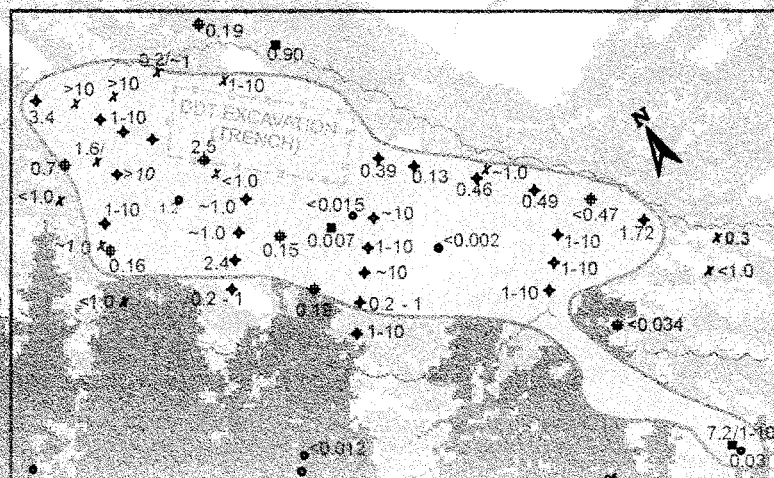


REMEDIATION AND CONFIRMATORY SAMPLING OF DDT CONTAMINATED SOILS AT BORDER PUMP STATION AND RAINY HOLLOW, BC, CANADA



Prepared for:
**INDIAN AND NORTHERN AFFAIRS, CANADA
WASTE MANAGEMENT PROGRAM
YUKON REGION**

Prepared by:



Applied Research Division

March 1999

**REMEDIATION AND CONFIRMATORY SAMPLING OF DDT
CONTAMINATED SOILS AT BORDER PUMP STATION AND
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Prepared for:

Indian and Northern Affairs Canada
Waste Management Program, Whitehorse, Yukon

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March 1999

EXECUTIVE SUMMARY

A summary of existing information and current data on the remediation and confirmatory sampling of DDT (includes p,p'-DDT, o,p'-DDT, p,p'-DDD, o,p'-DDD, p,p'-DDE, and o,p'-DDE isomers) contaminated soils at Border Pump Station and Rainy Hollow is presented in this report. Border Station, originally a pump station along the Haines-Fairbanks pipeline is within northwestern British Columbia, 8 km north of the Canada/U.S. border. The lower bench of the station is known as Rainy Hollow. The site was operated by the US military from the mid 1950's until it was decommissioned in 1972. Buildings and facilities at the site were subsequently used by various organizations until they were demolished in 1992-93. An emergency site investigation and cleanup was conducted in 1994 after canisters containing DDTs were discovered buried in a dump (Trench) at the lower bench. The canisters, along with soils and other materials suspected to be contaminated, were excavated and shipped off-site for disposal. Other contaminated soils remaining in the Trench were removed and stored in a Temporary Storage Facility constructed on the upper bench at Border Station. Contaminated materials in this facility were removed and disposed off-site in 1996.

Preliminary environmental investigations at Rainy Hollow in 1994 and Border Pump Station in 1995, indicated subsurface soils and groundwater contamination with DDTs and hydrocarbons. Subsurface contamination with DDTs was noted at Rainy Hollow in the area where the canisters were recovered while the hydrocarbon contamination was encountered at both sites. Results of a detailed site investigation and screening-level risk assessment (DSI) that was conducted in 1996 confirmed the hydrocarbon and DDT contamination. In addition, elevated concentrations of DDTs were detected in surface soils near the Trench, in the vicinity of the Temporary Storage Facility, and on access roads between the two facilities. Recommendations provided in the DSI report included removal of contaminated surface soils with DDT concentrations greater than 10 mg/kg (or ppm), capping of soils with DDT concentrations between 1- 10 mg/kg and site restoration to minimize surface soil erosion.

A total of 125 m³ of surface soils contaminated with DDTs at concentrations exceeding 10 mg/kg were excavated from the vicinity of the former Temporary Storage Facility and near the Trench at Rainy Hollow in 1997 and disposed off-site. This was to curtail the possible exposure pathways for DDTs in surface soils to wildlife and humans. The remaining DDT-contaminated soils with DDT concentration in the range of 1 to 10 mg/kg and hydrocarbon-contaminated soils with concentrations exceeding 1000 mg/kg were capped using a minimum of 0.5m of clean granular material.

A review of the confirmatory sampling results indicated additional sampling was needed, especially along the access roads to the Temporary Storage Facility at Border Station. Forty-two surface soil samples were therefore, collected from various locations along the access roads in the vicinities of the former Temporary Storage Facility in August 1998. All the samples were analyzed using immunoassay test kits. Ten split replicate samples were also analyzed at Axys Analytical Laboratory using gas chromatography with mass

spectrometric detection (GC-MS). Both the field test kit and laboratory results indicated that the concentrations of DDTs in most of the samples were less than 1.0 mg/kg. However, two locations in depressions along the access road east of the Temporary Storage Facility had DDTs in excess of 10 mg/kg. Contaminated soils in these two areas were excavated on October 29 and 30, 1998. The excavated soils were placed into 16 Mega Bag™ (Trimeg Holdings, Alberta) each with a capacity of 1 m³.

Field test kit and laboratory data for samples collected after excavation indicated successful removal of soils containing DDTs at concentrations exceeding 10 mg/kg. The excavated areas along with other locations identified as containing DDTs with concentrations between 1 – 10 mg/kg were capped with clean granular material. These areas were then re-graded to conform to the natural contours.

Over the course of the DSI and remedial activities (1996 – 1998), 200 soil samples collected from Border Station and Rainy Hollow were analyzed with the immunoassay field test kits. Out of these, 39 samples were analyzed using both field test kits and laboratory gas chromatographic methods, which represents 19% of total analyzed by test kits. A majority of the concentrations obtained using the field test kits agreed with the laboratory data. However, there was one false negative (underestimation of DDT concentration by the field test kit) and eight false positives (i.e., overestimation of the true DDT concentration). While some analyses were over-sensitive in no case did a sample determined to contain less than 1 mg/kg DDT using the field test kits have a real total DDT concentration greater than 1 mg/kg. According to the US EPA SW846-4000 Method for Immunoassay, the maximum permissible false negative rate is 5% while producing as few false positive results (nominally less than 20%). The results obtained in this investigation, 2.5% occurrence of false negatives and 20% false positives are therefore, within acceptable limits indicating that the EnviroGard™ DDT in Soil Test Kit served as a useful tool for field analysis.

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1. INTRODUCTION

1.1 Background

This report presents a summary of all new and existing information on the remediation and confirmatory sampling of DDT contaminated soils at Border Station and Rainy Hollow. These two contiguous sites are located in northwestern British Columbia, 8 km north of the Canada Customs Pleasant Camp. Border Station is situated on an upper bench, along the Old Haines Highway and Rainy Hollow is located on an old flood plain below Border Station and along the Klehini River. A general layout is given in Figure 1-1.

Rainy Hollow and Border Station are within the Tatshenshini-Alsek Wilderness Park. This park was created in 1993 and afterwards designated as a United Nations World Heritage Site in 1994. Although both sites are located in the Tatshenshini-Alsek Wilderness Park, they are presently under different jurisdictions. The upper site, Border Station, is the property of the Government of Canada, under the jurisdiction of Indian and Northern Affairs Canada (DIAND), and administered by the Waste Management Program, Whitehorse office. It is currently not included in the park. The lower site, Rainy Hollow, which is within the park, is the property of the Government of BC.

Border Station and Rainy Hollow are also located within the southern portion of traditional lands of the Champagne-Aishihik First Nations and Southern Tutchone. The land claim for the area has not been settled with the Government of British Columbia.

Rainy Hollow and Border Station were originally used together as a pump station along the Haines-Fairbanks pipeline. Facilities constructed at the upper bench consisted of a main line pump building, warehouse-garage-shop building, utility building, wood frame construction family housing (10 person dormitory and two apartment-type 6 unit buildings), a cement cold storage locker building, and petroleum oil and lubricant (POL) storage facilities. The lower bench, Rainy Hollow, was used as an airstrip by small aircraft for light re-supply of the pumping station during construction and operation; it was also used in later years for transporting station personnel to nearby communities. Aviation fuel was probably also located near the airstrip during its operation, along with dumps for station wastes. A small pump house at Rainy Hollow served to deliver water from the Klehini River to Border Station.

The pump station was operated by the US military from the mid 1950's until it was decommissioned in 1972. Following this, the infrastructure was used as a base camp for the Haines Road re-alignment in 1978 and 1979, and for mineral exploration from 1983 to 1987. The station was finally closed in 1987. A historical review of the sites has been presented in a report prepared for Indian and Northern Affairs by K. Bisset and Associates (1995).

1.2 Site Cleanup Operations (1987 – 1992)

The BC Ministry of Forests conducted a cleanup of the Border Station site in 1987. Details of this effort are not available; it is assumed, however, that cleanup was cosmetic in nature and consisted of the clearing away loose debris to be stockpiled or later salvaged; most buildings and facilities were left intact. Further decommissioning of the site, specifically buildings and facilities, was undertaken by the Department of Public Works under contract to DIAND in 1991-92. A synopsis of the cleanup operations may be found in a report prepared by Royal Roads University (Royal Roads, 1996a). Briefly, salvaging operations began with the removal of the pipeline followed by the demolition of the buildings on site. All recoverable materials were dismantled and moved out by truck. Such materials included fuel and water storage tanks, sheet metal, dispensing pumps, storage tank building, antennae, freezer unit, fencing, and a vehicle hoist. Flammable materials were burned, and the remaining waste materials including scrap metal, asbestos sheeting/siding, and boiler pipes were buried in apartment building foundations as recommended in a letter to DIAND dated June 1990 from BC Ministry of Environment Lands and Parks. Fuel-contaminated soil was removed and stored in the same manner. Additional non-contaminating materials including warehouse concrete slabs and rebar, scrap metal, and fence post butts were buried at locations near the warehouse/garage/shop building. The site was subsequently graded and leveled to conform to the original contours of the site. The burial locations at the dormitory site were seeded to promote re-vegetation.

1.3 Emergency Action Response and Temporary Storage Facility (1994)

In 1994, buried canisters containing DDT (dichloro-diphenyl-trichloroethane or 1,1,1-trichloro-2,2-bis(4-chlorophenyl) ethane CAS Registry 50-29-3) pesticide were found at Rainy Hollow, prompting an Emergency Response and clean up (Golder, 1995). The excavated DDT canisters, along with other materials which were suspected to contain contaminants (wastewater, empty barrels, transformer oil, and unknown solids) were placed in overpack barrels and shipped off-site for treatment at a facility in the USA. After completion of the excavation, an Arctic grade polyethylene liner was placed in the bottom of the excavation and the "Trench" was filled with surface material. A reinforced polyethylene liner was placed over the back-filled material to prevent water infiltration and the area was fenced off.

DDT contaminated soil was also removed from the Trench during excavation of the canisters. These were temporary stockpiled for testing, and subsequently relocated by truck from the lower site to a "Temporary Storage Facility" constructed on the upper bench at Border Station. Approximately 550 m³ of DDT contaminated soil (concentrations between 2.85 – 25 mg/kg) was removed from the Trench and transported to the Temporary Storage Facility during extreme weather conditions. The contaminated soils were placed onto a reinforced polyethylene liner, covered with liners and enclosed in a fence.

1.4 Preliminary Environmental Assessments (1994 and 1995)

Golder Associates Ltd. conducted a preliminary environmental assessment of Rainy Hollow in conjunction with the Emergency Response effort (Golder 1995). The sampling program consisted of the excavation of 13 test pits in the vicinity of the Trench, as well as three additional pits at Border Station for subsurface investigations. Locations of these test pits are shown on Figure 1.2. Another set of 13 test pits were excavated and well points (50 mm diameter) for groundwater sampling were placed in each of the test pits and back-filled. Well depths ranged from 1.98 to 4.11 m and no sand filters or fine screens were installed. The original excavation soil was used as backfill in the test pit starting with the last excavated material first, in an attempt to maintain the homogeneity of the surrounding substrata.

Soil samples were collected from the test pits and analyzed for chlorinated pesticides, hydrocarbons, volatile organic compounds and metals. The maximum concentrations of DDT detected in each test pit are shown in Figure 1.1. The highest concentration of 5.3 mg/kg was found at a depth of 1.7 m in a test pit excavated at the southern edge of the Trench. The results also suggested that the zone of DDT contamination was localized around the Trench and might have represented the release of DDT from the canisters. The concentrations of BTEX, VOCs were below detection. These results were, however, deemed to be inconclusive due to the fact that "sample storage time and unavoidable headspace in sample jars may have compromised some of these results". Floating hydrocarbon products were observed on the surface of water that infiltrated test pits excavated near the Trench. Field organic vapour monitor (OVM) readings also indicated hydrocarbon contamination around the Trench.

Groundwater samples were also analyzed for DDT and hydrocarbons. The results obtained also confirmed the hydrocarbon and DDT contamination around the Trench. Detail drawings that indicated impacted areas are given in the preliminary assessment report (Golder, 1995).

In a separate study conducted in the summer of 1995, hydrocarbon contamination of subsurface soil and groundwater at the Border Station site was identified. This study was part of preliminary environmental assessments along the Haines-Fairbanks Pipeline by UMA Engineering and Ambio Research Associates on behalf of Indian and Northern Affairs (UMA/AMBIO, 1995, Royal Roads, 1996b). The concentration of hydrocarbons detected in test pits and boreholes are also indicated on Figure 1.1. The results of the study also suggested that the hydrocarbon contamination might be passing with groundwater down through Rainy Hollow to the Klehini River.

In order to obtain a better understanding of outstanding issues pertaining to the two sites, all available site information was collated and reviewed by Royal Roads University (Royal Roads, 1996a). Outstanding environmental issues at the sites were identified to include:

- the need for a better understanding of the spatial and vertical distribution of subsurface hydrocarbon contamination;

- DDT contamination in soil and groundwater;
- the presence of buried debris which may be potentially contaminated; and
- the need for a risk assessment in the terrestrial environment around the two sites and the aquatic environment of the Klehini River.

1.5 Detailed Site Investigation and Risk Assessment

1.5.1 Summary of Field and Laboratory Program

A team comprising participants from Royal Roads University, UMA Engineering Ltd., and Golder Associates Ltd. conducted the detailed site investigation (DSI) and screening-level risk assessment in 1996 (Royal Roads, 1997).

The field program, which took place in August and September 1996, included excavation of 24 test pits, drilling of 15 boreholes and installation of monitoring wells in all but one of the boreholes. Locations of test pits and boreholes are also given in Figure 1-1. The field program was followed by the analysis of over 200 surface or subsurface soil samples for one or more of the following principal contaminants of concern - hydrocarbons, chlorinated pesticides (including DDTs), PCBs and metals. Groundwater samples were also analyzed for these contaminants. Samples of sediments, surface water and benthic organisms collected from the Klehini River along with terrestrial vegetation, berries and herbivorous and insectivorous small mammals were also analyzed in order to conduct a screening level risk assessment.

1.5.2 Subsurface Contaminant Distribution

The results of the DSI confirmed that some of the subsurface soils and groundwater at Border Station and Rainy Hollow were contaminated with hydrocarbons and DDTs. The maximum concentrations of DDTs and extractable hydrocarbons detected in sub-surface soil samples are summarized in Figure 1.1. Drawings indicating the areal extent of these contaminants in groundwater and subsurface soil have been presented in the DSI report (Royal Roads, 1997).

Hydrocarbons were encountered at depths varying from 3 to 15 m at Border Station (upper bench) with one monitoring well (MW-8B) containing approximately 3 cm of free product. The hydrocarbon contamination extended to a depth of up to 25 m below ground surface. Hydrocarbon contamination was also noted at Rainy Hollow (lower bench) and was up to 8 m thick beneath the surface in the vicinity of the Trench. This was reduced to about 4 m near the Klehini River.

Subsurface contamination with DDTs was noted at Rainy Hollow in the area where the canisters were recovered and extended to the river. The highest soil concentrations were directly adjacent to the Trench, and were in the range of 4 to 5 mg/kg. Further from the Trench, subsurface soil concentrations were typically less than 2 mg/kg. DDT concentrations of up to 400 ng/L were detected in groundwater wells installed adjacent to the Trench. The concentrations were significantly reduced by the time groundwater reached the river's edge, with DDT levels in the range of 1 to 8 ng/L.

The Trench was located along the migration pathway of subsurface hydrocarbons from the upper bench towards the river and it was evident that both DDT and hydrocarbons were being introduced to the Klehini River through the discharge of contaminated groundwater. Data from the analysis of samples of sediments, surface water and benthic organisms collected from the Klehini River indicated that the actual instantaneous release of these contaminants into the river was so low as to preclude any possibility of deleterious biological effects. A conceptual model of DDT transport model was developed.

1.5.3 Surface Contaminant Distribution

It was noted during the characterization of soils at the Temporary Storage Facility (Royal Roads University, 1996c) that some surface soils along the edge of the facility contained detectable concentrations of DDTs. As such, one of the objectives of the detailed site investigation was to delineate the extent of surface contamination both near the Temporary Storage Facility and around the Trench at Rainy Hollow. To achieve this objective, 66 surface soil samples collected around these facilities were analyzed for DDTs as follows: 29 were analyzed using immunoassay field test kits; 24 were analyzed in the laboratory at ASL; and 13 were analyzed using both field test kits and laboratory analysis. The locations of these samples and the results obtained are given in Figure 1.2.

The range of concentrations of DDTs in surface soil samples collected in the vicinity of the Trench at Rainy Hollow was 0.014 to 173 mg/kg, while the range in samples collected near the Temporary Storage Facility was <0.001 to 27 mg/kg. It should be noted that the maximum concentration of 173 mg/kg DDTs detected in surface soil samples collected near the Trench during the detailed site investigation actually exceeded the maximum concentration observed in soil samples taken from the stockpile at Temporary Storage Facility (Royal Roads, 1996c).

High concentrations of DDTs (up to 173 mg/kg) were detected in samples collected along a transect on the north side of the Trench and to a distance of between 10 and 20 m from the end of the Trench. This area was probably used during the 1994 emergency response for the temporary placement of the contaminated materials and soils prior to either their removal off-site or transport to the Temporary Storage Facility. In addition to the hotspots, surface soil samples in the vicinities of the Trench and the Temporary Storage Facility, and in areas of vehicular and heavy equipment usage contained DDTs at concentrations of up to 3 mg/kg. In contrast, all soil samples collected from undisturbed areas had DDTs at concentrations that were less than 1 mg/kg. DDT concentrations along the major portion of access road surfaces ranged from 0.43 to 27 mg/kg. The highest concentration was found in a depression along the eastern entrance to the Temporary Storage Facility, where water and fine particulates would tend to pool. It is clear from the data obtained that, while some airborne redistribution of DDT may have contributed to the contamination, (see Royal Roads, 1997, Section 5.6), the major mechanism of surface redistribution has been via tracking on heavy equipment and other vehicles. The redistribution was probably intensified during the 1994 emergency response by the adverse weather, which caused the site to be extremely muddy.

1.5.4 Recommendations and Remedial Action Plan

The results and recommendations of the DSI were presented to the Rainy Hollow Working Group at a meeting held at Royal Roads University on February 21, 1997. Members comprising representatives from Indian and Northern Affairs, Champagne and Aishihik First Nations, BC Ministry of Environment Land and Parks, Royal Roads University, Golder Associates, and UMA Engineering Ltd. reviewed and verbally approved the cleanup plan proposed in the report. Remedial actions proposed include:

- The curtailment of the possible exposure pathways for DDTs in surface soils to wildlife and humans by the removal and off-site disposal of soils with total DDT concentrations exceeding 10 mg/kg from the vicinity of the former Temporary Storage Facility and near the Trench at Rainy Hollow.
- The isolation of the remaining DDT-contaminated soils with total DDT concentration in the range of 1 to 10 mg/kg and hydrocarbon-contaminated soils with concentrations exceeding 1000 mg/kg by capping using a minimum of 0.5m of clean granular material.
- The development of a long term groundwater monitoring program to validate and improve predictions of contaminant fate. This included the monitoring of groundwater levels and DDT concentrations in the existing wells, in addition to the verification of the DDT contaminant transport model used.

1.5.5 Implementation of Remedial Action Plan

The long term monitoring program recommended in the DSI report, including the conceptual model of contaminant transport, was expanded and evaluated in a follow up document entitled "Rainy Hollow Contaminant Transport Modeling" (Woodbury, 1997). In order to implement the monitoring program, field programs were conducted in August 1997 and 1998. These involved the collection of groundwater samples from selected wells and surface water from three locations along the Klehini River. The field programs were followed by laboratory analyses for DDTs, metals and hydrocarbons. Royal Roads University (Royal Roads, 1999) has presented the results of both the 1997 and 1998 monitoring programs in a separate report.

Construction specifications for the removal or encapsulation of contaminated soils were developed by UMA Engineering (UMA, 1997) using recommendations outlined in the previous section. The specifications were then employed for site remediation between August 20 and September 14, 1997. The clean up project team consisted of representatives from Indian and Northern Affairs, Champagne-Aishihik First Nations, Haines Junction, Royal Roads University and UMA Engineering Ltd. Surface soils contaminated with DDTs at concentrations exceeding 10 mg/kg were excavated from the vicinity of the former Temporary Storage Facility and near the Trench at Rainy Hollow. The excavated soils were taken to the East Peace Industrial Waste Treatment and Disposal Site, Peace River, Alberta for disposal. The remaining DDT-contaminated soils (with total DDT concentration in the range of 1 to 10 mg/kg) and hydrocarbon-

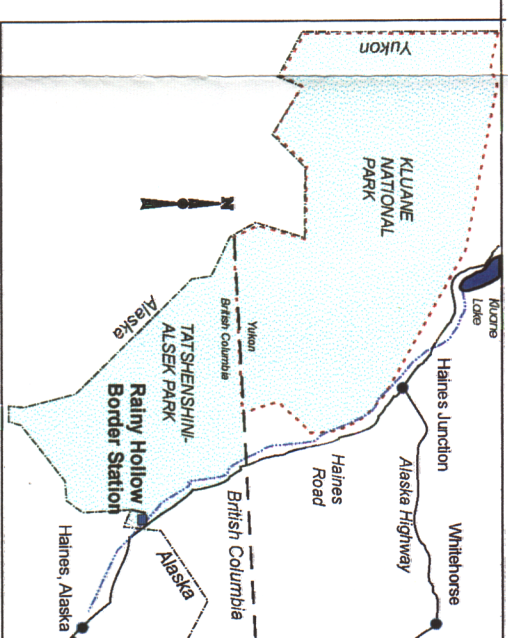
contaminated soils (with concentrations exceeding 1000 mg/kg) were capped using a minimum of 0.5m of clean granular material. A report of remedial activities, including confirmatory sampling, was prepared for DIAND in January 1998 (Royal Roads, 1998).

1.6 Objectives of this Report

The site remediation report (Royal Roads, 1998) was reviewed in a meeting of the Rainy Hollow Working Group in March 1998 at Royal Roads University. Recommendations arising out of this meeting included the following:

- Additional confirmatory sampling, especially along the access roads to the Temporary Storage Facility at Border Station.
- Preparation of maps showing all sampling locations to-date at the sites.

A review of previous information has been presented in preceding sections and Figures 1-1 and 1-2 indicate sampling locations as well as, DDT and hydrocarbon concentrations. The remainder of this report provides the results of the confirmatory sampling at Border Station that was conducted in August 1998 and October 1998. A synopsis of the 1997 confirmatory sampling program is also given.



LEGEND

APPROXIMATE LOCATION OF FORMER BUILDING

- A - Main Pump Line Building
- B - Utility Building
- C - Warehouse
- D - Apartment
- E - Dormitory

- Former Location of Roadway
- Treeline
- Monitoring well (UMA 1995 & RRU, 1996)
- Monitoring well (Golder, 1994)
- Testpit (Golder, 1994)
- Testpit (RRU, 1996)
- Borehole (UMA, 1995 & RRU, 1996)

0.41 Maximum concentration of DDT (mg/kg) detected in test pit/borehole samples

77 Maximum concentration of EPH (mg/kg) detected in test pit/borehole samples



BORDER PUMP STATION AND RAINY HOLLOW

GENERAL SITE LAYOUT AND CONCENTRATIONS OF DDTs AND HYDROCARBONS IN SUB-SURFACE SAMPLES OBTAINED FROM TEST PITs AND BOREHOLES IN 1994, 1995 AND 1996

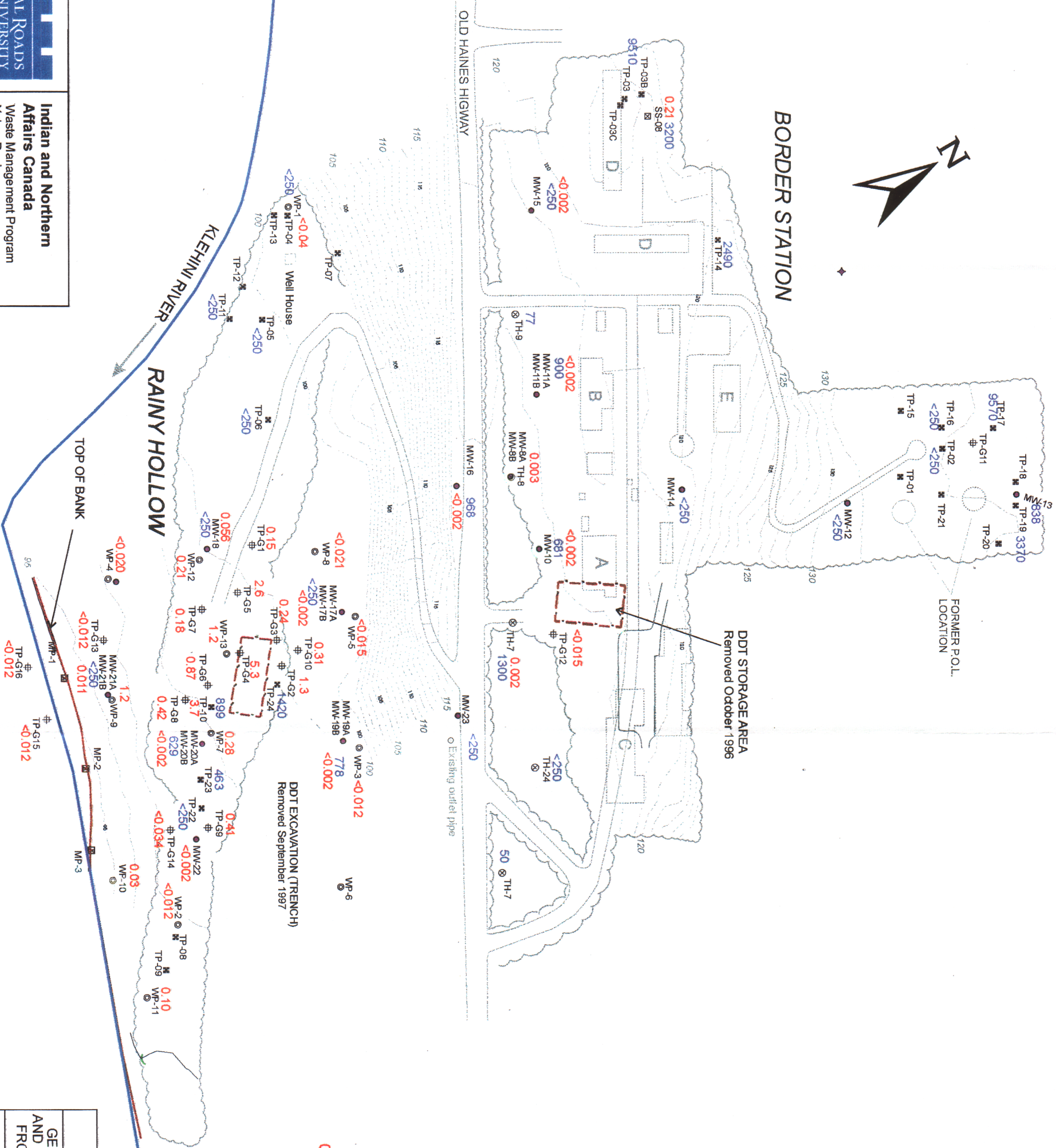
PROJECT No. 96-015

DATE: March 1999

Figure 1-1



Indian and Northern Affairs Canada
Waste Management Program
Yukon Region



2. EXCAVATION, CAPPING AND CONFIRMATORY SAMPLING AT BORDER STATION

2.1 Removal of Temporary Storage Facility (1996)

Royal Roads University in May-June of 1996 characterized the concentrations of DDTs and hydrocarbons in the materials at the Temporary Storage Facility (Royal Roads, 1996c). The investigation also addressed soil contaminant leachability (BC Special Waste Extraction Procedure), bioassays (static acute trout), and physical characteristics of the soil pile. The total volume of the soil pile was estimated to be less than 330 m³ with DDT and its metabolites in collected soil samples ranging in concentration between 3.58 to 57 mg/kg (ppm). Elevated concentrations (2.34 to 4.71 mg/kg) were also detected in the retaining berm. Hydrocarbons in the soil were mostly diesel, with measurable quantities of heavy oils (lubricants and grease).

Contaminated soils in the Temporary Storage Facility along with substrate in retaining berms were removed on October 15, 1996 and transported to an industrial landfill in Alberta for disposal. The area was then re-graded and covered with clean granular material. The approximate area capped is indicated on Figure 2.1.

2.2 1997 Remedial Activities

2.2.1 Overview

A synopsis of the excavation, capping and confirmatory sampling conducted in 1997 is given in this section. Detailed methodology and analytical result have been presented in a remediation report (Royal Roads, 1998).

The excavation of soils contaminated with DDTs at concentrations greater than 10 mg/kg was completed using an excavator and dump trucks that were provided by the Champagne and Aishihik First Nation, Haines Junction, YT.

2.2.2 Sampling

Each sample was collected with a dedicated stainless steel scoop (which had been pre-washed, baked and stored in baked aluminum foil to preclude organic contamination). Samples for field test kit analyses were placed into 125 mL amber jars fitted with baked aluminum foil lined lids. The jars were pre-cleaned by washing with laboratory detergent, rinsed with deionized-distilled water and followed by hexane. They were then baked at 400°C for 4 h. Laboratory samples were placed into jars supplied by the either Axys Analytical Laboratories, Sydney, BC or CanTest Ltd., Vancouver BC.

2.2.3 Delineation

The limits of the contaminated areas were laid out on the basis of the results of the 1996 DSI results. Additional samples were then collected from the peripheries of these areas, especially in locations where information was limited. These samples were analyzed

using immunoassay field test kits and the data obtained was used to revise the marked areas. Sampling locations, concentration of DDTs and approximate limits of the contaminated areas are indicated in Figure 2-1. As part of the QA/QC process, field duplicates of three of the samples analyzed in the field were submitted to Axys Analytical Services for laboratory analysis by gas chromatography with mass spectrometric detection (GC-MS). A comparison of the field test kit data and laboratory results is discussed in Chapter 4.

2.2.4 Excavation

Three localized areas were found to contain DDT concentrations in excess of 10 mg/kg (Figure 2-1). All three locations were in shallow depressions where water with fine particulate matter would tend to pool. DDTs have been shown to be transported by association to particulate matter and this may account for the high levels detected in the depressions. Substrates in these three areas were excavated on August 25, 1997 under fair weather conditions with no precipitation. To facilitate calculation of excavation volumes, the ground surface was surveyed using a rod and level before and after the excavation was completed.

The total volume of soil excavated from these three locations for disposal off site was 14.5 m³. Drawings, cross-sections and photographs of the excavated areas have been presented in the remediation report (Royal Roads, 1998). One soil sample each was collected from the centre of each excavation (at a depth of 0.20 m) and analyzed with the field test kit. DDTs concentrations were 1 – 10 mg/kg. This indicated the successful removal of the contaminated material. The excavated sections, along with the entire area identified as containing DDTs between 1 – 10 mg/kg were then capped with a minimum of 0.5 m of clean gravel fill as described in the next section.

2.2.5 Capping and Confirmatory Testing

Detail methodology on the placement and grading of the cap over the designated areas is described in the remediation report (Royal Roads, 1998). Briefly, capping material was hauled to the site and placed on the designated area using a D7 Bulldozer. The majority of the cap was placed between August 24 and 30. Contaminated soils excavated during the cleanup were temporarily stock piled on a tarpaulin in this area and that delayed completion of the cap. The cap was completed on September 14 after removal of the contaminated soils from the site. The total volume of this cap was 1650 m³.

Ten confirmatory soil samples (CC3 - CC12) were collected from the area and analyzed with the field test kits. The concentrations of total DDTs in these samples were generally less than 1.0 ppm except for CC11, which had 1-10 ppm. Sample CC11 was collected from a wooded area along the southern edge. The cap was extended to the edge of the brush and no further action was taken at this location since the brush was well established and the test kits had been shown to overestimate the total DDT concentrations (Chapter 4). The capped areas and confirmatory samples are shown in Figure 2-2. Detail results, drawings, cap cross-sections and photographs may be found in a previous report (Royal roads, 1998).

2.3 Confirmatory Testing in August 1998

2.3.1 Sampling and Analytical Program

Following a meeting of the Rainy Hollow Working Group at Royal Roads University in March 1988, additional confirmatory testing was recommended for the southeastern portion of Border Pump Station. This was to confirm that soils with DDT concentrations greater than 1 mg/kg do not presently exist in surface soils along the roadway and access to the former Temporary Storage Facility.

Representatives from Royal Roads University and DIAND Waste Management, Whitehorse conducted the field program on August 8, 1998. Sampling locations are presented in Figure 2-3. Forty-two surface soil samples were collected from locations along the access roads and the edge of the cap as follows:

- Road Northwest of Cap - A shallow depression with standing water was noted along the road northwest of the cap. This originated from the edge of the cap and extended for approximately 15 m. Four soil samples (CCC1 to CCC4) were collected at 10-m intervals along the road. Results of the 1996 DSI indicated that the concentration of DDTs in a surface soil sample collected along this road, approximately 30 m from the edge of the cap was 0.5 mg/kg during, as such no samples were collected beyond 30 m.
- North and South Edges of Cap - To ensure adequate coverage of the periphery of the gravel cap, 13 additional samples (C5 – C18) were collected from the south and north edge of the cap as shown in Figure 2-3.
- Main Access to Temporary Storage Facility – One soil sample (CCC19) was obtained at the southern end of the cap, where it intersects the Old Haines Highway. This was augmented by the collection of one sample each at 10-m distance west (CCC20) and east (CCC21) of sample location CCC19.
- Old Access Road East of the Temporary Storage Facility – Four soil samples (CCC22 – CCC25) were taken along the Old Haines Highway, near the old access road east of the Temporary Storage Facility. A soil sample collected from a shallow depression at the entrance of this access road was found to contain 27 mg/kg of DDT in during the DSI. Soil from this location was therefore removed in 1997 and the area capped with clean gravel fill (see Section 2.2 above). Samples CCC26 – CCC37 were collected along two trisects set at 10 m intervals along the road.
- Road Southeast of Cap – Five samples (CCC38 – CCC42) were obtained along this road.

All the samples were analyzed using immunoassay test kits. For QA/QC purposes, 10 of the samples were submitted to Axys Analytical Laboratory for analysis by GC-MS. The

results obtained are given in Table 2.1 and also in Figure 2-3. The laboratory report is attached in Appendix A.

Table 2.1: Field and Laboratory Data for the Analysis of DDTs in Soil Samples Collected from the Temporary Storage Facility on August 8, 1998

Sample ID	Optical Density at 450 nm	DDT Concentration by Field Test Kit (mg/kg)	DDT Concentration by Lab GC-MS (mg/kg)
Batch #1			
0 mg/kg	1.33	Control	-
1.0 mg/kg	1.23	Standard	-
10 mg/kg	0.47	Standard	-
CCC1	1.27	<1.0	0.75
CCC2	0.83	1 - 10	-
CCC3	0.67	1 - 10	-
CCC4	0.66	1 - 10	3.3
CCC5	1.64	<1.0	-
CCC6	1.34	<1.0	0.64
CCC7	1.36	<1.0	0.65
CCC8	1.59	<1.0	-
CCC9	1.51	<1.0	-
CCC10	1.53	<1.0	-
CCC11	1.85	<1.0	-
CCC12	1.65	<1.0	-
CCC13	1.68	<1.0	-
CCC14	1.88	<1.0	0.009
Batch # 2			
0 mg/kg	0.90	Control	-
1.0 mg/kg	0.64	Standard	-
10 mg/kg	0.43	Standard	-
CCC15	0.60	1 - 10	-
CCC16	0.67	<1.0	-
CCC17	0.53	1 - 10	-
CCC18	0.57	1 - 10	-
CCC19	0.51	1 - 10	3.7
CCC20	0.65	<1.0	-
CCC21	0.67	<1.0	-
CCC22	0.47	1 - 10	-
CCC23	0.62	1 - 10	-
CCC24	0.70	<1.0	0.54
CCC25	1.08	<1.0	-

Table 2.1: (Continued)

Sample ID	Optical Density at 450 nm	DDT Concentration by Field Test Kit (mg/kg)	DDT Concentration by Lab GC-MS (mg/kg)
CCC26	1.09	<1.0	-
CCC27	0.93	<1.0	-
CCC28	0.93	<1.0	-
Batch #3			
0 mg/kg	1.39	Control	-
1.0 mg/kg	1.18	Standard	-
10 mg/kg	0.48	Standard	-
CCC29	0.64	1 - 10	-
CCC30	0.70	1 - 10	-
CCC31	0.60	1 - 10	-
CCC32	0.45	>10	-
CCC33	0.39	>10	81
CCC34	0.77	1 - 10	-
CCC35	0.67	1 - 10	-
CCC36	0.65	1 - 10	-
CCC37	0.61	1 - 10	15
CCC38	1.11	1 - 10	-
CCC39	1.21	<1.0	-
CCC40	1.13	1 - 10	2.4
CCC41	1.16	~1.0	-
CCC42	1.34	<1.0	-

2.3.2 Discussion of Results

The field test kit results indicated that the concentrations of DDTs in almost all the samples were less than 10 mg/kg. However, both field duplicate samples (CCC32 and CCC33) collected from a depression along the access road east of the Temporary Storage Facility had DDTs in excess of 10 mg/kg. Results of the laboratory analysis confirmed that location CCC33 contained 81 mg/kg of DDTs.

The concentration of DDTs in Sample CCC37 was determined to be 1 –10 mg/kg using field test kit. A concentration of 15 mg/kg was however, found in the split laboratory sample. The samples required dilution and re-spiking with surrogate due to the high target concentration encountered during laboratory analysis. The results obtained were not recovery corrected as a consequence (see laboratory report in Appendix A). Historical data indicate that recoveries of over 70% can be expected. An examination of the results for the other samples analyzed in the batch indicated that the average value of surrogate

recoveries for 13C-DDE and 13C-DDT was 55%. If the total DDT concentration of 15 mg/kg is corrected by this factor, the resulting value of 8.25 will agree with the field test kit data. Although laboratory re-analysis using a smaller sample size would have provided confirmation, this was not deemed feasible due to the long hold time of over two months. The location was therefore, treated as containing DDTs in excess of 10 mg/kg as a precautionary measure.

DDT concentrations in a number of samples collected along the above access road were 1 – 10 mg/kg. It should be noted that a soil sample (M14) obtained from a shallow depression at the entrance of this access road (off the Old Haines Highway) was also found to contain 27 mg/kg of DDT during the DSI. The elevated DDTs concentration found along this road may be attributed to tracking by heavy equipment and other vehicles. This mechanism was probably exacerbated during the 1994 emergency response by the adverse weather, which caused the site to be extremely muddy. Low levels of DDTs associated with fine particulate matter on this road may have been carried by surface run-off into the shallow depressions. Evaporation of water in these depressions will concentrate the particles thereby resulting in elevated DDTs concentration in the residual substrate.

Soil samples from CCC32 and CCC37 were excavated in October 1998 following receipt of the confirmatory data from the laboratory analysis. Excavation and confirmatory sampling is discussed in the next section.

The concentrations of DDTs in samples collected in the shallow depression with standing water, along the road northwest of the cap (CCC1 – CCC3) were between 1 – 10 mg/kg. Similar results were also found in samples collected from the main entrance to the Temporary Storage facility (CCC19 and CCC21). These areas were covered with gravel fill and re-graded during a follow-up visit in October 1998.

Samples that were taken from locations along the northern and eastern edges of the cap contained DDTs at concentrations below 1 mg/kg. Two samples along the southern edge (CCC17 and CCC18), however, had between 1 – 10 mg/kg DDTs. No further action was taken along the southern edge since vegetation in this area was well established.

2.4 Excavation and Confirmatory Testing in October 1998

Excavation and off-site disposal of contaminated soils with DDTs at concentrations exceeding 10 mg/kg detected during the August 1998 confirmatory sampling program was conducted on October 29 and 30, 1998. The cleanup team comprised two representatives from DIAND Waste Management Whitehorse, and one each from Royal Roads (confirmatory testing) and Champaign and Aishihik First Nations, Haines Junction (front-end loader operator).

2.4.1 CCC37

An area of approximately 6 m by 3 m was excavated to a depth of 15 – 20 cm using the bucket of the front-end loader on October 29, 1998. The excavated soils were placed into

three 1-m³ bags (Mega Bag™ supplied by Trimeg Holdings, Alberta). This yielded 3 m³ of contaminated materials which were subsequently shipped off-site for disposal.

A 3 m x 1.5 m grid was laid in the excavated area and samples were collected from the bottom and edges of the excavation along the grid transects. These samples were analyzed on site using the immunoassay test kits; three of the samples were shipped to CanTest Ltd., Vancouver, BC, for laboratory analysis by GC-ECD. The results obtained are given in Table 2-2 and also in Figure 2-4. The laboratory report is included in Appendix B.

The concentrations of DDTs, as determined by the field test kits, were 1.0 mg/kg or less. This indicated the successful removal of the DDT contaminated soils. Results obtained for the three split samples analyzed in the laboratory concurred with the field data. The excavated area, along with location CCC40, which was found to contain 1 – 10 mg/kg DDTs, was covered with clean gravel fill. The area was then re-graded to conform to the natural contours.

Table 2.2: Field and Laboratory Data for the Analysis of DDT in Soil Samples Collected after Excavation at Location CCC37

Sample ID	Optical Density at 450 nm	DDT Concentration by Field Test Kit (mg/kg)	DDT Concentration by Lab GC-ECD (mg/kg)
<i>Batch #1</i>			
0 mg/kg	0.47	Control	-
1.0 mg/kg	0.35	Standard	-
10 mg/kg	0.26	Standard	-
H1	0.40	<1.0	-
H2	0.44	<1.0	-
H3	0.45	<1.0	<0.003
H4	0.36	<1.0	-
H5	0.37	<1.0	0.041
H6	0.36	<1.0	-
H7	0.33	1 - 10	-
H8	0.35	~1.0	0.102
H9	0.39	<1.0	-
H10	0.41	<1.0	-
H11	0.35	~1.0	-
H12	0.35	~1.0	-
10 mg/kg	0.25	Standard	-

2.4.2 Location CCC32/CCC33

Both the field duplicate and laboratory sample collected from this area contained over 10 mg/kg of DDT as such, soil was removed from this location on October 29. An area measuring 8 m by 3 m was excavated to a depth of 0.2 m. Following this, confirmatory samples were collected along transects of a 2 x 1.5 m grid and analyzed on site using the immunoassay test kit. Two of the samples were submitted to CanTest Ltd. for laboratory analysis by GC-ECD. Confirmatory sampling results are given in Table 2.3. The area excavated and the concentrations of DDTs in confirmatory samples are also shown in Figure 2.5.

Table 2.3: Field and Laboratory Data for DDTs in Soil Samples Collected after Initial Excavation at Location CCC32/CCC33

Sample ID	Optical Density at 450 nm	DDT Concentration by Field Test Kit (mg/kg)	DDT Concentration by Lab GC-ECD (mg/kg)
Batch #1			
0 mg/kg	0.47	Control	-
1.0 mg/kg	0.35	Standard	-
10 mg/kg	0.26	Standard	-
G1	0.23	>10	-
G2	0.20	>10	-
G3	0.21	>10	-
Batch #2			
0 mg/kg	0.35	Control	-
1.0 mg/kg	0.15	Standard	-
10 mg/kg	0.12	Standard	-
G4	0.12	10	-
G5	0.10	>10	0.77
G6	0.10	>10	-
G7	0.10	>10	-
G8	0.08	>10	16
G9	0.18	<1.0	-
G10	0.10	>10	-
G11	0.07	>10	-
G12	0.13	1 – 10	-
G13	0.19	<1.0	-
G14	0.13	1 – 10	-
G15	0.09	>10	-
G16	0.14	1- 10	-
G17	0.19	<1.0	-
G18	0.12	10	0.009

The field test kit data indicated soils with concentrations exceeding 10 mg/kg were still present at G8 (this was confirmed latter by laboratory analysis that indicated a DDT concentration of 16 mg/kg). Additional soil was therefore excavated from the area on the following day. Data obtained for confirmatory samples collected along a 2 x 2 m grid (Table 2.4, Figure 2.5) indicated successful removal of soils with DDT concentrations exceeding 10 mg/kg. Data from the three samples analyzed latter in the laboratory also confirmed the field data with concentrations of 0.55, 0.19 and 0.074 and mg/kg, respectively.

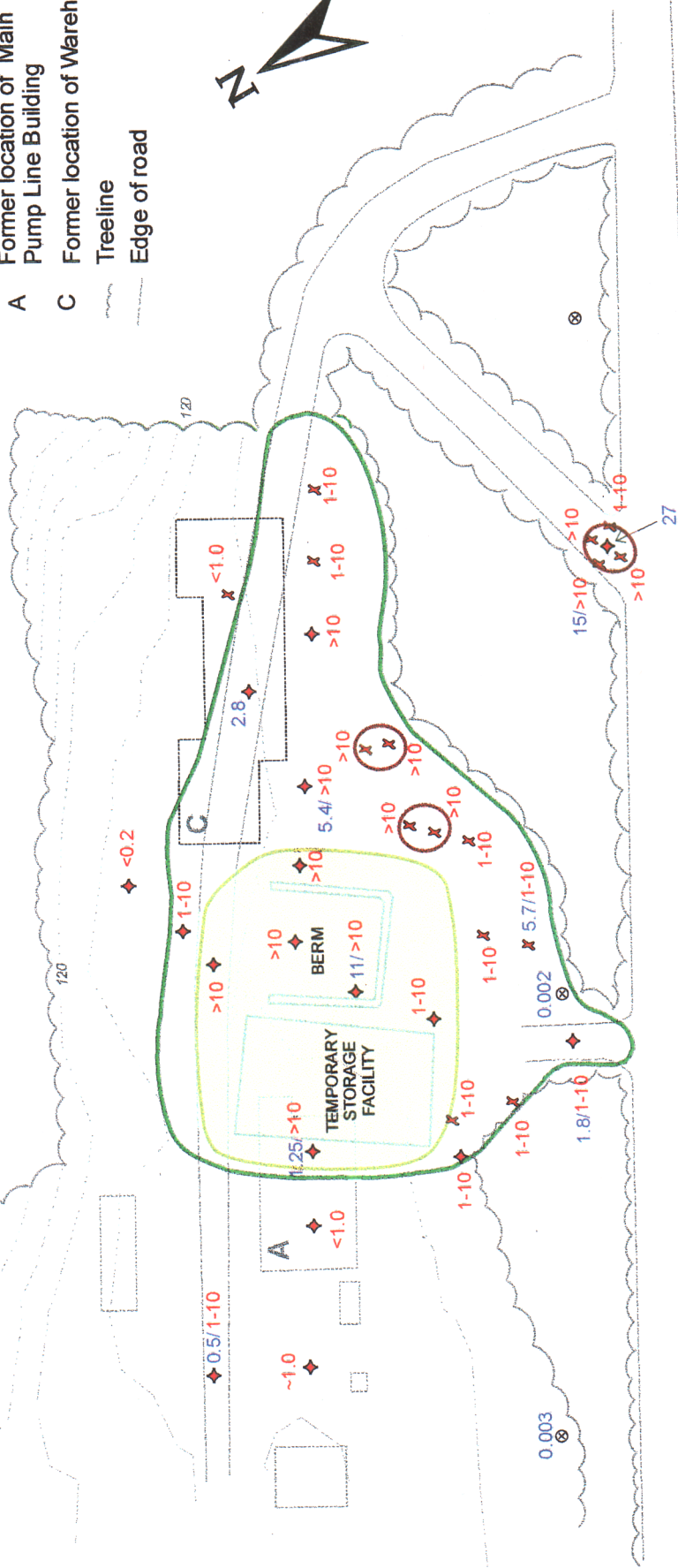
The excavated soils were placed into 12 Mega Bags™ (approximately 12 m³ of contaminated material) which were subsequently shipped off-site for disposal. The excavated area, including that enclosed by sampling locations CCC30 and CCC34 were capped then with clean gravel fill.

Table 2.4: Field and Laboratory Data for DDTs in Soil Samples Collected after the Second Excavation at Location CCC32/CCC33

Sample ID	Optical Density at 450 nm	DDT Concentration by Field Test Kit (mg/kg)	DDT Concentration by Lab GC-ECD (mg/kg)
<i>Batch #1</i>			
0 mg/kg	0.72	Control	-
1.0 mg/kg	0.46	Standard	-
10 mg/kg	0.29	Standard	-
G19	0.33	1 – 10	-
G20	0.31	1 – 10	-
G21	0.38	1 – 10	-
G22	0.49	1 – 10	-
G23	0.43	1 – 10	-
G24	0.50	<1.0	-
G25	0.48	<1.0	0.55
G26	0.30	1 – 10	-
G27	0.27	10	0.19
G28	0.36	1 – 10	-
G29	0.32	1 – 10	-
G30	0.34	1 – 10	-
G31	-	-	0.074
10 mg/kg	0.28	Standard	-

◆ 0.07/-0.2

- A Former location of Main Pump Line Building
- C Former location of Warehouse
- Treeline
- Edge of road



Approximate limit of area re-graded and covered with granular material after removal of Temporary Storage Facility and Berm in October 1996

Approximate limits of surface area affected with DDT concentrations >10 mg/kg

Approximate limits of surface area affected with DDT concentrations 1 - 10 mg/kg

- ⊗ Borehole 1996)
- ◆ Surface Soil Sample (1996)
- ✕ Surface Soil Sample (1997)
- 1.8 Laboratory Analytical Results (mg/kg)
- 1-10 Field Test Kit Data (mg/kg)

BORDER PUMP STATION

DDT CONCENTRATIONS IN SURFACE SOIL SAMPLES USED TO DELINEATE CONTAMINATION IN THE VICINITY OF THE TEMPORARY STORAGE FACILITY IN 1997

PROJECT No: 98-015

DATE: March 1999

Figure 2-1

Scale

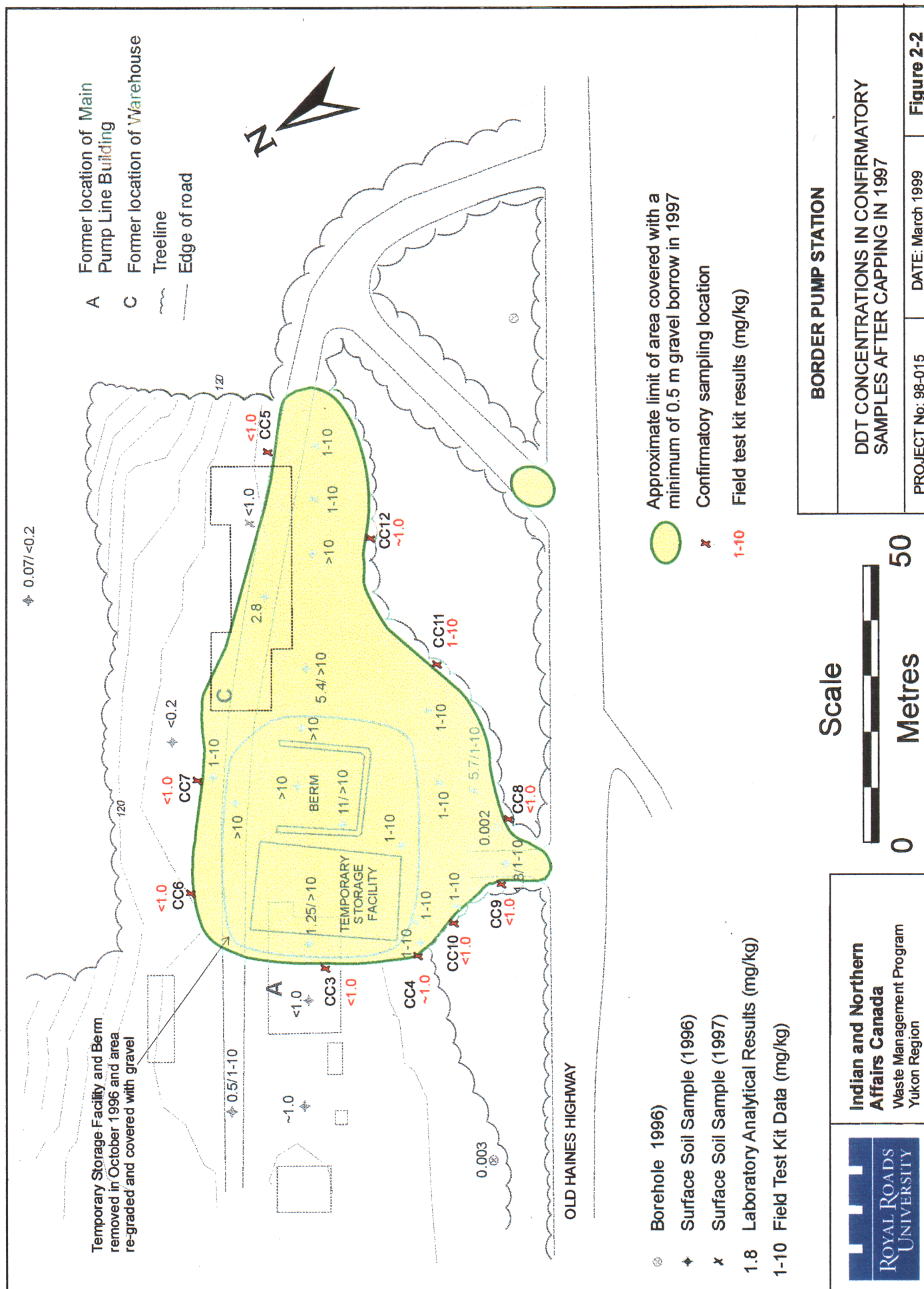


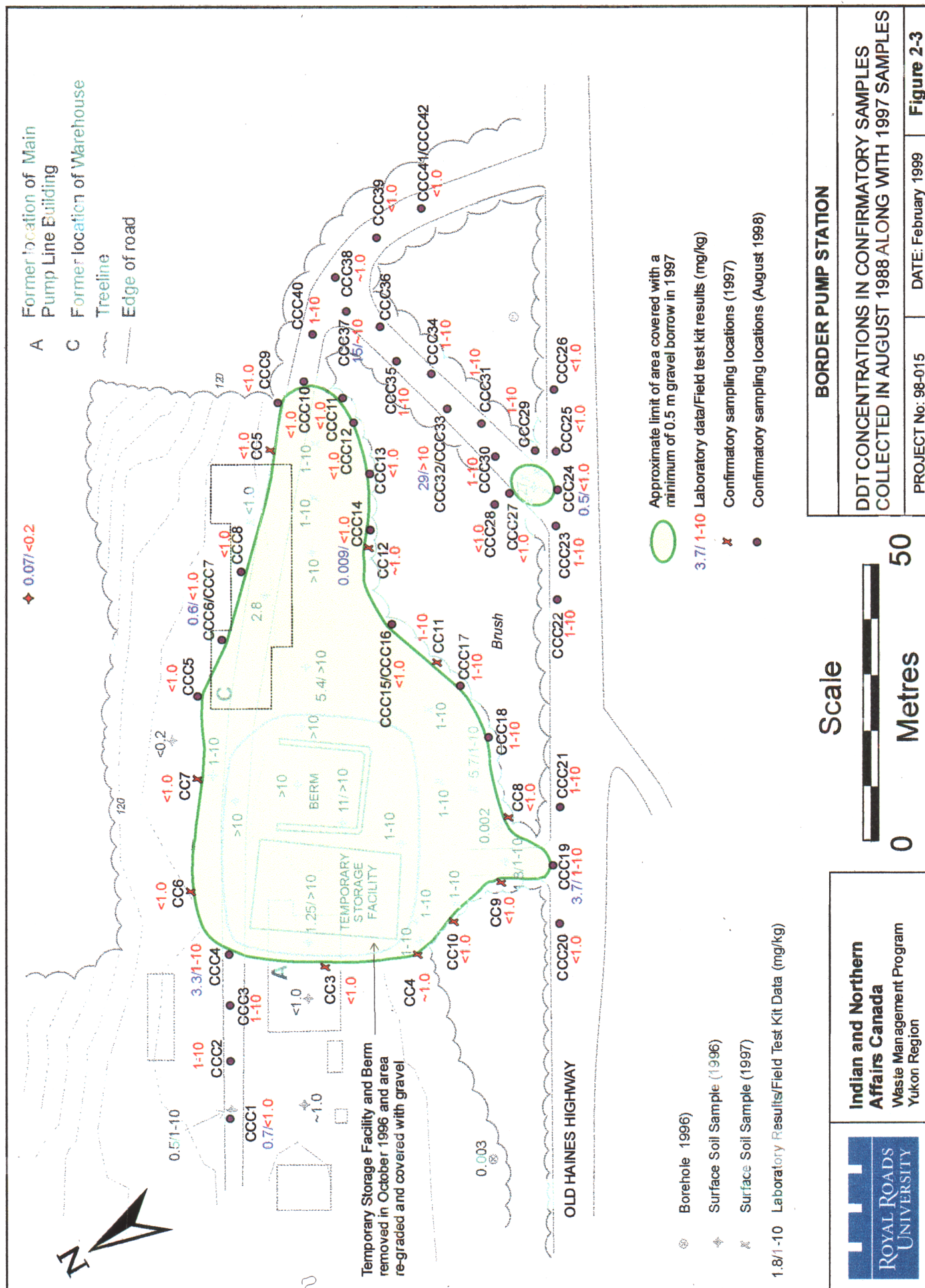
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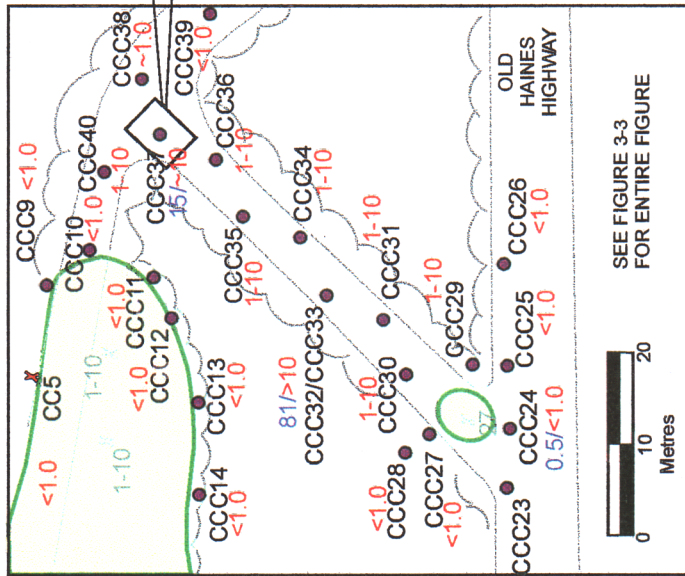
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Yukon Region





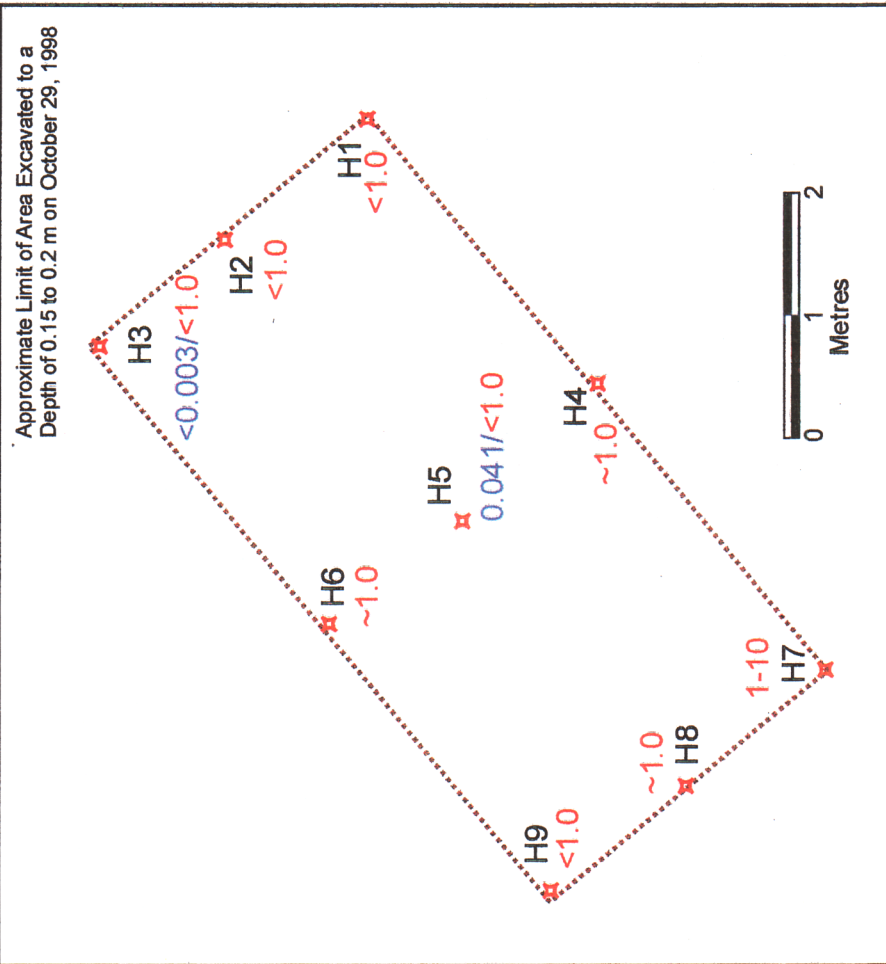




LEGEND

- Approximate limit of area covered with a minimum of 0.5 m gravel borrow in 1997
- Surface soil sample location (1996)
- Confirmatory sampling location (1997)
- Confirmatory sampling location (August 1998)
- Confirmatory sampling location (October 1998)
- Laboratory data/Field test kit results (mg/kg)

Indian and Northern Affairs Canada
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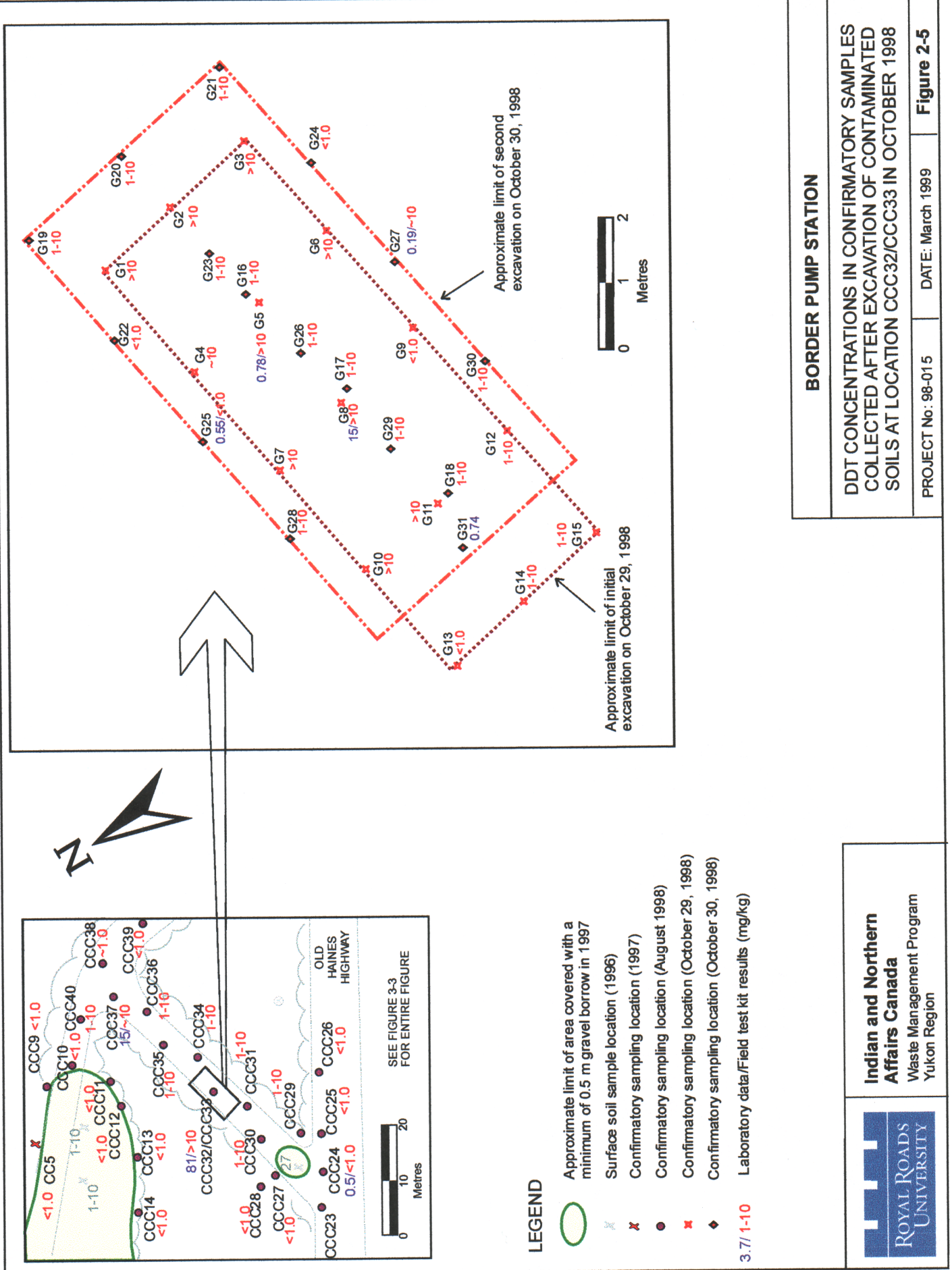
BORDER PUMP STATION

DDT CONCENTRATIONS IN CONFIRMATORY SAMPLES
COLLECTED AFTER EXCAVATION OF CONTAMINATED
SOILS AT LOCATION CCC37 IN OCTOBER 1998

PROJECT No: 98-015

DATE: March 1999

Figure 2-4



Indian and Northern Affairs Canada
Waste Management Program
Yukon Region



3. SYNOPSIS OF THE 1997 EXCAVATION, CAPPING AND CONFIRMATORY SAMPLING AT RAINY HOLLOW

A synopsis of the excavation, capping and confirmatory sampling at the lower site is presented in the following section. Detailed methodology and analytical result have been presented in the remediation report (Royal Roads, 1998).

3.1 Delineation

On the basis of the results obtained from both the preliminary and detailed site investigations, as well as the analysis of 15 additional samples on-site using field test kits, the contaminated areas were demarcated. Sampling locations, the concentrations of total DDTs and the affected areas are indicated on Figure 3-1. An area to the north of the Trench contained DDTs at concentrations exceeding 10 mg/kg and was marked for excavation. The remaining areas identified had DDTs between 1 to 10 mg/kg and were therefore marked for capping with clean gravel borrow. As part of the Quality Assurance/Quality Control (QA/QC) process, a number of samples were analyzed with the field test kits and also at Axys Analytical Services laboratory by gas chromatography with mass spectrometric detection. A comparison of the field test kit and laboratory results is given in Chapter 4.

3.2 Excavation and Confirmatory Testing

The area of surface soil affected with DDTs at concentrations exceeding 10 mg/kg, as outlined in Figure 3-1, was excavated for off site disposal on August 21 and 22, 1997 under generally fair weather conditions with minimal or no precipitation. After excavation to a depth of up to 0.15 m, eight confirmatory samples (AA1 - AA8) were collected from the excavated area and analyzed on-site using the field test kits. Samples AA1, AA2 and AA5 contained DDTs at concentrations exceeding 10 mg/kg while the remaining samples had levels between 1-10 mg/kg (Figure 3-2). This indicated additional excavation was needed in the vicinities of AA1, AA2 and AA5. As such, soils in these locations were removed to a maximum depth of 0.25m. Samples AA9 and AA10 collected after the second series of excavations contained 1-10 and <1.0 mg/kg DDT, respectively. This indicated the successful removal of soils affected with DDTs exceeding 10 mg/kg. The ground surface was surveyed using a rod and level before and after the excavation. The elevations were then used to plot cross sections of the excavated area and from these the volume of excavated material was calculated. The total in place volume of soil excavated was 110.5 m³. Copies of the cross section plots are given in Appendix B of the remediation report (Royal Roads, 1998).

3.3 Capping and Confirmatory Sampling

The excavated area, along with the remaining areas identified as containing DDTs at concentrations between 1 to 10 mg/kg was capped with a minimum of 0.5 m of clean gravel borrow. Capping commenced on August 22 and was completed on August 26,

1997. The ground surface was surveyed using a rod and level before and after the capping was completed. These elevations were then used to plot cross sections of the cap and from these the cap volumes were calculated to be approximately 1600 m³. Copies of the cross section plots are given in Appendix B of the remediation report (Royal Roads, 1998).

Confirmatory soil samples (A11 - A20) were collected from the periphery of the capped area and analyzed with the field test kits. The concentrations of total DDTs in all the samples were less than 1 mg/kg. Sampling locations and DDT concentrations are indicated on Figure 3-3.



3.4

AA7
1-10

<1.0
AA10
(25 cm depth)
AA5
>10

AA3
1-10

0.2/~1

1-10

0.7

0.19/1-10
AA6

AA4
1-10

AA9
~10
AA1
>10
AA2
>10

AA8
1-10

<1.0

1.2

~1.0

- ✖ Confirmatory samples at a depth of 15 cm
- ✖ Confirmatory samples at a depth of 25 cm
- ⊙ Monitoring well location
- ✦ Surface Soil Sample (RRU, 1996)
- ✧ Surface Soil Sample (RRU, 1997)
- 4.1/1-10 Laboratory Results/Field Test Kit Data (mg/kg)

TRENCH

Approximate limits of area excavated to a depth of 0.25 m

Approximate limits of area excavated to a depth of 0.15

RAINY HOLLOW

DDT CONCENTRATIONS IN CONFIRMATORY SAMPLES
AFTER EXCAVATION NEAR THE TRENCH IN 1997

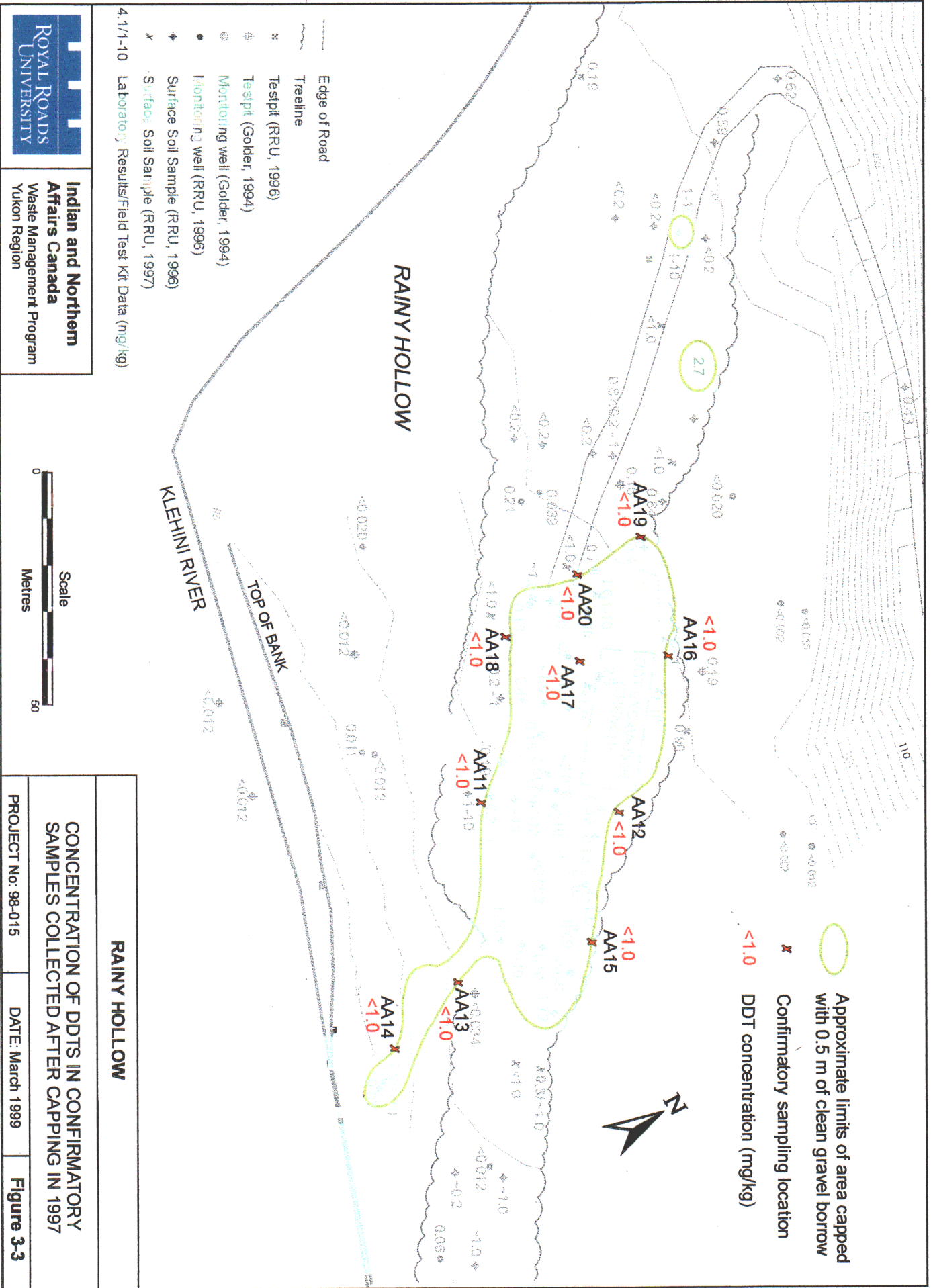
PROJECT No: 98-015 DATE: March 1999 Figure 3-2



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Scale





4. ON-SITE ANALYSIS BY IMMUNOASSAY FIELD TEST KITS

4.1 Methodology

Field analysis for DDT was performed using EnviroGard™ Test Kits. The kits utilize enzyme immunoassay, which is based on polyclonal antibodies that are specifically designed to bind to either the target analyte molecules or enzyme conjugate. The EnviroGard™ DDT in Soil kit has been evaluated and validated by the US EPA resulting in its incorporation into EPA Method SW846-4042.

The antibodies are bound to the walls of a 12 mm X 75 mm polystyrene test tube. A sample containing the analyte is added to the test tube followed by the addition of its enzyme conjugate. The analyte and enzyme conjugate compete for the limited number of antibody binding sites on the test tube. The test tube is then incubated for 10 to 15 minutes. After incubation, the unbound enzyme conjugate is washed off. A solution of a colour developing substrate is then added to the test tube. The substrate reacts with the bound enzyme conjugate to give a blue-coloured solution. A solution, which contains a low concentration of the analyte, will allow many enzyme conjugates to bind to test tube resulting in an intense colour. The intensity of the colour, therefore, is inversely proportional to the concentration of the analyte.

The immunoassay was carried out according to the manufacturer's instructions (Strategic Diagnostics Inc., 1997). A 5 g portion of the soil sample was weighed and extracted with 5 mL of methanol. About 1 mL of the extract was filtered and placed into a 2 mL amber glass vial. An aliquot of the extract was then used for the immunoassay analysis. Calibration was performed with standards supplied with the kits, which were 0.2, 1, and 10 mg/kg.

4.2 Comparison of Immunoassay Field Test Kit to Laboratory Gas Chromatography Results

The initial validation of the immunoassay test kits as a possible analytical method for confirmatory testing was carried out during the Detailed Site Investigation and Risk Assessment (Royal Roads, 1997). Thirteen samples were analyzed for DDT using field test kits and latter re-analyzed at Analytical Services Laboratory (ASL) by gas chromatography with electron capture detection (GC-ECD). The results obtained are reproduced in Table 4-1.

Table 4-1: Immunoassay Field Test Kit and Laboratory Gas Chromatography Results for Total DDTs in Soil Samples Collected at Border Station and Rainy Hollow in 1996

Sample Number	Concentration of Total DDTs (mg/kg)		Results Agree?
	Immunoassay Test Kit	Laboratory GC	
L1-1	>10	1.25	False Positive
L1-10	~0.2	0.089	Yes
L2-30	> 10	5.38	False Positive
L4-20	<0.2	0.043	Yes
L4-48	~0.2	0.072	Yes
L6-0	1-10	0.532	False Positive
M3	>10	11.2	Yes
M8	1-10	1.79	Yes
M10	1-10	7.2	Yes
TP4-2	<0.2	0.023	Yes
TP10-1	<0.2	0.007	Yes
TP10-2	1-10	0.39	False Positive
TP10-3	1-10	3.70	Yes

The field test kits accurately estimated the 'true' concentration as determined by GC/ECD for nine of the samples. For the remaining four samples, the DDT concentration was over-estimated by the field test kits (False Positives). While some analyses were over-sensitive (i.e., over-estimate the true total DDT concentration), in no case did a sample determined to contain less than 1 mg/kg DDT using the field test kits have a real total DDT concentration greater than 1 mg/kg. It was concluded that the DDT field test kit data would provide a good indication of soil samples at the sites with DDT concentrations above or below 1 mg/kg.

The immunoassay field test kits were consequently used for all on-site analysis for delineation and confirmatory sampling. As part of the quality assurance/quality control, a sub-set of split replicate samples in each batch of field determination was submitted to either Axys Analytical Laboratory or CanTest Ltd. for analysis. Axys conducted the analysis using gas chromatography with mass spectrometric detection (GC-MS) while CanTest employed gas chromatography with electron capture detection. Twenty-six soil samples were analyzed by both field and laboratory methods over the two-year period. The results are given in Table 4-2 and Table 4-3.

Table 4-2: Immunoassay Field Test Kit and Axys Analytical Laboratory Results for Total DDTs in Soil Samples Collected at Border Station and Rainy Hollow in 1997 and 1998

Sample Number	Concentration of Total DDTs (mg/kg)		Results Agree
	Immunoassay Test Kit	Laboratory GC	
A9	~1.0	0.2	Yes
A12	~1.0	0.33	Yes
A15	1-10	1.6	Yes
AA6	1-10	0.19	False Positive
AA10	<1.0	0.032	Yes
B2	>10	15	Yes
C3	1-10	5.7	Yes
C8	1-10	9.4	Yes
CCC1	<1.0	0.75	Yes
CCC4	1-10	3.3	Yes
CCC6	<1.0	0.64	Yes
CCC7	<1.0	0.65	Yes
CCC14	<1.0	0.009	Yes
CCC19	1-10	3.7	Yes
CCC24	<1.0	0.54	Yes
CCC33	>10	81	Yes
CCC37	1-10	15	False Negative
CCC40	1-10	2.4	Yes

Table 4-3: Immunoassay Field Test Kit and CanTest Laboratory Results for Total DDTs in Soil Samples Collected at Border Station in 1998

Sample Number	Concentration of Total DDTs (mg/kg)		Results Agree?
	Immunoassay Test Kit	Laboratory GC	
H3	<1.0	<0.003	Yes
H5	<1.0	0.041	Yes
H8	~1.0	0.102	Yes
G5	>10	0.77	False Positive
G8	>10	16	Yes
G18	>10	0.009	False Positive
G25	<1.0	0.55	Yes
G27	>10	0.19	False Positive

The results presented above were comparable to that obtained during the DSI (Royal Roads, 1997) with the field test kits providing the 'true' concentration as determined by laboratory GC for a majority of the samples. There were four of false positives (over-estimation of the concentration by the field test kit) and one false negative.

Sample CCC37 that generated the false negative required dilution and re-spiking with surrogate due to the high target concentration. The results obtained were not recovery corrected as a consequence (see laboratory report in Appendix A). Historical data indicate that recoveries of over 70% can be expected. An examination of the results for the other samples analyzed in the batch indicate that the average value of surrogate recoveries for 13C-DDE and 13C-DDT was 55%. If the total DDT concentration of 15 mg/kg is corrected by this factor, the resulting value of 8.25 mg/kg will agree with the field test kit data.

A summary of all the results obtained during the DSI and the subsequent remedial activities is presented graphically in Figure 4-1. A total of 200 soil samples collected from Border Station and Rainy Hollow were analyzed with the immunoassay field test kit over the three-year period. Out of these, 39 samples were analyzed using both the field test kit and laboratory GC, which represents 19% of total analyzed by test kits. As depicted in the figure above, a majority of the concentrations obtained using the field test kits agreed with the laboratory data. However, there was one false negative (2.5% occurrence) and eight false positives (20% occurrence).

According to the US EPA SW846-4000 Method for Immunoassay, the maximum permissible false negative rate is 5% while producing as few false positive results (nominally less than 20%). The results obtained in this investigation are therefore, within acceptable limits indicating that the EnviroGard™ DDT in Soil Test Kit served as a useful tool for the field analysis.

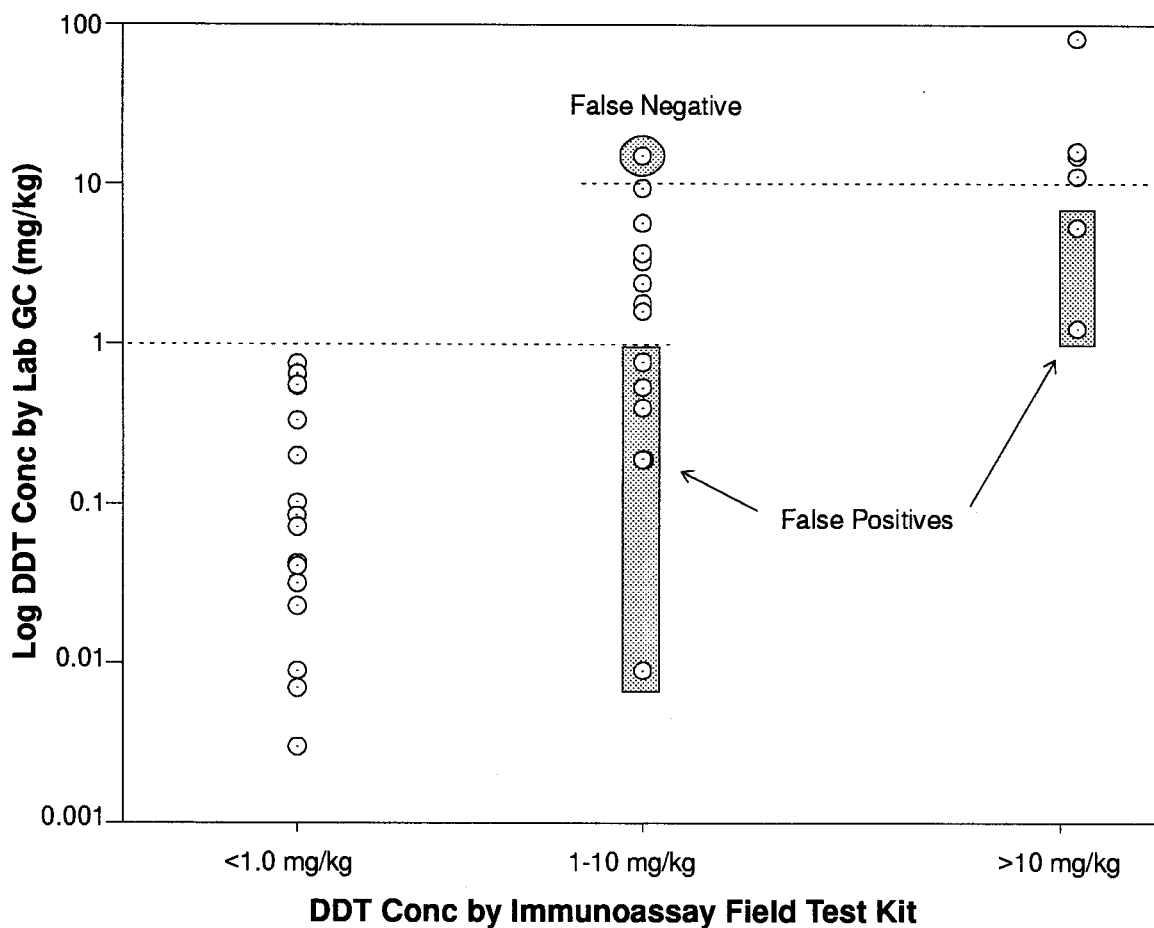


Figure 4-1: Comparison of Immunoassay Field test Kit Results to Laboratory Gas Chromatography Data for the Analysis of Total DDT in Soil Samples Collected at Border Station and Rainy Hollow in 1996, 1998 and 1998.

5. CONCLUSION

This report has been prepared for DIAND to document the results of the excavation and capping of DDT (including all p,p'-DDT, o,p'-DDT, p,p'-DDD, o,p'-DDD, p,p'-DDE, and o,p'-DDE isomers) contaminated soils at Border Station and Rainy Hollow in northern British Columbia. One hundred and twenty-five cubic metres of surface soils contaminated with DDT at concentrations exceeding 10 mg/kg were excavated from the vicinity of the former Temporary Storage Facility and near the Trench at Rainy Hollow in the summer of 1997 and disposed off-site. This was to curtail the possible exposure pathways for DDTs in surface soils to wildlife and humans. The remaining DDT-contaminated soils with total DDT concentration in the range of 1 to 10 mg/kg and hydrocarbon-contaminated soils with concentrations exceeding 1000 mg/kg were capped using a minimum of 0.5m of clean granular material.

Results of additional confirmatory sampling at locations along the access roads to the Temporary Storage Facility indicated that the concentrations of DDTs in most of the samples were less than 1.0 mg/kg. However, two locations in depressions along the access road east of the Temporary Storage Facility had DDTs in excess of 10 mg/kg. Contaminated soils in these two areas were excavated in October 1998 and removed off-site for disposal. Confirmatory samples collected after excavation indicated successful removal of the DDT contaminated soils. The excavated areas along with other locations identified as containing DDTs at 1 – 10 mg/kg concentrations were capped with clean granular material and re-graded to conform to the natural contours.

EnviroGard™ DDT in soil test kits were used for field analyses. A comparison of field test kits to laboratory gas chromatography results indicated good agreement between the two sets of data. There was one false negative (underestimation of DDT concentration by the field test kit) and eight false positives (i.e., overestimation of the true DDT concentration). While some analyses were over-sensitive in no case did a sample determined to contain less than 1 mg/kg DDT using the field test kits have a real total DDT concentration greater than 1 mg/kg. According to the US EPA SW846-4000 Method for Immunoassay, the maximum permissible false negative rate is 5% while producing as few false positive results (nominally less than 20%). The results obtained in this investigation, 2.5% occurrence of false negatives and 20% false positives are therefore, within acceptable limits indicating that the EnviroGard™ DDT in Soil Test Kit served as a useful tool for field analysis.

6. REFERENCES

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- Royal Roads University - Applied Research Division (1996a). Haines-Fairbanks Pipeline: Environmental Issues at Border Pump Station and Rainy Hollow Sites. Report prepared for Indian and Northern Affairs (DIAND) AES, March, 1996.
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- Royal Roads University - Applied Research Division (1996c). Characterization of Soils at the Temporary Storage Facility, Border Pump Station. Report prepared for Indian and Northern Affairs (DIAND) AES, October, 1996.
- Royal Roads University - Applied Research Division (1998). Site Remediation of Border Pump Station and Rainy Hollow, British Columbia Canada. Report prepared for Indian and Northern Affairs (DIAND), Waste Management Program, Whitehorse, Yukon, January 1998.
- Royal Roads University (Royal Roads, 1999). Annual Monitoring Program of Border Pump Station and Rainy Hollow, British Columbia, Canada. Report prepared for Indian and Northern Affairs (DIAND), Waste Management Program, Whitehorse, Yukon, February 1999.
- UMA Engineering Ltd. and AMBIO Research Associates, Inc., 1995. Preliminary Environmental Assessment Haines-Fairbanks Pipeline. Report prepared for AES-Whitehorse (DIAND) in August, 1995.
- UMA Engineering Ltd., 1997. Construction Specifications for the Site Remediation of the border Pump Station and Rainy Hollow Sites, British Columbia, Canada. Prepared for Indian and Northern Affairs Canada, Waste Management, Yukon, July 1997.
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Appendix A:
Axys Analytical Laboratory
Data Reports for Soil Samples Collected
at Border Station in August 1998

**AXYS**Axys Analytical
Services LtdPO Box 2219, 2045 Mills Road West
Sidney, British Columbia, Canada V8L 3S8

DATE: 16 October 1998
TO: Matt Dodd
ORGANIZATION: Royal Roads University **Our File:** 9809
ADDRESS: **Batch ID:** CL-1417
FAX: 391-2560 **Sample:** -27,30,31,32,34,35,36,37,38,39
FROM: Dale Hoover **total no. pages:** 14

Please find attached the DDE/DDT analysis results for ten soil samples. Should you have any questions, please do not hesitate to contact me.

Regards

TEL: (250) 656-0881
E-MAIL: analytical@axys.com

FAX: (250) 656-4511
toll-free: 1-888-373-0881

BATCH SUMMARY

Batch ID: CL-1417	Date: 16 October 1998
Analysis Type: PCB/Pesticide	Matrix Type: Soil
BATCH MAKEUP	
Samples: 9809 -27 -30 -31 -32 -34A -35 -36 -37 -38 -39	Blank: <div style="text-align: center;">CL-S-BLK 1417</div>
	Reference or Spike: <div style="text-align: center;">CL-S-SPM 1055</div>
	Duplicate: <div style="text-align: center;">9809-34B</div>
Comments <ol style="list-style-type: none"> 1. Please note that sample results have not been corrected for concentrations detected in laboratory procedural blanks. 2. Samples 9809-37, -38, and -39 required dilution / re-spiking with surrogate due to the high target concentrations. Results are not recovery corrected as a consequence. If confirmation is required, analysis can be repeated with a smaller sample size. 	

Copyright Axys Analytical Services Ltd.
February 1993

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: Procedural Blank

AXYS ID: CL-S-BLK 1417

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Blank

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 9.00 g

INSTRUMENT: GC-MS

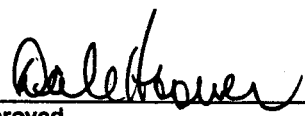
RUNFILE ID: CL893204.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.01
p,p'-DDE	ND	0.03
o,p'-DDD	ND	0.03
p,p'-DDD	ND	0.02
o,p'-DDT	ND	0.05
p,p'-DDT	ND	0.07

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	56
13C-p,p'-DDE	58
13C-p,p'-DDT	69
13C-PCB 101	65
13C-PCB 180	67

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: Spiked Matrix

AXYS ID: CL-S-SPM 1055

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 9.45 g

INSTRUMENT: GC-MS

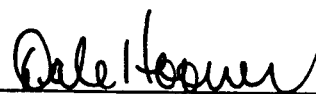
RUNFILE ID: CL893206.D

CONCENTRATION IN: ng/g

Compounds	Determined	Expected	% Recovery
o,p'-DDE	6.0	6.3	95
p,p'-DDE	5.6	6.1	92
o,p'-DDD	5.9	5.7	104
p,p'-DDD	7.6	7.5	101
o,p'-DDT	5.8	6.9	84
p,p'-DDT	7.5	6.8	110

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	36
13C-p,p'-DDE	42
13C-p,p'-DDT	46
13C-PCB 101	47
13C-PCB 180	51

1. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT
PRELIMINARY

CL002

CLIENT SAMPLE I.D: CCC1

AXYS ID: 9809-27

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 9.38 g wet

INSTRUMENT: GC-MS

% MOISTURE: 13

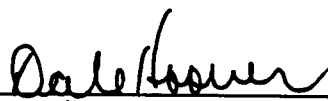
RUNFILE ID: CL893207.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	0.48	0.01
p,p'-DDE	15	0.04
o,p'-DDD	16	0.04
p,p'-DDD	60	0.05
o,p'-DDT	* 150	0.05
p,p'-DDT	* 510	0.05

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	43
13C-p,p'-DDE	63
13C-p,p'-DDT	60
13C-PCB 101	59
13C-PCB 180	62

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected
6. * - response exceeds calibration range and extracts are being diluted and re-analyzed.


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: CCC4

AXYS ID: 9809-30 N

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 9.07 g wet

INSTRUMENT: GC-MS

% MOISTURE: 9.4

RUNFILE ID: CL893294.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	2.0	0.2
p,p'-DDE	120	0.5
o,p'-DDD	44	0.2
p,p'-DDD	180	0.8
o,p'-DDT	300	0.5
p,p'-DDT	2700	0.5

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	75
13C-p,p'-DDE	62
13C-p,p'-DDT	60
13C-PCB 101	73
13C-PCB 180	61

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: CCC6

AXYS ID: 9809-31

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 9.64 g wet

INSTRUMENT: GC-MS

% MOISTURE: 7.5

RUNFILE ID: CL893209.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	0.11	0.03
p,p'-DDE	2.6	0.02
o,p'-DDD	1.2	0.02
p,p'-DDD	3.5	0.07
o,p'-DDT	7.2	0.02
p,p'-DDT	50	0.02

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	36
13C-p,p'-DDE	54
13C-p,p'-DDT	55
13C-PCB 101	55
13C-PCB 180	60

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: CCC7

AXYS ID: 9809-32

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 9.41 g wet

INSTRUMENT: GC-MS

% MOISTURE: 8.3

RUNFILE ID: CL893210.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	0.09	0.03
p,p'-DDE	2.4	0.04
o,p'-DDD	1.3	0.03
p,p'-DDD	3.9	0.04
o,p'-DDT	7.4	0.2
p,p'-DDT	50	0.02

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	35
13C-p,p'-DDE	41
13C-p,p'-DDT	45
13C-PCB 101	43
13C-PCB 180	53

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: CCC14

AXYS ID: 9809-34 A

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 9.03 g wet

INSTRUMENT: GC-MS

% MOISTURE: 13

RUNFILE ID: CL893217.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.03
p,p'-DDE	1.2	0.04
o,p'-DDD	0.24	0.03
p,p'-DDD	0.79	0.05
o,p'-DDT	0.85	0.04
p,p'-DDT	5.6	0.04

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	44
13C-p,p'-DDE	41
13C-p,p'-DDT	56
13C-PCB 101	47
13C-PCB 180	64

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: CCC14

AXYS ID: 9809-34 B

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 8.99 g wet

INSTRUMENT: GC-MS

% MOISTURE: 14

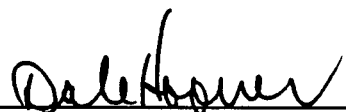
RUNFILE ID: CL893218.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.04
p,p'-DDE	1.8	0.06
o,p'-DDD	0.25	0.03
p,p'-DDD	1.1	0.05
o,p'-DDT	0.72	0.05
p,p'-DDT	12	0.04

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	36
13C-p,p'-DDE	32
13C-p,p'-DDT	49
13C-PCB 101	36
13C-PCB 180	45

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: CCC19

AXYS ID: 9809-35 N

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 9.54 g wet

INSTRUMENT: GC-MS

% MOISTURE: 7.2

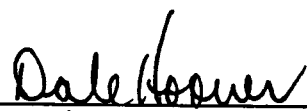
RUNFILE ID: CL893295.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	10	0.3
p,p'-DDE	60	0.2
o,p'-DDD	80	0.4
p,p'-DDD	220	0.6
o,p'-DDT	480	0.5
p,p'-DDT	2800	0.5

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	54
13C-p,p'-DDE	51
13C-p,p'-DDT	50
13C-PCB 101	55
13C-PCB 180	76

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: CCC24

AXYS ID: 9809-36 N

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 10.0 g wet

INSTRUMENT: GC-MS

% MOISTURE: 2.6

RUNFILE ID: CL893296.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	4.7	0.3
p,p'-DDE	16	0.3
o,p'-DDD	42	0.4
p,p'-DDD	48	0.3
o,p'-DDT	71	0.4
p,p'-DDT	360	0.4

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	73
13C-p,p'-DDE	62
13C-p,p'-DDT	60
13C-PCB 101	71
13C-PCB 180	72

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: CCC37

AXYS ID: 9809-37 NK

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 9.09 g wet

INSTRUMENT: GC-MS

% MOISTURE: 13

RUNFILE ID: CL893297.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	61	11
p,p'-DDE	2400	8.6
o,p'-DDD	410	10
p,p'-DDD	1100	13
o,p'-DDT	1700	6.1
p,p'-DDT	9400	26

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	NQ ⁶
13C-p,p'-DDE	NQ ⁶
13C-p,p'-DDT	NQ ⁶
13C-PCB 101	NQ ⁶
13C-PCB 180	NQ ⁶

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. NOTE: CONCENTRATIONS ARE NOT RECOVERY CORRECTED.
6. Surrogate recoveries could not be determined due to large dilution/surrogate respiking required to bring target response within calibration range. Historical data indicate recoveries of greater than 70% can be expected.


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: CCC40

AXYS ID: 9809-38 NK

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 9.31 g wet

INSTRUMENT: GC-MS

% MOISTURE: 8.9

RUNFILE ID: CL893298.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	ND	14
p,p'-DDE	480	8.8
o,p'-DDD	60	12
p,p'-DDD	240	25
o,p'-DDT	180	21
p,p'-DDT	1500	19

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	NQ ⁶
13C-p,p'-DDE	NQ ⁶
13C-p,p'-DDT	NQ ⁶
13C-PCB 101	NQ ⁶
13C-PCB 180	NQ ⁶

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. NOTE: CONCENTRATIONS ARE NOT RECOVERY CORRECTED.
6. Surrogate recoveries could not be determined due to large dilution/surrogate respiking required to bring target response within calibration range. Historical data indicate recoveries of greater than 70% can be expected.


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: CCC33

AXYS ID: 9809-39 NK

CLIENT: Royal Roads University

DATE: 16/Oct/98

SAMPLE TYPE: Soil

METHOD NO.: CL-S-01/Ver.2

SAMPLE SIZE: 8.91 g wet

INSTRUMENT: GC-MS

% MOISTURE: 12

RUNFILE ID: CL893299.D

CONCENTRATION IN: ng/g

Compounds	Concentration	(SDL)
o,p'-DDE	240	8.2
p,p'-DDE	7700	12
o,p'-DDD	1900	13
p,p'-DDD	4400	64
o,p'-DDT	8700	10
p,p'-DDT	58000	10

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	NQ ⁶
13C-p,p'-DDE	NQ ⁶
13C-p,p'-DDT	NQ ⁶
13C-PCB 101	NQ ⁶
13C-PCB 180	NQ ⁶

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. **NOTE: CONCENTRATIONS ARE NOT RECOVERY CORRECTED.**
6. Surrogate recoveries could not be determined due to large dilution/surrogate respiking required to bring target response within calibration range. Historical data indicate recoveries of greater than 70% can be expected.


Approved

Appendix B:
CanTest Ltd. Analysis Report
for Soil Samples Collected at
Border Station in October 1998

Analysis Report

CANTEST

CanTest Ltd

Professional
Analytical
Services**REPORT ON:** Analysis of Soil Samples**REPORTED TO:** Royal Roads University
2005 Sooke Road
Victoria, B.C.
V9B 5X2Att'n: Mr. Matt Dodd**CHAIN OF CUSTODY:** 40824
PROJECT NAME: Rainy Hollow1523 West 3rd Ave
Vancouver, BC
V6J 1J8

Fax: 604 731 2386

Tel: 604 734 7276

1 800 665 8566


NUMBER OF SAMPLES: 8**REPORT DATE:** November 9, 1998**DATE SUBMITTED:** November 2, 1998**GROUP NUMBER:** 8110235**SAMPLE TYPE:** Soil**TEST METHODS:**

Organochlorine Pesticides in Water and Soil - analysis was performed using procedures based on U.S. EPA Method 608/8080, including extraction, clean-up steps, and analysis using GC/ECD.

TEST RESULTS:

(See following pages)

CAN TEST LTD.


Zhenyong Gao, M.Sc.
Coordinator, Trace Organics

Page 1 of 3



REPORTED TO: Royal Roads University

REPORT DATE: November 9, 1998

GROUP NUMBER: 8110235

Organochlorine Pesticides in Soil

CLIENT SAMPLE IDENTIFICATION:	H3	H5	H8	G5	DETECTION LIMIT
DATE SAMPLED:	Oct 29/98	Oct 29/98	Oct 29/98	Oct 30/98	
CAN TEST ID:	811020124	811020125	811020126	811020127	
Aldrin	<	<	<	<	0.001
alpha-BHC	<	<	<	<	0.001
beta-BHC	<	<	<	<	0.001
delta-BHC	<	<	<	<	0.001
gamma-BHC (Lindane)	<	<	<	<	0.001
alpha-Chlordane	<	<	<	<	0.005
gamma-Chlordane	<	<	<	<	0.005
p,p-DDD	<	<	0.036	0.098	0.005
o,p-DDE	<	<	<	<	0.003
p,p-DDE	<	0.003	0.017	0.039	0.003
o,p-DDT	<	<	<	<	0.003
p,p-DDT	<	0.038	0.049	0.64	0.003
Dieldrin	<	<	<	<	0.003
Endosulfan I	<	<	<	<	0.01
Endosulfan II	<	<	<	<	0.01
Endosulfan Sulphate	<	<	<	0.026	0.01
Endrin	<	<	<	<	0.01
Endrin Aldehyde	<	<	<	<	0.01
Heptachlor	<	<	<	<	0.001
Heptachlor Epoxide	<	<	<	<	0.001
Methoxychlor	<	<	<	<	0.01
Toxaphene	<	<	<	<	0.3

Results expressed as micrograms per gram, on a dry weight basis. ($\mu\text{g/g}$)

< = Less than detection limit

REPORTED TO: Royal Roads University

REPORT DATE: November 9, 1998

GROUP NUMBER: 8110235

Organochlorine Pesticides in Soil

CLIENT SAMPLE IDENTIFICATION:	G8	G27 Grey	G27 Red	G31	DETECTION LIMIT
DATE SAMPLED:	Oct 30/98	Oct 30/98	Oct 30/98	Oct 30/98	
CAN TEST ID:	811020128	811020129	811020130	811020131	
Aldrin	<	<	<	<	0.001
alpha-BHC	0.001	<	<	<	0.001
beta-BHC	<	<	<	<	0.001
delta-BHC	0.002	0.001	<	<	0.001
gamma-BHC (Lindane)	<	<	<	<	0.001
alpha-Chlordane	0.006	<	<	<	0.005
gamma-Chlordane	0.043	<	<	<	0.005
p,p-DDD	1.8	0.10	0.040	0.017	0.005
o,p-DDE	0.004	<	<	<	0.003
p,p-DDE	0.32	0.023	0.014	<	0.003
o,p-DDT	2.8	0.096	0.046	0.010	0.003
p,p-DDT	11	0.33	0.093	0.047	0.003
Dieldrin	<	<	<	<	0.003
Endosulfan I	0.01	<	<	<	0.01
Endosulfan II	<	<	<	<	0.01
Endosulfan Sulphate	0.65	0.026	<	<	0.01
Endrin	<	<	<	<	0.01
Endrin Aldehyde	<	<	<	<	0.01
Heptachlor	0.004	<	<	<	0.001
Heptachlor Expoxide	<	<	<	<	0.001
Methoxychlor	<	<	<	<	0.01
Toxaphene	<	<	<	<	0.3

Results expressed as micrograms per gram, on a dry weight basis. ($\mu\text{g/g}$)

< = Less than detection limit

