The report of the ad hoc panel convened by the National Research Council of Canada to review the spill of polychlorinated biphenyls at the Federal Pioneer Ltd. site in Regina, Saskatchewan.

National Research Council of Canada

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THE REPORT OF THE AD HOC PANEL CONVENED BY THE NATIONAL RESEARCH COUNCIL OF CANADA TO REVIEW THE SPILL OF POLYCHLORINATED BIPHENYLS AT THE FEDERAL PIONEER LTD. SITE IN REGINA, SASKATCHEWAN

OTTAWA, ONTARIO

JANUARY 30, 1980

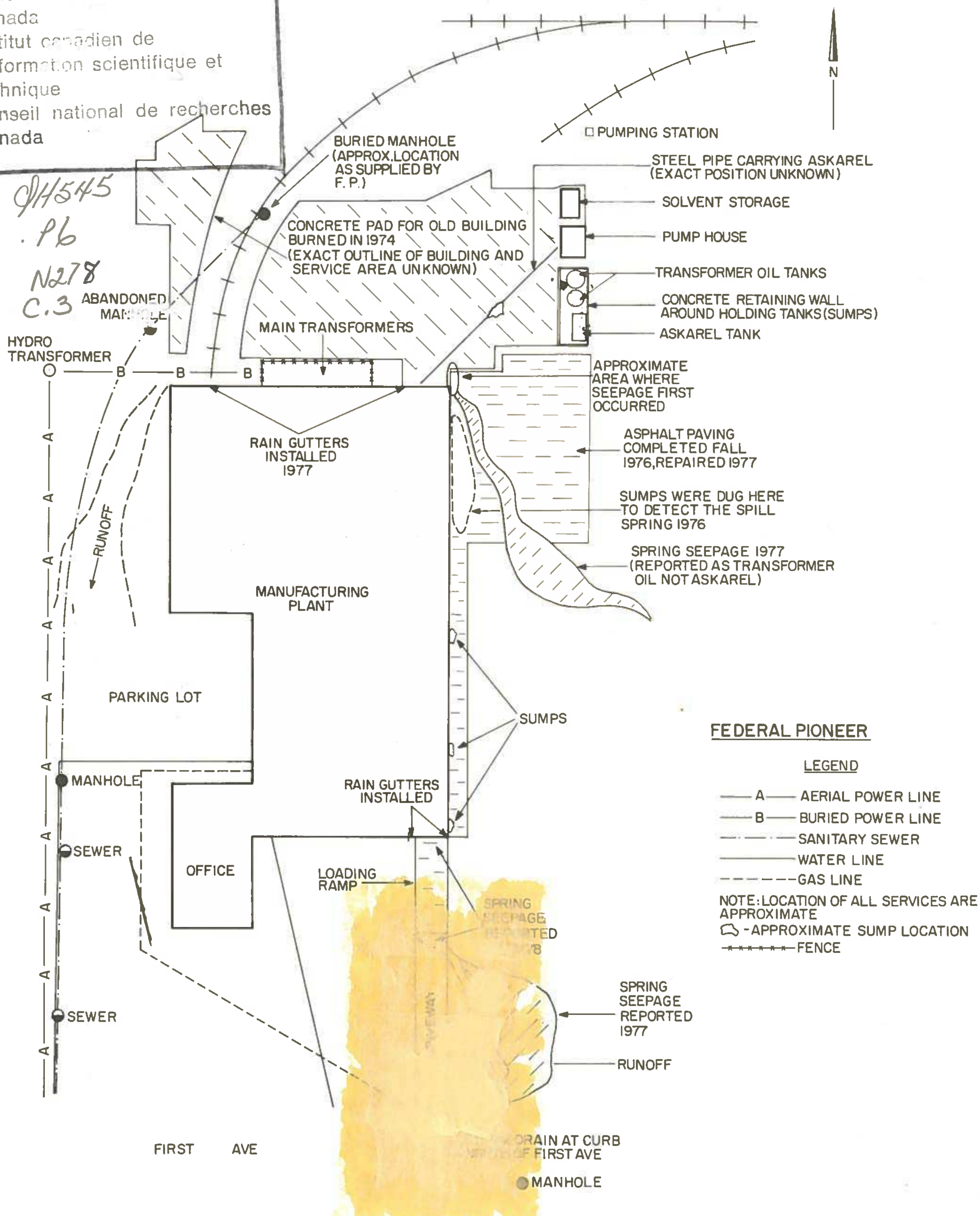

Figure 1. Historical site plan.

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Division of Biological Sciences | Division des sciences biologiques

File Reference 6110-15
6 February 1980

Mr. H.S. Maliepaard
Acting Deputy Minister
Saskatchewan Environment
5th Floor, 1855 Victoria Avenue
REGINA, Saskatchewan
S4P 3V5

Dear Mr. Maliepaard:

Re: PCB Spill at FPL, Regina

The NRC ad hoc Panel has been investigating this problem and conferring during the past year. Enclosed are 100 copies of "The Report of the Ad Hoc Panel Convened by the National Research Council of Canada to Review the Spill of Polychlorinated Biphenyls at the Federal Pioneer Ltd. Site in Regina, Saskatchewan", which contains the conclusions and recommendations of the Panel. The full details, results and analysis of the work are contained in NRCC report No. 17586 entitled "A CASE STUDY OF A SPILL OF INDUSTRIAL CHEMICALS — POLYCHLORINATED BIPHENYLS AND CHLORINATED BENZENES". This report has the following four parts:

I. "The Report of the Ad Hoc Panel Convened by the National Research Council of Canada to Review the Spill of Polychlorinated Biphenyls at the Federal Pioneer Ltd. Site in Regina, Saskatchewan" (prepared for the Government of Saskatchewan, 30 January 1980)

II. History, Distribution and Surface Translocation

III. Hydrogeological Conditions and Contaminant Migration

IV. Options for Remedial Actions

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Ottawa, Canada
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The final manuscripts of parts II, III and IV are in the last stages of editing for publication and we anticipate providing you with a prepublication copy by the end of February.

The Panel will describe verbally the contents of parts II, III and IV when we visit Regina on 14 February 1980.

Yours sincerely,

G.C. Butler

G.C. Butler
Chairman, NRC-PCB Panel

GCB/em

THE REPORT OF THE AD HOC PANEL CONVENED BY THE NATIONAL RESEARCH COUNCIL OF CANADA TO REVIEW THE SPILL OF POLYCHLORINATED BIPHENYLS AT THE FEDERAL PIONEER LTD. SITE IN REGINA, SASKATCHEWAN

OTTAWA, ONTARIO
30 JANUARY 1980

INTRODUCTION

In this decade, much public and scientific concern has been expressed about the presence of polychlorinated biphenyls (PCBs) in our environment and in our food. It is usually not the immediate lethal or overt effects associated with short-term exposures to PCBs that are of major concern, but the long-term cumulative effects. Attention is generally centered on their effects on reproduction, their role in carcinogenesis, their effect on liver functions and their potential as immunosuppressive agents.

PCBs were used in paints, lubricating oils and plastics, as heat transfer agents, as waterproofing agents, as dielectrics in transformers, and in many other products encountered by the public in their everyday activities. Voluntary restraints have decreased the use of PCBs since the early seventies. Since the middle of 1977, Federal restrictions have prohibited the use of PCBs in most products. However, PCBs are extremely persistent in the environment and, in spite of the present restrictions on their use, we can expect to encounter them in the environment and in our food for decades. It is not reasonable to expect that any regulatory or remedial action taken today can eliminate them completely. Thus, when considering measures to control PCBs in the environment, it is particularly important to distinguish between purely cosmetic actions that do not significantly decrease the exposure we encounter and those which really improve the situation.

HISTORY OF THE SPILL AT THE FEDERAL PIONEER LTD. FACTORY

In mid-1976 an underground pipe carrying PCBs from a 31,000 litre tank ruptured at a factory of Federal Pioneer Ltd. (FPL) in Regina, Saskatchewan, permitting leakage into the ground. The exact amount that was lost is not established, but Company records indicate that from 6800 to 21,000 litres of Inerteen 70-30[a] were involved. This material contains about 70% PCBs and about 30% chlorobenzenes (TCBs). Some of the PCBs were collected and removed soon after the spill, but a large portion remained in the ground at the site. Major remedial actions in the intervening years included the installation of eavestroughs on the building and the paving of the surface with asphalt in the general area of the leak. It was hoped that these actions would minimize the further spread of PCBs. As well, a limited sampling program was initiated in an attempt to define the extent of contamination.

The last transformer containing Inerteen 70-30 was shipped from the plant on 31 August 1976. Since then only mineral-oil-based transformer fluids have been used at FPL. Additional historical details can be found in Figure 1 and in the Scientific Report.

In the Fall of 1978, much concern was expressed publicly about the possible contamination by PCBs of groundwater in Regina. In response to these concerns, the Government of Saskatchewan asked the President of the National Research Council of Canada to establish an ad hoc panel of scientists to evaluate the available information on the nature and consequences of the spill and to prepare a public report. The terms of reference provided by the Government of Saskatchewan are:

1. To establish:
   - i) the chemical nature and quantity of the material released, as well as the conditions and duration of the release;
   - ii) the location and nature of the terrain receiving the material;
   - iii) what remedial measures were taken, and when.

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[a] Trade name.

2. To examine and evaluate the program of subsurface drilling and sample analysis carried out to date and in progress.
3. To determine and call for any additional monitoring and tests needed to assess the risk of future contamination of drinking water, groundwater, surface water, and the associated food chains in the region surrounding the spill. The results of the additional monitoring and tests may be required by the panel to reach its conclusions.
4. To assess the efficacy of containment measures already taken and, depending on the conclusions of this investigation, to recommend additional remedial measures including whether the contaminated soil on-site should be removed and, if so, to make recommendations with respect to its disposal.
5. To prepare a final report for Saskatchewan Environment which will be made public.

The members of the Panel are:

Dr. G.C. Butler (Chairman)
Consultant, Division of Biological Sciences
National Research Council of Canada
Ottawa, Ontario

Prof. J.A. Cherry
Department of Earth Sciences
University of Waterloo
Waterloo, Ontario

Dr. I. Hoffman
Environmental Secretariat
Division of Biological Sciences
National Research Council of Canada
Ottawa, Ontario

Dr. J.R. Roberts (Secretary)
Environmental Secretariat
Division of Biological Sciences
National Research Council of Canada
Ottawa, Ontario

Prof. F.W. Schwartz
Department of Geology
University of Alberta
Edmonton, Alberta

On 26 January 1979, the Panel met in Regina to examine the information provided by the Saskatchewan Department of the Environment, Environment Canada and FPL. It was the consensus of the Panel that the available information was not sufficient either to establish the extent of contamination or to determine the potential for PCBs to migrate at the site. It was concluded that additional site-specific information was needed concerning the distribution of PCBs and TCBs, as well as the relevant local geology and hydrology in the vicinity of the site. The Panel requested that basic information be obtained on the local stratigraphy, on the nature of the major geological units, on the extent of existing contamination, on the occurrence and movement of groundwater at the site, and on the horizontal and vertical movement of PCBs. In addition, the Panel sought information on the presence or absence of abandoned wells in the vicinity of the site and additional documentation on the nature and amounts of the chemicals involved in the spill.

The Saskatchewan Government agreed to mount and fund these studies with the understanding that members of the Panel would serve as voluntary consultants to the contractors and define the scope of work as well as the methodology. The studies could not have been completed without the cooperation and patience of the contractors and the personnel of FPL. Drs. Cherry, Schwartz and Roberts served as the consultants for the Panel. Dr. Roberts coordinated the studies.

GEOLOGY OF THE SITE

The factory and adjacent areas at the FPL site are underlain by a zone of highly porous granular fill, generally less than 2 m thick, that influences the accumulation and lateral movement of water near the surface. Underneath the fill, there is a 6-8 m thick zone of highly fractured clay that is referred to as the Regina clay. Below the Regina clay, Condie silt (approximately 4-7 m thick) rests on a zone of sandy glacial till (approximately 1-3 m thick) and about 3-4 m of hard till. Although there is reason to suspect that the deeper geological units may be fractured, the frequency of fractures is probably much reduced in the strata below the Regina clay. The permanent water table at the site is situated below the Condie silt in the sandy glacial till. The hard till is above a zone of bedded silt and fine sand, about 20-25 m thick. A zone of sand and gravel underlies the silt and is found about 37-59 m from ground surface. This unit is a major source of potable water and we have referred to it as the Regina Aquifer System.

CONTAMINATION PATTERNS

The following are the key findings on the extent of the contamination and the geological characteristics of the site which influence the migration of PCBs. More detailed discussions and supporting data are presented in Sections II and III of the Scientific Report.

Large quantities of PCBs lie within three zones bordering the building and extending under the floor, as well as in the sump around the tank in which PCBs were stored (see Figure 2 for details). One of these zones extends north along the railroad tracks. The sampling indicates that the contaminated areas are restricted to the FPL property and to a small number of areas immediately adjacent to the site. The downward migration of PCBs has been detected in the zones extending under the plant. While processes such as photolysis and microbial degradation will contribute to losses of the less chlorinated PCBs and TCBs at the surface, both classes of compounds are expected to be extremely persistent once they penetrate below the shallow biologically active zone of soil.

In one of the contaminated zones under the factory in the region of the leak, high levels of PCBs, exceeding 500 mg/kg, have been found throughout the Regina clay. Numerous small fractures in the clay enable the PCBs to move downward. Below the clay, the levels are up to 50,000 times lower than those in the upper strata of clay.

The contaminated zones which extend under the building are found in areas where water remains in depressions in the clay. The fill in these areas is saturated with water, resulting in a perched ground-water system. It is probable that this water promotes the movement of the PCBs both downward into the fractured clay and along the boundary between the Regina clay and the fill. PCBs are moving in a southerly direction under the building and this migration probably accounts for the seepage previously observed south of the building. In the other areas

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Units: 1 mg/kg = 1 ppm = one part in a million (1,000,000)
1 μg/litre = 1 ppb = one part in a billion (1,000,000,000)
1 ng/litre = 1 ppt = one part in a trillion (1,000,000,000,000)

examined, the downward movement of the PCBs has generally not been as extensive as that at the northeast corner.

While the majority of the zones of shallow contamination contain low levels of PCBs, a number of highly contaminated areas exist where PCB levels are in excess of 1000 mg/kg. In one place the concentration was 21,000 mg/kg. Much of the relatively low-level surface contamination is probably associated with the accumulation of contaminated soil because of the occurrence of erosion at the site. This process may account for the relatively small amounts of PCBs which are being transported to the storm sewer.

The Panel concludes on the basis of these data that the remedial measures have not been effective in controlling the spread of PCBs and that there is a need (i) to contain the surface contamination and (ii) to prevent downward and lateral migration of PCBs. The first objective must be accomplished immediately. A longer period of time will probably be needed to accomplish the second objective which would protect the quality of water in the Regina Aquifer System. From the monitoring of wells in the Regina region, including those closest to FPL, it can be concluded that unusual levels of PCBs or TCBs are not now entering Regina's water system.

The Regina Aquifer System receives a significant portion of its recharge from regional leakage through overlying layers of fine sand, silt and till. Downward recharge to the aquifer system occurs at the FPL site. Although it is unlikely that downward movement of PCBs from the sandy till through fractures in the hard till and through the interbedded silt and fine sand will cause a significant contribution of PCBs to wells in the Regina Aquifer System, this possibility cannot be conclusively discounted as a potential long-term threat to the quality of water in the aquifer system. The present level of understanding of the physical and chemical factors influencing the migration of PCBs in geological formations and of the hydrology of the FPL site in relation to the Regina Aquifer System are not sufficient, and not likely soon to be sufficient, to permit more certain predictions. Experience has shown that awareness of buried hazards tends to fade with time. There is, therefore, a real possibility that some future activity of man may open a direct connection to the Regina Aquifer System. Another possible problem is that PCBs may in future move laterally in the permanent water table zone to areas beyond the boundary of the FPL property where multiple pathways to aquifer systems may exist. In view of these doubts, we recommend:

i) the removal of the deeper, most highly contaminated areas in order to protect the Regina Aquifer System; and
ii) that new wells not be placed close to the site until the potential for lateral and downward migration of PCBs is corrected.

REMEDIAL ACTIONS

In recognition of the need to improve the situation at the site, the Panel has reviewed the available options and identified a set which will lead to a significant improvement not only in the short term but also in the long term. In light of this analysis, the Panel recommends the following:

A. Actions to Restrict the Surface and Near Surface Migration of PCBs

1. The earth in the highly contaminated shallow zones (Figure 2) should be removed to a depth of about 0.3-1 m into the Regina clay. The

excavated areas should be filled and capped with materials that will prevent the infiltration of water.

2. All erosion at the site should be controlled with sod or other effective techniques. If the measures are correctly designed, there should be no need to limit access to the areas now contaminated.

3. Runoff from the site should be collected and the suspended solids should be allowed to settle out before the water is drained away. If the system is well designed, the levels of PCBs in the drain water should be well below 40 μg/litre. Water containing these concentrations would not significantly add to the PCB exposure encountered by the residents of Regina if it is released into the storm or sanitary sewer systems. Initially, a monitoring program should confirm the effectiveness of the control measures.

4. The tank containing transformer oil (mineral oil) is presently situated in a concrete sump with an earth floor which contains high levels of PCBs. The tank should be relocated to an above-ground covered impermeable reservoir. The highly contaminated soil in the bottom of the old sump should be removed, and the hole should then be filled with materials that will prevent the infiltration of water. The Panel suggests that soils containing less than about 50-100 mg/kg wet weight (around 60-120 mg/kg on a dry-weight basis) could be left in place in this area. Underground service trenches filled with porous materials and other areas such as the railroad bed, which could act as paths for PCB migration, should be sealed.

5. Because high-yield wells placed close to the site may become contaminated and their placement may further aggravate the situation by changing groundwater flow patterns, we suggest that no new wells be installed closer to the plant than existing wells until the downward

migration is controlled or firm, well documented assurances can be given by hydrogeologists that the migration patterns of the PCBs at the site will not be affected by the installation(s).

B. Actions to Restrict the Deep Subsurface Migration of PCBs

The contaminated material that extends under the building should be removed if it contains more than about 50-100 mg/kg wet weight (about 60-120 mg/kg on a dry-weight basis) (see Figure 2).

Action B could involve the excavation and removal of 10,000-20,000 cubic metres of clay and fill from the site. This should not begin until adequate facilities are ready for the safe storage or destruction of the PCBs in the contaminated soil. Otherwise, the problem would merely be transplanted from one location to another.

It is essential that facilities for storage of PCBs be provided immediately and that the capability for their destruction be developed as soon as possible. If, however, there is to be any substantial delay it will be necessary to control the horizontal sub-surface migration of the PCBs with low permeability barriers. The installation of such barriers would be an added expense and any contaminated soil resulting from the excavation would itself require safe storage facilities. Also, such barriers are not permanent and they cannot be guaranteed to control the deep downward or deep lateral migration of the PCBs. Hence, we cannot accept them as a permanent method of preventing the spread of PCBs.

C. Requirements for Storage Facilities

Today, there are no approved operations or installations for the disposal or destruction of PCBs in soils in Canada. The problem is not due to a lack of technology, but rather to the fact that the general public and the regulatory authorities have not agreed on how our society should handle toxic wastes in Canada. Satisfactory techniques for the storage of PCBs in landfills and above-ground facilities can be envisaged. These could be applied to the Saskatchewan situation; the technical requirements will be outlined in Section IV of the Scientific Report. Ultimately the choice is between long-term containment in a landfill, with monitoring until the effectiveness of the system is established, or the destruction of the PCBs. The preferable method would be their destruction for this offers a permanent solution. While acceptable methods are available for the destruction of liquids containing PCBs, there are no economically acceptable methods for the destruction of PCBs in large amounts of solids such as soil. A number of promising techniques can be envisaged, but their practicality would have to be demonstrated through further research and development.

Agreement on the construction and operation of facilities for the containment of PCBs is the first step to improving the situation in Regina. The second step is to implement the recommendations in this report, including the establishment of the following monitoring program.

D. Monitoring Requirements for the FPL Site

It will be necessary to confirm the efficacy of the remedial program through future monitoring of the levels of PCBs and TCBs in:

i) water from the wells in the vicinity of the site;

ii) runoff and erosion reaching the storm sewers and sanitary sewers;

iii) soil strata below the Regina clay at the site including the water fraction.

Appropriate control samples should be included and analyzed as part of any monitoring program. It must be recognized by those designing or interpreting the program that the fracturing complicates the monitoring of the various soil strata. This must be taken into consideration in choosing the size of the samples and in interpreting the results. This point is discussed in more detail in Section II of the Scientific Report. It is important for the soil sampling program to be designed and validated by scientists experienced in the methodology of sampling deep strata for PCBs under the conditions found at the FPL site.

REQUIREMENTS FOR RESEARCH AND DEVELOPMENT

At all stages of the investigation the Panel was struck by the serious gaps in the scientific knowledge basic to handling chemical spills with confidence. The following detailed conclusions apply not only to the FPL site in Regina, but also to the management of toxic wastes anywhere in Canada.

1. Because spills of toxic wastes will continue to occur, facilities and accepted guidelines are required for the handling of all kinds of toxic wastes in Canada. Facilities should be licensed and a comprehensive waste management policy accepted and established.

2. There is a need for research that will lead to an improved understanding of the factors that influence the migration of PCBs and similar materials in soil.

3. The levels of PCBs in soils after a spill are often sufficiently high that their dynamics are described by complex equilibria between PCBs

in the soil, the water and the pure material. Studies are needed to establish the influence of these phenomena on the migration of PCBs in fractured and unfractured clays.

4. There will probably be a need in the future to remove chlorinated hydrocarbons, including PCBs, from potable water. Some approaches are promising but their effectiveness, reliability and costs are not established. Demonstration systems should be developed in Canada that permit one to lower PCB levels in large volumes of potable waters from the low μg/litre range to the low ng/litre range at an acceptable cost.

5. There is a need for rapid, inexpensive screening procedures for PCBs in soils.

6. There is a need for an economical method to destroy PCBs and other organic chemicals in large quantities of soils or other solids.

The Scientific Report, "A Case Study of a Spill of Industrial Chemicals — Polychlorinated Biphenyls and Chlorinated Benzenes" (NRCC No. 17586), is being published by the National Research Council of Canada. Copies may be purchased from Publications, NRCC, Ottawa, Ontario K1A 0R6.

ORGANIZATIONS CONSULTED IN THIS STUDY

Organization	General work description
Agriculture Canada, Swift Current, Saskatchewan and Ottawa, Ontario	neutron probe analysis, characterization of soil properties
BBT Geotechnical Consultants Ltd., Regina, Saskatchewan	soil sampling, mini-piezometer installation and contour maps
Clifton Associates Ltd., Regina, Saskatchewan	consulting engineer
E.A. Christiansen Consulting Ltd., Saskatoon, Saskatchewan	consulting geologist
Environment Canada, Edmonton, Alberta	soil analysis for PCBs and TCBs
Ontario Research Foundation, Mississauga, Ontario	soil analysis for PCBs and TCBs
SCIEX Inc., Thornhill, Ontario	soil analysis for PCBs and TCBs
Terraqua Investigations Limited, Waterloo, Ontario	piezometer installation, soil sampling and isotope analysis
Weizmann Institute of Science, Rehovot, Israel	isotope analysis

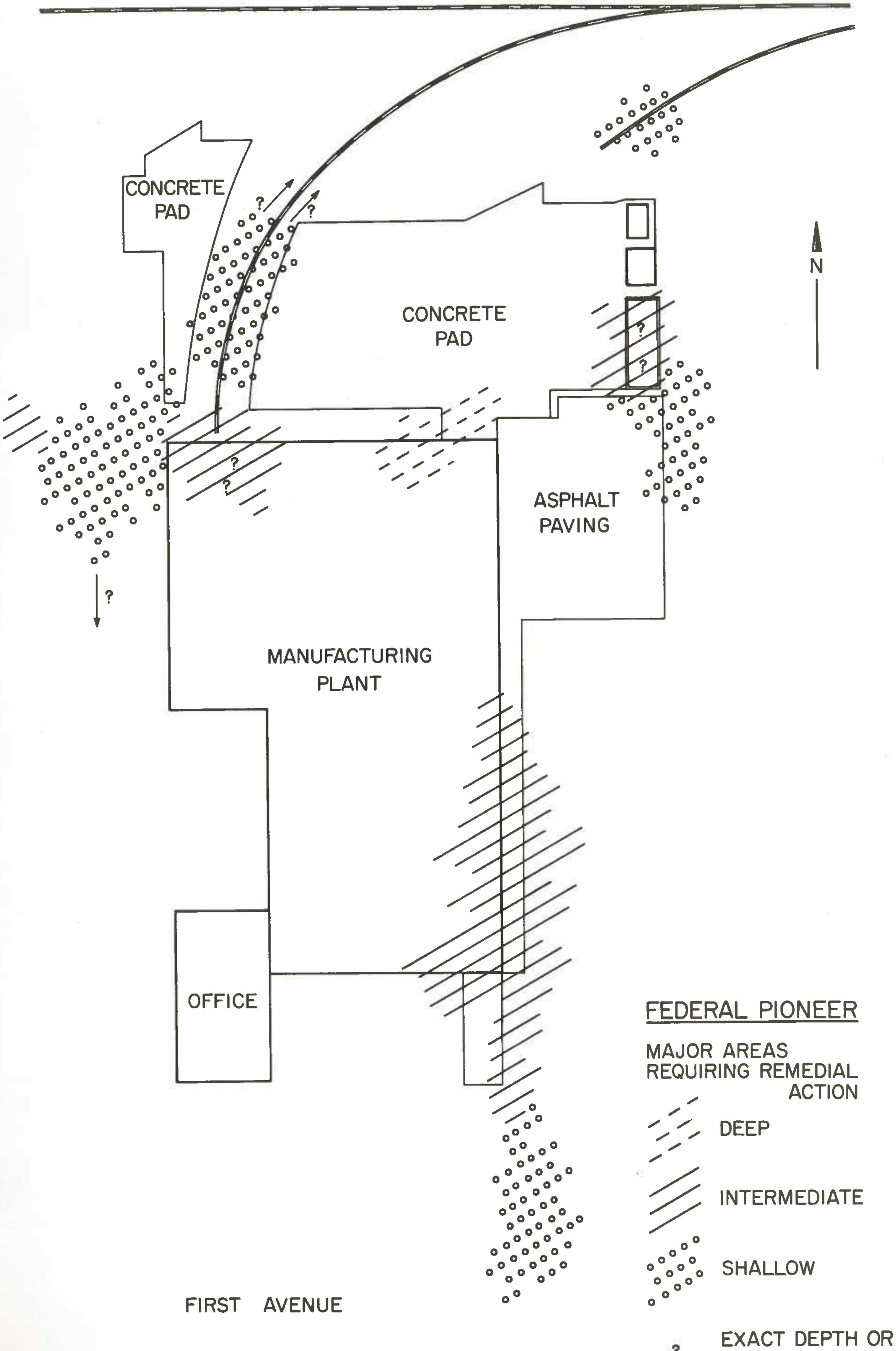

Figure 2. Major areas requiring remedial action.