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AN OVERVIEW OF PCBs AND THEIR CURRENT STATUS IN BRITISH COLUMBIA

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By

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ABSTRACT

This report has been prepared to provide a summary of the current status of PCBs in British Columbia. A general overview of PCBs is provided in order to allow the reader to put the British Columbia data into the proper perspective. The main objectives of this report were to: identify current uses of PCBs in British Columbia and potential sources of release to the environment; assess the potential for environmental impacts as a result of these releases; document available information on PCB levels in the British Columbia environment and compare these levels to those reported for other areas of the world; and, identify localized areas of particularly high concentrations.

Much of the data included were obtained through Environmental Protection Service monitoring and industrial surveys. Published and unpublished data were also obtained from other federal and provincial government agencies, environmental consultants and research organizations.

RÉSUMÉ

Le présent rapport a pour objet de donner un résumé de la situation actuelle en ce qui concerne les BPC en Colombie-Britannique. Un aperçu général sur les BPC permet au lecteur de mettre en perspective les données relatives à la Colombie-Britannique. Les principaux objectifs de ce rapport consistaient à déterminer les quantités de BPC utilisées présentement en Colombie-Britannique et les causes possibles des fuites menaçant l'environnement, évaluer les risques de contamination du milieu à la suite de ces fuites, interpréter les renseignements obtenus sur la concentration des BPC relevés dans l'environnement en Colombie-Britannique et comparer ces niveaux à ceux qui ont été relevés dans d'autres régions du monde; identifier les zones où la concentration est particulièrement élevée.

Beaucoup de ces données ont été obtenues grâce aux études du Service de la protection de l'environnement et à ses enquêtes menées dans des entreprises industrielles. D'autres données, publiées ou non publiées, ont également été obtenues d'organismes gouvernementaux, fédéraux et provinciaux, d'experts-conseils et d'organisations de recherche spécialisées dans le domaine de l'environnement.

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SUMMARY AND CONCLUSIONS

This report is a sequel to the 1976 Environmental Protection Service report entitled "Environmental Contamination by Polychlorinated Biphenyls (PCBs) in British Columbia - A Summary of Current Data, 1976". Since 1976, increasing awareness of the hazards of PCBs has resulted in more extensive environmental monitoring and the implementation of regulations governing the uses of PCBs and the development of guidelines for the disposal of PCBs and contaminated materials. Consequently, much additional information relating to PCB use, environmental levels, disposal and sources of release in British Columbia has been obtained since 1976. Information obtained since the publication of the 1976 document has been compiled and summarized in this report.

Levels in the Environment

With the exception of a few water systems, PCBs were not detected in British Columbia surface waters. Detectable concentrations were, however, present in Lime Creek, near the Amax Kitsault Mine and in Coldstream Lake in the Okanagan. The presence of PCBs in Lime Creek may be associated with a past PCB spill or the accidental release of PCBs from electrical equipment at the mine. Potential sources of PCB to Coldstream Creek have not been identified and the possibility of sample contamination cannot be ruled out at this time. The elevated PCB concentrations detected in the McLeese Lake area were attributed to leakage from damaged capacitors buried during the construction of B.C. Hydro's capacitor station at that location.

Elevated sediment concentrations (often exceeding 1000 ppb) have been detected in the vicinity of several industrial facilities in British Columbia. These have usually been attributed to PCB releases from electrical equipment during routine use and servicing, or as a result of malfunction, accidental damage or improper disposal. In recent years many industrial facilities have taken action to prevent such releases to the environment and, in many cases, the elevated PCB levels detected in the environment are probably due to historical releases.

Highly industrialized areas such as False Creek and Burrard Inlet contain widespread, but usually moderate levels of, PCB contamination. High PCB levels have been detected in the sediments of Vancouver Harbour, particularly in the vicinity of ship building and repair facilities in Coal Harbour. These findings are in agreement with those reported by researchers in other areas of the world. PCB contamination in the vicinity of drydocks is attributed to past PCB leakage from electrical and hydraulic equipment and to the application and removal of marine anti-fouling paints which, at one time, contained PCBs. Levels of PCB in sediments from Victoria Harbour are also elevated but to a lesser degree.

The presence of PCBs in sediments under the Granville Street bridge, and soil under the Burrard Street bridge, was attributed to the leakage of PCBs from bridge bearings. The use of PCBs for bearing lubrication is thought to be unique to these two bridges. The leaking bearings have now been drained and the PCBs have been replaced with an alternate dry lubricant. The contaminated soil has been removed and disposed of.

Resampling of the Fraser River near the Belkin Paperboard paper recycling plant in 1979, confirmed earlier findings that sediments adjacent to the plant contained elevated PCB levels. Monitoring of plant effluents demonstrated that significant amounts of PCBs were being discharged to the river. Improvements to the waste treatment system have now significantly decreased PCB releases.

Two major sampling programs, one in 1973 and the other in 1980, have provided data on PCB concentrations in numerous fish species from several areas of the Fraser River. Mean PCB levels in fish species sampled in the Fraser River were well below the Health and Welfare guideline of 2 ppm. The highest levels were generally present in the North Arm which is the most industrialized region of the Fraser River.

Two other less extensive studies conducted in 1980 identified higher levels of PCB in fish collected near Belkin Paperboard than in fish collected from other areas of the river. The higher levels in fish from the Belkin area could not be attributed solely to PCB releases from Belkin due to the mobility of fish, and to past observations that PCB levels in fish from the industrialized North Arm are generally higher than those detected in fish from other regions of the river. It is likely, however, that the Belkin plant was the main contributor of PCBs to the river in this immediate area and consequently the main source of the PCBs detected in local biota. PCB discharges from this plant have now been substantially reduced and meet the allowable limits.

The analysis of biota (fish and invertebrates) from the Fraser estuary region has shown that PCB levels in organisms from Roberts Bank are lower than those in organisms from Sturgeon Bank. Sampling in the Sturgeon Bank area revealed that PCB levels in crabs decrease with increasing distance from the Iona Island sewage treatment plant outfall. Additional monitoring is required to determine the extent to which PCB levels in Sturgeon Bank biota are influenced by discharges from the Iona Island sewage treatment plant. From the limited data available, however, the PCB concentrations in biota collected near the Iona Island plant outfall appear to be lower than the levels detected in biota near sewage outfalls in southern California.

Information on PCB levels in aquatic invertebrates from other areas of British Columbia is very limited. PCB levels in mussels from Alice Arm near the Amax Kitsault mine were surprisingly high (100 times higher) compared to the levels detected in this species from the False Creek area. Water samples collected in the vicinity of the Kitsault Mine also contained elevated levels of PCBs and the source of this contamination warrants further investigation. Studies in southern California have shown that PCB levels in mussels from active harbour regions are comparable to those detected in mussels from Alice Arm, while

PCB levels in mussels from False Creek were lower and were similar to levels in coastal areas of southern California.

With the exception of heron eggs collected in 1977 and 1978, no additional monitoring for PCB levels in British Columbia wildlife has been conducted since 1976. PCB concentrations in heron eggs are higher than those detected in other species in British Columbia. Levels in the Coquitlam, Kootenay and University of British Columbia heron colonies are especially high but no impacts on these populations have been identified.

Uses and Sources

Industrial Uses and Discharges

In the past PCBs were used extensively in such products as plastics, inks, carbonless copypaper, paints, pesticides, investment casting waxes and as dielectric, hydraulic, high temperature lubricating and heat transfer fluids. Due to increasing awareness of their environmental hazards, the manufacture of PCBs in North America was terminated in the early 1970's and the allowable uses have been severely restricted.

In 1978, under the mandate of the Environmental Contaminants Act, the Environmental Protection Service (EPS) conducted a national survey of potential PCB users. Information on the locations and amounts of PCB in use was obtained and is routinely updated by regional EPS offices.

The greatest volume of PCB in use in British Columbia is in electrical equipment. All electrical equipment in Canada which is known to contain PCBs has been identified by an EPS labelling and coding system. Regulations prohibit the manufacture or importation of PCB filled electrical equipment in Canada. Current PCB losses associated with electrical equipment may occur as a result of malfunctioning or damage; spillage during routine servicing; or as a result of improper disposal.

The contamination of mineral oil transformers with PCBs is not uncommon and a recent EPS survey of transformer oils in British Columbia revealed that 22% of the mineral oil fluids tested contained concentrations of over 50 ppm PCBs.

PCBs have also commonly been used in dielectric fluids in electromagnets such as those used over coal, ore and grain conveyors. Eleven PCB-containing units were found in British Columbia grain elevator facilities and leakage of PCBs onto a grain conveyor occurred at one of these facilities. Due to the potential hazard to human health, the use of PCBs in electromagnets in food or feed handling facilities was prohibited under Environmental Contaminants Act regulations in 1980.

The 1978 survey of PCB users indicated that PCBs have not been used in heat transfer or hydraulic equipment in British Columbia since 1977. Information on usage prior to 1977 was not available. Recently, several samples of heat transfer and hydraulic fluids currently in use in British Columbia, were collected and analyzed for PCBs. The results indicate that these fluids were not contaminated with PCBs (less than 1 ppm).

Similarly, samples of natural gas pipeline compressor oils were analyzed due to reports that high levels of PCB contamination had been found in these types of oils in the United States. None of the samples collected in British Columbia contained detectable concentrations of PCBs.

The use of PCBs as lubricants in rocker and roller bearings on the Burrard Street and Granville Street bridges in Vancouver, appears to be unique to these two bridges. The accidental leakage of PCBs from some of these bearings has resulted in localized areas of high PCB levels in soil under the Burrard Street bridge. The leaking bearings have now been drained and the contaminated soil has been removed.

The use of waste oils for dust control on roads in rural areas has been identified as a possible source of PCB entry into the environment. A survey of waste oils in Ontario demonstrated that PCBs were present in more than 50% of the samples. A similar study in British Columbia revealed detectable (but low) PCB levels in only a few samples of waste oil. However, elevated PCB levels were detected in the soil from oiled roads in several areas of the Lower Mainland. PCB levels in road soils were particularly high in the Municipality of Surrey.

Until the early 1970's PCBs were used extensively as plasticizing additives and in numerous other consumer products including paints. The high concentrations of PCBs detected in the sediments adjacent to ship building and repair facilities in British Columbia are probably due, at least in part, to the past application and removal of marine antifouling paints containing PCBs. Similarly, high PCB levels have been detected in harbour regions of southern California and have been attributed to the use of antifouling paints.

The release of PCBs from paper recycling and de-inking plants in North America has also resulted in environmental contamination. The presence of PCBs in wastes from these facilities is associated with the past use of PCBs in inks and paper coatings (particularly carbonless copypaper). Sampling of paper plant effluents in British Columbia in 1976 indicated that only the Belkin Paperboard plant, which discharges into the North Arm of the Fraser River, was releasing significant amounts of PCBs. Since this time, reductions in the suspended solids content of discharges have significantly decreased PCB loadings. The provincial pollution control permit for the Belkin plant has been amended and now specifies a maximum allowable PCB release. Recent data indicate that current releases from the Belkin plant meet the permit requirements.

With the exception of the Belkin plant, very little information is available on PCB releases from industrial facilities in British Columbia. In 1977 a national sampling program was initiated to determine PCB levels in effluents from various industry sectors across Canada. In British Columbia, sampling was conducted at specific oil refineries, mines, smelters, chemical manufacturing plants, pulp mills and a coal bulk loading facility. PCBs were not detectable in most discharges.

Concentrations close to the limit of detection were present in single grab effluent samples taken from the Imperial Oil refinery, Eurocan pulp-mill, Cloverdale Paint and Chemical plant and in one of the discharges from the Alcan smelter. Significant PCB concentrations were detected only in coke-calciner area surface drainage at the Alcan smelter and in settling pond wastes at the Roberts Bank coal superport. The sources of PCBs at these facilities were not identified but they may originate from accidental leakage from electrical or hydraulic equipment. The low levels of PCBs in wastes from the Cloverdale Paint and Chemical plant may have been due to the past use of PCBs in some types of pigments.

Municipal Discharges

A survey of sewage treatment plants in British Columbia in 1976 revealed low PCB levels in discharges from all plants, with the highest levels occurring at plants such as Iona Island (serving Vancouver) and Prince George, which receive large amounts of industrial wastes. The discharges from the Annacis Island plant, which also receives a large proportion of industrial waste, contained surprisingly low PCB levels.

The resampling of wastes at the three major Vancouver area plants in 1978 confirmed the presence of PCBs but the levels detected were generally higher than those observed in 1976.

PCB levels in wastewaters are variable and can be influenced by the time of day at which samples are collected, flow rate, number and type of industries discharging into the system, and suspended solids content. It is also possible that differences in concentrations may occur as a result of variations in efficiency of extraction or other differences in analytical techniques or sampling procedures. Additional sampling with interlaboratory analytical comparisons would be required to more reliably determine PCB releases from these facilities.

In comparison to plants in British Columbia, PCB concentrations in sewage treatment plant effluents were somewhat higher in more heavily industrialized areas of North America.

The removal efficiencies for PCBs at the treatment plants in British Columbia were variable, but the removal from wastes at secondary treatment facilities was generally more effective than at primary plants. This finding is in agreement with studies conducted in eastern Canada.

Particularly high PCB levels are associated with the suspended solids in sewage wastes. The settling of this material generates a sludge which may contain substantial amounts of PCBs and, therefore, present a disposal problem. Few sludges from British Columbia plants have been analyzed but significant concentrations of PCBs have been detected in some samples.

Losses of PCBs at landfills occur through volatilization (especially during burning) from paints, coatings, plastics, electrical products containing small capacitors, and other wastes containing PCBs. Other potential sources of release include leachate and surface runoff. PCBs have been detected in the leachates, soils and sediments at Richmond Landfill but the magnitude of PCB release to the environment, from this or other landfills, has not been investigated.

Storm sewers and surface runoff from urban areas have been identified as significant sources of PCBs to aquatic systems in certain areas of North America. Sanitary and storm water collection systems in the Greater Vancouver area were sampled in 1976. Significant PCB levels were detected in some samples, indicating that these systems contribute measureable amounts of PCBs to the aquatic environment in British Columbia.

Spills

All reported PCB spills which have occurred in British Columbia since 1976 have been investigated and documented by the Environmental Protection Service and/or the provincial pollution control agencies. Fewer spills have occurred in recent years due to increased industry awareness regarding the potential hazards of PCBs; the development and implementation of guidelines for handling, storage and disposal; and the ban imposed on most past "open-system" uses of PCBs.

Section 6 of this report summarizes the PCB spills which have occurred in British Columbia from 1976 to June, 1982.

The most significant spill occurred in 1977 at the Canadian Cellulose Pulp mill near Prince Rupert. A poorly maintained transformer malfunctioned and spilled approximately 800 litres of PCB fluid into a storm sewer system which drains into the marine waters off Porpoise Harbour.

Extremely high levels of PCB were detected in the sediment and biota from the immediate spill area. Additional sampling indicated that the elevated PCB concentrations were confined to Porpoise Harbour.

Following the consideration of various clean-up options, in-situ containment was selected as the best method for minimizing the spread of contamination from the spill area and preventing further uptake into aquatic organisms. The containment plan was carried out in two phases. The first phase involved the deposition of a 20 foot depth of leached hog fuel over the spill area and the second phase was the addition of a 2 foot deep protective rock cover.

Monitoring of the sediments and crabs in the spill area is being conducted annually by EPS to ensure that PCB concentrations in the biota remain within acceptable levels; to assess the effectiveness of the spill containment over a long period of time; and to ensure that the integrity of the cover is being maintained.

The Environmental Protection Service subsequently charged Canadian Cellulose Company under Subsection 33(2) of the Fisheries Act as it applied prior to its September 1977 amendments. This was a precedent setting case in that it was the first prosecution for PCBs under the Fisheries Act. The company was convicted on one count of deposition of PCBs in a place, and under conditions, where it may enter water frequented by fish.

Some of the other spills discussed in Section 6 of this report include:

- the leakage of an undetermined amount of PCBs from damaged B.C. Hydro capacitors near McLeese Lake.

- the loss of 600 to 660 litres of PCB from a transformer at the Cominco salvage yard in Trail.

- the loss of approximately 90 litres of PCB from a vandalized transformer at the abandoned Bonlie sawmill at Stewart.

- the loss of an unknown amount of PCB lubricant into False Creek from bearings located on the Granville and Burrard Street bridges.

- the leakage of approximately 30 litres of PCB onto a grain conveyor belt at the Saskatchewan Wheat Pool.

- the spillage of 230 to 450 litres from a transformer at B.C. Coal (formerly Kaiser Resources), at Harmer Ridge.

- the loss of an unknown amount of PCBs from a heat exchanger in the concentrate dryer at the Amax Kitsault mine site.

Disposal and Storage

Guidelines for the management of PCBs with respect to the storage, collection, handling and disposal of PCBs and contaminated wastes have been developed and distributed to all major users of PCB-filled electrical equipment in British Columbia and elsewhere in Canada.

At present there are no ultimate PCB disposal facilities in Canada and, as of May 1st, 1980, the transport of PCBs into the United States for disposal was terminated by the United States Environmental Protection Agency. PCB wastes are currently being stored at the site of origin or at hazardous waste collection/storage facilities. Most of the PCB wastes from British Columbia have been transported to collection/storage facilities near Edmonton. There are no similar storage facilities in British Columbia. At present, PCB wastes and out-of-service electrical equipment in British Columbia are being stored at the individual industrial sites.

The long-term storage of toxic wastes is not a solution to the PCB disposal problem. The construction of disposal facilities in Canada, which are capable of the ultimate destruction of toxic wastes such as PCBs, is essential.

Numerous methods of PCB destruction are being tested. However, to date, high temperature incineration appears to be the most practical method. A few incineration facilities have been approved by the Environmental Protection Agency (EPA) for PCB disposal in the United States. EPA has also approved the incineration of waste PCBs at sea on incinerator ships such as the 'Vulcanus'.

Studies in Canada have shown that cement kilns are capable of destroying wastes containing up to 50% PCB with a maximum combustion efficiency of 99.9%. Following extensive tests a temporary licence was issued to allow the St. Lawrence Cement Company in Mississauga, Ontario to continue incinerating PCBs. Despite the demonstrated efficiency of PCB destruction via this method, strong public opposition resulted in the introduction of a by-law prohibiting the incineration of PCBs in Mississauga.

Some of the other methods of PCB destruction being tested are fluidized bed incineration, rotary kiln furnaces, microwave plasma reactors, microbial degradation, diesel engines, plasma arc pyrolysis, and chemical destruction techniques.

Regulations

Regulations governing the use of PCBs in Canada have been developed under the Environmental Contaminants Act (ECA). The ECA was promulagated on April 1, 1976 and is administered jointly by Environment Canada and Health and Welfare Canada. This Act provides the federal government with the authority to obtain from Canadian industry, information on potentially hazardous chemicals or new chemicals in use or intended for use in Canada. The Act also gives the government the power to restrict or prohibit the use, manufacture and importation of prescribed substances. PCBs were the first class of substances to be regulated under the ECA.

Regulations were promulgated under the ECA in September, 1977 prohibiting most non-electrical uses of PCBs. These regulations were amended on July 1, 1980 to include controls on PCB use in electrical equipment. The amended regulations prohibit the import or manufacture of all PCB-filled equipment; prohibit the operation of PCB-filled electromagnets over food or feed; restrict PCB usage to existing electrical equipment and facilities intended to destroy PCBs; and, prohibit the use of PCB as a new filling or make-up fluid in the servicing or maintenance of electrical transformers or electromagnets.

These regulations are meant to stop all new entry of PCB equipment into the marketplace; ban the use of PCB-filled electromagnets over food or animal feed; restrict existing uses to totally enclosed electrical equipment which, under normal operation conditions, does not present a threat to human health or environmental quality; and eliminate existing stocks of make-up or bulk dielectric fluids to minimize occupational exposure and spills of PCBs during maintenance or servicing activities.

Regulations are also currently being developed to control the release of PCBs to the environment and to restrict the sale of equipment containing PCBs.

Other Canadian federal legislation which may be used to control PCBs include the Fisheries Act and, to some extent, the Transportation of Dangerous Goods Act. There are also several provincial government agencies whose legislation can be used to control PCBs in British Columbia. These include the Ministry of Environment, the Ministry of Labour, and the Workers' Compensation Board.

1 INTRODUCTION

This report has been prepared as a sequel to the 1976 Environmental Protection Service (EPS) report entitled "Environmental Contamination by Polychlorinated Biphenyls (PCBs) in British Columbia - A Summary of Current Data, 1976". Since 1976, increasing government, industry and public awareness of the hazards of PCBs has resulted in more extensive environmental monitoring, the implementation of regulations governing PCB usage and the development of guidelines for the disposal of PCBs and contaminated materials. Consequently, much additional information relating to PCB use, environmental levels, disposal and sources of release in British Columbia has been obtained since 1976. Information obtained since the publication of the 1976 report has been compiled and summarized in this report, however, it is recommended that the 1976 report be reviewed first to allow the reader to obtain the necessary background information. Information on PCB concerns in other geographical areas has been presented for comparison. In addition, a discussion of existing regulations, disposal options and accidental spills in British Columbia has been included.

Current information on the environmental dynamics, toxicity and human health concerns of PCBs has also been discussed.

The data presented herein was obtained through EPS monitoring programs and industrial surveys as well as from other federal and provincial government agencies and industries. It includes the published and unpublished information which was available to January 1st, 1982.

All British Columbia data have been individually referenced in the appendices and, for this reason, the references have not been repeated during the discussion of the data throughout the text.

2 LEVELS IN THE ENVIRONMENT

2.1 Water and Sediments

2.1.1 Water. Upon entering the environment, PCBs accumulate in various media at concentrations which are influenced by a variety of factors. Partitioning of PCBs between surface waters and bottom sediments depends upon such variables as salinity, amount of suspended matter, particle size, organic content and sediment characteristics.

PCBs have very low solubilities and receiving water concentrations are often below or near detection levels even in highly contaminated areas. The solubilities of the individual PCB isomers vary with the position of the chlorine atoms and decrease with increasing chlorination. For this reason the lower chlorinated isomers are present in higher concentrations in the water column than are the higher chlorinated isomers (1,2,3,4). Estimates of PCB solubilities vary significantly. The solubilities of the various chlorobiphenyl isomers as tested by Wallnofer et al (4) ranged from 0.015 ppb for decachlorobiphenyl to 1.17 to 5.8 ppm for monochlorobiphenyl (depending on the position of the chlorine atom). Other researchers have reported much lower solubilities.

There is also some disparity in the reported solubilities of commercial PCB formulations. Zitko (5) observed saturation concentrations for Aroclor 1254 ranging between 300 and 3000 ppb in fresh water and 300 and 1500 ppb in seawater. Other authors, however, have reported much lower solubilities of 56 ppb in freshwater (1) and 24 to 28 ppb in seawater (6). Several factors influence solubility calculations including agitation, dissolved organic matter content, salinity, water temperature and the presence of suspended solids. It has been suggested that Zitko's estimates exceeded others due to a higher suspended solids content (6). PCBs preferentially adhere to particulate matter in the water column and the actual concentrations of dissolved PCB in aquatic systems are normally far below estimated saturation levels. High levels of PCBs occasionally detected in surface waters are associated primarily with suspended solids. The transport of this material by tidal action and water currents can result in the spread of contamination to areas removed from the point of PCB entry (7).

When not in contact with particulate matter or bottom sediments, chlorinated hydrocarbons (including PCBs) tend to concentrate at the air-water interface (8,9,10) and volatilization to the atmosphere may occur. The rate of volatilization in the natural environment has not been well studied. Under laboratory conditions, some PCBs volatilize quite rapidly from test water, while the highly chlorinated isomers have a lower vapour pressure and volatilize much less readily (11,12). The atmosphere can, in turn, contribute to the enrichment of surface waters with PCBs (9,13,14) through precipitation and dry fallout.

The 1976 United States Environmental Protection Agency (EPA) water quality objective for the protection of marine and freshwater aquatic life was 1 ppt PCB (15). This value was below the detection limits for most labs. PCB levels in certain marine and freshwater systems from various areas of the world are listed in Table 1 on the following page. It is apparent that many water systems do not meet the 1976 EPA criteria.

In 1980, the EPA Water Quality objectives were revised. The criteria for the protection of freshwater and saltwater aquatic life are now 14 ppt and 30 ppt, respectively (16).

British Columbia

Information obtained since 1976 on PCB levels in surface waters in British Columbia is limited and is presented in Appendix 1. No data were available for marine waters off British Columbia, but PCBs have not

TABLE 1: PCB CONCENTRATIONS IN SURFACE WATERS FROM OTHER AREAS OF THE WORLD

LOCATION	PCB CONCENTRATION (ppt)	REFERENCE
a) MARINE WATERS		
N.W. Atlantic Ocean	9 - 35	14
N.W. Mediterranean Sea	L0.2 - 19	17
N.W. Mediterranean coast	13	18
California coast	11 - 50	19
California current	4.4	20
South California Bight	7.4	21
Palos Verdes	8.8	20
Puget Sound	6.7	20
Mexican coast	12 - 90	19
Gulf of Mexico	0.8 - 4.1	22
b) FRESH WATERS		
Lake Michigan	L10	22
Tributaries to Lake Michigan	10 - 65	22
Lake Superior	0.8	22
Lake Erie	35 - 56	22
Lake Ontario	100 - 170	22
Hudson River	27	22
Duwamish River	22	22

been detected in the vast majority of the freshwater systems sampled (23). Detectable levels were found in the McLeese Lake area (Appendix 10), in Coldstream Creek in the Okanagan and in Lime Creek near the Amax Kitsault Mine.

The presence of PCBs in the McLeese Lake area is probably associated with the use of PCBs and the disposal of capacitors at a nearby B.C. Hydro substation (refer to Section 6.2). The sources of PCB (Aroclor 1254) in Coldstream Creek are unknown but possibilities include: past PCB usage as pesticide extenders; leakage from electrical equipment; aerial long range transport; and the use of PCB contaminated waste oils as dust inhibitors on gravel and dirt roads. The PCB concentrations detected by the British Columbia Ministry of Environment in this water system were unusually high, with concentrations of up to 5.0 ppb reported in June, 1979. Additional sampling would have been required to verify these levels and the possibility of sample contamination cannot be ruled out at this time. It is interesting to note, however, that during an investigation of a sabatoged transformer at an industrial facility near Coldstream Creek in 1979, low levels of PCB contamination were detected in soil samples. The oil from the sabotaged transformer did not contain PCBs, however, and the source of the soil contamination was not identified.

A concentration of 4.8 ppb PCB was detected in Lime Creek near the Kitsault Mine millsite while levels of 0.16 - 0.17 ppb were detected further downstream. Possible sources of contamination in this area include a 1979 PCB spill as well as accidental releases from electrical equipment at the minesite.

2.1.2 Sediments. Munson et al (7) observed that suspended sediments contained PCBs at concentrations 4 to 10 times higher than did bottom sediments. This observation is probably associated with the fact that suspended sediments generally have a much smaller grain size than do bottom sediments. Finer sediments contain higher concentrations of contaminants per unit weight due to the larger surface area available for adsorption.

Much of the particulate matter does eventually settle out of the water column and is deposited in the bottom sediments. Sediments in highly industrialized areas serve as a reservoir for PCBs.

For this reason PCBs present a long term environmental hazard. Upon release to the environment PCBs can persist for many years or even decades (24). Although it is difficult to estimate the half-life for these compounds in the environment, a study by Hom et al (25) in the Santa Barbara basin demonstrated that, under anaerobic conditions and in the absence of burrowing organisms, PCBs can persist in the sediments for at least 30 years.

The analysis of environmental samples shows a preponderance of isomers with five or more chlorine atoms (26). This is probably due, at least in part, to the greater resistance of the higher chlorinated biphenyls to degradation. The metabolism of biphenyl, mono- and dichlorinated biphenyls by bacteria in the environment can occur quite readily, but the higher chlorinated forms are degraded much more slowly (27, 28, 29). Reichardt et al (30) demonstrated that biphenyl and monochlorobiphenyl could be metabolized in Alaskan coastal waters. The position of the chlorine significantly affected the rate of degradation. Although several authors have discussed the mechanisms of PCB metabolism, the factors controlling the rate of degradation are largely unknown.

Photodegradation studies with PCBs have shown a decrease in higher chlorinated isomers and an increase in lower chlorinated forms, but over a three week period there was little overall degradation observed (31). Some researchers have shown evidence of PCB formation as a result of the photolysis of DDT (32, 33) and certain chlorinated benzenes (34).

Concentrations in sediments depend on the composition of the sediments and their adsorbing capacity. Sediments and soils with high organic clay content have a high adsorbency potential for PCBs while sand does not (8). The degree of adsorption also increases with increasing chlorination of the PCB molecule and is, therefore, inversely related to the solubility of the PCB isomer. There is also some indication that adsorption of PCBs to sediments increases with increasing salinity (35).

Extremely high sediment levels have been detected in the vicinity of accidental spills and point source discharges from electrical equipment manufacturers, and industries utilizing such equipment; paper recycling plants; and municipal waste treatment facilities.

Concentrations of up to 10 ppm have been detected in the bottom sediments near large municipal wastewater outfalls along coastal southern California while PCB levels a few kilometers removed were approximately 0.2 ppm (36).

Sediments in the vicinity of municipal discharges in British Columbia have not been monitored although low PCB levels have been detected in wastewaters. Also, PCBs were present in biota collected in the vicinity of the Iona Island sewage treatment plant.

Billings et al (37) reported very high levels of PCB contamination in a creek which receives discharges from a capacitor plant in North Carolina. Sediments collected 100 metres downstream from the plant contained 33 ppm. Monitoring near the General Electric plants on the Hudson River in New York revealed PCB (Aroclor 1016) levels of up to 6700 ppm in the sediments collected in the outfall stream and 2980 ppm 0.8 km downstream from the outfall. Elevated PCB levels (6.6 ppm) were also present in sediments approximately 1.2 km downstream. It has been estimated that approximately 0.23 million kilograms of PCBs have been discharged to the Hudson River (38). Sediments off the General Electric plant in Pittsburgh, Massachusetts contained 130 to 1300 ppm PCB in the vicinity of the discharge (39).

British Columbia

Data on PCB levels in sediments of British Columbia are presented in Appendix 2 and sampling locations are shown in Figure 1. High sediment concentrations, often exceeding 1000 ppb dry weight, have been detected off certain industrial facilities in British Columbia. In many instances this contamination has probably resulted from leaks or spills from PCB-containing electrical or hydraulic equipment. While there are no capacitor, transformer or hydraulic equipment manufacturing plants in British Columbia, PCB releases from such equipment may occur during routine use, servicing, malfunction, and as a result of inadequate disposal. For example, leakage from equipment containing PCBs is thought to be the source of the moderately elevated PCB levels in the sediments adjacent to several pulp and paper mills in the province. Concentrations of up to 1500 ppb have been detected in sediments off the MacMillan Bloedel plant at Harmac; up to 5500 ppb at the Port Alberni division; and up to 1700 ppb at Powell River. Similarly, PCB levels of up to 4460 ppb and 3890 ppb were detected in sediments off Rayonier at Woodfibre and Bay Forest Products in False Creek, respectively. Because of the numerous past and present industrial discharges to False Creek it is not possible to attribute the elevated levels in the sediments off Bay Forest Products solely to this facility.

Very high levels of PCBs in the sediments of Porpoise Harbour near Prince Rupert were detected following the malfunction of a PCB filled transformer at the Canadian Cellulose pulp mill. This incident and the associated environmental contamination are discussed in detail in Section 6.3.

Many plants have recently taken preventative measures to eliminate or reduce releases to the environment and, in most instances, the faulty equipment responsible for these elevated environmental levels is no longer in use. For this reason, the contamination detected in the receiving environments of many of these industries may be a result of historical rather than current releases.

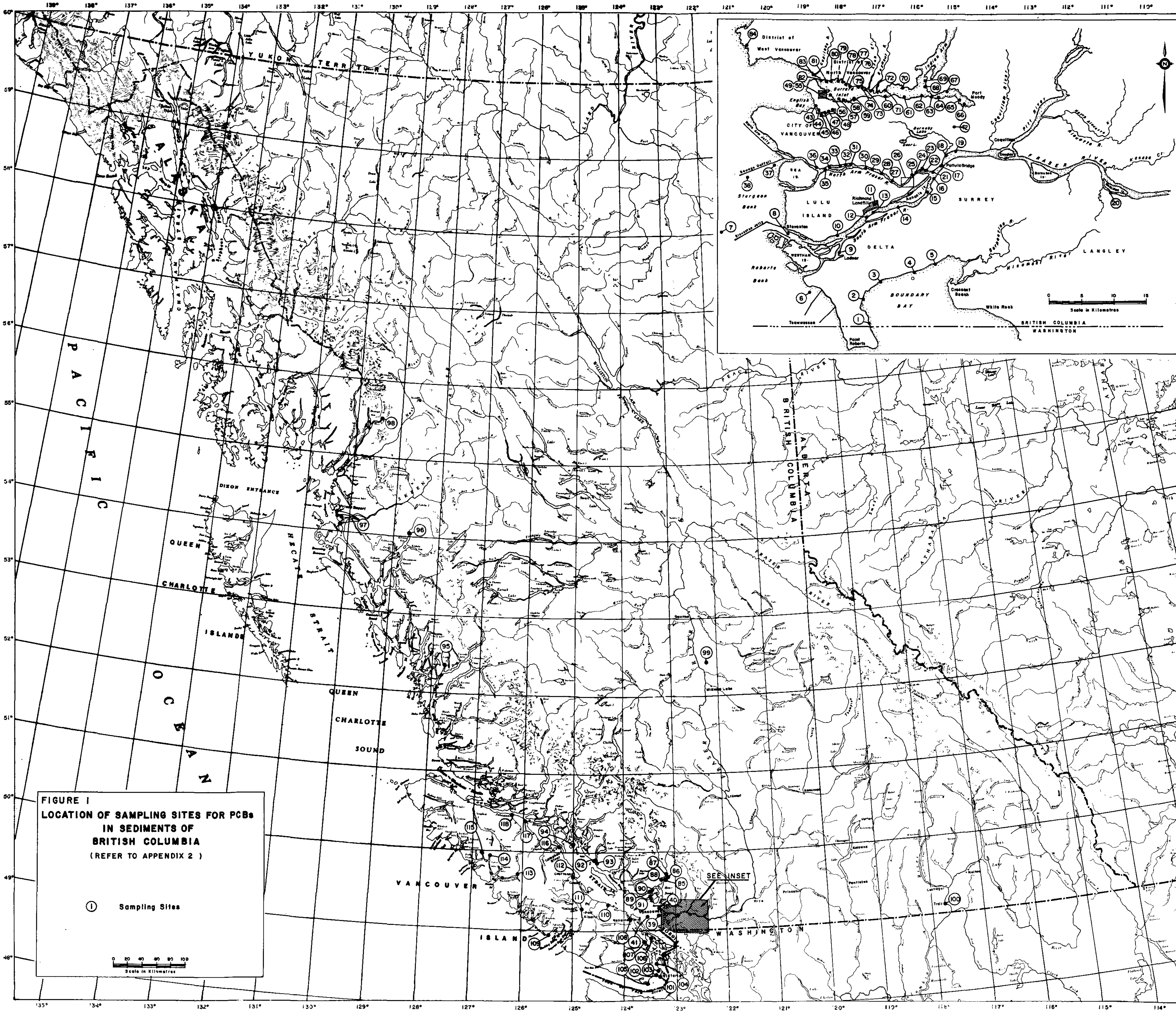


FIGURE I
LOCATION OF SAMPLING SITES FOR PCBs IN SEDIMENTS OF BRITISH COLUMBIA
(REFER TO APPENDIX 2)

Elevated PCB concentrations have also been detected throughout Burrard Inlet with particularly high concentrations occurring in the vicinity of the ship building and ship repair facilities. For example, PCB concentrations of up to 16800 ppb were detected in sediments off the Bayshore Inn in Coal Harbour. This contamination may be attributable to the past use of PCB-containing marine paints and/or leaks and spills from electrical and hydraulic equipment at shipyards located in this general vicinity. High PCB levels were also detected in Burrard Inlet sediments in the vicinity of Burrard Yarrows Shipyards, Vancouver Wharves, Benson's Shipyard, Burrard Shipyard and Vancouver Shipyard. Sediment PCB levels off these facilities were; 17000 ppb, 14400 ppb, 6200 ppb, 2200 ppb and 4090 ppb, respectively.

The sources of PCBs in other areas of Burrard Inlet have not been identified but this water system receives sewer wastes, aerial fallout, effluent discharges and runoff from numerous industries as well as extensive marine traffic. Concentrations of up to 3600 ppb PCB have also been detected in the bottom sediments of Victoria's Inner Harbour. Although no point sources have yet been identified, Victoria Harbour receives inputs similar to those described for Vancouver Harbour (Burrard Inlet), but on a smaller scale. It is not known whether a paint manufacturing plant which was once located in this area utilized paints containing PCBs.

Harbour areas often contain particularly high levels of PCBs. The continual discharges into these water systems, the water current patterns and the inadequate flushing of these sheltered areas tend to confine pollution to the low energy regions of harbours. PCB levels in Baltimore Harbour were between 1000 and 2000 ppb at most locations although a concentration of 84000 ppb was detected in one sample. In comparison, concentrations outside the harbour region were below 50 ppb (40). Similarly, in British Columbia, PCB levels in sediments outside harbour regions and away from point sources are very low.

High PCB levels have also been detected in sediments from False Creek under the Granville Street Bridge and in soil under the Burrard Street Bridge. PCBs are used for lubrication purposes in the rocker and roller bearings of these two bridges. Releases to the environment occurred as a result of cracks which developed occasionally due to unusual pressure on the bearing cases (refer to Section 6.7). Very limited sampling of sediments under the Granville Street Bridge roller bearings in 1978 revealed PCB levels of up to 6900 ppb, while concentrations in sediments under the Burrard Bridge were low. More extensive sampling conducted by the Environmental Protection Service (EPS) in 1981 did not show any indication of elevated PCB levels in sediments near the bridges, with concentrations ranging from $\leq$ 10 ppb to 430 ppb dry weight ($\bar{x}$ = 120 ppb).

In 1976, the Belkin Paperboard paper recycling plant in Burnaby was identified as a significant source of PCB release to the Fraser River (23). Levels of up to 1000 ppb dry weight were identified in the sediments immediately adjacent the plant. At this time it was expected that, as old supplies of PCB-containing paper were used up in the recycling process, PCB releases and environmental levels would decrease. However, subsequent monitoring by EPS in 1979 indicated that both effluent releases and sediment concentrations were of a greater magnitude than indicated by the 1976 sampling. Sediments adjacent to the outfall contained 1500 ppb while a sample collected several hundred metres upstream contained 1300 ppb. Although the source of the upstream contamination has not been positively identified, the fact that the sludge plume from the Belkin plant has been observed to extend over 0.8 km upstream during tide reversal, suggests that PCBs in this area also originate from the Belkin plant. Furthermore, no other sources of PCB release in this immediate vicinity have been identified. Improved pollution control measures at the Belkin plant have now reduced PCB releases substantially.

Sediments collected adjacent to certain Municipality of Delta land drainage pump stations indicated the presence of elevated PCB levels at two stations and very low levels at another three. The sediments collected at the airport and Beharrel (96th St.) pump stations contained PCB levels of up to 1200 ppb and 3800 ppb, respectively. Resampling of the airport pump station, however, revealed no evidence of PCBs and, therefore, the possibility of contamination of the first set of samples must be considered.

Sediments in the vicinity of municipal discharges in British Columbia have not been monitored although low PCB levels have been detected in wastewaters. Also, PCBs were present in biota collected in the vicinity of the Iona Island sewage treatment plant.

The remobilization of contaminants during dredging of industrial areas, and the subsequent disposal of bottom sediments from such areas, is of concern. The ultimate fate of resuspended particulates is the subject of considerable controversy. Some studies have shown that relatively little PCB is desorbed from the sediments during resuspension and that suspended contaminants will return to background levels in a short time (41). However, the possibility of spreading contamination through the resuspension of contaminated sediments does exist. In addition, some researchers feel that any disturbance of the buried sediments which removes contamination from the sink and redistributes it, may make contaminants more available to aquatic life.

Acceptable levels of PCBs in materials destined for ocean disposal have been established under the <u>Ocean Dumping Control Act</u>. PCBs are listed under Schedule 1 of the Act which states that the maximum quantity or concentration of PCBs (or other organohalogen compounds) in materials to be ocean disposed must not exceed "0.01 parts of the concentration shown to be toxic to marine animal and plant sensitive organisms in a bioassay sample and test carried out in accordance with procedures established or approved by the Minister".

Such regulations are extremely difficult to interpret and enforce for the following reasons:

1) it is not specified whether the allowable level should be based on the concentration found to be toxic in sediments or in water.
2) indicator organisms to be used in these tests are not specified despite the fact that PCB toxicity varies greatly with species.
3) the length of the bioassay test is not specified although acute and chronic toxic values are significantly different
4) it is not clear whether, for the purposes of this regulation, the term toxic should be interpreted as lethal or whether it should include sublethal effects.

Sediment samples from various ocean disposal sites along the coastal regions of British Columbia were collected and analyzed for PCBs in 1976. The initial analyses indicated that, although PCBs were present in the sediments of all dumpsites sampled (with the exception of Sandheads), levels were not usually high in comparison to other areas of the province. The highest values were detected at the Point Grey dumpsite (90-1050 ppb) and concentrations at all sites appeared to decrease with increasing sediment depth.

2.2 Fish and Aquatic Invertebrates

When PCBs enter an aquatic ecosystem in industrial or municipal wastewater or as a result of a spill, their low solubility in water results in their accumulation to high concentrations in the sediments. Currents and tidal action can distribute contaminated material from the initial point of entry and contaminate surrounding waters and sediments (42). Leaching from heavily contaminated sediments can cause elevated water concentrations at the sediment/water interface, even when PCB discharges to the area have ceased (42,43). PCBs also adhere to particulates and suspended solids in the water column and can be ingested by local biota. Thus, there are numerous ways in which aquatic organisms can be exposed to PCBs.

The potential for the uptake of PCBs into local biota exists even in aquatic systems where PCB inputs are low. Detectable levels of PCB in tissues of aquatic organisms have been reported in systems far removed from obvious sources of PCB release and in areas where ambient water concentrations are close to, or below, the limits of detection.

Aquatic organisms can rapidly accumulate tissue residue levels many thousands of times higher than water concentrations. Under laboratory conditions a 1 day exposure of various organisms to Aroclor 1254 at concentrations of between 1 and 2 ppb resulted in magnification factors as listed below (44):

Daphnia	24,700
Midge	22,000
Scud	17,000
Mosquito larvae	12,600
Glass shrimp	10,300
Stonefly	2,100
Dobsonfly	1,400
Crayfish	570

The exposure of estuarine animals resulted in concentration factors of 85,000 for oysters (45), 10,000 for shrimp (46) and 30,000 for fish (47). Data obtained from Escambia Bay in Florida indicate somewhat higher concentration factors; 10,000 for oysters, 230,000 for shrimp, and 670,000 for fish (48). It appears that the bioconcentration potentials of PCBs may be underestimated by laboratory evaluations.

Although significant magnification of PCB residues in aquatic organisms at lower trophic levels has been observed, some authors report that magnification factors are smaller than at the higher trophic levels (particularly fish-eating birds and mammals). PCB levels correlate directly with lipid content (49, 50, 51) and Goerke et al (52) demonstrated that PCB levels calculated on lipid basis increase with trophic level from bivalves to fish. However, according to Risebrough and Lappe (49) the relationship between lipid content and PCB levels in organisms can, in some cases, confound the common food chain concentration theory. For example herring from both coastal Nova Scotia and the Baltic Sea contained higher PCB levels (approximately 1 order of magnitude) than did cod from these locations despite the fact that cod occupy a higher level in the food chain. This finding was attributed to the higher fat content in herring.

PCB concentrations in certain bivalve species have been shown to vary with the time of year. Levels have been shown to decrease in clams (53) and oysters (52) in association with the increased lipid metabolism which occurs before and during spawning. It is important to consider this fact when bivalves are used as indicator organisms to assess contamination levels in the natural environment.

Aquatic organisms can accumulate PCBs directly from the water and sediments or via the food chain. Courtney and Langston (54) reported that polychaetes accumulate similar levels of PCB through exposure to 1 ppb in seawater or 1 ppm in sediments. In studies with shrimp and fiddler crab, Nimmo et al (46, 55) demonstrated that, in the environment, PCBs are accumulated by ingesting contaminated sediment particles or by absorbing PCBs directly from the water. In most cases PCB levels in the hepatopancreas of shrimp from the highly contaminated Escambia Bay, Florida were directly related to concentrations in the sediments (46). Khan et al (56) have shown that PCBs are readily adsorbed onto the outer shell or chitinous material suggesting that this is a possible site of PCB accumulation in aquatic species having outer shells.

Juvenile Atlantic salmon have been shown to accumulate relatively large amounts of PCB from contaminated food and suspended solids (57). Other researchers acknowledge that fish accumulate PCB from dietary sources but suggest that uptake from ambient waters is the major route of entry (58,59). Jensen et al (60) studied PCB uptake by five fish species in Lake Michigan and Green Bay. They concluded that the relative contribution of food to PCB body burdens in fish vary significantly between water systems and are dependent on the PCB concentrations in food sources. These authors reported that whitefish in Green Bay obtained approximately 90% of the PCB body burdens from food compared to 58% in Lake Michigan.

Variations in PCB levels in tissues of aquatic organisms from the same vicinity are influenced by such factors as the age of the organism, individual aggressiveness in feeding, feeding habits, and specific behaviorial patterns (61). Narbonne (62) demonstrated that residue levels in fish fed PCBs experimentally were higher in the older fish than in young fish. This was attributed, in part, to differences in the diets of fish from the various age groups. Levels of contaminants are normally higher in species or age groups whose diets consist of a high proportion of animal material.

Jensen et al (60) reported that PCB levels in lake whitefish from Lake Michigan varied more with location than did levels in lake trout. The authors suggested that this disparity may be due to the fact that whitefish incorporate bottom and detritus feeders into their diet whereas trout do not. Hence, PCB uptake in whitefish would be influenced by both water and sediment levels while trout would be affected only by water levels. PCB levels in sediments are geographically more variable than are PCB levels in water. Other researchers have also observed particularly high PCB concentrations in detritus feeders (63).

Mayer et al (64) and other researchers (44) have reported that, when exposed to Aroclor 1254, amphipods and other invertebrates accumulate particularly high concentrations of lower chlorinated compounds (tri- and tetra- isomers). In fish, however, the highly chlorinated PCB compounds (penta- and hexa- isomers) were often accumulated more readily and eliminated much more slowly than were the lower chlorinated isomers.

Zitko and Hutzinger (59) found that accumulation coefficients in fish were lower for the more highly chlorinated compounds during uptake from water (possibly due to their low solubility) but increased with increasing chlorination during uptake from food. Gruger et al (65) also found that juvenile coho salmon fed equal proportions of tetra- and hexachlorobiphenyl accumulated the hexa- isomers to a greater extent. The fact that the lower chlorinated compounds are more rapidly metabolized is probably an important factor (66).

Wszolek et al (67) attributed the higher proportion of hexachlorobiphenyl in trout from Cayuga Lake in New York to the greater persistence of these isomers in the environment. These authors also suggest that the highly chlorinated isomers may be selectively absorbed and less easily metabolized than lower chlorinated compounds in trout and possibly also in organisms lower in the food chain.

The highest levels of PCB and other lipophilic compounds are found in the livers and adipose due to the high lipid content of these tissues (62, 65, 68). Studies on the uptake of PCBs by fish showed the greatest retention in the liver followed by the gills, whole fish, heart, brain and muscle (47). High concentrations have also been found in the hepatopancreas of shrimp (55) and lobster (69) from contaminated areas.

PCBs are retained in the tissues of aquatic organisms for long periods of time even after the termination of exposure. Courtney and Denton (70) found that contamination in clams that had been exposed to 1.25 ppb PCB for 21 days did not decrease significantly, even over a period of 3 months, when placed in a clean environment. Clams which had been exposed to higher concentrations (12.5 ppb) showed a decrease in PCB levels in the muscular foot but concentrations in the visceral mass remained virtually unchanged after 6 months in a clean environment.

Fish which had accumulated PCBs over 56 days from ambient water with a concentration of 1 ppb, also lost tissue burdens very slowly when placed in a PCB-free environment. Tissue concentrations decreased by approximately 73% after 84 days. This finding indicates that PCB persists in fish tissues for approximately 3 months after removal from contaminated environments (68). As a result of studies on PCB uptake and elimination in fish, Narbonne concluded that the capability of fish to metabolize PCB was low in comparison to mammals (58).

British Columbia

Information on current levels of PCB in fish and aquatic invertebrates in British Columbia is limited and is presented in Appendices 3 and 4. The sampling stations are shown on Figure 2. The majority of the recent information relates to the receiving environment around the Canadian Cellulose pulp mill near Prince Rupert and was obtained following a major PCB spill in 1977. Monitoring of fish in the water systems around the McLeese Lake area (near Williams Lake) was conducted in 1976 when it was discovered that capacitors buried at a B.C. Hydro substation may be leaking. The data obtained as a result of these two incidents will be discussed in Section 6 which deals with spills.

Sampling of Fraser River fish species by the Westwater Research Centre in 1973 demonstrated that residue levels of PCBs were highest in the industrial regions and upper estuarine portions of the river (72).

This finding indicated that industrial development and urbanization in the Greater Vancouver area has contributed PCBs to the Fraser River.

Although mean concentrations for all species were below the Health and Welfare guideline for fish and shellfish (2 ppm or 2000 ppb) certain coarse fish species contained elevated levels. One largescale sucker contained over 3000 ppb and tissue levels in two northern squawfish approached 2000 ppb. Concentrations in most species were between 100 and 900 ppb. Other fish samples collected during the 1973 Westwater survey were stored for future analysis. In 1978, under contract to the Environmental Protection Service (EPS), these samples were analyzed for a variety of organic contaminants including PCBs (71). The results of these analyses confirmed the earlier findings of Johnston et al (72) with respect to the general levels of contamination and the higher incidence of elevated tissue concentrations in fish collected around Vancouver.

In 1980 the British Columbia Ministry of Environment collected a variety of fish species from several areas of the Fraser River. Analytical results again demonstrated higher levels in the industrialized regions of the river. PCB residues in muscle tissue of fish from the North Arm ranged from less than 100 to 800 ppb. No fish from the 1980 survey exceeded or approached the 2 ppm Health and Welfare guideline. Mean concentrations ranged from less than 100 ppb in rainbow trout and sockeye salmon to 200 ppb in staghorn sculpin, Dolly varden and white sturgeon. PCB levels were below the limits of detection in all species collected from the other Fraser River sampling locations. The only exceptions were white sturgeon collected from Hope which contained up to 400 ppb PCB.

Also in 1980, under contract to EPS, additional fish were collected from 4 stations in the Fraser River (73). The purpose of this survey was to compare PCB levels in fish from the vicinity of Belkin Paperboard to levels in fish collected elsewhere in the river. Peamouth chub collected near Belkin contained high levels of PCB (2400 ppb in a composite of 9 fish). Unfortunately this species was not collected in other areas of the river during this survey. However, peamouth chub collected in other parts of the river in 1980 by the British Columbia Ministry of Environment, contained much lower levels of PCB. Mean levels in other species collected near Belkin ranged from 110 to 400 ppb. Prickly and staghorn sculpins collected at Belkin contained higher concentrations of PCB (320 and 210 ppb, respectively) than did these species collected at Tilbury Island in the Main Arm (60 and 90 ppb) and at Pitt River (20 ppb in prickly sculpin). Starry flounder collected off Belkin and at Pitt River contained 110 ppb while those from the Tilbury Island station contained 40 ppb.

The elevated PCB levels in fish from the Belkin area could not be attributed solely to PCB releases from Belkin due to the mobility of fish and to past observations that PCB levels in fish from the industrialized North Arm are generally higher than those detected in fish from other regions of the river. It is likely, however, that the Belkin plant was the main contributor of PCBs to the river in this immediate area and consequently the main source of the PCBs detected in local biota.

The analysis of prickly sculpin conducted under contract to Fisheries and Oceans Canada in 1980 also indicated that levels in fish off Belkin were higher than in other areas of the river (74). In this survey 4 stations were sampled; Mitchell Island in the North Arm, Tree Island (near Belkin Paperboard) in the North Arm, Annacis Island in the Main Arm and the Whonnock government dock in the Main Stem. The highest concentrations were again detected in sculpin collected near Belkin ($\bar{x}$ = 610 ppb). These levels are similar to the concentrations detected during the 1980 EPS survey discussed previously. Levels in fish collected at the other North Arm station (Mitchell Island) were much lower ($\bar{x}$ = 140 ppb). Mean concentrations at the Annacis and Whonnock sampling stations were low (30 ppb and 70 ppb, respectively). These findings lend

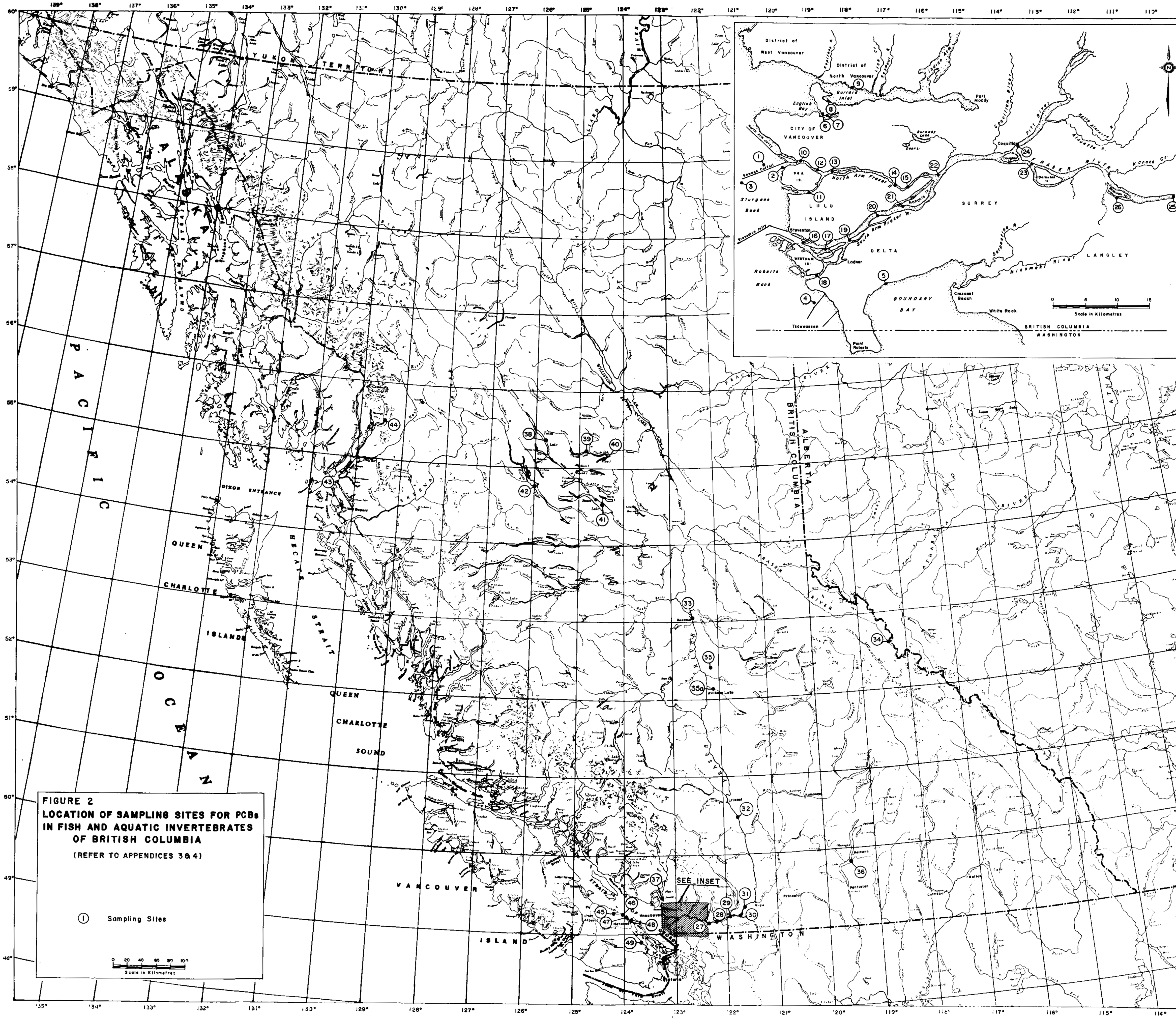


FIGURE 2
LOCATION OF SAMPLING SITES FOR PCBs IN FISH AND AQUATIC INVERTEBRATES OF BRITISH COLUMBIA
(REFER TO APPENDICES 3&4)

further support to the theory that PCB releases from the Belkin plant were contributing significant amounts of PCBs to local biota. It should be noted that PCB discharges from the Belkin plant have now been greatly reduced.

In 1978 a limited number of fish were collected from the mud-flats around Iona Island under contract to Fisheries and Oceans Canada. Analysis of these samples revealed that concentrations ranged from less than detectable levels to 650 ppb ($\bar{x}$ = 364.5 ppb) in flounder, 44 ppb in a salmon and 214 ppb in a speckled sanddab. Levels in flounder from the Roberts Bank area were significantly lower (1-2 ppb)(75).

The analysis of crabs from the estuary region also indicated that individuals from the Sturgeon Bank area contained somewhat higher concentrations (56-213 ppb) than did crabs from Roberts Bank (ND-14 ppb) (75). Similar results were reported by Bawden et al (76) in 1973 who found that concentrations of PCB in crabs were highest in the immediate vicinity of the Iona Island sewage outfall with levels decreasing with increasing distance from the plant.

More extensive sampling would be required to determine the influence of the Iona Island sewage treatment plant on PCB levels in local biota. Although higher PCB levels have been detected in the vicinity of the treatment plant than in other areas of the estuary, the presence of PCBs in this area may be due, at least in part, to the transport and ultimate deposition of contaminated particulates originating upstream in the Fraser system.

Sewage wastewater discharges have been demonstrated to be significant sources of environmental contamination in certain areas. Studies by McDermott et al (77) in the South California Bight have shown that Dover sole collected near large sewage outfalls contained much higher PCB concentrations than sole collected away from outfalls. In addition, although PCB discharges from these outfalls had decreased significantly between 1971 and 1975, tissue concentrations in sole had not.

Median levels in muscle tissue from sole collected near three of the larger southern California wastewater outfalls ranged from 700-1900 ppb in 1971-72 and 600-2000 ppb in 1974-75.

Concentrations of PCB in benthic crab and intertidal mussels from southern California were also much higher in specimens collected near outfalls than from control sites. Mean levels in crabs from the vicinity of outfalls in 1971-72 ranged from 290 to 1000 ppb while control crabs contained 15 ppb. The highest levels in mussels from coastal regions were found off major outfalls at Palos Verdes (up to 520 ppb). Unlike levels in sole, tissue concentrations in mussels decreased significantly (54%) between 1971 and 1975 (77).

Although the data from the Iona mud flats are very limited, PCB levels in the crabs and bottom fish appear to be somewhat lower than levels reported for these organisms near outfalls in southern California. The highest concentrations detected in these species from the Iona area are, however, comparable to median levels reported at certain outfalls in southern California.

Very high PCB levels have been detected in the sediments from Coal Harbour and crabs from this area contained a mean concentration of 200 ppb. The same species from False Creek contained PCB levels approximately 10 fold lower. One composite sample of small shore crabs from under the Granville Street bridge, however, contained 160 ppb.

Mussels collected under the Burrard and Granville bridges contained very low concentrations of PCB, 14 and 17 ppb, respectively. Mussels collected in the Alice Arm area near the Kitsault Mine, however, contained unusually high PCB levels (up to 1700 ppb). Limited data indicate that water samples collected in this area were also elevated (Section 2.1.1) although sediment levels were low. Further investigation into possible past and present sources of contamination in this area is warranted.

Mussels from harbour regions in southern California, especially in areas of heavy vessel activity, contained similar PCB concentrations

(800-1300 ppb), while mussels from coastal locations away from urban centres ranged from 14 to 26 ppm (77).

PCBs were not detectable in oysters collected from various locations on Vancouver Island including Crofton, Nanoose Bay, Piper's Lagoon, and Shoregrove Resort. These stations are thought to be relatively free from significant sources of PCB release although there are minor domestic sewage discharges at Crofton, Piper's Lagoon and Shoregrove Resort, and the Crofton area also receives wastes from a pulp mill. Prawns obtained from the vicinity of the outfall at Nanaimo contained less than 5 ppb of PCBs.

2.3 Wildlife

Certain wildlife species, particularly fish eating birds and aquatic mammals, accumulate high tissue levels of contaminants including PCBs.

Very little information on PCB levels in British Columbia wildlife has been obtained since 1976. Consequently almost all of the existing data was included in a 1976 EPS report (23). This report should be consulted for a review of the available data and comparisons to levels in wildlife in other areas of the world.

Limited data was obtained as a result of a Canadian Wildlife Service survey investigating contaminant levels in Great Blue Heron eggs from the Lower Mainland (Appendix 5). The PCB levels in eggs from this species were much higher than the levels detected in eggs of other species in British Columbia. Mean levels in eggs from the Coquitlam and University of British Columbia populations were especially high (14.9 and 21.4 ppm, respectively, on a whole egg wet weight basis). According to Gilbertson and Reynolds (78) the dry weight equivalent for eggs is approximately 5 times greater than the wet weight concentration. Using this conversion factor, mean dry weight PCB levels in heron eggs from Coquitlam and U.B.C. were 75 and 107 ppm, respectively, with levels ranging up to 324 and 251 ppm, respectively.

Residue levels in heron eggs collected in the Kootenay River area in 1969 (23) ranged from 0.036 to 25.9 ppm wet weight with a mean concentration of 12.97 ppm (75 ppm dry weight).

Although these levels are higher than those found to cause embryonic deformities and mortalities in poultry, (79) there is substantial variation between species sensitivities. No impacts on heron colonies in British Columbia have been observed.

3 TOXICITY

3.1 Aquatic Organisms

Acute and chronic lethal toxicities and sublethal effects of PCBs to fish and aquatic invertebrates have been listed in Tables 2a and b and Tables 3a and b, at the end of this section.

Species differ considerably in their responses to various kinds and concentrations of Aroclor. Acute toxicities to aquatic organisms appear to be related to their solubilities and hence are indirectly proportional to the relative chlorine content of the mixture. Due to the insoluble nature of the highly chlorinated isomers, even toxicity tests using Aroclors comprised largely of highly chlorinated isomers may reflect the toxicity of the more soluble lower chlorinated components (5). The toxicities of commercial PCB formulations may also vary according to the presence of chlorinated dibenzofurans or other toxic impurities.

There are indications from intermittent and continuous flow laboratory bioassays extending for periods of two weeks and longer that acute static bioassays underestimate the toxicities of PCBs to fish. Aroclors are more toxic in continuous and intermittent flow tests than in static conditions due to continual replacement of the toxicant. It is estimated that almost one third of the original PCB content in the water is lost to the air during static tests. For example, a static bioassay over 3 weeks demonstrated the LC_{50} of Aroclor 1248 for Daphnia to be 25 ppb while the LC_{50} during a continuous flow study was 2.6 ppb (80). Also, the onset of death in the extended or long term bioassays appears to be delayed and the LC_{50} values decrease significantly with longer exposure, indicating a greater PCB hazard with increased exposure time.

Many freshwater and estuarine organisms, particularly invertebrates, exhibit extreme sensitivity to PCBs as indicated by the seven day LC_{50} tests for the following species: grass shrimp, 3 ppb;

crayfish, 30 to 100 ppb; and dragonfly, 800 to 1000 ppb (81). Invertebrates are especially sensitive to the toxic effects of PCBs during molting (82,83). Freshwater crustaceans are very sensitive to low concentrations of PCBs and, due to their short life cycles, they can be rapidly eliminated from PCB contaminated waters (84). Aroclor 1254 has been found to affect the species composition and reduce the species diversity in invertebrate communities. Exposure to 1.0 ppb or greater decreased the populations of arthropods, amphipods, bryozoans, crabs, and molluscs and resulted in a dominance of the community by the more pollution resistant tunicates (85).

The exposure of aquatic organisms to PCBs experimentally has resulted in reproductive impairments and productivity and hatchability failures in: Daphnia, Gammarus and Tanytarsus at water concentrations of less than 1 ppb (8o); Atlantic salmon eggs containing 0.4 to 1.9 ppb (86); in striped bass eggs containing concentrations of up to 1.8 ppm (87); and in fathead minnows at water concentrations of 0.9 ppb (81).

PCB inhibits growth in marine diatoms at concentrations as low as 10-25 ppb, and in fathead minnows and flagfish at 2.2 ppb (88). Oyster shell growth was inhibited by 59% at a concentration of 10 ppb Aroclor 1254 (43). Other sublethal toxic effects of PCBs to aquatic organisms include:

i) inhibition of photosynthesis in phytoplankton at 10.0 ppb (89) and in the aquatic plant Spirodela oliogorhiza (90)
ii) disruption of osmoregulation in marine teleosts (81)
iii) interference with ATPase enzymes in fish (81) and shrimp (91)
iv) stimulation of thyroid activity in salmon and channel catfish at levels as low as 0.001% of the lethal dose (92)
v) a strong association between PCB body burden concentrations and fin erosion in Dover sole taken off Palos Verdes and Orange County (77) and in various species of fish exposed to PCBs experimentally (47, 80, 93, 94).

vi) a significant increase in transaminase activity in fish, indicating hepatocellular damage (95)

vii) hemorrhaging, emaciation, and the development of ragged fins and body lesions in fish (47)

viii) an increase in susceptability to disease in some fish species (47)

Very little information is available on bioaccumulation or toxic effects resulting from elevated PCB levels in sediments. Nimmo *et al* (83) exposed caged pink shrimp directly to the contaminated bottom sediments of Escambia Bay for a period of 3 weeks. While no increase in mortality was noted, the shrimp accumulated approximately three times more PCB than did the controls. Similarly, fiddler crab and grass shrimp are capable of accumulating Aroclor 1254 from contaminated bottom sediments. Bioaccumulation is influenced by the PCB concentration in the sediment and by the sediment type (46, 83). Atlantic salmon have been shown to absorb PCBs from contaminated silica particles suspended in the water column (57).

Although present levels of PCBs in the aquatic environment are generally lower than concentrations found to be acutely toxic to aquatic organisms, it is estimated that biological magnification of PCBs in the food chain can occur by a factor of 10 to 100 at each step. Fish and aquatic animals can accumulate PCBs to levels of 10^3 to 10^5 times those in ambient waters (81).

There is much information on PCB levels in tissues of aquatic organisms, however, it is extremely difficult to relate such levels to potential toxic effects. Freeman and Uthe (96) have shown that PCB levels currently found in cod from the North Sea may be causing deleterious effects. Cod which accumulated 2 to 5 times the control levels of PCB ($\bar{x}$ = 5.1 ppm wet weight) in liver tissue in lab experiments exhibited the following effects:

i) interference with sperm production

ii) gill damage

iii) fatty changes in the liver

iv) interference with metabolism of steroid sex and stress hormones

Hogan and Brauhn (92) reported a 10-28% mortality rate in rainbow trout eggs containing 0.39 ppb Aroclor 1254. The threshold concentration for salmon egg mortality is approximately 0.5 ppb which is equivalent to a whole fish concentration of approximately 2.5 to 5.0 ppb (97). Studies with Baltic flounder indicate that PCB concentrations above 120 ppb in eggs can result in decreased survival of developing eggs and larvae (98).

The possibility of synergistic effects resulting from exposure to multiple contaminants in the environment is an important aspect of aquatic toxicology. The presence of other contaminants such as arsenic (99) and DDT (100) has been found to increase the toxicity of PCBs to certain organisms. In addition, a study by Fingerman (101) demonstrated that the toxic effects of a combination of toxicants is not consistent throughout the year. Exposure of gulf killifish to a combination of Aroclor 1248 and fuel oil in the spring resulted in greater inhibition of fin regeneration than did a similar exposure in the autumn.

3.2 Wildlife

3.2.1 Birds. Certain species of birds, particularly fish-eating species, accumulate high levels of contaminants including PCBs. Although LC_{50} values for most avian species are quite high (usually several hundred ppm), experimental work has shown that PCBs may contribute to reproductive impairment in birds through reduced hatchability (117), behavioural modifications (118, 119, 120, 121), decreased egg production (79) and embryo abnormalities (79, 117). Abnormalities associated with unhatched embryos include; edema, unabsorbed yolk (117), the inability of

TABLE 2: ACUTE TOXICITIES OF PCBs TO AQUATIC ORGANISMS AS DETERMINED BY LC_{50} TOXICITY TESTS
(a) Fish

Aroclor	Species	Exposure Time/Type[1]	LC_{50}(ppb)	Reference
1221	Cutthroat trout	96 hour/s	1170.0	64
1232			2500.0	64
1242			5430.0	64
1248			5750.0	64
1254			42500.0	64
1260			60900.0	64
1262			50000.0	64
1268			50000.0	64
1254	Coho salmon - alevins	72 day/-	L15.0	94
1248	Channel catfish	96 hour/s	6000.0	102
1254			12000.0	102
1242		25 day/c	132.0	64
1248			104.0	64
1254			181.0	64
1260			465.0	64
1248	Bluegill	96 hour/s	280.0	102
1254			12000.0	102
1242		25 day/c	120.0	64
1248			100.0	64
1254			239.0	64
1242		15 day/-	54.0	84
1016		35 day/-	43.0	84
1016		96 hour/-	48.0-260.0	84
1016	Rainbow trout	96 hour/-	135.0	84
1242		10 day/-	39.0	84
1016		17 day/-	49.0	84
1242		25 day/c	12.0	64
1248			3.4	64
1254			27.0	64
1260			49.0	64
1248	Fathead minnow -newly hatched	96 hour/c	15.0	88
1254			7.7	88
1248	-larva	30 day/c	4.7	103
1260			3.3	103
1242	-3 month old	96 hour/c	300.0	103
1254	Pinfish	12 day/c	5.0	47
1254	Spot	18 day/c	5.0	47
1016	Atlantic salmon	96 hour/-	134.0	84
1016	Yellow perch	96 hour/-	185.0	84

1 The type of bioassay used is designated by either 'c' indicating continuous flow or 's' indicating static. The symbol '-' indicates that the testing method is unknown.

TABLE 2: ACUTE TOXICITIES OF PCBs TO AQUATIC ORGANISMS AS DETERMINED BY LC_{50} TOXICITY TESTS
(b) Aquatic Invertebrates

Aroclor	Species	Exposure Time/Type[1]	LC_{50}(ppb)	Reference
1254	Daphnia magna	14 day	24.0	100
1248		2 week/c	2.6	80
1254			2.8	80
1221		3 week/s	180.0	80
1232			72.0	80
1242			67.0	80
1248			25.0	80
1254			31.0	80
1260			36.0	80
1262			43.0	80
1268			253.0	80
1254		3 week/c	1.3	80
1242	Gammarus pseudolimnaeus	96 hour/c	73.0	80
1248			20.0	80
1242		60 days/c	8.7	80
1248			5.1	80
1254	Tanytarsus dissimilis			
	-larvae	3 week/c	0.65	80
	-pupae		0.45	80
1242	Amphipod	4 days/c	10.0	64
1248			52.0	64
1254			2400.0	64
2,3,4'- trichlorobiphenyl			70.0	64
4,4'- dichlorobiphenyl			100.0	64
2,4'- dichlorobiphenyl			120.0	64
2,4,6,2',4',6'- hexachlorobiphenyl			150.0	64
2,4,5,2',5'- pentachlorobiphenyl			210.0	64
1016	Grass shrimp	96 hour	10.0	15
			12.5	104
1254			41.0-86.0	105
		7 day/c	3.0	64
		16 day	4.0	46
1016	Brown shrimp	96 hour	10.0	15
			10.5	104
1254	Pink shrimp			
	- juvenile	15 day	0.94	83
	- adult	35 day	3.5	83
1254	Crayfish	7 day/c	30.0-100.0	64
		96 hour	80.0	15
1016	Oyster	96 hour	10.0	15
1242	Damselfly	4 day/c	400.0	64
1254			200.0	64
1242	Dragonfly	7 day/c	800.0	64
1254			1000.0	64

TABLE 3: SUBLETHAL TOXICITIES OF PCBs TO AQUATIC ORGANISMS
a) Fish

Aroclor	Species	Concentration (ppb)	Effect	Ref.
1254	Brook trout (from eyed egg stage to 118 days after hatching)	13.0	- decreased survival of fry 48 days after hatching	106
		≥ 1.5	- decreased hatching and growth of fry	106
		≥ 3.1	- decreased hydroxyproline and vitamin C concentrations in backbones of sac fry - backbone development altered after 118 days	106
Chlophen A50	Brown trout	dosage of 10 ug/g body wt.	- blood anemia, hyperglycaemia and metabolic disturbances	107
1254	Coho salmon	56.4	- reduced hatchability by 30% - reduced yolk sac utilization	108
		≥ 4.4	- premature hatching - reduced alevin survival	108
		≥ 15.0	- decreased length and weight of alevins	108
		≥ 480 in diet	- 52% increase in thyroid activity	64
		1000 in diet	- induced hepatic aryl hydrocarbon hydroxylase	65
		500,000 in diet	- decreased serum triioidothyronine levels - decreased body weight despite aggressive feeding	109
	Atlantic salmon (eggs exposed from gastrulation to hatching)	≥ 0.05	- retarded behavioural development and impaired balance	110
1016	Pinfish	32.0	- liver and pancreatic alterations	104
1254		≥ 5.0	- increased susceptability to disease	47
1254	Spot	≥ 5.0	- fatty changes in the liver	111
			- increased susceptability to disease	47
1242	Fathead minnow	> 10.0	- decreased survival of newly hatched fry	88
		> 0.9	- decreased number of eggs produced	88
1248		> 2.2	- inhibited growth	88
1254		1.8	- decreased spawning and reproduction	88
		4.6	- inhibited growth	88
1260		0.4	- 20% reduction in standing crop of 2nd generation due to larvae mortality	88
1254	Sheepshead minnow	0.1	- decreased survival of hatchlings	94
1242	Gulf killifish	4000.0	- increased locomotor activity in 24 hrs. due to alterations in brain levels of biogenic amines	112
1248	Flagfish	≥ 2.2	- decreased growth	88
		≥ 5.1	- decreased survival	88
1254	Channel catfish	8000.0	- increased transaminase activity and suggestions of hepatocellular damage after 4 hrs exposure	95
			- lethargy, petechiae around the mouth dyspnea, and disorientation	95
1242	- fingerlings	20,000 in diet	- reduced weight gain and liver hypertrophy	113

TABLE 3: SUBLETHAL TOXICITIES OF PCBs TO AQUATIC ORGANISMS
b) Invertebrates

Aroclor	Species	Concentration (ppb)	Effect	Ref.
1221	Daphnia magna	89.0	- 16% reproductive impairment	80
1232		53.0	(in static flow bioassays)	80
1242		48.0		80
1248		16.0		80
1254		18.0		80
1260		22.0		80
1262		24.0		80
1268		162.0		80
1248		1.0	(in continuous flow bioassays)	80
1254		0.48		80
1016 & 1254	Snails	> 500 in diet	- shell damage due to inhibition of calcium	114
1254	Tanytarsus dissimilis	0.45	- growth decreased 50%	80
1254	Invertebrate community	≥ 1.0	- affected species compostion and diversity by decreasing the number of arthropods, amphipods, bryozoans, crabs and molluscs resulting in a dominance of tunicates	85
		≥ 0.1	- decreased number of molluscs	85
1254	Eastern oyster	10.0	- inhibited shell growth by 41%	43
		5.0	- depressed growth rate	115
		5.0	- tissue alterations in digestive system	111
1254	Shrimp	3.0	- crystalloid formation in hepatopancreas	111
1242	Fiddler crab	8000	- inhibit ecdysis after 14 days exposure even after termination of exposure	116

chicks to break the shell and emerge (117, 121) and leg, toe and neck deformities (79).

Work done by various researchers (122, 123) suggests that PCBs may affect breeding cycles by stimulating the production of liver hydroxylases which reduce circulating estrogen levels. Very high doses in the diet exert an antiandrogenic effect on male chickens and discourage the normal development of primary and secondary sexual structures (124).

Other effects of PCB exposure in birds include decreased avoidance responses (118), increased nocturnal activity (119,120), and decreased hatching of eggs due to inadequate parental care (125). Pathological changes associated with PCB poisoning include thyroid enlargement and altered thyroid activity (126), liver and kidney (121, 127, 128, 129), atrophy of the spleen (121) and internal hemorrhaging (129). The level of PCB exposure necessary to cause these effects varies significantly depending on species sensitivities and the length of exposure. However several of these toxic effects have been noted in birds fed 10-50 ppm PCB for several weeks.

Most of the toxic effects of PCBs have been observed in laboratory situations. Very little information is available on the effects of PCBs on wild populations. It is very difficult to isolate the toxic effects of each contaminant, due to the fact that wild birds are usually exposed to, and accumulate, multiple contaminants. High levels of PCBs and DDE, for instance, often occur in the same bird colonies. Whereas population declines, when identified, are more commonly attributed to the egg-shell thinning effects of DDE (130), PCBs are sometimes suspected of contributing to reproductive abnormalities.

Studies by Tumasonis et al (79) have shown that embryo abnormalities and death occur in poultry when PCB levels in egg yolks reach 10-15 ppm (wet weight). This level is thought to be roughly equal to 10-15 ppm PCB dry weight in the whole egg (130). In 1974, herring gull eggs from colonies in the Great Lakes were found to contain PCB levels 1 to 2 orders of magnitude higher than the levels shown to be toxic experimentally. Researchers speculated that the severe reproductive impairment of this species in the Great Lakes region was due to the high levels of PCBs, DDE and possibly other toxic contaminants (130). Some researchers have shown a positive correlation between death and PCB levels in the brains of birds. Experimentally poisoned cormorants contained PCB levels of 75 to 180 ppm (131) while the mean PCB level in cormorants found dead in the Netherlands was 319 ppm. The cause of death of these birds was not known but this finding indicates that, in some bird populations, PCBs are at or near lethal levels (132). Similar work with blackbirds (133) and pheasants (121) suggest that brain residues in the ranges 350 to 760 ppm and 300 to 400 ppm, respectively, are indicative of PCB poisoning.

PCBs are stored in fatty tissues and are not easily eliminated. Unusually high levels of organochlorines have been found in the muscle tissue of birds with low visceral fat reserves. It has been demonstrated that PCB and certain other contaminants are mobilized from the fat into other body tissues and vital organs under stress conditions (134, 135). This may explain, at least in part, the observation that PCBs are more toxic to birds under stress conditions such as food deprivation (127, 136).

The simultaneous administration of PCB and DDE can result in more pronounced toxic effects than either of these contaminants when administered singly. The addition of PCB (Aroclor 1254) to diets already containing DDE resulted in significantly increased eggshell thinning, breakage and embryo mortality in American Kestrel (137) and decreased egg production in mallards (138).

Some of the common effects of PCB exposure (edema and hydropericardium) are characteristic of 'chick edema disease'. This condition is often attributed to exposure to chlorinated dibenzodioxins. However, its manifestation following PCB exposure is probably due to the chlorinated dibenzofurans found as impurities in commercial PCB formulations. Chlorinated dibenzofurans are embryotoxic and may also be responsible, at least in part, for the embryo mortality which occurs following PCB exposure (22). However, porphyria and other liver effects appear to be caused by the PCBs themselves (139).

3.2.2 Mammals. Toxic effects in mammals occur as a result of exposure to PCBs through ingestion, absorption through the skin or inhalation. Although PCBs generally have a low acute toxicity to most mammalian species, some species (such as mink) exhibit an extreme sensitivity to low levels in the diet. A decline in the reproductive success of commercially reared mink was ultimately attributed to the high PCB concentrations in the Great Lakes coho salmon which comprised approximately 30% of their diet (140, 141). Experiments on the dietary effects of PCBs on mink demonstrated that 10-30 ppm Aroclor 1254 in the diet was fatal, while 5-10 ppm inhibited reproduction and 1 ppm significantly reduced reproductive success (142). When PCBs were administered in the form of contaminated beef they were observed to be much more toxic. A concentration of 3.57 ppm in beef resulted in 100% mortality in adult mink, while increased mortality in the young (and in some adults) and decreased reproduction in adults were observed at a concentration of 0.64 ppm. It appears that the storage and metabolism of PCBs in the cows may have increased the toxicity of these chemicals (142). Toxic symptoms observed in poisoned mink included anorexia, liver and kidney damage, and internal hemorrhaging (140).

Organochlorine pesticides and PCBs are also suspected of contributing to the decreased reproductive success of California sea lions (143) and ringed seals from the Baltic Sea (144). Premature births and unusually high organochlorine pesticide and PCB residues were observed in California sea lions from San Miguel Island. In Baltic ringed seals only 27% of an expected 80-90% of the reproductively mature females were pregnant at the time of inspection. Elevated DDT and PCB levels were detected in non-pregnant female ringed seals as were uterine abnormalities. These findings were indicative of fetal resorption or abortion. It is possible that these effects are due to exposure to a combination of contaminants which may act synergistically. Simultaneous exposure to DDT or dieldrin intensifies the toxic effects of PCB to mink (145).

PCB has been shown to be more acutely toxic to the big brown bat than is DDE, and is fatal to some adults at a concentration of 10 ppm in the diet [reported in (133)]. Work by Clark and Lamont (146) has demonstrated that PCB is transported through the placenta in big brown bats much more readily than is DDE.

The most commonly reported toxic effect of dietary exposure to PCBs is liver damage, although numerous other effects have been observed. Studies have shown that the 3,4,5,3',4',5' - hexachlorobiphenyl isomer is particularly toxic (22).

The majority of mammalian toxicity studies have been conducted on laboratory animals such as rats and mice and little information is available on toxic effects on wildlife populations. Some of the toxic effects observed in experimental animals, in addition to liver damage, are as follows:

i) decrease in mating performance of adult rats and increase in mortality of offspring (147)
ii) hemorrhaging in lung, stomach and pancreas in rats (148)
iii) pulmonary congestion in rats (148)
iv) atrophy of thymus and spleen resulting in increased susceptability to disease in several species (139, 149, 150, 151, 152, 153, 154)
v) porphyria in many species (150, 155, 156, 157)
vi) decreased reproductive success, enlarged liver and erosions of the gastric mucosa in adult swine and offspring and reduced size of spleens and thyroids in offspring (151)
vii) stomach lesions and increased leukocyte count in dogs fed PCBs for 2 years (22)

In addition, several studies have indicated that long term high dosage exposures to Aroclors 1242, 1248, 1254 and 1260 induce neoplastic and pre-neoplastic lesions in rats and mice (147, 158, 159). It has also been suggested that PCBs may activate or deactivate other carcinogens or mutagens by stimulating the cytochrome P-450 dependent mixed function oxidase system. The potential of PCBs to suppress the immune system may be also an important factor in the development of carcinomas (22, 160, 161, 162).

Primates

Some primate species (particularly Rhesus monkeys) have been shown to be more sensitive to PCBs than are many other species of experimental animals.

Many of the toxic effects observed in Yusho victims have also been observed in rhesus monkeys exposed to PCBs in their diet. These include facial acne, subcutaneous edema, proliferation of the endoplasmic reticulum, increased hepatic microsomal enzyme activity, reduced size of infants at birth, excessive secretion of Meibomian gland, hyperpigmentation of skin and hyperplasia of the hair follicles. Marked alopecia and ulcerations of the gastric mucosa were common in rhesus monkeys but were not routinely observed in humans (163).

Many of these effects were observed in female monkeys fed dietary levels of 2.5 and 5.0 ppm Aroclor 1248. Transplacental movement of PCBs was also observed in monkeys. Infants born to affected mothers, and whose exposure continued through the ingestion of mother's milk, developed skin disorders and 50% did not survive past 4 months of age (164).

Female rhesus monkeys receiving a diet containing 25 ppm Aroclor 1248 for a 2 month period became pregnant but experienced either fetal resorption or abortion. Male rhesus monkeys seemed to be less affected by ingestion of PCBs than were females (164).

It is not clear which toxic effects in mammals are attributable to toxic impurities in PCB formulation and which are caused by the PCBs themselves. There is evidence to suggest that skin responses, edema and, to some extent, liver damage may be caused by the chlorinated dibenzofurans. These effects may also be caused, but to a lesser degree, by pure PCBs. Porphyria, however, has been attributed mainly to PCBs.

4 PCB's IN HUMANS

4.1 Toxic Effects

4.1.1 Occupational Exposure.

Human exposure to PCBs has occurred since 1929 when PCBs were first manufactured for industrial use. The potentially toxic nature of these compounds and the chemical impurities associated with them became evident soon afterwards. In 1933, an examination of plant workers at a PCB manufacturing plant showed that 23 out of 24 had developed choracne. Chloracne among workers' wives and children was also reported and was attributed to exposure to workers' PCB contaminated clothing. It was thought that the chloracne was caused by one particular batch of PCB produced. This batch was reported to have an unusual appearance and, although the cause was never conclusively identified, contamination with toxic chlorinated chemical impurities was suspected (165, 166).

In 1951, seven cases of chloracne occurred in workers at a chemical plant in Connecticut, United States, which used an Aroclor product as a heat exchanger. Due to a leakage, workers had been exposed to small concentrations of PCB vapours (approximately 0.1 mg/m^3) over a period ranging from 5 to 19 months (167).

Chloracne has been associated with occupational exposure to a number of compounds including chlorinated napthalenes, chlorinated phenols, 2,4,5-T, chlorinated dibenzofurans and some chlorinated dibenzodioxins (22, 168). With respect to PCBs, chloracne has been associated mainly with the tetra-, penta- and hexachlorobiphenyl isomers (22) and typically occurs approximately seven months after exposure.

Since the 1940's, reported outbreaks of chloracne as a result of occupational exposure to these compounds have been rare due, at least in part, to increased industry awareness regarding their toxicity and better worker hygiene. Other health effects resulting from occupational exposure to PCBs have not been confirmed.

A study was conducted by the Mount Sinai Hospital in New York on 326 capacitor workers at the General Electric Hudson Falls Plant in New York state. The mean length of employment for these workers was > 15 years. The main route of PCB exposure was via inhalation, but other possible routes include dermal absorption and ingestion. Ambient air concentrations throughout the plant varied from 7-11,000 ug/m^3. Acne-like skin eruptions, numerous other dermatological diseases, some pulmonary impairment and altered liver functions were evident but could not be directly correlated with PCB exposure. However, PCB concentrations in plasma and adipose tissue were related to the duration and level of exposure, and levels of PCB in adipose tissue were proportional to those in plasma. Also, there was a correlation between plasma PCB levels and abnormal SGOT levels and, in some individuals, the liver enzyme cytochrome P-450 showed abnormal functional changes (169, 170, 171, 172).

Studies were conducted by the National Institute for Occupational Safety and Health (NIOSH) on workers at two capacitor manufacturing plants (173). It was reported that the workers selected for the study had little potential for exposure to other toxic chemicals. While no increases in overall deaths from cancers and various other diseases were noted, slight (though not significant) increases in deaths from liver and rectal cancer and liver cirrhosis were observed at one of the plants. An accurate assessment of findings was confounded by the low number of deaths overall. Exposure of workers to PCBs at these plants was considered to be quite high and average ambient air levels ranged from 3 to 810 ug/m^3. In 1973, the American Conference of Government Industrial Hygienists' (ACGIH) recommended threshold limit for PCBs in the workplace atmosphere was 1000 ug/m^3 for Aroclor 1242 and 500 ug/m^3 for Aroclor 1254 (174).

Smith et al (175) studied employees of 2 utility companies and an electrical equipment manufacturing plant. Ambient air concentrations at the manufacturing plant ranged from ND-264 ug/m^3 as Aroclor 1242. Ambient air concentrations (as Aroclor 1254) were ND-215 ug/m^3 at one utility company and 0.4-8.8 ug/m^3 at the other. Significant skin contamination was observed at the manufacturing plant and at one utility company.

Serum PCB concentrations were substantially higher in employees of the electrical equipment manufacturing plant than in the general population. Symptoms of mucous membrane and skin irritation, systemic malaise and altered peripheral sensation were positively correlated with serum PCB levels. However, there was no evidence that exposure to PCBs had resulted in clinical abnormalities such as chloracne. Positive correlations between serum PCB and SGOT, serum GGTP and plasma triglyceride, and a negative correlation between serum PCB and plasma high density lipoprotein cholesterol, were observed. According to Smith et al (175) these results are indicative of physiological effects on the liver and, possibly, long term cardiovascular effects.

A study of workers exposed to PCBs and other chemicals over a period of up to 9 years at a petrochemical plant in New Jersey revealed a higher than usual incidence of malignant melanomas. Out of a total of 31 workers observed, 2 cases of melanoma were identified compared to the expected 0.04 cases (176). These effects cannot be attributed to PCB exposure, however, due to the fact that exposure of workers to other potentially carcinogenic chemicals at the plant was not considered in this study.

Although PCB levels in the blood and fat of workers at the Northeast Electrical Testing Company in Connecticut increased with exposure to PCBs, no unusually elevated tissue levels or physiological symptoms were identified in a survey conducted by Yale University (177).

An Australian study reported a mean PCB level of 400 ppb in the blood of workers at an electrical equipment manufacturing plant using

Aroclor 1242 while PCBs were not detected in the blood of control individuals. Although liver function tests were normal, workers' complaints included burning sensations of facial skin and hands, nausea, 1 case of chloracne and 5 cases of an eczema type skin rash. A level of 200 ppb was suggested as an acceptable level of Aroclor 1242 in the blood of occupationally exposed workers as no adverse health effects were observed on workers whose blood levels were below 200 ppb (178).

Maroni et al (179, 180, 181) conducted a study of 80 electrical workers at two plants in Italy. The workers were exposed to a PCB-based dielectric fluid similar to Aroclor 1242. Ambient air concentrations in the work area ranged from 48-275 ug/m^3 PCBs, consisting mainly of the more volatile lower chlorinated compounds. Work surfaces and tools were heavily contaminated, as were workers hands, and dermal absorption was thought to be the main route of exposure. Blood PCB concentrations in workers ranged from 41-1319 ug/kg and levels were closely correlated with the length of the exposure.

Various skin diseases (chloracne, dermatitis, folliculitis) were noted among workers. In 16 workers liver tests showed abnormalities in the form of liver enlargement and increased serum enzyme activity (indicating liver dysfunction). There was a positive correlation between PCB levels in the blood and liver abnormalities, but no correlation was found between blood PCB levels and chloracne. The authors noted that 20% of the workers with abnormal liver results had blood PCB levels lower than the 200 ug/kg threshold limit suggested by Ouw et al (178).

Haemangiomas were observed in two workers and myelocytic chronic leukaemia in another, but no evidence of a direct relationship to PCB exposure was provided.

It is important to note that, in most instances, toxic effects in humans have been observed only following exposure to heated PCBs. Vapourization of PCBs increases exposure via inhalation and may also increase exposure to toxic impurities. Chlorinated dibenzofurans are present in some commercial PCB formulations and heating PCB fluids has been shown to increase their concentrations (22).

4.1.2 Yusho. Perhaps the best known and most extensively documented case of PCB poisoning is the 'Yusho' incident which occurred in 1968 as a result of the accidental contamination of rice oil with high concentrations of PCB. As a result of ingesting varying amounts of rice oil over an extended period of time, more than 1200 Japanese people were officially diagnosed as having Yusho disease as of April 30, 1975 (182).

Symptoms attributed to ingestion of the contaminated oil include: chloracne; weight loss (182); a marked increase in serum triglyceride levels; hypersecretion of the Meibomian gland; subcutaneous edema particularly around the eyes and lips (182); neurotoxic effects in the form of reduced sensory nerve conduction velocity (183); fatigue; joint swelling, pain and numbness; nausea; coughing and other respiratory problems; visual disturbances; jaundice; and abdominal pain (182). Onset of symptoms was typically 3 to 7 months following the initial exposure (184).

An incident of Yusho disease was noted in an infant whose only exposure was through ingestion of contaminated breast milk (birth occurred prior to mother's exposure) (182). It was also noted that PCBs were capable of crossing the placental barrier. In many cases, even a few years after exposure, infants born to mothers suffering from Yusho also showed symptoms of the disease. These symptoms included hyper-pigmentation of the skin, below normal size, eruption of teeth at birth and hypersecretion of Meibomian gland. Within 2 to 5 months after birth the skin pigmentation disappeared and growth became normal (182). The height and weight gain in school children affected by Yusho were studied and, while the growth of girls appeared unaffected, the growth of boys was significantly less than that of controls (185).

The Criteria Document for PCBs (22) states that a preliminary review of the death statistics for Yusho victims suggests a possible increased incidence of cancer, particularly in the stomach and liver, compared to the normal population. The available information was too limited to make any definite conclusions, however.

Although there were no deaths directly attributed to Yusho, recovery from the disease was very slow. Disorders of the skin and mucous membranes persisted even 5 years after exposure, but improved gradually with time. Other symptoms such as fatigue, appetite loss, numbness, pain in the limbs and abdomen, headache, cough and excess sputum production worsened and were attributed to internal disorders (182).

With the exception of serum triglyceride levels, there was no apparent correlation between symptoms and PCB levels in the blood, however, blood samples were not analyzed for PCBs until 1972. At this time levels in both blood and tissues were approaching (although still somewhat higher than) normal levels despite the fact that victims were still exhibiting symptoms (176).

A 1973 national survey in Japan indicated that PCB levels in adipose and liver tissue were 0.2-4.0 ppm and 0.01-0.06 ppm (whole tissue basis), respectively. In comparison, PCB levels in the adipose tissue of Yusho victims were 13.0-76.0 ppm and 1.9-4.3 ppm in 1968 and 1972, respectively, while liver concentrations were 0.14-0.2 ppm one year after exposure and 0.08 ppm in 1972 (182).

Originally, it was reported that the Yusho oil contained 2000-3000 ppm PCB in the form of Kanechlor 400 (184), which is roughly equivalent to Aroclor 1248. More recent reports, however, estimate that the oil actually contained 900-1000 ppm PCB and approximately 5 ppm of various chlorinated dibenzofurans (CDFs) (182, 186). This level of CDFs is much higher than what would be expected based on CDF levels normally found in unused Kanechlor 400 or other commercial PCB formulations. In addition, the Yusho oil contained a hexachlorodibenzofuran isomer which is not present in Kanechlor 400 (182, 186). This suggests that dibenzofurans were formed during use as a heat exchange fluid (182) It is reported that while unused Kanechlor 400 contains approximately 20 ppm CDFs, used oil from a heat exchanger contained up to 11765 ppm (182, 186).

Assuming that the later estimates for PCBs and CDFs in the oil were correct (900-1000 ppm PCB; 5 ppm CDFs), the smallest known dose which caused symptoms of the disease was estimated to be 70-100 ug/kg body weight/day PCBs and 0.4 ug/kg body weight/day CDFs (22).

Chlorinated dibenzofurans (CDF's) were not present in the tissues of control individuals but were detected in the adiipose and liver tissue of Yusho victims. Analysis on fat basis indicate that CDF's were present in much higher concentrations in the liver than in the adipose tissue. This was surprising in that PCBs normally accumulate to higher levels in the adipose tissue than in the liver. It is not known whether CDF's preferentially accumulate in the liver tissue or whether they are formed in this organ. The CDF's present in the liver were primarily penta- and hexa-isomers (182).

It is not known to what extent the CDFs influenced the toxicity of the contaminated rice oil, but considering the extreme toxicity of certain isomers, it is likely that they were at least partially responsible for the disease. Many of the symptoms of Yusho, including chloracne, can be induced by CDFs (125) but also by PCBs containing very low levels of CDFs and by pure PCB isomers (to a lesser degree) (149). It is, therefore, not possible to conclusively isolate and identify the toxic effects attributable to each of these compounds in the Yusho incident.

It should be noted that, due to the large quantity of PCBs ingested and the unusually high contamination with chlorinated dibenzofurans in the rice oil, the health effects resulting from the Yusho incident are not indicative of possible toxic effects from normal occupational exposures.

4.1.3 Taiwan. In March, 1979 a tragedy similar to the Yusho incident occurred in Taiwan. PCB poisoning affected approximately 2000 people following the ingestion of PCB contaminated bran oil. Analysis of the oil revealed that PCB levels ranged from 53 to 99 ppm (1 sample contained 405 ppm). Polychlorinated dibenzofuran (PCDF) levels were typically less than 0.5 ppm (1 sample contained 1.7 ppm) (187). Based on this information it is apparent that PCB and PCDF levels in the bran oil were approximately one tenth (or less) of those detected in the Japanese rice oil which led to the Yusho incident.

Symptoms of poisoning were similar to those observed in the Yusho victims. Blood samples collected from Taiwanese victims 9 months to 1 year after exposure contained 11 to 720 ppb PCB ($\bar{x}$ = 49 ppb). These concentrations are much higher than those detected in Yusho victims ($\bar{x}$ = 5.9 ppb five years after exposure) (182). The difference in blood levels is probably due to the long (5 year) lapse between PCB exposure and blood analyses in Yusho victims. In general larger amounts of PCBs were ingested by the victims in Taiwan than in Japan. Also, the contaminated oil ingested by the Taiwanese victims contained a higher proportion of highly chlorinated PCBs (penta-, hexa-, hepta-isomers) than the oil which caused Yusho disease. The highly chlorinated compounds are retained in the body for longer periods of time than the lower chlorinated compounds (188).

4.2 Levels in Human Tissues

Surveys of PCB levels in human tissues have been conducted in many countries. In the United States, analysis of tissue collected in 1971 during surgery or post mortem examinations indicated that 49.3% of the samples did not contain detectable levels of PCB (< 1.0 ppm), 19.6% contained trace levels to 1.0 ppm, 25.9% contained between 1 and 2 ppm and 5.2% contained over 2 ppm (189). In another national survey conducted in the United States in 1973 and 1974, 40.3% of the adipose tissue samples analyzed contained greater than 1 ppm PCB (wet weight). It was noted that, although the levels in human adipose tissue did not appear to be changing with time, there was an increase in the frequency with which PCBs were detected compared to the 1971 survey. The results indicated that the PCBs in human tissues most closely resemble Aroclor 1254 and Aroclor 1260 with the penta-, hexa-, and hepta- isomers being detected most frequently. Human milk samples collected in this study consistently contained trace quantities of PCBs (<1 ppm) (190). An Environmental Protection Agency survey of mother's milk detected PCBs in virtually all samples analyzed. The overall mean concentration detected was 2.64 ppm (191). PCBs were detected in 40% of the samples of mother's milk obtained from rural Colorado. PCB concentrations ranged from 40 to 100 ppb (whole milk) (192).

Approximately 81% of a group of refuse workers exposed to PCBs through refuse incineration contained detectable levels of PCBs in the blood plasma compared to only 11% of the control group. The levels detected in both groups were similar, being 2.6 ppb in the refuse workers and 3.7 ppb in the controls (193). A study conducted by Finklea et al (194) indicates that these concentrations in the blood plasma are not unusual. Approximately 43% of the non-occupationally exposed residents of South Carolina sampled contained PCBs in their blood plasma (detection limit of 0.1 ppb). Mean levels in the blood plasma of rural and urban whites were 3.1 and 2.3 ppb, respectively while mean levels in rural and urban blacks were 0.3 and 1.8 ppb, respectively.

Several surveys of PCB levels in Japanese people have been conducted as a result of the Yusho incident. Fujiwara (195) compiled information obtained from other researchers and concluded that PCB levels in body fat of Japanese people were higher than those reported for United States residents. Mean PCB concentrations in body fat of people from various areas of Japan ranged from 1.0 to 7.5 ppm. Mean blood plasma and human milk levels throughout Japan ranged from 2.2 to 5.1 ppb and from 26 to 47 ppb, respectively. The overall mean values for 1972 and 1973 were 35 ppb and 32 ppb, respectively.

In 1974, 30 samples of human adipose tissue from residents of Tokyo were found to contain a mean concentration of 1.04 ppm PCB and ranged from 0.38 to 2.50 ppm. The mean blood level from 10 individuals sampled in 1975 was 2.59 ppb and concentrations ranged from 1.8 to 3.8 ppb (196).

Kuwabara et al (197) conducted a study on the effects of breast feeding on PCB levels in the blood of children (ages ranging 1 month to 6 years). Out of 17 children studied, 9 had higher blood levels than did their mothers. Blood residue levels in mothers ranged from 1.7 to 4.6 ppb while levels in children ranged from non detectable to 12.8 ppb. Mean concentrations were 2.8 ppb and 3.8 ppb, respectively. It was apparent that PCB levels in childrens' blood were more variable than in mothers' blood. It was also observed that levels in childrens' blood increased with the length of the breast feeding period and that levels in breast-fed infants (1 and 7 months old) were higher than in formula-fed children. Kuwabara et al (197) state that in their previous studies with occupationally exposed mothers, very high PCB levels (up to 115 ppb) were detected in the blood of their children and some clinical signs in the children were noted.

No PCBs were detected in mothers' milk from metropolitan areas in Australia in 1973 (198). This supports the findings of Ouw et al (178) who reported that PCBs were not detectable in the blood of the non-occupationally exposed Australian population.

Samples of human fat obtained during autopsies in a city in New Zealand consistently contained PCBs. The mean concentration in 51 samples was 0.82 ppm but levels increased with the age of the individual (199).

A national survey conducted by Health and Welfare Canada in 1972 revealed that PCB (Aroclor 1260) levels in adipose tissue of Canadians tested ranged from 0.11 to 6.6 ppm. Concentrations of over 1 ppm were most commmon in Ontario (49%) and least common in Manitoba and Saskatchewan (5%). Overall, 30% of Canadians tested contained residue levels of more than 1 ppm in adipose tissue, although the national average was 0.907 ppm. It was also reported that males contained higher PCB levels than did females. Concentrations did not appear to vary with age (200). However, the Ontario provincial government conducted a survey of Ontario residents between 1969 and 1974 and, although not statistically proven, PCB levels in adipose tissue did appear somewhat higher in individuals over 40 years of age (200).

A national Health and Welfare survey conducted in 1976 (201) indicated that average PCB level (Aroclor 1260) in adipose tissue (0.944 ppm) had not changed since 1972. The highest average concentrations were again detected in Ontario (1.791 ppm) and the lowest in Saskatchewan and Manitoba (0.779 ppm). Contrary to the 1972 study, females contained slightly higher levels than did males and concentrations did appear to increase somewhat with age. However, these differences were not statistically significant. Aroclor 1242, which was reported in the 1976, but not in the 1972 survey, was present at much lower concentrations than Aroclor 1260. The national average for Aroclor 1242 in adipose tissue was 0.307 ppm. Unlike Aroclor 1260, 1242 levels were highest in Saskatchewan and Manitoba (average 0.416 ppm). There were no statistically significant differences between the sexes or age groups (201).

Human milk samples collected in Ontario contained a mean PCB level of 1 ppm (fat basis). The levels did not vary during the 1969 to

1974 study period (200). A 1975-1976 national survey conducted by Health and Welfare Canada (202) showed that levels in mothers' milk ranged from 1 to 68 ppb (whole milk) and 98% of the samples contained less than 50 ppb. According to Atkinson, (203) a comparison of 1971 to 1974 data on PCB levels in Ontario mothers' milk to data collected in 1978, indicates that PCB contamination in breast milk may be decreasing.

Musial et al (204) reported that mean levels of PCB in human milk from New Brunswick and Nova Scotia were 22 ppb whole milk (1.53 ppm fat basis) and 18 ppb whole milk (1.86 ppm fat basis), respectively. The Health Protection Branch of Health and Welfare Canada has suggested a guideline of 50 ppb PCB in whole milk. The Branch also recommends that, if PCBs in any mother's milk exceeds this value, both mother and infant should receive close attention with respect to the mother's exposure and the child's growth and development (203).

A University of Guelph research team has recently expressed the opinion that the 50 ppb guideline may be approximately 5 times too high. They state that this guideline does not take into account the range in toxicities of the various forms of PCB or the fact that humans tend to selectively concentrate some of the more toxic isomers (205).

Similarly, according to Fujiwara (195), based on the 32-35 ppb average breast milk concentration in Japan, Japanese babies are ingesting approximately 5 ug PCBs/kg body weight which is the allowable level for PCB intake in adults set by the Official Committee for Food Hygiene Research. Fujiwara estimated that approximately 30% of Japanese babies are ingesting more than the allowable limit.

The British Columbia Ministry of Health conducted a survey of mothers' milk from several areas of the province. Over 400 samples were analyzed for PCBs and residue levels were correlated with such factors as diet records, weight loss, and nutrient analysis. The average PCB level in milk samples was 12 ppb (whole milk basis), which is well below the 50 ppb federal guideline (206).

5 USES AND SOURCES

5.1 Industrial Usage and Associated Releases

For approximately 40 years PCBs were used extensively by industry in such products as plastics, inks, carbonless copy paper, paints, pesticides, investment casting waxes and as dielectric, hydraulic, insulating and heat transfer fluids. Due to increasing awareness of their environmental hazards, in 1971, Monsanto (the only North American producer of PCBs) voluntarily restricted the sale of PCBs for use in closed electrical systems. In 1977, Monsanto terminated the manufacture and sale of PCBs entirely, forcing industry to search for suitable alternate fluids. Adequate information on the environmental persistence and long term toxicity of certain alternate fluids is lacking, however, they are generally considered more biodegradable and of less environmental concern than are PCBs. Since this time, regulations have been developed both in Canada and the United States which ban the importation and manufacture of PCBs in North America and severely restrict their legal uses and methods of disposal (see Section 8 on regulations).

In 1977, under the mandate of the Environmental Contaminants Act, EPS conducted a national survey of potential PCB users. All companies using PCBs in 1976 were asked to report the type of PCB used and the volume of usage. Usage information has since been updated through questionnaires and communication with companies currently using PCBs. Information on usage in British Columbia and the Yukon as of June, 1982, is summarized in Table 4 and 5. Information on the use of PCBs in Canadian commerce will be updated at regular intervals by EPS regional offices. Information obtained through industrial surveys and on-site inspections in the Pacific Region will be discussed in detail in another Pacific Region EPS report (207).

Very few industrial facilities in British Columbia have been sampled for PCB releases. In 1977 a national sampling program was initiated to determine PCB levels in effluents from various industry sectors across Canada. In British Columbia, sampling was conducted at specific oil refineries, mines, smelters, chemical manufacturing plants, pulp mills and at a coal bulk loading facility. PCBs were not detectable in most discharges. Concentrations close to the limit of detection (0.02-0.1 ppb, depending on the lab conducting the analysis) were present in one sample each from Imperial Oil refinery, Eurocan pulpmill, Cloverdale Paint and Chemical plant and in one of the discharges from the Alcan smelter. Elevated PCB concentrations were detected only in coke-calciner area surface drainage at the Alcan smelter (ND-3.29 ppb) and in settling pond wastes at the Roberts Bank coal superport (ND-2.98 ppb). The sources of PCBs at these facilities were not identified but they may originate from accidental leakage from electrical or hydraulic equipment. The low levels of PCBs in wastes from the Cloverdale Paint and Chemical plant may have been due to the past use of PCBs in some types of pigments (refer to section 5.1.7).

In a separate study EPS detected significant PCB levels in the effluents and clarifier sludges from the Belkin paper recycling plant. Through more effective solids removal the PCB concentrations in discharges from the Belkin plant have now been significantly reduced (refer to Section 5.1.4).

TABLE 4 PCB USAGE IN THE PACIFIC REGION BY INDUSTRIAL SECTOR

(June, 1982)

	QUANTITY OF PCB IN USE (kg)	PERCENTAGE OF TOTAL PCB IN USE
1. UTILITY	580,592	30.1
2. FOREST INDUSTRY	844,011	43.8
3. MINING AND SMELTING	292,216	15.2
4. REFINING (METAL)	12,488	0.7
5. STEEL AND IRON	-	-
6. CEMENT	54,547	2.8
7. CHEMICAL MANUFACTURE	8,082	0.4
8. RUBBER	-	-
9. TEXTILE	-	-
10. ELECTRICAL	6,439	0.3
11. HOSPITAL/SCHOOL	20,603	1.1
12. FOOD AND BEVERAGE	14,382	0.8
13. GOVERNMENT INSTALLATIONS	16,196	0.8
14. PETROLEUM	3,705	0.2
15. OTHER	75,571	3.9
TOTAL	1,928,832	100.0

TABLE 5 QUANTITY OF PCBs IN USE IN THE PACIFIC REGION

	NO. OF UNITS	QUANTITY OF PCB (kg)
ELECTRICAL EQUIPMENT		
TRANSFORMERS	814	1,298,789
CAPACITORS	73,412	619,943
ELECTROMAGNETS	0	0
OTHER	0	0
MECHANICAL EQUIPMENT		
HYDRAULIC SYSTEMS (Bridge Bearings)	46	10,100
HEAT TRANSFER SYSTEMS	0	0
VACUUM EQUIPMENT	0	0
TOTAL PCB IN USE		1,928,832

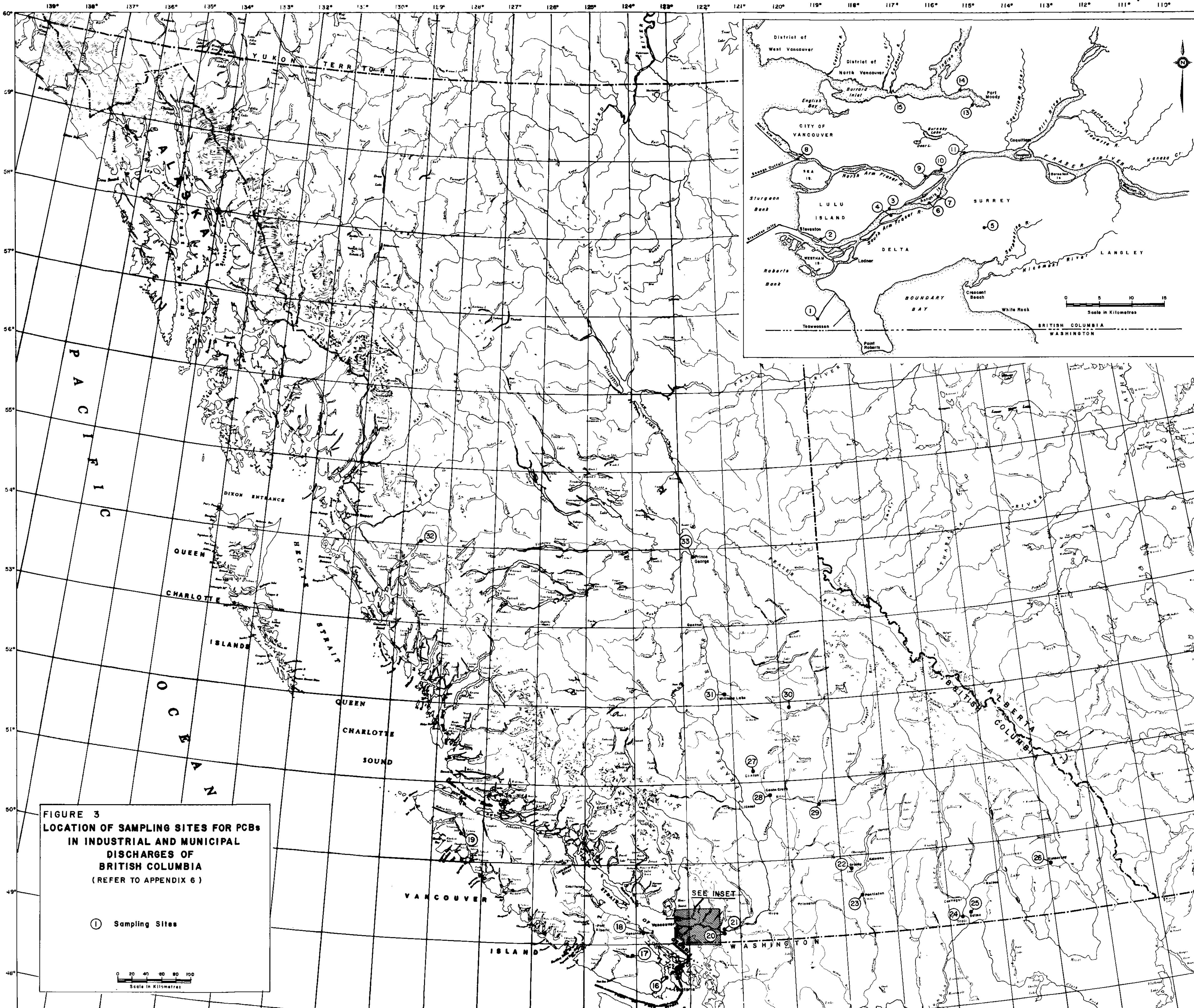


FIGURE 3
LOCATION OF SAMPLING SITES FOR PCBs IN INDUSTRIAL AND MUNICIPAL DISCHARGES OF BRITISH COLUMBIA
(REFER TO APPENDIX 6)

5.1.1 Electrical Equipment. In British Columbia, as elsewhere in North America, the greatest volume of PCBs currently in use are contained in electrical transformers and power factor correction-type capacitors. A recent survey of users in British Columbia revealed a total quantity of 1,928,832 kg of PCB still in use, of which 1,918,732 kg was in electrical equipment (Table 5) (208).

All known PCB filled electrical equipment in Canada is required to be identified by an EPS labelling and coding system. A record of the location, type, size, serial number and PCB fluid content has been entered on EPS computer logsystems and this information is routinely updated. All users of such electrical equipment have been requested to notify EPS regional offices when equipment is taken out of service, disposed of, or relocated.

PCBs are used in only a small percentage of transformers in North America, with most being either 'dry type' (containing no fluid) or mineral oil filled. Transformers containing PCBs are less flammable; however, and these units are usually located inside or close to buildings where safety from fire hazards is of prime importance (209). Transformers contain between 180 and 2300 litres (270 to 3400 kg) of dielectric fluid (average of 1070 litres (1600 kg)) (210) consisting of a mixture of 60 to 70% PCB (usually Aroclor 1254) and 30 to 40% tetra- and trichlorobenzene (211).

Almost all capacitors (approximately 95%) manufactured in North America between 1930 and 1977 contained PCBs (212). Capacitors normally contain Aroclor 1016 or 1242 in an amount dependent on the size of the unit. Capacitors used in fluorescent lighting and air conditioners contain 0.02 to 0.45 kg while the larger power capacitors contain approximately 35 kg (212).

The life expectancy for PCB-filled capacitors used in lighting units is over 10 years and for capacitors at electrical utilities, over 20 years. Askarel filled transformers commonly remain in service for more than 30 years (209). For this reason PCB-filled electrical equipment already in service could present a threat to the environment for many years to come unless adequate precautions are taken.

PCB filled electrical equipment is no longer being manufactured in North America, however, past releases from manufacturing facilities have resulted in significant environmental contamination.

A 1976 Environment Canada survey of PCB sources revealed that the Westinghouse Canada plants in London and Hamilton, Ontario and the Canadian General Electric plant at Peterborough, Ontario were the largest sources of PCB release identified in Canada. The London plant discharged an estimated 48.8 ± 9.1 kg/yr at the time of sampling. Atmospheric emissions from the Canadian General Electric plant in Peterborough were approximately 2.7 ± 0.5 kg/yr and were attributed to the continuous storage of PCB fluids at elevated temperatures under vacuum conditions (213).

Losses associated with PCB use in electrical equipment have occurred as a result of malfunction or damage to the unit (see Section 6 on spills) and through leaks and spillage during topping up, routine servicing or ultimate disposal.

Damage to a stored transformer at a meat packing plant in Montana resulted in the entry of PCB into meat meal destined for use as poultry feed. The subsequent contamination of poultry necessitated the destruction of large numbers of chickens, eggs and commercial baked goods. Some of this contaminated meal reached markets in British Columbia which also resulted in the destruction of poultry and feed. A recent inspection of food and feed plants in British Columbia revealed that PCB transformers are no longer in use at these facilities.

One power company in Michigan reported a loss of 12300 lbs PCB/year to soil from ruptured and salvaged capacitors (214). Such losses can best be prevented by good "housekeeping" practices. It should be noted that topping up electrical equipment with PCB fluids is no longer permitted in Canada. This restriction should have eliminated existing stocks of PCB make-up or bulk dielectric fluids which would help reduce occupational exposure and spills of PCBs during maintenance or servicing activities.

A handbook for the proper management and disposal of electrical equipment and wastes containing PCBs (215) has been distributed to all known users of this equipment. Periodic inspections of the major users of PCB-filled electrical equipment are conducted by regional EPS and provincial government personnel to ensure that adequate precautions against spills are taken and good "housekeeping" practices maintained. A recent EPS report describes in detail the results of these inspections (207).

Many plants utilize both mineral oil and PCB-type transformers. PCB contamination of mineral oil filled units can occur during maintenance procedures and during the retrofilling of PCB units with mineral oil. PCB contamination of mineral oil filled transformers has also historically occurred at manufacturing plants before 1970 due to cross-contamination during the filling of both PCB and mineral oil transformers in the same plant. Under Environment Canada waste management guidelines, transformer fluids containing greater than 50 ppm PCB are considered to be PCB contaminated and must be handled and disposed of in a prescribed manner. In 1981, a survey of mineral oil transformers in British Columbia was conducted under contract to EPS. Ninety-nine oil samples collected from transformers were analyzed for PCBs and approximately 22% contained concentrations of more than 50 ppm, with the highest concentration being 640 ppm (216).

5.1.2 Hydraulic and Heat Transfer Systems. Under the Environmental Contaminants Act (ECA) regulations, PCBs are no longer permitted for use in heat transfer and hydraulic systems in Canada other than those in use prior to September 1, 1977.

These systems are considered 'semi-closed' and operating losses were, at one time, significant. Wastewater discharges from users of PCB heat transfer fluids in Michigan contained levels of up to 5.2 ppm PCB. Similar concentrations (up to 7.1 ppm) were detected in the effluents of facilities using PCB based hydraulic systems and daily losses from such facilities were as high as 14 kg. One company reported losses of up to 13620 lbs/yr with approximately one third of this amount being released to the atmosphere by vapourization (214). Although all facilities surveyed in Michigan had now switched to phosphate ester hydraulic fluids as a replacement for PCBs, these replacement fluids were found to be contaminated with PCBs at concentrations of up to 100 ppm (214).

Contamination of poultry and eggs has also occurred as a result of a leakage from heat transfer equipment in a North Carolina fish meal plant. The fish meal poultry feed from this plant contained PCB levels of up to 350 ppm (217).

Two British Columbia mining companies reported the limited use of PCB heat exchange fluids in the early 1970's. Further details are described in another EPS report (207). The only use of PCBs as hydraulic fluids was reported by a tugboat company which used a total of 324 litres in Mitsubitshi tugboat couplings. The PCBs have since been replaced with silicone fluid.

A recently completed survey of hydraulic and heat exchange fluids in British Columbia indicated that these fluids are not significantly contaminated with PCBs. None of the heat transfer fluids analyzed contained detectable amounts of PCB (less than 1 ppm), while one sample of hydraulic fluid from a fork lift contained 11 ppm PCB (216).

5.1.3 Investment Casting Wax. In the past, decachlorobiphenyl was incorporated at a concentration of approximately 20-30% into wax (deka wax) molds used for the production of low-tolerance quality metal castings. It is reported that some waxes contained up to 60% PCB. Although much of the wax was recovered and reused, significant losses probably occurred as a result of vapourization and poor housekeeping and the ultimate disposal of used waxes in landfills. Decachlorobiphenyl used by the investment casting wax industry in North America was often imported from other countries (209, 214)

Monsanto also manufactured various Aroclor products for use in precision wax casting of aircraft parts, in dental castings and in the casting of costume jewelry (218, 219).

Sampling of the receiving environment at two investment casting facilities in the United States in 1976 indicated that PCB levels at these sites were elevated. PCB concentrations of up to 5.2 ppm were detected in soils collected near one of the casting facilities (220).

No such uses of PCBs in British Columbia have been reported.

5.1.4 Carbonless Copypaper and Paper Recycling Plants. Prior to 1971, PCB plasticizers had been used in the ink and paper coatings of thermographic, xerographic or pressure sensitive copying processes (214). The major usage of PCB (Aroclor 1242) for this application was in carbonless copypaper (221). Recycling of these products has resulted in the contamination of food packaging materials and other paper products.

In the early 1970's the detection of PCBs in food packaging materials raised concern over possible health effects. A survey of food packaging materials and packaged goods was conducted by the Canadian Health Protection Branch. Approximately 15% of the samples analyzed contained between 1 and 10 ppm PCB and 3.4% contained more than 10 ppm. A limit for PCB content in Canadian food packaging materials has not been specified but the tolerance limit for PCBs in paper food packaging material in the United States is 10 ppm. The survey indicated that, although paperboard contained the highest levels of PCBs, paper also contained significant levels. Clear cellulose and other plastic containers contained much lower levels. Most packaged foods analyzed contained very low PCB concentrations, but concentrations of over 1.0 ppm in food such as rice (2.1 ppm) and dried fruit (4.5 ppm) indicated that PCBs could migrate into food products from the packaging (222).

While there are no regulations governing allowable levels of PCBs in food packaging materials in Canada, Section 5 of the Food and Drug Act prohibits the presence of unsafe compounds. In Canada, monitoring of PCB levels in food, but not food packages, is conducted routinely.

The release of PCBs from paper recycling and de-inking plants has resulted in environmental contamination. According to Kleinert (223) the PCBs detected (> 1 ppb) in discharges from the Portage sewage treatment plant in Wisconsin during a 1972 to 1974 survey were attributed primarily to contributions from a facility using PCBs in the manufacturing of carbonless copypaper prior to 1971. The contamination had been decreased substantially by cleansing the holding tank but residuals still remained in the sewer system.

Kleinert (223) also reported that several Wisconsin paper recycling plants discharged PCBs in the effluents in concentrations ranging from 0.1 to >25 ppb. Aroclor 1242 was most commonly detected but Aroclor 1254 was present in some cases. Wisconsin mills were required to substantially reduce their suspended solids discharge and one mill introduced a treatment system which reduced solids output from 18,160 kg/day to 1,362 kg/day. While wastes containing approximately 39 ppb entered the treatment system, final effluent concentrations were reduced to 1 ppb.

Contaminated fish and sediments have been reported in the Kalamazoo River near the centre of Michigan's paper industry. Concentrations of up to 110 ppm in fish and 380 ppm in sediments have been detected. Although past de-inking practices at certain local mills is thought to be the main source of contamination, the processing of recycled paper contributes lower levels of contamination. At the time of the survey, Michigan paper plant effluents contained from 1 to 10 ppb PCB (214).

In 1976 the effluents and receiving environments of three paper plants on the Fraser River were sampled by the Environmental Protection Service. Only the Belkin Paperboard Ltd. plant was found to be discharging detectable amounts of PCB. Unlike the other two plants, Belkin relies almost totally on recycled material for paper production. Belkin effluents contained 0.45 ppb PCB in 1976 (23), however, a mean concentration of 2.4 ppb was detected in the effluent in 1979. It is unlikely that this variation reflects an increase in effluent levels between 1976 and 1979, but rather the discrepancy is probably due to fluctuations in effluent suspended solids content.

The high levels of PCBs are associated primarily with the suspended paper solids which enter the effluent stream prior to discharge. Concentrations of up to 70 ppm have been detected in the Belkin clarifier underflow solids (sludge). Sludges have been continually recycled as of September 1979, however, until recently the limited capacity of the clarifier resulted in continued entry of PCB-contaminated solids to the receiving environment. Due to the current practice of effluent recycle and partial replacement of plant freshwater intake with recycled clarified process water, effluent discharges to the Fraser River have been reduced from 24,220 m^3/day in the 1st quarter of 1980 to 10,970 m^3/day in the 4th quarter. Solids loadings have also been significantly reduced from 10.86 metric tonnes/day to 1.15 metric tonnes/day. Suspended solids concentrations in the effluents have been reduced from 449 mg/l in the 1st quarter of 1980 to 102 mg/l in the 4th quarter. These reductions in effluent and solids output have significantly decreased PCB loadings to the Fraser River.

The February 1980 amendment to Belkin's pollution control permit specified an interim maximum discharge of 0.11 kg (110 g) PCB/day. Results supplied by the company to date suggest that this objective is being met. PCB loadings for the period May to December, 1980 and for 1981 ranged from < 0.01 to 0.10 kg/day and from 0.003 to 0.004 kg/day, respectively. In comparison, estimates of PCB loadings for 1979 and the month of April 1980 were 1 kg/day and from 0.03 to 0.31 kg/day, respectively, based on EPS data.

5.1.5 Plasticizers. Until the early 1970's PCB's manufactured in North America were used extensively as plasticizers and this was the single largest dissipative use of PCBs (209). The Aroclor plasticizers sold by Monsanto were comprised of various chlorinated biphenyls and chlorinated terphenyls. Like the PCB askarels, these materials are identified by a four digit code with the first two digits indicating the type of material (12 = chlorinated biphenyls; 25 = blend of chlorinated biphenyls and chlorinated terphenyls (75:25); 44 = blend of chlorinated biphenyls and chlorinated terphenyls (60:40); 54 = chlorinated terphenyls). The last two digits indicate the percent chlorine contained by weight. Therefore, Aroclor 5460 is a chlorinated terphenyl product containing 60% chlorine by weight. These materials range from clear fluids to powders depending on the chlorine content. Aroclor plasticizers are among the most versatile due to a variety of characteristics. They are chemically resistant, permanently thermoplastic, compatible with most resins, fire retardant, adhesive and non-oxidative. They could be used to plasticize resins without softening and were useful in many synthetic resins including polyvinyl chloride, polyethylene, polystyrene and polyurethane. Aroclor plasticizers were promoted for use in imparting flexibility and other desirable qualities to sealing compounds, adhesives, lacquers, paints, inks, varnishes, fabric coatings, chlorinated rubbers, pigment dispersions, and also as extenders in elastomers and waxes.

Addition of Aroclor 4456 and 5460 resulted in quick drying paints of great durability. Aroclor plasticizers were excellent dispersion media for pigments used in paints and varnishes and were important additives to heat-resistant aluminum paints and enamels containing silicone resins. Aroclor plasticizers resist salt water and deter algae growth. For this reason chlorinated rubber coatings and marine antifouling paints containing Aroclor plasticizers have been widely used in the marine industry for the protection of wood and metal on marine vessels and other equipment (219). According to Young and Heesen (224) Aroclors 1254 or 1242 were detected in 7 of 28 wet paint samples analyzed in 1973. Median levels of Aroclor 1242 and 1254 were 0.3

mg/l and 0.7 mg/l, respectively, however, total PCB concentrations in two samples exceeded 40 mg/l. In addition, 16 samples of antifouling paints scraped from dry dock facilities usually contained PCBs at levels of less than 20 mg/l but concentrations of up to 150,000 mg/l were detected. Young and Heesen (224) suggest that the elevated PCB levels detected in harbour regions of southern California are related, in part, to inputs from PCB-containing antifouling paints. These paints are designed to release toxicants with time. According to these authors it has been estimated that 5-10% of the paint removed from vessel bottoms returns to harbour waters. Although there is no available information on PCB levels in paints used in British Columbia, very high PCB concentrations have been detected in the sediments off shipyards in the Vancouver area (refer to Section 2.1).

PCBs have also been detected in paints and sealants used on silos in the United States. Paint chips collected from the inside walls of silos contained up to 10,000 ppm. High levels have also been detected in the silage (up to 60 ppm) with the highest contamination occurring in the samples collected near the silo walls. The consumption of contaminated silage by dairy herds has on occasion resulted in milk containing PCB levels above the FDA guideline (225, 226, 227).

Other past uses of Aroclor plasticizers include pigment dispersion in printing inks and the decoration of glass and ceramics (228).

PCBs used in plasticizer applications ultimately find their way to dumps and landfills. Since PCBs are impregnated in the materials being discarded, they are released to the environment very slowly. Release to the atmosphere results through the direct vapourization from paints, coatings and plastics (up to 20%) and from the open burning of refuse at landfills (214).

5.1.6 Electromagnets. PCBs have also been used as dielectric fluids in electromagnets. A survey of such use in Canada revealed the presence of these units over coal, ore, and grain conveyors. Eleven units were found in British Columbia grain elevator facilities. Under normal operating conditions electromagnets are considered to be closed systems. Accidental leakage of PCB from electromagnets over ore or coal conveyors would not pose a serious environmental or health hazard as human contact would be negligible. However, spillage of PCBs onto grain conveyors poses a potentially serious health hazard. Such an incident has already occurred at one British Columbia facility. For this reason the operation of PCB-filled electromagnets in food or feed-handling facilities was banned under the Environmental Contaminants Act as of July 1, 1980. All PCB-filled electromagnets in British Columbia food and feed facilities have now been replaced with non-PCB types. British Columbia mining and coal companies have not reported any use of PCB-filled electromagnets over ore or coal conveyors.

5.1.7 Pigments. The presence of PCBs in diarylide and phthalocyanine pigments used in North America was recently investigated. These pigments have been found to contain PCB concentrations ranging from less than 50 to several thousand parts per million (229). They are present as a result of chemical reactions in the manufacturing process which utilizes trichlorobenzene as the reaction medium (228). In May of 1979 the United States Environmental Protection Agency announced in the Federal Register (229) that within 2 years the industry would have made the necessary changes to the manufacturing process to reduce PCB levels to below 50 ppm. The industry was authorized to continue the use of pigments containing more than 50 ppm until January 1, 1982 and to continue their processing and distribution until July 1, 1979.

5.2 Miscellaneous Uses

5.2.1 Natural Gas Pipelines. In the past PCBs were used in natural gas pipeline compressors. Residual PCB concentrations of up to 44,000 ppm have recently been found in compressors in the United States (229). Under contract to EPS, natural gas pipeline compressor oils in British Columbia were sampled to determine the extent of this problem. None of the samples analyzed contained detectable concentrations of PCBs (216).

5.2.2 Microscopy. PCBs have also been used as microscope immersion oils. In a 1978 study the majority of these oils in use in the United States contained 30-45% PCB's (Aroclor 1254) (230). This use has been eliminated in Canada and EPS undertook a collection program in 1977-78 to dispose of the PCB oils.

5.2.3 Bridge Bearings. A rather unusual use of PCBs has been identified in the Pacific Region. A mixture of extreme pressure oil (60%) and Aroclor 1248 (40%) is being used for rocker and roller bearing lubricants on the Burrard Street and Granville Street bridges in Vancouver. In 1978, PCB fluids were identified in 42 rocker and 10 roller bearings (total of 2,885 litres) on the Burrard Street bridge and in 14 roller bearings (total of 4,300 litres) on the Granville Street bridge. Approximately 150 litres of fluid were in storage.

Although the bearing cases were designed to be leak proof, metal covers on the Burrard Street bridge rocker bearing cases in the concrete section of the bridge had shifted with bridge movement and put sufficient pressure on the sides of the cases to cause cracks. Cracks in bearing cases have caused occasional PCB leaks to the soils and sediments below. These spills have resulted in localized areas of soil contamination (Appendix 7; Figure 4) directly below the Burrard Street bridge. The steel bridge construction and the neoprene covers on the Granville Street bridge bearing cases prevent this problem.

As requested by the Environmental Protection Service, PCB fluids now have been removed from all leaking bearings and replaced with a dry grease lubricant. The City of Vancouver has been investigating the suitability of replacement fluids or alternate methods of bearing lubrication for the remaining bearings. Lighter types of oil are not suitable as the design of the bearing cases allows the entry of water which would wash the oil out (PCB oils are heavier than water). EPS requested that the remaining PCB fluids be replaced and that the contaminated soils be removed and properly disposed of. The contaminated soil has been removed and the area backfilled with gravel and asphaltic concrete. The bearing cases still containing PCBs are being checked on a monthly basis. Although there are no immediate plans for the removal of the remaining PCB fluids, they do not appear to be posing a threat to the environment at the present time. The use of PCBs as bridge bearing lubricants appears to be unique to these bridges and PCB fluids have not been identified in bridge bearings elsewhere in Canada.

5.2.4 Road Oils. The use of waste oils to control dust on roads has also led to the entry of PCBs into the environment. Waste oils are often found to be contaminated with low levels of PCB. Of twenty-two samples of waste oils tested by the Ontario Ministry of the Environment, thirteen contained PCBs, with one sample containing 1135 ppm (231). Similar analysis of 7 waste oil samples from the Vancouver area by EPS did not detect PCBs in most instances. PCBs were detectable in only 2 samples with the highest concentration being 2.9 ppm Aroclor 1254. Most of the oils tested were comprised mainly of used motor oil and the absence of PCBs is not surprising. The sample containing the highest PCB concentration was a composite taken from 6 tanks at one of the waste oil companies. These tanks contained a mixture of oils from various sources and were being used as road oils.

Soil from several oiled roads around Vancouver were collected for analysis and PCBs were detected in almost all samples. Concentrations ranged from 5 to 120,000 ppb (Appendix 7; Figure 4). The highest levels were detected in the Municipality of Surrey. The mean PCB level in soils from five roads in Surrey was 31,600 ppb. The source of the waste oil used on these roads was not determined but it is likely that it contained at least some waste transformer oils.

A study conducted in the United States by the Environmental Protection Agency concluded that only 1% of the oil used as dust supressants on unpaved roads remains on the road surface. Between 70 and 75% is removed with surface runoff and dust and an additional 25-30% is lost through volatilization, adhesion to vehicles and biodegradation (232).

5.2.5 Cutting Oils. Aroclor 1254 has been used as an extreme pressure lubricant in the formulation of some cutting oils. The heat resistance imparted by PCBs is important in cutting oils used for machining high grade steel (218).

No such usage has been identified in British Columbia.

5.2.6 Pesticides. Several Aroclor products have been promoted as suitable for use in non-crop insect formulations containing chlorinated insecticides. They act as a dust suppressant and sticking agent and have been found to significantly extend the kill life (218).

In Baltimore, United States the use of transformer oils as a base for chemical defoliants applied to right-of-ways resulted in the contamination of nearby dairy farm pasture lands. Consequently, elevated levels of PCBs were detected in milk samples (217). Also, high PCB levels detected in feedlot cattle in Kansas (70 to 2200 ppm in fat) were traced to the use of waste transformer oil as an insecticide carrier in cattle backscratchers (233).

There is no evidence of PCB use as pesticide extenders or carriers in British Columbia.

5.3 Municipal Sources

Although the uses of PCBs have been severely restricted since the early 1970's, these compounds still enter the environment in significant amounts. Municipal sewage treatment plants, incinerators and landfills exist as potential sources of PCB release due to the past and present disposal of PCB-containing consumer products, and the past disposal of electrical equipment and industrial wastes.

5.3.1 Sewage Treatment Plants.

PCB levels in sewage treatment plant liquid effluents are usually low, however, the considerable volume of discharge from some of the larger plants can result in substantial loadings to the aquatic environment.

For example, in 1971 it was estimated that over one billion gallons of wastewater per day entered the coastal waters of southern California from sewage systems. This was considered to be the major source of PCB to the California Bight. Elevated PCB levels have been demonstrated in the biota and sediments around the larger wastewater outfalls (234). Inputs of PCB to the South California Bight have decreased significantly since the implementation of use restrictions. Discharges in 1971 were estimated to be 19,000 kg while releases in 1974 and 1975 were approximately 5400 kg and 3080 kg, respectively (224, 235).

Four day composites of influents and effluents from several sewage treatment plants in British Columbia were collected by the Environmental Protection Service (EPS) in 1976 (71, 208) (Appendix 6). Analytical results demonstrated that PCBs were present at all plants in ppt concentrations. The highest concentrations were detected in the influents of plants receiving large amounts of industrial wastes such as the Iona Island (0.143 ± 0.036 ppb) and Prince George plants (0.108 ± 0.047 ppb). Influents at the Annacis Island plant were surprisingly low (0.059 ± 0.023 ppb) considering the large volume of industrial wastes received. Concentrations in the Annacis samples were comparable to those detected in the wastes of smaller towns such as Cache Creek, Mission and Williams Lake. Effluents from the Iona Island plant contained significantly higher concentrations of PCB (0.081 $\pm$ 0.018 ppb) than did effluents from any of the other plants (< 0.005 - 0.048 ppb).

Grab samples of effluent were collected at the Iona Island, Lulu Island and Annacis Island plants by Cain et al (236) in 1978 (Appendix 6). These samples contained much higher levels of PCBs than were detected during the EPS survey; concentrations at the three plants were 0.3, 0.13 and 0.24 ppb, respectively. PCB levels in wastewaters are variable and can be influenced by the time of day at which samples are collected, flow rate, number and type of industries discharging into the system, and suspended solids content. It is also possible that differences in concentrations may occur as a result of variations in efficiency of extraction or other differences in analytical techniques or sampling procedures. Additional sampling with interlaboratory analytical comparisons would be required to more reliably determine PCB releases from these facilities.

In comparison, the sampling of sewage treatment plant effluents in more heavily industrialized areas of North America demonstrated somewhat higher levels of PCBs. Four out of six sewage treatment plants sampled in southern Ontario contained more than 2 ppb PCB in the raw influent. The highest concentration (10.8 ppb) was detected at the Hamilton plant (237). Data presented in the 1976 Task Force Report on PCBs (238) indicates that although most of the 33 Ontario plants monitored discharged less than 1 kg of PCB/year, the most industrialized plants discharged much larger amounts. The Hamilton plant released approximately 26 kg/yr; Toronto (Main), 119 kg/yr; Toronto (Humber), 42 kg/yr; and Windsor West, 36 kg/yr.

The efficiency of PCB removal from municipal wastewaters depends upon the level and type of treatment employed by the treatment plant. Secondary treatment systems are normally more effective at removing contaminants than are primary systems.

In a study conducted under the Canada-Ontario Great Lakes Water Quality Agreement 33 sewage treatment plants were sampled for PCBs. The average efficiencies of PCB removal from primary and secondary systems were approximately 50% and 66%, respectively (239).

Of the sewage treatment plants sampled in British Columbia, PCB removal efficiencies for the two primary plants, Annacis Island and Iona Island, were 42% and 43%, respectively. The percent removals of secondary treatment plants varied from plant to plant but in most cases were substantially higher than those of primary plants.

Clinton and Williams Lake are secondary systems employing biological lagoons. The reason for the higher PCB removal from the Williams Lake plant (89% as compared to 53% at Clinton) is not known. The Williams Lake plant utilized mechanical aeration while Clinton relies on natural aeration. A comparison of NH_3 and COD reduction at both plants do not indicate a lower level of treatment at Clinton.

Of the activated sludge plants, Prince George had the highest removal (75%) followed closely by Penticton (69%). Both plants were operating well at the time of sampling as demonstrated by the good COD removal and nitrification. Mission and Cache Creek plants were operating less effectively as reflected by lower PCB removals and also by the fact that there was little or no nitrification. In both cases, poor efficiency may be attributed to high sludge age and consequent poor secondary clarification (240).

Tucker _et al_ (241) showed that under experimental conditions, the mono- and dichlorobiphenyl isomers undergo primary degradation by cultures of activated sludge microorganisms. However, several researchers (239, 241, 242) have concluded that there is no indication of significant biodegradation of highly chlorinated Aroclors 1254 and 1260 in conventional secondary treatment systems. The resistance of PCBs to biological degradation increases with increasing chlorination of isomers. For this reason, Aroclors 1254 and 1260 are found most commonly in wastewater systems. Due to their extreme persistence it is also these highly chlorinated compounds which are detected most frequently in environmental samples.

PCB removal during primary and secondary treatment is mainly associated with the removal of suspended solids by settling. For this reason PCB concentrations of sewage sludges are very high. PCBs adsorb to suspended matter in sludges, are dissolved in fats and ingested by microorganisms (237, 243).

Undigested sludges from 4 sewage treatment facilities in Ontario contained PCBs ranging from 0.6-76.6 ppm (dry weight), with the highest levels being detected in sludges from the Hamilton plant. Sludges from all other plants were less than 3.2 ppm (239). PCB concentrations in sludges from Michigan sewage treatment facilities were much higher, averaging 15.6 ppm with a maximum of 350 ppm (214).

Very few samples of sewage sludges from British Columbia plants have been analyzed. However, in 1976 significant levels of PCBs were found in digester sludges from Penticton (840 ppb) and Prince George (2900 ppb) and in raw and digester sludges from Iona Island (1900 and 1100 ppb, respectively) (208). Surprisingly only trace concentrations of PCBs were detected in Annacis Island sludges in 1979 (71).

Due to the potentially high concentrations of PCBs and other toxic chemicals, the disposal of sewage sludges is of concern. Sludges are normally disposed of by incineration, deposition on agricultural land, or landfilling. High temperature incineration (815 to 925 degrees centigrade (C) with an exhaust temperature of 590 degrees C) in a multiple hearth furnace has been found to be an effective disposal method for contaminated sludges. According to Shannon et al (239), at this temperature, over ninety-nine percent of the PCB in sludge is destroyed during incineration. At somewhat lower exhaust temperatures of 370 to 425 degrees C there may be losses due to volatilization. This method of sludge disposal is not widely practiced.

Deposition of sludges on agricultural land is a more common method of disposal. Due to increasing evidence of PCB uptake into crops, some researchers recommend that such application be discontinued. Lawrence and Tosine (237) report significant uptake of PCBs into the leaf portion of grass and corn grown on sludge treated land. Grass samples contained 71-128 ppb and corn contained 45-81 ppb and it appeared that crops were preferentially accumulating Aroclor 1260. Landfilling of sludges is also widely practiced and may result in releases to receiving waters through surface runoff and leaching into groundwater systems and releases to the atmosphere by volatilization.

Sludge disposal practices vary throughout the province. According to a 1979 Waste Management Branch survey, 40% of the communities contacted use sludge for agricultural purposes, 35% landfill, 5% incinerate, 8% store in sludge lagoons and 12% discharge to outfalls (244).

The City of Kelowna is combining raw sludge with hog-fuel to form compost (244). Similarly, aerobically digested sludge at Iona Island is removed from the lagoon and stockpiled. The stockpiled sludge is available to the public at the plant but the majority is picked up by a contractor who screens, shreds and dries it in a rotary kiln and then sells it for soil amendment purposes.

Lulu Island incinerates sludge on site but no information on the effectiveness of the system for PCB destruction or on atmospheric releases of PCBs was available (244).

Concern has been raised over the possible formation of chlorinated hydrocarbons during the super-chlorination of sewage effluents (245, 246, 247, 248, 249). Some authors, including Mori et al (245) who conducted tests with super-chlorinated effluents from a Vancouver area plant, have reported the formation of new chlorinated compounds following super-chlorination. However, there was no evidence that PCB concentrations were increased during this process. It is likely that, if PCBs were formed during super-chlorination, they would be the lower chlorinated isomers.

5.3.2 Landfills. In the early 1970's it was estimated that more than 50% of the PCBs manufactured were ultimately deposited in landfills and releases from landfills were thought to constitute a major portion of total input to the environment (238, 250). Due to increasing awareness regarding the environmental hazards of PCBs and to the implementation of regulations governing the disposal of highly contaminated wastes, the current PCB inputs to landfills are much lower. However, in a 1976 report prepared by Versar Inc. for the United States Environmental Protection Agency (251) it was estimated that there is twice the amount of PCB in landfills and dumps as in the receiving environment. The largest source of PCB to landfills was thought to be failed capacitors or capacitors contained in redundant equipment.

Losses of PCB from landfills occur through vapourization from paints, coatings, plastics and other PCB-containing wastes especially during burning. Other sources include leachate and surface runoff.

PCBs are highly insoluble in water and adhere tightly to soil. Studies conducted by the University of Waterloo Research Institute in 1978 and 1979 (252, 253) indicated that water passing through contaminated soils contained measureable levels of PCBs (in the order of 40 ppb). However, as the affinity for soils is high, the amount of PCBs released is just a fraction (generally < 1%) of that present in the soil. The depth of groundwater from contaminated surface material also affects the contamination of leachates.

The co-discharge of PCBs with solvents may increase the solubility of PCB and increase the possibility of their release from landfills. A study done by the Illinois State Geological Survey (254) has shown that carbon tetrachloride increases the mobility of PCBs in soils. A mixture of the solvent with water, however, as would occur under normal landfill leaching conditions, decreases the mobility to some extent. Soil micro-organism cultures were capable of degrading water soluble Aroclor 1242 with the lower chlorinated isomers being degraded more rapidly than the higher chlorinated forms. The higher chlorinated isomers were also found to be less soluble in water, less mobile in soil and less volatile in water.

As a result of the Environmental Protection Service (EPS) sampling in 1976, PCBs were detected in the sediments and leachates of Richmond Landfill. Concentrations of 20-30 ppb were detected in sediments and 20 ppb in leachates (71). Additional sampling conducted in 1977 confirmed the presence of PCBs in soils (Appendix 7) and sediments (Appendix 2) but levels in the leachate were much lower (ND-1.4 ppb) (Appendix 6). These lower concentrations correspond well to PCB levels in leachates from Ontario landfills (ND-1.2 ppb) in 1975 (238). Similarly, five out of nine surface runoff samples collected from landfills in Michigan contained detectable PCB levels ranging from 0.04 to 0.03 ppb (214). The comparatively high levels detected in the 1976 leachate samples collected from Richmond landfill have not been explained.

5.3.3 Storm Sewers and Urban Runoff. In 1974, Westwater Research Centre collected street surface sediments from various land use areas in the Greater Vancouver area. These samples were analyzed for PCBs and other organic contaminants and the results indicated that street surface runoff could be a significant source of PCB to storm sewers (255).

For this reason, in 1976, EPS sampled sanitary sewers and storm water collection systems in the Greater Vancouver area. Several of these sewers discharge directly into local receiving waters, while others are routed to municipal treatment systems. Concentrations of PCBs in the samples ranged from 0.005 to 1.170 ppb, indicating that sewer systems do contribute measurable amounts of PCB to the aquatic environment (Appendix 6). Unfortunately, no information on flow rates of the sewer systems was available and, therefore, it was not possible to calculate total loadings.

Young and Heesen (224) report that surface runoff contributed 250-830 kg PCB/year to the South California Bight in the 1972 to 1973 sampling period. Storm runoff made the greatest contributions to this release.

6 SPILLS

The Environmental Protection Service (EPS) has been investigating and recording all reported PCB spills in British Columbia since 1976. Unfortunately there is no record of spills prior to 1976 and it is unlikely that many of these spills would have been reported to federal or provincial pollution control agencies. Due to the past lack of knowledge regarding the possible human health and environmental hazards associated with the release of PCBs, it is likely that spills prior to 1976 occurred with greater frequency and that fewer precautions were employed during cleanup. PCBs were identified as a priority pollutant under the Environmental Contaminants Act in 1976 and since this time industrial and public concern over PCBs has increased. It is imperative that the industrial sector be aware of the dangers associated with the use of chemicals such as PCBs so that suitable spill prevention and corrective measures can be implemented.

Many of the past uses of PCBs are now banned and the current major use of PCBs in British Columbia is in dielectric fluids in electrical equipment. All industries currently using PCBs in such equipment are required to take precautions to prevent the release of PCBs to the environment in the event of a spill. Federal and provincial government agencies conduct on-site inspections of PCB-containing electrical equipment in the province to ensure the adequacy of spill prevention measures. The banning of many uses of PCBs and the implementation of guidelines for the handling, storage, transport and disposal of PCBs and PCB-containing equipment have done much to lessen the threat posed by these chemicals. This section summarizes, in chronological order, the most significant PCB spills (releases of over 5 litres) which have occurred in British Columbia from 1976 to June, 1982. Other less significant, or less well documented spills, occurring between 1979 and 1982 are summarized in Table 6 at the end of this section.

6.1 Cominco Pb/Zn Smelter, Trail

In April, 1976 a transformer in storage at the Cominco salvage yard at Trail was damaged (drain valve broken off) and between 75 and 80% of the transformer content of 820 litres PCB was spilled into the soil below. Due to the extreme soil contamination (up to 42,000 ppm) in the spill area, it was necessary to remove several truckloads of soil (refer to Figures 4 and 5; Appendix 7). The contaminated material was placed in an old house foundation in the Warfield municipal dump and encapsulated in cement. Although PCB levels in the spill area were still high following removal, no additional soil was removed due to the problems associated with disposal. There is little rainfall in this area and the potential for leaching from soils was not considered to be of great concern. As drainage from the salvage yard enters the Columbia River (670 metres) a sample of Columbia River sediments was analyzed. The PCB level was not unusually elevated (85 ppb).

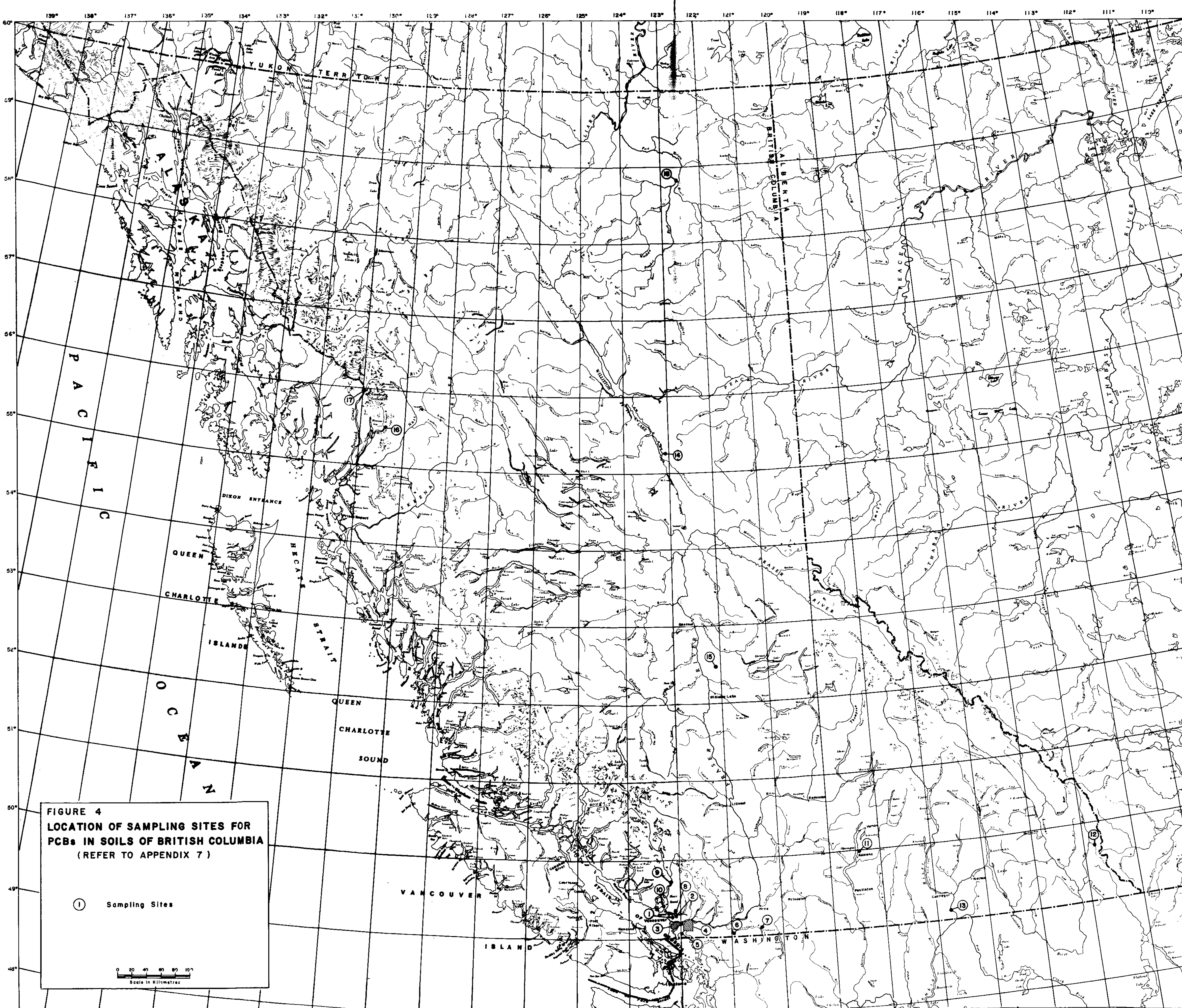


FIGURE 4
LOCATION OF SAMPLING SITES FOR PCBs IN SOILS OF BRITISH COLUMBIA
(REFER TO APPENDIX 7)

6.2 B.C. Hydro Capacitor Substation, McLeese Lake

In June, 1976 the past handling and disposal of damaged capacitors at the B.C. Hydro capacitor station near McLeese Lake was investigated by the Environmental Protection Service (EPS), after B.C. Hydro expressed concern that capacitors buried along the right-of-way may be a source of PCB contamination to groundwater.

In 1972, B.C. Hydro had buried numerous damaged or redundant capacitors containing Aroclor 1242 with the approval of a provincial pollution control agency. However, in 1976, with increasing industry and government awareness as to the toxicity and persistence of PCBs, and the importance of proper disposal methods, B.C. Hydro decided to remove the buried capacitors and find an alternate method of disposal. The involvement of the Environmental Protection Service was requested to assess the possible contamination of local groundwater and surface water systems. Approximately 69 capacitors were located and removed from the disposal site. The capacitors and 60 cubic yards of contaminated soil were shipped to Oregon for disposal.

Preliminary EPS sampling, conducted in June 1976, indicated that PCBs were present at trace levels in local surface waters and residential wellwater and, as a result, health officials were notified. Local residents were informed of potential drinking water contamination and B.C. Hydro supplied drinking water to residents while EPS, the provincial Waste Management Branch, and B.C. Hydro conducted additional monitoring. Soils, sediments, biota, and ground, surface and runoff water were collected in December at varying distances from the substation. Due to the potential human health concern, residential wells and home grown food products such as beef, vegetables, poultry and eggs were also analyzed (Appendix 11).

High concentrations of PCB (predominantly Aroclor 1242 with small amounts of Aroclor 1260) were detected in the sediments (620 ppm) (Appendix 2), soil (92,000 ppm) (Appendix 7; Figures 4 and 6) and groundwater (90.8 ppm) (Appendix 8; Figure 7) in the capacitor disposal pit area and the capacitor storage area.

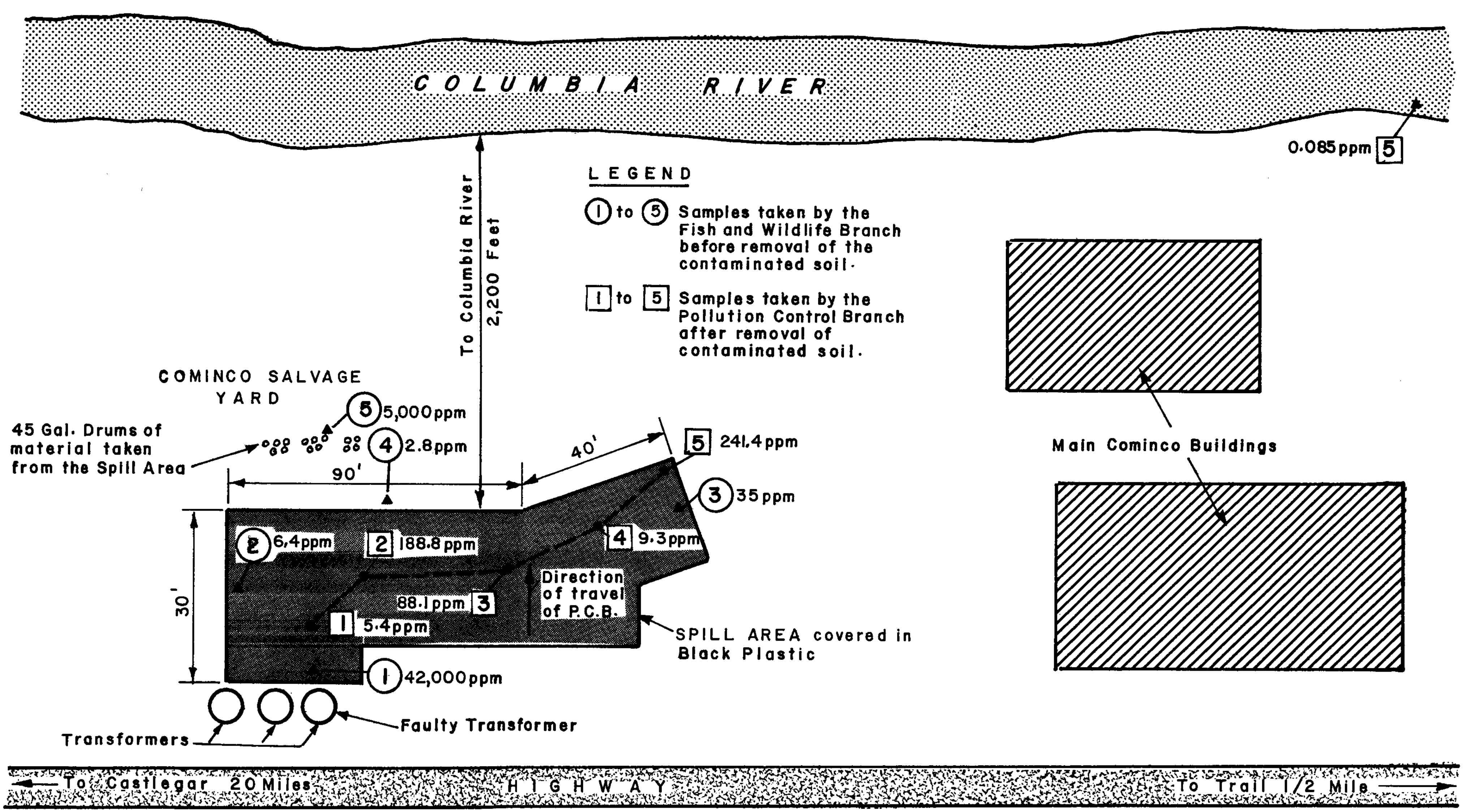


FIGURE 5 PCB LEVELS IN SOIL AND RIVER SEDIMENT FOLLOWING A SPILL AT THE COMINCO TRAIL SALVAGE YARD

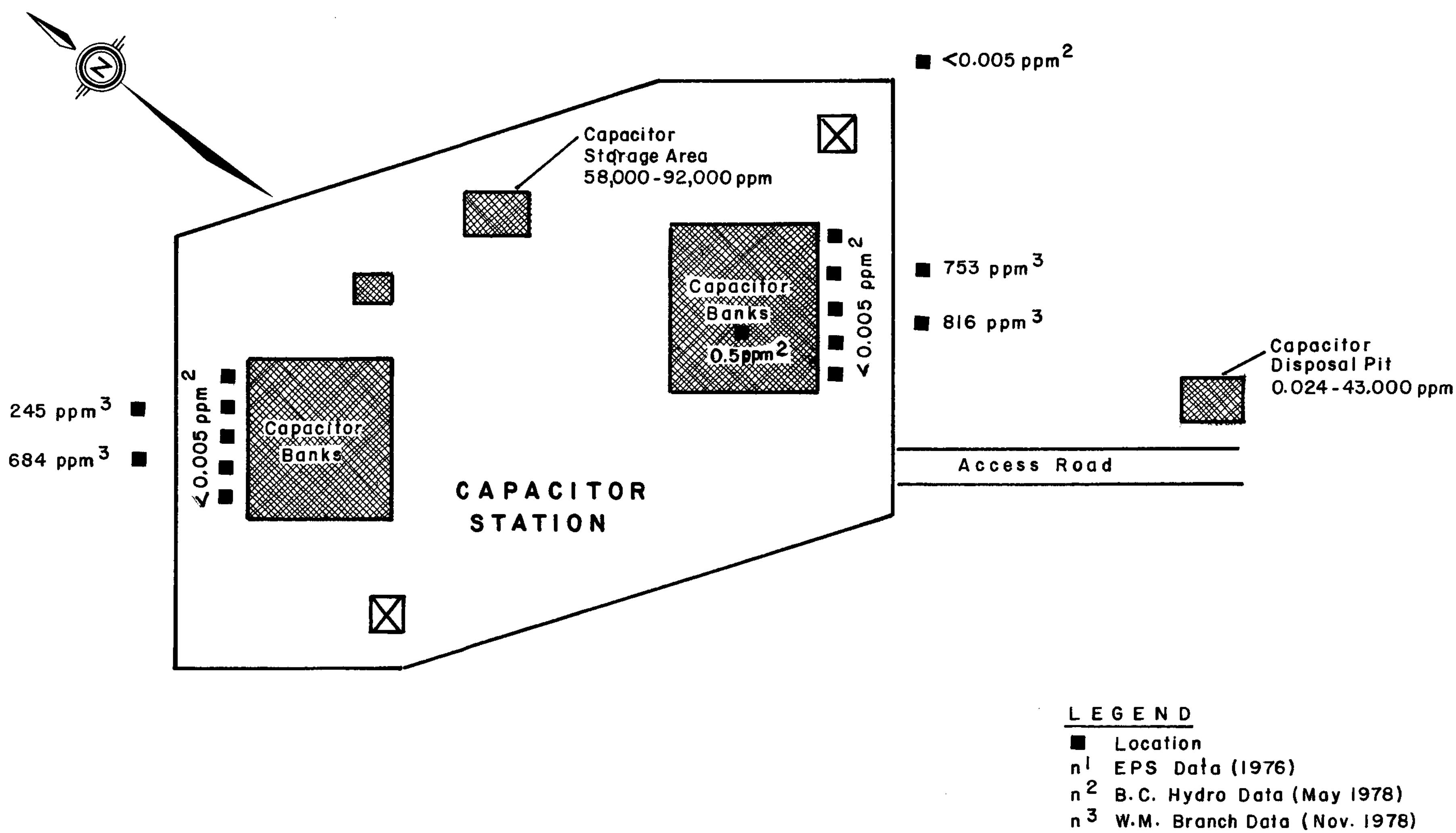


FIGURE 6 SOIL CONTAMINATION AT THE B.C. HYDRO CAPACITOR STATION AT McLEESE LAKE

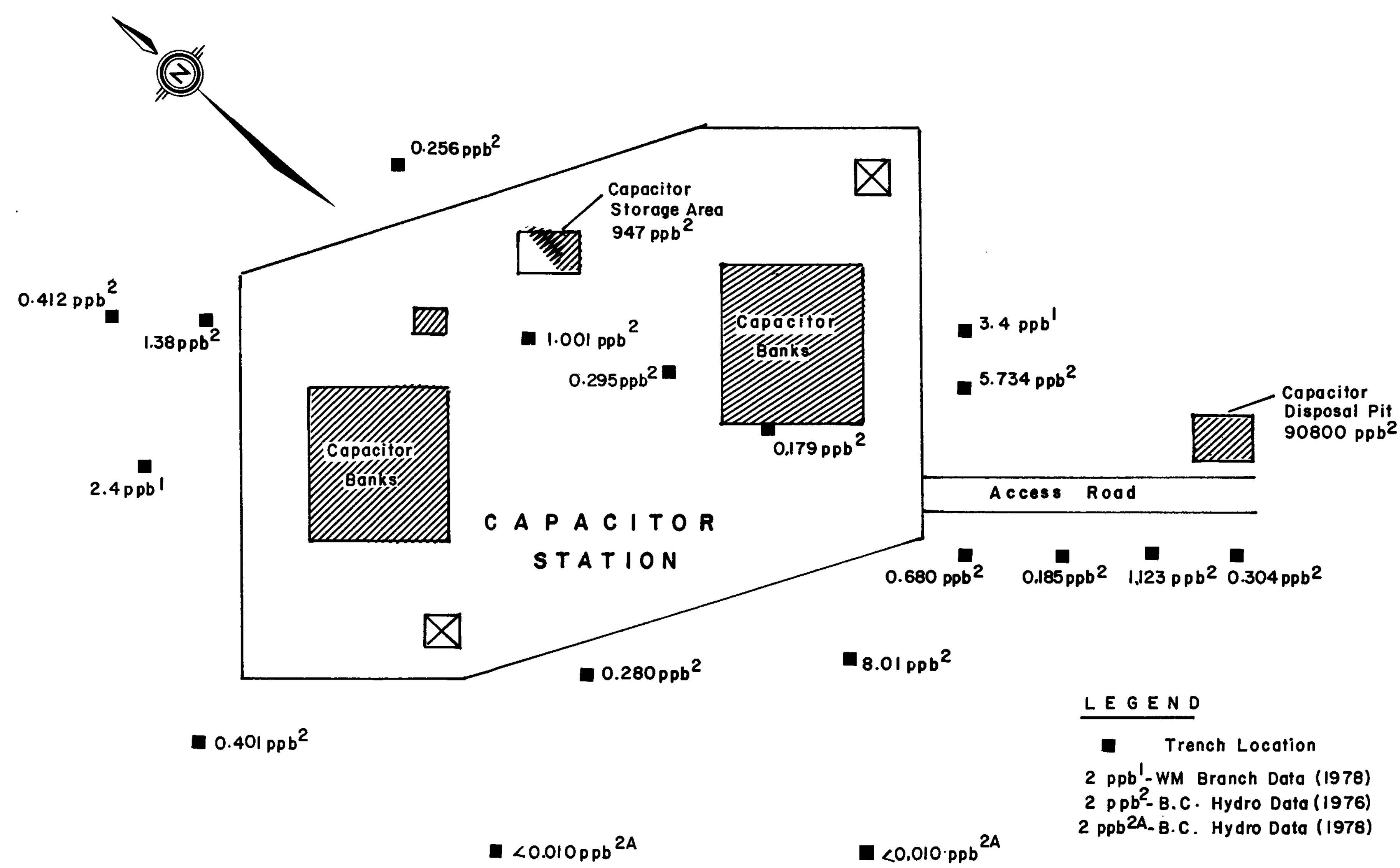


FIGURE 7 GROUNDWATER CONTAMINATION AT THE B.C. HYDRO CAPACITOR STATION AT McLEESE LAKE

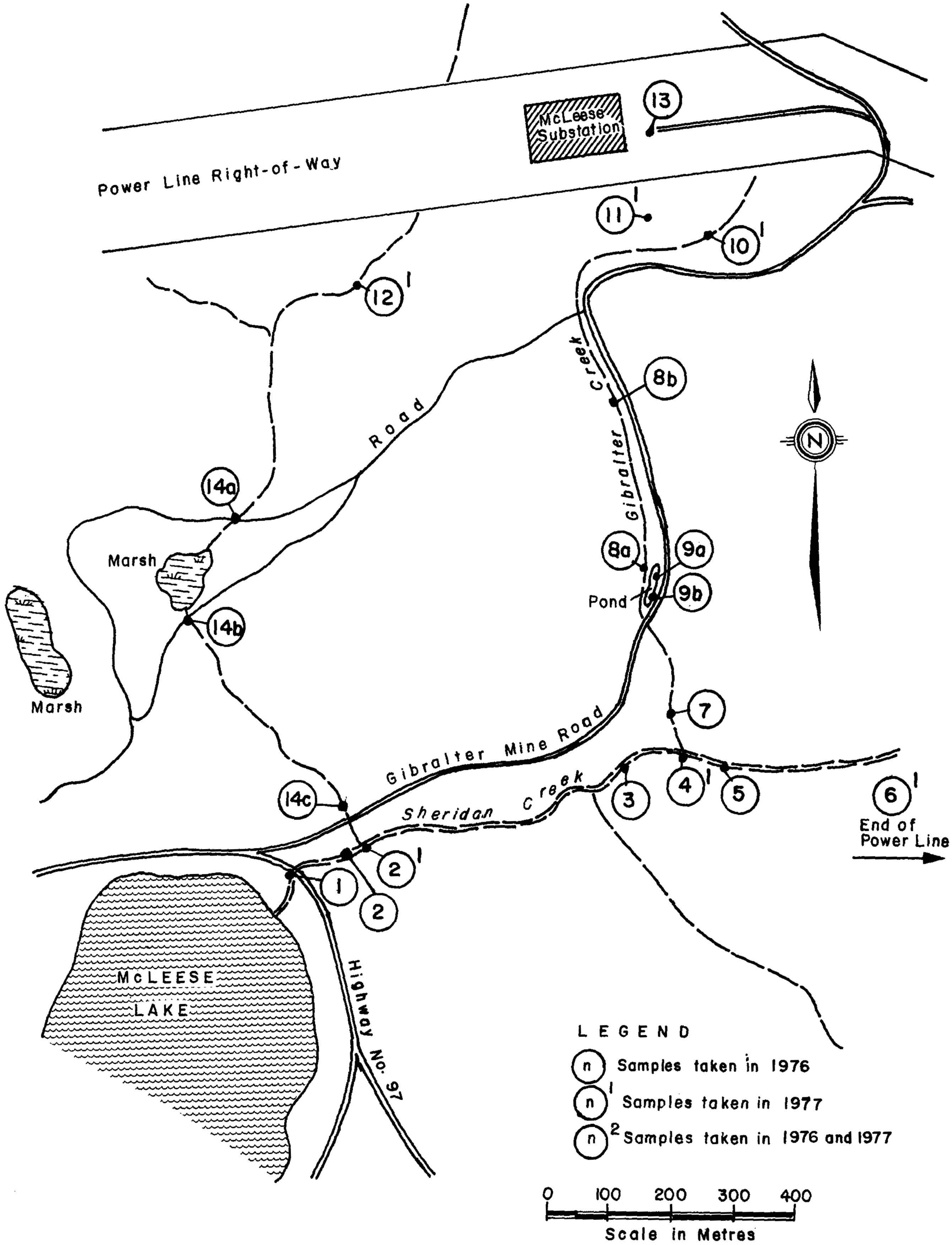


FIGURE 8 PCB SEDIMENT SAMPLING STATIONS IN THE McLEESE LAKE AREA

Sediment concentrations of PCBs ranged from 4 to 610 ppb in the Sheridan-Gibralter Creek watershed (refer to Appendix 2; Figure 8). Two PCB residue sinks were evident in quiescent areas at the mouth of Sheridan Creek (610 ppb in June, 1977 and 350 ppb in December, 1977) and in a small pond fed by Gibralter Creek (75 ppb in June and 120 ppb in December). These concentrations are moderately elevated and are similar to those detected in receiving waters in the vicinity of many industrial facilities in British Columbia. However, as most sediment samples collected contained non-detectable or very low levels of PCB, it is apparent that the contamination was not widespread. Stream sediments contained almost exclusively Aroclor 1242 while the pond sediments contained predominantly Aroclor 1260 when sampled in June but mainly Aroclor 1242 in December. The buried capacitors contained Aroclor 1242. Some Aroclor 1260 was also detected in samples from the capacitor disposal pit but the source of the Aroclor 1260 was not identified.

In 1976 PCB concentrations in muscle tissue of sucker and rainbow trout ranged from 300 to 890 ppb and from 130 to 310 ppb, respectively. Liver tissues from these species contained 160 to 400 ppb and 250 to 470 ppb, respectively. The PCB levels in these species are similar to concentrations detected in Fraser River fish. However, all residue levels were well below the Canadian guideline of 2 ppm in the edible tissue.

Subsequent monitoring of sucker, trout and squawfish from local water systems in 1977 and 1978 demonstrated very low PCB levels (ND-80 ppb) (Appendix 3). Aroclor 1242 was the major PCB component in fish tissues although 1260 was present at lower concentrations. Benthic macro-invertebrates (mayflies, stoneflies, damselflies, etc.) from Sheridan Creek contained a total of 380 ppb in 1976 (Appendix 4). PCBs were not detectable in aquatic invertebrates collected from Sheridan Creek, McLeese Lake and Cuisson Lake in 1977 and 1978.

Samples of aquatic vegetation collected from water systems in the area contained < 5 to 72 ppb PCB in 1977 but in 1978 samples PCBs were not detected.

Surface water samples from water systems in the area contained low levels of PCBs in most cases (Appendix 10; Figures 9a and b). Higher levels were detected in samples collected by the Waste Management Branch. These higher levels were thought to be due to sample contamination caused by inadequate cleaning of the sample containers and consequently were not included in Appendix 10. The highest reliable surface water concentrations were detected in Sheridan Creek near the mouth (0.387 ppb); in the pond fed by Gibralter Creek (0.236 ppb); and in Gibralter Creek above the pond (0.395 ppb). These findings are consistent with the fact that the highest PCB levels in sediments were detected at the mouth of Sheridan Creek and in the pond.

Low concentrations were generally detected in the water (0.015 and 0.046 ppb) and sediments (< 4 and 7 ppb) in the second drainage of the right-of-way area. The exception to this is a water sample collected in a pond just west of the substation. This sample was collected by B.C. Hydro in 1976 and contained 0.422 ppb PCB. Relatively high levels of PCB were also found in Cuisson Lake (up to 0.202 ppb by EPS and 0.78 by B.C. Hydro) considering that its distance from the capacitor station is approximately 4 km. It is unlikely that the substation was a source of contamination to this lake. Samples collected in Cuisson Lake in 1977 and 1978 contained very low levels of PCB.

Original sampling of two residential wells by EPS in June and December, 1976 showed concentrations of 0.008 ppb to 0.201 ppb. Resampling of these wells and 12 others by B.C. Hydro in December showed concentrations ranging from < 0.005 to 0.103 ppb Aroclor 1242 and 1260 (Appendix 9; Figure 10).

It was apparent that the improper handling and disposal of PCBs at the McLeese Lake substation during construction and operation resulted in the introduction of PCBs to the Sheridan Creek watershed.

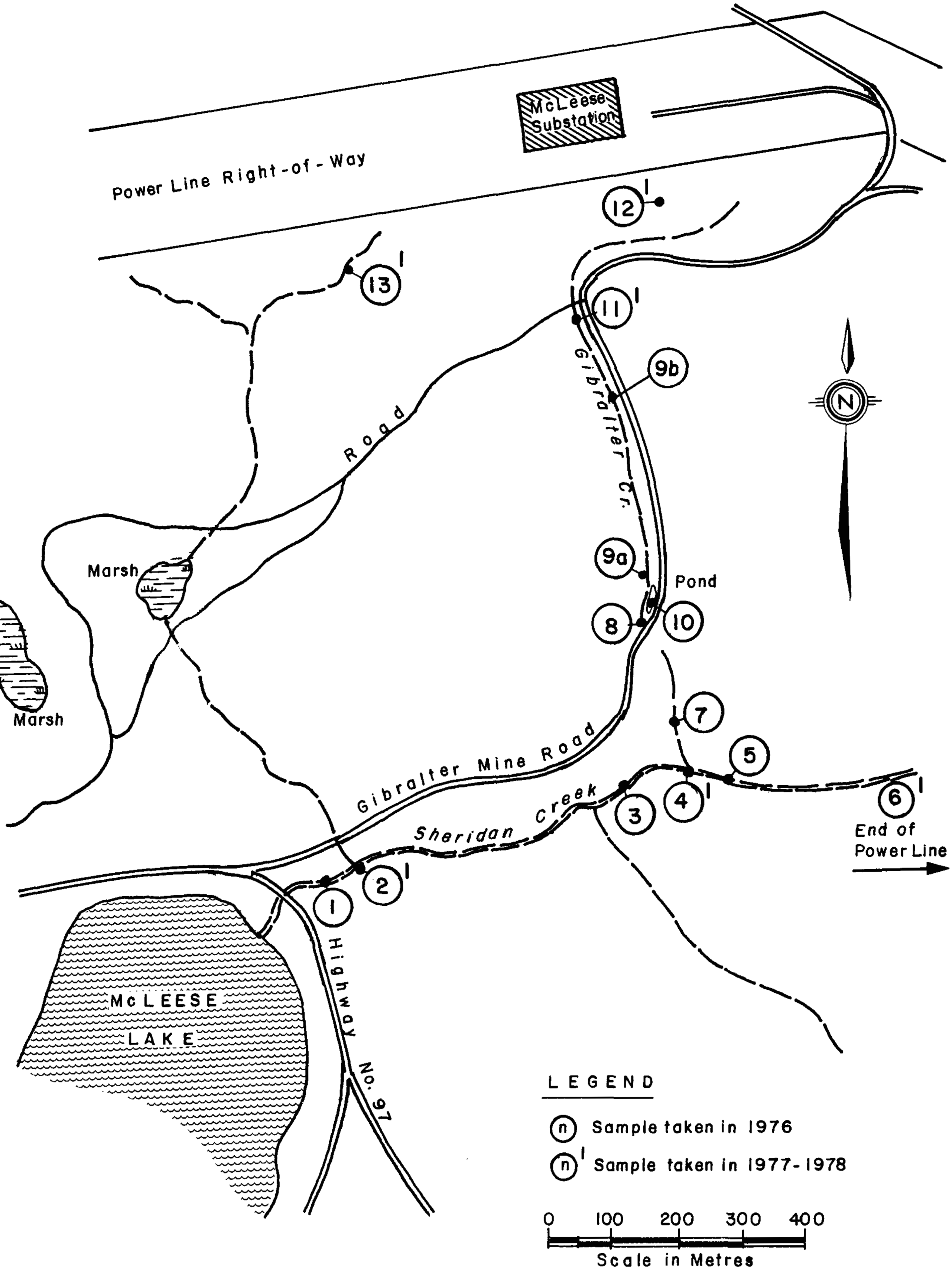


FIGURE 9a SURFACE WATER SAMPLING STATIONS IN THE McLEESE LAKE AREA

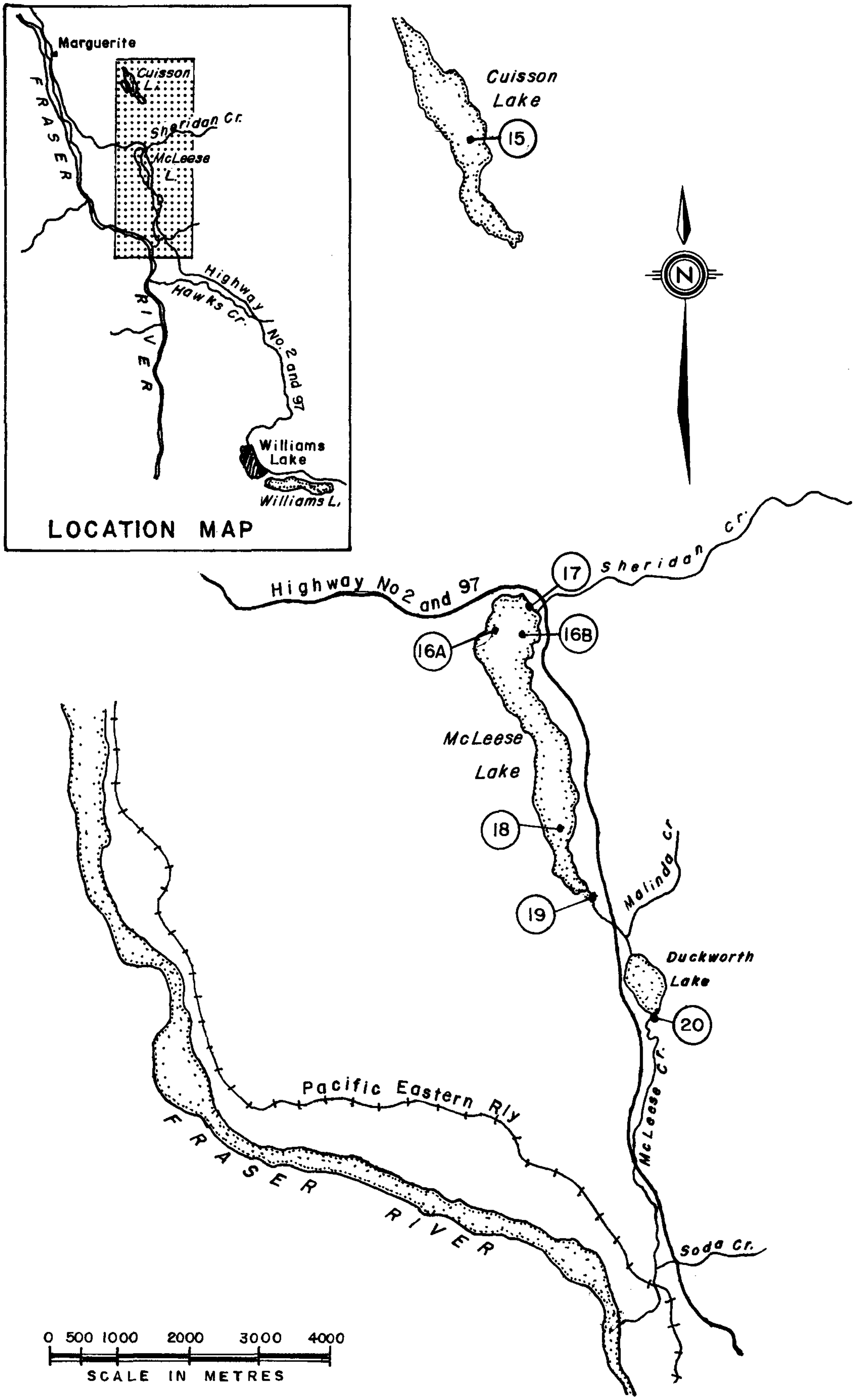


FIGURE 9b SURFACE WATER SAMPLING STATIONS IN THE McLEESE LAKE AREA

Groundwater and surface water flow are the likely mechanisms of PCB movement from the highly contaminated areas on the powerline right-of-way. Although PCBs generally do not move readily through the groundwater, substantial amounts may be leached from mineral or sandy soils. Groundwater transport was probably of less importance than surface lateral transport, but the contamination of groundwater near the substation and in residential wells indicates that groundwater transport did occur.

A hydrology study conducted by B.C. Hydro demonstrated that surface runoff from the substation enters a swampy area and then Gibralter Creek which ultimately discharges into Sheridan Creek. There was no evidence of runoff flowing north to the Cuisson Lake drainage system or west into the Sheridan Creek secondary drainage system. However, the study acknowledged that groundwater transport from the substation to the Sheridan Creek secondary system was possible.

The report concluded that, although other potential PCB users were present in the general vicinity (a mine site and a sawmill) , it was unlikely that the PCB contamination of Gibralter Creek and the lower Sheridan Creek originated from sources other than the McLeese Lake capacitor station.

Federal and provincial pollution control agencies agreed that although it was apparent that PCB release from the capacitor burial area had resulted in the transport of PCBs into local water systems, the level of contamination was not high enough to pose a threat to the environment or human health, or to warrant additional remedial action.

Low PCB levels were detected in wellwater (Appendix 9; Figure 10), eggs, milk, beef, quail, and chicken tissue (Appendix 11). All the data on PCB levels in wellwater and food products were reviewed by an interagency committee and it was concluded that no health hazard existed from the consumption of these products.

In order to prevent environmental contamination in the event of future spills, B.C. Hydro has made several improvements within the substation. An absorbant material was placed under both capacitor banks to prevent any PCB leaks or spills from penetrating the ground. Routine

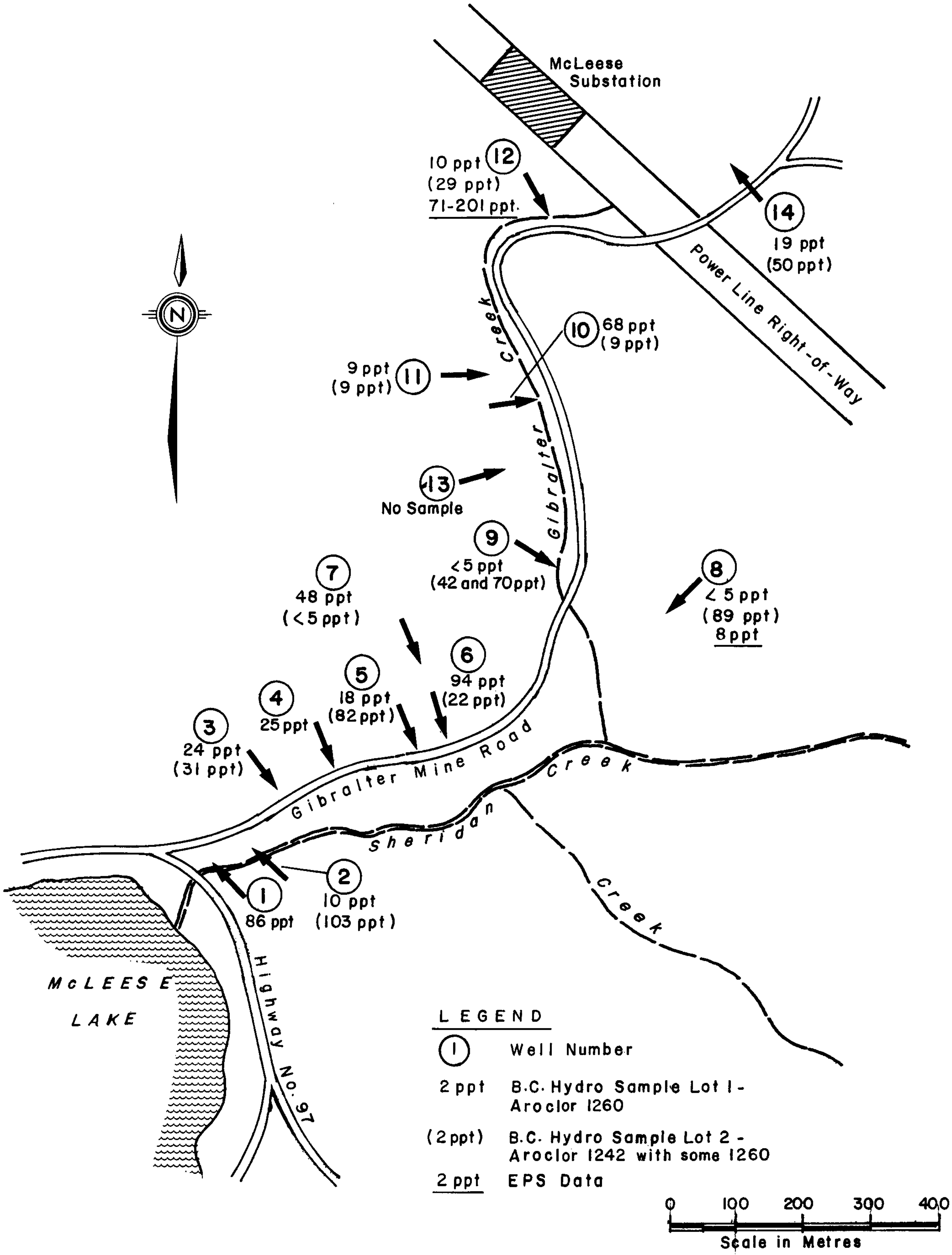


FIGURE 10 1976 PCB LEVELS IN RESIDENTIAL WELL WATER FROM THE McLEESE LAKE AREA inspections for spills or leaks are conducted and spill areas are cleaned regularly. In addition, improvements have been made to the drainage system in the substation area.

6.3 Canadian Cellulose Pulp Mill, Port Edward

a. Background

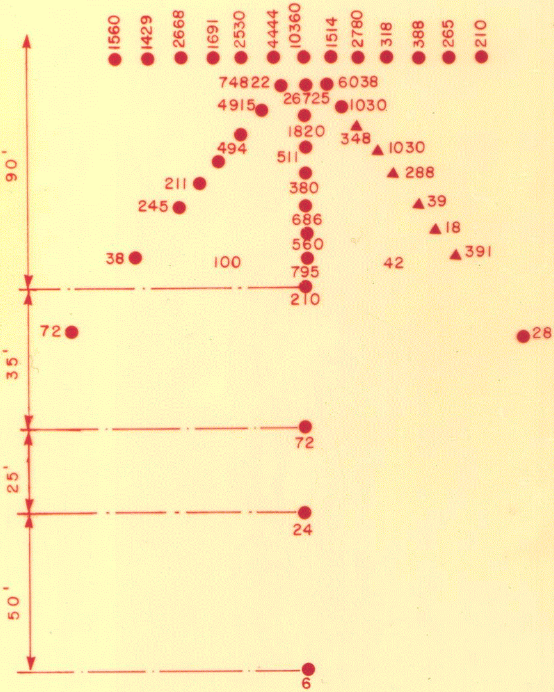
In January, 1977, a transformer at the Canadian Cellulose pulp mill near Prince Rupert malfunctioned and spilled approximately 800 litres of PCB fluid into the storm sewer system which drains into the marine waters of Porpoise Harbour. It was the largest known spill of PCBs in British Columbia to date.

The transformer was located on the roof of Woodroom #3 and PCBs leaked onto the roof, down the side of the building and onto the pavement below. Initial cleanup measures included the removal and replacement of a contaminated portion of the woodroom roof and outside wall. The liquid PCB on the ground was absorbed with sawdust and the underground sewer systems were cleaned. All contaminated material was placed in plastic lined 45 gallon steel drums and shipped to the United States for disposal. Investigation showed that the transformer was extensively corroded and that the cause of malfunction was due to poor maintenance.

b. Environmental Contamination

Preliminary monitoring indicated that the sediments and biota in the immediate vicinity of the spill contained excessively high levels of contamination (Appendices 2 and 4; Figures 11 and 14). Concentrations of up to 75,000 ppm were detected in the sediments immediately off the storm sewer outfall in the mill booming grounds.

PCB concentrations in the sediments of Prince Rupert Harbour, Tuck Inlet and Porpoise Harbour away from the spill area were much lower (<0.005-0.275 ppm) and levels appear to decrease with increasing distance


1560
1429
2668
1691
2530
4444
10360
1514
2780
318
388
265
210
74822
6038
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1030
1820
348
494
1030
511
211
288
380
245
39
686
18
560
38
100
42
391
795
210
90'
72
28
35'
72
25'
24
50'
6

June 1977

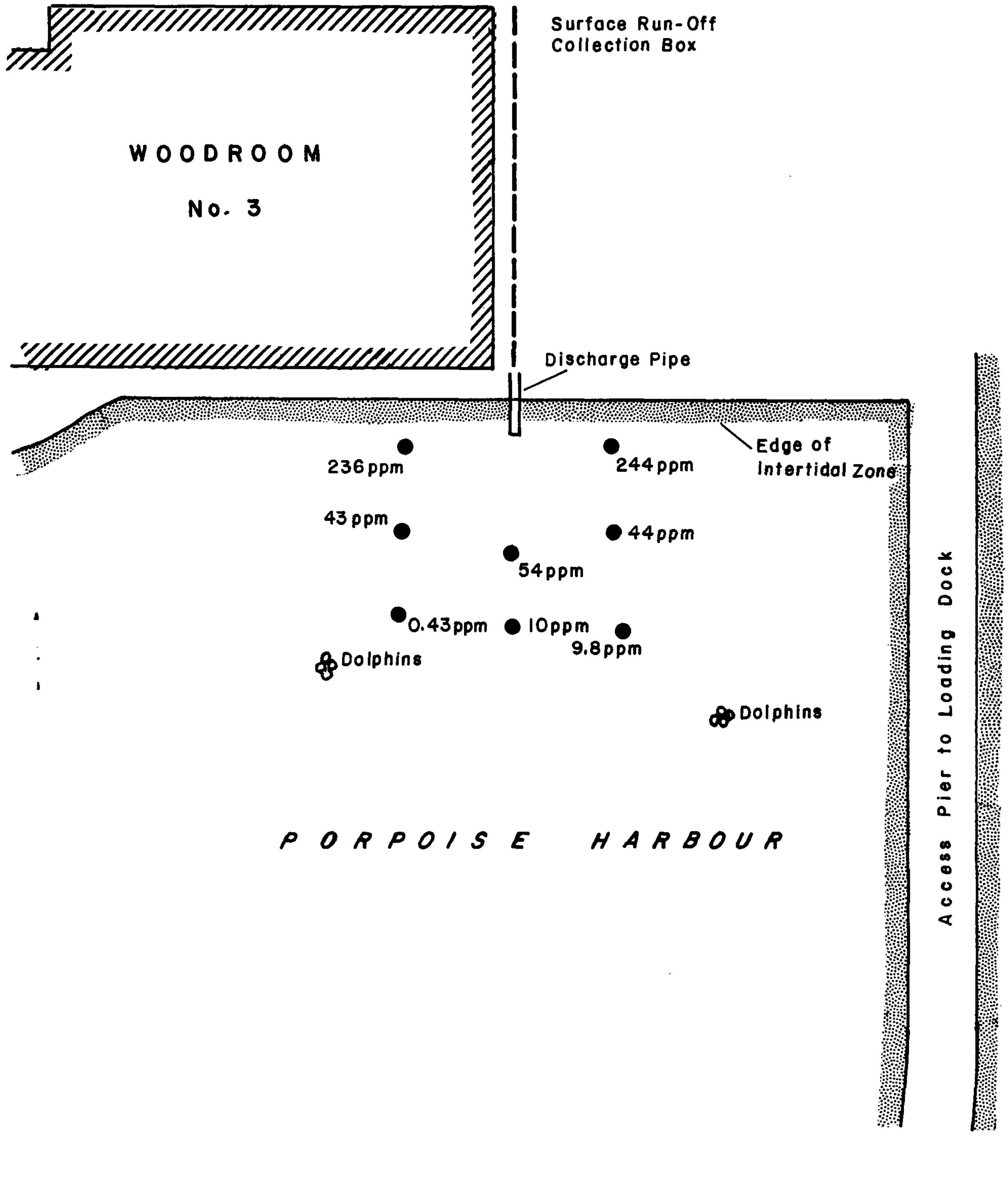
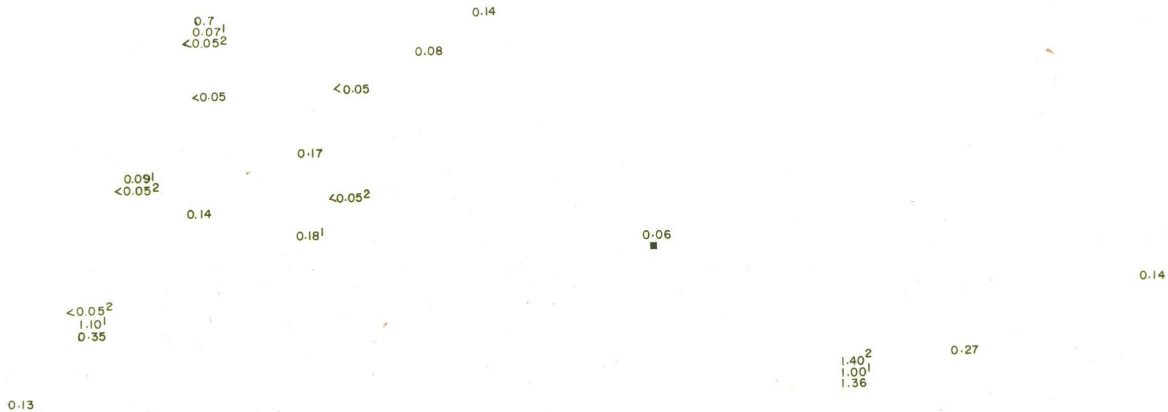
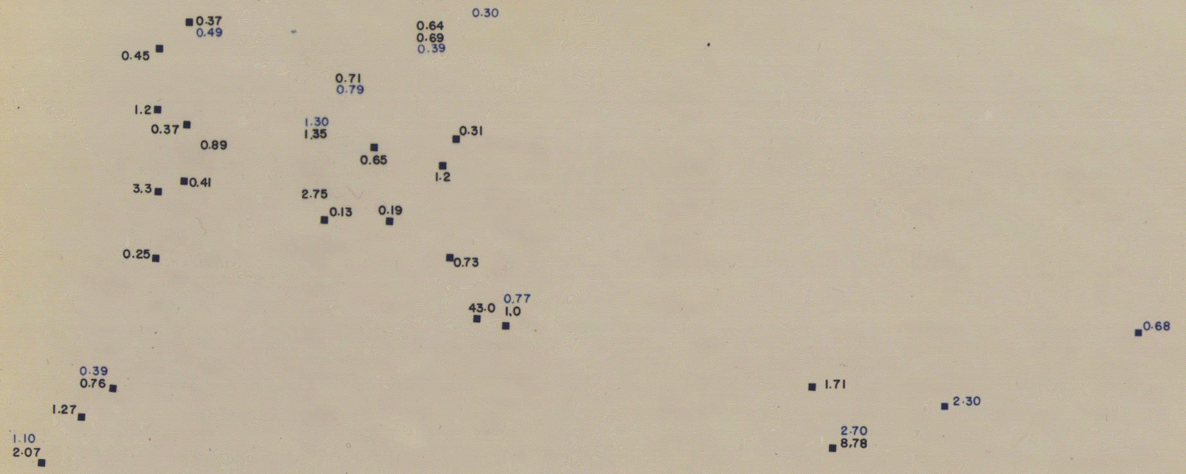


FIGURE 11a CONCENTRATIONS (ppm/Dry Weight) IN SEDIMENTS FROM THE PCB SPILL AREA OFF CANCEL January 1977



, August, 1981[n1], May, 1982[n2]

June, 1979



January, 1978 July, 1978

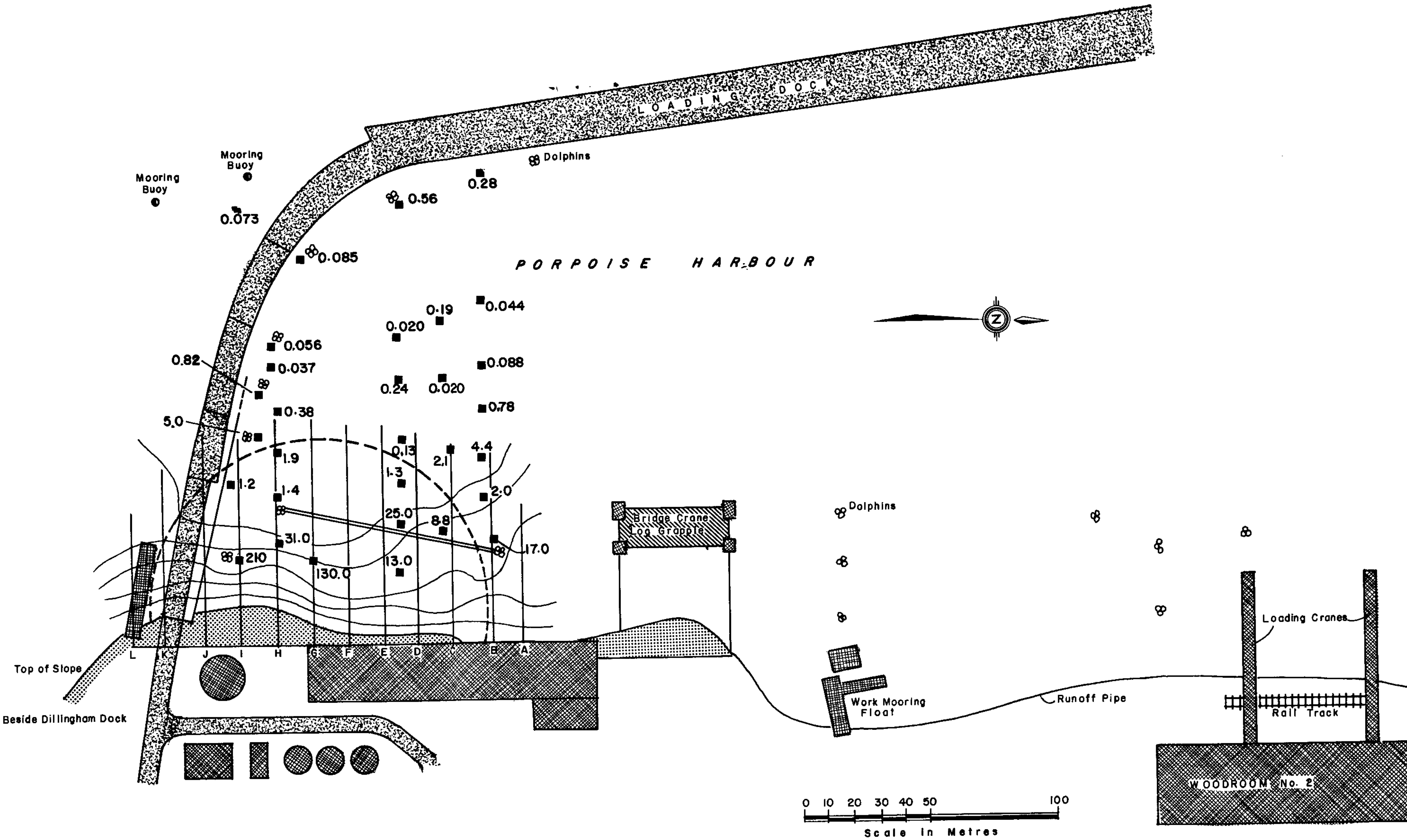


FIGURE 11b PCB CONCENTRATIONS (ppm / dry weight) IN SEDIMENTS FROM THE PCB SPILL AREA OFF CANCEL - September, 1977

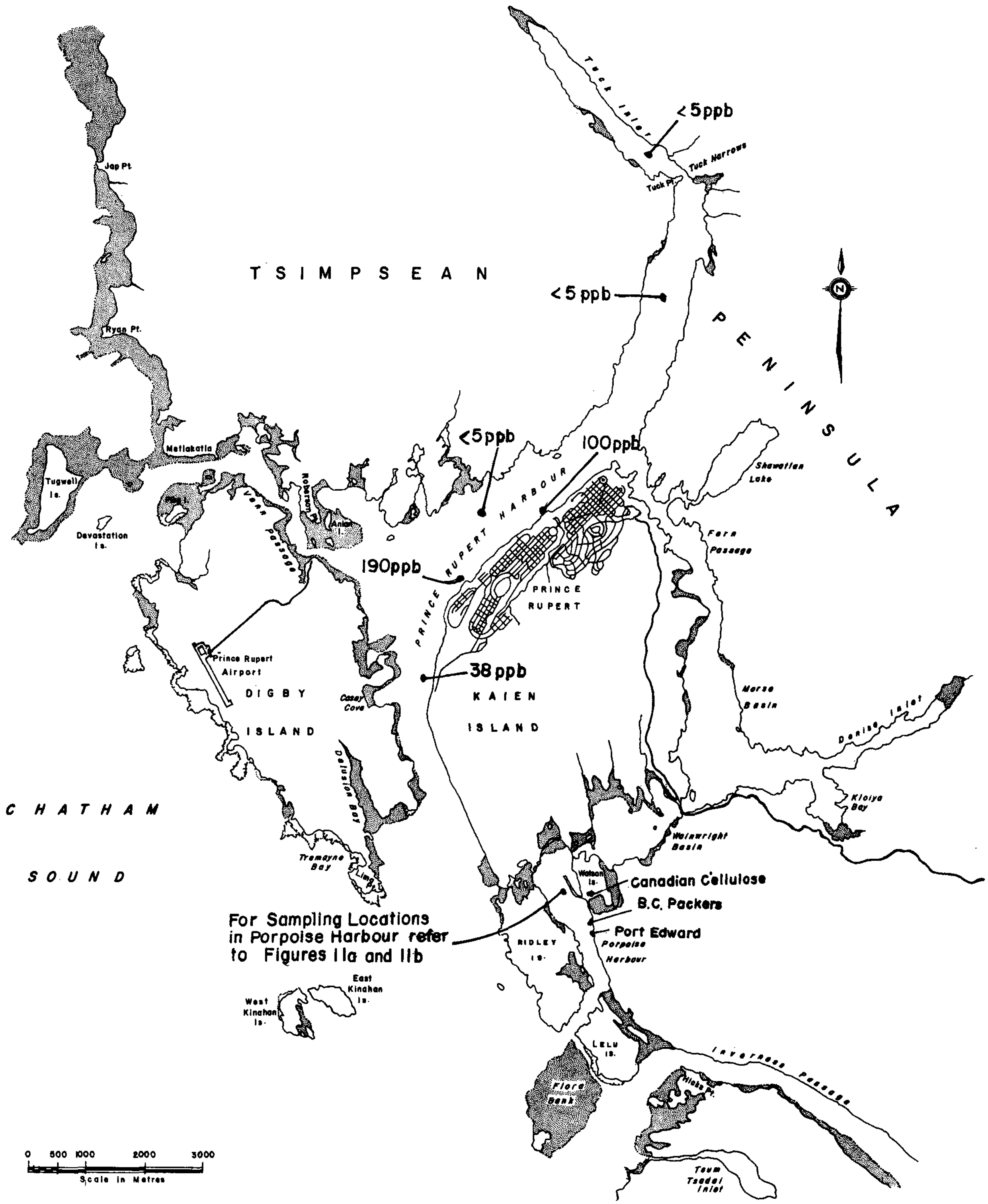


FIGURE 12 PCB CONCENTRATIONS IN SEDIMENTS FROM PRINCE RUPERT HARBOUR AND TUCK INLET

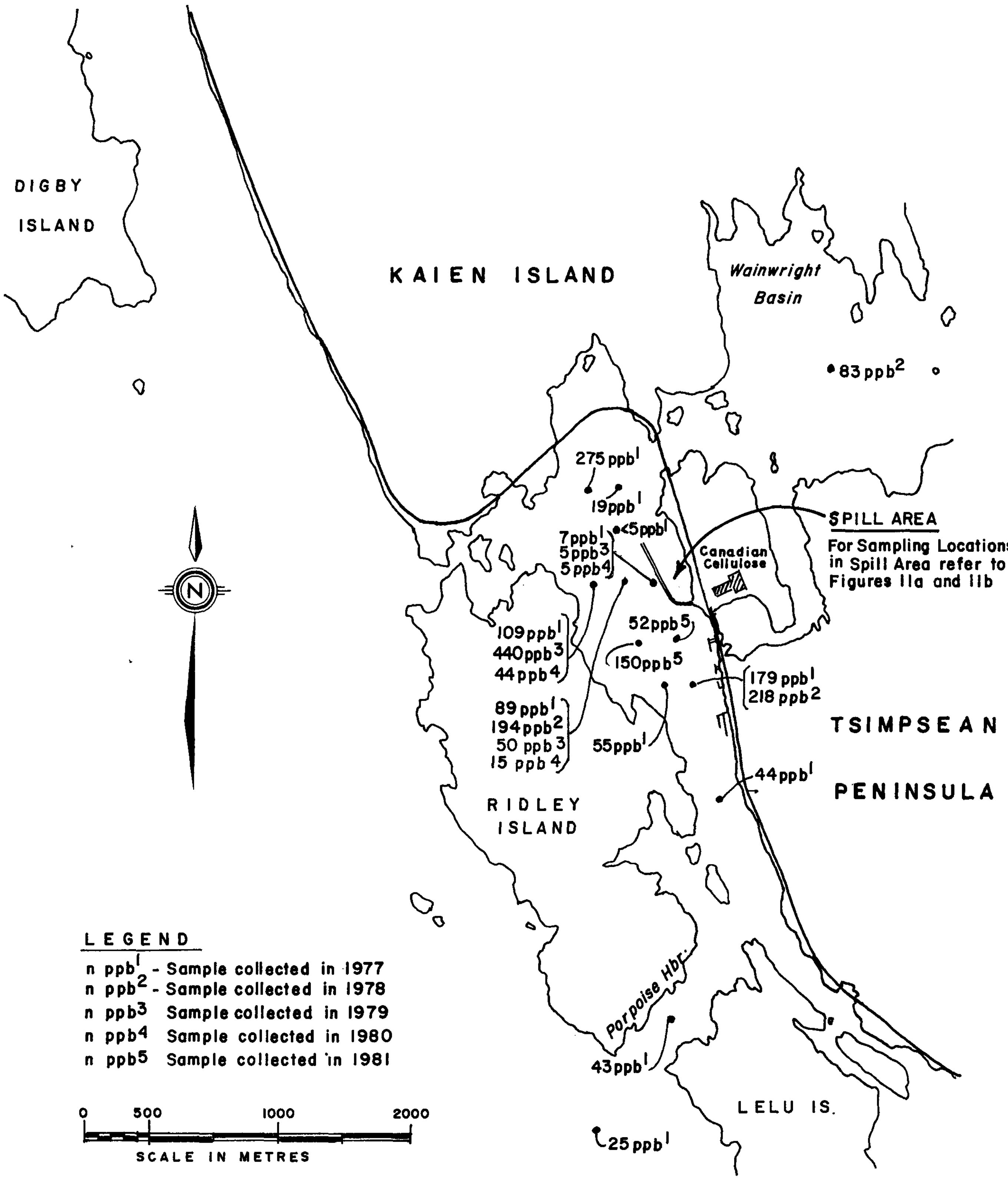


FIGURE 13 PCB CONCENTRATIONS IN SEDIMENTS OF PORPOISE HARBOUR OUTSIDE THE IMMEDIATE SPILL AREA (1977 - 1981)

from the mill (Appendix 2; Figures 12,13). These levels were not attributed to the January PCB spill at the Canadian Cellulose mill as the levels were not unusually high for an industrial area.

Very high concentrations of PCB were recorded in biota collected along the shoreline within 10 metres of the spill (isopods, 14 ppm; mussels, 17 ppm; alge, 83 ppm; and spider crabs, 72.9 ppm). The relative amounts of PCB contained within the tissues of these organisms versus the amount of PCB on their exteriors is uncertain (Appendix 4; Figure 14).

Beyond the immediate spill area, elevated PCB concentrations were confined to biota collected in Porpoise Harbour. Concentrations of PCB in biota in areas removed from Porpoise Harbour, such as Chatham Sound, were at or below the detection level of 0.005 ppm (Appendices 3 and 4; Figure 14, 15).

Dungeness crab have been monitored annually to ensure that PCB tissue concentrations remain within acceptable levels (Appendix 4; Figure 16). Although some evidence of contamination was present in crabs collected in 1977 (up to 2.7 ppm), and to some extent in 1978 (up to 0.34 ppm), mean values were generally comparable to the levels which would be expected in industrialized areas around Vancouver such as Sturgeon Bank and Coal Harbour. The levels in crabs collected near the spill were, however, significantly higher than the background concentrations detected in crabs from Lelu Island approximately 4 kilometres south of the spill site. This suggests that the PCBs spilled in Porpoise Harbour were an active source of contamination to the local biota prior to cleanup procedures. As mean values were well below the 2 ppm guideline recommended by Health and Welfare Canada for PCB levels in fish and shellfish for human consumption, fishing restrictions in Porpoise Harbour were lifted. Crabs collected annually since the spill cleanup have contained much lower levels of contamination and did not exceed 200 ppb in 1979 or 50 ppb in 1980 and 1981.

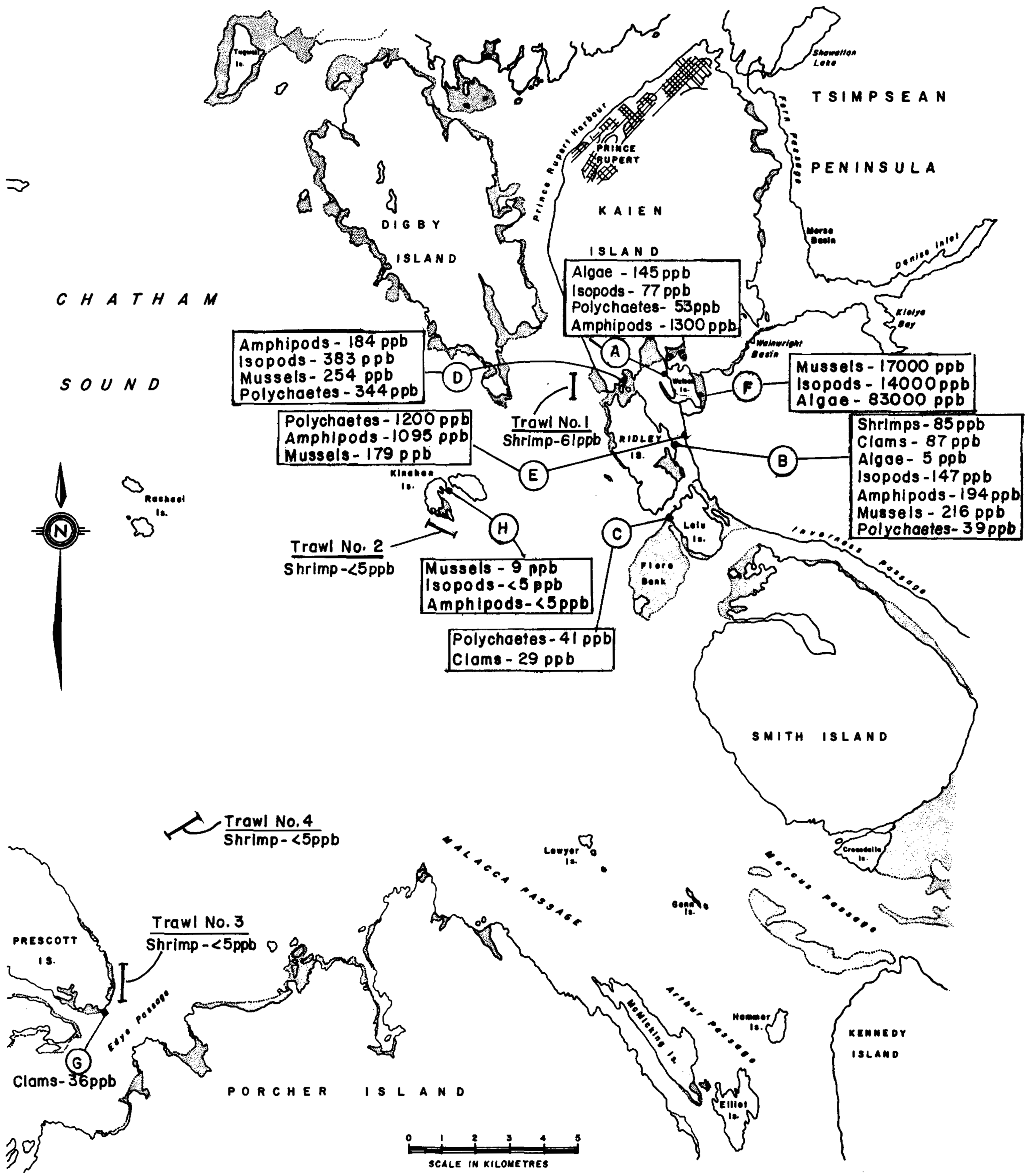


FIGURE 14 PCB CONCENTRATIONS IN INVERTEBRATES FROM THE PRINCE RUPERT AREA

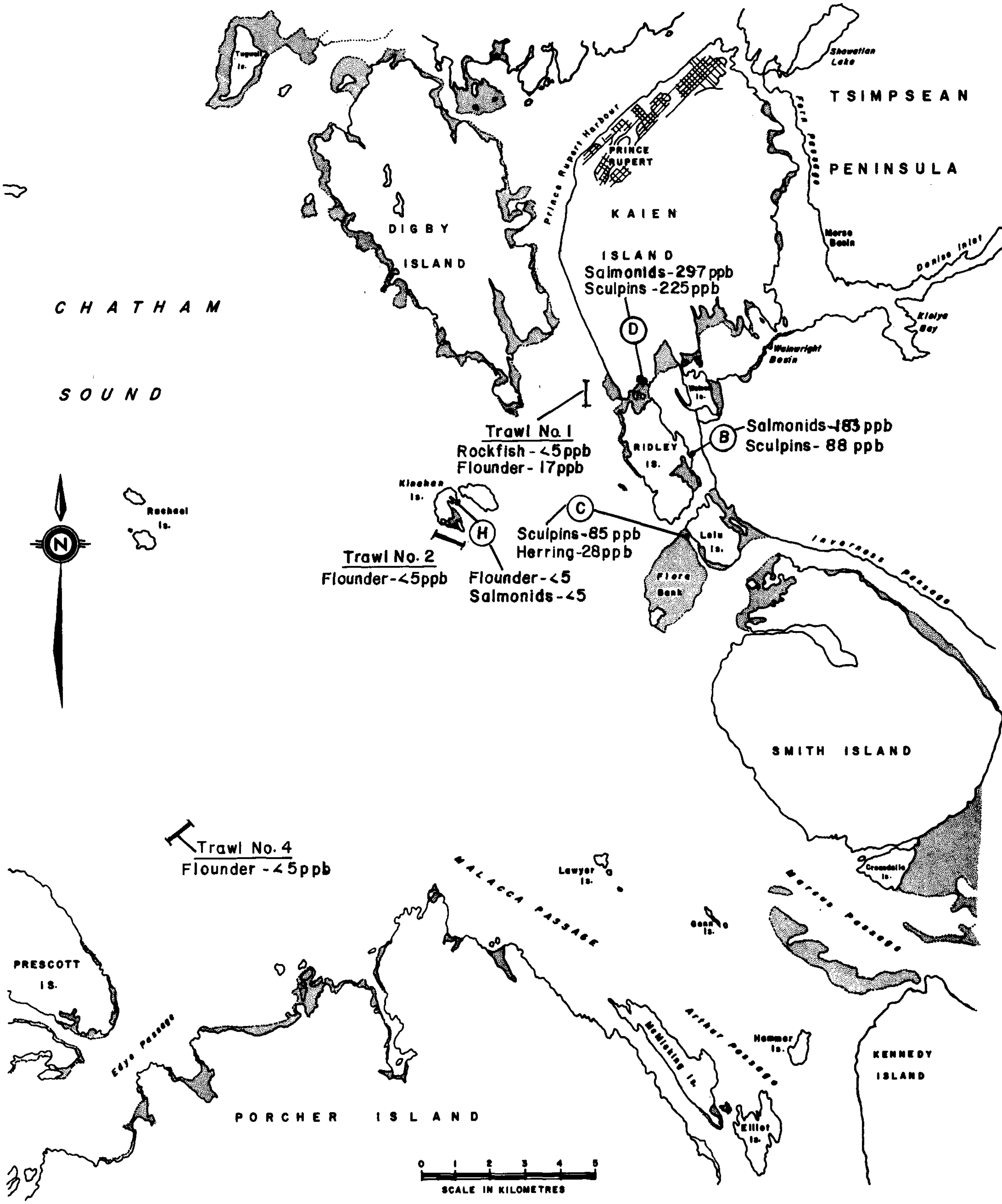
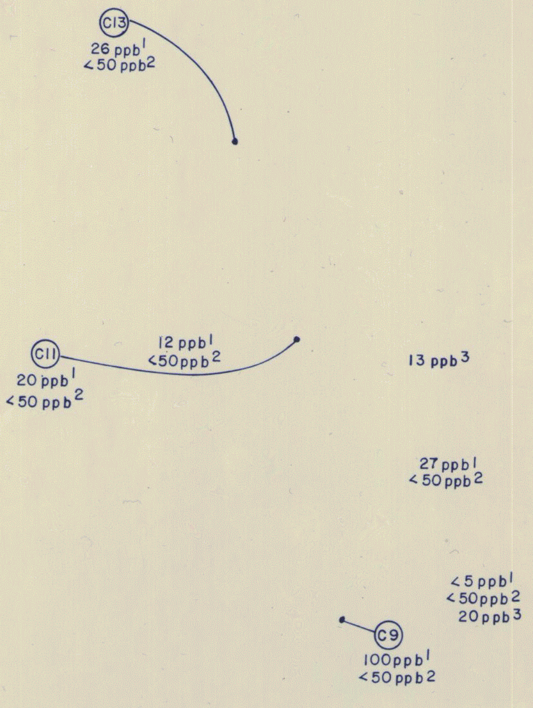
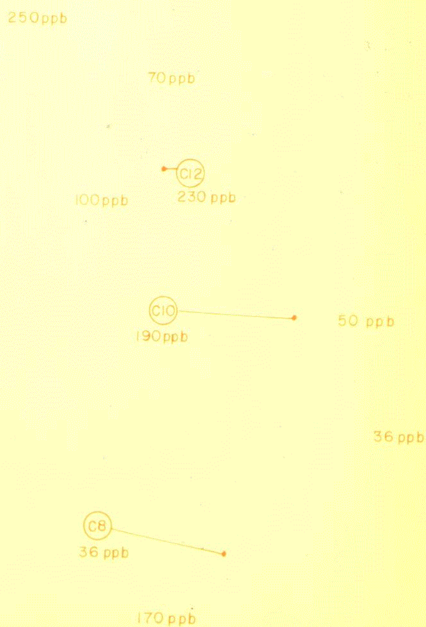


FIGURE 15 PCB CONCENTRATIONS IN FISH FROM PRINCE RUPERT AREA


C13
26 ppb[1]
<50 ppb[2]
C11
20 ppb[1]
<50 ppb[2]
12 ppb[1]
<50 ppb[2]
13 ppb[3]
27 ppb[1]
<50 ppb[2]
<5 ppb[1]
<50 ppb[2]
20 ppb[3]
C9
100 ppb[1]
<50 ppb[2]

(1979-1981)


250ppb
70ppb
C12
100ppb
230 ppb
C10
50 ppb
190ppb
36 ppb
C8
36 ppb
170 ppb

(1978)

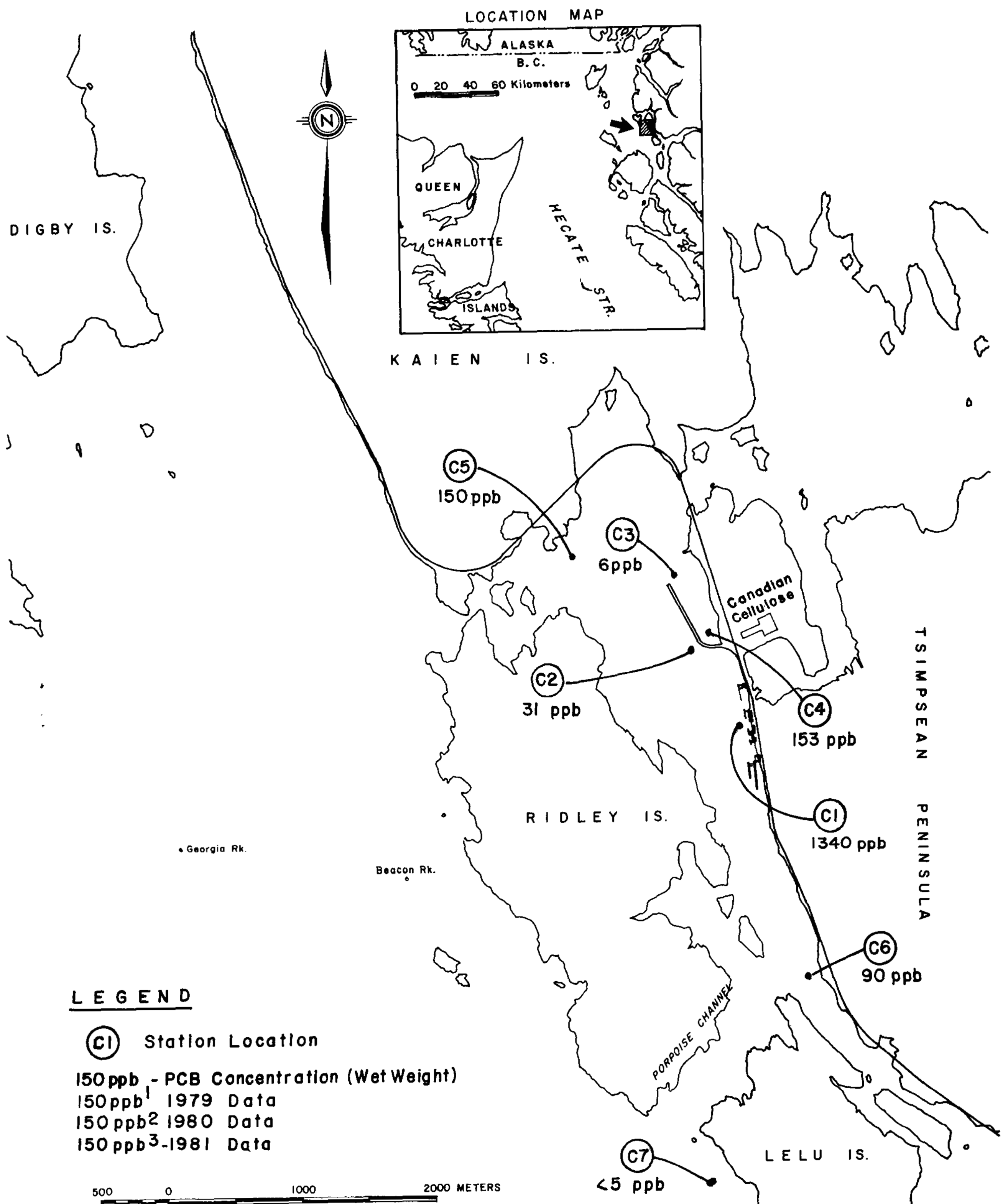


FIGURE 16 PORPOISE HARBOUR CRAB SAMPLING STATIONS (1977)

c. Clean-up Procedures

Three possible methods for cleanup were originally considered;

1) removal- removal and land disposal of contaminated sediments from the spill area
2) in-situ containment- in-situ physical isolation of the contaminated area from the rest of Porpoise Harbour to prevent the further spread of contamination
3) combination removal and in-situ containment- removal of the most highly contaminated sediments near the outfall and in-situ containment of the remainder

Removal of contaminated sediments (options 1 and 3) was ultimately considered infeasible for the following reasons:

a) the large amount of wood debris including submerged logs and bark contained in the bottom sediments could hinder dredging operations;

b) the possibility of resuspension of contaminated fine particulate matter and redissolution of PCBs could result in the spread of contamination to surrounding sediments during dredging and disposal operations;

c) the problems associated with locating adequate land disposal facilities for PCB contaminated sediments.

Consequently, option #2, in-situ containment, was selected as the best method for preventing the spread of contamination from the spill area and preventing further uptake of PCBs into aquatic organisms. The containment plan was carried out in two phases as shown in Figure 17. Phase 1 was initiated in January, 1978 and involved the deposition of a 20 foot depth of leached hogfuel over the spill area. Phase 2, the

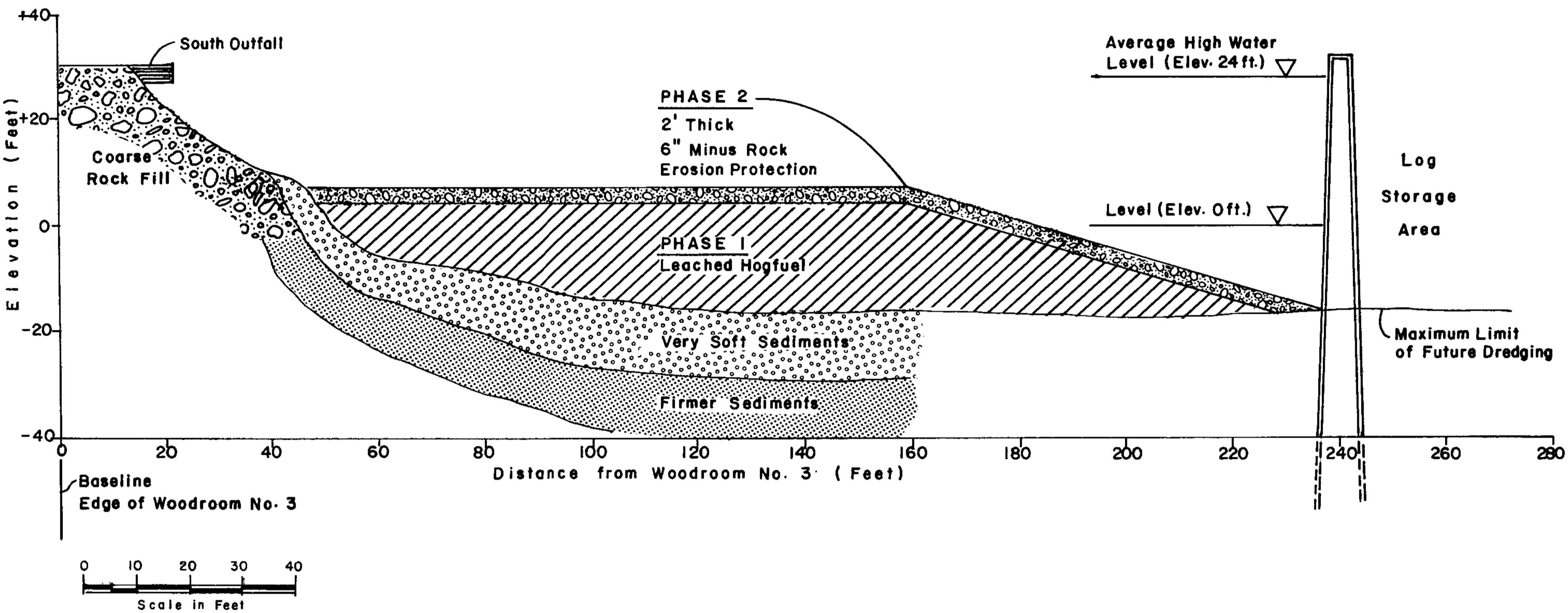


FIGURE 17 SIMPLISTIC CROSS SECTION OF CLEAN-UP PLAN

addition of a 2 foot deep protective rock cover, was completed in April, 1978. The rock cover was designed to prevent erosion of the hogfuel blanket which could occur as a result of tidal changes, water currents and boat activity in the area. Wooden pilings were also erected around the spill area to prevent boat and tug entry. The hogfuel and rock cover extended approximately 73 metres out from the shore and created, at low water level, an extension of the land.

Sediment sampling conducted around the perimeter of the cover indicated that the major area of contamination had been contained. Monitoring of the sediments and crabs in the spill area has been conducted annually by EPS to ensure that PCB concentrations in the biota remain within acceptable levels; to assess the effectiveness of the spill containment over a long period of time; and to ensure that the integrity of the cover is being maintained.

Sediments and crabs collected in Porpoise Harbour since the completion of the spill containment have contained very low or non-detectable levels of PCBs. The only site where PCB levels in the sediment remain elevated is adjacent to the workboat mooring float between Woodrooms 2 and 3. The sediments at this location have consistently contained over 1000 ppb PCB. This degree of contamination does not represent a significant concern, however, and is comparable to levels found in several industrialized areas of British Columbia.

d. Litigation

The Environmental Protection Service subsequently charged Canadian Cellulose Company under Subsection 33(2) of the Fisheries Act as it applied prior to its September 1977 amendments. This was a precedent setting case, in that, it was the first prosecution for PCBs under the Fisheries Act. The company was convicted of depositing PCBs in a place, and under conditions, where it may enter water frequented by fish.

6.4 West Kootenay Power and Light Ltd., Rutland

An electric short circuit at the West Kootenay Power and Light capacitor substation at Rutland in October, 1977 caused 1 or 2 capacitors to rupture and damaged 6 others. Several other capacitors were contaminated when PCBs were released from the ruptured units. It was estimated that 4.5 to 7 litres of fluid containing 0.1% PCB were released.

Concentrations of up to 14,000 ppm were detected in the soils collected from the spill area (Appendix 7; Figure 4). Cleanup procedures included the removal of soil from a 7.5 metre by 2 metre area to a depth of 1.0 to 1.2 metres. The soil and 18 damaged and contaminated capacitors were packed in 45 gallon steel drums for transport to a hazardous waste storage facility in the United States. Soil samples collected after cleanup did not contain detectable levels of PCBs indicating that virtually all of the contaminated material had been removed.

6.5 Bonlie Logging Mill Ltd., Stewart

Vandalism of a transformer at the abandoned Bonlie sawmill at Stewart resulted in the loss of approximately 91 litres of PCB. The spill was discovered in November, 1977 but may have occurred up to 1 year earlier. The PCB fluid on the cement pad was contained with absorbent material. Approximately 1.5 cubic metres of contaminated soil adjacent to the transformer pad were removed. The transformer and all contaminated material were placed in 45 gallon drums and shipped to a disposal facility in the United States. Analysis of the transformer oil showed that it contained 45,000 ppm PCB as Aroclor 1260. The contaminated gravel near the transformer pad contained up to 6,100 ppm. A sediment sample collected on the shore approximately 85 metres from the spill site contained 0.36 ppm (Appendix 7; Figure 4).

6.6 Granville and Burrard Street Bridge Bearings

In August of 1978, sampling conducted by EPS identified high PCB concentrations in the sediments under the Granville Street bridge (up to 6.9 ppm) and in the soil under the Burrard Street bridge (up to 7,900 ppm). Additional soil sampling conducted under the Burrard Street bridge in August 1980 revealed PCB levels of up to 64,000 ppm (Appendices 2, 6; Figures 1, 4).

The contamination under the Burrard Street bridge was attributed to the leakage of PCBs used in the lubrication of bridge bearings (refer to Section 5.2.3). There were no indications of leaking bearings on the Granville Bridge and elevated sediment concentrations may have resulted from past servicing or topping up procedures. The City of Vancouver was notified of the potential environmental concerns and was asked to remove the contaminated soil and to replace the PCBs in the bearings with alternate lubricating fluids. PCBs in the leaking bearings have now been replaced with a dry grease lubricant while bearings still containing PCBs are being inspected on a regular basis.

The contaminated soil has been removed and transported to a storage facility in Edmonton. The spill area has been covered with gravel and asphalt.

Additional sampling of the surface sediments under the bridges was conducted by EPS in September, 1981 and no indications of elevated PCB concentrations were detected.

6.7 Abandoned Transformer, False Creek

In September, 1978 an abandoned PCB filled transformer was found under the Granville Street bridge in the False Creek area. Samples of soil from around the transformer contained up to 120 ppm indicating that the transformer had been leaking (Appendix 7). The amount of PCB which escaped to the environment is unknown. The serial number of the transformer was located in EPS computer files and ownership traced to a local electric company. When contacted, the company agreed to remove the transformer and arranged for an alternate means of disposal or storage. No remedial action was required.

6.8 Saskatchewan Wheat Pool, North Vancouver

In February, 1979 an electromagnet at the Saskatchewan Wheat Pool leaked approximately 32 litres of PCB onto a grain conveyor belt. The conveyor belt and the magnet were replaced and numerous samples of grain were collected for PCB analysis. There was no evidence of PCB contamination in the grain. Two additional PCB filled electromagnets were found at this facility. These magnets have also been removed and replaced with non-PCB types. The use of PCB-containing electromagnets in food and feed facilities in Canada was banned in 1980.

6.9 B.C. Forest Products Ltd., MacKenzie

In May, 1979 a transformer was damaged during installation at the B.C. Forest Products mill in MacKenzie. Approximately 90 litres of PCB dielectric fluid escaped and contaminated the soil (up to 150,000 ppm detected) at the base of a power pole and 20,000 ppm at a depth of 0.9 metres beneath the soil surface.

The soil over a 1.0 metre diameter area was removed to a depth of 0.8 to 0.9 metres. The transformer was drained of the remaining PCB fluid. The liquid askarel, contaminated soil and gravel were placed in 45 gallon steel drums and shipped to the Waste Management Branch hazardous materials storage bunker in Kamloops for temporary storage prior to disposal. This material has since been transported to a disposal facility in the United States.

6.10 B.C. Coal (formerly Kaiser Resources Ltd.), Harmer Ridge

In September, 1979 an earth mover tire collided with, and damaged, a transformer at the Kaiser Resources site. Approximately 230-450 litres of PCB leaked into surrounding soils (Appendix 7; Figure 4). Excavation of the spill site was conducted due to the high soil contamination detected (over 100,000 ppm). A total of 269 forty-five gallon drums and two 300 gallon tanks were used to contain the soil. The damaged transformer, PCB liquid, contaminated soil and cleanup materials were shipped to a hazardous waste storage facility in Alberta.

6.11 Amax of Canada Ltd., Kitsault Mine, Kitsault

In December, 1979, during the draining and dismantling of a PCB-containing concentrate dryer at the Amax mine site it was discovered that, instead of the expected 2730 litres of PCB, the heat exchanger in the dryer contained only approximately 200 gallons. The dryer had been operated between 1967 and 1972 by the previous mine owner, B.C. Molybdenum Ltd. Former B.C. Molybdenum employees were contacted and it was learned that approximately fourteen 45 gallon drums of PCB had been removed from the heat exchanger and shipped to the United States for disposal. In addition, it was learned that one of these drums may have been bulldozed over the bank into the Lime Creek valley at the mill site. It was not known whether the drum had ever been recovered. Apparently several drums of various other wastes deposited in this area had later been recovered.

As a precaution the area surrounding the dryer, local streams and drinking water supplies were sampled for possible PCB contamination. The ground surrounding the dryer was contaminated, with the cement floor containing more than 300 ppm and the soil containing up to 195 ppm.

The second group of soil samples collected near the concentrate dryer contained very high PCB levels of up to 110,000 ppm or 11% PCB.

Cleanup of the contaminated area under the concentrate dryer commenced in April, 1980. Approximately 76 cubic metres of contaminated soil were removed and placed in 45 gallon steel drums and shipped to the United States for disposal. The heat exchanger was drained, dismantled and sent to a storage facility near Edmonton.

PCB's were not detectable (< 0.03 ppb) in the millsite and townsite drinking water supplies sampled in February, 1980. A water sample collected at the mouth of Lime Creek in February by the Waste Management Branch contained, 0.17 ppb PCB. Additional sampling of the millsite drinking water supplies and local surface waters was conducted by the Waste Management Branch in March and by Amax in March and April. The results showed that drinking water supplies contained low levels of PCB (ranging from 0.027- 0.064 ppb) but local surface waters (Appendix 1) contained surprisingly high concentrations (up to 4.8 ppb in Lime Creek). It is unusual for PCB concentrations in surface waters to exceed the limits of detection (usually 0.1 ppb or lower). However, water samples alone are not considered reliable indicators of contamination. It is unfortunate that no sediment samples were collected at that time to confirm the presence of PCBs in local water systems.

It is interesting to note, however, that mussels collected from this area by EPS in 1980 and 1981 contained unusually high levels of PCBs (up to 1.7 ppm). Surprisingly, sediment samples collected in 1980 and 1981 contained very low levels of PCB (< 20-170 ppb).

6.12 B.C. Hydro Electric Shop, Surrey

In March of 1980 a forklift accidentally damaged a PCB-containing voltage regulator in the storage yard of the B.C. Hydro electric shop. At the time of the spill it was estimated that 230 litres of PCB escaped, however, it was later determined that only 82 litres had been released.

The contaminated area was excavated and approximately 18 cubic metres of soil were placed in specially prepared plastic lined containers. The excavated soil and five 45 gallon drums containing liquid PCBs and contaminated rags and absorbent material, were transported to a hazardous waste disposal facility in Oregon.

The analysis of soil samples collected from the spill area following excavation indicated that the spill had been adequately cleaned up (< 0.005-0.120 ppm).

6.13 Fort Nelson Airport, Fort Nelson

In July, 1981 EPS was notified that an abandoned transformer near Fort Nelson was leaking PCBs. This transformer was one of three which had been removed from a local airport hanger in 1975 and dumped 270 metres from the Alaska Highway (near Mile 304). After being drained, the transformers and the PCB fluid were transported to a provincial Waste Management Branch (WMB) storage site in Kamloops. Soil from the spill site contained PCB concentrations of 100,000 to 300,000 ppm. The WMB funded the cleanup of 65 drums of contaminated soil. Further WMB inspections also revealed high PCB contamination in the old transformer room in the airport bunker. This room was subsequently sealed off and Transport Canada has been requested to initiate cleanup procedures.

TABLE 6 SUMMARY OF OTHER PCB SPILL INCIDENTS IN BRITISH COLUMBIA 1979 - 1982

DATE	COMPANY	DESCRIPTION OF INCIDENT
Jan. 23/79	B.C. Hydro 3 miles north of Williams Lake	A truck overturned and the capacitors it carried developed minor leaks.
Feb. 16/79	B.C. Hydro Merritt Substation	A 1 litre leakage of PCBs was reported. The cause was unknown.
Mar. 12/79	B.C. Hydro Pt. Hardy Substation	A capacitor exploded and necessitated the cleanup of a 3 m by 4.9 m section of ground
July 17/79	Weldwood Sawmill Williams Lake	PCB capacitor blew up.
Nov. 14/79	West Kootenay Power and Light Kelowna Substation	Transformer leak of approximately 0.5-1 litre.
Dec. 13/79	Vancouver Post Office (downtown)	A small capacitor exploded and spilled less than 0.5 litre.
Feb. 1/80	Granduc Mines Granduc, B.C.	A transformer leaked a little more than 4.5 litres of PCB.
Feb. 7/80	Environment Canada Upper Air Station Vernon	A capacitor spilled 9 litres of PCB in a warehouse.
Feb. 12/80	Sears Store Chilliwack	A mercury vapour light overheated and malfunctioned resulting in a very small PCB spill.
Feb. 15/80	B.C. Hydro Thetis Island (Marina Road)	A pole fell resulting in a damaged capacitor leaking 0.5 litre PCB.

TABLE 6 SUMMARY OF OTHER PCB SPILL INCIDENTS IN BRITISH COLUMBIA 1979 - 1982

(Continued)

DATE	COMPANY	DESCRIPTION OF INCIDENT
Mar. 3/80	West Kootenay Power & Light Glenmore Substation (Kelowna-Spa Road)	A capacitor exploded causing a 2 litre PCB spill.
Mar. 7/80	Klemtu (52°33'N - 128°31'W)	A discarded and rusted transformer was found and approximately 91 litres of PCBs may have been spilled.
Mar. 10/80	West Kootenay Power & Light Kelowna Substation (Corner of Richter & Recreational Ave.)	A short circuit caused a capacitor to explode with a resulting PCB spill of 1.63 litres.
Mar. 25/80	B.C. Hydro Victoria	An electrical surge caused some capacitors to blowup. An estimated 4 litres of PCB were spilled.
Apr. 8/80	B.C. Hydro Arnott Substation (Ladner)	A fuse failure cuased a capacitor to explode and release 2 litres of PCBs.
Apr. 24/80	Swanson Lumber Fort St. John	A small canister of PCB was found leaking.
May 5/80	Dolly Varden Mine Kitsualt	5 leaking abandoned transformers were located on an old platform 46 m above the Kitsault River. These transformers were not PCB-filled, however, two did contain low levels of PCB (33 and 41 ppm).
May 5/80	Duncan	A small PCB spill may have occurred in conjunction with leaking capacitor oil.

TABLE 6 SUMMARY OF OTHER PCB SPILL INCIDENTS IN BRITISH COLUMBIA 1979 - 1982

(Continued)

DATE	COMPANY	DESCRIPTION OF INCIDENT
June 13/80	B.C. Hydro Tisdale Substation (between Whistler and Pemberton)	A short circuit caused a capacitor to explode resulting in a spill of 1 litre.
June 24/80	Cominco Mines Trail	A 2-3 litre spill occurred after a capacitor exploded.
July 4/80	Canada Wide Mines Granduc-Stewart	A transformer leak at the lead wires caused a small spill of approximately 340 mls.
July 24/80	West Kootenay Power & Light Summerland Substation	A broken capacitor caused a 1 litre spill.
Aug. 13/80	Wesfrob Mines Queen Charlotte Isl.	A small transformer was overturned resulting in a spill of 0.5 litre.
Sept. 5/80	B.C. Hydro Surrey Electric Shop	A 2 litre spill resulted from a broken capacitor.
Sept. 8/80	B.C. Hydro Ahousat Diesel Generating Station	An 11 ml spill was reported.
Oct. 8/80	B.C. Hydro Surrey Electric Shop	A 57 ml spill was reported.
Oct. 24/80	B.C. Hydro Mile 73: Alaska Hwy.	A damaged bushing on a capacitor caused a 57 ml spill.
Nov. 18/80	B.C. Hydro Annacis Island	A bird shorted out a fuse causing 2 capacitors to fail and leak 1.14 to 2.28 litres of PCB.

TABLE 6 SUMMARY OF OTHER PCB SPILL INCIDENTS IN BRITISH COLUMBIA 1979 - 1982

(Continued)

DATE	COMPANY	DESCRIPTION OF INCIDENT
Nov. 19/80	Netherland Overseas Mills- Prince George	Ruptured capacitors released 2 litres of PCB.
Dec. 5/80	Canada Wide Mines Granduc-Stewart	An insulator was broken off a capacitor causing a leak of 2.5 litres to occur.
Dec. 12/80	Tree Island Steel New Westminster	A small hole or damaged bushing on a capacitor caused a minor leak of a few mls.
Jan. 12/81	Netherland Overseas Mills - Prince George	A capacitor spilled a very small volume of PCB.
Jan. 13/81	B.C. Telephone Switching Station - North Vancouver	A capacitor exploded resulting in a 100 ml spill.
Jan. 21/81	B.C. Hydro Horsey Substation (Victoria)	1-2 litres PCB spilled when a short circuit caused a capacitor to explode.
Feb. 16/81	B.C. Hydro Kennedy Substation (MacKenzie)	An electrical disturbance caused a capacitor to split, resulting in a 1 litre spill.
Feb 17/81	B.C. Hydro Brocklehurst Substn. (Kamloops)	Vandalism resulted in a broken bushing on a capacitor and a release of 10 ml of PCB.
Mar. 5/81	B.C. Hydro Murin Substation (Vancouver)	A ruptured capacitor caused a 0.25 litre spill.

TABLE 6 SUMMARY OF OTHER PCB SPILL INCIDENTS IN BRITISH COLUMBIA 1979 - 1982

(Continued)

DATE	COMPANY	DESCRIPTION OF INCIDENT
Mar. 11/81	B.C. Hydro Port Alberni Substn.	Corrosion caused a small hole in a capacitor which subsequently dripped 200 ml. of PCBs.
Mar. 20/81	B.C. Hydro North Vancouver Substn.	A 1 litre spill resulted from a ruptured capacitor.
Mar. 23/81	Beak Consultants Lab - Richmond	Fifteen 1 litre bottles containing PCB contaminated mineral oil (total of approximately 2 g PCB) were destroyed by a fire in the lab.
Apr. 14/81	Lornex Mines Kamloops	A capacitor leaked 1 litre of PCBs into a tailings pond.
Apr. 28/81	B.C. Hydro Westbank Substn.	A capacitor rupture resulted in a 1 litre spill.
Apr. 29/81	Bethlehem Copper Highland Valley Copper Mine	A capacitor malfunction resulted in a spill of less than 0.5 litre.
May 5/81	West Kootenay Power & Light Summerland Substn.	A 5.5 litre spill resulted from a capacitor failure.
June 10/81	B.C. Hydro Canal Flats Substn. (North of Cranbrook)	A capacitor bushing leak caused a 30 to 60 ml spill.
June 11/81	B.C. Pulp & Paper Port Alice	A leaking transformer resulted in a spill of a few millimeters.
June 23/81	B.C. Hydro Atlin Diesel Generating Station	A lightning strike caused a capacitor to spill 250 millilitres of PCBs.

TABLE 6 SUMMARY OF OTHER PCB SPILL INCIDENTS IN BRITISH COLUMBIA 1979 - 1982

(Continued)

DATE	COMPANY	DESCRIPTION OF INCIDENT
July 22/81	B.C. Hydro Kennedy Substation (Mackenzie)	A capacitor bushing shattered due to an electrical fault and caused a 0.5 litre spill.
July 27/81	Cominco Mines Trail	A minor PCB spill was reported.
Aug. 25/81	B.C. Hydro Vanc. Isl. Terminal (Duncan)	An electrical failure caused a capacitor to rupture which resulted in a 3 to 4 litre spill.
Sept. 3/81	B.C. Hydro Brocklehurst Substn. (Kamloops)	A bird shorted out 4 capacitors causing a 1 to 2 litre spill to occur.
Sept. 9/81	B.C. Hydro Kennedy Substation (Mackenzie)	A broken capacitor caused a 2 litre spill.
Sept. 21/81	B.C. Hydro Chemainus	Lightning struck a pole mounted capacitor which exploded and released 1 to 2 litres.
Oct. 7/81	Kin Centre Prince George	A leaking capacitor caused a spill of less than 1 litre.
Nov. 2/81	B.C. Hydro New Westminster Substation	A capacitor rupture resulted in a spill of slightly more than 1 litre.
Nov. 16/81	B.C. Hydro Surrey	A tree falling on a power line knocked a capacitor from the pole and resulted in a 0.5 litre PCB spill.

TABLE 6 SUMMARY OF OTHER PCB SPILL INCIDENTS IN BRITISH COLUMBIA 1979 - 1982

(Continued)

DATE	COMPANY	DESCRIPTION OF INCIDENT
Dec. 3/81	Cassiar Resources Cassiar	A capacitor spilled 0.5 litre of PCB onto an electrical shop floor.
Dec. 22/81	B.C. Hydro Annacis Isl. Substn.	An explosion caused by a bird resulted in a 1 litre spill.
Jan. 5/82	B.C. Hydro Terminal, North of Duncan	A capacitor failure caused a 2 litre spill.
Jan. 7/82	Weldwood Quesnel	A capacitor leaked 50-100 ml of PCBs.
Feb. 11/82	Gulf Oil Port Moody	A capacitor exploded and caused a 3.2 litre spill.
Mar. 17/82	B.C. Hydro Quesnel	A capacitor rupture resulted in a spill of 1 litre.
Mar. 19/82	B.C. Hydro Surrey	A 2 litre spill was the result of a capacitor explosion.
Apr. 16/82	B.C. Hydro Powell River	A leaking capacitor was the cause of a 1 litre spill.
May 12/82	University of British Columbia, Vancouver	15 year old drums were found rusted and leaking and a small spill is suspected.
May 21/82	B.C. Hydro Kennedy Substation (Mackenzie)	A spill of 5 litres occurred.

TABLE 6 SUMMARY OF OTHER PCB SPILL INCIDENTS IN BRITISH COLUMBIA 1979 - 1982

(Continued)

DATE	COMPANY	DESCRIPTION OF INCIDENT
June 2/82	B.C. Hydro Murrin Substation (Main and Union St.)	A capacitor overheated and ruptured, resulting in a 1 to 2 litre spill.
June 3/82	Neptune Terminals North Vancouver	A capacitor was damaged enroute to a storage area. Approximately 2 litres was spilled.

7 DISPOSAL AND STORAGE

Guidelines for the management of PCBs with respect to the storage, collection, handling and disposal of PCBs and PCB wastes were developed under contract to the Environmental Protection Service (EPS). The Handbook on PCBs in Electrical Equipment (215) also includes guidelines for in-plant housekeeping and maintenance of PCB-filled equipment. This document has been distributed to all major PCB users in the province and elsewhere in Canada.

Currently, the largest problem facing industry and government agencies with respect to PCBs and other hazardous materials is that of disposal. Although both government and industry have been seeking suitable sites, at present there are no licensed disposal or long term storage facilities in Canada. Until recently PCB-containing wastes from Canada have been transported to disposal facilities in the United States. However, in a May 1st, 1980 Federal Register notice, the Environmental Protection Agency (EPA) closed the United States borders to the importation of PCB wastes from other countries. This action has necessitated the storage of large amounts of PCB wastes in Canada in temporary hazardous waste collection/storage facilities. The bulk of PCB wastes from British Columbia have been transported to a temporary waste storage facility near Edmonton, Alberta. No similar facilities exist in British Columbia.

It is obvious that long-term storage of toxic wastes can not be considered a permanent solution to the waste disposal problem. Various methods of PCB destruction are being tested, however, to date high temperature incineration has been acknowledged as the most effective method.

A comprehensive review of the various waste destruction technologies has been presented in another recent Environmental Protection Service report (256). The following is a brief discussion of some of these processes, however, it is by no means complete.

The recommended operating conditions for incineration of PCBs include a 1.5 second dwell time at 1600°C and 2% oxygen or a 2 second dwell time at 1200°C and 3% oxygen (257). The incineration unit should be equipped with a gas scrubber to remove hydrochloric acid mist which is formed during PCB destruction (258).

In 1975, a study to test the effectiveness of cement kilns in destroying wastes containing up to 50% liquid PCBs, was conducted jointly by EPS, the St. Lawrence Cement Company in Mississauga, Ontario and the United States EPA. Details of these tests have been published in a Task Force report (257) and an EPS report (259). In summary, it was concluded that this method of destruction was effective and stack sampling analysis indicated that the minimum combustion efficiency was over 99.9%. In 1976, the Ontario provincial government subsequently issued a temporary license to allow St. Lawrence Cement to continue burning PCBs (260). However, opposition from local residents resulted in a halt to the destruction of PCBs at this facility and the introduction of a bylaw prohibiting the experimental burning of PCBs in Mississauga (261). Similar public opposition has arisen over plans to incinerate PCBs in cement kilns in the United States (262).

In the United States EPA has approved two incineration facilities for PCB disposal in El Dorado, Arkansas and Deer Park, Texas although others are currently under review and pending approval. It is estimated that the combined capacity of the two plants could result in the destruction of 50 million kilograms of PCB per year (263). The EPA Toxic Substances Control Act regulations specify that liquid wastes containing more than 500 ppm PCB must be destroyed in EPA-approved incinerators.

EPA has approved the burning of liquids containing 50 to 500 ppm PCB in utility boilers (264). One EPA test burn of PCBs at a General Motors high efficiency plant boiler in 1980 resulted in a destruction rate of 99.9%.

EPA has also issued a permit to Chemical Waste Management Inc. for the incineration of up to 13.6 million litres of waste PCB at sea this year. This company operates the 'Vulcanus' which is one of the three existing incinerator ships. PCB wastes are transported across the United States for temporary storage in Alabama. From here wastes are transferred to the 'Vulcanus' and incinerated (99.9% efficiency) at sea approximately 560 kilometres southwest of Mobile, Alabama (265). A boat building company in Tacoma, Washington is also planning to build two incinerator ships for the disposal of hazardous wastes. The ships, which will be owned and operated jointly with a New York based company should be operational by the end of 1983 (266). In Canada the incineration of PCB wastes at sea would be regulated under the Ocean Dumping Control Act although, to date, no Canadian wastes have been disposed of in this manner.

United States Environmental Protection Agency, Department of Energy and International Rockwell Ltd. have been involved with tests of the fluidized bed incineration of PCBs. Some researchers feel that this method of destruction has certain advantages over the conventional high temperature incineration method due to its lower operation temperature, and the fact that the necessary equipment can be transported to PCB storage areas. Final end products of this PCB destruction method include sodium chloride, carbon dioxide and ash (267).

The incineration of solid PCB wastes is not a common practice but is considered feasible in such units as rotary kiln furnaces equipped with after-burners and scrubbing systems (258). The American National Standards Institute recommends that solids not acceptable for incineration be placed in properly designed and managed government-approved landfills (268). There are no landfills of this type in British Columbia but certain industries in the province transported waste PCBs to chemical waste landfills in the United States prior to the border closure.

The disposal of PCB wastes in landfills not specifically designed for toxic materials disposal has resulted in environmental contamination and has necessitated clean-up operations in some areas of the United States including Tennessee (269) and New York (270). EPA currently has a list of requirements for PCB wastes deposited in landfills and also for the design and operation of landfills receiving such wastes (258, 271).

Various other methods for the destruction of PCBs or PCB-contaminated wastes are being investigated. One method being developed by Lockheed Research Centre in California utilizes a microwave plasma reactor to break down toxic compounds such as PCBs, kepone and nerve gas to steam, CO_2 and acid (272). Due to lack of funding this process is not presently being further developed.

Research at the National Water Research Institute (NWRI) in Ontario has shown that microbial degradation of PCB wastes containing between 100 and 300 ppm can be accelerated by emulsifying the PCB liquid. The greater surface area of the fine droplets speeds up the action of microbes. Using this method, Aroclor 1254 at a concentration of 300 ppm has been reduced to approximately 20 ppb in a 1 week period. This method may eventually be useful for initial effluent treatment (273).

Treatment of transformer oils containing low levels of PCBs (< 0.1%) with organometallic compounds such as sodium napthalide in a closed gas-tight vessel has also been found to be effective by the University of Waterloo and Goodyear Tire and Rubber Co. in the United States. The sodium combines with the chlorine of the PCB molecule and, following additional stages of treatment, the final products are sodium chloride, non-halogenated polyphenols and the treated oil (256). The efficiency of PCB destruction using this method is approximately 95% (274, 275). Other sodium dechlorination processes have been developed and are being investigated by several other companies and research organizations.

The Ontario Ministry of the Environment is supporting research on PCB incineration using the plasma arc pyrolysis process which is carried out at 50,000°C. One of the aspects of this process which must be more carefully investigated is the possibility of the formation of other potentially toxic compounds as the gasses cool (276).

Another method, called the PCBX process, was developed by a United States firm (Sunohio Co. Ltd.) and destroys PCB molecules by stripping the chlorine atoms and converting PCB to metal chlorides and polyphenyl compounds (similar to the Goodyear process). This system's advantages are that it can proceed in an enclosed system at low temperatures and pressure, and it is portable. The waste oils treated are not destroyed in the process but are decontaminated and available for re-use (277).

The use of diesel engines for the destruction of PCBs has also undergone preliminary testing in Ontario.

8 REGULATIONS

Regulations governing the use of PCBs in Canada have been developed under the Environmental Contaminants Act (ECA). The ECA was promulagated on April 1, 1976 and is administered jointly by Environment Canada and Health and Welfare Canada. This Act provides the federal government with the authority to obtain from Canadian industry, information on potentially hazardous chemicals or new chemicals in use or intended for use in Canada. The Act also gives the government the power to restrict or prohibit the use, manufacture and importation of prescribed substances. PCBs were the first class of substances to be regulated under the ECA.

The PCB regulations and amendments under the ECA as published in the Canada Gazette are included in Appendix 12. They are summarized briefly as follows.

Chlorobiphenyl Regulations No. 1 was introduced in September 1, 1977. These regulations prohibited the use of PCBs in the operation, servicing or maintenance of any product, machinery, or equipment other than:

1) electrical capacitors, transformers (and associated electrical equipment);
2) vapour diffusion pumps, heat transfer and hydraulic equipment and electromagnets in use in Canada prior to September 1, 1977;
3) machinery and equipment intended for use in the destruction of PCBs.

The use of PCBs as a constituent of any product, machinery or equipment manufactured in or imported into Canada after September 1, 1977 (other than electrical capacitors, transformers and associated electrical equipment) was also prohibited.

An amendment to Regulations No. 1 came into effect on July 1, 1980 and, in addition to the 1977 restrictions, prohibited the use of PCBs in:

a) electromagnets in operation over human and animal food and food additives;
b) electrical capacitors and transformers and associated electrical equipment manufactured in or imported into Canada after July 1, 1980;
c) servicing or maintenance of products, machinery or equipment other than electrical transformers, electromagnets and associated electrical equipment;
d) new filling or makeup fluid in servicing or maintenance of electromagnets or electrical transformers and associated equipment.

The implications of (c) and (d) above being that, while it is permissible to drain, filter and return PCB fluids to transformers, and electromagnets, the addition of new PCBs to any equipment is prohibited. In cases where topping up is required an alternate fluid must be used.

Other regulations are currently being developed to control the release of PCBs to the environment and to restrict the sale of products containing PCBs.

Other Canadian legislation which may be used to control PCBs include the Fisheries Act and, to some extent, the Transportation of Dangerous Goods Act.

Under Section 33 Subsection 2 of the Fisheries Act it is unlawful to deposit a deleterious substance into water frequented by fish. In a 1977 precedent setting case, the Canadian Cellulose pulp mill in Prince Rupert, British Columbia was charged and convicted under Subsection 33(2) (refer to Section 6.3). This was the first time the Fisheries Act had been used in Canada to prosecute a release of PCBs into the environment.

The transportation of PCB filled equipment and PCB wastes must comply with the requirements of the federal Transportation of Dangerous Goods Act and Regulations. The Act was proclaimed in 1980 in order to promote public safety in the transport of dangerous goods and applies only to federally-regulated modes of transport. The regulations, which will be published as three individual units, will identify the specific requirements for documentation (manifests and waybills), packaging, and labelling of dangerous goods including PCB equipment and wastes. The three units of regulations are expected to be promulgated during the latter part of 1983. In the interim, transportation procedures for PCB materials have been outlined in Chapter 7 of the EPS Handbook on PCBs in Electrical Equipment (215).

It is expected that new legislation soon to be put into effect by the British Columbia Ministry of Environment will also include some regulations on the handling, disposal and transportation of PCBs, as well as, other hazardous wastes.

Other provincial agencies whose legislation can be used to control PCBs in British Columbia include the Ministry of Labour and the Workers' Compensation Board.

In conjunction with the federal department of Consumer and Corporate Affairs, the Occupational Environment Branch of the Ministry of Labour is developing regulations requiring proper labelling of potentially hazardous chemicals used in industry and various institutions. Also regulations under the Electrical Energy Inspection Act, which is administered by the Electrical Safety Branch of the Ministry of Labour, prevent the installation of PCB-filled or other unapproved electrical equipment at British Columbia facilities. These facilities (including pulp and paper mills, sawmills and smelters) are inspected annually by Electrical Safety Branch inspectors.

The Workers' Compensation Board has adopted the American Conference of Governmental Industrial Hygienists standards for atmospheric levels of PCBs in the workplace. For chlorinated biphenyls containing 42% chlorine (by weight), the permissible concentrations in workplace air are 1 mg/m^3 over an 8 hour exposure period and 2 mg/m^3 for a 15 minute exposure period. Corresponding permissible concentrations for chlorinated biphenyls containing 54% chlorine (by weight) are 0.5 mg/m^3 and 1 mg/m^3, respectively (278). Workers' Compensation Board inspectors are responsible for ensuring worker protection by eliminating or reducing exposure to PCBs during their handling, storage and disposal.

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APPENDIX I

PCB CONCENTRATIONS IN SURFACE WATERS OF BRITISH COLUMBIA

APPENDIX 1 PCB CONCENTRATIONS IN SURFACE WATERS OF BRITISH COLUMBIA (ppb)

LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean + S.D.	PCB Concentrations Range	DATA SOURCE REFERENCE
Todd Cr. below Durrance Cr.	Jul/79	1	L0.4		13
Coldstream Cr. at Hwy. 6 Br.	Jun/79	2	1.0	L0.02 - 2.0	13
Coldstream Cr. u/s Coll. Dairy	Jun/79	1	5.0		13
Coldstream Cr.	Jun/79	1	L0.2		13
Sheridan Cr. near mouth	Mar/79	4	1.07	L0.4 - 3.0	13
Kickinghorse River at Crozier Bridge	Jun/76	1	L0.06		5
	Feb-Jul/77	3	L0.03	L0.005 - L0.06	5
	Jan/78	1	L0.005		5
Kickinghorse River at Hwy 1 near Leanchoil	Jun/76	1	L0.06		5
	Feb-Jul/77	3	L0.03	L0.005 - L0.06	5
	Jan/78	1	L0.005		5
Porcupine Cr. near mouth	Jun/76	1	L0.06		5
	Feb-Jul/77	3	L0.03	L0.005 - L0.06	5
	Jan/78	1	L0.005		5

Continued...

APPENDIX 1 PCB CONCENTRATIONS IN SURFACE WATERS OF BRITISH COLUMBIA (ppb)
(Continued)

LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean + S.D.	Range	DATA SOURCE REFERENCE
Ottertail R. near mouth	Jun/76	1	L0.06		5
	Feb-Jul/77	3	L0.03	L0.005 - L0.06	5
	Jan/78	1	L0.005		5
Lime Creek - at millsite	Mar/80	1	4.8		13
- at mouth	Feb/80	1	0.17		13
- above sewer outfall	Mar/80	1	0.16		13
	Mar/80	1	0.24		27
Kitsault River	Mar/80	1	0.13		13
Illiance River	Mar/80	1	0.01		13
- at Clary Creek	Mar/80	1	0.12		27
Clary Lake	Mar/80	1	0.027		27
Kickinghorse R. above Porcupide Cr.	Jun/76	1	0.008		5

APPENDIX 2

PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
	Delta Pump Stations					
1	3rd Ave. Pump Station	Dec/77	3	42 ± 12	34 - 55	1
2	12th Ave. Pump Station	Dec/77	3	40 ± 33	18 - 78	1
3	Airport Pump Station	Dec/77	3	468 ± 634**	110 - 1200**	1
		Aug/78	7	19 ± 36	L5 - 100	1
4	Beharrel Pump Station	Dec/77	3	1414 ± 2072**	72 - 3800**	1
5	Oliver St. Pump Station	Dec/77	3	58 ± 8	50 - 66	1
6	Roberts Bank	Nov/78	1	10.0*		2
		1980	1	L5.0		3
7	Sandheads Ocean Dump Site	Mar/76	1 core			4
	0-4 cm			ND		
	20-24 cm			ND		
	66-74 cm			ND		
	Fraser River - Main Arm					
8	at Steveston	Mar/77	12	ND	ND - ND	5
9	Ladner Marsh	Jun/79	Composite	L20		4
10	E. of Gilmore Island	Jul/76	1	50		4
11	Richmond Landfill	Feb/76	2	25 ± 7	20 - 30	6
		Apr/77	8	44 ± 63	ND - 190	4
12	N. side Tilbury Island	Jul/76	1	10		4
13	N. side Tilbury Island	May/77	12	ND	ND - ND	5

*Concentrations below the level of confident quantification.
**High concentrations likely due to sample contamination.

Continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
	Fraser River - Main Arm cont.					
14	Betw. Tilbury Island & Annacis Island	Jul/76	1	10		4
15	off Island Paper Mill	Feb/76	2	215 ± 21	200 - 230	6
		Apr/76	2	ND	ND - ND	4
16	E. tip of Annacis Island	Jul/76	1	40		4
17	at Patullo Bridge	Feb/76	2	ND	ND - ND	6
		Apr/76	2	ND	ND - ND	6
		Jul/76	1	10		4
		May/77	12	ND	ND - ND	5
18	at mouth of Brunette R.	Jul/76	1	30		4
19	off Western Canadian Lumber	Jul/76	1	30		4
20	Nathan Creek, Fort Langley	Jun/78	5	6 ± 3	L5 - 11	1
21	at Railway Bridge	Mar/79	1	L5		4
22	off Rayonier Ltd. (Western	Jul/76	1	230		4
	Forest Products)	Jan/81	2	L5	L5 - L5	1
23	u/s Scott Paper Ltd.	Feb/76	2	ND	ND - ND	6
		Apr/76	1	ND		6
	u/s Scott Paper Ltd.	Feb/76	2	ND	ND - ND	6
		Apr/76	1	ND		6
	Fraser River - North Arm					
24	near Queensborough Bridge	Jul/76	1	ND		4

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean + S.D.	Range	DATA SOURCE REFERENCE
	Fraser River - North Arm cont.					
25	near Queensborough Bridge,	Jul/76	1	30		4
	MacMillan Bloedel Wood	Nov/81	1	L10		1
	Preserving Division	Sept/81	1	10		1
26	Vicinity of Belkin Paperboard Ltd.					
	i) adjacent plant outfalls					
	A.	Feb/76	2	773 ± 325	543 - 1002	6
		Apr/76	1	704		6
		Mar/79	1	1500		4
	B.	Mar/79	1	46		4
	C.	Mar/79	1	10		4
	D.	Mar/79	1	L5		4
	E.	Mar/79	1	L5		4
	ii) downstream from plant					
	F.	Apr/76	1	50		6
	G.	Mar/79	1	L5		4
	H.	Mar/79	1	L5		4
	I.	Mar/79	1	L5		4
	J.	Mar/79	1	L5		4
	iii) upstream from plant					
	K.	Mar/79	1	L5		4
	L.	Mar/79	1	L5		4

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
	Fraser River - North Arm cont.					
26	Vicinity of Belkin Paperboard Ltd.					
	M.	Mar/79	1	560		4
	N.	Mar/79	1	L5		4
	O.	Jul/76	1	430		6
	P.	Mar/79	1	1300		4
	Q.	Mar/79	1	L5		4
27	Downstream CN Rail Bridge	Jul/76	1	20		4
28	near ft. Boundary Rd.	Jul/76	1	60		4
29	off MacMillan Bloedel White	Jul/76	1	20		4
	Pine Division	May/77	2	475 ± 106	400 - 550	4
		Sept/81	1	74		1
30	off Byrne Piledriving, Rmd.	Mar/80	2	180 ± 170	60 - 300	1
31	off Crown Zellerbach Mill	Jul/76	1	20		4
32	N. Mitchell Island off	Jul/76	1	60		4
	Terminal Sawmills	Apr/79	3	47 ± 46	L20 - 100	1
		Nov/81	1	160		1
33	N. Mitchell Island	Jul/76	1	30		4
34	W. tip of Mitchell Island	Jul/76	1	60		4
35	Oak St. Bridge off Mainland	Jul/76	1	70		4
	Sawmills	May/79	2	170 ± 85	110 - 230	1
	Oak St. Bridge	May/77	12	32 + 41	ND - 112	5

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean + S.D.	Range	DATA SOURCE REFERENCE
36	N.E. side of Sea Island	Jul/76	1	50		4
	Eburne Sawmills, Canadian Forest Products	Sept/81	3	35 ± 23	12 - 57	1
	Sturgeon Bank					
37	near Iona Isl. S.T.P. outfall	Aug/78	1	ND		2
		Nov/78	1	214		2
38	at W. end Iona Island S.T.P. breakwater	Nov/78	1	0.05*		2
39	Sturgeon Bank - offshore	Mar/76	1 core			4
	0-4 cm			ND		
	20-24 cm			ND		
	60-64 cm			ND		
40	Point Grey Dumpsite	Mar/76	1 core			4
	0-4 cm			1050		
	4-8 cm			980		
	12-14 cm			740		
	20-24 cm			410		
	40-44 cm			230		
	70-74 cm			90		
41	Georgia Strait	Mar/76	1 core			1
	0-4 cm			420		

*Concentrations below the level of confident quantification

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	PCB Concentrations Range	DATA SOURCE REFERENCE
	Georgia Strait cont.					
	20-24 cm			100		
	66-70 cm			ND		
42	Como Lake, Coquitlam	1977	4	ND	ND - ND	1
	False Creek					
43	Burrard St. bridge (directly under roller bearings N. end)	Aug/78	2	68 ± 60	26 - 110	1
	Burrard St. bridge - transect	Sept/81	10	119 ± 119	20 - 370	1
44	Granville St. bridge (directly under roller bearings N. end)	Aug/78	2	4200 ± 3818	1500 - 6900	1
	(directly under bearings S. end)		2	836 ± 1080	72 - 1600	1
	Granville St. Bridge - transect	Sept/81	8	115 ± 134	L10 - 430	1
45	off Granville Isl. old docks	Apr/79	1	51		1
	- marina under Granville St. Bridge	Apr/81	1	160		1
46	in marina area N. shore under Connaught bridge	Apr/79	1	140		1
47	B.C. Place Amphitheatre Excavation Site	Feb/81	3	9 ± 7	L5 - 17	1
48	Bay Forest Products	Oct/77	4	185 ± 299	11 - 630	1
		Apr/79	1	63		1
		Nov/79	4	120 ± 46	70 - 180	1
		Aug/80	4	33 ± 26	10 - 70	1
		Aug/80	3	2197 + 1468	1290 - 3890	1

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean + S.D.	Range	DATA SOURCE REFERENCE
48	Bay Forest Products cont.					
	Scow pockets	Feb/81	2	415 ± 106	340 - 490	1
	Log pockets	Feb/81	4	91 ± 91	14 - 20	1
	Coal Harbour					
49	off Vancouver Rowing Club	Jul/76	1	230		4
	Docks	Apr/79	1	197		1
		Oct/79	5	200 ± 6	90 - 460	1
50	Burrard Shipyard-midchannel	Apr/79	1	330		1
	-docks	Apr/79	1	2200		1
51	Bensons Shipyard	Apr/79	1	6200		1
52	Coal Harbour Marina, west floats	May/80	1	1100		1
53	off s. dock Royal Van Yacht	Jul/76	1	340		1
	Club	Apr/79	1	310		1
54	Menchions Shipyard - Bayshore Inn					
	1' depth	Jul/79	7	9463 ± 6326	900 - 16800	7
	2' depth	Jul/79	4	678 ± 765	ND - 1450	7
	3' depth	Jul/79	1	67		7
	- adjacent to docks	Jun/80	1	6200		1
	- midchannel	Apr/79	1	730		1
55	Kanata Shipyards- off docks	Apr/79	1	160		1
	- midchannel	Apr/79	1	65		1

Continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean + S.D.	Range	DATA SOURCE REFERENCE
56	Vancouver Harbour	Mar/76	1 core			1
	0-4 cm			210		
	4-8 cm			380		
	12-16 cm			330		
	20-26 cm			130		
	70-74 cm			ND		
	Burrard Inlet					
56	Standard Oil Floating Docks	Jul/76	1	380		1
57	off CP Ocean Wharves, Pier 2	Jul/76	1	300		1
58	Centennial Pier	Jul/76	1	300		1
		Aug/79	2	27 ± 6	22 - 31	1
		Sept/79	2	ND	ND - ND	1
59	Grain jetty #1	Jul/76	1	1620		1
60	"Stanovan", Standard Oil	Jul/76	1	340		1
61	"Shellburn", Shell Oil	Jul/76	1	490		1
62	Texaco	Jul/76	1	510		1
63	Bestwood Shingle Mill	Jul/76	1	660		1
64	N.E. Gulf Oil	Jul/76	1	660		1
65	N.W. Flavelle Cedar	Jul/76	1	550		1
66	N.E. Flavelle Cedar	Jul/76	1	260		1
67	Imperial Oil, Ioco Dock	Jul/76	1	440		1

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
	Burrard Inlet cont.					
68	N. of Admiralty Pt.	Jul/76	1	360		1
69	Belcarra Wharf	Jul/76	1	590		1
70	Matsumota Wharf	Jul/76	1	2580		1
71	E. of 2nd Narrows Bridge	Jul/76	1	270		1
72	W. of 2nd Narrows Bridge	Jul/76	1	220		1
72	Allied Shipbuilders	Nov/79	3	ND	ND - ND	1
73	Lynnterm	Jul/76	1	120		1
74	Neptune Terminals	Oct/80	2	58 ± 74	L5 - 110	1
74	Dillingham Yard	Jan/81	1	87		1
		Oct/81	1	46		1
75	Saskatchewan Wheat Pool	Jul/76	1	270		1
76	Burrard Terminals	Jul/76	1	300		1
77	E. of Burrard Drydocks	Jul/76	1	250		1
77	Burrard Yarrows Ship Repair	Oct/79	6	1593 ± 1410	160 - 3400	1
	Facility	1980	1	17000		3
78	Seabus Breakwater	Jul/76	1	420		1
79	off N. Shore Marine Stn. "Burner"	Jul/76	1	250		1
80	Vancouver Shipyards	Nov/80	2	885 ± 1223	20 - 1750	1
		Feb/81	2	L5	L5 - L5	1
		Apr/81	4	1954 + 1719	64 - 4090	1

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
	Burrard Inlet cont.					
81	Vancouver Wharves	Jul/76	1	180		1
	- off end Bollard 22	Aug/80	1	14400		1
	- Bollard 4	Aug/80	1	42		1
81	L & K Lumber	Apr/80	4	89 ± 68	34 - 180	1
82	Midchannel-off Calamity Point	Jul/76	1	70		1
83	Capilano River	Dec/76	1	L4		1
84	Thunderbird Marina, Fisherman's Cove-outside marina off E. Coast Eagle Isl.	Jun/77	1	L5		1
85	MacMillan Bloedel, Squamish	Feb/78	2	7 ± 3	5 - 9	1
	- dredge station	Feb/80	1	Trace		1
	- dredge material	Feb/80	1	5		1
		Feb/81	2	L5	L5 - L5	1
86	Weldwood of Canada, Empire Lumber Div, Squamish	Feb/79	8	32 ± 13	L20 - 50	1
	Empire Sawmill	Mar/80	4	L10	L10 - L10	1
		Mar/81	3	L20	L20 - L20	1
	Logging Division	Mar/80	3	25 ± 12	14 - 38	1
		Mar/81	1	L20		1
87	Squamish River	Aug/78	2	L5	L5 - L5	1
88	Rayonier Canada Ltd., Woodfibre,	Mar/80	2	4025 ± 615	3590 - 4460	1
	Howe Sound	Aug/80	4	33 + 26	10 - 70	1

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
89	Canadian Forest Products, Port	Sept/79	4	90 ± 30	60 - 120	1
	Mellon, Howe Sound	Jun/81	7	102 ± 78	L20 - 250	1
90	Port Mellon Ocean Dump Site					
	0-4 cm			620		
	11-15 cm			ND		
	18-22 cm			ND		
	35-39 cm			ND		
91	L & K Lumber, Howe Sound	Mar/81	1	L20		
92	MacMillan Bloedel, Powell River					
	Chip Scowdock	Jul/77	2	40 ± 14	30 - 50	1
	log pond	Jul-Sept/77	3	595 + 957	10 - 1700	1
	"A" dock	Sept/77	1	68		1
		Jun-Jul/80	4	13 ± 18	ND - 38	1
		Jul/80	3	631 ± 858	93 - 1620	1
	"F" dock	Jun/81	4	33 ± 18	14 - 50	1
93	Beach Gardens Resort Marina, Powell River	Jun/77				1
	N.E. of marina		1	L5		
	S.W. of marina		1	L5		
	in dock area		composite	L5		

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
94	Gorge Harbour Marina, Cortes Island	Jun/77				1
	at marina		1	L5		
	W. of marina		composite	L5		
	E. of marina		1	12		
95	Ocean Falls Mill, Ocean Falls	Aug/78	4	250 ± 101	170 - 380	1
96	Ocelot Industries Methanol Plant, Kitimat	Jun/80	6	17 ± 6	11 - 25	1
97	Prince Rupert area Canadian Cellulose Ltd., Port Edward - Porpoise Harbour					
	immediate PCB spill area	Jan/77	8	80,154 ± 100,522	430 - 244,000	1
		Jun/77	43	3,556,000 ± 11,946,000	6000 - 74,822,000	1
		Sept/77	31	14970 ± 43360	44 - 210,000	1
	perimeter of spill	Jan/78	26	2890 ± 8350	130 - 43,000	1
	containment area	Jul/78	11	1019 ± 798	300 - 2700	1
		Jun/79	11	398 ± 745	7 - 2600	1
		Aug/80	16	235 ± 328	L50 - 1360	1
		Aug/81	5	488 + 516	71 - 1100	1
		May/82	5		L50 - 1400	1

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
	Canadian Cellulose Ltd., proposed dredge sites	Jun/79				1
	off woodroom #2		2	17 ± 1	16 - 17	
	off woodroom #3		2	2100 ± 141	2000 - 2200	
	B.C. Packers Ltd., Port Edward	May/78				
	dredge spoils Barge 1		3	470 ± 806	L5 - 1400	
	Barge 2		3	16 ± 2	L5 - 39	
	Barge 3		3	15 ± 4	11 - 17	
	Barge 4		3	14 ± 3	12 - 18	1
	Porpoise Harbour - outside	Jun/77	12	74 ± 80	L5 - 275	1
	immediate spill area	Jul/78	2	206 ± 17	194 - 218	1
		Aug/80	3	213 ± 203	L50 - 440	1
		Aug/81	2	101 ± 69	52 - 150	1
	Chatham Sound	Jun/79	4	83 ± 81	L5 - 90	1
	Tuck Inlet	Jun/79	2	L5	L5 - L5	1
	Wainwright Basin	Jun/79	1	83		1
98	Lime Creek, Alice Arm	Feb/81	1	22		1
		May/81	3	15 ± 18	L5 - 36	1
	at mouth	Oct/80	2	L20	L20 - L20	1
	at Gauge Station	Oct/80	1	170		1

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
99	McLeese Lake area Sheridan Creek					
	1) near mouth	Jun/76	2	309 ± 426	8 - 610	1
		Dec/76	1	350		1
		Sept/77	2	L5	L5 - L5	8
		Sept/78	2	62.5 ± 81.3	L5 - 120	8
	2) at unnamed creek	Sept/77	1	L5		8
		Sept/78	1	L5		8
	3) downstream Gibralter Creek	Dec/76	1	4		1
	4) at Gibralter Creek	Sept/77	1	L5		8
		Sept/78	1	L5		8
	5) upstream Gibralter Creek	Dec/76	1	6		1
	6) at intersection with	Sept/77	1	L5		8
	powerline	Sept/78		L5		8
	Gibralter Creek (& small tributaries)					
	7) above Sheridan Creek	Dec/76	1	45		1
	8) above pond	a) Dec/76	1	15		1
		b) Dec/76	1	L4		1
	9) pond near Gibralter Creek	a) Jun/76	1	75		1
	& Gibralter Mine Rd.	b) Dec/76	1	120		1
	10) Gibralter Creek near	Sept/77	2	L5	L5 - L5	8
	substation	Sept/78	2	L5	L5 - L5	8
	11) Swamp near substation	Sept/77	1	62		8

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	PCB Concentrations Range	DATA SOURCE REFERENCE
		Sept/78	1	340		8
	12) unnamed creek west of	Sept/77	1	L5		8
	substation	Sept/78	1	L5		8
	13) culvert near substation	Dec/76	1	620,000		1
	14) unnamed creek in secondary drainage system near marsh	Dec/76	3	5.0 ± 1.73	L4 - 7	1
	McLeese Lake (Stn.18; Figure 8b)	Sept/77	1	160		8
		Sept/78	1	L5		8
	Cuisson Lake (Stn.15; Figure 8b)	Sept/77	1	L5		8
		Sept/78	1	L5		8
100	Columbia River-d/s PCB spill in Cominco salvage yard, Trail	Jun/76	1	85		9
	Vancouver Island					
101	Clover Pt., Victoria Harbour	Jul/78	6	230 ± 182	L5 - 470	1
102	Shoal Pt., Victoria Harbour	Jul/80	4	31 ± 46	L5 - 100	1
103	Victoria Inner Harbour	Oct/77	105	359 ± 467	L1 - 3640	10
104	Cleansteel (Island) Ltd., Victoria	Aug/79	3	110 ± 4	77 - 135	1
105	DND Rocky Pt. Ammunition Jetty Extension, Esquimalt	Mar/81	2	L5	L5 - L5	1
	- Magazine Jetty, Pedder Bay	May/81	6	11 ± 4	L10 - 19	1
	- Esquimalt Harbour	May/81	10	661 + 890	L10 - 2600	1
106	Saltspring Island, Ganges Harbour	Apr/81	5	117 ± 184	22 - 445	1

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
107	B.C. Forest Products, Crofton	Aug/79	2	55 ± 7	50 - 60	1
108	MacMillan Bloedel, Harmac Div.	Dec/78	8	321 ± 507	7 - 1500	1
	surface sediment	Dec/78	composite	1300		1
	deeper sediment	Feb/79	3	143 ± 108	20 - 220	1
	Nanaimo Harbour-Gov't Wharf	Aug/81	3	73 ± 15	60 - 90	1
109	Ucluelet	Nov/80	2	32 ± 16	21 - 43	1
110	French Creek Boat Harbour	Jun/77				1
	E. of dock area		1	L5		
	in dock area		composite	20		
			1	18		1
111	Port Alberni Fishing Harbour Improvement Site	Feb/79	3	L20	L20 - L20	1
111	MacMillan Bloedel, Alberni Valley Operations					1
	off mill	Aug/77	5	354 ± 206	130 - 670	
	Somass Estuary	Aug/77	2	15 ± 7	L10 - 20	
	at Airport (old sludge dump)	Aug/77	1	290		
	Johnson Isl. (new dump material)	Aug/77	1	80		
	Johnson Isl. (old dump material)	Aug/77	1	190		
	dredge spoil dumpsite N. of Stamp Narrows	Aug/77	3	283 ± 223	140 - 540	

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
111	MacMillan Bloedel (cont.)					1
	Alberni Pacific Division -	Aug/77	1	158		
	dredge area	Jan/80	3	793 ± 872	280 - 1800	
		Feb/80	1	100		
	pocket jack ladder area	Feb/79	1	1900		
	pocket barker barge area	Feb/79	1	7		
	China Creek log sorting area	Aug/77	1	20		
	Somass Division	Jan/79	2	120	120 - 120	
		Dec/79	2	205 ± 233	40 - 370	
	Sproat Lake Division dredge	Aug/77	1	50		
	area	Jan/79	1	20		
		Nov/79	2	24 ± 26	ND - 42	
		Jan/80	3	8 ± 5	ND - 14	
		Feb/80	2	81 ± 83	22 - 140	
		Feb/81	2	77 ± 102	L5 - 150	
		Jan/81	3	53 ± 84	120 - 120	
111	Alberni Inlet	Jun/81	2	58 ± 33	34 - 81	1
111	Alberni Pulp & Paper	Jan-Feb/79	8	322 ± 506	10 - 1500	1
	Division	Nov-Dec/79	7	626 ± 489	170 - 1400	
		Nov/80	5	1822 ± 2093	350 - 5500	
		Jun/81	3	46 ± 24	16 - 52	
		Dec/81	5	596 ± 481	42 - 1000	

continued...

APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
111	Clutesi Haven Boat Basin	Feb/79	3	L20	L20 - L20	1
111	Haggards Cove, Alberni Inlet	Jul/81	1	30		1
112	Courtenay Slough Marina	Jun/77				1
	at marina		1	L5		
	outside marina in Courtenay River		1	260		
113	Tahsis Co. Ltd. Gold R. Pulp Mill					
	Log Dump A-1	Aug/80	1	88		1
		Jan/80	2	L5	L5 - L5	
	Log Bundling Operation	Dec/79	2	9 ± 5	L5 - 12	
	Barkers #1 & 2	Dec/79	2	L5	L5 - L5	
	Pulp Mill at dock	Dec/79	2	24 ± 3	22 - 26	
	Pulp Mill-chip unloading	Dec/79	2	L5	L5 - L5	
114	Tahsis Inlet-sawmill					1
	Hemlock Mill-"A" log dump	Aug/80	1	42		
		Feb/80	1	30		
	Log Haul	Feb/80	1	L5		
		Feb/81	1	L5		
	Alberni Dock	Feb/80	1	L5		
		Feb/81	1	L5		
	H. Mill "area"	Jul/79	1	L5		
	#1 sea dock	Feb/80	1	170		
		Feb/81	1	8		
	dock area	Jul/79	1	L5		

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APPENDIX 2 PCB CONCENTRATIONS IN SEDIMENTS OF BRITISH COLUMBIA (ppb dry weight)

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
114	Tahsis Inlet (cont.)					1
	grid	Aug/80	1	24		
		Mar/81	1	L5		
	Cedar Mill-Alley 2	Feb/80	1	L5		
		Feb/81	1	L5		
	-Bark	Aug/80	1	24		
	-Gravel	Aug/80	1	6		
		Jan/80	2	L5	L5 - L5	
115	Zeballos - Logging					1
	Log dump	Jan/80	2	12 ± 9	5 - 18	
	Bark	Aug/80	1	62		
	Bark & Sand	Aug/80	1	6		
	Campbell R. Ferry Terminal		5	112 ± 140	13 - 350	1
116	Baikie's Slough, Campbell River	Jun/77				1
	dock area		composite	12 ± 1	11 - 13	
	Campbell R. at entrance to Baikie's Slough		1	L5		
	Campbell River, Ferry Terminal		5	112 ± 140	13 - 350	
116	Discovery Inn Marina, Campbell R.	Jun/77				1
	near gas floats		composite	112		
	in dock area		1	92		
	outside marina area		1	L5		
117	MacMillan Bloedel, Kelsey Bay	Dec/80	4	5 ± 6	L5 - 13	1
118	MacMillan Bloedel, Eve River	Feb/81	4	5 + 5	L5 - 10	1

APPENDIX 3

PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA

APPENDIX 3 PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA (ppb wet weight)

SITE NO.	LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	Range	DATA SOURCE REFERENCE
	Fraser River Estuary Sturgeon Bank							
1		Speckled sanddab	muscle	1973	composite	214.0		11
2		Flounder	muscle	Aug/78	1	640.0		2
			muscle	Nov/78	1	167.0		2
3		Salmon	muscle	Aug/78	1	44.0		2
		Flounder	muscle	Aug/78	1	650.0		2
			muscle	Nov/78	1	ND		2
	Roberts Bank							
4		Flounder	muscle	Aug/78	1	2.0*		2
			muscle	Nov/78	1	1.0*		2
	Fraser River - North Arm							
10-15		Northern squawfish	muscle	1973	2	1039.8 ± 867.1	426.7-1652.9	12
		Dolly varden	muscle	1973	1	ND		12
		Largescale sucker	muscle	1973	4	90.8 ± 104.2	ND-198.7	12
		Peamouth chub	muscle	1973	1	527.3		12
		White sturgeon	muscle	1973	2	167.3 ± 43.1	136.9-197.8	12
		Rainbow trout	muscle	1973	5	116.5 ± 171.8	TR-314.1	12
		Carp	muscle	1973	1	933.9		12

*Concentrations below the level of confident quantification

continued...

APPENDIX 3 PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA (ppb wet weight)

SITE NO.	LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	PCB CONCENTRATION Range	DATA SOURCE REFERENCE
	Fraser River - North Arm (cont.)							
		Staghorn sculpin	muscle	1973	2	5.45 ± 9.2	48.0-61.0	4
		Northern squawfish	muscle	1973	2	404.0 ± 519.0	37.0-771.0	4
		Dolly varden	muscle	1973	3	68.3 ± 55.5	11.0-122.0	4
		Largescale sucker	muscle	1973	2	44.0 ± 31.1	22.0-66.0	4
		Peamouth chub	muscle	1973	2	123.0 ± 111.7	44.0-202.0	4
		White sturgeon	muscle	1973	2	162.0 ± 42.4	132.0-192.0	4
		Cutthroat trout	muscle	1973	2	468.5 ± 392.4	191.0-746.0	4
		Black crappie	muscle	1973	5	13.4 ± 12.7	ND-31.1	4
		Staghorn sculpin	muscle	1980	2	200.0 ± 100.0	L100.0-300.0	13
		Northern squawfish	muscle	1980	10	180.0 ± 90.0	L100.0-300.0	13
		Dolly varden	muscle	1980	2	200.0 ± 100.0	L100.0-300.0	13
		Largescale sucker	muscle	1980	19	150.0 ± 100.0	L100.0-500.0	13
		Peamouth chub	muscle	1980	20	150.0 ± 160.0	L100.0-800.0	13
		White sturgeon	muscle	1980	6	200.0 ± 170.0	L100.0-500.0	13
		Rainbow trout	muscle	1980	2	L100.0	L100.0-L100.0	13
		Sockeye salmon	muscle	1980	7	L100.0	L100.0-L100.0	13
13	Mitchell Island	Prickly sculpin	muscle	Apr/80	5	140.0 ± 110.0	30.0-320.0	14
			liver	Apr/80	composite	820.0		14
15	off Belkin Paper-board plant	Prickly sculpin	muscle	Feb/80	4	320.0		15
		Staghorn sculpin	muscle	Feb/80	5	210.0		15
		Rainbow trout	muscle	Feb/80	1	400.0		15
		Peamouth chub	muscle	Feb/80	9	2400.0		15
		Starry flounder	muscle	Feb/80	5	110.0		15
	¼ mile u/s Belkin plant	Prickly sculpin	muscle	Feb/80	1	320.0		15

continued...

APPENDIX 3 PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA (ppb wet weight)

SITE NO.	LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	Range	DATA SOURCE REFERENCE
15	Tree Island	Prickly sculpin	muscle	Apr/80	5	610.0 ± 600.0	L20.0-1400.0	14
			liver	Apr/80	composite	740.0		14
	Fraser River - Main Arm							
16-21		Northern squawfish	muscle	1973	11	522.0 ± 547.7	ND-1894.4	12
		Largescale sucker	muscle	1973	6	163.2 ± 126.0	ND-259.4	12
		White sturgeon	muscle	1973	11	161.9 ± 118.5	ND-317.7	12
		Peamouth chub	muscle	1973	3	92.1 ± 156.1	ND-272.4	12
		Rainbow trout	muscle	1973	1	138.8		12
		Cutthroat trout	muscle	1973	2	118.6 ± 23.8	101.7-135.4	12
		Sockeye salmon	muscle	1973	5	ND	ND-ND	12
		Chinook salmon	muscle	1973	2	86.8 ± 4.7	83.5-90.1	12
		Staghorn sculpin	muscle	1973	5	171.4 ± 189.7	22.0-495.0	4
		Northern squawfish	muscle	1973	4	153.0 ± 155.0	40.0-382.0	4
		Dolly varden	muscle	1973	3	127.6 ± 128.4	26.0-272.0	4
		Largescale sucker	muscle	1973	2	166.5 ± 177.5	41.0-292.0	4
		Peamouth chub	muscle	1973	2	132.0	132.0-132.0	4
		White sturgeon	muscle	1973	2	372.0 ± 212.1	222.0-522.0	4
		Rainbow trout	muscle	1973	2	72.3 ± 93.0	9.5-141.0	4
		Staghorn sculpin	muscle	1980	1	L100.0		13
		Northern squawfish	muscle	1980	6	L100.0	L100.0-100.0	13
		Dolly varden	muscle	1980	3	L100.0	L100.0-100.0	13
		Largescale sucker	muscle	1980	10	L100.0	L100.0-100.0	13
		Peamouth chub	muscle	1980	12	L100.0	L100.0-100.0	13
		White sturgeon	muscle	1980	5	L100.0	L100.0-100.0	13

continued...

APPENDIX 3 PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA (ppb wet weight)

SITE NO.	LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	PCB CONCENTRATION Range	DATA SOURCE REFERENCE
20	Tilbury Island	Prickly sculpin	muscle	Mar/80	5	60.0		15
		Staghorn sculpin	muscle	Mar/80	3	90.0		15
		Starry flounder	muscle	Mar/80	5	40.0		15
		Eulachon-adult	muscle	Mar/80	1	20.0		15
		-juvenile	muscle	Mar/80	6	220.0		15
		Dolly varden	muscle	Mar/80	1	70.0		15
		Cutthroat trout	muscle	Mar/80	1	110.0		15
21	Annacis Island	Prickly scuplin	muscle	Apr/80	5	30.0 ± 4.0	22.0-32.0	14
			liver	Apr/80	composite	360.0		14
	Fraser River - downstream Mission							
22-25		Northern squawfish	muscle	1973	1	ND		12
		Largescale sucker	muscle	1973	1	623.4		12
		Peamouth chub	muscle	1973	1	ND	ND-ND	12
		White Sturgeon	muscle	1973	2	ND		12
		Mountain whitefish	muscle	1973	1	ND		12
		Rainbow trout	muscle	1973	5	143.2 ± 53.6	58.2-192.8	12
		Cutthroat trout	muscle	1973	4	128.2 ± 56.9	77.1-208.5	12
		Northern squawfish	muscle	1973	2	227.0 ± 213.5	76.0-378.0	4
		Largescale sucker	muscle	1973	2	150.0 ± 87.7	88.0-212.0	4
		Peamouth chub	muscle	1973	2	297.0 ± 154.1	188.0-406.0	4
		White sturgeon	muscle	1973	3	58.0 ± 14.0	42.0-68.0	4

continued...

APPENDIX 3 PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA (ppb wet weight)

SITE NO.	LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	PCB CONCENTRATION Range	DATA SOURCE REFERENCE
	Fraser River - downstream Mission							
24	at Pitt River	Prickly sculpin	muscle	Mar/80	4	30.0		15
		Starry flounder	muscle	Mar/80	5	110.0		15
		Eulachon -juveniles	muscle	Mar/80	8	230.0		15
		Chinook salmon	muscle	Mar/80	2	140.0		15
		Northern squawfish	muscle	Mar/80	2	110.0		15
25	upper Fraser R. near Whonnock gov't wharf	Prickly sculpin	muscle	Apr/80	5	70.0 ± 40.0	32.0-130.0	14
			liver	Apr/80	composite	640.0		14
26	Nathan Creek, Fort Langley	Coho salmon (fry/smolt)	whole fish	Jun/78	composite 5	20.0		1
		Coho salmon (fry/smolt)	whole fish	Jun/78	composite 5	30.0		1
		Coho salmon (fry/smolt)	whole fish	Jun/78	composite 6	20.0		1
		Steelhead-smolt	whole fish	Jun/78	1	20.0		1
		Steelhead-smolt	whole fish	Jun/78	composite (2)	20.0		1
		Lamprey-smolt	whole fish	Jun/78	1	80.0		1
		Sculpin-smolt	whole fish	Jun/78	1	30.0		1

continued...

APPENDIX 3 PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA (ppb wet weight)

SITE NO.	LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	PCB CONCENTRATION Range	DATA SOURCE REFERENCE
	Fraser River - downstream Chilliwack							
27-29		Northern squawfish	muscle	1973	4	43.4 ± 82.8	ND-167.5	12
		Dolly varden	muscle	1973	1	164.3		12
		Largescale sucker	muscle	1973	3	1330.3 ± 2053.0	ND-3694.9	12
		Peamouth chub	muscle	1973	3	ND	ND-ND	12
		White sturgeon	muscle	1973	1	ND		12
		Mountain whitefish	muscle	1973	1	ND		12
		Rainbow trout	muscle	1973	18	42.1 ± 43.5	ND-106.2	12
		Cutthroat trout	muscle	1973	1	ND		12
		Staghorn sculpin	muscle	1973	1	ND		4
		Northern squawfish	muscle	1973	2	153.5 ± 187.4	21.0-386.0	4
		Dolly varden	muscle	1973	3	27.0 ± 20.8	15.0-51.0	4
		Largescale sucker	muscle	1973	2	36.5 ± 48.8	Trace-71.0	4
		Peamouth chub	muscle	1973	2	267.0 ± 79.2	211.0-323.0	4
		White sturgeon	muscle	1973	3	126.0 ± 25.5	108.0-144.0	4
		Cutthroat trout	muscle	1973	4	131.3 ± 111.8	4.0-276.0	4
		Black crappie	muscle	1973	1	11.9		4
		Rainbow trout	muscle	1973	2	181.5 ± 19.1	168.0-195.0	4
	Fraser River - downstream Hope							
30-31		Northern squawfish	muscle	1973	26	46.0 ± 111.6	ND-526.7	12
		Largescale sucker	muscle	1973	18	142.9 ± 193.5	ND-589.7	12

continued...

APPENDIX 3 PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA (ppb wet weight)

SITE NO.	LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	Range	DATA SOURCE REFERENCE
	Fraser River - downstream Hope (cont.)							
30-31 (cont.)		Peamouth chub	muscle	1973	6	ND	ND-ND	12
		White sturgeon	muscle	1973	7	25.2 ± 61.5	ND-164.7	12
		Mountain whitefish	muscle	1973	6	ND	ND-ND	12
		Rainbow trout	muscle	1973	10	54.8 ± 82.3	ND-229.2	12
		Brown bullhead	muscle	1973	1	235.3		12
		Carp	muscle	1973	1	ND		12
		Northern squawfish	muscle	1973	2	171.5 ± 132.2	78.0-265.0	4
		Dolly varden	muscle	1973	1	61.0		4
		Largescale sucker	muscle	1973	2	114.5 ± 95.5	47.0-182.0	4
		Peamouth chub	muscle	1973	2	254.0 ± 2.8	252.0-256.0	4
		Cutthroat trout	muscle	1973	4	51.6 ± 14.4	39.0-65.0	4
		Rainbow trout	muscle	1973	2	26.0 ± 1.4	25.0-27.0	4
		Northern squawfish	muscle	1980	10	L0.1	L0.1-L0.1	13
		Dolly varden	muscle	1980	1	L0.1		13
		Largescale sucker	muscle	1980	9	L0.1	L0.1-L0.1	13
		Peamouth chub	muscle	1980	4	L0.1	L0.1-L0.1	13
		White sturgeon	muscle	1980	9	L0.1	L0.1-L0.1	13
		Sockeye salmon	muscle	1980	3	L0.1	L0.1-L0.1	13
	Fraser River - upstream Hope							
32-33		Northern squawfish	muscle	1980	25	L100.0	L100.0-L100.0	13
		Dolly varden	muscle	1980	12	L100.0	L100.0-L100.0	13

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APPENDIX 3 PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA (ppb wet weight)

SITE NO.	LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	PCB CONCENTRATION Range	DATA SOURCE REFERENCE
	Fraser River - upstream Hope (cont.)							
32-33 (cont.)		Largescale sucker	muscle	1980	30	L100.0	L100.0-L100.0	13
		Peamouth chub	muscle	1980	4	L100.0	L100.0-L100.0	13
		White sturgeon	muscle	1980	10	130.0 ± 90.0	L100.0-400.0	13
		Sockeye salmon	muscle	1980	11	L100.0	L100.0-L100.0	13
34	Moose Lake	Dolly varden	muscle	1980	6	L100.0	L100.0-L100.0	13
		Longnose sucker	muscle	1980	10	L100.0	L100.0-L100.0	13
		Rainbow trout	muscle	1980	3	L100.0	L100.0-L100.0	13
35	McLeese Lake	Sucker	muscle	Dec/76	composite	595.0 ± 417.0	300.0-890.0	16
			liver	Dec/76	composite	280.0 ± 170.0	160.0-400.0	16
		Rainbow trout	muscle	Dec/76	composite	220.0 ± 127.0	130.0-310.0	16
			liver	Dec/76	composite	360.0 ± 156.0	250.0-470.0	16
		Rainbow trout	muscle	Jul/77	4	35.0 ± 33.0	ND-80.0	13
		Sucker	muscle	Jul/77	2	ND	ND-ND	13
			muscle	Sept/77	6	8.33 ± 7.7	L5.0-24.0	8
		Squawfish	muscle	Jul/77	8	20.0 ± 13.0	ND-40.0	13
			muscle	Sept/77	5	7.39 ± 4.83	L5.0-16.0	8
		Minnows	muscle	Sept/77	1	11.0		8
		Rainbow trout	muscle	Sept/78	3	5.3 ± 0.6	L5.0-6.0	8
		Sucker	muscle	Sept/78	5	L5.0	L5.0-L5.0	8
		Squawfish	muscle	Sept/78	6	L5.0	L5.0-L5.0	8
35	Sheridan Creek near powerline	Unknown	muscle	Sept/77	1	L5.0		8
		Rainbow trout	muscle	Sept/78	1	L5.0		8
	at Gibralter Creek	Unknown	muscle	Sept/77	1	L5.0		8
		Rainbow trout	muscle	Sept/78	1	L5.0		8

continued...

APPENDIX 3 PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA (ppb wet weight)

SITE NO.	LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	Range	DATA SOURCE REFERENCE
	Fraser River - upstream Hope (cont.)							
35	Sheridan Creek cont.							
	at unnamed creek	Unknown	muscle	Sept/77	1	11		8
		Rainbow trout	muscle	Sept/78	1	6		8
	Cuisson Lake	Unknown	muscle	Sept/77	1	L5.0		8
		Rainbow trout	muscle	Sept/78	1	L5.0		8
35A	Williams lake	Whitefish	muscle	Jul/77	2	ND	ND-ND	13
		Sucker	muscle	Jul/77	2	ND	ND-ND	13
		Rainbow trout	muscle	Jul/77	2	250 ± 198	110-390	13
		Squawfish	muscle	Jul/77	2	75 ± 21	60-90	13
36	Okanagan Lake	Rainbow trout	muscle	1976		280.0 ± 270.0	ND-1830.0	16
38	Takla Lake	Lake whitefish	muscle	Jan/79	2	L23.0	L23.0-L23.0	17
		Lake trout	muscle	Jan/79	4	L23.0	L23.0-L23.0	17
39	Nation Lakes	Rainbow trout	muscle	Jan/79	4	L23.0	L23.0-L23.0	17
		Lake trout	muscle	Jan/79	8	L23.0	L23.0-L23.0	17
40	Witch Lake	Lake whitefish	muscle	Jan/79	3	L23.0	L23.0-L23.0	17
		Lake trout	muscle	Jan/79	3	L23.0	L23.0-L23.0	17
		Rainbow trout	muscle	Jan/79	1	L23.0		17
41	Stuart Lake	Sockeye salmon	muscle	Jan/79	2	L23.0	L23.0-L23.0	17
42	Babine Lake	Lake trout	muscle	Jan/79	7	35.0	L23.0-110.0	17
		Lake whitefish	muscle	Jan/79	1	L23.0		17
		Kokanee	muscle	Jan/79	3	L23.0	L23.0-L23.0	17

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APPENDIX 3 PCB CONCENTRATIONS IN FISH OF BRITISH COLUMBIA (ppb wet weight)

SITE NO.	LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	Range	DATA SOURCE REFERENCE
43	Prince Rupert Area							
	West Kinnahan Isl. -23mi. W. Port Edward	Flounder	whole fish	1977	composite	L5.0		1
		Salmonids	whole fish	1977	composite	L5.0		1
	Chatham Sound - Trawl #1	Flounder	whole fish	1977	composite	17.0		1
		Rockfish	whole fish	1977	composite	L5.0		1
	Trawl #2	Flounder	whole fish	1977	composite	L5.0		1
	Trawl #4	Flounder	whole fish	1977	composite	L5.0		1
43	Prince Rupert Area (cont.)							
	Porpoise Harbour Stn. B	Sculpins	whole fish	1977	composite	88.0		1
		Salmonids	whole fish	1977	composite	183.0		1
	Stn. C	Sculpins	whole fish	1977	composite	41.0		1
	N. of Stn. C	Herring	whole fish	1977	composite	28.0		1
	Stn. D	Salmonids	whole fish	1977	composite	297.0		1
		Sculpins	whole fish	1977	composite	225.0		1

APPENDIX 4

PCB CONCENTRATIONS IN AQUATIC INVERTEBRATES OF BRITISH COLUMBIA

APPENDIX 4 PCB CONCENTRATIONS IN AQUATIC INVERTEBRATES OF BRITISH COLUMBIA (ppb wet weight)

Site No.	LOCATION	SPECIES	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	PCB CONCENTRATION Range	DATA SOURCE REFERENCE
	Fraser River Estuary						
2	Sturgeon Bank	clams	Aug/78	composite	ND		2
			Nov/78	composite	0.05*		2
3		clams	Aug/78	composite	ND		2
			Nov/78	composite	0.3*		2
		crabs	Aug/78	composite	56.0		2
			Nov/78	composite	213.0		2
4	Roberts Bank	clams	Aug/78	composite	ND		2
			Nov/78	composite	76.0		2
			1980	composite	L20.0		3
		crabs	Aug/78	composite	0.014*		2
			Nov/78	composite	ND		2
5	Boundary Bay-vicinity of Airport pumphouse	marine gastropods	Aug/78	composite	L5.0	L5.0-L5.0	1
6	False Creek	crabs	May/79	2	26.0 ± 23.0	9.0-42.0	1
	under N. Arm Burrard Bridge	crabs	Aug/78	composite	23.0		1
		mussels	Aug/78	composite	14.0		1
7	under N. end Granville St. Bridge	crabs	Aug/78	composite	160.0		1
		mussels	Aug/78	composite	17.0		1
8	Coal Harbour	crabs	May/79	2	200.0 ± 110.0	120.0-280.0	1

* Concentrations below the level of confident quantification.

continued...

APPENDIX 4 PCB CONCENTRATIONS IN AQUATIC INVERTEBRATES OF BRITISH COLUMBIA (ppb wet weight)

Site No.	LOCATION	SPECIES	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	PCB CONCENTRATION Range	DATA SOURCE REFERENCE
9	Burrard Yarrows Shipyard, Burrard Inlet	mussels	1980	composite	400.0		3
		shipworms (Teredo)	1980	composite	L20.0		3
		crabs	1980	composite	L20.0		3
35	McLeese Lake Area						
	Sheridan Creek - entry to McLeese Lake	invertebrates	Dec/76	composite	370.0		1
	Sheridan Creek		Sept/77	(3) composite	6.3 ± 2.3	L5.0-9.0	8
			Sept/78	(3) composite	L5.0	L5.0-L5.0	8
	McLeese Lake		Sept/77	(2) composite	L5.0	L5.0-L5.0	8
			Sept/78	(2) composite	L5.0	L5.0-L5.0	8
37	Bowyer Island, Howe Sound	mussels	1980	composite	20.0		3
43	Prince Rupert area (following Cancel PCB spill)						
	Porpoise Harbour off Cancel Mill	Dungeness crab	Jan/77	2	81.6 ± 77.6	ND-240.0	1
		Spider crab	Jan/77	1	72,900		1
	off B.C. Packers	Dungeness crab	Jan/77	1	ND		1
	Porpoise Harbour	Dungeness crab					1
	Stn. C-1		Jun/77	3	1340 ± 1220	350-2700	
			Jul/78	2	50 ± 30	30-70	
			Jul/79	2	27 ± 2	25-58	
			Aug/80	1	L50		
	Stn. C-2		Jun/77	3	31 ± 23	10-55	
			Jul/78	2	100 ± 70	56-150	
			Jun/79	2	12 ± 10	L5-19	
			Aug/80	1	L50		

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APPENDIX 4 PCB CONCENTRATIONS IN AQUATIC INVERTEBRATES OF BRITISH COLUMBIA (ppb wet weight)

Site No.	LOCATION	SPECIES	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	PCB CONCENTRATION Range	DATA SOURCE REFERENCE
43	Prince Rupert area (cont.)						
	Porpoise Harbour	Dungeness crab					1
	Stn. C-3		Jun/77	3	6 ± 1	L5-7	
			Jul/78	2	70 ± 30	50-88	
	Stn. C-4		Jun/77	2	153 ± 208	6-300	
			Aug/81	3	13.3 ± 8.5	L5-22	
	Stn. C-5		Jun/77	2	150 ± 40	120-180	
			Jul/78	2	250 ± 10	240-260	
	Stn. C-6		Jun/77	2	90 ± 20	70-100	
			Jul/78	2	36 ± 17	24-48	
			Jun/79	2	L5	L5-L5	
			Aug/80	1	L50		
			Aug/81	3	19.7 ± 12.5	7-32	
	Stn. C-7		Jun/77	2	L5	L5-L5	
			Jul/78	2	170 ± 150	64-280	
	Stn. C-8		Jul/78	2	36 ± 17	24-48	
	Stn. C-9		Jun/79	2	100 ± 138	L5-200	
			Aug/80	1	L50		
	Stn. C-10		Jul/78	2	190 ± 140	90-290	
	Stn. C-11		Jun/79	2	20 ± 15	9-30	
			Aug/80	1	L50		
	Stn. C-12		Jul/78	2	230 ± 155	120-340	
	Stn. C-13		Jun/79	2	26 ± 29	L5-46	
			Aug/80	1	L50		
	Porpoise Harbour						1
	Stn. F immediately adjacent	mussels	Jun/77	composite	17,000*		
	spill area	isopods	Jun/77	composite	14,000*		
		algae	Jun/77	composite	83,000*		

*The elevated concentrations are due largely to external contamination of the organisms rather than to incorporation of PCB into the tissues.

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APPENDIX 4 PCB CONCENTRATIONS IN AQUATIC INVERTEBRATES OF BRITISH COLUMBIA (ppb wet weight)

Site No.	LOCATION	SPECIES	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	PCB CONCENTRATION Range	DATA SOURCE REFERENCE
43	Prince Rupert area (cont.)						
	Porpoise Harbour						1
	Stn. A - 800 m N. off spill	isopods	Jun/77	composite	770.0		
	area	amphipods	Jun/77	composite	1300.0		
		polychaetes	Jun/77	composite	530.0		
		algae	Jun/77	composite	150.0		
	Stn. D - S. of Kaien Isl.	amphipods	Jun/77	composite	184.0		
		isopods	Jun/77	composite	383.0		
		mussels	Jun/77	composite	254.0		
		polychaetes	Jun/77	composite	344.0		
	Stn. B. - off Ridley Isl.	shrimp	Jun/77	composite	85.0		
	E. coast	clams	Jun/77	composite	87.0		
		isopods	Jun/77	composite	147.0		
		amphipods	Jun/77	composite	194.0		
		mussels	Jun/77	composite	216.0		
		polychaetes	Jun/77	composite	39.0		
		algae	Jun/77	composite	L5.0		
	Stn. E. - off B.C. Packers	polychaetes	Jun/77	composite	1200.0		
		amphipods	Jun/77	composite	1095.0		
		mussels	Jun/77	composite	179.0		
	Chatham Sound						1
	Stn. C - Lelu Isl. W. coast	polychaetes	Jun/77	composite	85.0		
		clams	Jun/77	composite	29.0		
	Trawl #1	shrimp	1977	composite	61.0		
	Trawl #2	shrimp	1977	composite	L5.0		
	Trawl #3	shrimp	1977	composite	L5.0		
	Trawl #4	shrimp	1977	composite	L5.0		

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APPENDIX 4 PCB CONCENTRATIONS IN AQUATIC INVERTEBRATES OF BRITISH COLUMBIA (ppb wet weight)

Site No.	LOCATION	SPECIES	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean ± S.D.	Range	DATA SOURCE REFERENCE
43	Prince Rupert area (cont.)						1
	Stn. H - W. Kinnahan Isl. (3.3 mi. W. of Port Edward (control stn.))	mussels	Jun/77	composite	9.0		
		isopods	Jun/77	composite	L5.0		
		amphipods	Jun/77	composite	L5.0		
	Stn. G - Prescott Isl. (12.6 mi. W. of Port Edward) (control stn.)	clams	Jun/77	composite	36.0		
44	Alice Arm area						
	Lime Creek	mussels	Oct/80	composite	100.0		1
		mussels	Feb/81	1	1700.0		1
		mussels	May/81	composite (5)	86 ± 181	L5 - 410	1
	Roundy Creek	mussels	Oct/80	composite	210.0		1
		cockle	Oct/80	1	L20.0		1
		mussels	Feb/81	composite 3	860.0 ± 140.0	720.0-1000.0	1
	Perry Bay	mussels	Feb/81	composite 3	120.0 ± 20.0	110.0-140.0	1
	near Kitsault Mine	mussels	May/81	composite (2)	40 ± 47	6 - 73	1
45	Nanoose Bay	oysters	Mar/77	composite	ND		1
46	Piper's Lagoon	oysters	Mar/77	composite	ND		1
47	Shoregrove Resort	oysters	Mar/77	composite	ND		1
48	Nanaimo-Five Fingers Sewage outfall	prawns	Oct/78	composite	L5.0		1
49	Crofton	oysters	Jan/77	7	ND	ND-ND	1

APPENDIX 5

PCB CONCENTRATIONS IN BIRDS OF BRITISH COLUMBIA

APPENDIX 5 PCB CONCENTRATIONS IN BIRDS OF BRITISH COLUMBIA (ppm wet weight)

LOCATION	SPECIES	TISSUE	DATE	NO. OF SAMPLES	PCB CONCENTRATION Mean $\pm$ S.D.	PCB CONCENTRATION Range	DATA SOURCE REFERENCE
Coquitlam	Great Blue Heron	eggs	May/77	12	14.9 $\pm$ 22.5	0.65-64.8	18
Crescent Beach	Great Blue Heron	eggs	May/77	11	3.67 $\pm$ 0.87	2.88-5.65	18
Point Roberts	Great Blue Heron	eggs	May/77	13	7.28 $\pm$ 6.93	0.98-20.9	18
McGillvary Slough	Great Blue Heron	eggs	May/77	2	6.12 $\pm$ 6.91	1.23-11.0	18
Pender Harbour	Great Blue Heron	eggs	May/77	12	7.16 $\pm$ 8.67	0.84-33.2	18
UBC Endowment	Great Blue Heron	eggs	Feb/78	12	21.4 $\pm$ 13.4	6.9-50.2	18

APPENDIX 6

PCB DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean + S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
	OIL REFINERIES					
15	Standard Oil, Burnaby					
	- storm & cooling water	Jan/77	3	ND (ND-ND)	negligible	1
	- process wastewater	Jan/77	3	ND (ND-ND)	negligible[2]	1
14	Imperial Oil, Ioco					
	- combined process wastewater & cooling water	Jan/77	3	ND (ND-ND)	negligible	1
	- combined process wastewater & cooling water	Jan/77	1	0.017	negligible	1
	CHEMICAL & PAINT COMPANIES					
4	Dow Chemical, Ladner	Jan/77	2	ND (ND-ND)	negligible	1
		Jan/77	1	L0.005	negligible	1
13	Reichhold Chemical, Port Moody					
	- cooling water	Jan/77	1	ND	negligible	1
	- process wastewater		1	ND	negligible[2]	1
11	Domtar Chemicals, New Westminster					
	- cooling water	Jan/77	1	ND	negligible	1
		Jan/77	1	L0.005*	negligible	1
18	Hooker Chemicals, Harmac	Oct/78	1	0.005	negligible	1

continued...

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean + S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
	CHEMICAL & PAINT COMPANIES (cont.)					
5	Cloverdale Paint & Chemical, Surrey	Jan/77			(no direct discharge)	
	- process wastewater & solvents from holding tank		1	0.24	negligible[2]	1
	- cooling water		1	ND	negligible	1
	PULP AND PAPER INDUSTRY					
19	Rayonier Canada Ltd., Port Alice	Feb/77				
	- North Sewer (discharge from bleach plant)		2	ND (ND-ND)	negligible	1
	- Acid plant (cooling water)		2	ND (ND-ND)	negligible	1
	- Wood room (discharge from hydraulic debarker)			ND (ND-ND)	negligible	1
32	Eurocan Pulp & Paper Ltd., Kitimat	Feb/77	3	ND (ND-ND)	negligible	1
		Feb/77	1	0.014	negligible	1
29	Weyerhauser Can Ltd., Kamloops	Mar/77	3	ND (ND-ND)	negligible	1
	PAPER PLANTS					
10	Scott Paper, Burnaby	Apr/76	1	L0.020	negligible	6

continued...

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean ± S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
	PAPER PLANTS (cont.)					
7	MacMillan Bloedel Island Paper, Annacis Isl.	Apr/76	1	L0.020	negligible	6
9	Belkin Paperboard, Burnaby	Apr/76	1	0.454	5.07	6
	- clarifier effluent discharge	Nov/78	4	0.18 (0.12-0.28)	4.5 (3.0-7.0)	1
		Nov/78	composite	0.25	6.2	1
		Apr-May/79	4 composite	2.4 ± 2.1 (0.07-4.6)	51.3 (1.50-98.4)	15
	- clarifier sludge	Apr-May/79	4	2733 ± 2980 (4700-68500)		1
9	Belkin Packaging Ltd., Burnaby	Jan/80	1	0.08	1.64	19
		Feb/80	composite	0.13 ± 0.03 (0.11-0.17)	5.41 (2.29-3.54)	19
		Mar/80	composite	1.39 ± 1.65 (L0.02-4.24)	26.83 (0.39-81.83)	19
		Apr/80	composite	4.19 ± 2.62 (0.91-6.87)	76.1 (16.5-124.8)	19
9	Belkin Landfill-culvert leaving fill area	Jun/80	1	0.10		20
	- control site: peat bag N. of fill area	Jun/80	1	0.09		20
	- water immed adjacent to fill	Jun/80	1	0.10		20
	- outfall to river (#1)	Jun/80	1	0.06		20
	- outfall to river (#2)	Jun/80	1	0.21		20
9	Belkin Paperboard	May/80	4	----	52.5 (40.0-60.0)	21

continued...

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean ± S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
	PAPER PLANTS (cont.)					
9	Belkin Paperboard (cont.)	Jun/80	5	----	66.0 (40.0-100.0)	21
		Jul/80	4	----	32.5 (L10.0-60.0)	21
		Aug/80	4	----	L10.0 (L10.0-L10.0)	21
		Sept/80	4	----	L10.0 (L10.0-12.0)	21
		Oct/80	4	----	17.0 (16.0-18.0)	21
		Nov/80	8	----	12.5 (10.0-15.0)	21
		Dec/80	3	----	9.0 (6.4-12.0)	21
		Jan/81	4	----	7.5 (6.0-9.0)	21
		Feb/81	4	----	4 (1.0-7.0)	21
		Mar/81	3	----	1.5 (1.0-2.0)	21
		Apr/81	1	----	3.0	21
		May/81	1	----	4.0	21
		Jun/81	1	----	4.0	21
		Jul/81	1	----	4.0	21
		Aug/81	1	----	4.0	21
		Sept/81	1	----	3.0	21
		Oct/81	1	----	3.0	21

continued...

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean $\pm$ S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
9	Belkin Paperboard cont.					
		Nov/81	1	----	3.0	21
		Dec/81	1	----	3.0	21
	MINES & SMELTERS					
30	Noranda Boss Mountain	1977	1	L0.010	negligible	1
	United Keno Hill Yukon [Decant]		1	L0.010	negligible	1
22	Granby Mine, Greenwood					
	- pond seepage	1977	1	L0.010	negligible	1
25	Cominco - H.B. Salmo	1977	1	L0.010	negligible	1
26	Cominco - Kimberley	1977	1	L0.010	negligible	1
	Cyprus Anvil - Yukon					
	- tailings	1977	1	L0.010	negligible	1
	- seepage	1977		L0.010	negligible	1
32	Alcan Smelters & Chemicals Ltd., Kitimat	Feb/77				1
	Discharge #1					
	- wet scrubber liquor; pot lining scrap pile run off; casting cooling water;		2	ND (ND-ND)	negligible	
	surface drainage		1	0.019	negligible	
	Discharge #2					
	- surface drainage coke - calciner area drainage		2	1.66 $\pm$ 2.31 (ND-3.29)	negligible	

continued...

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean ± S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
	Discharge #3 - cooling water from casting; cooling water from rectifiers; surface drainage		2	ND (ND-ND)	negligible	
24	Cominco Trail	Feb/77				1
	Discharge #1 - cooling water; floor washings & coal dryer inpinger wastewater		1	ND	negligible	
	Discharge #2 - primarily cooling water for slag granulation		1	ND	negligible	
	Discharge #3/4 - cooling water from lead slag furnaces & slag furnaces & slag retreatment boilers		1	ND	negligible	
	Discharge #5 - from head sintering plant, lead slag furnace, zinc plant		1	ND	negligible	
	Discharge #6 - zinc plant effluent	Feb/77	1	ND	negligible	1
	Discharge #7 - lead smelter absorption plant & cooling tower water	Feb/77	1	ND	negligible	
	Discharge #8 - from zinc roasters, zinc & acid plants	Feb/77	1	ND	negligible	
	Discharge #9 - from assay labs & lead refinery generator rooms	Feb/77	1	ND	negligible	
	Discharge #10 - from lead refinery & research building	Feb/77	1	ND	negligible	

continued...

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean ± S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
	Cominco Trail cont.					
	Discharge #11					1
	- primarily cooling water from lead blast furnace	Feb/77	1	ND	negligible	
	OTHER FACILITIES					
1	Roberts Bank Westshore Terminals Coal Superport					
	- settling pond	Jan/77	1	2.98		1
	- runoff collection pond	Jul/78	1	L0.05	negligible	1
	SEWAGE TREATMENT PLANTS					
6	Annacis Island S.T.P.	Oct. 5-8/76				
	- influent		4	0.059 ± 0.023 (0.027-0.079)		1
	- effluent - pre-chlorination		4	0.066 ± 0.039 (0.028-0.120)		1
	- dechlorinated		4	0.034 ± 0.022 (0.021-0.067)	4.51 (2.78-8.88)	1
	- effluent	March 8,1978	1	0.24	35.57-44.74	22
6	Annacis Island S.T.P. - Raw sludge	Nov/79	1	trace		1
	- Digester sludge	Nov/79	1	trace		1
8	Iona Island S.T.P.	1976				1
	- influent		4	0.143 ± 0.036 (0.110-0.190)		1

continued...

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean ± S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
8	Iona Island S.T.P. cont.					1
	- effluent - pre-chlorination		4	0.090 ± 0.019 (0.068-0.110)		1
	- post-chlorination		4	0.081 ± 0.018 (0.064-0.100)	30.72 (24.27-37.93)	1 1
	- effluent	March 8,1978	1	0.3	93.54-171.0	22
	- digester sludge	1976	1	1100.0		1
	- raw sludge	1976	1	1900.0		1
2	Lulu Island S.T.P.- effluent	March 8, 1978	1	0.13	2.30-3.32	22
20	Abbotsford S.T.P.	June 24-25/76				1
	- influent		2	0.078 ± 0.017 (0.066-0.090)		
	- effluent - pre-chlorination		2	0.051 ± 0.011 (0.043-0.059)		
	- effluent - post-chlorination		2	0.048 ± 0.025 (0.030-0.065)	negligible	1
21	Mission S.T.P.	July 6-9/76	4			1
	- influent			0.052 ± 0.021 (0.031-0.078)		
	- effluent - pre-chlorination			0.037 ± 0.037 (0.013-0.092)		
	- effluent - post-chlorination			0.030 ± 0.010 (0.081-0.043)	negligible	
23	Penticton S.T.P.	July 20-23/76				1
	- influent		4	0.048 ± 0.008 0.039-0.057		

continued...

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean ± S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
23	Penticton S.T.P. (cont.)					1
	- effluent - pre-chlorination		4	0.019 ± 0.015 0.007-0.040		
	- post-chlorination		4	0.015 ± 0.004 0.011-0.020	negligible	
	- mixed liquor		1	0.47		
	- secondary digester sludge		1	840.0		
27	Clinton S.T.P.	Aug. 3-5/76				1
	- influent		2	0.039 ± 0.006 (0.035-0.043)		
	- effluent - unchlorinated		2	0.019 ± 0.001 (0.018-0.019)	negligible	
28	Cache Creek S.T.P.	Aug.31-Sept.3				1
	- influent		4	0.052 ± 0.011 (0.037-0.062)		
	- effluent - pre-chlorination		4	0.047 ± 0.004 (0.043-0.051)		
	- post-chlorination		4	0.036 ± 0.006 (0.031-0.044)	negligible	
31	Williams Lake S.T.P.	Aug.11-12/76	2			1
	- influent			0.052 ± 0.011 (0.044-0.059)		
	- effluent - pre-chlorination			0.006 ± 0.001 (L0.005-0.007)		
	- post-chlorination			0.005 ± 0.001 (L0.005-0.006)	negligible	

continued...

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean ± S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
17	Lake Cowichan S.T.P.	Oct.20-21/76				1
	- influent		2	0.047 ± 0.033 (0.024-0.070)	negligible	
	- effluent - pre-chlorination		2	L0.005 (L0.005-L0.005)		
	- post-chlorination		2	L0.005 (L0.005-L0.005)	negligible	
	- de-chlorinated		2	L0.005 (L0.005-L0.005)	negligible	
33	Prince George S.T.P.	Sept.14-17/76				1
	- influent		4	0.108 ± 0.047 (0.041-0.141)		
	- effluent - pre-chlorination		4	0.023 ± 0.008 (0.013-0.031)		
	- post-chlorination		4	0.028 ± 0.004 (0.024-0.033)	negligible	
	- primary digester sludge		2	2500 ± 566 (2100-2900)		
	LANDFILLS					
16	Hartland Dump - leachate	Jul/79	2	L0.4 (L0.4-L0.4)	NO	13 13
	Victoria Disposal - leachate	Jul/79	4	L0.4 (L0.4-L0.4)	AVAILABLE	13
3	Richmond Landfill - leachate	1976	1	20.0	INFORMATION	6
	Site A	1976	1	ND		13
	Site B	1976	1	1.4		13

continued...

APPENDIX 6 PCB EFFLUENT DISCHARGES FROM INDUSTRIAL AND MUNICIPAL SOURCES IN BRITISH COLUMBIA

Site No.	LOCATION	DATE	NO. OF SAMPLES	Concentration (ppb) Mean ± S.D. (Range)	Loadings (g/day)	DATA SOURCE REFERENCE
	STORM SEWERS	Jul/76				1
	88th Ave. & King George Hwy, Surrey (A/R)		1	0.196	NO	
	King George Hwy & Fraser Hwy, Surrey (C)		1	1.023		
	Bryne Rd., Burnaby (I/R)		1	0.055	AVAILABLE	
	Kaymar Ravine, Burnaby (R)		1	0.691		
	Deer Lake & Buckingham, Burnaby (R)		1	0.563	INFORMATION	
	Springer at Lumberland, Burnaby (R/F)		1	0.330		
	B.C.I.T. Pond, Burnaby (R)		1	1.170		
	Kyle St., Port Moody (R/C)		1	0.638		
	Williams St., Port Moody (R/I)		1	0.756		
	Schoolhouse Ave., Port Moody (R)		1	0.090		
	Grandview Hwy. & Nootka, Vanc. (R/I)		1	0.103		
	Boundary & 2nd Ave., Vanc. (R/C/I)		1	0.166		
	Collingwood St., Vanc. (R)		1	0.451		
	Rhodes St., Vanc. (R)		1	0.776		
	UBC Campus (near Cecil Green) (Campus)		1	ND		

1 Loadings calculated from maximum allowable volume of discharge specified on permit. These values probably represent an overestimate of actual loadings.

2 Process wastes do not discharge directly to the environment. Wastes are either discharged to sewer system or collected by a waste disposal company.

APPENDIX 7

PCB CONCENTRATIONS IN SOILS OF BRITISH COLUMBIA

APPENDIX 7 PCB CONCENTRATIONS IN SOILS OF BRITISH COLUMBIA (ppm dry weight)

LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	Range	DATA SOURCE REFERENCE
1 FALSE CREEK AREA					
Burrard St. bridge - directly under rocker bearings at S. end.	Aug/78	3	2777 ± 4438	130-7900	1
- grid sampling under bridge	Aug/80				1
Site 1		1	0.31		
2		1	1.4		
3		2	42,000 ± 31,000	20000-64000	
4		1	110		
5		1	4		
6		1	45		
7		1	11		
8 (control)		1	0.42		
9		1	50		
- following removal of surface soils	Apr/81	9	972 ± 1123	9-3200	1
B.C. Place Development Site	Feb/81	3	0.006 ± 0.010	L0.005-0.017	1
	Apr/81	5	0.059 ± 0.069	0.005-0.140	1
Granville St. bridge					1
- close to abandoned transformer	Aug/78	1	120		
	Sept/78	1	15		
- grid around transformer	Sept/78	2	0.090 ± 0.050	0.042-0.150	

continued...

APPENDIX 7 PCB CONCENTRATIONS IN SOILS OF BRITISH COLUMBIA (ppm dry weight)

LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean + S.D.	Range	DATA SOURCE REFERENCE
2 COAL HARBOUR					
Bayshore Inn construction site	Jul/79	1			23
Borehole 1'			0.018		
3'			ND		
8'			ND		
12'			ND		
17'			ND		
22'			ND		
3 RICHMOND					
Bridgeport Rd. area					
- soil from oiled road	Sept/78	1	0.008		1
- soil from base of power pole	Sept/78	1	L0.005		1
Ditch - area N. or Moncton St; S. of Granville Ave; E. of River Rd; W. of Gilbert Rd.	Jun/79	1	L0.020		1
Ditch - area N. of Williams Rd; S. of Granville Ave.; E. of Gilbert; W. of No.4 Rd.	Jun/79	1	L0.020		1
Ditch - River Rd. dyke; ditch W. of Dinsmore Bridge	Jun/79	1	L0.020		1
Ditch - ditch inside River Rd. dyke beside Sturgeon Bank	Apr/78	2	L0.020		1

continued...

APPENDIX 7 PCB CONCENTRATIONS IN SOILS OF BRITISH COLUMBIA (ppm dry weight)

LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean + S.D.	Range	DATA SOURCE REFERENCE
4 SURREY - soil from oiled roads	Aug/78	5	32 ± 51	0.58-120	1
SURREY - B.C. Hydro Electric Shop					
- following cleanup of soil area	Apr/80	2	0.062 ± 0.081	L0.005-0.120	8
5 BOUNDARY BAY - soil from oiled roads	Aug/78	1	L0.005		1
6 CULTUS LAKE					
- soil from oiled roads	Apr/78	7	0.034 ± 0.023	L0.005-0.061	1
7 CHILLIWACK LAKE Rd. area					
- soil from oiled roads	Apr/78	2	L0.005	L0.005-L0.005	1
8 NORTH VANCOUVER; B.C. Rail Yard					
- soil from yard & oiled roads	Aug/78	4	0.010 ± 0.008	L0.005-0.022	1
- ditch sediment	Aug/78	1	0.022		1
9 SQUAMISH area					
- soil from oiled roads	Aug/78	3	0.47 ± 0.49	0.03-1.0	1
10 BOWEN ISLAND					
- soil from oiled roads	Apr/78	16	0.04 ± 0.04	L0.005-0.11	1

continued...

APPENDIX 7 PCB CONCENTRATIONS IN SOILS OF BRITISH COLUMBIA (ppm dry weight)

LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean ± S.D.	PCB Concentrations Range	DATA SOURCE REFERENCE
11 RUTLAND-WEST KOOTENAY Power & Light Substation					
- PCB spill area	Oct/77	1	14,000		24
- excavation site after removal of 2' surface soils	Oct/77	4	0.43 ± 0.86	ND-1.72	24
- excavation site after removal of 4' depth of surface soil	Nov/77	4	ND	ND-ND	24
- soil just outside spill area	Nov/77	2	ND	ND-ND	24
12 HARMER RIDGE, Kaiser Resources Ltd.					
- PCB spill site during excavation of contaminated soil	Sept/79	3	108132 ± 50652	54400-155000	13
- PCB spill site 2 feet below surface during excavation	Oct/79	3	25164 ± 21526	5860-21256	13
- PCB spill site 1 metre below surface during excavation	Oct/79	3	121.8 ± 107.2	3.2-211.75	13
- PCB spill site 1.3 metre below surface during excavation	Nov/79	2	5.02 ± 0.4	4.73-5.31	13
13 TRAIL Cominco Smelter Salvage Yard					
- spill area prior to soil removal	Jun/76	5	9409 ± 18346	2.8-42,000	9
- spill area after soil removal	Jun/76	5	107 ± 106	9.3-241	26
14 MACKENZIE B.C. Forest Products,	May/79				
PCB spill area - surface soil		1	150,000		25
- soils at 3 ft. depth		1	20,000		25

continued...

APPENDIX 7 PCB CONCENTRATIONS IN SOILS OF BRITISH COLUMBIA (ppm dry weight)

LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations Mean + S.D.	Range	DATA SOURCE REFERENCE
15 MCLEESE LAKE area - B.C. Hydro Substation					
- capacitor burial pit	Dec/76	4	11650 ± 20919	0.024-43,000	1
- capacitor storage area - quadrat sample	Jun/76	2	7500 ± 24000	58,000-92,000	1
- core sample	Jun/76	1	8.1		1
- south capacitor bank	May/78	1	0.5		8
- outside south capacitor bank (east side)	May/78	5	L0.005	L0.005-L0.005	8
- control - outside N.E. corner substation fence	May/78	1	L0.005		8
- outside E. fence at south capacitor bank	Nov/78	2	785 ± 45	753-816	13
- outside north capacitor bank (west side)	May/78	5	L0.005	L0.005-L0.005	8
- outside W. fence at north capacitor bank	Nov/78	2	465 ± 310	245-684	13
16 KITSAULT, AMAX, Kitsault Mine	Feb/80	2	101 ± 132	7.7 - 195	13
- near concentrate dryer	Mar/80	22	5182 ± 23421	0.058 - 110000	13
	Apr/80	10	2316 ± 7268	0.023 - 23000	13
	Apr/80	7	64 ± 116	0.018 - 310	13
17 STEWART, B.C. - abandoned Bonlie Logging Mill	Nov/77				1
- gravel beside transformer platform (3' depth)		1	6100		
- gravel 3' from transformer platform (1' depth)		1	462		
- surface gravel-25' from transformer platform		1	13		
- surface sediment - shoreline 280' from mill buildings		1	0.360		
18 FORT NELSON					
- site of abandoned transformers	Jul/81	?	approximately 100,000 - 300,000		13

APPENDIX 8

PCB CONCENTRATIONS IN GROUNDWATER FROM THE MCLEESE LAKE AREA

APPENDIX 8 PCB CONCENTRATIONS IN GROUNDWATER FROM THE MCLEESE LAKE AREA

LOCATION	DATE	NO. OF SAMPLES	PCB Concentration (ppb) Mean ± S.D.	Range	DATA SOURCE REFERENCE
B.C. Hydro Substation area, MCLEESE LAKE					
- capacitor burial pit	Dec/76	1	90,800		8
- capacitor storage area		1	947		8
- capacitor substation yard: Trench #1		1	0.295		8
Trench #2		1	391.96		8
- outside substation fence - N. side		3	0.334 ± 0.110	0.256-1.380	8
- W. side		1	0.041		8
- S.W. side		1	0.208		8
- along substation access road across from burial pit		4	0.573 ± 0.423	0.185-1.123	8
- in drainage ditch flowing S.W. from substation		1	8.010		8
- between substation fence & capacitor burial pit		1	5.734		8
- from wells outside capacitor substation fence					
- S.W. side capacitor substation	May/78	2	L0.010	L0.010-L0.010	8
- near N. capacitor bank	Mar/78	1	2.4		13
- near S. capacitor bank	Mar/78	1	3.4		13

APPENDIX 9

PCB CONCENTRATIONS IN DOMESTIC WELLS FROM THE MCLEESE LAKE AREA

APPENDIX 9 PCB CONCENTRATIONS IN DOMESTIC WELLS FROM THE MCLEESE LAKE AREA

LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations (ppb) Mean ± S.D.	Range	DATA SOURCE REFERENCE
MCLEESE LAKE area					
Well # 1	Dec/76	1	0.086		8
# 2	Dec/76	2	0.057 ± 0.066	0.010-0.103	8
# 3	Dec/76	2	0.028 ± 0.005	0.024-0.031	8
# 4	Dec/76	1	0.025		8
# 5	Dec/76	2	0.050 ± 0.045	0.018-0.082	8
# 6	Dec/76	2	0.058 ± 0.051	0.022-0.094	8
# 7	Dec/76	1	0.048		8
# 8	Dec/76	2	0.047 ± 0.060	L0.005-0.089	8
	Dec/76	1	0.008		1
# 9	Dec/76	3	0.039 ± 0.032	L0.005-0.070	8
#10	Dec/76	2	0.039 ± 0.042	0.009-0.068	8
#11	Dec/76	2	0.009	0.009-0.009	8
#12	Dec/76	2	0.020 ± 0.013	0.010-0.029	8
	Jun/76	1	0.071		1
	Dec/76	1	0.201		1
#14	Dec/76	2	0.035 ± 0.022	0.019-0.050	8
Glencairn Trailer Court	Dec/76	1	0.036		8

APPENDIX 10

PCB CONCENTRATIONS IN SURFACE WATERS FROM THE MCLEESE LAKE AREA

APPENDIX 10 PCB CONCENTRATIONS IN SURFACE WATERS FROM THE MCLEESE LAKE AREA

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations (ppb) Mean + S.D.	Range	DATA SOURCE REFERENCE
1	Sheridan Creek - near mouth	Jun/76	1	0.020		1
		Dec/76	1	L0.005		1
		Dec/76	1	0.387		8
2	- at unnamed creek	Jun/77	3	L0.010	L0.010-L0.010	8
		May/78	3	L0.010	L0.010-L0.010	8
3	- downstream Gibralter Creek	Dec/76	1	L0.005		1
4	- at Gibralter Creek	Jun/77	3	0.010	L0.010-0.012	8
		May/78	3	L0.010	L0.010-L0.010	8
5	- upstream Gibralter Creek	Dec/76	1	0.007		1
6	- at intersection with powerline	Jun/77	3	0.022	0.019-0.026	8
		May/78	3	L0.010	L0.010-L0.010	8
7	Gibralter Creek - above Sheridan Creek	Dec/76	1	0.030		1
8	- below pond	Dec/76	1	0.009		1
9	- above pond a)	Dec/76	1	0.008		1
	b)	Dec/76	1	0.395		1
10	Pond near Gibralter Cr. & Gibralter Mine Road	Jun/76	1	0.236		1
11	Gibralter Creek below road near substation	Jun/77	3	0.024 ± 0.006	0.021-0.032	8
		May/78	3	L0.010	L0.010-L0.010	8
12	Marsh area between Gibralter Cr. and substation	Jun/77	4	0.029 ± 0.011	0.020-0.045	8
		May/78	6	0.034 ± 0.029	L0.010-0.076	8

Continued...

APPENDIX 10 PCB CONCENTRATIONS IN SURFACE WATERS FROM THE MCLEESE LAKE AREA

Site No.	LOCATION	DATE	NO. OF SAMPLES	PCB Concentrations (ppb) Mean ± S.D.	Range	DATA SOURCE REFERENCE
	Secondary drainage system: Unnamed Creek draining into Sheridan Creek					
13	- pond in 2nd drainage area					
	- near intersection of gas line and	Dec/76	1	0.422		8
		Jun/77	3	0.019 ± 0.004	0.016-0.023	8
		May/78	3	L0.010	L0.010-L0.010	8
14	- at creek entrance and exit from marsh	Dec/76	2	0.031 ± 0.022	0.015-0.046	1
15	Cuisson Lake	Dec/76	2	0.164 ± 0.054	0.126-0.202	1
		Dec/76	1	0.78		8
		Jun/77	3	0.028 ± 0.006	0.022-0.033	8
		May/78	3	L0.010	L0.010-L0.010	8
16	McLeese Lake - north end	Dec/76	2	0.029 ± 0.009	0.022-0.035	8
17	- at Sheridan creek #1	Jun/77	3	0.010 ± 0.003	L0.010-0.015	8
		May/78	3	0.010	L0.010-L0.010	8
	#2	Jun/77	3	0.013 ± 0.004	L0.010-0.017	8
		May/78	3	0.010	L0.010-L0.010	8
18	- south end	Jun/77	3	L0.010	L0.010-L0.010	8
		May/78	3	L0.010	L0.010-L0.010	8
19	McLeese Creek					
	- below Duckworth Lake	Dec/76	1	0.236		8

APPENDIX 11

a) PCB CONCENTRATIONS IN HOME-GROWN FOOD PRODUCTS FROM THE MCLEESE LAKE AREA

b) HEALTH AND WELFARE GUIDELINES FOR MAXIMUM ACCEPTABLE PCB LEVELS IN FOOD PRODUCTS

APPENDIX 11a PCB CONCENTRATIONS IN HOME-GROWN FOOD PRODUCTS FROM THE MCLEESE LAKE AREA (ppm wet weight)

SAMPLE	DATE	NO. OF SAMPLES	PCB Concentrations (ppb) Mean + S.D.	PCB Concentrations (ppb) Range	DATA SOURCE REFERENCE
Calf - kidney	Nov/76	1	0.53		1
- liver	Nov/76	1	0.13		1
Beef - liver	Dec/76	1	N.D.		13
- heart	Dec/76	1	N.D.		13
Cow's milk	Dec/76	2	0.002	0.002-0.002	13
Chicken - eggs	Nov/76	composite of 3	0.37		1
	Nov/76	composite of 4	0.21		1
	Dec/76	composite	0.028		13
	Dec/76	composite	0.051		13
Chicken - muscle	Dec/76	1	0.13		13
Quail - muscle	Nov/76	1	0.55		1
Turkey - muscle	Dec/76	1	N.D.		13
Human milk	Dec/76	1	0.036		13
Cabbage	Dec/76	composite	N.D.		13
Onions	Dec/76	composite	N.D.		13
Carrots	Dec/76	composite	N.D.		13
Potatoes	Dec/76	composite	N.D.		13
Red Beets	Dec/76	composite	N.D.		13
Beet Greens	Dec/76	composite	N.D.		13
Strawberries	Dec/76	composite	N.D.		13
Wax Beans	Dec/76	composite	N.D.		13
Rhubarb	Dec/76	composite	N.D.		13

APPENDIX 11b HEALTH AND WELFARE GUIDELINES FOR MAXIMUM ACCEPTABLE PCB LEVELS IN FOOD PRODUCTS (wet weight basis)

Fish and Shellfish	2 ppm
Dairy Products	0.2 ppm
Poultry	0.5 ppm
Eggs	0.1 ppm

APPENDIX 12

ENVIRONMENTAL CONTAMINANTS ACT REGULATIONS

Registration
SOR/80-461 20 June, 1980

ENVIRONMENTAL CONTAMINANTS ACT

Chlorobiphenyl Regulations No. 1, amendment

P.C. 1980-1637 19 June, 1980

Whereas a copy of a proposed amendment to Chlorobiphenyl Regulations No. 1 was published in the *Canada Gazette* Part I on December 2, 1978, pursuant to section 5 of the Environmental Contaminants Act;

Whereas two notices of objection to the proposed amendment were filed with the Minister of the Environment and an Environmental Contaminants Board of Review, established in accordance with section 6 of the Act, conducted an inquiry in accordance with that section;

Whereas on February 25, 1980, the Board submitted its report to the Minister of the Environment and to the Minister of National Health and Welfare together with its recommendations and all evidence that was before the Board in accordance with subsection 6(4) of the Act;

And Whereas the report of the Board was made public by a Press Release dated March 26, 1980 and at a press conference held on March 26, 1980.

Therefore, His Excellency the Governor General in Council, on the recommendation of the Minister of the Environment and the Minister of National Health and Welfare, and in accordance with the recommendations of the Environmental Contaminants Board of Review, pursuant to paragraph 18(*c*) of the Environmental Contaminants Act, is pleased hereby to amend the Chlorobiphenyl Regulations No. 1, C.R.C., c. 564, in accordance with the schedule hereto.

SCHEDULE

1. Section 2 of the *Chlorobiphenyl Regulations No. 1* is revoked and the following substituted therefor:

"2. In these Regulations,

"Act" means the *Environmental Contaminants Act*;

"chlorobiphenyls" means those chlorobiphenyls that have the molecular formula $C_{12}H_{10-n}Cl_n$ in which "n" is greater than 2;

"electrical transformers" includes transformer/rectifier assemblies installed in a common enclosure;

"Minister" means the Minister of the Environment."

Enregistrement
DORS/80-461 20 juin 1980

LOI SUR LES CONTAMINANTS DE L'ENVIRONNEMENT

Règlement n° 1 sur les biphényles chlorés—Modification

C.P. 1980-1637 19 juin 1980

Vu qu'une copie d'un projet de modification au Règlement n° 1 sur les biphényles chlorés a été publiée dans la *Gazette du Canada*, Partie I, le 2 décembre 1978, en vertu de l'article 5 de la Loi sur les contaminants de l'environnement;

Vu que deux avis d'opposition à ce projet de modification ont été déposés auprès du ministre de l'Environnement et qu'une Commission d'étude sur les contaminants de l'environnement établie en vertu de l'article 6 de la Loi a fait enquête aux termes de cet article;

Vu que le 25 février 1980, la Commission a présenté son rapport au ministre de l'Environnement et au ministre de la Santé nationale et du Bien-être social, ainsi que ses recommendations et l'ensemble de la preuve dont elle a pris connaissance, conformément au paragraphe 6(4) de la Loi;

Et vu que ledit rapport a été rendu public le 26 mars 1980 par communiqué et conférence de presse.

À ces causes, sur avis conforme du ministre de l'Environnement et du ministre de la Santé nationale et du Bien-être social, suivant les recommandations de la Commission et en vertu de l'alinéa 18*c*) de la Loi sur les contaminants de l'environnement, il plaît à Son Excellence le Gouverneur général en conseil de modifier, conformément à l'annexe ci-après, le Règlement n° 1 sur les biphényles chlorés, C.R.C., c. 564.

ANNEXE

1. L'article 2 du *Règlement n° 1 sur les biphényles chlorés* est abrogé et remplacé par ce qui suit:

«2. Dans le présent règlement,

«biphényles chlorés» désigne les composés de la formule moléculaire $C_{12}H_{10-n}Cl_n$ où «n» est plus grand que 2;

«Loi» désigne la *Loi sur les contaminants de l'environnement*;

«Ministre» désigne le ministre de l'Environnement;

«transformateurs électriques» comprend les ensembles transformateurs/redresseurs installés dans une même enceinte.»

2. Section 3 of the said Regulations is revoked and the following substituted therefor:

"3. For the purpose of subsection 8(2) of the Act, the following commercial, manufacturing or processing uses are hereby prescribed as uses in respect of which chlorobiphenyls may not be used:

(*a*) use in the operation of any product, machinery or equipment other than

(i) electrical capacitors, electrical transformers and associated electrical equipment,

(ii) heat transfer equipment, hydraulic equipment, electromagnets, and vapour diffusion pumps that were designed to use chlorobiphenyls and were in use in Canada before September 1, 1977, and

(iii) machinery or equipment, the operation of which is intended to destroy the chemical structure of chlorobiphenyls;

(*b*) use in the operation of electromagnets that are used to handle food, animal feed or anything intended to be added to food or animal feed for any purpose whatsoever;

(*c*) use as a constituent of any product, machinery or equipment manufactured in or imported into Canada after September 1, 1977, other than electrical capacitors, electrical transformers and associated electrical equipment;

(*d*) use as a constituent of electrical capacitors, electrical transformers and associated electrical equipment manufactured in or imported into Canada after July 1, 1980;

(*e*) use in the servicing or maintenance of any product, machinery or equipment, other than electromagnets, electrical transformers and associated electrical equipment; and

(*f*) use as new filling or as make-up fluid in the servicing or maintenance of any electromagnet, electrical transformer or associated electrical equipment."

3. Sections 1 and 2 shall come into force on July 1, 1980.

2. L'article 3 dudit règlement est abrogé et remplacé par ce qui suit:

«3. Aux fins du paragraphe 8(2) de la Loi, les emplois suivants des biphényles chlorés dans le commerce, la fabrication ou la transformation sont interdits:

a) l'emploi dans l'exploitation de tout produit, machinerie ou équipement, sauf

(i) les condensateurs électriques, les transformateurs électriques et l'équipement électrique connexe,

(ii) l'équipement de transfert de la chaleur, l'équipement hydraulique, les électro-aimants et les pompes à diffusion de vapeur conçus pour utiliser des biphényles chlorés et mis en service au Canada avant le 1[er] septembre 1977, et

(iii) la machinerie ou l'équipement destinés à détruire la structure chimique des biphényles chlorés;

b) l'emploi dans l'exploitation d'électro-aimants utilisés pour la manutention d'aliments destinés à l'homme ou aux animaux ou de leurs additifs;

c) l'emploi dans les produits, la machinerie ou l'équipement fabriqués ou importés au Canada après le 1[er] septembre 1977, sauf les condensateurs électriques, les transformateurs électriques et l'équipement électrique connexe;

d) l'emploi dans les condensateurs électriques, les transformateurs électriques et l'équipement électrique connexe fabriqués ou importés au Canada après le 1[er] juillet 1980;

e) l'emploi pour la réparation ou l'entretien des produits, de la machinerie ou de l'équipement autres que les électro-aimants, les transformateurs électriques et l'équipement électrique connexe; et

f) l'emploi comme nouveau fluide de remplissage ou comme fluide d'appoint pour la réparation ou l'entretien des électro-aimants, des transformateurs électriques ou de l'équipement électrique connexe.»

3. Les articles 1 et 2 entrent en vigueur le 1[er] juillet 1980.

EXPLANATORY NOTE

(This note is not part of the Regulation, but is intended only for information purposes.)

These amendments now have the following effects:

(1) The use of chlorobiphenyls is restricted to use in those items listed in subparagraphs 3(*a*)(i), (ii) and (iii).

(2) Paragraph 3(*b*) prohibits the use of chlorobiphenyls in the operation of electromagnets that are used to handle food, animal feed or anything intended to be added to food or animal feed for any purpose whatsoever.

(3) Paragraph 3(*c*) prohibits the use of chlorobiphenyls as a constituent of any product manufactured in or imported into Canada after September 1, 1977, other than electrical capacitors, electrical transformers and associated electrical equipment.

(4) Subsection 3(*d*) removes, effective July 1, 1980, the exemption regarding electrical capacitors, electrical transformers and associated electrical equipment so that thereafter the use of chlorobiphenyls is totally prohibited as a constituent of any product, machinery or equipment manufactured in or imported into Canada.

(5) Paragraph 3(*e*) allows the use of chlorobiphenyls after July 1, 1980 in the servicing or maintenance of electromagnets, electrical transformers and associated electrical equipment. This means, for example, that existing chlorobiphenyls may be removed, filtered and returned to the same piece of equipment. However, in paragraph 3(*f*) the use of additional chlorobiphenyls as a new filling or as make-up in servicing or maintenance is prohibited. This does not, though, prohibit the use of a suitable non-chlorobiphenyl fluid as a new filling or as make-up.

NOTE EXPLICATIVE

(La présente note ne fait pas partie du règlement et n'est publiée qu'à titre d'information.)

Ces modifications qui entrent en vigueur le 1er juillet 1980 visent:

(1) à limiter l'emploi de biphényles chlorés dans l'exploitation de tout produit, machinerie ou équipement sauf certains articles;

(2) à interdire leur emploi dans les électro-aimants utilisés pour la manutention dans l'industrie alimentaire;

(3) à interdire leur emploi dans les produits fabriqués ou importés au Canada après le 1er septembre 1977, sauf les condensateurs électriques, les transformateurs électriques et l'équipement électrique connexe;

(4) à ne plus exempter les articles visés au paragraphe (3) de la présente note;

(5) à interdire leur emploi pour la réparation ou l'entretien des produits de la machinerie ou de l'équipement sauf certains articles;

(6) à interdire leur emploi comme nouveau fluide de remplissage ou comme fluide d'appoint pour la réparation ou l'entretien de certains articles.

QUEEN'S PRINTER FOR CANADA, OTTAWA, 1980 IMPRIMEUR DE LA REINE POUR LE CANADA, OTTAWA, 1980

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