to biomass liquefaction, specialized organic analyses, and synthetic organic chemistry.
- Involved in methods development, process development, problem solving, and technical assistance to government, private industry, and the legal profession.

1979 – 1986
Senior Project Coordinator, Organic Chemistry Section, Environmental Laboratory, British Columbia Ministry of Environment

- Directed and managed organic chemistry projects for all British Columbia government ministries.

- Acted as provincial emergency coordinator for laboratory and appeared as an expert witness in legal cases.
- Experience in the analysis of insecticides, herbicides, fungicides, hydrocarbons, and other organic contaminants in all types of materials.

1972 – 1979
Head, Organic Analytical Section, Water Quality Branch
Environment Canada

- Responsible for planning and supervising analytical work for both organic and inorganic substituents in water, wastewater, sediments, and other substrates.
- Provided advice for field programs and participated in field trips.

1972
Post Doctoral Fellow, Department of Chemistry
University of British Columbia

Conducted research and prepared publications in the field of synthetic chemistry.

GRAEME MASSON

Education

B.Sc. Biology/Chemistry
University of British Columbia, 1972.

Experience

June 23, 1993 - Present
Industrial Chemistry and Engineering
B.C. Research Inc.

1988 – June 22, 1993
Research Scientist, Organic Analysis Group, Industrial Chemistry Division, British Columbia Research Incorporated

- Responsible for management of projects relating to industrial and environmental analytical chemistry.
- Focus areas relating to supervising GC/MS method development, analysis of pesticides, environmental pollutants and industrial products, related data interpretation and technical reports.
- Develop and supervise staff in the review and implementation of a broad range of specialized organic analytical methodology for industrial and environmental studies.
- Provide technical assistance and problem solving for interdisciplinary projects at BC Research, government agencies, industry and the legal profession.

Selection of projects managed and completed to date.

- Determination of PPT Level Pesticide Contamination in Lower Fraser Valley Aquifers.
- Analysis of PCBs, PAHs, Chlorophenols and PCDDs/PCDFs in Sediment and Biota.
- Review of Chemical Tracers Used For Monitoring Wood Smoke Emissions.
- A Study of Putrescine and Cadverine Levels in Fish Tissue.

- Analysis of Volatile Carbonyl Compounds in Early and Late Run Salmon.
- Analysis of Hexazinone in Ground Water and Soil - Study of Hexazinone Movement Following Aerial Application.
- Analytical Study of Insecticide, Herbicide and Trihalomethane Residues in Drinking Water.
- Evaluation of Proprietary Process for the Determination of Quaternary Alkyammonium Salts used as Anti-Sapstain Products in the Treatment of Lumber.

Other Project Involvement

- Determination of Polyaromatic Hydrocarbons in Wood Liquifaction Products by Gas Chromatography/Mass Spectrometry (SIM).
- Bioassay Toxicity Study of Garlon.
- Identification and Monitoring of Chlorinated Phenolics and Resin Acids in Kraft Pulp Mill Effluent.

1981 – 1987
Laboratory Scientist, Organic Chemistry Section
British Columbia Ministry of Environment

- Responsible for supervision and management of analysis and method development in the organic chemistry group.
- Liaise with clients regarding sampling procedures, analysis and interpretation of results.
- Supervise technical staff in the implementation of new organic chemistry methodology using GC/MS, GLC and HPLC procedures .
- Legal scientist - responsible for supervising analysis and final reports for legal samples. Identified as an expert witness by the British Columbia Provincial Court and have been subpoenaed to give testimony in court regarding analytical chemistry.
- Assist in the development of field sampling programmes.
- Direct and report the results of analyses of provincial emergency samples and hazardous waste materials.

1974 – 1980
Inorganic Chemistry Section
British Columbia Ministry of Environment

- Responsible for trace metal analysis of water, wastewater sediment and biological samples.
- Tabulate and report analytical results.
- Method development and implementation.
- Training of junior staff.
- Quality control.

PATRICIA LYNN KEEN

Education

B.Sc., Chemistry
University of British Columbia, 1986.

Diploma Technology, Chemistry and Metallurgy
British Columbia Institute of Technology, 1980.

Completed graduate level courses related to pulp and paper technology and environmental engineering at the University of British Columbia.

Experience

June 23, 1993 – Present
Aquatic Toxicity Laboratory, Environmental Science & Engineering Division
B.C. Research Inc.

As a member of the aquatic toxicity group, Ms. Keen manages the *Daphnia magna* and Microtox bioassay programs. She is involved in marine and sediment toxicity testing. As sales representative for the aquatic toxicity laboratory,she is responsible for promoting activities of the toxicity laboratory and the Environmental Science & Engineering division.

June, 1988 – June 22, 1993
Analytical Chemistry Section and Bioassay Section of Applied Biology
British Columbia Research Corporation

Responsibilities included inorganic chemical analyses of contract and QA/QC samples. Duties in the Bioassay Section include toxicity analyses of samples using aquatic and marine species, method development and non-routine biological analyses.

January – September, 1992
Aquatic Toxicity Laboratory, British Columbia Ministry of Environment

Responsibilities included toxicity analyses of water samples, effluents and sediments using a range of freshwater and marine species. Duties included sample preparation, analyses, statistical analysis of results, culture maintenance and method development.

May 1979 – May 1984
Technologist, Analytical Chemistry Laboratory, MacMillan Bloedel Research Ltd.

Experience involved chemical and biological analyses of samples originating from pulp and paper process sources.

Applicable Memberships

Society of Environmental Toxicology and Chemistry (SETAC)

JANET PICKARD

Education

B.Sc. in Natural Resources
Cornell University, 1973.

Technical Writing Course
Simon Fraser University, 1991.

Experience

June 23, 1993 – Present
Technologist, Environmental Sciences & Engineering
B.C. Research Inc.

1989 – June 22, 1993
Technologist, Waste Management Program
British Columbia Research Corporation

Technologist responsible for both field sampling and bioassays of samples. Developed and maintains daphnid cultures for bioassays.

- Sampling and reporting for permit compliance.
- Monitoring landfill leachate treatment system.
- Field sampling for site assessment.
- Toxicity testing with fish and daphnids.
- Developed daphnid culture and bioassay procedures.
- Chemical analysis of pollutants.

1980 – 1989
Farrs Honey House

- Owned and managed an apiary and honey processing/packaging plant.
- Processed financial statements.
- Hired and supervised staff.
- Insured quality control of final products.

1973 – 1974
National Oceanographic and Atmospheric Administration

- Conducted multi-user survey for recreation areas.
- Analysed fish and water samples.