ENVIRONMENTAL SITE ASSESSMENT
GULF OF GEORGIA CANNERY
NATIONAL HISTORIC SITE
STEVESTON, B.C.

Prepared for:

Public Works Canada
Architectural and Engineering Services for
Environment Canada

Prepared by:

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1.0 INTRODUCTION

1.1 Background

Envirochem Special Projects Inc. was retained by Public Works Canada, Architectural and Engineering Services for Environment Canada to conduct a three phase environmental assessment at the Gulf of Georgia Cannery National Historic Site in the village of Steveston in Richmond, B.C.. The Gulf of Georgia Cannery was built in 1894 and operated as a cannery and subsequently a reduction plant (reducing fish to fish oil and fish meal) until 1979. The property is now owned by the Canadian Parks Services of Environment Canada and part of the existing structure is leased to Canfisco for warehousing purposes. The future use of the site is intended as a museum open to the public with as much of the existing equipment remaining in place as possible.

Given the historic activity on the site, it was considered likely that it may contain soil and groundwater contaminants, and other wastes which might constitute an environmental or human health concern. The purpose of the assessment was to:

- characterize soil and groundwater conditions;
- establish the scope and nature of any environmental or human health concerns associated with past activity on the property; and,
- determine whether remedial action will be necessary to permit safe use of the site for its intended purpose or to alleviate any future environmental liability.

In addition to the identification of existing subsurface conditions and the evaluation of the nature and disposition of any organic and inorganic contaminants that might be encountered in the facility, the work involved the development in a preliminary sense, the necessary cleanup work required and the identification of potential disposal strategies for dealing with contaminants or wastes encountered on the site.

The report details the field investigation, including trenching, drilling, monitoring well installation and all sampling work undertaken. In addition, the report presents the analytical results of the chemical testing work carried out on selected soil, sediment and groundwater samples, and suspected hazardous materials recovered from the facility during the field program. A discussion of the findings of the investigation, as well as the most appropriate remedial alternatives has also been included.

1.2 Scope of Work

The environmental assessment was conducted using a phased approach. The first phase of the assessment consisted of a site inspection, a preliminary inventory of hazardous materials on the site and a review of historical activities related to the operation of the Cannery. The second phase of the assessment consisted of finalization of the hazardous materials inventory and field screening tests including shallow soil sampling and a geophysical survey to locate potential areas of contamination. The third phase consisted of intrusive field investigations to obtain specific information on contaminant presence, extent and severity in soils and groundwater at the former Cannery, including trenching and drilling.

The scope of work for the three phase assessment was the following:

- Historical review of the site and adjacent properties using available documents at the Cannery to identify any past activities or industrial processes which may have impacted on the lands of interest.

- Facility evaluation of the main Cannery building and associated buildings including the oil storage shed, the ice house and the lead foundry. The buildings were visually examined for the presence of controlled or designated substances which could pose an environmental or a health and safety concern (e.g. asbestos). Selected samples were submitted for analysis for the potential contaminants of concern.

- Subsurface investigations at selected locations to characterize the general soil, sediment and groundwater conditions across the site and at specific areas where contamination is suspected based on historic land use information and based on the results of the field screening tests.

- Identification of environmental or health and safety concerns associated with the facility.

- Identification of appropriate remediation alternatives and approximate cost estimates.

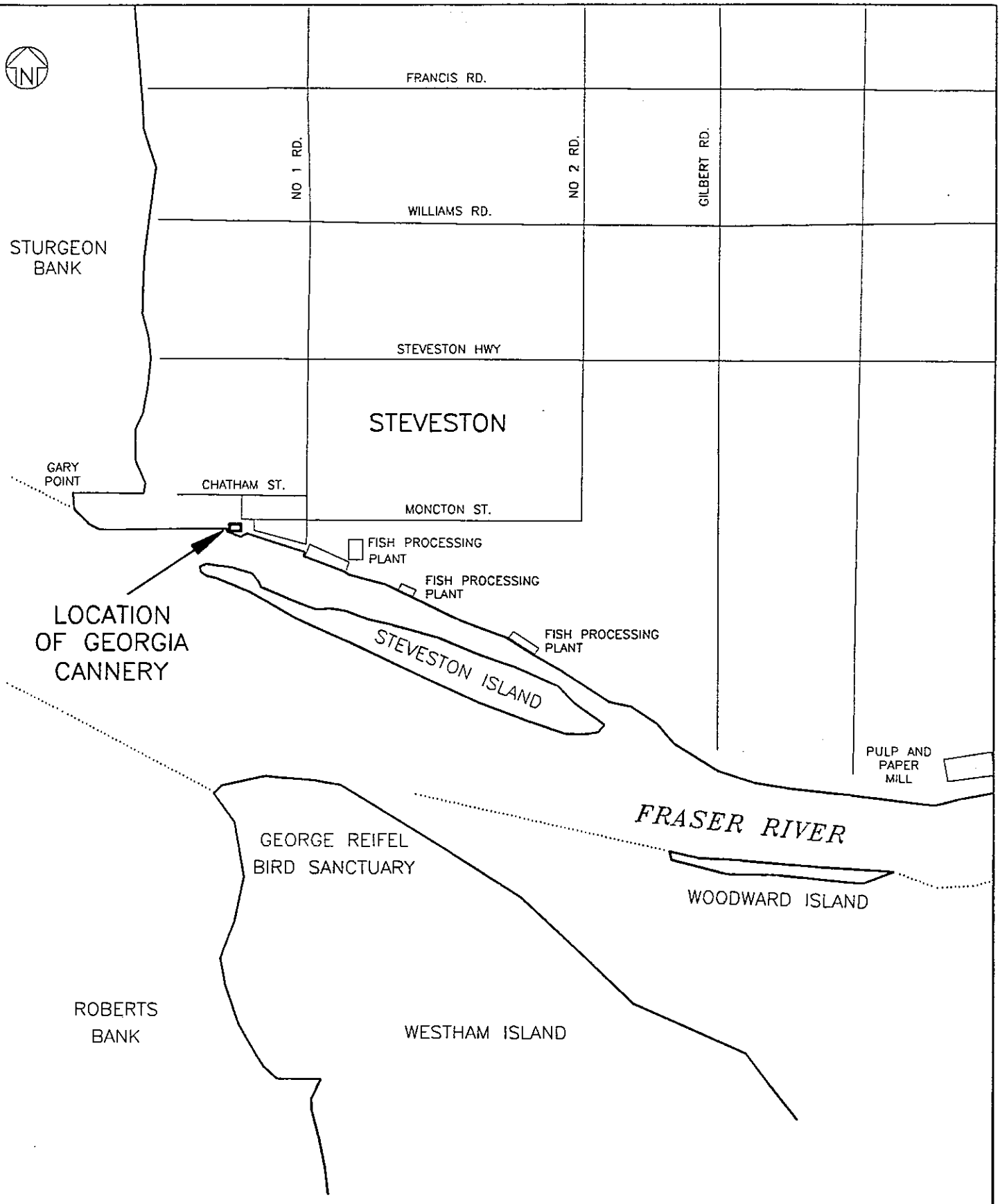
Due to the value of the Cannery as a historic site, the field work was designed to be as minimally intrusive as possible. Test trenching was generally limited to a small section of the property between the pedestrian walkway and the visitors centre where it was deemed less of an archeological concern.

2.0 SITE AND HISTORICAL SURVEY

The Gulf of Georgia Cannery (Cannery) site is located on the south arm near the Fraser mouth at the end of 4th Avenue in the village of Steveston in Richmond, B.C. (Figure 1). As shown in Figure 2, the main cannery structure is bounded to the south by the Fraser River and by mooring docks for fishing boats, to the east by the shops and restaurants of Steveston, to the north by the Cannery office with grounds extending to Chatham Street and to the west by Canfisco's warehouse and wharf. The area surrounding the Cannery is used by light industrial and commercial operations, generally warehousing, storage and boating activities related to fishing, and shops and restaurants along the main streets of Steveston. Residences are located to the north across Chatham Street. A portion of the Gulf of Georgia Cannery's main structure is currently leased by Canfisco for net storage and repair.

The entire facility is built on wooden piles over water and fill with the exception of the Cannery office (the visitor's centre) which lies approximately 25 m to the north of the historic dyke outlined in Figure 2. The area on the river side of the historic dyke has been built up by fill. The topography surrounding the Cannery is relatively flat and to the north of the dyke the ground slopes gradually down to the north and east. The only vegetation on the site is small portions of grass in the vicinity of the Cannery office building on the northern half of the facility and on either side of the pedestrian walkway. During high tide the water extends up to the oil storage shed (see Figure 2). At low tide the water extends only to as far as the wharf at the front of the building.

A review of historical land use of the property can provide valuable information on the nature and location of potential soil or groundwater contamination and thus comprises an important component of the site characterization investigation. The records held by the Canadian Parks Service in the Cannery's Visitor Centre were reviewed. The detailed history of the Cannery plant has been reconstructed in several documents (Barbour, 1986., A.P.T. Conference Draft, 1987). The fire insurance maps were also referenced as they provide specific detail of areas of potential concern.



0 0.2 0.4 0.6 0.8 1.0
KILOMETRES

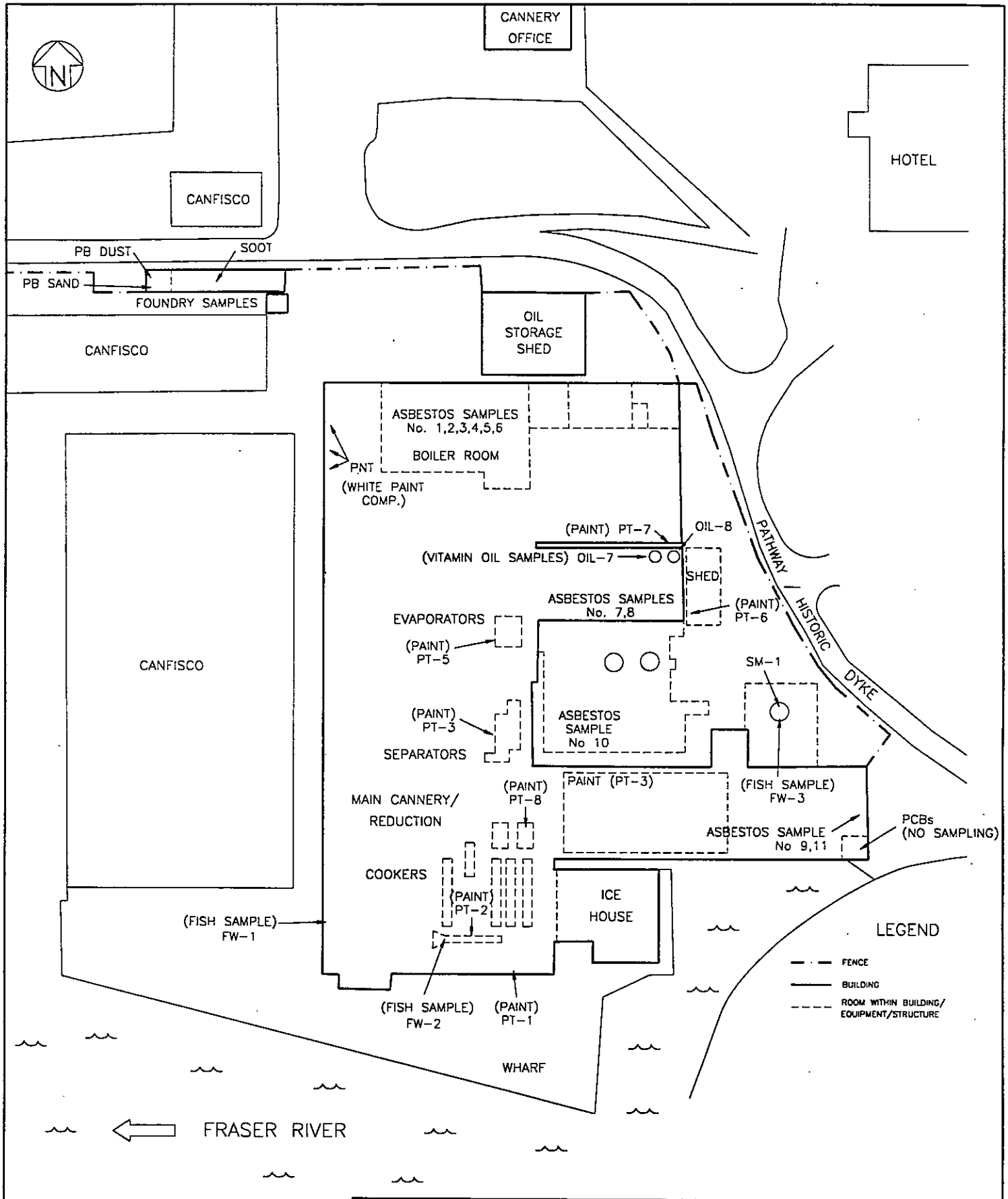
Envirochem

TITLE: LOCATION MAP

SUPERVISOR:	LJE	DATE OF WORK:	1993
DRAWN BY:	PW	DATE DRAWN:	17-MAR-93
REVISED BY:		DATE REVISED:	.
PROJECT NUMBER:	1253	DRAWING NUMBER:	1253-02

PROJECT: GULF OF GEORGIA CANNERY

FIGURE: 1



Envirochem

TITLE:
SITE PLAN
SHOWING FACILITY SAMPLING LOCATIONS

SUPERVISOR:	LJE	DATE OF WORK:	1993
DRAWN BY:	PW	DATE DRAWN:	12-MAR-93
REVISED BY:	PW	DATE REVISED:	27-APR-93
PROJECT NUMBER:	1253	DRAWING NUMBER:	1253-01

PROJECT:
GULF OF GEORGIA CANNERY

FIGURE:
2

The Gulf of Georgia Cannery was built in 1894 and most of the original Cannery building is still in place. The buildings are constructed of wood and stand on pilings over tide water. It was originally built as a salmon cannery. In the 1940s, the Cannery shifted to a herring canning line and a reduction plant. During this time period, major changes were made to the Cannery, including the addition of cookers, presses, a drier, centrifuge, settling tanks, a metal grinder and a sacking machine. It was also during this period that the new structures included a vitamin oil shed, refrigerator tanks, a fish oil tank wharf platform to accommodate external storage tanks, a fish oil drum storage shed, a meal warehouse and an ice house. The canning operation was phased out by the end of the 1940s but continued to operate as a reduction plant until 1979. Currently part of the main structure continues to be used by Canfisco as a storage warehouse, particularly for net storage. In 1984, Environment Canada took over the Cannery and in 1987 began its architectural stabilization. The Cannery office to the north is used as a Visitors Centre and as a Parks Canada office.

While Cannery operations do not generally involve complex chemical processes utilizing or generating large quantities of hazardous raw materials or wastes, a number of organic and inorganic contaminants would have been produced and possibly discharged to the property. The predominant potential sources of contamination to the buildings, air, soil or groundwater affecting the property include:

i) lead contamination through fallout from the stack of the lead foundry, as well as, associated dust and soot within the building
ii) petroleum products from above-ground storage tanks
iii) organic contaminants associated with fish oil production and storage
iv) contamination associated with fill material placed on the site
v) historic discharge of oils, grease, cleaning solvents, paints, acids or other waste compounds into the ground surface around the plant
vi) pathological waste associated with residual fish which remains in equipment and on ceilings
vii) asbestos use throughout the building
viii) PCB equipment in service or in storage, and
ix) lead dust generated from flaking and peeling paint throughout the facility.

3.0 FACILITY EVALUATION

A preliminary walk-through facility inspection of the Cannery complex was conducted on 6 November, 1992. The complex consists of the original Cannery built in 1894 as well as several additional structures built in the 1940s.

The purpose of the audit was to establish whether any controlled (e.g. PCBs), designated (e.g. asbestos) or hazardous (e.g. solvents) materials existed within or in close proximity to the buildings which could potentially affect the future use of the building as a museum open to the public or impact on soil and groundwater conditions. The buildings and surrounding yard were inspected for the presence of PCBs, asbestos, chemical and fuel storage tanks and other materials with potential for concern.

Asbestos

Hansen & Associates Ltd. were sub-contracted to evaluate the presence of asbestos materials in the building that may pose a hazard to the general public if the Cannery is used as a museum, or may pose a hazard to maintenance or outside contractors. The complete report on the sampling locations and detailed results is included as Appendix A.

Samples taken as part of the survey are shown in Figure 2 and are as follows:

- boiler room (northwest portion of cannery)
  - No.1 - exterior boiler insulation on the eastern most boiler (denoted Boiler #1)
  - No.2 - the brick mortar on the centre boiler (Boiler #2)
  - No.3 - the strap material from the western most boiler (Boiler #3)
  - No.4 & 5 - the plaster from the walls of the boiler room and underlying cement
  - No.6- the rolls of gasket material stored in the boiler room

- vitamin oil room
  - No.7 - packing material
  - No.8 - gasket on the wall

- siding and roofing

  No.9 - the grey transit siding on the east side of the drier room

  No.11- black tarry roofing material

- miscellaneous

  No.10 - pump stored outside on the oil tank storage platform. > not owned by CPS.

Analysis of samples taken during the survey confirmed asbestos was present in the following locations:

Friable (readily crumbled, brittle)

- insulation between the metal shells of the two main boilers #1 & #2 (central and eastern most boilers)
- exterior insulation on redundant pump found outside

Non-friable

- textile material on boiler #3
- gasket material in boiler room locker
- manufactured gaskets throughout
- exterior building siding (east side)
- gland packing material on stored shelves

The friable asbestos within the boiler insulation is not accessible nor susceptible to damage unless work is done on the boilers, and therefore is not an immediate concern. The friable asbestos on the redundant pump is vulnerable to disturbance and thus poses a significant concern. The non-friable asbestos is not a concern in its present condition. It could become a concern if it became friable i.e. easily broken and crumbled.

PCBs

Eight GE PCB capacitors are located on the mezzanine level of the former bagging room on the eastern side of the building. Another potential source of PCBs are the very limited number of fluorescent lighting ballasts. Results of previous investigations have shown that 50 to 70 % of fixtures currently in use and installed before 1979 have ballasts containing PCBs. It is therefore

assumed that the existing fluorescent fixtures at the Cannery have a high probability of containing PCB-containing ballasts.

Vitamin Oil

During a preliminary classification of the site by Environment Canada, a concern was raised that wood stained with fish oil may be toxic. The fish oil was one of two products from the reduction process and was supplemented with Vitamin A and D and used as animal feed.

Oil samples were recovered from each of the fish oil aging tanks and submitted for analysis of Vitamin A and Vitamin D at General Testing, a division of SGS Laboratory. The results of both oils were the same -

Vitamin A	-	0.27 mg/g	(approx. 810 I.U./g)
Vitamin D	-	0.02 mg/g	(approx. 800 I.U./g)

Vitamin A is an essential organic compound. Deficiencies may produce eye lesions, nerve degeneration and bone abnormalities. However, toxic symptoms from large doses of Vitamin A occur. Acute health effects to adults from Vitamin A exposure have been reported upon ingestion of doses from 2,000,000 and 5,000,000 I.U.. Chronic health effects have been reported at dosages in excess of 3,000 I.U./kg body wt/day (3,000 I.U. is approximately 1,000 μg micrograms).

Therefore, a person weighing 50 kg would experience chronic health effects with a dosage of 150,000 I.U./day. The Vitamin A concentration of the oil from the Cannery is 0.27 mg/g or 270 μg/g, which is approximately 810 I.U./g. This means that someone would have to ingest 185 g of Cannery oil (i.e., just over 1/3 of a pound) to reach a chronic dosage for one day and at least 2.5 kg (5 lbs.) to reach an acute dosage. A child of 15 kg would be sensitive to a dosage of 53 grams. By analogy there should be little risk to visitors of the museum from the limited amount of Vitamin A stained wood located in the Vitamin Oil Shed. If it is assumed that the wood contains 10 % fish oil, ingestion of 1 lb of wood by a child would be required. In addition, vitamins break down over time through exposure to light and heat, and thus the concentration will decrease over time.

Similarly for Vitamin D, the concentration in the oil is 0.02 mg/g or 20 μg/g. There are approximately 40 I.U. of Vitamin D per μg. Therefore, the concentration is 800 I.U./g. The recommended daily allowance for Vitamin D is 400 I.U.. The "no toxic effect" level for infants is reported at 2,000 I.U. per day and Vitamin D is considered toxic at 1,000 I.U./kg body wt/day. Ingestion of 20 grams of Cannery oil would be required to exceed the toxic limit for a 15 kg child. Such intakes from wood are highly unlikely. Thus, there is minimal cause for concern with regard to the oil-soaked wood.

Envirochem contacted Mr. Barry Morgan, the Chief of Food Inspection Division of Health and Welfare Canada for further guidance. Mr. Morgan believed there was no human health concern through either dermal absorption or ingestion, based on the concentrations found in the oil relative to typical dosages.

Pathological Substances

Several areas of the Cannery have fish remains splattered on the walls and ceiling, as well as, fish remains in conveyors and presses. Although it seemed unlikely, a concern was raised that salmonella may be associated with the fish remains. Envirochem recovered three fish gut samples; one from the wall in the southwest corner of the building; one from the raw fish conveyor; and one from the "stinkeroo". The samples were analyzed for *Salmonella* and *Listeria*. The latter was thought more likely, given the Cannery had been closed for at least thirteen years. Both tests were negative for each of the three samples and thus should not pose any further concern in the Cannery.

Histoplasmosis can be caused by pigeon feaces which were present at the Cannery site. However, most feaces were cleaned up at the Cannery by the time the site inspection was undertaken. Wiring has been installed to prevent pigeons from reentering the Cannery, therefore, alleviating this concern in the future.

Lead Contaminated Materials

Due to the lead foundry operation, the potential for lead contamination was a concern particularly in the westernmost one-third of the building where the foundry stack is located. Samples were taken of dust and debris from the vicinity of the stack as well as a sample of sand

in a 5-gal pail. The lead concentration in the dust was 25 % and poses a significant potential concern to human health and the environment. The concentrations of lead in the sand was negligible.

Due to the age of the Cannery, the white exterior and interior paint on all of the buildings was suspected as containing lead and poses a potential concern as the paint is flaking and coming off in publicly accessible locations. Lead comprised the only major white pigment available until the 1940s with the introduction of titanium oxide. In addition, coloured paint on the equipment was also suspect. Therefore, select equipment and wall samples were analyzed for metals including lead. In total, three white wall paint samples were analyzed, as well as, green paint from the conveyors, blue paint from a pump stored outside, yellow paint from the evaporators, black paint from the centrifuges, grey paint from the presses and white paint from the ends of the drier units. The only existing regulatory guideline for metals in paint is for lead and therefore, the interpretation of the quantitative results for the other metals is subject to some uncertainty. The lead concentrations are presented below:

Sample Location (Fig.2)	**Lead Concentration (ppm)** = mg/L
# 1 Wall - Northwest Corner (PNT)	2,010
# 2 Wall - Southwest - Mezzanine (PT-1)	2,110
#3 Wall - East Wall by doorway (PT-7	17,100
Green paint - conveyor (PT-2)	5,270
Blue paint - pump (stored outside) (PT-6	65,700
Black paint - centrifuge (PT-3)	9,210
Yellow paint - evaporator (PT-5)	12,200
Grey paint - presses (PT-8)	37,900
White paint - drier (PT3)	482

There are currently no criteria or standards for lead in paints, but a standard of 500 ppm has been applied during abatement projects for lead-contaminated dusts in South Riverdale of Toronto, Ontario. With the exception of the white paint on the end of the driers, all of the paint sampled was well in excess of 500 ppm. The lead-based white paint also contained high levels of barium and zinc, the yellow paint contained high levels of nickel, chromium (lead-chromate paint) and arsenic, the blue paint contained high levels of copper and chromium. The laboratory reports including all metal results are included as Appendix 8.

The paint on most of the equipment and limited portions of the walls is flaking and peeling off and will be removed prior to repainting. Special precautions will be necessary to protect workers and the environment from fugitive dust emissions and for disposal of the resulting accumulated dust and debris.

"Stinkeroo"

The "stinkeroo" is an exterior stack located on the concrete pad to the north of the drier building and is approximately 3 m in diameter and 10 m high. It is reported to have been used to vent or burn off odoriferous volatiles from the fish reduction process.

A sample of the oily, gummy cake lining the "stinkeroo" was submitted for mineral oil and grease analysis, polycyclic hydrocarbon analysis (PAHs) and metals analysis in order to characterize the material. The results are compared to existing Special Waste criteria for the B.C. MOE under the B.C. MOE Special Waste Regulation.

In order to determine whether a waste classifies as a Special Waste containing polycyclic aromatic hydrocarbons (PAHs) under the B.C. MOE Special Waste Regulation, a weighted calculation procedure is used to generate a single PAH toxicity equivalent (TEQ) value. The waste is considered a Special Waste containing PAHs if the TEQ is greater than 100 ppm.

Sample of Oily Cake Lining Inside of "Stinkeroo"

Parameters		Concentration (ppm)	B.C. MOE Special Waste Criteria
Metals	Copper	289	100 (CCME residential)
	Nickel	105	100 (CCME residential)
PAHs	PAH TEQ	2.40	100
Extractables	Oil and Grease	19%	-
	Mineral Oil and Grease	11%	3%

The oily cake lining in the "stinkeroo" classifies as a fully regulated Special Waste as the mineral oil and grease concentration is greater than 3 %. Therefore the oily cake must be handled and disposed of in full compliance with B.C. Ministry of Environment (B.C. MOE) Special Waste Regulation.

Miscellaneous Substances

A small inventory of liquid and hazardous wastes remains in Cannery including:

- creosote (1 litre can)
- lubricating oil (5 gal. pail)
- gear oil (5 gal. pail)
- cylinder oil (5 gal. pail)
- marine paint (1 litre)
- asphalt paving seal (5 gal pail)
- empty freon canisters
- industrial cleaner (45 gal. drum)

The materials represent a very small volume of waste and do not pose a significant concern. They should be consolidated and disposed by permitted receivers of liquid and hazardous wastes.

Fish oil was the largest volume of liquid handled and stored in the facility and therefore had the greatest chance of release to the soil and groundwater through spillage and leakage. Prior to the 1990s, fish oils reportedly contained high concentrations of chlorinated organic compounds such as PCBs and DDTs as a result of bioaccumulation. Therefore, the fish oil was submitted for analysis for polychlorinated biphenyls (PCBs) and organochlorine pesticides to determine the potential for contaminating the soil and groundwater. The laboratory report is included as Appendix B. The results are presented below:

Parameter	Concentration (ppm)
Total PCBs	0.86
Total Organochlorine Pesticides	<0.864
4, 4' DDD	0.059
4, 4' DDE	0.597
4, 4' DDT	<0.010

It is suggested that these concentrations should not pose any concern with regard to soil and groundwater contamination. The Health and Welfare Canada limit for PCBs in fish tissue is 2.0 ppm, and the Environment Canada limit for PCBs in transformer oil is 5.0 ppm. The Canadian DDT (total) limit in fish tissue is 1.0 ppm.

Air Sampling - Lead Dust

Hansen & Associates conducted air sampling for lead dust on March 30, 1993 to determine if the lead paint on the wall and/or the equipment poses any immediate concern to the staff of the Cannery, Canfisco or to the general public if the buildings are used as a museum. The Hansen report is included as Appendix C. The sampling was conducted in three separate areas of the building by using a leaf blower to disturb the walls, floor, ceiling and any equipment in the vicinity. This was done in order to simulate airborne dust generated during heavy traffic

through the Cannery, i.e. the worst case scenario. Three samples were taken and the results are as follows:

Sample Location	Concentration (mg/m^3)
North Entrance	<0.01
South Entrance	<0.01
East Entrance	<0.01

The Workers' Compensation Board of British Columbia permissable exposure limits for airborne dust is 0.15 mg/m^3. Therefore, potential exposure to lead dust in the Cannery building should not be a concern.

4.0 SUBSURFACE INVESTIGATIONS

4.1 Preliminary Investigations

Preliminary field investigations were conducted to assess potential sources of contamination with minimal expense and disturbance to the site. Unfortunately, the geophysical survey was limited to the small area of property south of the visitor's centre and north of the blacktop pedestrian walkway as all other areas were too close to sources of interference. Shallow soil sampling was conducted using a Vibra Corer Portable Drill.

4.1.1 Geophysical Survey

A geophysical survey was conducted on the northern portion of the Cannery site on November 12, 1992 by Delta Geoscience Ltd..

The objective of the geophysical survey was to map anomalous magnetic susceptibility and ground conductivity which may be related to buried metals and debris at the site.

The geophysical survey consisted of a total magnetic field survey combined with vertical magnetic gradient measurements using the E.D.A. Omni Proton Magnetometer. The survey area was limited due to the close proximity of interfering objects, such as steel fences, poles, building walls, etc.. The geophysical survey is presented in more detail in Appendix D, including all of the maps.

With reference to the Contoured Total Field Map (Map #1) and the Vertical Gradient Profile (Map #2), the relatively strong linear looking gradient anomalies which occur in line along coordinated 147E-148E (running north-south aligned with the eastern edge of the Cannery office - Maps, Appendix B) are probably due to a buried pipe, such as the old gas line entering the Cannery. The anomalies present at 126E, 86N (centre of study area aligned with western edge of Cannery office - Maps, Appendix B) could be associated with piping or valves from the Bunker C storage tank, formerly located in this area. The relatively small areal distribution of any anomalies indicates it is unlikely that an underground steel tank or similar structure is buried in the study area.

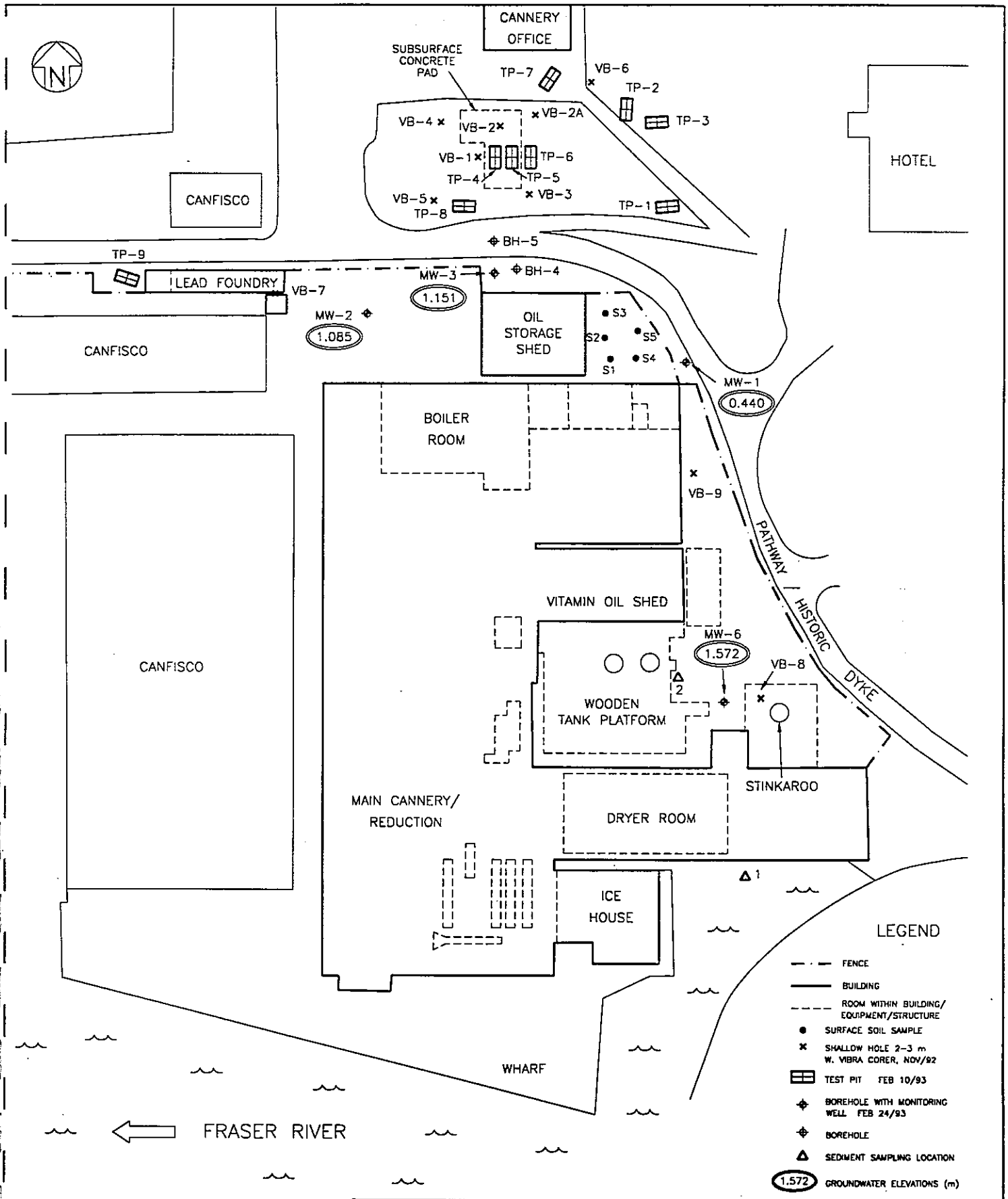
4.1.2 Shallow Soil Sampling

Shallow soil sampling was conducted on November 19, 1992, using a Vibra Corer Portable Sampling Drill. The Vibra Corer provided 5 cm continuous cores to depth of 1.5 m in order to visually observe the subsurface conditions and recover soil samples for subsequent laboratory analysis. The eight test hole locations are shown in Figure 3.

The primary potential for contamination was the area of the former above-ground Bunker C tanks between the public walkway and the Cannery office (visitor's centre). Six shallow holes VB-1 - VB-6 were placed in this area at depths to 3 m. Bunker C contaminated soil was evident in VB-1, VB-2, VB-2A and VB-6 at depth ranging from approximately 30 cm to 60 cm below grade. The concrete pad on which the three Bunker C tanks were stored is still in place (Figure 3). It seems that when the tanks were decommissioned a layer of Bunker C remained on the concrete pad and clean pre-load sand was placed on top followed by a thin layer of top soil and sod. Visual observation of soils from the shallow holes suggested that the Bunker C contamination spreads northwest beyond the concrete pad.

Selected samples were submitted for mineral oil and grease analysis, total petroleum hydrocarbon analysis and metals. The results are summarized in Table 1 and 2. As there is currently no CCME criteria for mineral oil and grease, the B.C. MOE Criteria for Managing Contaminated Sites have been used for comparison purposes. Mineral oil and grease concentrations in excess of the B.C. MOE Level C Criteria (remediation criteria for industrial land use) was found in VB-1, VB-2A and VB-6, ranging in concentration of 2.07% to 11.4%. One sample of the Bunker C contaminated soil constituted a Special Waste under the B.C. MOE Special Waste Regulation as the mineral oil and grease concentration was greater than 3% (i.e. 11.4 %).

Metals analysis was conducted on two samples from a test hole adjacent to the lead foundry (VB-7), one sample adjacent to the "stinkeroo" (VB-8), and one located along the east side of the building (VB-9). Only one parameter, copper, slightly exceeded the CCME Remediation Soil Criteria for residential land use. This surface soil sample was obtained from VB-7, adjacent to the lead foundry.



Envirochem

TITLE: SITE PLAN

SUPERVISOR:	LJE	DATE OF WORK:	1993
DRAWN BY:	PW	DATE DRAWN:	12-MAR-93
REVISED BY:	PW	DATE REVISED:	27-APR-93
PROJECT NUMBER:	1253	DRAWING NUMBER:	1253-01

PROJECT: GULF OF GEORGIA CANNERY

FIGURE: 3

Sample ID Depth (m)	VB-7 S1 0.2-0.3	VB-7 S2 1.0-1.5	VB-8 S1 0.1-0.2	VB-9 S1 0.1-0.2	CCME Remediation Soil Criteria Residential	 Industrial
Arsenic	11.5	7.8	4.53	1.85	30	50
Barium	332	66.2	46.8	52.6	500	2000
Cadmium	0.46	<0.10	<0.10	<0.10	5	20
Chromium	47.5	47.3	13	29	250	800
Cobalt	8.4	14.1	5.6	8.9	50	300
Copper	159	49.8	15.1	14.1	100	500
Lead	410	68.4	8.9	3.6	500	1000
Mercury	1.35	0.205	0.006	0.024	2	10
Molybdenum	<4.0	<4.0	<4.0	<4.0	10	40
Nickel	34.8	35.7	7.2	32.2	100	500
Selenium	0.13	0.23	<0.10	<0.10	3.0	10
Silver	<2.0	<2.0	<2.0	<2.0	20	40
Tin	37	<30	<30	<30	50	300
Zinc	308	106	49.6	46.3	500	1500

Exceeds Residential Criteria
Exceeds Industrial Criteria

TABLE 1: GULF OF GEORGIA CANNERY VIBRA CORER SOIL SAMPLES (mg/Kg)
RESULTS OF METAL ANALYSES:

Sample ID	Depth (m)	Mineral Oil & Grease	TPH
VB-1	0.3-0.6	20700	4380
VB-1	0.6-1.2	583	NA
VB-2A	0-0.6	1100	NA
VB-2A	0.8-0.9	3890	1200
VB-2A	1.5	28600	NA
VB-2A	3	144	NA
VB-3	0.3-0.6	314	< 10
VB-4	0.2-0.6	271	NA
VB-6	0.5-0.6	114000*	29300
VB-7	0.2-0.3	NA	NA
VB-8	0.1-0.2	70	NA
VB-9	0.1-0.2	NA	NA
BC MOE Criteria			
Level B		1000	400
Level C		5000	2000
Special Waste	*	30000	-

NA not analysed
- no criteria

TABLE 2: GULF OF GEORGIA CANNERY VIBRA CORER SOIL SAMPLES (mg/kg)
RESULTS OF MINERAL OIL & GREASE ANALYSES:

Greater details of soil contamination were required in the vicinity of the previous Bunker C storage area and the lead foundry. As a result, trenching and drilling were used to provide detailed information on horizontal and vertical dispersal of contaminants.

4.2 Trenching, Drilling and Soil Sampling

The detailed field investigations consisted of trench excavations, drilling, soil sampling, monitoring well installation and groundwater sampling. Field investigations were initiated February 10 and completed March 2, 1993.

4.2.1 Trenching and Soil Sampling

Nine test trenches were excavated by use of a mini-excavator to enable a visual inspection and sampling in the unsaturated zone. The locations of trenches are shown in Figure 3. Eight trenches were located in the vicinity of the oil contamination previously identified during the shallow soil sampling using the Vibra Corer, and one trench was placed in the vicinity of the lead foundry. The purpose of the trenches was to more fully delineate the petroleum hydrocarbon contamination and to recover additional soil samples in the limited area in the vicinity of the lead foundry for metal analysis.

The trenches were excavated to depths ranging from approximately 1 to 2 m. Visual and olfactory observations were used for soils from various depth intervals. Observations included: stratigraphic changes, presence of buried debris, presence of an oil phase, and hydrocarbon or other odours. Trench soil samples to 1 m depth were obtained from the wall of the trench and soils to 2 m depth were obtained from the backhoe bucket using a clean scoopula. Nineteen soil samples were collected from the trenches. Descriptions of the trench soil samples are provided in Appendix E.

4.2.2 Drilling and Soil Sampling

A sonic drilling rig was mobilized to the site on February 24, 1993 and a series of six boreholes were drilled with monitoring wells installed in four of the boreholes. The sonic rig was selected for its ability to produce a continuous, 10 cm diameter soil core, allowing for full description of soil stratigraphy and unrestricted soil sampling.

The borehole and monitoring well locations are shown in Figure 3. Monitoring wells were installed in boreholes 1, 2, 3, and 6 hence the designation MW. Boreholes 4 and 5 were not used for monitoring wells hence the designation BH. Boreholes MW-1 and MW-2 were located in positions to assess the fill material and to provide information on groundwater gradient. Boreholes MW-3, BH-4, and BH-5 were located to assess contamination associated with the Bunker C supply line into the warehouse and to assess contaminant migration from the source. Borehole MW-6 was located to assess contamination in the vicinity of the "stinkeroo". Fourteen soil samples were collected on the basis of field observations (soil type, groundwater depth, soil staining or odour where present) and the samples were immediately archived in the Envirochem cold room prior to submission for analyses.

4.3 Installation, Development and Groundwater Sampling

Monitoring wells consisting of 5 cm diameter slotted PVC pipe were installed in Boreholes MW-1, MW-2, MW-3, and MW-6 for the purposes of monitoring groundwater levels, conducting hydraulic conductivity testing, and collecting groundwater samples. The details of the monitoring well construction are shown on the borehole logs included in Appendix F. Monitoring wells were not installed in Boreholes BH-4 and BH-5 as these were shallow boreholes intended to delineate the extent of oil contamination identified in Borehole MW-3.

The site was revisited on March 2, 1993 and a level survey was conducted to establish the elevations of the monitoring well collars and the ground surface adjacent to the monitoring wells. The depth to water in each well was measured and the groundwater elevation calculated in order to allow for determination of the direction of groundwater flow. Water samples were collected from each well following purging of the appropriate volume of water using dedicated inertial water sampling pumps.

4.4 Foreshore Sediment Sampling

Foreshore sediment samples were collected from the southeastern corner of the Cannery beneath the wharf and from beneath the oil storage tank platform during low tide as shown on Figure 3. Sediment samples were submitted for a Microtox test as well as analysis for metals and mineral oil and grease to determine if off-site migration was occurring from the contaminated areas.

4.5 Analytical Program

Soil samples were obtained during trenching and drilling as described in Section 4.2. The samples were stored in glass containers covered with teflon lined lids. Sample descriptions are provided in trench and borehole logs in Appendix E and F. A total of 19 soil samples were collected during trenching and 14 soil samples were collected during drilling.

The recovered soil samples were reviewed by Envirochem in conjunction with the field test trench and borehole logs. Selected soil samples were submitted to Analytical Service Laboratories (ASL) for determination of: metals, polycyclic aromatic hydrocarbons (PAHs), and organochlorine pesticides. Mineral oil and grease, total oil and grease and total petroleum hydrocarbons (TPH) were conducted an Envirochem's in-house laboratory. The laboratory and Quality Assurance and Quality Control reports are included in Appendix B.

Groundwater samples were submitted to Analytical Service Laboratories Ltd. for metals, total petroleum hydrocarbons (TPH), PAHs and organochlorine pesticides.

5.0 PHYSICAL CHARACTERIZATION OF SUBSURFACE

The subsurface soil conditions, as encountered in the nine trenches and six boreholes completed on-site, are described below. A detailed record of the soil and groundwater conditions in each borehole and trench is given in the individual borehole and test trench logs included in Appendix E and F.

5.1 Site Stratigraphy

The soil stratigraphy at the site is highly variable, but in general consists of fill material (silt, sand, rip rap) to approximately 3 m depth underlain by native silt and sand to at least 6.7 m, the maximum depth of borehole placement. Evidence of buried metal ceramic debris was found in the fill of MW-2 and buried slag in TP-9. The soil stratigraphy in the eight test pits excavated south of the Cannery office and north of the pedestrian walkway, generally consisted of 0-0.6 m of pre-load medium brown sand underlain by grey clay, and brown silt underlain by coarse sand to at least 2 m, the maximum depth of trenching. Evidence of petroleum hydrocarbon contaminated soil was observed at shallow depths in Borehole MW-3 and trenches TP-4, TP-5, TP-6, and TP-7. This contamination was not observed in the immediately adjacent boreholes BH-4, BH-5. The detailed stratigraphy, variations between boreholes, and soil sample locations are shown on the borehole logs in Appendix F.

5.2 Groundwater Regime

Water levels in the four monitoring wells installed at the site were measured during relatively high tide conditions on March 2, 1993 and the groundwater elevations are shown on Figure 3 and Appendix G. As all of the monitoring wells were located along the edge of the foreshore area, it is not possible to illustrate a groundwater gradient for the site without additional wells located farther inland. However, it is inferred that the groundwater gradient and the net direction of groundwater flow will be towards the Fraser River.

6.0 CONTAMINANT DISTRIBUTION

The overall purpose of the three phase site assessment was to identify any potential environmental concerns and to identify possible remediation options to ensure the site does not pose any risks to human health and the environment. The Interim Canadian Environmental Quality Criteria for Contaminated Sites (CCME, 1991) was used to assess the severity of contamination in the soils and groundwater at the Gulf of Georgia Cannery. The CCME guidelines include numerical values for the assessment and remediation of water and soil for agricultural, residential/parkland and commercial/industrial land uses. To evaluate data for a site investigation the criteria appropriate for the intended land use are used to assess the severity of contamination. Because the eventual land use at the Gulf of Georgia Cannery is anticipated to be a public museum, the criteria specified for commercial/industrial have been used to assess the severity of contamination at the site.

The CCME Criteria have adopted contaminated sites criteria from several Canadian jurisdictions including the B.C. Ministry of Environment Criteria for Managing Contaminated Sites. For some parameters such as mineral oil and grease and total petroleum hydrocarbons, which do not have CCME Criteria, the B.C. Ministry of Environment Criteria have been used for comparison purposes.

6.1 Subsurface Soil Quality

Metal Contamination

The results of the metals analysis are shown in Table 3A and 3B. Metals analyses were emphasized on soil samples obtained near the lead foundry. Additional soil samples from other test areas were submitted to obtain a general characterization of the soil on the property.

Elevated levels of lead in excess of the CCME industrial/commercial criterion (1750 ppm vs. 1000 ppm) were found in the near-surface sample obtained from TP-9, the test trench excavated adjacent to the lead foundry. A slightly elevated level of barium above the CCME industrial criterion of 2000 ppm was found at 0.4 m from the same test trench. In addition, copper and lead above CCME residential criteria were found in soil samples taken from depths at 0.4 m and

Sample ID	TP - 1	TP - 1	TP - 6	TP - 9	TP - 9	TP - 9	TP - 9	CCME Soil Criteria	
Depth (m)	0.7	1.2	0.5-0.7	0.15-0.2	0.4	0.5-0.6	0.8	Residential	Industrial
Arsenic	1.43	1.18	3.27	2.41	3	7.35	7.71	30	50
Barium	50.6	140.0	69.4	90.5	2070	194	68.3	500	2000
Cadmium	<0.10	<0.10	0.26	0.17	<0.10	<0.10	<0.10	5	20
Chromium	12.9	7.8	29.3	25	54.2	54.6	50	250	800
Cobalt	5.8	4.5	5.8	7.7	15.8	9.1	6.5	50	300
Copper	14.6	10.9	17.6	80.3	206	158	31.8	100	500
Lead	9.5	4.6	50	1750	686	642	18.4	500	1000
Mercury	0.022	0.007	0.036	0.026	0.016	0.234	0.058	2	10
Molybdenum	<4.0	<4.0	<4.0	<4.0	4.3	<4.0	<4.0	10	40
Nickel	8.1	4.5	30.7	21.3	78	32.8	26.6	100	500
Selenium	<0.10	<0.10	0.1	<0.10	0.13	0.34	0.31	3.0	10
Silver	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	20	40
Tin	<30	<30	<30	<30	<30	<30	<30	50	300
Zinc	41.7	37.2	107.0	114	67.6	98.7	75	500	1500

Exceeds Residential Criteria
Exceeds Industrial Criteria

TABLE 3A: GULF OF GEORGIA CANNERY TEST TRENCH SOIL SAMPLES (mg/kg)
RESULTS OF METALS ANALYSES:

Sample ID	MW1 S1	MW1 S2	MW1 S3	MW2 S4	MW2 S5	MW3 S8	MW3 S9	BH4 S11	MW6 S13	MW6 S14	S1-S5	CCME Soil Criteria	
Depth (m)	0.8	2.2	4.5	1.1	3.5	1.2	2	0.8	2.8	4.2	Comp.	Residential	Industrial
Arsenic	3.39	5.46	2.81	0.55	18.5	4.61	3.49	5.28	6.49	2.81	15	30	50
Barium	123	74.6	65.4	44.1	134	70.9	67.5	126	72.1	55	111	500	2000
Cadmium	<0.10	<0.10	<0.10	<0.10	0.56	<0.10	<0.10	0.15	<0.10	<0.10	1.18	5	20
Chromium	38.7	58.2	55	36.9	27.1	50.9	52.1	54.7	46.9	49.5	47.6	250	800
Cobalt	13.1	18.3	15.5	9.3	8.1	7.4	7.8	11.1	12.9	13.9	11.5	50	300
Copper	36.2	37	33.3	13.6	121	32.4	23.5	86	36.3	27.6	128	100	500
Lead	10.8	15.8	6.1	<2.0	578	8.2	7.6	87.7	26.1	5.5	1080	500	1000
Mercury	0.038	0.074	0.049	0.02	3.33	0.052	0.059	0.199	0.049	0.055	1.18	2	10
Molybdenum	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	10	40
Nickel	25.7	41.2	46.7	31.5	45	20.5	24.8	44.9	33.9	45.2	34.2	100	500
Selenium	0.11	0.25	0.17	<0.10	<0.10	0.21	0.18	0.19	0.2	0.18	0.26	3	10
Silver	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	20	40
Tin	<30	<30	<30	<30	433	<30	<30	49	<30	<30	222	50	300
Zinc	78.8	91.8	84.6	40.8	488	66.7	62.4	177	94.4	73.3	850	500	1500

Exceeds Residential Criteria
Exceeds Industrial Criteria

TABLE 3B: GULF OF GEORGIA CANNERY BOREHOLE AND SURFACE SOIL SAMPLES (mg/kg)
RESULTS OF METALS ANALYSES:

at 0.5-0.6 m. The upper 0.6 m of TP-9 consisted of fill material including sand, slag and crushed asphalt. Based on the lead level from the near-surface sample taken from VB-7 which was below the CCME residential criterion of 500 ppm the approximate extent of lead contamination on the Cannery property in excess of CCME industrial criteria is shown in Figure 4.

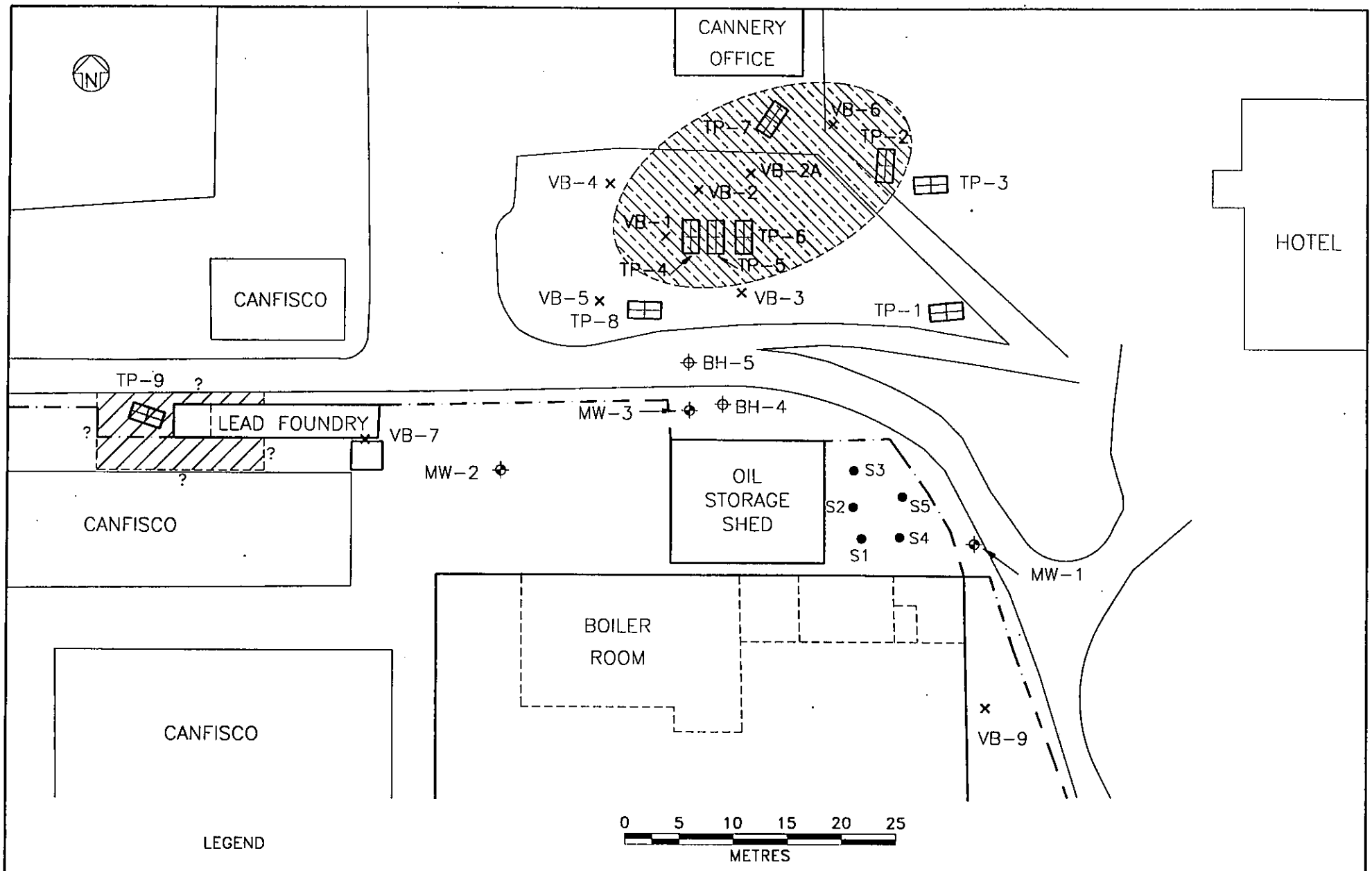
Slight elevated levels of copper, and mercury above the CCME residential criteria were found in Borehole MW-2 in the asphalted area adjacent to the guard house and the lead foundry. In addition, lead levels were found slightly above the CCME residential criteria in the same test location at a depth of approximately 3.5 m. An elevated level of tin above the CCME commercial/industrial criteria was also found in this sample. Buried metal scrap and debris were found in the fill material in the area of MW-2 and are likely responsible for the elevated metal levels. The depth of contamination prevents exposure to the general public.

A surface sample composite obtained from beneath the former fish oil cradles at the northeast corner of the property (Figure 3) slightly exceeds the CCME Remediation industrial criteria for lead. The specific source of the lead is uncertain but reflects the ubiquitous nature of lead at the site. Contaminated fill and vehicle activities are likely the sources in this area. The concentrations are not considered to be of concern because this area is inaccessible to the public (fenced off) and vegetated.

Petroleum Hydrocarbon Contamination

The primary purpose of undertaking the test trenching at the Gulf of Georgia Cannery was to delineate the Bunker C oil contamination found during the shallow soil sampling using the Vibra Corer. Soil samples were selected for mineral oil and grease analysis primarily on the basis of visual and olfactory observations in each trench to determine the vertical extent of contamination.

The mineral oil and grease results are shown on Table 4. Mineral oil and grease levels above the B.C. Ministry of the Environment Special Waste level of 3 % were found in vicinity of the Bunker C storage tank area, i.e. in test trenches TP-2 and TP-6 and Vibra Corer samples VB-6 Heavy contamination was visually observed in TP-4, TP-5 and TP-7. The estimated extent of contamination is shown in Figure 4. The high levels of oil and grease are in all cases probably



Envirochem

SUPERVISOR:	LJE	DATE OF WORK:	1993
DRAWN BY:	PW	DATE DRAWN:	12-MAR-93
REVISED BY:	PW	DATE REVISED:	27-APR-93
PROJECT NUMBER:	1253	DRAWING NUMBER:	1253-03

TITLE:

SITE PLAN

SHOWING AREAS OF CONTAMINATION

PROJECT:

GULF OF GEORGIA CANNERY

FIGURE:

4

Sample ID	Depth (m)	Mineral Oil & Grease
TP-1	0.7	392
TP-1	1.2	122
TP-2	0.8	65000 **
TP-2	1.8	483
TP-3	1	799
TP-6	0.3	< 100
TP-6	0.5-0.7	267000 **
TP-6	0.7-0.8	37900**
TP-6	2	320
TP-7	1	3490
TP-8	1.1	7740
MW-1	0.8	770
MW-1	2.2	2810
MW-1	4.5	< 100
MW-2	1.1	5300
MW-2	3.5	612
MW-3	1.2	17200
MW-3	2	278
MW-4	0.8	< 100
MW-6	2.8	774
MW-6	4.2	< 200
BC MOE Criteria		
Level A		100
Level B		1000
Level C		5000
Special waste	**	30000

TABLE 4: GULF OF GEORGIA CANNERY TRENCH AND BOREHOLE SOIL SAMPLES (mg/kg)
RESULTS OF MINERAL OIL & GREASE ANALYSES

the result of Bunker C contamination from the former above-ground storage tanks. The oil contamination originates in the general area of TP-4, TP-5 and TP-6 where the oil and grease concentrations are as high as 26.7%. A free oil phase is present and gradually spreads to the northeast up to the visitor's centre. The concrete pad for the former oil tanks is approximately 0.6 m below grade. The approximate thickness of oil contamination lying on the concrete pad varies from approximately 0.2 to 0.3 m.

Slightly elevated levels of mineral oil and grease above the B.C. MOE Level C (industrial) criteria were found in TP-8 and MW-2. A layer of crushed asphalt was found in TP-8 and is the likely source of the elevated level. The sample from MW-2 at a depth of 1 m was marginally over the B.C. MOE Level C criteria. There was no visible nor olfactory evidence of petroleum contamination as occurred in vicinity of the previous Bunker C storage area. Therefore, the contamination is likely associated with the fill material observed in that area.

Oil contaminated soil samples from TP-6 and MW-3 were submitted for analysis of polycyclic aromatic hydrocarbons (PAHs) primarily for characterization purposes. The results are presented in Table 5. The sample from TP-6 which originally contained 26 % oil and grease exceeded the CCME industrial/commercial criteria for several PAH parameters including benzo(a)anthracene, benzo(a)pyrene and phenanthrene. The PAH Toxicity Equivalency (TEQ) was calculated as 21 ppm which is less than the B.C. MOE Special Waste level of 100 ppm PAH TEQ.

On the basis of the oil and grease analysis, the oil contaminated soil in vicinity of the previous Bunker C storage area must be treated as a fully regulated Special Waste according to the B.C. MOE Special Waste Regulation. The approximate volume of this material is 75 m^3.

Miscellaneous Analyses

One oil contaminated soil sample from TP-6 was submitted for polychlorinated biphenyls (PCBs) for characterization to enable and assessment of ultimate disposal options. The concentration of PCBs was below the detection limit and therefore are not a concern.

Sample ID	TP - 6	BH3 S8	CCME Remediation Criteria	
Depth (m)	0.7-0.7	1.2	Residential	Industrial
Acenaphthene	<5.0	<0.10	10	100
Acenapthylene	<2.0	<0.050	10	100
Anthracene	9.01	1.02	10	100
Benzo(a)anthracene	17.4	6.72	1	10
Benzo(a)pyrene	14.6	6.09	1	10
Benzo(b)fluoranthene	9.09	2.23	1	10
Benzo(ghi)perylene	7.66	3.26	-	-
Benzo(k)fluoranthene	1.65	0.227	1	10
Chrysene	16	6.12	-	-
Dibenz(ah)anthracene	3	1.29	1	10
Fluoranthene	8.96	0.9	-	-
Fluorene	20.7	0.521	-	-
Indeno(1,2,3-cd)pyrene	3.48	0.759	1	10
Naphthalene	<2.0	<0.02	5	50
Phenanthrene	67.3	4.05	5	50
Pyrene	47.7	11.8	10	100
PCB	<0.05	NA	5	50

Exceeds CCME Residential Criteria
Exceeds CCME Industrial Criteria

NA = Not analysed
- = No Criteria

TABLE 5: GULF OF GEORGIA CANNERY TRENCH AND BOREHOLE SOIL SAMPLES (mg/kg)
RESULTS OF PAH AND PCB ANALYSES

In addition, one soil sample from MW-1 was submitted for organochlorine pesticides. This area had the greatest potential for release of fish oil. All organochlorine pesticides were below the detection limit and should not be a concern on the site.

6.2 Foreshore Sediment Quality

Two foreshore sediment samples were obtained during low tide from beneath the Cannery building and submitted for mineral oil and grease analysis, metals analysis, and to Beak Consultants for a Microtox analysis. The locations of sediment sampling is shown on Figure 3 Sediment #1 from the southeast corner and Sediment #2 from below the fish oil storage tank platform on the east side of the building. The Microtox bioassay measures the toxicity of the sediment based on light emission from a bioluminescent bacteria in the presence or absence of a toxicant. The EC_{50} is the concentration of sample causing a 50% reduction in bioluminescence. Therefore, the higher the EC_{50}, the less toxic the sediment. The Microtox bioassay results, the mineral oil and grease results and metals analyses are summarized in Table 6.

Sediment quality criteria have not yet been developed at either the provincial or federal regulatory level. The B.C. MOE is currently establishing provisional Water Quality Objectives which also include sediment quality on a site-specific basis. Limited objectives have been published for the Fraser River estuary and Burrard Inlet (B.C. MOE; 1988, 1990). However, because the objectives are site-specific they cannot be applied generically. Hence, the water quality objectives for sediments in Burrard Inlet have been summarized in the data tables for discussion purposes only. The Burrard Inlet objectives were chosen because they have been developed for a larger group of contaminants. Other related regulatory standards listed are the Washington state, Department of Ecology, Sediment Management Standards (1991) developed for the Puget Sound area. As regulatory criteria for mineral oil and grease concentrations in marine sediments have not been established the analytical results were compared to the B.C. MOE's Level B and C Criteria.

Both sediment samples exceeded the B.C. MOE Level B criteria for oil and grease. Elevated levels of mineral oil and grease are not unexpected as the wharves in front of and adjacent to the Cannery are used for mooring fishing boats which likely represented an ongoing input of petroleum hydrocarbons into the water from fuel drips, leaks and spills over the years.

Sample ID	SED1	SED2	MOE Objective	Washington State Standard
Arsenic	18.4	70.5	20	57
Barium	109	135	-	-
Cadmium	0.16	0.31	1	5.10
Chromium	54.2	66.8	60	260
Cobalt	14.9	12.8	-	-
Copper	64.5	107	100	390
Lead	24.3	76.7	30	450
Mercury	0.084	0.176	0.15	0.41
Molybdenum	<4.0	<4.0	-	-
Nickel	53.1	51.5	45	-
Selenium	0.31	0.39	-	-
Silver	<2.0	<2.0	-	6.10
Tin	<30	49	-	-
Zinc	160	238	150	410
	Exceeds MOE Provisional Objectives			
	Exceeds Washington State Standards			
Microtox EC50	1312	9104	-	-
Mineral Oil & Grease	1775	2631	Level B 1000	Level C 5000

TABLE 6: GULF OF GEORGIA CANNERY MARINE SEDIMENT SAMPLES (mg/kg)
RESULTS OF METALS AND MINERAL OIL & GREASE ANALYSES:

The sediment sample taken beneath the fish oil storage tank platform exceeded the B.C.MOE provisional sediment quality guidelines and the Washington State criteria for arsenic. Elevated levels of arsenic are not uncommon in seawater sediments. Typical levels of arsenic found in the sediments of Puget sound ranged from 57 to 640 ppm (Konasewich *et al.*, 1982). The Sediment #2 sample also exceeded the B.C. MOE provisional guidelines for chromium, copper, lead, mercury, nickel and zinc whereas the Sediment #1 sample only slightly exceeded the guideline for nickel and zinc.

Despite the fact that Sediment #2 had higher overall levels of metals and mineral oil and grease the results of the Microtox test showed a higher toxicity in Sediment #1 (EC_{50} 1,312 ppm) taken from the southeast corner of Cannery closest to the Fraser River than Sediment #2 (EC_{50} 9,104 ppm) taken directly beneath the Cannery in the vicinity of the oil storage tank platform. Microtox values from other Fraser River sediments have ranged from 2,000-10,000 ppm according to Beak Consultants. As the downstream sample (#1) was more toxic than the sample (#2) closest to the potential chemical releases from the Cannery, it is considered that the Cannery is not significantly impacting the foreshore sediments.

6.3 Groundwater Quality

In order to define the level of chemical contamination in groundwater, groundwater samples were recovered from each monitoring well drilled at the site: MW-1, MW-2, MW-3 and MW-6. The groundwater would not be used for domestic consumption and releases to the marine environment are the only potential concern. Specific criteria levels for groundwater for the protection of saltwater aquatic life are not available. Therefore, the data were compared with the CCME Assessment Criteria for Water and the U.S. EPA published reviews of toxicity to marine biota. The CCME Assessment Criteria represents the approximate achievable analytical detection limits for organic parameters and the approximate background levels for inorganic parameters. Groundwater with concentrations at or below this level are considered uncontaminated.

Metals Analyses

The results of the dissolved metals analyses of the groundwater samples are shown in Table 7. The concentrations of dissolved metals in MW-1 slightly exceeded the CCME Assessment criteria for arsenic, molybdenum and nickel; in MW-2 exceeded the criteria for barium, copper, lead, nickel and zinc; in MW-3 exceeded the criteria for nickel. The results from MW-6 are all within the Interim Assessment Criteria.

Copper and lead are the only metals which exceed concentrations for documented chronic effects to marine biota. Copper in MW-2 exceeded the acute toxicity values reported for blue mussels. The elevated levels of metals detected in the groundwater are likely due to the fill material, particularly in the vicinity of MW-2 where buried scrap metal and debris were found. The overall loading of copper and lead from the site cannot be estimated, however, the effects if any would be localized. Lead in MW-2 exceeded reported chronic effect levels by a factor of three, and copper exceeded the lowest reported chronic effect levels by a factor of 20.

Petroleum Hydrocarbon Analyses

Groundwater samples from each monitoring well were analyzed for total petroleum hydrocarbons (TPH) in order to assess whether the Bunker C contamination found in the soils north of the pedestrian walkway was impacting the groundwater downgradient and potentially discharging into the Fraser River. In addition, groundwater from MW-3 and MW-6 were analyzed for polycyclic aromatic hydrocarbons (PAHs) as PAHs were detected in the soil at MW-3 and were found in the "stinkeroo", upgradient of MW-6. The results are given in Table 7. All results are less than the analytical detection limits and therefore the groundwater does not appear to have been impacted by the oil contaminated soil on the site.

Miscellaneous Analyses

For general characterization purposes, groundwater from MW-6 was also analyzed for PCBs and organochlorine pesticides as this test location is in close proximity to the oil storage tank platform. PCBs and organochlorine pesticides were detected in the fish oil. Both PCBs and all organochlorine pesticides analyzed were less than the analytical detection limit and therefore should not pose a further concern.

Well Number	1	2	3	6	CCME Assess. Criteria	US EPA Marine Biota Toxicity Chronic	Acute
Dissolved Metals							
Aluminum	2.47	0.41	0.35	<0.2	-	-	-
Antimony	<0.2	<0.2	<0.2	<0.2	-	-	-
Arsenic	0.0057	0.004	0.0043	0.0005	0.005	0.1	0.2-16
Barium	0.029	0.052	<0.01	<0.01	0.050	-	>50
Cadmium	<0.0002	<0.0002	0.0002	<0.0002	0.001	-	-
Calcium	29.5	18.2	8.17	16.1	-	-	-
Chromium	<0.015	<0.015	<0.015	<0.015	0.015	0.03-0.13	2-105
Cobalt	0.003	0.005	0.003	0.002	0.010	-	-
Copper	<0.01	0.116*	0.019*	<0.01	0.025	0.005	0.006-0.6
Iron	1.96	11.9	0.334	8.62	-	-	-
Lead	0.001	0.164	0.001	<0.001	0.010	0.05	0.7-23
Magnesium	35.6	12.4	5.67	29.7	-	-	-
Manganese	1.23	0.727	0.302	1.22	-	-	-
Mercury	<0.00005	0.00006	<0.00005	<0.00005	0.0001	-	-
Molybdenum	0.008	0.002	0.004	<0.001	0.005	-	-
Nickel	0.015	0.025	0.015	0.004	0.010	0.3	0.3-1.2
Potassium	13.7	7.9	3.9	9.7	-	-	-
Selenium	<0.0005	<0.0005	<0.0005	<0.0005	0.001	-	-
Silver	<0.0001	<0.0001	<0.0001	<0.0001	0.005	-	-
Sodium	130	285	41.2	254	-	-	-
Tin	<0.3	<0.3	<0.3	<0.3	0.01	-	-
Zinc	0.012	0.061	0.013	0.005	0.050	0.06	0.17
Total PAH	NA	NA	<DL	<DL	-	-	-
Total PCB	NA	NA	NA	<0.0001	-	-	-
Total Organochlorine Pesticides	NA	NA	NA	<DL	-	-	-

	Exceeds CCME Assessment Criteria
	Exceeds US EPA Marine Biota Toxicity Criteria (Chronic)
*	Exceeds US EPA Marine Biota Toxicity Criteria (Acute)

NA	Not analysed
-	No Criteria
<DW	Below Detection Limit

TABLE7: GULF OF GEORGIA CANNERY
RESULTS OF DISSOLVED METALS, PAH, PCB AND ORGANOCHLORINE ANALYSES:
MONITORING WELL WATER SAMPLES (mg/L)

7.0 SITE REMEDIATION REQUIREMENTS

As reported above, environmental concerns at the Gulf of Georgia Cannery are primarily the result of petroleum hydrocarbon contamination in the soil over a limited area of the property. Further, while the CCME industrial/commercial criteria has been exceeded for lead in surface soil samples taken adjacent to the lead foundry, the levels have only been marginally exceeded and represent a very small area of the property. Lead contamination has been found in the dust and debris in the vicinity of the stack in the lead foundry, in the white paint on the exterior and interior walls throughout the Cannery, and in the black, yellow, grey, blue and green coloured paint on several pieces of equipment in the Cannery.

The object of the recommended site remediation is to ensure that the site does not pose any risk to human health or to the environment and to satisfy the regulatory authorities that any latent environmental and human health concerns have been addressed in accordance to the regulations.

Order of magnitude estimates have been prepared to reflect the costs of undertaking the work that are considered necessary for the facility and subsurface cleanup to permit the use of the Cannery as a museum. Disposal costs vary greatly depending on obtaining the appropriate approval by the regulatory agencies and the acceptance by the disposal facility.

7.1 Facility

Asbestos Materials

The redundant pump discovered during the asbestos survey on the exterior oil storage tank platform contains friable asbestos. However, subsequent to the survey the pump could not be located on the Cannery property. If it is found the asbestos should be removed by a qualified asbestos removal contractor. Friable asbestos was also found in the insulation in the exterior shell at the bottom of the two boilers -the central and eastern boilers (denoted Boiler #1 and Boiler #2 during the asbestos survey). However, the asbestos found on the boilers is fully encased in the metal shell and does not pose a concern in its present condition. It is therefore, not critical that the asbestos be removed prior to opening the boiler room open to the public. The two main boilers should be labelled clearly with regard to the presence of friable asbestos

to prevent accidental exposure to maintenance or outside contractors in the event that work is done on the boilers or they are decommissioned.

The remaining non-friable products including the textile material on Boiler #3 (west), the gasket material in the boiler room locker, gland packing materials on the shelves in the vitamin oil shed, the exterior building siding, and gaskets throughout the Cannery can remain in their current locations without posing any hazard to the building occupants or the general public. The exterior siding of the drier room identified as containing asbestos should be clearly labelled to prevent accidental exposure to workers during maintenance or removal activities. The non-friable asbestos identified during the survey should be observed periodically to ensure they remain in their current condition.

Action: **Remove friable asbestos from redundant pump (if located)**

Priority: **High**

Estimated Cost: **$ 5,000**

Action: **Label boilers #1 and #2 (east and centre) and exterior siding as "Containing Asbestos"**

Priority: **High**

Estimated Cost: **nominal**

Action: **Remove friable asbestos from boilers #1 and #2 (east and centre)**

Priority: **Low**

Estimated Cost: **$ 50,000**

PCB Storage

The eight PCB capacitors currently in service in the mezzanine on the eastern end of the drier room should be taken out of service and placed in storage in compliance with all federal PCB storage requirements as set out in the Canadian Environmental Protection Act. In addition, any fluorescent lighting ballasts removed during relighting programs should be considered 'PCB ballasts' and placed into storage. The capacitors and ballasts should be placed into 18 gauge 45-gal lined or painted drums and vermiculite added to absorb any moisture or leaking liquid. Due to the few capacitors currently in use and the limited number of fluorescent lights in the Cannery, two to three drums would likely suffice. The sealed and fully labelled drums must then be placed on a pallet in a locked, secure storage facility in compliance with the federal storage requirements. An arrangement should be sought with the Department of Fisheries and Oceans to place the drums into their established PCB storage facility in Steveston. Public Works Canada also has an established PCB storage facility which can accommodate three drums.

Action: **Remove PCB capacitors and ballasts from service, place in storage.**

Priority: **Medium**

Estimated Cost: **$ 2,000**

Liquid and Hazardous Material Disposal

There is a small inventory of liquid and hazardous materials on the site including small quantities of creosote (1 litre can), lubricating oil, gear oil, cylinder oil (three 5-gal pails), marine paint (1 litre), asphalt paving seal (5-gal), five small freon canisters and one 45-gal drum of and industrial cleaning product. These materials should be consolidated, packed and disposed of by a hazardous materials disposal contractor (e.g. Laidlaw or Philip Environmental) to prevent the risk of spillage, fire or accidental exposure to the general public. Due to the age of some of the material, the uncertainty of purity and the small quantity, disposing of some of these materials to an oil recycler may not be a viable option but should be investigated.

Empty containers accumulated in the Vitamin A shed such as the Vitamin A canisters can be sent for landfill disposal and the empty 45-gal drums can be sent to an drum recycler such as Can-Am Steel Drums, Great Western Containers or Western Drum Recyclers.

Action: **Dispose of small inventory of liquid and hazardous materials on-site.**

Priority: **High**

Estimated Cost: **$ 3,000**

Cleanup and Disposal of Foundry Lead Dust

Removal of all accumulations of lead-contaminated dust identified in the westernmost segregated portion of the foundry should be undertaken to prevent the ongoing exposure to workers or to the general public as well as discharge to the environment. Although discharge of hazardous dust can potentially be controlled by effectively sealing off that portion of the foundry to the public, it is recommended that the dust be removed using industrial washing and vacuuming procedures by qualified contractors and disposed of as a hazardous waste. The entire brick foundry stack or portions thereof may have to be removed as this structure contains the bulk of the lead dust and contaminated brick. The estimated cost does not include dismantling the stack and resealing the roof.

Action: **Remove and dispose of contaminated dust in the western portion of the foundry.**

Priority: **High**

Estimated Cost: **$ 6,000**

Lead-Based Paint Removal/Stabilization

The interior and exterior walls of the Cannery are painted with a white lead-based paint. There are localized sections of the walls where the paint is flaking and peeling off. The general public would be in direct contact with some of these areas where the wall paint is flaking off during a museum tour. Air sampling results indicate that the lead level in the Cannery is acceptable and thus the paint should not pose an immediate concern to the general public through inhalation. Concerns for lead-based paint have occurred when there was potential for ingestion of paint by children. The concerns are also based on the potential for long-term ingestion, e.g. paint of childrens' cribs etc.. With the possibility of increased public traffic at the Cannery, it is recommended that any potential risks to the public should be reduced. In the absence of long-term exposure by the public, hence reduced rates of ingestion, we suggest that the priority for stabilization is not high.

There are a few options with dealing with the lead-based painted walls. It is possible to completely remove the lead based paint with chemical strippers using qualified contractors and costs can be as high as $ 30 per sq. foot for paint removal alone. The second option is to scrap the easily removed, flaking paint from the localized areas by a qualified contractor and repaint the entire Cannery with a high quality exterior paint to effectively seal the lead in the paint. This would probably have to be redone every three or four years as the paint begins to flake again. The third option is to remove the flaking paint only in those areas of potential concern and repaint the area with a high quality exterior sealant paint. The estimates provided are based on approximate wall area and informal quotes from contractors. More accurate quotes will be necessary by soliciting formal bids from qualified contractors.

An innovative method of removing the paint flakes from areas of the Cannery accessible to the public is by using modified sandblast equipment replacing sand with baking soda proposed by Ceda-Reactor Ltd.. This work area would require encapsulation, a negative airspace and industrial vacuuming cleanup the blasted material. This method ensures that the wood is not damaged, is relatively fast and disposal costs are kept to a minimum as baking soda weighs less than sand.

Option 1: **Remove all lead-based paint from flaking interior walls and those accessible to the public.**

Priority: **Low**

Estimated Cost: **$ 100,000**

Option 2: **Scrap affected areas and repaint entire Cannery.**

Priority: **Low**

Estimated Cost: **$ 25,000**

Option 3: **Scrap affected areas and repaint affected areas.**

Priority: **Medium**

Estimated Cost: **$ 5,000**

Cleanup of Equipment and Tanks:

The majority of the equipment in the Cannery still requires cleaning and painting as much of it still contain fish remains and/or are severely corroded. Metal testing of the paints on the presses, evaporators, conveyors, separators and pumps revealed that the majority of the paints on the equipment have a high concentration of lead. Thus precautions need to be taken in undertaking the cleaning and the disposal and handling of the material removed from the equipment. The equipment can be sandblasted using the same level of control as is used during asbestos removal including encapsulation and personal protective equipment with collection and disposal of the resulting sandblast grit as a hazardous waste. Qualified contractors capable of industrial tank and equipment washing and decontamination should undertake this work. Such contractors include Ceda-Reactor Ltd..

The eight vitamin oil tanks contain residual oil product and although they currently do not pose a concern to human health or the environment it is generally desirable to remove all liquid waste from the Cannery to prevent any accidental spillage or leakage. The tanks should be cleaned using high pressure water or steam with storage and disposal of the oily water and sludge. This work should also be done by a qualified contractor such as Ceda-Reactor Ltd.

Action: **Sandblast equipment to remove lead-based paint.**

Priority: **High**

Estimated Cost: **$ 15,000**

Action: **Clean out vitamin oil tanks.**

Priority: **Low**

Estimated Cost: **$ 7,000**

Cleanup of "Stinkeroo"

There is thick gummy, oily cake buildup on the inside of the "stinkeroo" which should be removed or sealed to prevent leakage onto the ground or exposure to the general public. Removing the cake from the "stinkeroo" would involve setting up a scaffolding and using a high-pressure lance from the top. The water and sludge would then be pumped into a storage tank or vacuum truck for subsequent disposal. The alternative to removing the cake from inside the "stinkeroo" would be to pump out any free liquids at the bottom of the "stinkeroo" and then seal the top and bottom to ensure no rainwater can enter the "stinkeroo" and no sludge can leak out the bottom.

Action: **Remove and dispose of the oily cake and residues in the "stinkeroo".**

Priority: **Low**

Estimated Cost: **$ 12,000**

7.2 Soils and Groundwater

Bunker C Contaminated Soils:

Bunker C contaminated soil was identified in the vicinity of the former above-ground Bunker C fuel tanks just south of the Cannery office and visitor's centre. The oil contamination appears to be limited to an approximate layer of 0.2-0.3 m at a depth of 0.6 m below grade and comprises an in-situ volume of approximately 75 m^3. The concentration of oil in the soil generally ranges from 3 % to 10 % with small pockets of free phase oil. Oil at concentrations above 3 % classify the soil as a Special Waste under the B.C. MOE Special Waste Regulation and require disposal as a hazardous waste to a licensed facility. It is recommended that the contaminated soil be excavated and disposed of to prevent ongoing environmental contamination and to prevent exposure to the general public. The soil, once excavated would be stabilized and disposed of in a secure landfill in the United States through Laidlaw or Philip Environmental (@ $400/tonne) or through Hazco (@ $ 200/tonne) in Alberta.

Action: **Excavate and dispose of Bunker C contaminated soil.**

Priority: **High**

Estimated Cost: **$ 30,000 - $ 70,000**

Lead Contaminated Soil:

Localized lead contaminated soil slightly in excess of the CCME commercial/industrial criteria was identified in the upper 0.5 m of fill material adjacent to the lead foundry. If the soil is covered with grass, therefore there is minimal exposure to the general public through airborne soil. It is recommended that the lead contaminated soil be excavated and disposed of a part of remediation work at the Cannery, but does not constitute an urgent priority.

Action: **Excavate and dispose of top 0.5 m of fill adjacent to foundry.**

Priority: **Medium**

Estimated Cost: **$ 20,000**

ESTIMATED COST OF HIGH PRIORITY ACTION ITEMS: **$ 60-100,000**

ESTIMATED COST OF MEDIUM PRIORITY ACTION ITEMS: **$ 30,000**

ESTIMATED COST OF LOW PRIORITY ACTION ITEMS: **$ 95-170,000**

8.0 CONCLUSIONS AND RECOMMENDATIONS

Envirochem Special Projects Inc. has completed an environmental assessment at the Gulf of Georgia Cannery in Steveston, B.C. The overall objective of the assessment was to characterize soil and groundwater conditions, to establish the scope and nature of any environmental or human health concerns with the property and to determine whether remedial action will be necessary to permit safe use of the site for its intended use as a public museum. The field program consisted of a hazardous materials inventory, a geophysical survey, shallow soil sampling, test trenching, monitoring well installation, air sampling and foreshore sediment sampling.

The hazardous materials inventory identified the presence of products and chemicals which require further actions:

- Friable asbestos (brittle-easily turned to dust) is located in the insulation of two of the boilers and one pump. Removal of the asbestos from the pump is recommended. The asbestos in the boilers is not accessible and does not pose a concern to the general public but may become a concern to outside contractors doing work on or near the boilers in the future. Labelling of the boilers is suggested.

- Eight PCB capacitors and a limited number of suspect PCB ballasts are presently in service in the Cannery. Removal of the capacitors and ballasts is recommended with storage at the Department of Fisheries and Oceans facility in Steveston.

- Lead was found in three wall paint samples, green paint from the conveyors, blue paint from a pump stored outside, yellow paint from the evaporators, black paint from the centrifuges, grey paint from the presses and white paint from the ends of the drier units. With the exception of the white paint on the end of the driers, all of the paint sampled was well in excess of 500 ppm a standard used in Ontario for the cleanup of lead-contaminated dusts. Air sampling at the Cannery revealed non-detectible lead concentrations, and immediate action is not required. As a means of risk reduction to the public, three remediation options for the lead-based paints are identified. The lead-

based white paint on the wall also contained high levels of barium and zinc, the yellow paint contained high levels of nickel, chromium (lead-chromate paint) and arsenic, the blue paint copper and chromium. As a result, maintenance workers will require precautions to prevent inhalation and ingestion of the paint residues. Special disposal of the paint residues will also be required.

- The "stinkeroo" is lined with an oily residue with oil and grease concentration in excess of 3% classifying the material as a Special Waste under the B.C. Special Waste Regulation. Removal and disposal is recommended.

- A small inventory of miscellaneous liquid and hazardous wastes were found including 5-gal pails of oils and lubricants and a 45-gal drum of industrial cleaner, and residual fish oil in the storage tanks. Disposal of this inventory is recommended. Cost reductions could be realized by recycling portions of the inventory.

Shallow soil sampling, trenching and drilling during the field investigations showed that the stratigraphy is highly variable, but in general consists of fill material (silt, sand, rip rap) from surface to approximately 3 m depth underlain by native silt and sand to depths depth in excess of 6.7 m (the maximum depth of borehole placements). Fill material in the test trench on the west side of the lead foundry contained buried slag, and the fill encountered in the monitoring well on the east side of the foundry contained buried metal debris.

Groundwater elevations, flow directions, and gradients at the site will vary greatly with tidal and seasonal fluctuations in water levels in the Fraser River however the net gradient and groundwater flow direction will be towards the Fraser River.

For the purpose of characterizing the soil conditions the CCME Interim Assessment and Remediation Criteria for soils were used to assess the severity of contamination on the site. For some parameters such as mineral oil and grease and total petroleum hydrocarbons, which do not have CCME Criteria, the B.C. Ministry of Environment Criteria for managing Contaminated Sites have been used for comparison purposes. Two areas with soil contamination of concern were identified:

- Petroleum hydrocarbon contamination was found in excess of the B.C. MOE Special Waste Level of 3% for mineral oil and grease, and in excess of the CCME Remediation Soil Criteria for commercial/industrial use for PAHs as a result of contamination from the former above-ground Bunker C oil tanks on the site. Small pockets of free phase oil were observed. The oil concentration is shallow and excavation and disposal is highly recommended. The volume of contaminated soil is approximately 75 m^3.

- Elevated levels of lead and barium were found above the CCME Remediation Soil Criteria for industrial land use adjacent to the lead foundry to a depth of approximately 0.5 m. Excavation and disposal, including verification of the extent of contamination is recommended.

- Fill material to the north of the main building between the lead foundry and the oil drum storage shed contained elevated levels of copper, lead, mercury in excess of the CCME residential criteria and tin in excess of the CCME industrial criteria at a depth of 3.5 m. Surface soil contamination was also found within the fenced-off northeast corner beneath the former oil tank cradles with copper, tin and zinc in excess of the CCME residential criteria and lead marginally in excess of the CCME industrial criteria. As both of these locations are inaccessible to the general public, they do not pose a significant concern and probably do not require excavation. Consolidation of the surface contamination in vicinity of the former fish oil tank cradles with the material from the vicinity of the lead foundry could be considered when/if excavation of the latter is undertaken.

- The net direction of groundwater flow is toward the Fraser River. One groundwater sample (from MW-2) had copper and lead in excess of the U.S. EPA marine biota chronic effect levels. The impact of loading of copper and lead being discharged to the Fraser River cannot be estimated, but is likely localized. Marine sediment obtained closest to the Cannery foreshore showed less toxicity than marine sediment closer to the river. This may indicate that groundwater discharging from the Cannery site to the Fraser River does not pose a significant concern.

9.0 REFERENCES

B.C. Ministry of Environment. Criteria for Managing Contaminated Sites in British Columbia. 1989. Waste Management Branch, Victoria, B.C.

B.C. Ministry of Environment. 1990. Coquitlam-Pitt River Area, Burrard Inlet, Water Quality Assessment and Objectives. Victoria, B.C.

Canadian Council of Resource and Environment Ministers (CCME). 1991. Interim Canadian Environmental Quality Criteria for Contaminated Sites. Prepared by the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites.

Effects, Pathways, Processes, and Transformation of Puget Sound Contaminants of Concern. 1982. Konasewich, Chapman, et. al. E.V.S. Consultants Ltd. NOAA Technical Memorandum OMPA-20.

Gulf of Georgia Reduction Plant. 1986. A. Barbour. Restoration Services Division, Environment Canada.

Gulf of Georgia Cannery Site Structural History. 1987. Text of Talk given to Delegates to A.P.T. Conference.

Toxicants Occurring Naturally in Foods. 1973. National Academy of Sciences. Second Edition. Washington, DC 1973.

Washington State of Ecology. 1991. Sediment Management Standards. Chapter 173-204 WAC.

10.0 DISCLAIMER

This Environmental Site Assessment Report has been prepared for Public Works Canada. It is intended to provide Public Works Canada with an understanding of the potential hazards that the property evaluated in this report may pose to human health, or to the general environment due to chemical contamination. It describes what Envirochem Special Projects Inc. believes are reasonable concerns about how the property could potentially become involved in various environmental problems resulting from hazardous or special waste, and hazardous materials. Envirochem Special Projects Inc. has neither created nor contributed to the creation or existence of any hazardous, radioactive, toxic, irritant, pollutant, special waste, or otherwise dangerous substance, or condition at the site.

This report is based upon data and information obtained from boreholes, surveys, explorations and sampling during a Phase II study by Envirochem Special Projects Inc. personnel to the property identified herein and is based solely upon the condition of the property on the date of such inspection, supplemented by information and data obtained by Envirochem Special Projects Inc. and described herein.

The Client recognizes that subsurface conditions may be variable throughout the site, and that there is the potential for variations from conditions encountered at locations where boreholes, surveys or explorations were conducted by Envirochem Special Projects Inc..

The data, interpretations and recommendations of Envirochem Special Projects Inc. are based solely on the information available to them. Envirochem Special Projects Inc. shall not be responsible for the interpretation by others of the information developed. The evaluation and conclusions contained in this report have been prepared in light of the expertise and experience of Envirochem Special Projects Inc..

Envirochem Special Projects Inc. has performed the work, made the findings, and proposed the recommendations described in this report in accordance with generally accepted environmental science practices for Phase II Environmental Site Assessments in effect at the time the work was performed. This warranty stands in lieu of all other warranties, expressed or implied. While this report can be used as a guide by Public Works Canada, it must be understood that it is neither a rejection nor an endorsement of the property.

Limit of liability:

The liability of Envirochem Special Projects Inc. to the owner, the Client and to all third parties shall be limited to injury or loss caused by the negligent acts, error or omissions of Envirochem. The total aggregate liability of Envirochem related to this agreement shall not exceed the lesser of the actual damages incurred, or the total fee of Envirochem for services rendered on this project.

The Client has, by contract, agreed to defend, indemnify and hold harmless Envirochem, its affiliates, officers, directors, employees and agents, from any and all liabilities, in excess of the limits of Envirochem Special Projects Inc. entire liability set out above, incurred by Envirochem Special Projects Inc. or any other party, in connection with the services hereunder, or arising from or in any way connected to uninsurable obligations including those arising from the presence, discharge, dispersal, release, escape or effect of radiation, nuclear reaction of radioactive, toxic, explosive or hazardous substances, or any other pollutants including solid, liquid, gaseous, thermal irritants or contaminants. Such indemnity shall include the costs of the time spent and expenses incurred by Envirochem Special Projects Inc. and its affiliates in connection with the defence of the claims.

Protection against errors of others:

The Client has, by contract, agreed to defend, indemnify and save harmless Envirochem Special Projects Inc., agents and employees against any and all claims, costs suites and damages, including attorney's fees, arising out of errors, omissions and inaccuracies in documents and information provided to Envirochem Special Projects Inc. by the Client, its officers, agents and employees.

APPENDIX A

Asbestos Survey - Hansen & Associates Ltd.

27th November 1992

Envirochem Services
145 Riverside Drive
North Vancouver
B.C. V7H 1T6.

Attention: **Mr. Tom W. Finnbogason, B.Sc., Principal.**

Dear Sir,

Reference: **Gulf of Georgia Cannery**

In response to your request, Hansen & Associates Ltd. conducted a survey of asbestos materials in the above referenced facility. The focus of the survey was to identify any asbestos materials in the building that would pose a hazard to members of the general public were the plant to be operated as a museum.

Survey.

All accessible areas of the building were inspected for the presence and asbestos materials, and analysis of samples taken during the survey confirmed asbestos was present in the following locations.

- Exterior insulation beneath the metal shell of the two main boilers # 1 & #2 (see sketch).
- Textile material on boiler #3.
- Gasket material in boiler room locker.
- Gland packing materials on stores shelves.
- Manufactured gaskets throughout.
- Exterior building siding (east side).
- Exterior insulation on redundant pump outside.

Recommendations.

The following recommendations are made in accordance with the requirements of the Canadian Occupational Health & Safety Regulations governing federal employees.

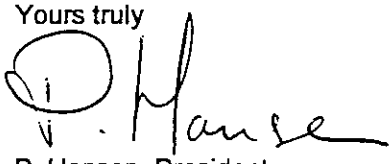
- In summary we recommend that the asbestos located on the redundant pump currently being stored outside of the building be completely removed by a trained and competent asbestos removal contractor.

- The two main boilers should be labelled clearly with regard to the presence of friable asbestos to prevent accidental exposure to maintenance or outside contractors in the event that some work is required to be undertaken in the future.

- The remaining non friable products can remain in their current locations, and as long as they remain in their present condition, they will pose no hazard to the building occupants or the general public. We do recommend however that the exterior siding be identified as being asbestos containing, again to prevent accidental exposure to maintenance or outside contractors.

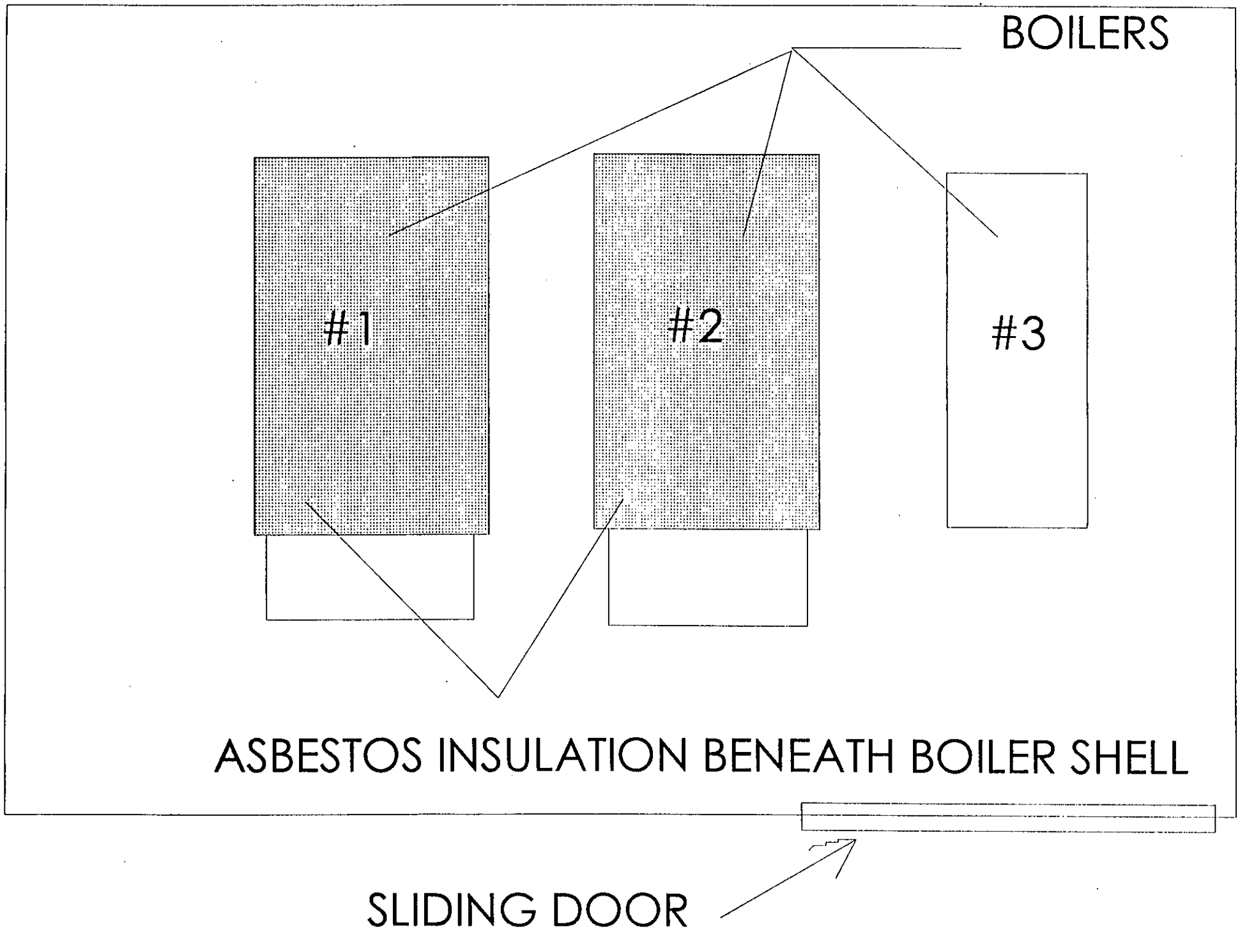
Should you require any additional information, please do not hesitate to contact the writer.

Yours truly



P. Hansen, President

270AL1


BOILERS
#1
#2
#3
ASBESTOS INSULATION BENEATH BOILER SHELL
SLIDING DOOR

Hansen & Associates Ltd. Environmental Consulting Services
Project Number: 270D
Envirochem - Gulf of Georgia Cannery - Bulk Sample Results

NO.	DATE	SAMPLE INFORMATION	DESCRIPTION	ASBESTOS		OTHER	ANALYST
1	20/11/92	Building 9 Boiler room Boiler #1 (East) Ext. boiler ins.	1. White fibrous mass (70%) 2. Brown cement (30%)	Chrysotile Chrysotile	80% 15%	NF (20%) Glass fibers (5%), NF (80%)	GC
2	20/11/92	Building 9 Boiler room Boiler #2 (Center) Brick mortar	1. Gray cement with white stones (100%)	Chrysotile	< 1%	Cellulose (<1%), Glass fibers (<1%), NF (99%)	GC
3	20/11/92	Building 9 Boiler room Boiler #3 (West) Strap material	1. White textile (100%)	Chrysotile	45%	Cellulose (30%), Rayon (20%), NF (5%)	GC
4	20/11/92	Building 9 Boiler room Plaster on walls	1. Beige cement with small stones (100%)	None Detected		Cellulose (<1%), NF (100%)	GC
5	20/11/92	Building 9 Boiler room Cement (behind plaster)	1. White chalky cement (100%)	None Detected		NF (100%)	GC
6	20/11/92	Building 9 Boiler room Stored gasket material (rolls)	1. Gray fiber mat (100%)	Chrysotile	60%	NF (40%)	GC

NF = Non-Fibrous material; SS = Small Sample size

NO.	DATE	SAMPLE INFORMATION	DESCRIPTION	ASBESTOS		OTHER	ANALYST
7	20/11/92	Building 9 Storage room Packing material	1. White textile (70%) 2. Red rubbery material (30%)	Chrysotile Chrysotile	55% 1-5%	Cellulose (30%), Rayon (2%), NF (13%) Cellulose (2%), NF (93%)	GC
8	20/11/92	Building 9 Storage room Gasket on wall	1. Compressed beige fiber mat (100%)	Chrysotile	75%	NF (25%)	GC
9	20/11/92	Building 9 East side Transite siding (52 4x8 sheets)	1. Hard gray cement (100%)	Chrysotile	40%	NF (60%)	GC
10	20/11/92	Building 9 Pump stored outside Insulation on side of pump	1. Beige fibrous mass (100%)	Chrysotile	30%	Cellulose (<1%), NF (70%)	GC
11	20/11/92	Building 9 Roofing material	1. Gray tar (2%) 2. Black tar [1] (96%) 3. Black tar [2] (2%)	None Detected None Detected None Detected		Cellulose (<1%), NF (100%) Glass fibers (<1%), Cellulose (<1%), NF (100%) Glass fibers (10%), Cellulose (<1%), NF (90%)	GC

NF = Non-Fibrous material; SS = Small Sample size

APPENDIX B

Laboratory and QA/QC Reports

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5

analytical
service
laboratories
ltd.

FAX: (604) 253-6700 TEL: (604) 253-4188

RECEIVED MAR 2 5 1993

CHEMICAL ANALYSIS REPORT

Date: March 19, 1993

ASL File No. 9041C

Report On: Water Analysis; Project # 1253

Report To: **Envirochem Services**
310 East Esplanade
North Vancouver, BC
V7L 1A4

Attention: **Ms. Linda Eastcott**

Received: March 3, 1993

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Jasper van de Wetering, B.Sc.
Project Chemist

Scott Hannam
Manager, Trace Organics Lab

CELEBRATING 10 YEARS OF EXCELLENCE

RESULTS OF ANALYSIS - Water

File No. 9041C

		1	2	3	6
		93 03 02	93 03 02	93 03 02	93 03 02
Physical Tests					
Conductivity	umhos/cm	1000	1430	348	1400
pH		8.62	8.57	7.81	7.79
Dissolved Metals					
Aluminum	D-Al	2.47	0.41	0.35	<0.20
Antimony	D-Sb	<0.20	<0.20	<0.20	<0.20
Arsenic	D-As	0.0057	0.0040	0.0043	0.0005
Barium	D-Ba	0.029	0.052	<0.010	<0.010
Cadmium	D-Cd	<0.0002	<0.0002	0.0002	<0.0002
Calcium	D-Ca	29.5	18.2	8.17	16.1
Chromium	D-Cr	<0.015	<0.015	<0.015	<0.015
Cobalt	D-Co	0.003	0.005	0.003	0.002
Copper	D-Cu	<0.010	0.116	0.019	<0.010
Iron	D-Fe	1.96	11.9	0.334	8.62
Lead	D-Pb	0.001	0.164	0.001	<0.001
Magnesium	D-Mg	35.6	12.4	5.67	29.7
Manganese	D-Mn	1.23	0.727	0.302	1.22
Mercury	D-Hg	<0.00005	0.00006	<0.00005	<0.00005
Molybdenum	D-Mo	0.008	0.002	0.004	<0.001
Nickel	D-Ni	0.015	0.025	0.015	0.004
Potassium	D-K	13.7	7.9	3.9	9.7
Selenium	D-Se	<0.0005	<0.0005	<0.0005	<0.0005
Silver	D-Ag	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	D-Na	130	285	41.2	254
Tin	D-Sn	<0.30	<0.30	<0.30	<0.30
Zinc	D-Zn	0.012	0.061	0.013	0.005
Extractables					
Total Petroleum Hydrocarbons		<1	<1	<1	<1

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.

RESULTS OF ANALYSIS - Water

File No. 9041C

	3 93 03 02	6 93 03 02
Polyaromatic Hydrocarbons		
Acenaphthene	<0.0005	<0.0005
Acenaphthylene	<0.0005	<0.0005
Anthracene	<0.0002	<0.0002
Benzo(a)anthracene	<0.00001	<0.00001
Benzo(a)pyrene	<0.00001	<0.00001
Benzo(b)fluoranthene	<0.00001	<0.00001
Benzo(ghi)perylene	<0.0001	<0.0001
Benzo(k)fluoranthene	<0.00001	<0.00001
Chrysene	<0.0001	<0.0001
Dibenzo(a,h)anthracene	<0.00001	<0.00001
7,12-Dimethyl-1,2-benzanthracene	<0.0001	<0.0001
Fluoranthene	<0.0001	<0.0001
Fluorene	<0.0001	<0.0001
Indeno(1,2,3-cd)pyrene	<0.00001	<0.00001
3-Methylcholanthrene	<0.0001	<0.0001
Naphthalene	<0.0002	<0.0002
Phenanthrene	<0.0002	<0.0002
Pyrene	<0.0002	<0.0002
Polychlorinated Biphenyls		
Total Polychlorinated Biphenyls	-	<0.0001
Organochloride Pesticides		
Aldrin	-	<0.001
alpha-BHC	-	<0.001
beta-BHC	-	<0.001
gamma-BHC (Lindane)	-	<0.001
delta-BHC	-	<0.001
cis-Chlordane (alpha)	-	<0.005
4,4'-DDD	-	<0.001
4,4'-DDE	-	<0.001
4,4'-DDT	-	<0.001
Dieldrin	-	<0.001
Endosulfan I	-	<0.002
Endosulfan II	-	<0.001
Endosulfan Sulfate	-	<0.010
Endrin	-	<0.001
Heptachlor	-	<0.001

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.

RESULTS OF ANALYSIS - Water

File No. 9041C

	3	6
	93 03 02	93 03 02
Organochloride Pesticides		
Heptachlor Epoxide	-	<0.010
Methoxychlor	-	<0.005
Toxaphene	-	<0.030

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.

RESULTS OF ANALYSIS - QA Data[1]

File No. 9041C

		CRM APG # 10369 found	CRM ERA Lot#9943 found
Total Metals			
Aluminum	T-Al	<0.20	-
Antimony	T-Sb	0.42	-
Arsenic	T-As	0.0500	-
Barium	T-Ba	0.780	-
Cadmium	T-Cd	0.0610	-
Calcium	T-Ca	40.2	-
Chromium	T-Cr	0.027	-
Cobalt	T-Co	0.039	-
Copper	T-Cu	0.043	-
Iron	T-Fe	0.087	-
Lead	T-Pb	0.028	-
Magnesium	T-Mg	6.14	-
Manganese	T-Mn	0.068	-
Mercury	T-Hg	-	0.00746
Molybdenum	T-Mo	0.105	-
Nickel	T-Ni	0.080	-
Potassium	T-K	26.0	-
Selenium	T-Se	0.0256	-
Silver	T-Ag	0.0710	-
Sodium	T-Na	33.6	-
Tin	T-Sn	<0.30	-
Zinc	T-Zn	0.017	-

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.
[1]CRM = Certified Reference Material.

RESULTS OF ANALYSIS - QA Data[1]

File No. 9041C

		Blank
Dissolved Metals		
Aluminum	D-Al	<0.20
Antimony	D-Sb	<0.20
Arsenic	D-As	<0.0001
Barium	D-Ba	<0.010
Cadmium	D-Cd	<0.0002
Calcium	D-Ca	<0.050
Chromium	D-Cr	<0.015
Cobalt	D-Co	<0.001
Copper	D-Cu	<0.010
Iron	D-Fe	<0.030
Lead	D-Pb	<0.001
Magnesium	D-Mg	<0.010
Manganese	D-Mn	<0.005
Mercury	D-Hg	<0.00005
Molybdenum	D-Mo	<0.001
Nickel	D-Ni	<0.001
Potassium	D-K	<2.0
Selenium	D-Se	<0.0005
Silver	D-Ag	<0.0001
Sodium	D-Na	<2.0
Tin	D-Sn	<0.30
Zinc	D-Zn	<0.005

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.
[1]CRM = Certified Reference Material.

RESULTS OF ANALYSIS - QA Data[1]

File No. 9041C

	Blank	Spike[2] (% Rec)
Polyaromatic Hydrocarbons		
Acenaphthene	<0.0005	-
Acenaphthylene	<0.0005	-
Anthracene	<0.0002	-
Benzo(a)anthracene	<0.00001	-
Benzo(a)pyrene	<0.00001	-
Benzo(b)fluoranthene	<0.00001	-
Benzo(ghi)perylene	<0.0001	-
Benzo(k)fluoranthene	<0.00001	-
Chrysene	<0.0001	-
Dibenzo(a,h)anthracene	<0.00001	-
7,12-Dimethyl-1,2-benzanthracene	<0.0001	-
Fluoranthene	<0.0001	-
Fluorene	<0.0001	-
Indeno(1,2,3-cd)pyrene	<0.00001	-
3-Methylcholanthrene	<0.0001	-
Naphthalene	<0.0002	-
Phenanthrene	<0.0002	-
Pyrene	<0.0002	-
Polychlorinated Biphenyls		
Total Polychlorinated Biphenyls	<0.001	83
Organochloride Pesticides		
Aldrin	<0.001	83
alpha-BHC	<0.001	76
beta-BHC	<0.001	103
gamma-BHC (Lindane)	<0.001	89
delta-BHC	<0.001	109
cis-Chlordane (alpha)	<0.005	110
4,4'-DDD	<0.001	39
4,4'-DDE	<0.001	105
4,4'-DDT	<0.001	148
Dieldrin	<0.001	108
Endosulfan I	<0.002	92
Endosulfan II	<0.001	109
Endosulfan Sulfate	<0.010	132
Endrin	<0.001	116
Heptachlor	<0.001	98

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.
[1]CRM = Certified Reference Material.
[2]Spike data for PAH not available for this batch.

RESULTS OF ANALYSIS - QA Data[1]

File No. 9041C

	Blank	Spike[2] (% Rec)
Organochloride Pesticides		
Heptachlor Epoxide	<0.010	106
Methoxychlor	<0.005	148
Toxaphene	<0.030	-
Extractables		
Total Petroleum Hydrocarbons	<1	73

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.
[1]CRM = Certified Reference Material.
[2]Spike data for PAH not available for this batch.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed. published by the American Public Health Association, 1992. Further details are available on request.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 17th Edition published by the American Public Health Association, 1989. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

Polynuclear Aromatic Hydrocarbons in Water

This analysis is carried out in accordance with U.S. EPA Method 3510/8270. (publ. #SW-846, 3rd Ed., Washington, DC 20460). This method involves the extraction of the sample with methylene chloride followed by silica column chromatography cleanup. The resulting extract was analysed by capillary column gas chromatography with mass spectrometric detection.

Polychlorinated Biphenyls in Water

This analysis is carried out in accordance with U.S. EPA Method 3510/8080. (Publ. #SW-846, 3rd Ed., Washington, DC 20460). This procedure involves sample extraction with dichloromethane followed by column chromatography cleanup. The concentrated extract is analysed using capillary column gas chromatography with electron capture detection.

Organochloride Pesticides in Water

This analysis is carried out in accordance with U.S. EPA Method 3510/8080 (Publ. #SW-846 3rd ed., Washington, DC 20460). The procedure involves a solvent extraction using dichloromethane. The extract is then solvent exchanged to hexane followed by an alumina column clean-up. The final extract is analysed by dual capillary column gas chromatography with electron capture detection.

Total Petroleum Hydrocarbons in Water

This analysis is carried out in accordance with U.S. EPA Methods 3510/8015 (Publ. # SW-846 3rd ed., Washington, DC 20460). The procedure involves a solvent extraction with dichloromethane, solvent exchange to hexane, followed by a silica gel cleanup. The final extract is analysed by capillary column gas chromatography with flame ionization detection.

APPENDIX

REFERENCE MATERIAL CERTIFICATION DATA

ENVIRONMENTAL
RESOURCE ASSOCIATES
Arvada, Colorado 80002 1-800-ERA-0122

Certification

WasteWatR™ Quality Control Standards

LOT NO. 9943

Parameter	Certified Value[1]		Advisory Range[2]	
MINERALS WasteWatR™	mg/l		mg/l	
total solids at 105°C	686		585-801	
dissolved solids at 180°C	686		585-801	
conductivity at 25°C	858	micromhos	695-1030	micromhos
alkalinity	176		150-195	
chloride	60		51-65	
fluoride	9.85		7.4-11	
sulfate	89		77-101	
potassium	93		73-113	
sodium	120		102-138	
pH	9.1	S.U.	8.9-9.3	S.U.
HARDNESS WasteWatR™	mg/l		mg/l	
suspended solids at 105°C	21.1		15-26	
calcium	83.0		71-95	
magnesium	10.0		9.0-13	
hardness as $CaCO_3$	248		211-286	
GREASE & OIL WasteWatR™				
Gravimetric	36.9	mg/bottle	22-46	mg/bottle
Infrared	44.3	mg/bottle	26-55	mg/bottle
DEMAND WasteWatR™	mg/l		mg/l	
BOD	104		52-120	
COD	173		147-199	
TOC	66.5		57-76	
total phosphorus as P	4.16		3.5-4.8	
Kjeldahl nitrogen as N	3.75		3.1-4.7	
NUTRIENTS WasteWatR™	mg/l		mg/l	
ammonia as N	2.78		2.2-3.3	
nitrate plus nitrite as N	1.99		1.8-2.3	
phosphate as P	6.80		5.8-7.8	

CYANIDE & PHENOL WasteWatR™	mg/l	mg/l
total cyanide	0.081	0.048-0.11
complex cyanide	0.037	0.022-0.046
weak & dissociable cyanide	0.044	0.026-0.055
phenol	0.251	0.19-0.31

RESIDUAL CHLORINE WasteWatR™	mg/l	mg/l
	1.50	1.1-1.7

TRACE METALS WasteWatR™	µg/l	µg/l
aluminum	400	320-480
antimony	101	76-126
arsenic	128	95-150
barium	275	226-320
beryllium	91.2	74-108
boron	243	200-287
cadmium	152	124-180
chromium	422	346-500
cobalt	106	87-125
copper	681	590-790
iron	407	335-480
lead	562	465-660
manganese	185	152-219
mercury	11.5	6.2-13
molybdenum	336	276-396
nickel	405	332-470
selenium	216	160-260
silver	130	100-160
strontium	335	275-390
thallium	191	145-225
vanadium	163	130-192
zinc	174	143-210

[1]Certified values are equal to 100% of each parameter in the indicated standard.
[2]Advisory ranges are listed as guidelines for acceptable recoveries given the limitations of the EPA methodologies commonly used to determine these parameters. The range closely approximates the 95% confidence interval for these parameters based upon the experimental data generated by ERA and data from the USEPA WP, WS and CLP interlaboratory performance evaluation programs.

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Aluminum Units: ug/L

True Value	79.650
Mean	83.268
Standard Deviation	15.338
Number of Laboratories	81
Average % Recovery	104.542
95% Confidence Limits	53.205 - 113.330
99% Confidence Limits	43.696 - 122.840

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Setpoint Laboratory Standards

Certified Reference Material

Setpoint Laboratory Standards are verified in a nationwide interlaboratory program. The data supplied with this standard was developed in this program. Laboratories reporting data analyzed this sample as an unknown.

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Antimony Units: ug/L

True Value	413.050
Mean	397.757
Standard Deviation	44.707
Number of Laboratories	68
Average % Recovery	96.298
95% Confidence Limits	310.132 - 485.383
99% Confidence Limits	282.414 - 513.101

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4200

Setpoint Laboratory Standards

Standard: Trace Metals Product Code: 7878

Preparation Instructions:

Pipet 1.5ml of reagent grade Nitric acid and 10ml of the enclosed vial into a one (1) Liter volumetric flask and dilute to volume with laboratory grade water. Vial #3 (or #4) may be analyzed for Antimony, Boron, and Molybdenum. Vial #1 (or #2) may be analyed for all other metals listed below.

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Beryllium Units: ug/L

True Value	62.750
Mean	61.127
Standard Deviation	4.015
Number of Laboratories	82
Average % Recovery	97.414
95% Confidence Limits	53.257 - 68.997
99% Confidence Limits	50.768 - 71.486

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4200

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Arsenic Units: ug/L

True Value	58.050
Mean	56.621
Standard Deviation	6.335
Number of Laboratories	94
Average % Recovery	97.539
95% Confidence Limits	44.204 - 69.039
99% Confidence Limits	40.276 - 72.967

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Boron Units: ug/L

True Value	175.600
Mean	181.618
Standard Deviation	27.501
Number of Laboratories	52
Average % Recovery	103.427
95% Confidence Limits	127.718 - 235.521
99% Confidence Limits	110.665 - 252.572

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Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Barium Units: ug/L

True Value	785.080
Mean	775.081
Standard Deviation	51.274
Number of Laboratories	90
Average % Recovery	98.728
95% Confidence Limits	674.584 - 875.578
99% Confidence Limits	642.794 - 907.368

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371

Product Code: 7878

Statistical Summary

Parameter: Cobalt

Units: ug/L

True Value	37.550
Mean	37.892
Standard Deviation	3.810
Number of Laboratories	71
Average % Recovery	100.910
95% Confidence Limits	30.424 - 45.359
99% Confidence Limits	28.062 - 47.721

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4200

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371

Product Code: 7878

Statistical Summary

Parameter: Copper

Units: ug/L

True Value	40.600
Mean	40.656
Standard Deviation	3.321
Number of Laboratories	115
Average % Recovery	100.139
95% Confidence Limits	34.147 - 47.166
99% Confidence Limits	32.087 - 49.225

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4200

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371

Product Code: 7878

Statistical Summary

Parameter: Cadmium

Units: ug/L

True Value	58.100
Mean	58.137
Standard Deviation	5.084
Number of Laboratories	113
Average % Recovery	100.063
95% Confidence Limits	48.171 - 68.102
99% Confidence Limits	45.019 - 71.255

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-42

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371

Product Code: 7878

Statistical Summary

Parameter: Chromium

Units: ug/L

True Value	28.670
Mean	28.984
Standard Deviation	2.929
Number of Laboratories	122
Average % Recovery	101.094
95% Confidence Limits	23.244 - 34.724
99% Confidence Limits	21.428 - 36.540

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Manganese Units: ug/L

True Value	70.280
Mean	70.223
Standard Deviation	4.287
Number of Laboratories	96
Average % Recovery	99.919
95% Confidence Limits	61.820 - 78.626
99% Confidence Limits	59.162 - 81.284

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4200

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Iron Units: ug/L

True Value	87.090
Mean	89.313
Standard Deviation	11.308
Number of Laboratories	106
Average % Recovery	102.553
95% Confidence Limits	67.151 - 111.476
99% Confidence Limits	60.140 - 118.487

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-42

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Mercury Units: ug/L

True Value	1.190
Mean	1.278
Standard Deviation	0.311
Number of Laboratories	96
Average % Recovery	107.365
95% Confidence Limits	0.667 - 1.888
99% Confidence Limits	0.474 - 2.081

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4200

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Lead Units: ug/L

True Value	27.340
Mean	28.210
Standard Deviation	4.453
Number of Laboratories	107
Average % Recovery	103.182
95% Confidence Limits	19.481 - 36.938
99% Confidence Limits	16.720 - 39.700

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-42

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Selenium Units: ug/L

True Value	25.060	
Mean	25.107	
Standard Deviation	3.325	
Number of Laboratories	90	
Average % Recovery	100.188	
95% Confidence Limits	18.591 -	31.624
99% Confidence Limits	16.529 -	33.685

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4200

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Molybdenum Units: ug/L

True Value	114.720	
Mean	112.578	
Standard Deviation	16.888	
Number of Laboratories	60	
Average % Recovery	98.133	
95% Confidence Limits	79.478 -	145.679
99% Confidence Limits	69.007 -	156.150

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-42

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Silver Units: ug/L

True Value	71.650	
Mean	72.248	
Standard Deviation	4.675	
Number of Laboratories	99	
Average % Recovery	100.835	
95% Confidence Limits	63.086 -	81.411
99% Confidence Limits	60.187 -	84.310

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4200

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Nickel Units: ug/L

True Value	77.420	
Mean	77.243	
Standard Deviation	6.606	
Number of Laboratories	107	
Average % Recovery	99.771	
95% Confidence Limits	64.295 -	90.190
99% Confidence Limits	60.200 -	94.285

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4.

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Zinc		Units: ug/L
True Value	13.470	
Mean	15.129	
Standard Deviation	4.198	
Number of Laboratories	102	
Average % Recovery	112.317	
95% Confidence Limits	6.901 -	23.357
99% Confidence Limits	4.299 -	25.960

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4200

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Thallium		Units: ug/L
True Value	121.250	
Mean	121.462	
Standard Deviation	19.122	
Number of Laboratories	65	
Average % Recovery	100.174	
95% Confidence Limits	83.982 -	158.941
99% Confidence Limits	72.126 -	170.797

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-42

Setpoint Laboratory Standards

Explanation of Terms

True Value:
This is the theoretical True Value of the Standard. Based upon the method of preparation.

Mean:
The average value reported by laboratories participating in the interlaboratory program. These labs tested the Standard as an unknown.

Standard Deviation:
The actual Standard Deviation developed in the interlaboratory program.

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-4200

Setpoint Laboratory Standards

Standard: Trace Metals
Lot Number: 10369-10371 Product Code: 7878

Statistical Summary

Parameter: Vanadium		Units: ug/L
True Value	351.590	
Mean	352.492	
Standard Deviation	19.537	
Number of Laboratories	71	
Average % Recovery	100.257	
95% Confidence Limits	314.198 -	390.785
99% Confidence Limits	302.085 -	402.898

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800 272 4442 614-4

Number of Laboratories:
The number of laboratories whose data was used to develop the Mean and Standard Deviation. Statistical Outliers were removed by the ASTM t Test.

Average % Recovery:
The Mean divided by the True Value times 100.

Confidence Limits:
These are calculated based upon the Mean and Standard Deviation reported. The USEPA suggests using the 95% Confidence Limits for Quality Control limits.

APG Analytical Products Group, Inc. 2730 Washington Blvd., Belpre, OH 45714 1-800-272-4442 614-423-

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5

analytical
service
laboratories
ltd.

FAX: (604) 253-6700 TEL: (604) 253-4188

RECEIVED MAR 5 - 1993

CHEMICAL ANALYSIS REPORT

Date: February 26, 1993

ASL File No. 8720C

Report On: Soil Analysis; Project #1253

Report To: **Envirochem Services**
310 East Esplanade
North Vancouver, BC
V7L 1A4

Attention: **Ms. Linda Eastcott**

Received: February 15, 1993

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Jasper van de Wetering, B.Sc.
Project Chemist

Scott Hannam
Manager, Trace Organics Lab

CELEBRATING 10 YEARS OF EXCELLENCE

RESULTS OF ANALYSIS - Sediment/Soil

File No. 8720C

		Sediment #1 93 02 10	Sediment[1] #1 Dup. 93 02 10	Sediment #2 93 02 10	TP-9 15-20cm 93 02 10	TP-9 40cm 93 02 10
Physical Tests						
Moisture	%	46.0	-	37.2	8.22	31.4
Total Metals						
Arsenic	T-As	18.4	17.2	70.5	2.41	3.00
Barium	T-Ba	109	110	135	90.5	2070
Cadmium	T-Cd	0.16	0.19	0.31	0.17	<0.10
Chromium	T-Cr	54.2	53.7	66.8	25.0	54.2
Cobalt	T-Co	14.9	14.6	12.8	7.7	15.8
Copper	T-Cu	64.5	59.5	107	80.3	206
Lead	T-Pb	24.3	25.4	76.7	1750	686
Mercury	T-Hg	0.084	0.080	0.176	0.026	0.016
Molybdenum	T-Mo	<4.0	<4.0	<4.0	<4.0	4.3
Nickel	T-Ni	53.1	51.7	51.5	21.3	78.0
Selenium	T-Se	0.31	0.36	0.39	<0.10	0.13
Silver	T-Ag	<2.0	<2.0	<2.0	<2.0	<2.0
Tin	T-Sn	<30	<30	49	<30	<30
Zinc	T-Zn	160	153	238	114	67.6

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
[1]Dup. = Duplicate.

RESULTS OF ANALYSIS - Sediment/Soil

File No. 8720C

		TP-9 50-60cm 93 02 10	TP-9 80cm 93 02 10	Pb Dust 93 02 10	Pb Sand 93 02 10	Pb Sand[1] Dup. 93 02 10
Physical Tests						
Moisture	%	24.6	21.2	4.44	0.60	-
Total Metals						
Arsenic	T-As	7.35	7.71	11.7	3.52	3.02
Barium	T-Ba	194	68.3	93.5	57.1	58.6
Cadmium	T-Cd	<0.10	<0.10	35.5	<0.10	<0.10
Chromium	T-Cr	54.6	50.0	22.5	36.9	39.0
Cobalt	T-Co	9.1	6.5	6.4	6.2	6.5
Copper	T-Cu	158	31.8	218	18.7	18.3
Lead	T-Pb	642	18.4	252000	<2.0	<2.0
Mercury	T-Hg	0.234	0.058	0.106	0.021	0.024
Molybdenum	T-Mo	<4.0	<4.0	50.3	<4.0	<4.0
Nickel	T-Ni	32.8	26.6	44.1	26.5	27.2
Selenium	T-Se	0.34	0.31	0.15	<0.10	<0.10
Silver	T-Ag	<2.0	<2.0	<2.0	<2.0	<2.0
Tin	T-Sn	<30	<30	<30	<30	<30
Zinc	T-Zn	98.7	75.0	1030	39.5	36.7

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
[1]Dup. = Duplicate.

RESULTS OF ANALYSIS - QA Data[1]

File No. 8720C

		Blank	CRM NRC MESS-1 found	CRM NRC BEST-1 found
Total Metals				
Arsenic	T-As	<0.05	8.75	-
Barium	T-Ba	<1.0	49.3	-
Cadmium	T-Cd	<0.10	0.60	-
Chromium	T-Cr	<2.0	29.6	-
Cobalt	T-Co	<2.0	10.5	-
Copper	T-Cu	<1.0	24.5	-
Lead	T-Pb	<2.0	30.0	-
Mercury	T-Hg	<0.005	-	0.093
Molybdenum	T-Mo	<4.0	<4.0	-
Nickel	T-Ni	<2.0	27.4	-
Selenium	T-Se	<0.10	0.36	-
Silver	T-Ag	<2.0	<2.0	-
Tin	T-Sn	<30	<30	-
Zinc	T-Zn	<1.0	193	-

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
[1]CRM = Certified Reference Material.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103 C.

Metals in Sediment/Soil

These analyses are carried out using procedures that are consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 3050 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedures involve a digestion using a combination of nitric and hydrochloric acids. The resulting extract is bulked to volume with deionized/distilled water. The digested portion is then analysed by a variety of instrumental techniques, which may include specific atomic absorption spectrophotometric techniques (AAS) and/or atomic emission spectrophotometry (ICP), to obtain the required detection limit for each element. Specific details are available upon request.

PLEASE NOTE (When the following elements are reported):

Aluminum, barium, calcium, chromium, iron, magnesium, manganese, molybdenum and vanadium are often associated with the silicate matrix of the sediment. Because of this, the recoveries of these elements may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

End of Report

APPENDIX

REFERENCE MATERIAL CERTIFICATION DATA

National Research Council Canada
Conseil national de recherches Canada

Division of Chemistry
Division de chimie

Marine Analytical Chemistry Standards Program
Programme de standards de chimie analytique marine

Ottawa, Canada
K1A 0R6

Telephone (613) 993-2359
Facsimile (613) 993-2451
Telex 053-3145

January, 1981
Revised February, 1987
Revised October, 1987
Revised April, 1990

BCSS-1, MESS-1, PACS-1, BEST-1

Marine Sediment Reference Materials for Trace Elements and Other Constituents

The following tables show those constituents for which certified values have been established. Certified values are based on the results of determinations by at least two independent methods of analysis. The uncertainties represent 95% confidence limits for an individual subsample. That is, 95% of samples from any bottle would be expected to have concentrations within the specified range 95% of the time.

Trace Metals — Milligrams per Kilogram

	MESS-1	BCSS-1	PACS-1
Antimony (g,h,i,n)	0.73 ± 0.08	0.59 ± 0.06	171 ± 14
Arsenic (b,h,i,n,p)	10.6 ± 1.2	11.1 ± 1.4	211 ± 11
Beryllium (g,i)	1.9 ± 0.2	1.3 ± 0.3	—
Cadmium (g,i,m,q)	0.59 ± 0.10	0.25 ± 0.04	2.38 ± 0.20
Chromium (m,n,p,q,x)	71 ± 11	123 ± 14	113 ± 8
Cobalt (f,g,i,m,n,p,x)	10.8 ± 1.9	11.4 ± 2.1	17.5 ± 1.1
Copper (f,g,i,m,n)	25.1 ± 3.8	18.5 ± 2.7	452 ± 16
Lead (f,g,i,m,p,q,x)	34.0 ± 6.1	22.7 ± 3.4	404 ± 20
Manganese (f,i,n,p,x)	513 ± 25	229 ± 15	470 ± 12
Mercury (c,q)	—	—	4.57 ± 0.16
Molybdenum (g,i,q)	—	—	12.9 ± 0.9
Nickel (g,i,m,n,q)	29.5 ± 2.7	55.3 ± 3.6	44.1 ± 2.0
Selenium (g,h,l,m)	0.34 ± 0.06	0.43 ± 0.06	1.09 ± 0.11
Strontium (f,i,g)	—	—	277 ± 11
Tin (g,h,i,q)	3.98 ± 0.44	1.85 ± 0.20	41.1 ± 3.1
Vanadium (f,i,m,n)	72.4 ± 17	93.4 ± 4.9	127 ± 5
Zinc (f,i,m,n,q,x)	191 ± 17	119 ± 12	824 ± 22
Tributyltin	—	—	1.27 ± 0.22 (as Sn)
Dibutyltin	—	—	1.16 ± 0.18 (as Sn)
Monobutyltin	—	—	0.28 ± 0.17 (as Sn)

* See overleaf for key to coding.

Canada

Matrix and Minor Constituents — Percent

	MESS-1		BCSS-1		PACS-1	
Al_2O_3 (d,f,i,n,x)	11.03	± 0.38	11.83	± 0.41	12.23	± 0.22
C (e,r)	2.99	± 0.09	2.19	± 0.09	3.69	± 0.11
CaO (f,i,n,p,x)	0.674	± 0.064	0.760	± 0.074	2.92	± 0.13
Cl (n,v,x)	0.82	± 0.07	1.12	± 0.05	2.39	± 0.09
Fe_2O_3 (d,f,i,n,p,x)	4.36	± 0.25	4.70	± 0.14	6.96	± 0.12
K_2O (f,n,x)	2.24	± 0.04	2.17	± 0.04	1.50	± 0.09
MgO (d,f,i,p)	1.44	± 0.09	2.44	± 0.23	2.41	± 0.09
Na_2O (f,i,n,p)	2.50	± 0.15	2.72	± 0.21	4.40	± 0.11
P_2O_5 (i,x)	0.146	± 0.014	0.154	± 0.016	0.233	± 0.018
S (i,x,x)	0.72	± 0.05	0.36	± 0.05	1.32	± 0.08
SiO_2 (f,x)	67.5	± 1.9	66.1	± 1.0	55.7	± 0.5
TiO_2 (d,f,i,n,p,x)	0.905	± 0.028	0.734	± 0.024	0.703	± 0.011

BEST-1

Mercury (a,c,q)	0.092	± 0.009 milligrams per kilogram

Coding

a — Atomic fluorescence spectrometry
b — Inductively coupled plasma mass spectrometry
c — Cold vapour atomic absorption spectrometry
d — DC plasma atomic emission spectrometry
e — Coulometry
f — Flame atomic absorption spectrometry
g — Graphite furnace atomic absorption spectrometry
h — Hydride generation atomic absorption spectrometry
i — Inductively coupled plasma atomic emission spectrometry
l — Liquid chromatography
m — Isotope dilution solid source mass spectrometry
n — Instrumental neutron activation analysis
p — Instrumental photonuclear activation analysis
q — Isotope dilution inductively coupled plasma mass spectrometry
r — Infrared spectrometry
v — Volumetric analysis
x — X-ray fluorescence spectrometry

Not all the methods listed above were applied to all materials

These reference materials are primarily for use in the calibration of procedures and the development of methods used for the analysis of marine sediments and materials with similar matrices.

Preparation of material

MESS-1 and BCSS-1 were collected by MacLaren Plansearch Ltd., Dartmouth, Nova Scotia, from the Gulf of St. Lawrence (MESS-1 from the Miramichi River estuary and BCSS-1 from the Baie des Chaleurs). PACS-1 was collected by Dobrocky Seatech Ltd., Sidney, British Columbia in the harbour of Esquimalt, British Columbia. BEST-1 is from the Beaufort Sea. They were freeze dried (Freeze-Dry Foods, Oakville, Ont.), screened to pass a No. 120 (125 μm) screen, blended and bottled by Chemistry Division staff using the facilities of the Canada Centre for Mineral and Energy Technology in Ottawa. After bottling, the samples were radiation sterilized with a minimum dose of 2.5 Mrad by the Canadian Irradiation Centre (formerly Atomic Energy of Canada Ltd.) to minimize effects from biological activity.

Envirochem Special Projects Inc.

CHEMICAL ANALYSIS REPORT

Date:	December 4, 1992
Date of Analysis:	December 3, 1992
File #:	B0025 & C0048
Report On:	Gravimetric Mineral and Total Oil and Grease Total Petroleum Hydrocarbon
Report To:	Gulf of Georgia - Cannery c/o Envirochem Services
Attention:	Linda Eastcott
Date of Sampling:	November 19, 1992
Sample Identification:	Labelled as shown in results section.

Methodology (Mineral Oil and Grease)
The sample is extracted with hexane/acetone and run through a silica gel clean-up. The extract thus produced is evaporated to dryness and the residue weighed to determine gravimetric mineral oil and grease.

Methodology (Total Oil and Grease)
The sample is extracted with hexane/acetone. The extract thus produced is evaporated to dryness and the residue weighed to determine gravimetric oil and grease.

Methodology (Total Petroleum Hydrocarbon)
The samples were analyzed using the procedure outlined by the U.S. EPA Method 3550/8015. First the sample was extracted with acetone\hexane, roto-evaporated to dryness, cleaned up by silica gel and made up to volume with hexane. Then the extract was analyzed using a Hewlett Packard 5890 Series II gas chromatograph with a flame ionization detector. Petroleum Hydrocarbons (TPH) are quantified by use a diesel fuel standard which is evaluated during each batch of TPH analysis. QA/QC consisted of a blank and a sample duplicate during the run.

Results of Analysis
Results are presented in the table attached.

ENVIROCHEM SERVICES ANALYTICAL DEPARTMENT

Alien Wan, B.Sc
Chemist

RESULTS OF ANALYSIS

Sample Identification	Total Petroleum Hydrocarbon (mg/Kg of dry sample)	Total Oil and Grease (mg/kg of dry sample)	Mineral Oil and Grease (mg/Kg of dry sample)
GGC VB-1 S1	4380	-	20700
GGC VB-1 S2	-	-	583
GGC VB-2A S1	-	-	1100
GGC VB-2A S3	1200	-	3890
GGC VB-2A S4	-	-	28600
GGC VB-2A S5	-	-	144
GGC VB-3 S1	<10	-	314
GGC VB-4 S1	-	-	271
GGC VB-6 S1	29300	-	114000
GGC VB-6 S1 Duplicate	25100	-	104000
SS1 -SS5 Composite	522	1160	816
Blank	<10	-	<100

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5

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service
laboratories
ltd.

FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date: March 23, 1993

ASL File No. 8995C

Report On: Soil Analysis; Project 1253

Report To: **Envirochem Services**
310 East Esplanade
North Vancouver, BC
V7L 1A4

Attention: **Ms. Linda Eastcott**

Received: February 25, 1993

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Jasper van de Wetering, B.Sc.
Project Chemist

Scott Hannam
Manager, Trace Organics Lab

RESULTS OF ANALYSIS - Sediment/Soil

File No. 8995C

		TP-1 70cm	TP-1 1.2m	TP-6 50-70cm	VB-7 S2 4-5'	SS1-SS5 Comp.
		93 02 10	93 02 10	93 02 10	92 11 19	92 11 19
Physical Tests						
Moisture	%	6.35	5.65	14.5	24.6	37.6
Total Metals						
Arsenic	T-As	1.43	1.18	3.27	7.80	15.0
Barium	T-Ba	50.6	140	69.4	66.2	111
Cadmium	T-Cd	<0.10	<0.10	0.26	<0.10	1.18
Chromium	T-Cr	12.9	7.8	29.3	47.3	47.6
Cobalt	T-Co	5.8	4.5	5.8	14.1	11.5
Copper	T-Cu	14.6	10.9	17.6	49.8	128
Lead	T-Pb	9.5	4.6	50.0	68.4	1080
Mercury	T-Hg	0.022	0.007	0.036	0.205	1.18
Molybdenum	T-Mo	<4.0	<4.0	<4.0	<4.0	<4.0
Nickel	T-Ni	8.1	4.5	30.7	35.7	34.2
Selenium	T-Se	<0.10	<0.10	0.10	0.23	0.26
Silver	T-Ag	<2.0	<2.0	<2.0	<2.0	<2.0
Tin	T-Sn	<30	<30	<30	<30	222
Zinc	T-Zn	41.7	37.2	107	106	850
Polyaromatic Hydrocarbons						
Acenaphthene		-	-	<5.00	-	-
Acenaphthylene		-	-	<2.00	-	-
Anthracene		-	-	9.01	-	-
Benzo(a)anthracene		-	-	17.4	-	-
Benzo(a)pyrene		-	-	14.6	-	-
Benzo(b)fluoranthene		-	-	9.09	-	-
Benzo(ghi)perylene		-	-	7.66	-	-
Benzo(k)fluoranthene		-	-	1.65	-	-
Chrysene		-	-	16.0	-	-
Dibenzo(a,h)anthracene		-	-	3.00	-	-
Fluoranthene		-	-	8.96	-	-
Fluorene		-	-	20.7	-	-
Indeno(1,2,3-cd)pyrene		-	-	3.48	-	-
Naphthalene		-	-	<2.00	-	-
Phenanthrene		-	-	67.3	-	-
Pyrene		-	-	47.7	-	-
Polychlorinated Biphenyls						
Total Polychlorinated Biphenyls		-	-	<0.050	-	<0.050

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.

RESULTS OF ANALYSIS - Sediment/Soil

File No. 8995C

	SS1-SS5 Comp.
	92 11 19
Organochloride Pesticides	
Aldrin	<0.001
alpha-BHC	<0.001
beta-BHC	<0.002
gamma-BHC (Lindane)	<0.001
delta-BHC	<0.001
cis-Chlordane (alpha)	<0.001
4,4'-DDD	<0.001
4,4'-DDE	<0.001
4,4'-DDT	<0.001
Dieldrin	<0.001
Endosulfan I	<0.001
Endosulfan II	<0.001
Endosulfan Sulfate	<0.005
Endrin	<0.005
Heptachlor	<0.002
Heptachlor Epoxide	<0.001
Methoxychlor	<0.005
Toxaphene	<0.030

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.

RESULTS OF ANALYSIS - Sediment/Soil

File No. 8995C

		SS1-SS5 Comp. Dup. 92 11 19	BH1 S1 0.8m 93 02 24	BH1 S2 2.2m 93 02 24	BH1 S3 4.5m 93 02 24	BH2 S4 1.1m 93 02 24
Physical Tests						
Moisture	%	-	15.8	29.9	25.9	4.15
Total Metals						
Arsenic	T-As	14.7	3.39	5.46	2.81	0.55
Barium	T-Ba	103	123	74.6	65.4	44.1
Cadmium	T-Cd	1.37	<0.10	<0.10	<0.10	<0.10
Chromium	T-Cr	47.3	38.7	58.2	55.0	36.9
Cobalt	T-Co	12.1	13.1	18.3	15.5	9.3
Copper	T-Cu	122	36.2	37.0	33.3	13.6
Lead	T-Pb	939	10.8	15.8	6.1	<2.0
Mercury	T-Hg	1.24	0.038	0.074	0.049	0.020
Molybdenum	T-Mo	5.0	<4.0	<4.0	<4.0	<4.0
Nickel	T-Ni	34.5	25.7	41.2	46.7	31.5
Selenium	T-Se	0.26	0.11	0.25	0.17	<0.10
Silver	T-Ag	<2.0	<2.0	<2.0	<2.0	<2.0
Tin	T-Sn	141	<30	<30	<30	<30
Zinc	T-Zn	1000	78.8	91.8	84.6	40.8

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.

RESULTS OF ANALYSIS - Sediment/Soil

File No. 8995C

		BH2 S5 3.5m 93 02 24	BH2 S5 3.5m Dup. 93 02 24	BH3 S8 1.2m 93 02 24	BH3 S9 2.0m 93 02 24	BH4 S11 0.8m 93 02 24
Physical Tests						
Moisture	%	21.7	-	28.1	27.8	31.6
Total Metals						
Arsenic	T-As	18.5	10.2	4.91	3.49	5.28
Barium	T-Ba	134	139	70.9	67.5	126
Cadmium	T-Cd	0.56	0.59	<0.10	<0.10	0.15
Chromium	T-Cr	27.1	26.1	50.9	52.1	54.7
Cobalt	T-Co	8.1	12.1	7.4	7.8	11.1
Copper	T-Cu	121	98.7	32.4	23.5	86.0
Lead	T-Pb	578	668	8.2	7.6	87.7
Mercury	T-Hg	3.33	3.53	0.052	0.059	0.199
Molybdenum	T-Mo	<4.0	<4.0	<4.0	<4.0	<4.0
Nickel	T-Ni	45.0	45.4	20.5	24.8	44.9
Selenium	T-Se	<0.10	<0.10	0.21	0.18	0.19
Silver	T-Ag	<2.0	<2.0	<2.0	<2.0	<2.0
Tin	T-Sn	433	541	<30	<30	49
Zinc	T-Zn	488	498	66.7	62.4	177
Polyaromatic Hydrocarbons						
Acenaphthene		-	-	<0.100	-	-
Acenaphthylene		-	-	<0.050	-	-
Anthracene		-	-	1.02	-	-
Benzo(a)anthracene		-	-	6.72	-	-
Benzo(a)pyrene		-	-	6.09	-	-
Benzo(b)fluoranthene		-	-	2.23	-	-
Benzo(ghi)perylene		-	-	3.26	-	-
Benzo(k)fluoranthene		-	-	0.227	-	-
Chrysene		-	-	6.12	-	-
Dibenzo(a,h)anthracene		-	-	1.29	-	-
Fluoranthene		-	-	0.900	-	-
Fluorene		-	-	0.521	-	-
Indeno(1,2,3-cd)pyrene		-	-	0.759	-	-
Naphthalene		-	-	<0.020	-	-
Phenanthrene		-	-	4.05	-	-
Pyrene		-	-	11.8	-	-

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.

RESULTS OF ANALYSIS - Sediment/Soil

File No. 8995C

		BH6 S13 2.8m 93 02 24	BH6 S14 4.2m 93 02 24	BH6 S14 4.2m Dup. 93 02 24
Physical Tests				
Moisture	%	22.9	24.6	-
Total Metals				
Arsenic	T-As	6.49	2.81	2.51
Barium	T-Ba	72.1	55.0	42.9
Cadmium	T-Cd	<0.10	<0.10	<0.10
Chromium	T-Cr	46.9	49.5	48.8
Cobalt	T-Co	12.9	13.9	15.4
Copper	T-Cu	36.3	27.6	28.5
Lead	T-Pb	26.1	5.5	5.6
Mercury	T-Hg	0.049	0.055	0.064
Molybdenum	T-Mo	<4.0	<4.0	<4.0
Nickel	T-Ni	33.9	45.2	44.2
Selenium	T-Se	0.20	0.18	0.16
Silver	T-Ag	<2.0	<2.0	<2.0
Tin	T-Sn	<30	<30	<30
Zinc	T-Zn	94.4	73.3	73.1

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.

RESULTS OF ANALYSIS - QA Data

File No. 8995C

		Method blank	Spike[1] (% Rec.)	CRM NRC MESS-1 found	CRM NRC BEST-1 found
Total Metals					
Arsenic	T-As	<0.05	-	9.50	-
Barium	T-Ba	<1.0	-	68.0	-
Cadmium	T-Cd	<0.10	-	<0.10	-
Chromium	T-Cr	<2.0	-	35.7	-
Cobalt	T-Co	<2.0	-	9.2	-
Copper	T-Cu	<1.0	-	26.0	-
Lead	T-Pb	<2.0	-	28.8	-
Mercury	T-Hg	<0.005	-	-	0.098
Molybdenum	T-Mo	<4.0	-	<4.0	-
Nickel	T-Ni	<2.0	-	26.8	-
Selenium	T-Se	<0.10	-	0.34	-
Silver	T-Ag	<2.0	-	<2.0	-
Tin	T-Sn	<30	-	<30	-
Zinc	T-Zn	<1.0	-	180	-
Polyaromatic Hydrocarbons					
Acenaphthene		<0.020	-	-	-
Acenaphthylene		<0.020	-	-	-
Anthracene		<0.020	-	-	-
Benzo(a)anthracene		<0.020	-	-	-
Benzo(a)pyrene		<0.020	-	-	-
Benzo(b)fluoranthene		<0.020	-	-	-
Benzo(ghi)perylene		<0.020	-	-	-
Benzo(k)fluoranthene		<0.020	-	-	-
Chrysene		<0.020	-	-	-
Dibenzo(a,h)anthracene		<0.020	-	-	-
Fluoranthene		<0.020	-	-	-
Fluorene		<0.020	-	-	-
Indeno(1,2,3-cd)pyrene		<0.020	-	-	-
Naphthalene		<0.020	-	-	-
Phenanthrene		<0.020	-	-	-
Pyrene		<0.020	-	-	-
Polychlorinated Biphenyls					
Total Polychlorinated Biphenyls		<0.050	92	-	-

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.
[1]PAH spike data not available for this batch.

RESULTS OF ANALYSIS - QA Data

File No. 8995C

	Method blank	Spike[1] (% Rec.)
Organochloride Pesticides		
Aldrin	<0.001	80
alpha-BHC	<0.001	75
beta-BHC	<0.002	65
gamma-BHC (Lindane)	<0.001	74
delta-BHC	<0.001	60
cis-Chlordane (alpha)	<0.001	93
4,4'-DDD	<0.001	33
4,4'-DDE	<0.001	87
4,4'-DDT	<0.001	104
Dieldrin	<0.001	88
Endosulfan I	<0.001	84
Endosulfan II	<0.001	84
Endosulfan Sulfate	<0.005	98
Endrin	<0.005	94
Heptachlor	<0.002	100
Heptachlor Epoxide	<0.001	90
Methoxychlor	<0.005	104
Toxaphene	<0.030	-

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
Dup. = Duplicate.
[1]PAH spike data not available for this batch.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103 C.

Metals in Sediment/Soil

These analyses are carried out using procedures that are consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 3050 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedures involve a digestion using a combination of nitric and hydrochloric acids. The resulting extract is bulked to volume with deionized/distilled water. The digested portion is then analysed by a variety of instrumental techniques, which may include specific atomic absorption spectrophotometric techniques (AAS) and/or atomic emission spectrophotometry (ICP), to obtain the required detection limit for each element. Specific details are available upon request.

PLEASE NOTE (When the following elements are reported):

Aluminum, barium, calcium, chromium, iron, magnesium, manganese, molybdenum and vanadium are often associated with the silicate matrix of the sediment. Because of this, the recoveries of these elements may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

Polynuclear Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted by ASL from U.S. EPA Methods 3540, 3630, and 8270 (Publ. # SW-846 3rd ed., Washington, DC 20460). The procedure involves a triple solvent extraction with dichloromethane and clean-up using silica gel column chromatography. This clean-up procedure has been found to effectively remove aliphatic and heterocyclic hydrocarbons which could potentially interfere with the analysis. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection.

Polychlorinated Biphenyls in Sediment/Soil

This analysis is carried out in accordance with U.S. EPA Method 8080. The procedure involves drying prior to using either a soxhlet extraction or solid-liquid extraction. The extract is reduced in volume and cleaned-up with florisil. The final extract is analysed by capillary column gas

chromatography with electron capture detection.

Organochloride Pesticides in Sediment/Soil

This analysis is carried out in accordance with U.S. EPA Method 8080 (Publ. # SW-846 3rd ed., Washington, DC 20460). The procedure involves a solvent extraction with acetonitrile. The extract is then solvent exchanged to hexane followed by an alumina column clean-up. The final extract is analysed by dual capillary column gas chromatography with electron capture detection.

End of Report

APPENDIX

REFERENCE MATERIAL CERTIFICATION DATA

National Research Council Canada
Conseil national de recherches Canada

Division of Chemistry
Division de chimie

Marine Analytical Chemistry Standards Program
Programme de standards de chimie analytique marine

Ottawa, Canada
K1A 0R6

Telephone (613) 993-2359
Facsimile (613) 993-2451
Telex 053-3145

January, 1981
Revised February, 1987
Revised October, 1987
Revised April, 1990

BCSS-1, MESS-1, PACS-1, BEST-1

Marine Sediment Reference Materials for Trace Elements and Other Constituents

The following tables show those constituents for which certified values have been established. Certified values are based on the results of determinations by at least two independent methods of analysis. The uncertainties represent 95% confidence limits for an individual subsample. That is, 95% of samples from any bottle would be expected to have concentrations within the specified range 95% of the time.

Trace Metals — Milligrams per Kilogram

	MESS-1	BCSS-1	PACS-1
Antimony (g,h,i,n)	0.73 ± 0.08	0.59 ± 0.06	171 ± 14
Arsenic (b,h,i,n,p)	10.6 ± 1.2	11.1 ± 1.4	211 ± 11
Beryllium (g,i)	1.9 ± 0.2	1.3 ± 0.3	—
Cadmium (g,i,m,q)	0.59 ± 0.10	0.25 ± 0.04	2.38 ± 0.20
Chromium (m,n,p,q,x)	71 ± 11	123 ± 14	113 ± 8
Cobalt (f,g,i,m,n,p,x)	10.8 ± 1.9	11.4 ± 2.1	17.5 ± 1.1
Copper (f,g,i,m,n)	25.1 ± 3.8	18.5 ± 2.7	452 ± 16
Lead (f,g,i,m,p,q,x)	34.0 ± 6.1	22.7 ± 3.4	404 ± 20
Manganese (f,i,n,p,x)	513 ± 25	229 ± 15	470 ± 12
Mercury (c,q)	—	—	4.57 ± 0.16
Molybdenum (g,i,q)	—	—	12.9 ± 0.9
Nickel (g,i,m,n,q)	29.5 ± 2.7	55.3 ± 3.6	44.1 ± 2.0
Selenium (g,h,l,m)	0.34 ± 0.06	0.43 ± 0.06	1.09 ± 0.11
Strontium (f,i,g)	—	—	277 ± 11
Tin (g,h,i,q)	3.98 ± 0.44	1.85 ± 0.20	41.1 ± 3.1
Vanadium (f,i,m,n)	72.4 ± 17	93.4 ± 4.9	127 ± 5
Zinc (f,i,m,n,q,x)	191 ± 17	119 ± 12	824 ± 22
Tributyltin	—	—	1.27 ± 0.22 (as Sn)
Dibutyltin	—	—	1.16 ± 0.18 (as Sn)
Monobutyltin	—	—	0.28 ± 0.17 (as Sn)

* See overleaf for key to coding.

Canada

Matrix and Minor Constituents — Percent

	MESS-1		BCSS-1		PACS-1	
Al_2O_3 (d,f,i,n,x)	11.03	± 0.38	11.83	± 0.41	12.23	± 0.22
C (e,r)	2.99	± 0.09	2.19	± 0.09	3.69	± 0.11
CaO (f,i,n,p,x)	0.674	± 0.064	0.760	± 0.074	2.92	± 0.13
Cl (n,v,x)	0.82	± 0.07	1.12	± 0.05	2.39	± 0.09
Fe_2O_3 (d,f,i,n,p,x)	4.36	± 0.25	4.70	± 0.14	6.96	± 0.12
K_2O (f,n,x)	2.24	± 0.04	2.17	± 0.04	1.50	± 0.09
MgO (d,f,i,p)	1.44	± 0.09	2.44	± 0.23	2.41	± 0.09
Na_2O (f,i,n,p)	2.50	± 0.15	2.72	± 0.21	4.40	± 0.11
P_2O_5 (i,x)	0.146	± 0.014	0.154	± 0.016	0.233	± 0.018
S (i,x,x)	0.72	± 0.05	0.36	± 0.05	1.32	± 0.08
SiO_2 (f,x)	67.5	± 1.9	66.1	± 1.0	55.7	± 0.5
TiO_2 (d,f,i,n,p,x)	0.905	± 0.028	0.734	± 0.024	0.703	± 0.011

BEST-1

Mercury (a,c,q) 0.092 ± 0.009 milligrams per kilogram

Coding

a — Atomic fluorescence spectrometry
b — Inductively coupled plasma mass spectrometry
c — Cold vapour atomic absorption spectrometry
d — DC plasma atomic emission spectrometry
e — Coulometry
f — Flame atomic absorption spectrometry
g — Graphite furnace atomic absorption spectrometry
h — Hydride generation atomic absorption spectrometry
i — Inductively coupled plasma atomic emission spectrometry
l — Liquid chromatography
m — Isotope dilution solid source mass spectrometry
n — Instrumental neutron activation analysis
p — Instrumental photonuclear activation analysis
q — Isotope dilution inductively coupled plasma mass spectrometry
r — Infrared spectrometry
v — Volumetric analysis
x — X-ray fluorescence spectrometry

Not all the methods listed above were applied to all materials

These reference materials are primarily for use in the calibration of procedures and the development of methods used for the analysis of marine sediments and materials with similar matrices.

Preparation of material

MESS-1 and BCSS-1 were collected by MacLaren Plansearch Ltd., Dartmouth, Nova Scotia, from the Gulf of St. Lawrence (MESS-1 from the Miramichi River estuary and BCSS-1 from the Baie des Chaleurs). PACS-1 was collected by Dobrocky Seatech Ltd., Sidney, British Columbia in the harbour of Esquimalt, British Columbia. BEST-1 is from the Beaufort Sea. They were freeze dried (Freeze-Dry Foods, Oakville, Ont.), screened to pass a No. 120 (125 μm) screen, blended and bottled by Chemistry Division staff using the facilities of the Canada Centre for Mineral and Energy Technology in Ottawa. After bottling, the samples were radiation sterilized with a minimum dose of 2.5 Mrad by the Canadian Irradiation Centre (formerly Atomic Energy of Canada Ltd.) to minimize effects from biological activity.

Envirochem Special Projects Inc.
310 EAST ESPLANADE
NORTH VANCOUVER, B.C.
V7L 1A4

CHEMICAL ANALYSIS REPORT

Date:	March 1, 1993
Date of Analysis:	February 24, 1992
File #:	C0061
Report On:	Gravimetric Mineral Oil and Grease
Report To:	Gulf of Georgia Cannery c/o Envirochem Services 310 East Esplanade North Vancouver, B.C. V7L 1A4
Attention:	Linda Eastcott
Date of Sampling:	February 10, 1993
Sample Identification:	Labelled as shown in results section.

Methodology

The sample is extracted for 4 hours with hexane/acetone using a soxlet extraction apparatus. The extract is evaporated to dryness, redissolved in solvent, followed by a clean up with silica gel. The extract is then re-evaporated to dryness and weighed to determine gravimetric mineral oil and grease.

Results of Analysis

Results are presented in the attached table.

ENVIROCHEM SERVICES ANALYTICAL DEPARTMENT

Megan Sterling

Megan Sterling, B.Sc.
Chemist

RESULTS OF ANALYSIS

SAMPLE IDENTIFICATION	Mineral Oil and Grease (mg/Kg of dry sample)
Blank	<100
Sediment #1	1775
Sediment #2	2631
Spike	104%

* The blank is a sediment sample with no detectable oil and grease.
** The spike is a weighed portion of motor oil in the sediment used for blanks.

Envirochem Special Projects Inc.
310 EAST ESPLANADE
NORTH VANCOUVER, B.C.
V7L 1A4

CHEMICAL ANALYSIS REPORT

Date:	March 5, 1993
Date of Analysis:	March 2, 1993
File #:	C0062
Report On:	Gravimetric Mineral Oil and Grease
Report To:	Gulf of Georgia Cannery c/o Envirochem Services 310 East Esplanade North Vancouver, B.C. V7L 1A4
Attention:	Linda Eastcott
Date of Sampling:	February 10, 1993
Sample Identification:	Labelled as shown in results section.

Methodology

The sample is extracted for 4 hours with hexane/acetone using a soxhlet extraction apparatus. The extract is evaporated to dryness, redissolved in solvent, followed by a clean up with silica gel. The extract is then re-evaporated to dryness and weighed to determine gravimetric mineral oil and grease.

Results of Analysis

Results are presented in the table attached.

ENVIROCHEM SERVICES ANALYTICAL DEPARTMENT

Megan Sterling

Megan Sterling, B.Sc.
Chemist

RESULTS OF ANALYSIS

SAMPLE IDENTIFICATION	Oil and Grease (mg/Kg of dry sample)
Blank	<100
TP-1 70cm	392
TP-1 1.2m	122
TP-2 80cm	65000
TP-2 1.8m	483
TP-2 1.8m Duplicate	392
TP-3 1m	799
TP-6 30 cm	<100
TP-6 50-70cm	267000
TP-6 70-80cm	37900
TP-6 2m	320
Spike	86%
TP-7 1m	3490
TP-8 1.1m	7740

* The duplicate is a separate portion of sample TP-2 1.8m run through the entire procedure.

** The blank is a sediment sample with no detectable oil and grease.

*** The spike is a weighed portion of motor oil in the sediment used for blanks.

Envirochem Special Projects Inc.
310 EAST ESPLANADE
NORTH VANCOUVER, B.C.
V7L 1A4

CHEMICAL ANALYSIS REPORT

Date:	March 8, 1993
Date of Analysis:	March 5, 1993
File #:	C0063
Report On:	Gravimetric Mineral Oil and Grease
Report To:	Gulf of Georgia Cannery c/o Envirochem Services 310 East Esplanade North Vancouver, B.C. V7L 1A4
Attention:	Linda Eastcott
Date of Sampling:	February 10, 1993
Sample Identification:	Labelled as shown in results section.

Methodology

The sample is extracted for 4 hours with hexane/acetone using a soxhlet extraction apparatus. The extract is evaporated to dryness, redissolved in solvent, followed by a clean up with silica gel. The extract is then re-evaporated to dryness and weighed to determine gravimetric mineral oil and grease.

Results of Analysis

Results are presented in the table attached.

ENVIROCHEM SERVICES ANALYTICAL DEPARTMENT

Megan Sterling

Megan Sterling, B.Sc.
Chemist

RESULTS OF ANALYSIS

SAMPLE IDENTIFICATION	Oil and Grease (mg/Kg of dry sample)
Blank	<100
S1	770
S2	2810
S3	<100
S4	5300
S5	612
S8	17200
S9	278
S9 Duplicate	462
S11	<100
S13	774
S14	<200
Spike	79%

* The duplicate is a separate portion of sample S9 run through the entire procedure.
** The blank is a sediment sample with no detectable oil and grease.
*** The spike is a weighed portion of motor oil in the sediment used for blanks.
**** The higher detection limit for sample S14 is necessary because of the high moisture content of the sample.

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5 FAX:(604) 253-6700 TEL:(604) 253-4188

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CHEMICAL ANALYSIS REPORT

Date: December 4, 1992

ASL File No. 7365C

Report On: Soil Analysis Project #1253

Report To: **Envirochem Services**
310 East Esplanade
North Vancouver, BC
V7L 1A4

Attention: **Ms. Linda Eastcott**

Received: November 20, 1992

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Jasper van de Wetering, B.Sc.
Project Chemist

Howie Ho, B.Sc.
Project Chemist

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RESULTS OF ANALYSIS

File No. 7365C

		SM-1	GGC VB-7 S1	GGC VB-9 S1	GGC VB-8 S1	GGC[1] VB-8 S1 Dup.
		92 11 19	92 11 19	92 11 19	92 11 19	92 11 19
Physical Tests						
Moisture	%	15.7	21.5	9.96	8.07	-
Total Metals						
Arsenic	T-As	13.3	11.5	1.85	4.53	3.85
Barium	T-Ba	3.6	332	52.6	46.8	35.0
Cadmium	T-Cd	<0.10	0.46	<0.10	<0.10	<0.10
Chromium	T-Cr	113	47.5	29.0	13.0	10.9
Cobalt	T-Co	23.5	8.4	8.9	5.6	4.6
Copper	T-Cu	289	159	14.1	15.1	11.0
Lead	T-Pb	47.2	410	3.6	8.9	7.7
Mercury	T-Hg	0.037	1.35	0.024	0.006	<0.005
Molybdenum	T-Mo	<4.0	<4.0	<4.0	<4.0	<4.0
Nickel	T-Ni	105	34.8	32.2	7.2	6.8
Selenium	T-Se	<0.10	0.13	<0.10	<0.10	<0.10
Silver	T-Ag	<2.0	<2.0	<2.0	<2.0	<2.0
Tin	T-Sn	<30	37	<30	<30	<30
Zinc	T-Zn	137	308	46.3	49.6	43.7
Polyaromatic Hydrocarbons						
Acenaphthene		0.220	-	-	-	-
Acenaphthylene		0.062	-	-	-	-
Anthracene		2.29	-	-	-	-
Benzo(a)anthracene		2.56	-	-	-	-
Benzo(a)pyrene		1.27	-	-	-	-
Benzo(b)fluoranthene		1.30	-	-	-	-
Benzo(ghi)perylene		1.37	-	-	-	-
Benzo(k)fluoranthene		0.130	-	-	-	-
Chrysene		5.08	-	-	-	-
Dibenzo(a,h)anthracene		0.570	-	-	-	-
Fluoranthene		3.62	-	-	-	-
Fluorene		0.610	-	-	-	-
Indeno(1,2,3-cd)pyrene		0.500	-	-	-	-
Naphthalene		0.690	-	-	-	-
Phenanthrene		35.7	-	-	-	-
Pyrene		11.2	-	-	-	-
Extractables						
Oil and Grease		190000	-	-	140	130
Mineral Oil & Grease		110000	-	-	70	-

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
[1]Dup. = Duplicate.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103 C.

Metals in Sediment/Soil

These analyses are carried out using procedures that are consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 3050 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedures involve a digestion using a combination of nitric and hydrochloric acids. The resulting extract is bulked to volume with deionized/distilled water. The digested portion is then analysed by a variety of instrumental techniques, which may include specific atomic absorption spectrophotometric techniques (AAS) and/or atomic emission spectrophotometry (ICP), to obtain the required detection limit for each element. Specific details are available upon request.

PLEASE NOTE (When the following elements are reported):

Aluminum, barium, calcium, chromium, iron, magnesium, manganese, molybdenum and vanadium are often associated with the silicate matrix of the sediment. Because of this, the recoveries of these elements may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

Polynuclear Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted by ASL from various literature and U.S. EPA Methods 610/625 (40 CFR Part 136, Federal Register 49:209). The procedure involves a triple solvent extraction with acetonitrile. The initial extract is cleaned-up using solid phase extraction columns containing octadecylsilane followed by a further clean-up using silica gel solid phase extraction columns. These clean-up procedures have been found to effectively remove aliphatic and heterocyclic hydrocarbons which could potentially interfere with the analysis. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection.

Oil and Grease in Sediment/Soil

This analysis is carried out by extracting the sample with hexane. The extract thus produced is evaporated to dryness and the residue weighed to determine gravimetric oil and grease.

Mineral Oil & Grease In Sediment/Soil

This analysis is carried out in accordance with U.S. EPA Method 9071 (Pub.# SW-846, 3rd Ed., 1986, Washington, DC 20460). The procedure involves extraction of the dried soil with hexane followed by silica-gel clean-up, evaporation to dryness, and gravimetric determination.

End of Report

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FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date: March 22, 1993

ASL File No. 8910C

Report On: Paint Analysis; Project # 1253

Report To: **Envirochem Services**
310 East Esplanade
North Vancouver, BC
V7L 1A4

Attention: **Ms. Linda Eastcott**

Received: February 24, 1993

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Jasper van de Wetering, B.Sc.
Project Chemist

Frederick Chen, B.Sc.
Project Chemist

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REMARKS

File No. 8910C

A Standard Reference Material (SRM) certified by the National Institute of Standards and Technology (NIST) was analysed concurrently with these paint chip samples. This SRM is a powdered lead-based paint which is certified, using an isotope dilution mass spectrometric method, to contain 120000 milligrams per kilogram of lead.

The recovery of lead from the SRM, using an aqua-regia digestion in conjunction with inductively coupled plasma, is outside the 95% confidence interval. Paint matrices vary considerably and it is difficult to determine if the submitted samples have similar characteristics. The NIST paint SRM is not certified for any metals other than lead.

RESULTS OF ANALYSIS - Solids

File No. 8910C

		1253 PT #1 93 02 23	1253 PT #2 93 02 23	1253 PT #3 93 02 23	1253 PT #4 93 02 23	1253 PT #5 93 02 23
Total Metals						
Aluminum	T-Al	2480	28500	6360	1560	17700
Antimony	T-Sb	38	<25	<25	<25	<25
Arsenic	T-As	<100	<100	<100	<100	215
Barium	T-Ba	7990	21.0	38.8	40.0	125
Cadmium	T-Cd	15.7	<2.0	<2.0	16.9	19.8
Calcium	T-Ca	14800	2860	68000	12300	1010
Chromium	T-Cr	56.0	823	17.7	674	4470
Cobalt	T-Co	88.7	190	172	1120	162
Copper	T-Cu	22.9	202	19.7	114	419
Iron	T-Fe	900	153000	64300	8880	503000
Lead	T-Pb	2110	5270	482	9210	12200
Magnesium	T-Mg	9370	1850	10100	1360	850
Manganese	T-Mn	57.2	771	346	362	5170
Molybdenum	T-Mo	20.1	<5.0	<5.0	<5.0	19.9
Nickel	T-Ni	<2.0	50.7	15.7	20.7	223
Selenium	T-Se	<50	<50	<50	<50	<50
Silver	T-Ag	<2.0	<2.0	<2.0	<2.0	<2.0
Tin	T-Sn	<30	<30	58	<30	49
Vanadium	T-V	<2.0	5.7	<2.0	<2.0	238
Zinc	T-Zn	124000	2810	2000	1290	652

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Solids

File No. 8910C

		1253 PT #6 93 02 23	1253 PT #7 93 02 23	1253 PT #8 93 02 23
Total Metals				
Aluminum	T-Al	2890	2720	121000
Antimony	T-Sb	<25	64	46
Arsenic	T-As	<100	<100	<100
Barium	T-Ba	3290	21000	592
Cadmium	T-Cd	5.2	20.5	3.9
Calcium	T-Ca	19800	4550	3060
Chromium	T-Cr	11300	34.3	1160
Cobalt	T-Co	708	188	122
Copper	T-Cu	1010	15.5	135
Iron	T-Fe	38800	2840	122000
Lead	T-Pb	65700	17100	37900
Magnesium	T-Mg	2530	5100	1390
Manganese	T-Mn	168	34.5	554
Molybdenum	T-Mo	113	10.8	15.5
Nickel	T-Ni	9.3	<2.0	65.3
Selenium	T-Se	<50	<50	<50
Silver	T-Ag	<2.0	<2.0	2.6
Tin	T-Sn	<30	60	<30
Vanadium	T-V	11.2	<2.0	13.7
Zinc	T-Zn	3320	82900	5610

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

NIST-SRM Powdered Pb Based Paint		crm	Certified Value	Confidence Interval
Total Metals				
Lead	T-Pb	77300	120000	± 310

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

QUALITY CONTROL - Method Blank

File No. 8910C

		Method Blank 93 03 19
Total Metals		
Aluminum	T-Al	<50
Antimony	T-Sb	<25
Arsenic	T-As	<100
Barium	T-Ba	<1.0
Cadmium	T-Cd	<2.0
Calcium	T-Ca	<50
Chromium	T-Cr	<2.0
Cobalt	T-Co	<2.0
Copper	T-Cu	<1.0
Iron	T-Fe	<50
Lead	T-Pb	<10
Magnesium	T-Mg	<50
Manganese	T-Mn	<0.10
Molybdenum	T-Mo	<5.0
Nickel	T-Ni	<2.0
Selenium	T-Se	<50
Silver	T-Ag	<2.0
Tin	T-Sn	<30
Vanadium	T-V	<2.0
Zinc	T-Zn	<1.0

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Metals in Paint Solids

These analyses are carried out using procedures that are consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 3050 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedures involve a digestion using a combination of nitric and hydrochloric acids. The resulting extract is bulked to volume with deionized/distilled water. The digested portion is then analysed by a variety of instrumental techniques, which may include specific atomic absorption spectrophotometric techniques (AAS) and/or atomic emission spectrophotometry (ICP), to obtain the required detection limit for each element. Specific details are available upon request.

End of Report

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5

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FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date: January 15, 1993

ASL File No. 7692C

Report On: Solids and Fish oil analysis
Project # 1253

Report To: **Envirochem Services**
310 East Esplanade
North Vancouver, BC
V7L 1A4

Attention: **Ms. Linda Eastcott**

Received: December 8, 1992

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Jasper van de Wetering, B.Sc.
Project Chemist

Scott Hannam
Supervisor, Trace Organics Lab

CELEBRATING 10 YEARS OF EXCELLENCE

RESULTS OF ANALYSIS - Solids[1]

File No. 7692C

		1253-Soot 92 12 03	1253-PNT 92 12 03	1253-PNT[2] Dup. 92 12 03
Physical Tests				
Moisture	%	<0.01	<0.01	-
Total Metals				
Lead	T-Pb	73.0	2360	2150

< = Less than the detection limit indicated.
[1]Solids results are expressed as milligrams per kilogram.
[2]Dup. = Duplicate.

RESULTS OF ANALYSIS - Oil[1]

File No. 7692C

	1253-Oil 7 92 12 03	1253-[2] Oil 7 Dup. 92 12 03
Polychlorinated Biphenyls		
Total Polychlorinated Biphenyls	0.86	0.98
Organochloride Pesticides		
alpha-BHC	0.027	0.027
beta-BHC	<0.010	<0.010
gamma-BHC (Lindane)	<0.010	<0.010
delta-BHC	<0.010	<0.010
cis-Chlordane (alpha)	0.062	0.055
4,4'-DDD	0.059	0.077
4,4'-DDE	0.597	0.523
4,4'-DDT	<0.010	<0.010
Dieldrin	0.019	0.019
Endosulfan I	<0.010	<0.010
Endosulfan II	<0.010	<0.010
Endrin	<0.010	<0.010
Heptachlor	<0.010	<0.010
Heptachlor Epoxide	<0.010	<0.010
Toxaphene	<0.010	<0.010

< = Less than the detection limit indicated.
[1]Oil results are expressed as milligrams per kilogram.
[2]Dup. = Duplicate.

RESULTS OF ANALYSIS - QA Data[1]

File No. 7692C

	Spike (% Rec.)	Blank
	92 12 29	92 12 29
Total Metals		
Lead T-Pb	-	<2.0
Polychlorinated Biphenyls		
Total Polychlorinated Biphenyls	-	<0.05
Organochloride Pesticides		
alpha-BHC	84	<0.010
beta-BHC	95	<0.010
gamma-BHC (Lindane)	87	<0.010
delta-BHC	88	<0.010
cis-Chlordane (alpha)	95	<0.010
4,4'-DDD	97	<0.010
4,4'-DDE	109	<0.010
4,4'-DDT	120	<0.010
Dieldrin	95	<0.010
Endosulfan I	96	<0.010
Endosulfan II	93	<0.010
Endrin	119	<0.010
Heptachlor	88	<0.010
Heptachlor Epoxide	92	<0.010
Toxaphene	-	<0.010

< = Less than the detection limit indicated.
[1]Spike results are expressed as percent recovery.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103 C.

Metals in Sediment/Soil

These analyses are carried out using procedures that are consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 3050 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedures involve a digestion using a combination of nitric and hydrochloric acids. The resulting extract is bulked to volume with deionized/distilled water. The digested portion is then analysed by a variety of instrumental techniques, which may include specific atomic absorption spectrophotometric techniques (AAS) and/or atomic emission spectrophotometry (ICP), to obtain the required detection limit for each element. Specific details are available upon request.

Organochloride Pesticides and Polychlorinated Biphenyls in Fish Oil

This analysis is carried out in accordance with U.S. EPA Method 8080 (Publ. #SW-846 3rd Edition, Washington, DC 20460). A portion of the sample is dissolved in hexane and cleaned up using gel permeation and alumina column chromatography. The final extract is analysed by dual capillary column gas chromatography with electron capture detection.

End of Report

beak consultants limited
160 - 14480 River Road
Richmond, B.C.
V6V 1L4
Off. (604) 278-7714
Fax (604) 278-7741

REPORT TO: Mr. Dennis Konasewich
Envirochem Special Projects Inc.
310 East Esplanade
North Vancouver, B.C. V7P 1A4

DATE: February 25, 1993

MICROTOX SOLID-PHASE BIOASSAY RESULTS

Sample Name: Sediments (Project No. 1253; P.O. #65392)
Collection Date: 10 February 1993
Date, time received: 16 February 1993; 1100 hrs.
Date, time tested: 18 February 1993; 0900 hrs.

METHODS

The Microtox bioassay measures toxicity based on light emission from a bioluminescent bacteria in the presence or absence of a toxicant. The bacteria are exposed to different concentrations of a sample and the light loss over time is recorded; the EC_{50} is the concentration of sample causing a 50% reduction in bioluminescence.

RESULTS

Sample ID	5 Minute EC_{50} (95% Confidence Range)
Sediment #1	1,312ppm (900ppm - 1912ppm)
Sediment #2	9,104ppm (8443ppm - 9817ppm)

Reference Toxicant Information:
Chemical Used: Phenol
EC_{50}: 19.8ppm, with a 95% confidence interval between 19.3ppm and 20.3ppm.

Bioassays are performed on the Beckman Model 500 Microtox Toxicity Analyzer System using the methods described in "Microtox Manual, A Toxicity Testing Handbook" 1992.

Beak Consultants Limited

Marian Zazzi
Biologist
b062.1

#1253

Certificate

WOOD LABORATORY (1984) LTD.

ANALYTICAL & CONSULTING CHEMISTS • BACTERIOLOGISTS & FOOD TECHNOLOGISTS

555 HOMER ST., VANCOUVER, B.C. V6B 2V7
TELEPHONE (604) 684-8732
FACSIMILE (604) 684-3917

TO: Envirochem Special Projects Inc.
310 E. Esplanade
North Vancouver, B.C.

DATED: Dec. 17/92

CERTIFICATE NO.: 92-L-37

We have had analyzed the herein described submitted sample(s) and report as follows:

SAMPLE: 3 fish remains SUBMITTED: Dec. 8/92

MARKED: #1 - 1253 - FW1
#2 - 1253 - FW2
#3 - 1253 - FW3

ANALYSIS:

Sample #	Salmonella	Listeria
1	NEgative	Negative
2	Negative	Negative
3	Negative	Negative

WOOD LABORATORY (1984) LTD.

A. Piesik
Microbiologist

RECEIVED DEC 17 1992

SGS Supervision Services Inc.
General Testing Laboratories Division

1001 East Pender Street
Vancouver, B.C.
Canada V6A 1W2
Telephone (604) 254-1647
Fax (604) 254-2148
Telex 04507514

ENVIROCHEM SPECIAL PROJECTS INC.
310 East Esplanade
North Vancouver, B.C.
V7L 1A4

CERTIFICATE OF ANALYSIS

Date: December 16, 1992
File: 0104-25625

WE HAVE ANALYZED the herein described submitted sample and reports as follows:

DESCRIPTION : FISH OIL

SAMPLE RECEIVED : December 8, 1992

ANALYSIS	1253-Oil 7	1253-Oil 8
Vitamin A	0.27 mg/g	0.27 mg/g
Vitamin D	0.02 mg/g	0.02 mg/g

SGS SUPERVISION SERVICES INC.

[signature]

CC/el

Cipriano Cruz, Senior Chemist

APPENDIX C

Air Sampling Survey - Hansen & Associates Ltd.

HANSEN & ASSOCIATES LTD.

Environmental Consulting Services

March 31, 1993

Envirochem Special Projects Inc.
310 East Esplanade
North Vancouver, B.C.
V7L 1A4

Attention: Mr. Tom Finnbogason

Dear Mr. Finnbogason;

Hansen & Associates has completed the inspection of the Gulf of Georgia Cannery for the presence of airborne lead and report as follows.

Samples were collected at the North entrance to the building, near the South end of the building and at the East entrance. Results of analysis are:

1	North Entrance	<0.01 mg/m^3
2	South end	<0.01 mg/m^3
3	East Entrance	<0.01 mg/m^3
Blank		<0.001 mg

Note: mg - milligrams
m3 - cubic metre
< - less than

The Workers' Compensation Board of British Columbia (WCB) permissible exposure limits for airborne dust is 0.15 mg/m3. Samples were collected and analyzed in accordance with WCB analytical method 1050.

Potential exposure to lead dust in the Cannery building should not be of concern. The only likely sources of lead in the building are from lead based paints and the possible presence of solder used in the canning process. These materials are not considered friable (easily turned to dust) and are unlikely to contribute to airborne dust concentrations unless actively disturbed.

I hope this information is helpful to you and I look forward to working with you in the future.

Yours truly,

Robert Christie

Robert Christie, B.Sc., MBA
Principal

270D-R1

1324 Main Street, North Vancouver, B.C. V7J 1C3 • Phone: (604) 980-3577 • Fax: (604) 980 2188

APPENDIX D

Geophysical Survey - Delta Geoscience

DELTA GEOSCIENCE LTD.
Mineral Exploration Geophysics
Consulting and Contracting

642 English Bluff Rd.
Delta, B.C., Canada V4M 2N4
Tel: (604) 943-0983
Fax: (604) 943-3907

November 13, 1992.

Envirochem Special Projects Inc,
310 East Esplanade,
North Vancouver, B.C.,
V7L 1A4.

Attn: Ms. Linda Eastcott.

Dear Linda,

Re: Magnetic Survey -
Gulf of Georgia Cannery

The recently completed geophysical survey of this area consisted of a total field magnetic survey, combined with vertical magnetic gradient measurements. Instruments used were E.D.A. Omni Proton Magnetometers. These instruments measure the magnitude of the earth's magnetic field vector independent of its direction, i.e. total field intensity.

Magnetic anomalies in the earth's magnetic field are generally caused by induced magnetization. Induced magnetization is the action of the earth's field on any material (in this case probably steel or iron pipelines), wherein the ambient field is enhanced and the material itself acts as a magnet. The magnetization of any iron objects will be directly proportional to the intensity of the ambient field (56000 nt at the site) and the ability of the material to enhance the local field - a property called magnetic susceptibility.

The earth's magnetic field varies slowly with time, thus the survey was corrected for the diurnal variation through the use of a base station magnetometer. The base station monitored the earth's field every 30 seconds. This information was cross correlated in time with the portable magnetometer to remove any temporal variation.

When local near-surface targets are being explored, it's often advantageous to measure the vertical gradient (rate of change in one meter) of the magnetic field.

The fall-off factor (attenuation of response with height) is much larger for small near surface sources than for more distant sources, thus the gradient measurement helps to differentiate, or enhance the shallow target response.

If one assumes that buried magnetic objects behave like a magnetic dipole (the most normal case), the fall-off factor with height would be 3 and since we know the gradient $\frac{dT}{dz}$ and the total field anomaly, T, one can determine the anomaly depth Z, i.e. $Z = \frac{-3T}{\frac{dT}{dz}}$

$$\frac{\text{"dT"}}{}$$

Note: "T" and dz are the maximum values above the background response. Remember to subtract 2 meters from the depth estimate, since the sensor was held two meters above the ground surface.

I am enclosing a table and a graph showing the average magnetic response at a distance from several common iron/steel objects.

CANNERY SITE:

Most of the attached maps:

Fig. #1 - Total Field Profiles.
Fig. #2 - Vertical Gradient Profiles.
Fig. #3 - Contoured Total Field (colour version is Fig. #3C).
Fig. #4 - Contoured Vertical Gradient (colour version is Fig. #4C).

are at 1 to 100 scale, i.e. 1cm = 1 meter, however two of the profile maps are at 1:200. We initially prepared the 1:200 maps to first view the data and it was apparent that the southernmost lines were too strongly affected by the steel fence to the south, thus these lines were dropped from the final presentation at 1:100 scale.

The relatively strong linear looking gradient anomalies which occur in-line are probably due to thin buried iron or steel pipelines. The profile plots assist in the viewing of the continuity of some of the responses. Underground services would probably account for most of the magnetic anomalies. The engineering department of the City of Richmond should have accurate location information for their services. The relatively small areal distribution of any of these anomalies indicates it is unlikely that a large steel tank could be buried at this site, although a small tank (1 meter by 2 meters) could be present at 126E, 86N. This location probably was the centre of the Cannery's oil storage area and the anomaly (very distinct magnetic low) may just originate from the northern end of the pipe or pipes that took oil into the plant. There may have been some large steel valves left on the end of these pipes.

All of the anomalies appear to originate within 1 to 2 meters of the ground surface.

To assist in the relocation of the grid, the following survey control can be used:

1) the museum office corner co-ordinates are:
   southeast corner 100.5N, 138E.
   southwest corner 100.5N, 125.5E.

2) lamppost at 93N, 125E.

3) fire hydrant at 80N, 118E (strong response from this object).

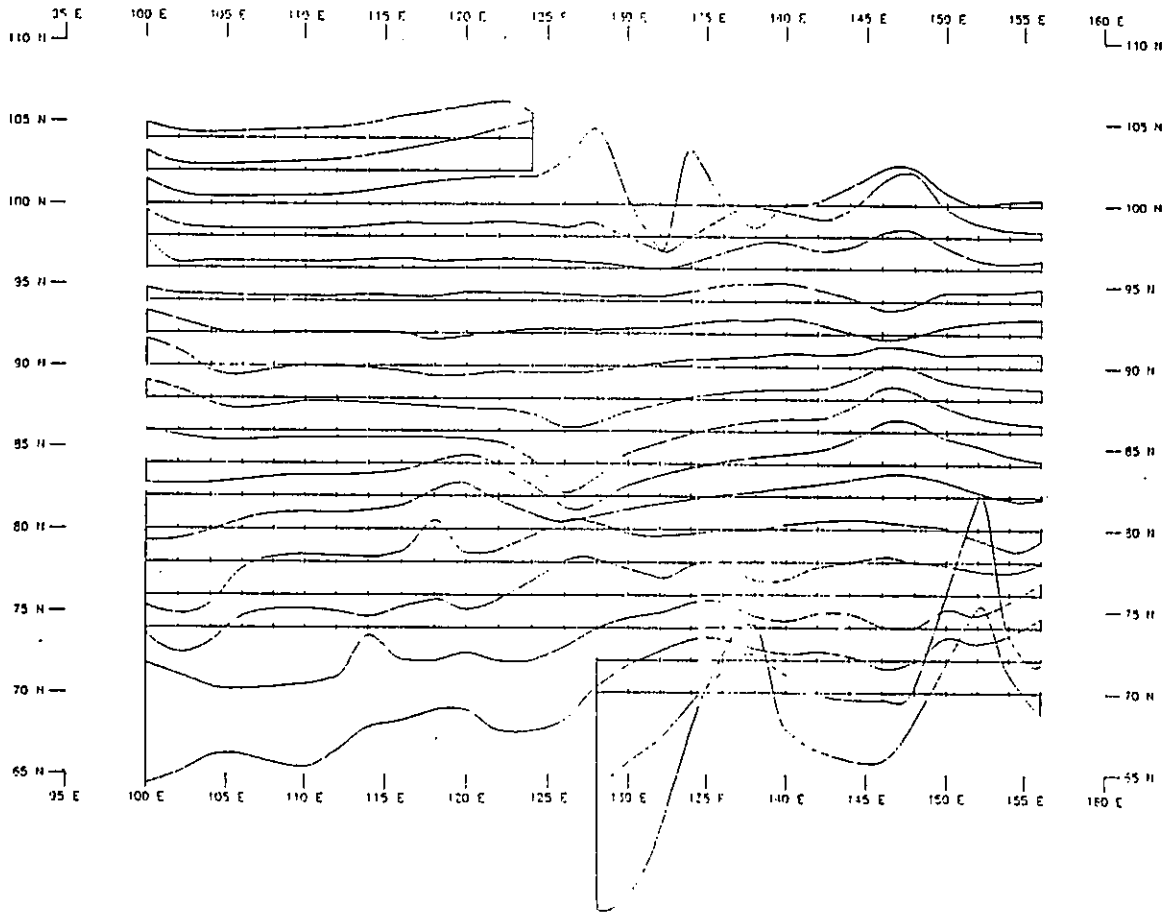
4) lamppost at 70N, 151E.

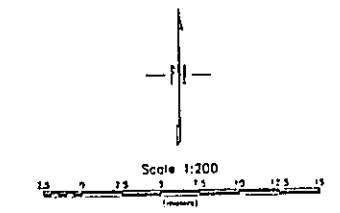
Yours truly,

DELTA GEOSCIENCE LTD.

G Hendrickson

Grant A. Hendrickson, P.Geo.





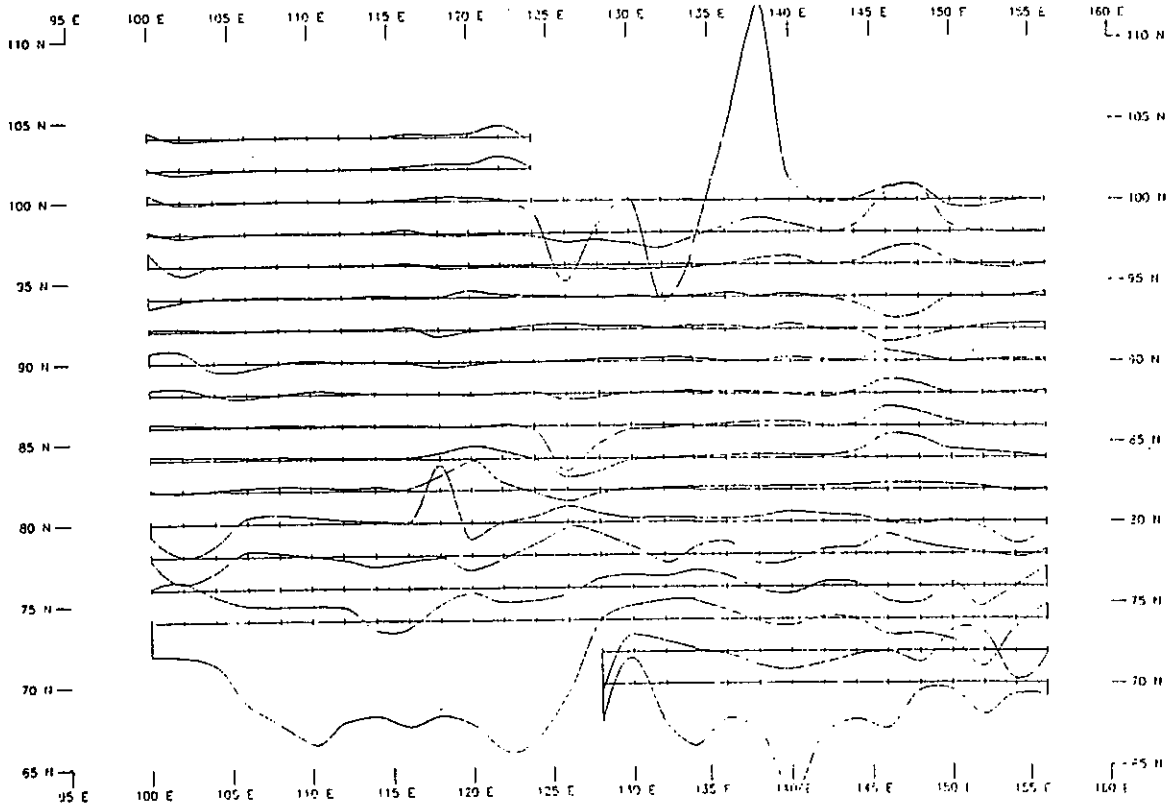
ENVIROCHEM SPECIAL PROJECTS INC.

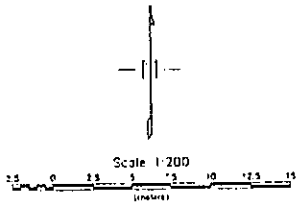
GULF OF GEORGIA CANNERY
TOTAL FIELD MAGNETICS PROFILES

Profile scale 1cm = 500nT, Base 56000nT
EDA Gluta Mag. systems
Nov. 12, 1992

DELTA GEOSCIENCE LTD

MAP #1





ENVIROCHEM SPECIAL PROJECTS INC.

GULF OF GEORGIA CANNERY
VERTICAL MAGNETIC GRADIENT PROFILES

Profile scale 1cm = 500 nT/m Base 0
EDA GSM Mag systems
Nov 13, 1992

DELTA GEOSCIENCE LTD

MAP #2

APPENDIX E

Trench and Vibra Corer Logs

GULF OF GEORGIA CANNERY

VIBRA CORER AND TRENCH LOGS

Vibra Corer Shallow Soil Sampling

VB-1

0-0.45 m	medium brown sand
0.45-0.6 m	tarry, oily sand, difficult to penetrate
S1 @ 0.6 m	
0.6-1.2 m	wet brown sand, moderate hydrocarbon smell
S2 @ 0.8 m	
1.2-1.5 m	moist grey clay, no odour
S3 @ 1.5 m	

VB-2

0-0.3 m	medium brown sand
0.3-0.6 m	oily sand and gravel
S1 @ 0.6 m	
refusal at 0.6 m	

VB-2A

0-0.6 m	medium brown sand
S1 @ 0.6 m	
0.6-0.75 m	oily product and gravel
S2 @ 0.7 m	
0.75-1.5 m	grey clay
S3 @ 0.9 m	-moderate hydrocarbon odour, no staining
S4 @ 1.5 m	-slight odour, no staining
1.5-3 m	grey silty clay
S5 @ 3 m	-no odour

VB-3

0-0.75 m	medium brown sand, no odour
0.75-1 m	wet gravel, no odour
S1 @ 0.3-0.6 m	
1-1.5 m	moist silty clay, no odour
1.5-2.4 m	silty clay w/ black organic silt lens, no odour
2.4-3.0 m	grey clay, no odour

VB-4

0-0.45 m	coarse brown sand w/ pebbly gravel, no odour
0.45-1.0 m	mottled grey-brown clay, no odour
S1 @ 0.45-0.6 m	
1-1.5 m	grey clay to sandy silt, no odour

VB-5

0-0.6 m	brown sand
0.6-2.4 m	sandy silt w/ boulders, timbers
refusal at 2.4 m (?)	

VB-6

0-0.5 m brown sand
0.5-0.6 m oil product and oily sand
S1 @ 0.5-0.6 m
refusal at 0.6 m -boulder ?

VB-7

0-0.2 m topsoil
S1 @ 0.2-0.3 m
0.2-1.5 m silt and fine sand
S2 @ 1-1.5 m

VB-8

0-0.6 m fine brown sand
S1 @ 0.1-0.2 m
0.6-1.2 m brown sandy silt
S2 @ 0.6-1.2 m
1.2-1.5 m brown silt w/ grey clay lenses
S3 @ 1.2-1.5 m

VB-9

0-0.3 m medium brown sand
S1 @ 0.1-0.2
0.3-3 m brown silty clay
S2 @ 0.3-0.9 m
S3 @ 0.9-1.5 m
S4 @ 1.5-2.1 m

Test Trench Soil Sampling

TP-1

0-0.3 m medium brown sand
0.4-0.5 m grey clay
0.5-0.6 m black organic silt
0.6-1.2 m red-brown coarse sand to wet grey coarse sand and gravel
S1 @ 0.4 m
S2 @ 0.7 m
S3 @ 1.2 m

TP-2

0-0.6 m medium brown sand
0.6-.7 m oil-saturated sand
0.7-1 m brown-grey clay w/ hydrocarbon odour
1.2-1.8 m blue-grey clay, no odour
S1 @ 0.3 m
S2 @ 0.6-0.7 m
S3 @ 0.8 m
S4 @ 1.8 m

TP-3

0-0.8 m medium brown sand
0.8-1.1 m fine grey clay
S1 @ 1 m

TP-4 & TP-5

0-0.5 m brown sand
0.5-0.6 m oil product and sand, some product
no samples

TP-6

0-0.5 m brown sand
0.5-0.7 m oil saturated sand and oil product
0.7-0.9 m grey coarse sand w/ hydrocarbon odour
0.9-2 m grey sand, no odour
S1 @ 0.3 m
S2 @ 0.5-0.7 m
S3 @ 0.7-0.8 m
S4 @ 2 m

TP-7

0-0.7 m medium brown sand
0.7-0.9 m oil saturated sand
0.9-1.0 m grey clay, no odour
S1 @ 0.7-0.9 m
S2 @ 1 m

TP-8

0-0.8 m brown sand
0.8-1.5 m crushed asphalt and large timbers
S1 @ 1.1 m

TP-9

0-0.3 m brown sand, no odour
0.3-0.5 m light brown-red and black fill, crushed slag, no odour
0.5-0.8 m brown and grey clay, no odour
0.8-1.2 m grey clay
S1 @ 0.15-0.2 m
S2 @ 0.4 m
S3 @ 0.5-0.6 m
S4 @ 0.8 m

APPENDIX F

Borehole Logs

Envirochem

BOREHOLE LOG

Borehole Name: 1

Borehole 1 of 6

Project No.: 1253

Project: GULF OF GEORGIA CANNERY

Page 1 of 1

Location: Richmond, B.C.

Drilling Method: Sonic

Diameter: 115 mm

Date: 24 FEB 1993

Elevation: 3.210 m

Logged By: LJE

Depth ft	Depth m	Sample	Stratigraphy	Piezometer Installation
		S1	SILT, some fine sand, trace gravel to 20 mm diam. Loose, grey, moist (FILL)	
5	1			
	2	S2		
10	3		SILT, grading downwards to SILT, some fine sond. Grey, wet.	
	4	S3		
15	5		Gradational contact	
			SAND, fine to medium. Grey, wet.	
20	6			
	7		End of Hole at 6.7 m	
25				

LEGEND

Sampled Core | Solid PVC Pipe 50 mm ø | Slotted PCV Pipe 50 mm ø | Bentonite Seal | Silica Sand | Cement | Elevation of Water Table Below Ground Level

Envirochem

BOREHOLE LOG

Borehole Name: 2

Borehole 2 of 6

Project No.: 1253

Project: GULF OF GEORGIA CANNERY

Page 1 of 1

Location: Richmond, B.C.

Drilling Method: Sonic

Diameter: 115 mm

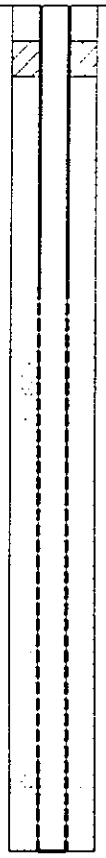
Date: 24 FEB 1993

Elevation: 3.045 m

Logged By: LJE

Depth ft	Depth m	Sample	Stratigraphy
			SAND, medium. Loose, beige, moist (FILL)
5	1	S4	
	2		
10	3		SILT, some debris (ceramic, metal), trace gravel. Orange to black, loose, moist (FILL)
	4	S5	
15	5	S6	SILT, trace fine sand, trace fibrous wood material. Grey, dense, wet.
20	6		SAND. Fine grading downwards to medium. Dark grey, wet, loose.
	7		End of Hole at 6.7 m
25			

Piezometer Installation



LEGEND

Sampled Core | Solid PVC Pipe 50 mm ø | Slotted PCV Pipe 50 mm ø | Bentonite Seal | Silica Sand | Cement | Elevation of Water Table Below Ground Level

Envirochem

BOREHOLE LOG

Borehole Name: 3

Borehole 3 of 6

Project No.: 1253 | Project: GULF OF GEORGIA CANNERY | Page 1 of 1

Location: Richmond, B.C.
Drilling Method: Sonic
Diameter: 115 mm

Date: 24 FEB 1993
Elevation: 3.065 m
Logged By: LJE

Depth ft	Depth m	Sample	Stratigraphy	Piezometer Installation
			SAND, fine to medium. Beige, loose, moist (FILL)	
		S7		
	1			
		S8		
5				
	2	S9		
			SILT, trace fine sand. Heavy oil contamination (NAPL) in upper 0.15 m, traces of oil in fractures to 1.5 m depth, no oil below. Beige to 2 m, grey below, moist to wet (fill to 2 m)	
10	3			
	4	S10		
15				
	5		SAND, fine grading downwards to medium. Grey, wet.	
20	6			
			End of Hole at 6.7 m	
	7			
25				

LEGEND

Sampled Core | Solid PVC Pipe 50 mm ø | Slotted PCV Pipe 50 mm ø | Bentonite Seal | Silica Sand | Cement | Elevation of Water Table Below Ground Level

Envirochem

BOREHOLE LOG

Borehole Name: 4

Borehole 4 of 6

Project No.: 1253

Project: GULF OF GEORGIA CANNERY

Page 1 of 1

Location: Richmond, B.C.

Drilling Method: Sonic

Diameter: 115 mm

Date: 24 FEB 1993

Elevation: 3.179 m

Logged By: LJE

Depth ft	Depth m	Sample	Stratigraphy	Piezometer Installation
			SAND, fine to medium. Beige, loose, moist (FILL)	NO PIEZOMETER INSTALLED
		S11	SILT, trace roots. Beige, mottled, moist.	
5	1		End of Hole at 1.3 m.	
	2			
10	3			
	4			
15	5			
20	6			
	7			
25				

LEGEND

Sampled Core | Solid PVC Pipe 50 mm ø | Slotted PCV Pipe 50 mm ø | Bentonite Seal | Silica Sand | Cement | Elevation of Water Table Below Ground Level

Envirochem

BOREHOLE LOG

Borehole Name: 5

Borehole 5 of 6

Project No.: 1253 | Project: GULF OF GEORGIA CANNERY

Page 1 of 1

Location: Richmond, B.C.
Drilling Method: Sonic
Diameter: 115 mm

Date: 24 FEB 1993
Elevation: 3.342 m
Logged By: LJE

Depth ft	Depth m	Sample	Stratigraphy	Piezometer Installation
		S12	SAND, fine, some grovel to 20 mm diam. Beige, moist (FILL)	NO PIEZOMETER INSTALLED
5	1			
	2		End of Hole at 1.9 m	
10	3			
	4			
15	5			
20	6			
	7			
25				

LEGEND

Sampled Core | Solid PVC Pipe 50 mm ø | Slotted PCV Pipe 50 mm ø | Bentonite Seal | Silica Sand | Cement | Elevation of Water Table Below Ground Level

Envirochem

BOREHOLE LOG

Borehole Name: 6

Borehole 6 of 6

Project No.: 1253

Project: GULF OF GEORGIA CANNERY

Page 1 of 1

Location: Richmond, B.C.

Drilling Method: Sonic

Diameter: 115 mm

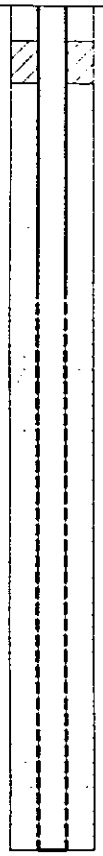
Date: 24 FEB 1993

Elevation: 3.020 m

Logged By: LJE

Depth ft	Depth m	Sample	Stratigraphy
			SAND and GRAVEL to 20 mm diam. Beige, loose.
5	1		RIP RAP. No core recovery.
	2		
		S13	GRAVEL (RIP RAP) to 100 mm diam., some silt. Beige, loose wet.
10	3		
	4	S14	SILT and fine SAND. Grey, laminated, wet.
15	5		
			End of Hole at 5.2 m
20	6		
	7		
25			

Piezometer Installation



LEGEND

Sampled Core | Solid PVC Pipe 50 mm ø | Slotted PCV Pipe 50 mm ø | Bentonite Seal | Silica Sand | Cement | Elevation of Water Table Below Ground Level

APPENDIX G

Groundwater Elevations

ENVIROCHEM

Project Number: 1253
Client: Public Works Canada
Project: Gulf of Georgia Cannery
Datum: Geodetic

Date/Time: 93 Mar 02 / 1130h
By: AFW,MZ
Weather: high cloud, 10C

Piezometer	Piezometer Elevation (m)	Depth To Water (m)	Water Elevation (m)	Comments
1	3.141	2.701	**0.440**	
2	2.953	1.868	**1.085**	
3	2.974	1.823	**1.151**	
6	2.956	1.384	**1.572**	
Ocean	3.346	2.466	**0.880**	

ENVIROCHEM

Project #:	1253	**Date:**	93 Mar 02
Client:	Public Works Canada	**Time:**	1600h
Project:	Gulf of Georgia Cannery	**By:**	AFW,MZ
Datum:	Geodetic	**Weather:**	mostly cloudy

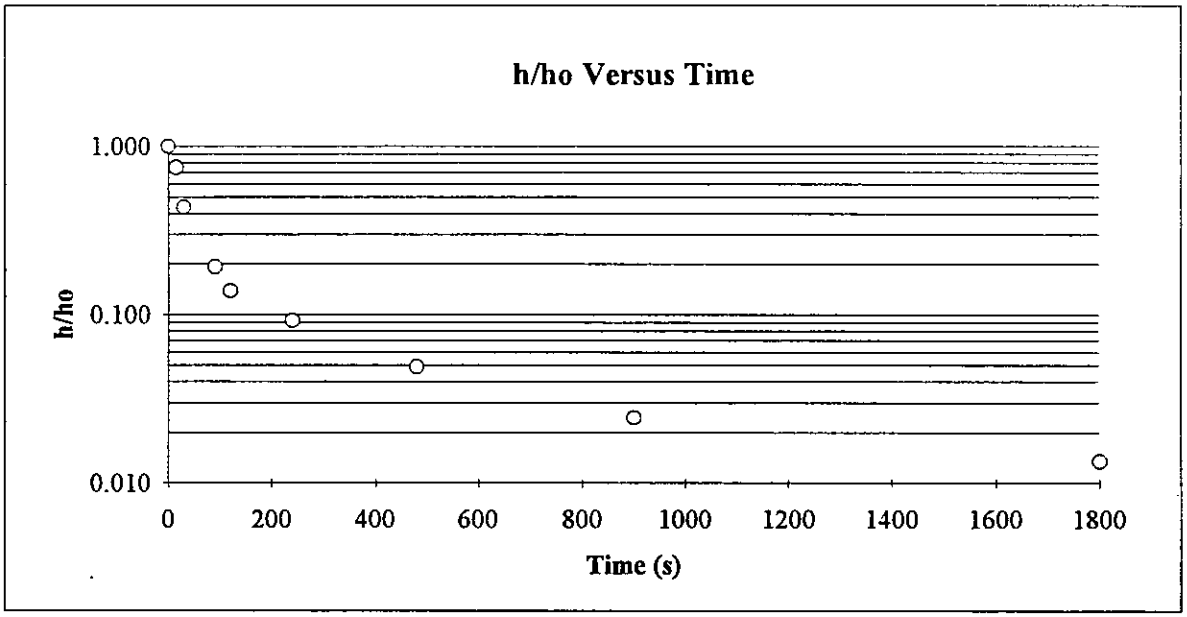
STA	BS	HI	IFS	FS	ELEV
BM C1	0.320	3.034			**2.714**
TP1	1.593	2.989		1.638	**1.396**
TP2	2.438	3.873		1.554	**1.435**
BM BV		3.873	0.685		**3.188**
TP3	1.584	3.019		2.438	**1.435**
TP4	1.671	3.068		1.622	**1.397**
BM C1				0.354	**2.714**

Hydraulic Conductivity Test Analysis

Project Number:	1253	**Casing Radius:**	0.060
Borehole:	2	**Screen Radius:**	0.025
Date/Time:	93 Mar 02 1436h	**Screen Length:**	3.048
Test By:	AFW,MZ	**Static Level (ft):**	6.13
Analysis By:	AFW	**(m):**	1.868

time (s)	depth (ft)	depth (m)	change (m)	h/ho	exp(h/ho)
0	10.60	3.231	1.362	1.000	2.718
15	9.50	2.896	1.027	0.754	2.125
30	8.08	2.463	0.594	0.436	1.547
90	6.99	2.131	0.262	0.192	1.212
120	6.75	2.057	0.189	0.139	1.149
240	6.54	1.993	0.125	0.092	1.096
480	6.35	1.935	0.067	0.049	1.050
900	6.24	1.902	0.034	0.025	1.025
1800	6.19	1.887	0.018	0.013	1.014

K= 0.000007 m/s

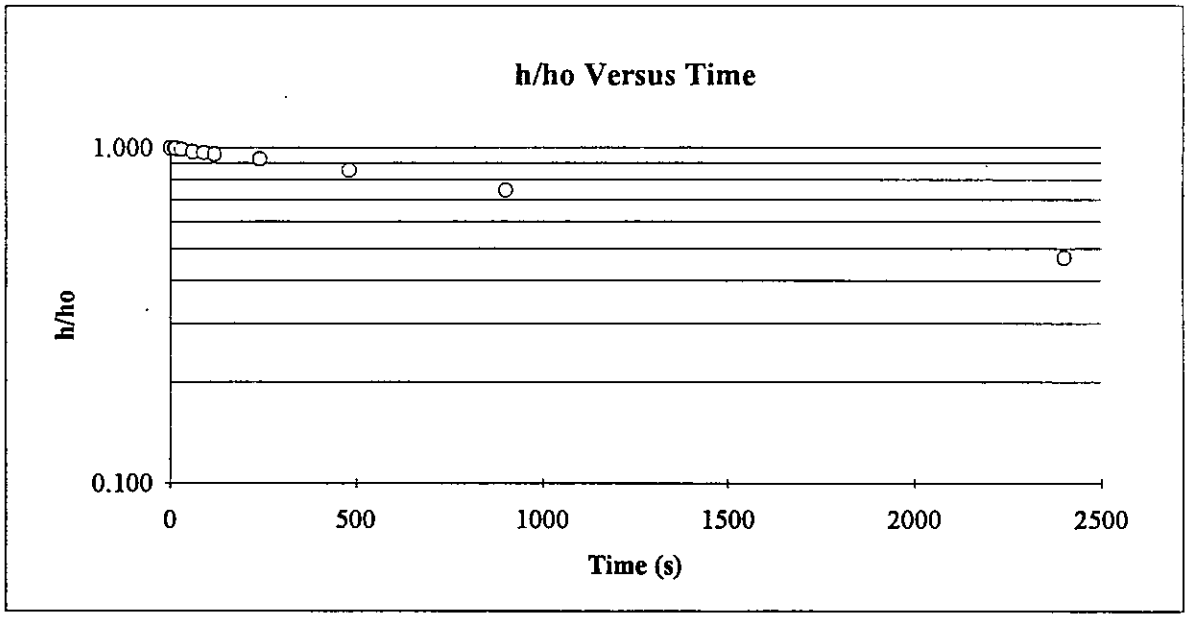


Hydraulic Conductivity Test Analysis

Project Number:	1253	**Casing Radius:**	0.060
Borehole:	3	**Screen Radius:**	0.025
Date/Time:	93 Mar 02 1452h	**Screen Length:**	3.048
Test By:	AFW,MZ	**Static Level (ft):**	5.98
Analysis By:	AFW	**(m):**	1.823

time (s)	depth (ft)	depth (m)	change (m)	h/ho	exp(h/ho)
0	14.21	4.331	2.509	1.000	2.718
10	14.18	4.322	2.499	0.996	2.708
15	14.17	4.319	2.496	0.995	2.705
30	14.08	4.292	2.469	0.984	2.676
60	13.99	4.264	2.441	0.973	2.647
90	13.91	4.240	2.417	0.964	2.621
120	13.85	4.221	2.399	0.956	2.602
240	13.56	4.133	2.310	0.921	2.512
480	13.03	3.972	2.149	0.857	2.355
900	12.12	3.694	1.871	0.746	2.109
2400	9.85	3.002	1.180	0.470	1.600

K= 0.000001 m/s

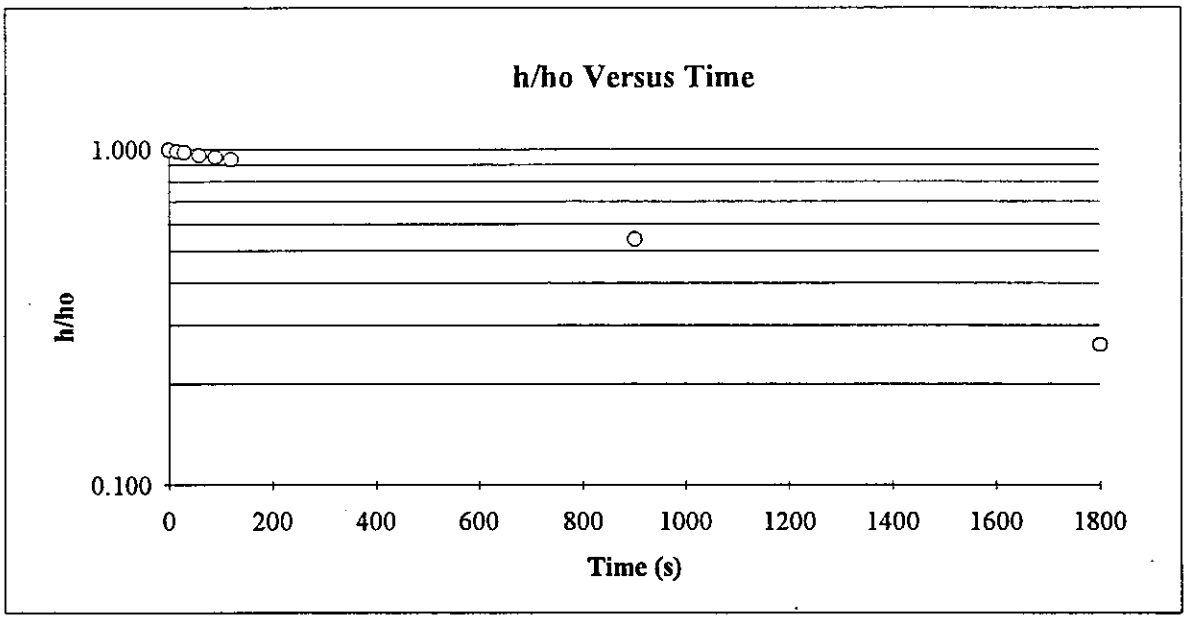


Hydraulic Conductivity Test Analysis

Project Number:	1253	**Casing Radius:**	0.060
Borehole:	6	**Screen Radius:**	0.025
Date/Time:	93 Mar 02 1514h	**Screen Length:**	3.048
Test By:	AFW,MZ	**Static Level (ft):**	4.54
Analysis By:	AFW	**(m):**	1.384

time (s)	depth (ft)	depth (m)	change (m)	h/ho	exp(h/ho)
0	13.42	4.090	2.707	1.000	2.718
15	13.30	4.054	2.670	0.986	2.682
30	13.25	4.039	2.655	0.981	2.667
60	13.05	3.978	2.594	0.958	2.607
90	12.96	3.950	2.566	0.948	2.581
120	12.81	3.904	2.521	0.931	2.538
900	9.35	2.850	1.466	0.542	1.719
1800	6.87	2.094	0.710	0.262	1.300

K= 0.000002 m/s



ENVIROCHEM

Project Number: 1253
Client: Public Works Canada
Project: Gulf of Georgia Cannery
Datum: Geodetic

Date/Time: 93 Mar 05 / 1130h
By: DG
Weather: -

Piezometer	Piezometer Elevation (m)	Depth To Water (m)	Water Elevation (m)	Comments
1	3.141	2.582	**0.559**	
2	2.953	1.795	**1.158**	
3	2.974	1.512	**1.462**	
6	2.956	1.451	**1.505**	
Ocean	3.346			

ENVIROCHEM

Project #:	1253	**Date:**	93 Mar 02
Client:	Public Works Canada	**Time:**	1130h
Project:	Gulf of Georgia Cannery	**By:**	AFW,MZ
Datum:	Geodetic	**Weather:**	mostly cloudy

STA	BS	HI	IFS	FS	ELEV
BM BV	1.570	4.758			**3.188**
TP1	1.417	4.887		1.288	**3.470**
TP2	1.646	4.943		1.590	**3.297**
6G		4.943	1.923		**3.020**
6		4.943	1.987		**2.956**
OCEAN		4.943	1.597		**3.346**
TP3	1.632	4.943		1.632	**3.311**
1G		4.943	1.733		**3.210**
1		4.943	1.802		**3.141**
3G		4.943	1.878		**3.065**
3		4.943	1.969		**2.974**
TP4	1.339	4.681		1.601	**3.342**
2G		4.681	1.636		**3.045**
2		4.681	1.728		**2.953**
5G		4.681	1.339		**3.342**
4G		4.681	1.502		**3.179**
TP5	1.261	4.619		1.323	**3.358**
TP6	1.625	4.899		1.345	**3.274**
TP7	1.310	4.778		1.431	**3.468**
BM BV				1.590	**3.188**