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vironmental Information Document

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BUREAU OF REMEDIAL ACTION
DIVISION OF SOLID WASTE

SITE INVESTIGATIONS AND REMEDIAL ACTION ALTERNATIVES LOVE CANAL

Task III
Black and Bergholtz Creeks

For

Division of Solid and Hazardous Waste
New York State Department
of Environmental Conservation
Albany, New York

August 1983

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By

Malcolm Pirnie, Inc.
Niagara Falls, Albany and White Plains, New York

MALCOLM PIRNIE

MALCOLM PIRNIE, INC.
ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

August 12, 1983

Norman H. Nosenchuck, Director
Division of Solid and Hazardous Waste
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, New York 12233

Re: Site Investigations and Remedial
Action Alternatives, Love Canal

Dear Mr. Nosenchuck:

Submitted herewith is the Environmental Information Document (EID) for Task III, Black and Bergholtz Creeks. As marked, this report is a draft and is subject to revision based upon your review, USEPA Region II comments, as well as the reviews performed by other cognizant New York State agencies.

A voluminous amount of detailed supporting documentation stands behind this EID. That back-up information which includes sampling logs, chain-of-custody forms, analytical data, QA/QC reports, and so on, will be submitted to you separately. Additionally, a summary document will be prepared to address all five project task areas. That summary document is intended to be submitted with the final EIDs.

We would be pleased to make a presentation to you concerning this report at your request. If either of the undersigned may be of further assistance to you, please feel free to contact us.

Very truly yours,

MALCOLM PIRNIE, INC.

Michael J Mann

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1.0 INTRODUCTION

The former chemical waste disposal site at Love Canal occupies a 16-acre rectangular plot of ground in the LaSalle District of Niagara Falls, New York as shown on Figure 1-1. The site is bounded by Colvin Boulevard on the north, 99th Street on the east, Frontier Avenue on the south, and 97th Street on the west. Two roads, Read and Wheatfield Avenues, cross the landfill in an east-west direction. A public elementary school, known as the 99th Street School, occupies a portion of the land between Read and Wheatfield Avenues and was built adjacent to the eastern boundary of the landfill. The southernmost portion of the site is approximately 1,500 feet north of the Niagara River.

The first signs of serious chemical contamination at Love Canal became evident in 1975, and by November 1976 the frequency and magnitude of the problems cited by area residents prompted an investigation of the site by the New York State Department of Environmental Conservation (NYSDEC). As a result of this investigation, a barrier drain, a clay cap over the former canal, and permanent on-site leachate treatment facilities were completed by the end of 1979.

The primary objectives of this initial remedial construction at Love Canal were to halt further lateral migration of contaminants from the landfill, prevent runoff of contaminated surface water, and minimize leachate generation. A United States Environmental Protection Agency (USEPA) study, released in May, 1982, concluded that the barrier drain was functioning effectively to halt the lateral transport of contaminants through the soil.

FIGURE I-1

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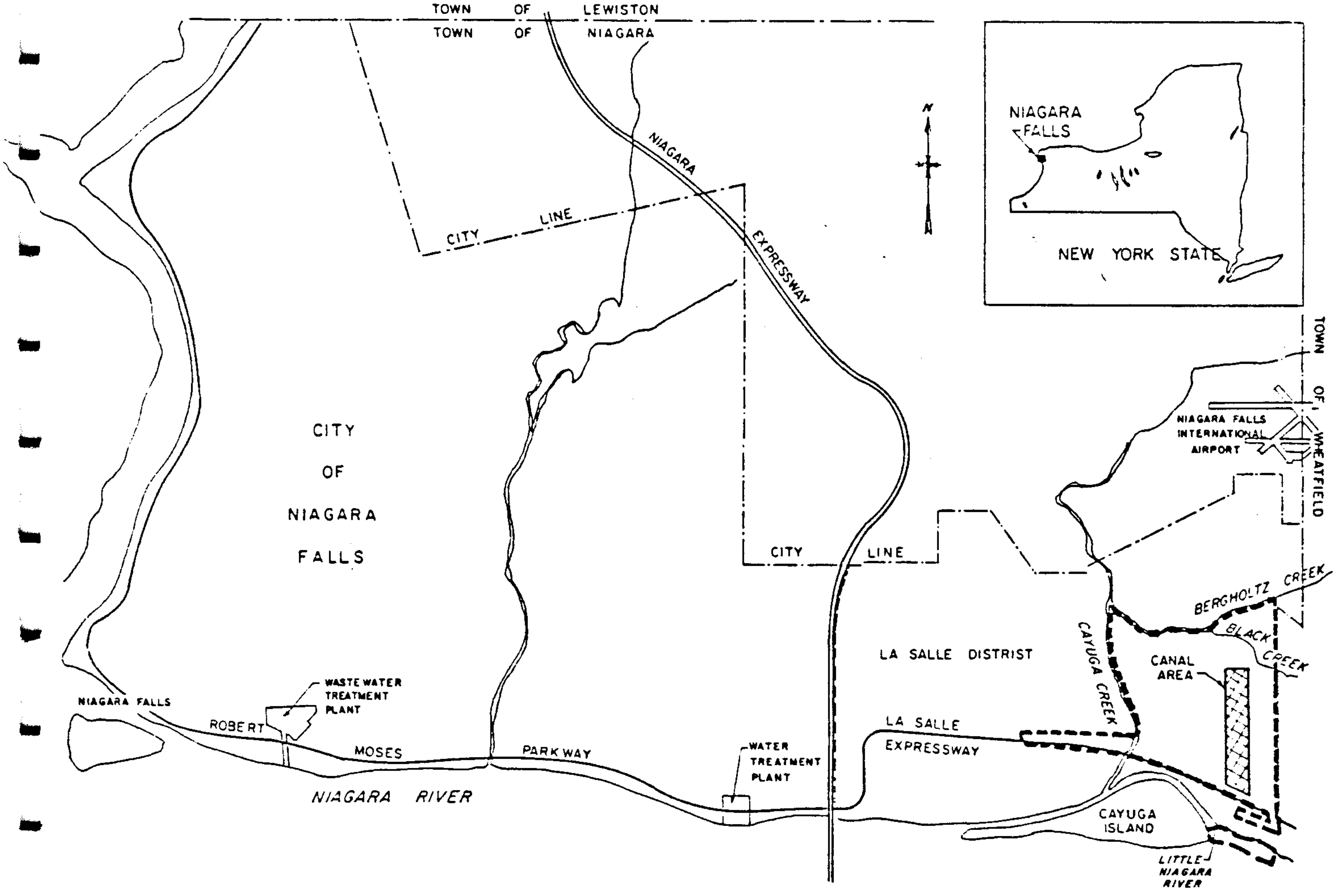

LOVE CANAL
SITE INVESTIGATIONS AND REMEDIAL
ACTION ALTERNATIVES
REGIONAL MAP

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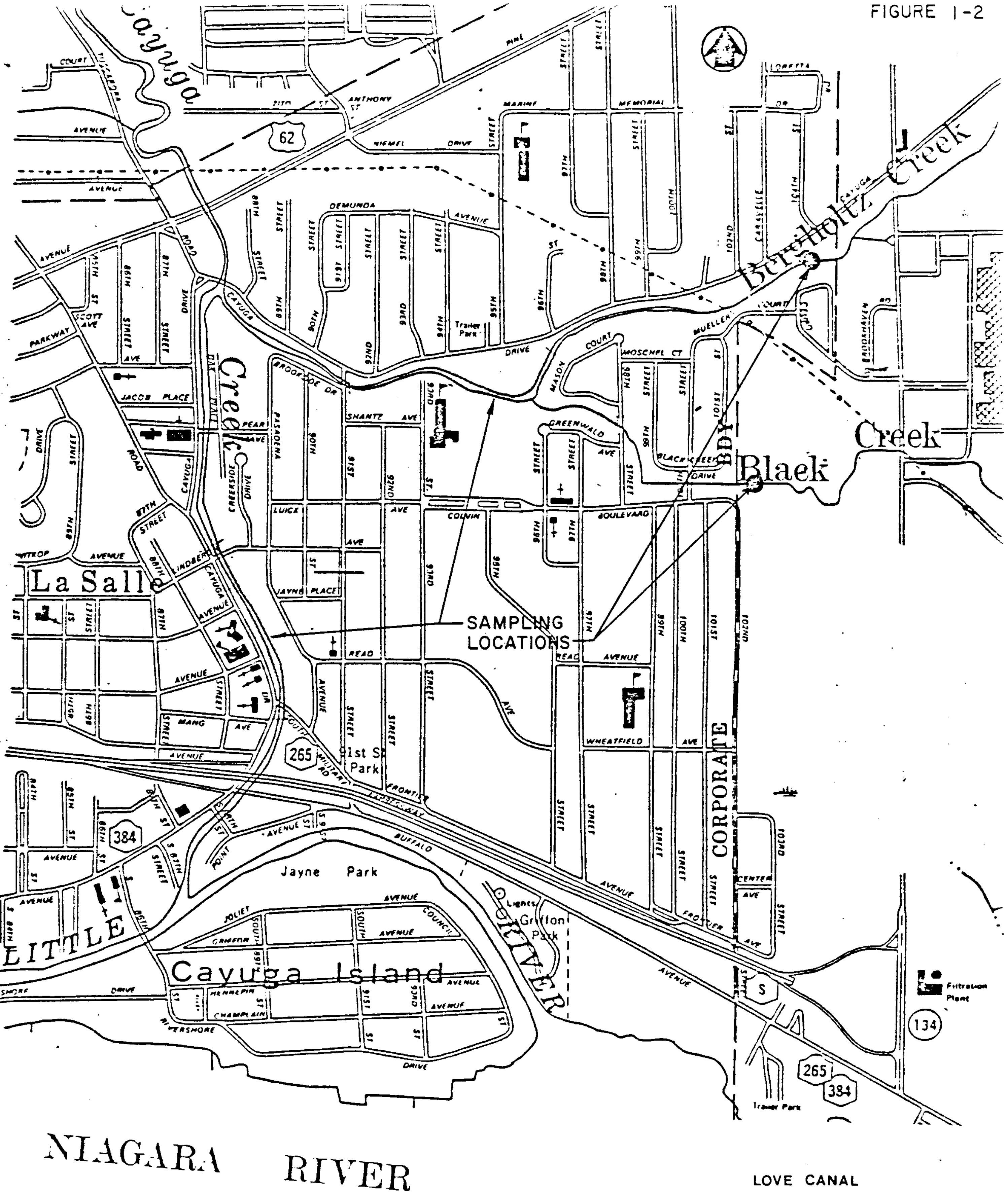
In January, 1983, five engineering investigations were initiated in areas adjacent to Love Canal. These engineering investigations were conducted by Malcolm Pirnie, Inc. as part of seven additional Love Canal remedial projects being administered by the NYSDEC Division of Solid Waste under a cooperative agreement with the USEPA. Task Areas II, IV and VII address contamination in adjacent storm and sanitary sewers, while Task Areas III and VI are concerned with contaminated sediments in Black, Bergholtz and Cayuga Creeks and in the Niagara River near the 102nd Street storm sewer outfall. The Study Area, comprised of the five Task Areas, the area encompassed by the May, 1980 emergency declaration, and the immediate canal area (i.e. Rings 1 and 2 inside the fence), is illustrated on Figure 1-2.

This Environmental Information Document (EID) presents a detailed contamination assessment and evaluates remedial alternatives for Task Area III, the Black, Bergholtz, and Cayuga Creeks. EIDs addressing the four other Task Areas and a summary document describing the findings in all five Task Areas have been prepared separately.

FIGURE 1-2



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LOVE CANAL
FIVE ENGINEERING STUDIES

BLACK AND
BERGHOLTZ CREEK
TASK III

VICINITY MAP

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2.0 PROJECT OBJECTIVES

2.1 Overall Program

The overall objective of the project is to develop the most environmentally sound and economically feasible remedial action plan for any Love Canal-related contamination which has migrated away from Rings 1 and 2. The specific work items associated with each of the five Task Areas are summarized below:

- Determination of the extent of contamination in the task area.
- Identification of the pathways for migration of contaminants into and away from the task area.
- Assessment of the effects of contaminants in and migrating from the task area.
- Development of remedial alternatives to prevent further contamination of the environment from the contamination in the task area.
- Evaluation of the implementability of each alternative.
- Recommendation of the alternative to be implemented.

2.2 Task Specific Objectives

The objective of the creek sampling program is to determine the quality of the creeks and to ascertain if contaminants have migrated from Love Canal. The suspected modes of transport for possible contamination are storm sewer discharges and

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sanitary sewer overflows into the creeks. The collection and analysis of both water and sediment samples are to aid in identifying any specific transport modes. This would also characterize the contamination as either historical or current in nature.

Should any contamination be found, an assessment would be made of present and potential impacts on the local environment. The development of remedial alternatives, their evaluation, and the recommendation of a remedial program would be the end result of the sampling program.

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3.0 BACKGROUND INFORMATION

3.1 Site Description

The Black, Bergholtz, and Cayuga Creeks are small tributaries of the Niagara River. They pass through the northern and western portions of the Love Canal Declaration Zone and provide natural drainage for much of the area.

Black Creek Flows in an east-to-west direction from the edge of the Love Canal Declaration Zone to a point near Colvin Boulevard and 102nd Street where it enters an underground pipe. This underground portion of the Black Creek flows to the west, then north, then west to the area of Greenwald Avenue and 98th Street where it receives stormwater from the Canal area. Just north of Greenwald Avenue, Black Creek resurfaces and flows west to its confluence with Bergholtz Creek in the vicinity of 96th Street. Approximately 100 feet upstream from this confluence is the 96th Street outfall which discharges Love Canal related stormwater.

Bergholtz Creek flows in a southwesterly direction from the northeast corner of the Love Canal Declaration Zone to its confluence with Black Creek in the area of 96th Street. From here the Creek continues to flow to the west until joining Cayuga Creek near the intersection of Cayuga Drive and 88th Street. There are no known direct piped discharges to Bergholtz Creek within the study area.

Cayuga Creek forms the western boundary of the Declaration Zone and flows in a north-to-south direction from the mouth of Bergholtz Creek to its confluence with the Little Niagara

River near South 87th Street. The little Niagara River empties into the Niagara River on the west end of Cayuga Island. There are numerous stormwater and sanitary sewer overflow discharges to Cayuga Creek some of which originate in the Love Canal area.

Overall, the three Creeks are gently sloped as they flow from the study area to the Niagara River. Due to the flat stream gradient, the Niagara drastically affects flow patterns in the Creeks. Certain weather-related conditions on the Niagara River, such as strong headwinds, can result in local and temporary reversal of flows in the three Creeks. The Creeks also experience wide fluctuations in depths due to varying quantities of water being withdrawn from the Niagara River at different times of the day by the New York and Canadian power companies. These variations in flows and depths complicate the review of water and sediment sampling results and attempts to identify specific contaminant sources.

Numerous documents exist which directly or indirectly address Love Canal, and other nearby inactive hazardous waste disposal sites and their effect on the environment. The following summarizes the findings of these previous reports relative to the extent of contamination in the Task III Creeks.

3.2 USEPA Monitoring Study

The most recent and comprehensive report on environmental contamination, "Environmental Monitoring at Love Canal", was published by the USEPA in May 1982. The report was based on extensive analyses of air, water, sediment, and biota samples collected during August, September, and October of 1980. The USEPA data indicated that contamination was present in storm sewer lines which originated near the former canal.

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Water samples and sediment samples were collected from six (6) sites located in the Black, Bergholtz, and Cayuga Creeks. The samples were analyzed, and detectable levels of Benzene, Toluene, and Benzene Hexachloride (BHC) were reported.

Black Creek was sampled at 98th Street and at the 96th Street storm sewer outfall. At the 98th Street sampling location trace levels of Benzene in the sediments and Toluene in the water were identified. Concentrations of 3 ppb of BHC and 0.075 ppb of Dioxin were also reported in the sediments. At the 96th Street outfall sampling location trace levels of Toluene and BHC were identified in the water while the sediment samples contained concentrations of 45 ppb of Benzene, 63 ppb of Toluene, 6,325 ppb of BHC, and 37.4 ppb of Dioxin.

Bergholtz Creek was sampled at its confluence with Black Creek near the 96th Street outfall, upstream near 98th Street, and downstream at 92nd Street. At the upstream sampling location trace levels of Toluene in the water and 52 ppb of BHC in the sediments were identified. At the downstream sampling location only trace levels of Toluene in the sediments were reported. At the sampling location near the outfall, trace levels of Touluene were detected in the water while trace levels of Benzene, 15 ppb of Toluene, 21 ppb of BHC, and 1.32 ppb of Dioxin were found in the sediment samples.

Cayuga Creek was sampled in one location near the south end of the 89th Street. Trace levels of BHC in the water and Benzene and Toluene in the sediments were detected. A concentration of 42 ppb of BHC in the sediments was also reported.

The contaminant levels reported in Black Creek appeared to be an indication of Love Canal contamination transmitted by way of the storm sewer system. However, the pathways of contaminant migration to the upper Bergholtz and Cayuga Creeks are indirect and poorly defined. Based on this lack of well defined pathways and the presence of several other potential sources of contamination in the area, it was not possible to clearly identify Love Canal as the source of the contaminants in the upper Bergholtz and Cayuga Creeks.

3.3 Other Environmental Monitoring Studies

An analytical survey of the Love Canal area storm sewers flowing northward into Black Creek was performed by USEPA Region II between March and May of 1980. As part of this study the following locations were sampled on the Black Creek:

- BC-1, confluence with Bergholtz Creek.
- BC-2, midway between confluence (BC-1) and 96th Street outfall.
- BC-3, one foot downstream from the 96th Street outfall.
- BC-4, one foot downstream from the twin, forty-eight inch culverts at 98th Street.
- BC-5, forty feet upstream from the intake structure at 102nd Street.

Each sample was a composite of grab samples taken at five locations across the width of the Creek. The sediments sampled at theses locations were analyzed for various isomers of BHC, TCP, and Di-chlorobenzene. The concentration ranges for these compounds at each sampling location, as reported by USEPA, are shown below.

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TABLE 3-1

Black Creek Contaminant Levels
Concentration Ranges (ppb)

Location	Isomers of Benzene Hexachloride (BHC)	2,4,5 Trichlorophenol (TCP)	Isomers of Dichlorobenzene
BC-1	50	210	180 - 670
BC-2	610 - 1,610	90	110 - 3,850
BC-3	2,280 - 11,900	60	500 - 9,090
BC-4	30 - 140	10	250 - 1,030
BC-5	ND	ND	2,060

ND = Not Detected

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These analyses were the first comprehensive test results for the Black Creek and provided a baseline for use in comparing future analytical work.

The New York State Department of Health (NYSDOH) detected 2,3,7,8 - TCDD (Dioxin) at levels from 15 ppb to 31 ppb in sediments collected from the 96th Street stormwater outfall to Black Creek in November of 1979. Prior sampling of liquid and sediment from Black Creek by the USEPA detected no 2,3,7,8 - TCDD at or above 1 ppb in reaches upstream, adjacent to or downstream from the Canal area.

3.4 Other Abandoned Hazardous Waste Disposal Sites

Inactive hazardous waste disposal sites in the Niagara Falls area (see Figure 3-1) are believed to be a major source of persistent chemical substances that contribute to contamination in the Niagara River, and subsequently Lake Ontario. Investigations by the NYSDEC and the Interagency Task Force have identified 155 disposal sites within 3 miles of the Niagara River. Several sites are located close to the canal area and therefore complicate the identification of contaminant sources and remedial measures for the Black, Bergholtz and Cayuga Creeks. Specifically, the sites of major concern are: the Niagara County Refuse Disposal (Wheatfield) site along the upper reaches of Black Creek, the 93rd Street School site along Bergholtz Creek, and the Charles Gibson site along the upper reaches of Cayuga Creek.

The Niagara County Refuse Disposal (Wheatfield) site is located in the Town of Wheatfield east of Love Canal in the Black Creek watershed. While accurate information is unavailable, thousands of tons of hazardous wastes, including some material excavated from Love Canal when Frontier Avenue was

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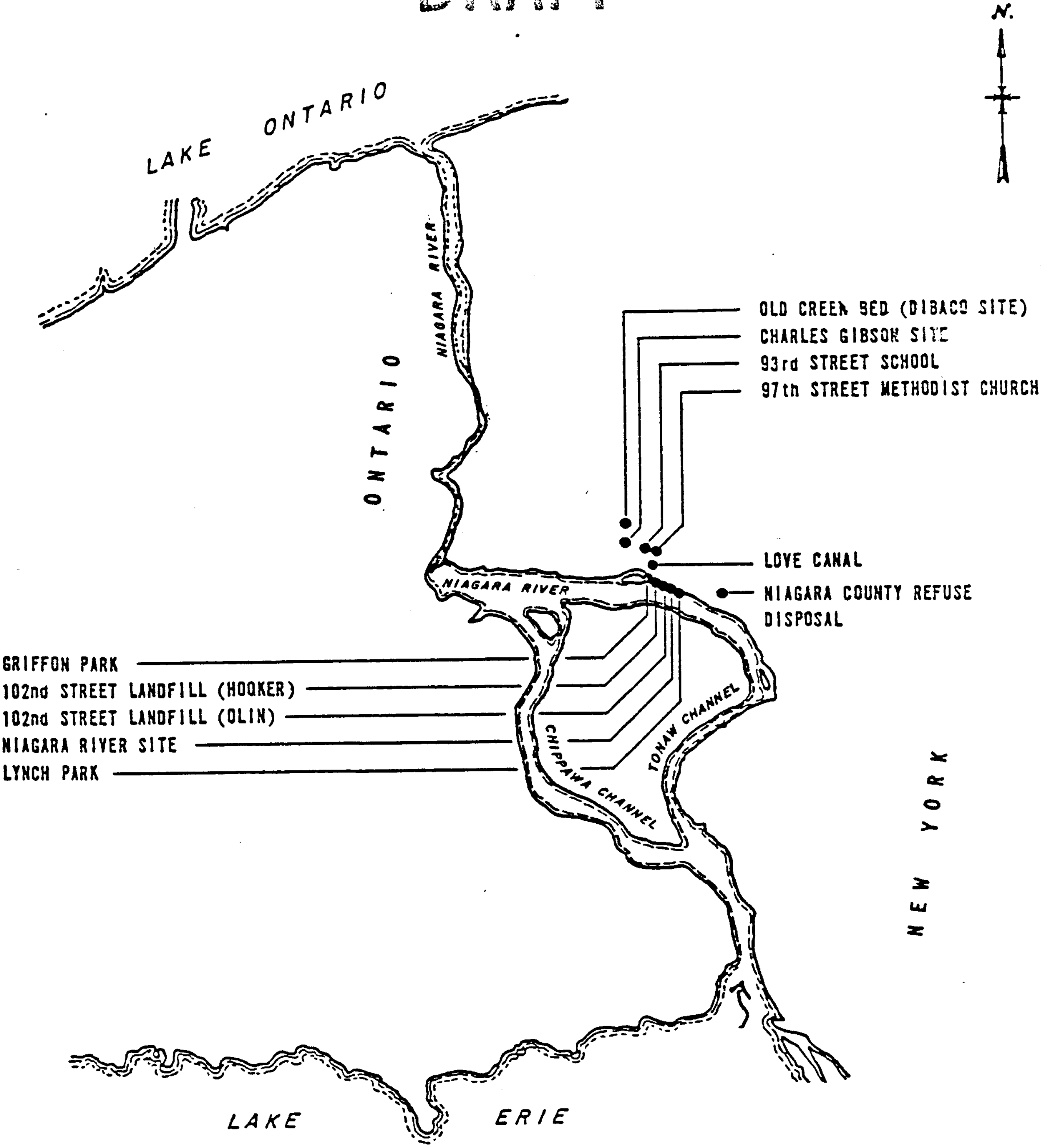
FIGURE 3-1



LOVE CANAL
FIVE ENGINEERING STUDIES
HAZARDOUS WASTE DISPOSAL
SITES OF CONCERN

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relocated in 1968, were deposited in the 50-acre site. A recent inspection by the NYSDEC revealed heavy erosion and exposure of some dumped materials in the site. Recent water sampling has identified chlorinated organics leaking from the site. Contaminated runoff and ground water contributions from this site must be considered when assessing alternative remedial actions in Black and Bergholtz Creeks.

During construction of the 93rd Street School in early 1954, 3,000 cubic yards of flyash and BHC cake excavated from the Love Canal site were used as fill material. The school is located on 93rd Street north of Colvin Boulevard along Bergholtz Creek. The NYSDEC has found the soil to be contaminated with trichlorobenzene and tetrachlorobenzene. Results of monitoring conducted by the USEPA in 1980 indicated trace levels of Love Canal-related contaminants in the shallow ground water and relatively high cadmium concentrations in the soil at the site. Migration of contaminants from this site into Bergholtz Creek must be considered in evaluating alternative remedial actions downstream of this site.

The Charles Gibson site is located just north of Niagara Falls Boulevard, adjacent to Cayuga Creek. The amount and types of materials deposited are not documented, but it operated during the same period as the Love Canal site and its composition is presumed to be similar. Migration of contaminants from this site must be considered in evaluating alternative remedial actions in the Cayuga Creek.

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4.0 CONDUCT OF FIELD INVESTIGATIONS

4.1 General Approach

A field office was established at the corner of Colvin Boulevard and 98th Street to coordinate the sampling activities in each task area. A work trailer was sited within the restricted canal area to allow for outfitting and decontaminating the sampling crews. The vehicles used by the crews were divided into "clean" and "dirty" sections. The "clean" section was used to transport the crew to the sampling site. The "dirty" section was used to return both crew and samples to the trailer for decontamination. Upon completion of the project, the "dirty" sections underwent a thorough decontamination. The samples were decontaminated at the work trailer and transported to the field office for final packaging before shipment to the analytical laboratory.

Safety was a prime consideration throughout the sampling program. In addition to the dangers associated with sampling potentially hazardous wastes, the sampling crews had to work in cold waist deep water encumbered by many layers of protective clothing and gear. The ensure rapid communication and response in the event that a crewmember fell in the icy or creeks or sustained accidental injury, two-way radios were carried by the crew and a base station was continuously monitored in the office.

4.2 Sampling Methodology

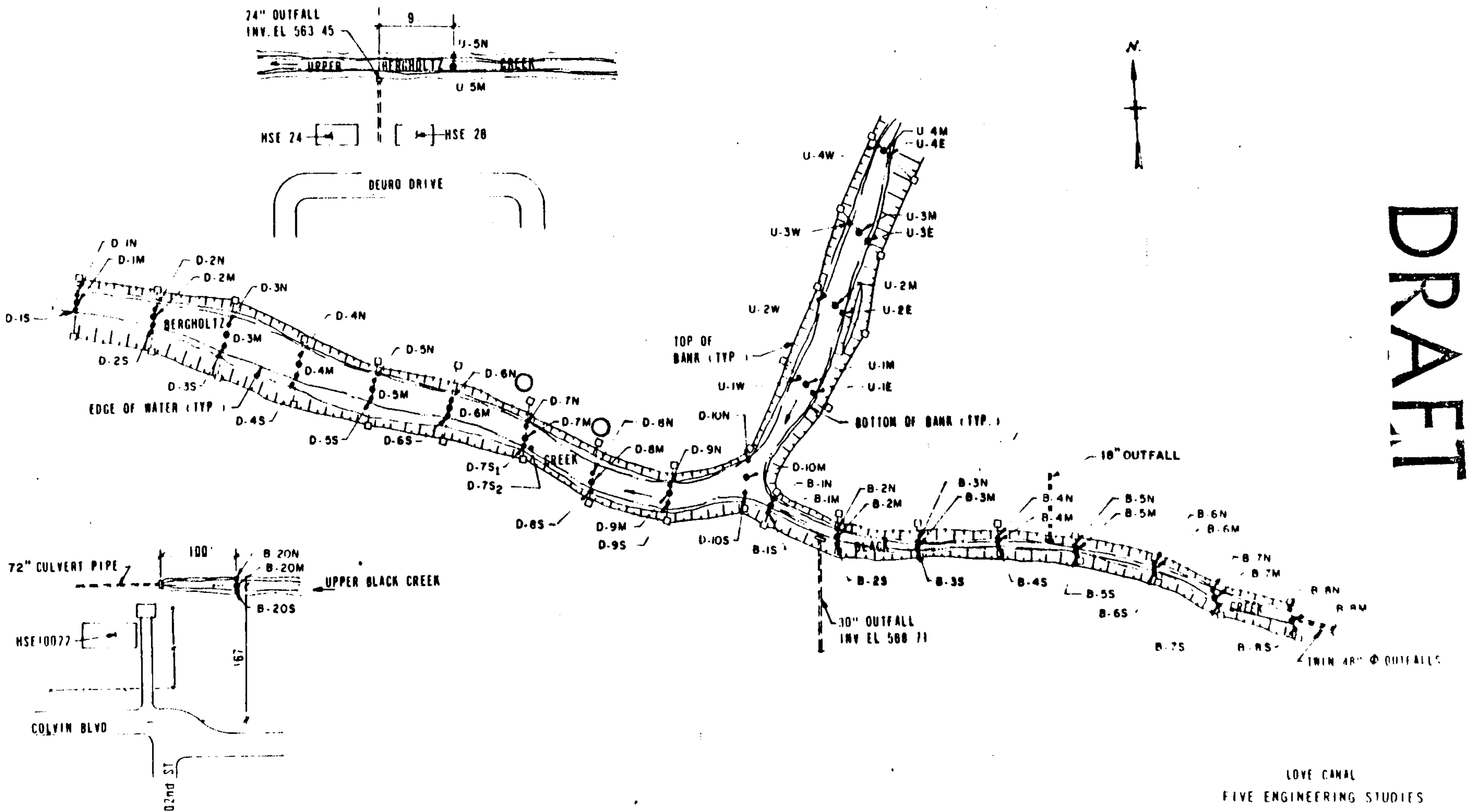
4.2.1 Selection of Sampling Locations

The specific sampling locations were selected based on a review of existing data and the knowledge of potentially active transport through on 93rd Street and 96th Street storm sewer outfall. Portions of the creeks in the vicinity of storm sewer discharges and sanitary sewer overflows. Samples were taken both upstream and downstream of each major discharge to the creek to ascertain its effect. The specific type of outfalls and their location is discussed in Section 4.3. At each sampling location, three (3) sediment samples and one (1) water sample were collected for analysis. For the sediment sampling, the creek was cross sectioned with one sample being taken in the center of the channel and the others taken near each bank. The single water sample at each location was collected either in the center of the channel or, for the wider Cayuga Creek, towards the bank of the creek on which the nearest discharge point (pipe outfall) was located. Two sampling locations were selected on the Bergholtz Creek and the Black Creek to characterize their quality upstream of the Love Canal area. Figures 4-1 and 4-2 show the specific cross sections and sampling locations for the Creeks.

4.2.2 Sampling Implementation

The creek sampling program took place during the first three weeks of January, 1983. The below freezing temperatures and occasional snowfalls during this period complicated the sampling procedure. A sampling crew of seven persons was organized and outfitted in the necessary protective clothing as required in the Site Health and Safety Plan. Four members of the crew wore chest waders and were primarily responsible for sample collection and conveyance to the processing area. The three remaining crew members were responsible for sample processing, surveying sample locations and creek topography, maintaining

FIGURE 4-1



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BERGHOLTZ & BLACK CREEK
SAMPLE LOCATION POINTS
TASK III

FIGURE -2

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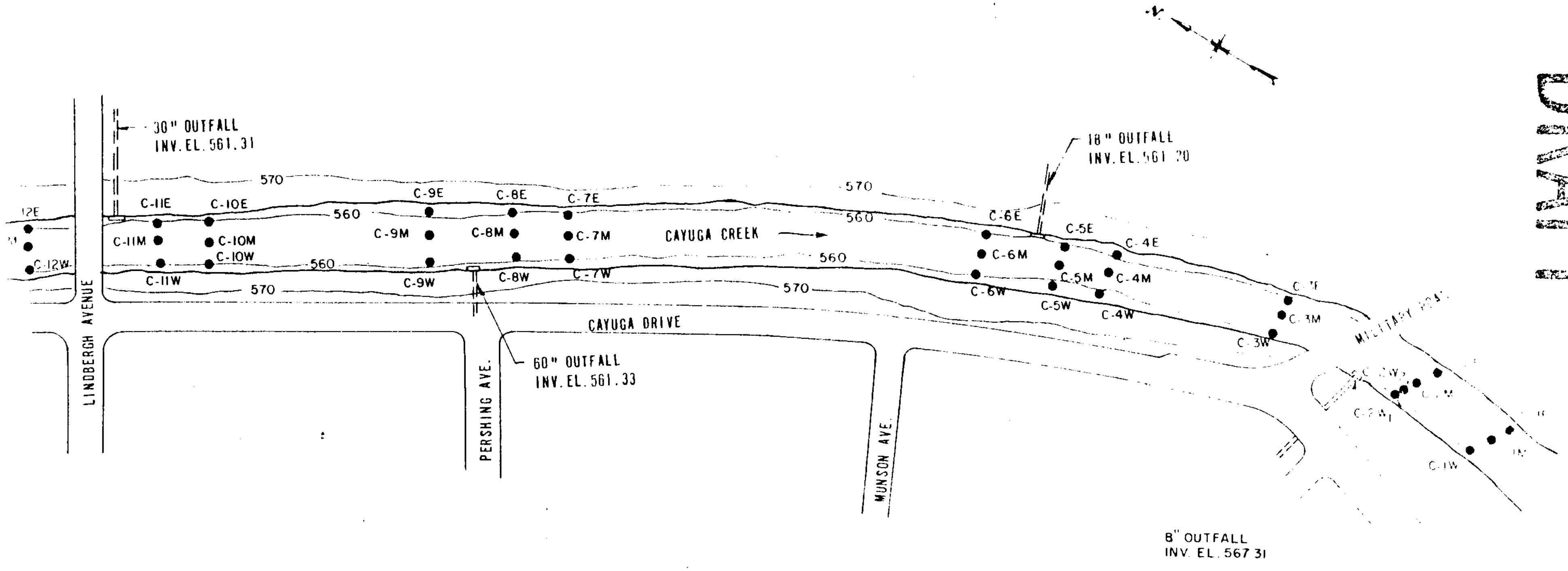

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FIVE ENGINEERING STUDIES
CAYUGA CREEK
TASK III

SAMPLE LOCATION POINTS

the sample logs, and providing assistance, as necessary, to the crew members in the creek.

Initially during the sampling program the creeks were covered with a thin layer of ice, which was easily broken, and were therefore readily accessible. However, as time progressed the ice thickened and access for sampling became difficult. The ice was not easily broken but was still not of sufficient thickness to adequately support the crew. Drilling sample holes with an ice auger was necessary and breakthroughs became prevalent resulting in frequent delays. This occurred primarily on the Bergholtz Creek where the water depths rarely exceeded three feet and therefore did not present a serious safety problem. Fortunately, the ice on the deeper Cayuga Creek proved adequate to support the crew. For safety purposes, a 12-foot aluminum boat was carried onto the ice in the deep center channel of the Cayuga.

To minimize cross contamination and the collection of unrepresentative samples, the following precautions were taken:

- For both sediment and water sampling, the crew began downstream and worked upstream.
- A water sample was taken before sediment sampling at each of the creek cross sections.
- Disturbance of the sediments was avoided during the water sampling and minimized for the sediment sampling.

4.2.3 Sampling Procedures and Techniques

The sediment sampling technique initially proposed for the creek sediments was the standard Shelby Tube technique often used for in-situ soil sampling. It was expected that this would allow for the collection of an undisturbed, 36-inch long sample of bottom sediments. However, due to nature of existing sediments, actual field application of the standard Shelby Tube equipment proved unsuccessful in retaining the sediments when pulled from the creek bottom. Therefore, the equipment and techniques were modified, primarily through a reduction in the collection tube diameter from 3 inches to 1½ inches. The specific sampling technique, described below, proved successful on all samples except those in the gravel bottom of the upper reaches of Bergholtz Creek.

The sediment sample was extracted using 1½-inches diameter thin-walled conduit 7 to 10 feet in length. The conduit was driven into the sediment by use of a post driver until approximately 36-inches of sediment was in place or refusal was encountered. Once driven in place, an air-tight plug was installed at the top of the conduit to maintain suction forces which would aid in retention of the sediment sample as the conduit was removed from the creek bottom. Removal of the sample was performed by two men with large pipe wrenches steadily pulling the conduit up out of the sediment. In several locations along Black Creek, removal of the sample conduit required the strenuous efforts of four men. As the conduit cleared the water surface, the bottom was quickly covered with a teflon lined rubber cap to prevent any loss of sediment.

Once the sediment sample was taken, the conduit was marked to indicate the sample location and the approximate position of the sample in the conduit. The excess water was decanted from the top of the sample and the exterior of the conduit was wiped down to remove any sediment. The conduits were kept in a sloped position to keep the sample intact and carried to the support vehicle where processing for shipment took place. As each sample was taken, the processing crew recorded the sample location, sample identification number, estimated sample length, maximum depth driven and water depth on sample log sheets. This provided additional information in analyzing the results of the sampling program and prevented any confusion or misrepresentation of samples.

To begin the sample processing, the conduits were cut to a length approximately 6-inches longer than the indicated sample length. The top of each conduit was then filled with approximately 1-inch of wax and allowed to solidify. Newspaper was packed tightly into the tube above this layer of wax and a final, 1-inch layer of sealing wax was applied to keep the sample intact. The conduit top was then capped with three layers of duct tape to prevent damage during shipment.

Once the top was sealed, the temporary teflon lined rubber cap was removed from the bottom. A teflon liner was inserted and covered with two stretched surgical gloves which were taped down to prevent any movement. Three layers of duct tape were again applied to prevent damage during shipment. The exterior of each sample conduit was then cleaned with a decontamination (detergent) solution, wiped dry and marked with the sample identification number as recorded on the log sheets. The samples were then boxed and affixed with a chain of custody form for shipment to the laboratory for analysis as described in Chapter 5 of this Report.

The water sampling program consisted of the collection of: 4 vials for volatile organic analyses, 4 one-liter glass bottles for organic analyses, and 2 half-liter plastic containers for metal analyses. Disturbance of the volatile organic samples was minimized to avoid any premature volatilization. The samples were labeled with sample location and identification number, packaged in a specially designed transport box, and affixed with a chain of custody form for shipment to the laboratory for analysis as described in Chapter 5.

4.2.4 Sampling Logs and Visual Description of Cores

As part of the sampling program, sampling logs were maintained to aid in interpreting the analytical results and to provide information necessary to the review of the remedial alternatives. For each sediment sample taken the date, time, location, identification code, depth driven, length, water depth, and any specific comments were recorded on the log sheet. The sample location was keyed to Figures 4-1 and 4-2 by an alphanumeric system. The first letter identified the creek (Bergholtz - D, Black - B, Cayuga - C), the number indicated the specific cross section, and the final letter represented the position of the core on the section. The sample identification code was a cumulative numbering system for all the samples. This cumulative three digit number was preceded by the prefix, III-0-, which identified a sample as originating from Task Area III and was therefore a creek sample. The three digit number was followed by the letter S to signify a sediment sample. The depth to which the sample conduit was driven was recorded together with the field measurement of sample length. This information was recorded after it was noted that consolidation of the sample occurred while driving the conduit into the sediment. Often it was necessary to drive the conduit 5 feet or more to allow for removal of a 3 foot sample. The disturbance caused by this consolidation may have altered the representative nature of the sample. The degree of alteration, if any, is unclear and referenced here for consideration during review of the results. Specific comments on the log sheets were noted only when they were pronounced and specific to the sample.

For each water sample taken the date, time, location, identification code, and the distance from the bank of the creek were recorded on the log sheet. The sample location and the sample identification code are arranged the same as for the sediment samples. However, the water sample identification code has a separate cumulative numbering system followed by the letter L to signify a liquid sample.

Upon receipt of the sediment samples at the laboratory, they were extruded from the conduit. Prior to compositing the samples for chemical analysis, a visual description of each sediment core was performed. The examiner's log recorded the date, identification code, location, and an incremental description of the sediment layers present in the sample. These descriptions, in conjunction with the observations of the sampling crew, are discussed in Section 4.3.

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4.3 Physical Findings

A broad generalized description of the Black, Bergholtz, and Cayuga Creeks is included in Chapter 3, Background Information. To properly assess the analytical results of the sediment and water sampling program, a more detailed description of the individual creeks is necessary. This is also required to adequately address the feasibility of any remedial measures under consideration.

4.3.1 Black Creek

The Black Creek enters the eastern end of the Declaration Zone and flows along the southern edge of an open field to the area of Colvin Boulevard and 102nd Street. At this point, the channel is about ten feet wide with about a three foot bank to the south and a lower bank about one foot high to the north along the open field. The channel and bank are overgrown with small brush consisting primarily of cattails. The stream itself varied from 2 to 4 feet in width as it meandered through the cattails and brush within the channel. The water depth was generally less than 1 foot and the flow velocity was nearly imperceptible at the time of sampling.

The sediment material is clay which, based on the sediment core sample results, extends to at least 21 inches below the creek bed. Access to the Creek in this area would not be difficult as it is in a wide, flat, open area, a short distance from the street.

At 102nd Street Black Creek enters a storm sewer at a concrete headwall and is piped underground due west for about 500 feet and then northwest for about 500 feet to

98th Street. The storm sewer consists of 72-inch pipe in some reaches and dual, 48-inch pipe in others. Storm sewers on 98th, 100th, and 101st Streets discharge into the piped portion of the Creek. The Creek discharges through twin 48-inch pipes into an open creek bed along 98th Street just north of Greenwald Avenue and then flows west to its confluence with Bergholtz Creek just north of 96th Street. A 30-inch storm sewer outfall is located about 100 feet upstream from Bergholtz Creek. This outfall discharges storm water from the Canal area and is believed to be a source of contamination of Black Creek. A fence has been built along both sides of the creek from the outlet of the twin 48-inch sewers to Bergholtz Creek.

In the area of the 48-inch outfalls, the creek channel is over 20 feet wide and is thickly overgrown with brush and small trees. The channel narrows to a width of about ten feet and widens to about 17 feet at the outlet to the Bergholtz. The stream has a gentle slope and varied from 4 to 8 feet in width within the channel. At the time of sampling, flow velocity was very low and water depths did not exceed 1 foot.

Numerous dwellings abut the Creek on both the north and south banks. The south bank is steep and varies in height from four to eight feet. The north bank is more gradual in slope and varies from about three feet to six feet in height. Along the length of the Creek the banks are overgrown with brush and small trees. Access to this portion of Black Creek would be difficult due to the high banks, numerous small and medium sized trees, and the fencing. At the lower end access from the northeast corner of the 93rd Street School grounds might be practical. At other points access from the north bank would seem to be the least difficult.

The stream bed sediment composition is clay overlaid with organic material. Based on the sediment core sample results, the clay extends to at least three feet below the creek bed. At the sampling location immediately downstream from the 96th Street storm sewer outfall, strong odors were detected during sampling. Throughout this portion of the Creek, oily films surfaced whenever the sediments were disturbed. The sampling crew noted a marked increase in the cohesiveness of the sediments as they moved upstream, and the samples became more difficult to remove.

4.3.2 Bergholtz Creek

The Bergholtz Creek enters the Declaration Zone from the northeast and flows west to form the northern boundary of the Zone. At the northeast corner of the Declaration Zone, the Bergholtz is bordered by Cayuga Drive to the north and Deuro Drive to the south. At this point, the channel is about thirty feet wide with about a ten foot high bank to the north and a lower bank of about five feet to the south. The stream has a moderate gradient and varied from 5 feet to 10 feet in width within this channel. At the time of sampling, it was actively flowing with water depths of up to two feet.

Dwellings abut both banks of the Creek promoting recreational use in this reach. Both banks are covered with brush and small trees. Access to this portion of the Creek would be difficult due to the height of the banks. Despite its height, access would be preferable from the north bank because of the density and close proximity of housing along the southern bank.

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Based on field observations the creek bed is composed of gravels, cobbles, and other coarse material. The sampling technique was not suitable for this type of material and several attempts were made before two limited samples were collected. These samples, less than one foot in length, were taken in pockets where sediment had accumulated over the coarse material. During the sampling, disturbance of the sediments released an oily film to the surface and a strong odor of decaying material. The accumulated sediment was a mixture of clay and organic material as determined by the sediment core sample results.

Further downstream on Bergholtz Creek, a stretch running from its confluence with Black Creek upstream about four hundred feet to an area bounded by Cayuga Drive on the north and Mason Court on the south was examined. In this area the Creek flows to the south with the channel width increasing from about twenty-five feet in the north to about forty feet just above the confluence with the Black Creek. The stream has a gentle slope and varied from 15 feet to 30 feet in width within the channel. At the time of sampling, flow was marginal and water depths only rarely exceeded three feet.

In this area the banks are covered with brush and large trees which often extend out over the channel. The east bank of the Creek is steep and varies from six to eight feet in height. The west bank of the Creek is lower and ranges from about seven feet in height in the northern portion to about three feet at the south end of this stretch. Dwellings abut both banks and recreational use of the ice covered Creek by small children was observed during sampling. Access to the Creek in this area would be preferable from the west bank since it is lower and the homes are set back from the Creek. Another possible access point is the 93rd Street School property which is a large open field bordering the Bergholtz just below the confluence with Black Creek.

The sediment composition is clay overlaid with organic material and, based on the sediment core sample results, the clay extends to at least four feet below the creek bed. Throughout this portion of the Creek disturbance of the sediment resulted in the release of an oily film which rose to the surface.

A thousand foot stretch of the Bergholtz Creek from its confluence with the Black Creek downstream to the 93rd Street pedestrian bridge was also examined. In this area the Creek flows due west and the channel varies from thirty-five to sixty feet in width. The stream has a very gentle gradient and varied from 25 feet to 45 feet in width within the channel. At the time of sampling, flow was marginal and water depths did not exceed three feet.

The north bank rises in height from two feet at the confluence to over four feet at the foot bridge. Dwellings abut this bank and recreational use of the ice covered Creek by small children was observed during sampling. The south bank is steeper and varies in height from three feet at the confluence to over seven feet at the foot bridge. Along the south bank is a large open field which is part of the 93rd Street School property. Both banks of the Creek are covered with brush and large trees which often extend out over the channel. Access to the Bergholtz in this area would be easily accomplished by way of the currently inactive school property to the south.

The sediment composition is clay overlaid with organic material. Based on the sediment core sample results, the clay extends to at least four feet below the creek bed. Throughout this portion of the Creek disturbance of the sediments often resulted in an oily film on the water and an odor of decaying organic material. In 1954 the school property was filled with material excavated from the Love Canal and is considered a potential source of contamination for the Bergholtz Creek. This is compounded by a large open swale which collects stormwater from the property and discharges it into the Creek.

4.3.3 Cayuga Creek

The Bergholtz Creek empties into the Cayuga Creek near 88th Street and Cayuga Drive. The Cayuga Creek flows from north to south parallel to the western boundary of the Declaration Zone. While it is three or more blocks to the west of the Zone, it is described here because it receives discharges from storm sewers and sanitary sewer overflows originating from the Canal area. Along the Cayuga Creek just south of Lindbergh Avenue, a 30-inch storm sewer outfall discharges from the east bank. Further downstream about 400 feet north of Military Road, an 18-inch storm sewer outfall discharges from the east bank. These sewers convey stormwater from the Love Canal area. Along the west bank of the Creek at Persching Avenue is a 60-inch, pumped, sanitary sewer overflow outfall. Further downstream, just below Military Road on the west bank, is an 8-inch sanitary sewer overflow outfall from the adjacent pump station. These sewer overflows could convey sanitary sewage from the Love Canal area to the Cayuga Creek. This potential for contamination of the Creek from the aforementioned Love

Canal sources prompted the inclusion of the Cayuga in this study.

An eighteen hundred foot portion of the Cayuga Creek flowing due south from Lindbergh Avenue to Military Road was examined. In this area the channel varies from about eighty to one hundred feet in width in the northern portion to about sixty feet wide south of Military Road. The stream is gently sloped and varied from about 60 feet wide in the northern reach to about 35 feet south of Military Road. At the time of sampling, flow was marginal and water depths ranged from three to five feet at the northern end and from five to seven feet at the southern end.

Both banks of the Creek are steep and vary from six to ten feet in height. The banks are covered with brush and large trees. The west bank borders on Cayuga Drive which is a busy thoroughfare. At the southern end, the west bank abuts a commercial area, and several buildings are built into the bank itself with foundations just above the creek level. The east bank is bordered by the rear lots of homes fronting on Pasadena Avenue. These are large lots and the homes are set back considerably from the Creek. At the time of sampling, flow was marginal and water depths ranged from three to five feet at the northern end and from five to seven feet at the southern end.

During sampling, it was noted that the ice covered creek was used by numerous children for recreational purposes such as ice hockey. Access to Cayuga Creek for remedial work would be preferable from the east bank through the large open rear yards of the adjoining homes.

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However, if easements were not obtainable, access from Cayuga Drive would be possible although severe traffic problems would be encountered.

The sediment composition is clay overlaid with organic material and, based on the sediment core sample results, the clay extends to about four feet below the creek bed. In portions of the Creek, disturbance of the sediments resulted in the release of an oily film that rose to the surface. The portion of the Creek under the Military Road Bridge was found to have several feet of unconsolidated sediment mixed with organic material. The sediments in this area were unstable and, when disturbed, produced a very strong odor. A sanitary sewage pump station with an overflow to the Creek is located just south of this bridge and may be a source of this material.

5.0 ANALYTICAL METHODS

The next aspect of the site investigation for the Love Canal involved the generation of chemical analysis data on samples collected from the site. These data were used to establish the presence or absence of contaminants. Further, where contamination was indicated, the data were essential to establish the type and magnitude of that contamination. The use of the analytical data was for the determination of contaminant migration pathways, development and evaluation of alternatives to deal with that presence and migration, and ultimately to recommend remedial action alternatives to minimize impacts from that contamination.

The challenge to the analytical laboratory was manifold: to keep the time required to analyze a large number of samples to a minimum; to design a program to minimize the total number of samples; to design an analytical program which would maximize information output on all samples while limiting detailed quantitative analyses to only those samples indicating a need for such work; and finally, to execute that analytical program for maximum benefit-to-cost ratio and maximum quality.

The analytical scheme which evolved to address these challenges was a two-phase program executed in a sequential manner. The first phase required the "screening" of a representative and therefore large population of samples from the five specific task areas under study. The objective of the screening analysis phase was to expeditiously, and inexpensively feed back preliminary analytical data to the engineer. These data were used as a decision-making tool to select only those samples with a likelihood of producing significant positive results after undergoing more costly, detailed quantitative analysis.

The second phase of the analytical effort was the detailed qualitative and quantitative analysis of selected samples for targeted and nontargeted contaminants. The analytical effort of this phase was comprised of three parts: qualitative and quantitative analysis of organic compounds; quantitative analysis for 2,3,7,8-TCDD (Dioxin); and quantitative analysis for inorganics (toxic elemental metals).

5.1 Contaminant Screening Analysis by GC/MS

The screening of all samples from the Love Canal site was necessary to determine the location and magnitude of contaminated areas for more detailed study. Given the history of materials disposed at the site, the screen had to be capable of detecting a wide variety of different chemicals at widely varying concentrations. The screening approach implemented was a solvent extraction of the sample followed by direct injection of the extract for GC/MS (gas chromatography/mass spectrometry) analysis. While other screening techniques were available, they were not as informative as the extraction -- GC/MS analysis method ultimately used.

The specific methodology involved the extraction of both liquid and solid (sludge, soil, sediments) matrices with the solvent hexadecane using mechanical agitation. After extraction, the solvent portion was separated from the sample and internal standards were added to the extract. These standards served two purposes: as retention time markers to classify contaminants as volatile or semi-volatile components, and as a benchmark from which estimated concentrations of contaminants could be established.

After sample preparation, the hexadecane extract was directly injected into the GC/MS instrument. The controlling

GC/MS software examined the number, location (with respect to retention time), and magnitude of contaminants present in each sample screened.

The data output from the contaminant screening analysis was formatted in such a way as to allow the rapid and justifiable selection of a subset of samples to be subjected to full and detailed quantitative analysis. The tabular output indicated the sample identification, number of volatile and/or semi-volatile contaminants detected above a threshold value and the concentration range of each of those contaminants. A reconstructed ion chromatogram was also presented for each sample.

5.2 Organic and Inorganic Analyses

5.2.1 Introduction

After completion of the contaminant screening phase of the project, specific samples from the total population were selected to undergo detailed and extensive chemical analysis. This section discusses two components of that work: quantitative and qualitative GC/MS analysis for both target and nontarget organic compounds and instrumental analysis of ICAP (inductively coupled argon plasma) for toxic elemental metals.

5.2.2 GC/MS Analysis of Organics

5.2.2.1 Conceptual Approach

The analysis for organic constituents required that specific target compounds be quantitated against authentic calibration standards. Additionally, a qualitative and semi-quantitative analysis was carried out for any other nontarget compounds present in the sample above a threshold level. The target compounds were those 113 organics commonly referred to as the "Priority Polluants" (40 CFR 136, Appendix I). These compounds were quantitatively analyzed as two classes of compounds: volatiles and semivolatiles.

The nontarget compounds were any other organic constituents present in the sample which were not a member of the set of 113 compounds. These compounds were qualitatively identified by comparison of the mass spectrum of the unknown with a computer library of over 30,000 spectra of organic chemicals. Additionally, an estimated concentration of each of these nontarget compounds was computed.

5.2.2.2 Analytical Method

Each sample subjected to quantitative analysis underwent two separate preparatory and instrumental techniques: one for volatiles, and one for semivolatile compounds. The volatile sample preparation differed depending on whether the sample was a liquid or solid matrix. For liquid samples, preparation was minimal and simply involved aliquoting a portion of the original sample into a sparging vessel attached to the GC/MS. Appropriate surrogates and internal standards were added to each sample to monitor sparging efficiency and allow accurate quantitation respectively. After sparging the sample, the sparged constituents were trapped within the instrument and subsequently desorbed into the GC section of the GC/MS. Constituents were consequently chromatographed and then introduced into the mass spectrometer for generation of the mass spectral data. After data acquisition, the mass spectra of the components in the sample were compared to spectra of authentic calibration standards of the priority pollutants. Spectral and retention time matches of a sample component with a calibration standard resulted in the subsequent identification of that component as a priority pollutant. If such a match occurred, that component was then quantitated using the method of internal standard calculation.

Sample preparation for solids required a significantly different technique due to the special challenges presented with solid matrices. Solids, by defintion, are not as homogeneous as liquids. Consequently, special efforts must be employed to obtain as representative a solid sample as possible for volatile analysis. The approach utilized by the laboratory was two-fold. First, the "as-received" solid sample was mechanically composited to present as uniform a sample as possible to the second stage of preparation. That stage consisted of an extraction of the volatile constituents from the solid using tetraglyme (tetraethylene glycol dimethyl ether). The solid/liquid extraction was carried out by either vortexing or sonification of the mix. As with liquid volatiles, surrogate standards were added prior to the extraction. An aliquot of the tetraglyme extract was added, along with internal standards, to 5 milliliters of water in a sparging vessel attached to the GC/MS.

The instrumental analysis for volatiles in solids proceeded as previously described for volatiles in liquids. Both utilized a 1 percent SP1000 on 6/80 mesh carbopack gas chromatographic column.

Any constituents present in the sample which were not identified as a volatile priority pollutant underwent a mass spectral library search to attempt to identify that unknown constituent. The library search was carried out if the peak of interest had a peak height to of 25 percent or greater of the height of the nearest internal standard (this criterion was established to prevent searching peaks which were components of the natural "noise" level of the sample). If the match of the unknown peak mass spectrum to the spectrum of the compound in the spectral library were of high enough quality, an estimated concentration of the tentatively identified peak was computed by comparison of the peak height of the nearest internal standard (of known concentration) to the peak height of the identified compound.

The second subset of the 113 priority pollutant compounds prepared and analyzed were the semi-volatiles. The subset is comprised of 82 compounds with different chemical characteristics which required that two separate extractions be undertaken to provide the most reliable data. For liquid samples, a liquid/liquid extraction was performed using methylene chloride as the extraction solvent. The extraction was carried out in a separatory funnel. The extraction process on any sample resulted in the generation of two final extracts. The preparation involved adding one liter of original sample to a two liter separatory funnel. The pH was first adjusted to 11 or greater using sodium hydroxide. Surrogate standards and methylene chloride were then added after which the extraction of base/neutral/pesticide compounds was undertaken. This extract was set aside while the pH was again adjusted to 2 or less with sulfuric acid. Again, methylene chloride was added and the second extraction for acid extractable compounds was undertaken.

After the acid and base/neutral pesticide extracts were obtained, the extracts were independently concentrated in constant temperature water baths in a Kuderna-Danish apparatus with an evaporative flask and concentrator tube attached. The extracts were concentrated to a final volume of 1 ml. After concentration, internal standards were added to both concentrates prior to analysis.

After sample preparation was concluded, both concentrates underwent quantitative analysis by GC/MS for the target priority pollutant compounds. Further, the qualitative and semi-quantitative analyses for nontarget compounds were accomplished by GC/MS in conjunction with the quantitative analysis. Unlike the sample introduction technique used for volatile compounds, the semi-volatile compounds were introduced to the GC/MS by directly injecting 1 microliter of the concentrate into the gas chromatograph section of the GC/MS. A separate injection was performed for the acid fraction and the base/neutral/pesticide fraction on different instruments tuned and calibrated for the compounds of interest in each fraction. The qualitative, quantitative and semiquantitative instrumental analysis proceeded in the same fashion as described for the volatile instrumental analysis.

5.2.2.3 Data Output

The data output from the GC/MS organics analysis was compiled into a summary data report for ease and speed of reference. Each data report included a laboratory chronicle providing the history of events which the sample underwent. For the quantitative analysis, a compound list displayed each of the 113 target compounds. For each compound, the detection limit achieved on that sample was displayed. If the compound was detected at or above the detection limit, the actual quantitated value was given along with the scan number for that compound peak on the reconstructed ion chromatogram.

For the library search output, the name of the tentatively identified compound was provided if the quality (purity) of the spectrum match was above 800 (out of a possible maximum value of 1,000). The computed estimated concentration and scan number for that peak was given. The organic fraction which contained the nontargeted peak was also indicated. Summary results are presented in Appendix A.

5.2.3 Analysis of Inorganics

5.2.3.1 Conceptual Approach

The inductively coupled argon plasma (ICAP) instrument was utilized for the analysis of elemental metals except for mercury. Mercury analysis was conducted by an automated cold vapor technique. The elements of interest were the 13 priority pollutant toxic metals. With the large numbers of samples involved, high anticipated concentrations, and varying matrices, the ICAP technique represented both the most cost and time-effective approach to the project. Mercury, having special physio-chemical characteristics was best addressed with the cold vapor technique.

5.2.3.2 Analytical Method

The sample preparation for both liquid and solid matrices is similar. A measured volume or mass of sample was placed into appropriate glassware. The aliquot was subjected to a solution of nitric acid which initiates the digestion of the metals present in the sample. The digestion solution was then taken to near dryness and the cycle was repeated until the digestion process was completed. The final digestion solution was then diluted with pure water and subsequently filtered to remove solids. The filtrate was then taken to final volume with pure water. The prepared sample was now ready for instrumental analysis.

The instrumental analysis was carried out using a sequential multi-element ICAP. The procedure involved producing an aerosol of the digestion solution. This aerosol is then introduced into the argon plasma torch which produces characteristic atomic-line emission spectra if elements are present.

When produced, the spectra are dispersed and wavelengths and intensities are compared to the wavelength and intensity of authentic calibration standards. Through this comparison, the presence and concentration of elements was established.

5.2.3.3 Data Output

The data output for the elemental metals analysis was straightforward. A compound list of the 13 elements of interest was prepared for each sample. The concentration of each element detected at or above the detection limit was provided. The detection limit for each element was also displayed. Summary results are presented in Appendix A.

5.2.4 2,3,7,8-TCDD (Dioxin) Analysis

5.2.4.1 Conceptual Approach

The analytical approach to the analysis for 2,3,7,8-TCDD went through several stages of evolution before the final methodology was selected and executed. Originally, a qualitative analysis by GC/MS was to be performed. The analysis was to be run on a split from the base/neutral/pesticide concentrate with 1,2,3,4-TCDD being added to the sample prior to extraction. The split extract was to be cleaned up to eliminate potential intereferences, then, the concentrate would be analyzed for GC/MS in the selected ion monitoring (SIM) mode to search specifically for ions of 2,3,7,8-TCDD. The 1,2,3,4 isomer was to be used as a retention time marker and surrogate for the 2,3,7,8 isomer. This technique was to simply detect the presence or absence of the 2,3,7,8 isomer. If detected, that sample would then undergo a re-extraction specific to the TCDD compound and then be subjected to quantitative GC/MS analysis.

The quantitative GC/MS technique was to be performed by application of EPA Method 613, adapated to accommodate solid matrices. The use of Cl isotopically labeled 2,3,7,8-TCDD was envisioned for the internal standard while 1,2,3,4-TCDD was to be added as a surrogate standard.

During the project time frame, Region VII, USEPA was developing methods specific to the analysis of TCDD in conjunction with studies they were undertaking at Times Beach, Missouri. The methods developed were then provided to laboratories qualified by and under contract to the EPA. One such protocol was published in February 1983 and colloquially came to be called the "February Protocol."

In the ensuing period, it was agreed that all samples which displayed positive contaminant screening reuslts and were then relegated to full quantitation would also undergo full quantitation for TCDD. No screening for the presence of TCDD would be performed -- all would be quantitated.

When the final decision was received to proceed with the quantitative analysis of TCDD, a new protocol has been published called the "May Protocol." As it was desired to use the most recent EPA dioxin protocol for the Love Canal study, the May protocol was specified. Unfortunately, the May protocol has not been in the hands of the EPA contract laboratories long enough to confirm that all details of the methodology were effective and appropriate. As experience was gained, it was determined that the GC column specified in the May protocol (an SP2340) was not adequate for the analysis. A dioxin workshop sponsored by EPA in mid-July 1983 supported this conclusion.

Because of this fact, the Love Canal samples were analyzed using the DB-5 column specified in the February protocol but employing sample preparation, cleanup, and analytical procedures specified in the May protocol.

5.2.4.2 Analytical Method

The method employed utilizes high resolution gas chromatography/low resolution mass spectrometry in the SIM mode. As most samples were solid matrices, the following discussion relates to that matrix. Differences appropriate for water matrices will be highlighted.

All samples were spiked with isotopically labeled 2,3,7,8-TCDD. The $^{37}Cl_{40}$ isotope was used as a surrogate standard while $^{13}C_{12}$ isotope was used as the internal standard. After spiking, anhydrous sodium sulfate was mixed with the sample prior to adding a mixture of methanol and hexane. The sample was then extracted using the jar technique with a platform mechanical shaker. After extraction, a phase separation was undertaken for solid samples to obtain the final extract. This extract was then concentrated prior to application of any cleanup procedures or instrumental analysis.

The method provided for the application of four concentrate cleanup procedures in the event of analytical interferences, difficulty with concentration, difficulty in achieving desired detection limits, or coloration, viscosity or cloudiness of the concentrate. The specific options included acid and base washes, and column chromatography using silica gel, activated alumina, or activated carbon. The actual instrumental analysis was executed by injecting 1 to 3 ul of concentrate into the GC/MS. The SIM mode was used to search for specific ions of both isotopically labelled isomers of 2,3,7,8-TCDD and native 2,3,7,8-TCDD. If the proper ions were observed in the proper ratio, the presence of native 2,3,7,8 was confirmed. Once confirmed, quantitation was based on the response of native TCDD relative to the isotopically labeled TCDD internal standard. Method performance is assessed by monitoring the isotopically labeled surrogate standard results.

5.2.4.3 Data Output

The data output for the TCDD analysis is straightforward. The compound was listed along with the detection limit achieved on each sample. If detected above that limit, the concentration quantitated was given. Each sample output also displays the level of recovery of the surrogate standard. The summary reports for Dioxin are shown in the supporting documents. All dioxin hits, however, are shown on the hot spot maps of Section 6.

5.4 Summary of Quality Assurance and Quality Control Programs

5.4.1 Intent and Purpose of QA and QC Programs

Mead CompuChem, the analytical subcontractor, has an established Quality Assurance Program which covers all projects. The objective of the QA program is to provide the desired level of data quality for the customer. This is accomplished by specifying criteria for methods and performance on samples received, and by providing appropriate standards for referencing results against absolute values. Project-specific quality control programs are designed to determine that the criteria established for specific methods and sample types are met. These include control limits for blanks, spikes, duplicates, and surrogate recoveries, as well as criteria for review of data prior to release to customers. As part of the criteria, corrective actions are required if data exceed control limits.

5.4.2 QA Programs in Effect for this Study

For this study, standards were prepared at the Research Triangle Park, North Carolina (RTP) location, tested, and shipped weekly to the Cary, Illinois facility for organics analysis. Metals standards were prepared and tested for use in the RTP lab. Standard Operating Procedures were written and analysts were trained in their use prior to sample receipt. Methods used were evaluated for their applicability to the matrices in the study, using approved analytical techniques referenced above in Sections 5.2 and 5.3. Acceptance criteria for the quality control samples associated with the study were established and applied.

5.4.2.1 QC Program for Screening Analysis

For the organic screening analyses, blanks, spikes and duplicates were prepared and analyzed. This procedure is qualitative and semi-quantitative; it is intended to determine whether certain classes of organic compounds are present, and the approximate numbers and concentration levels of these classes. Then a decision could be made to whether or not to analyze them for particular compounds. For these analyses, blanks were run with each set of samples prepared to verify there was no laboratory contamination during preparation. Spiked and duplicate samples were prepared and analyzed at the rate of 5 percent each, to verify that consistent and accurate results were produced by the methods applied. The spike mixtures consisted of several levels of organic volatile and semi-volatile compounds added to samples.

5.4.2.2 QC Programs for Organic Priority Pollutant Analyses

For analysis of volatile and semi-volatile organic compounds using EPA-approved methods, the quality control program specified 5 percent of samples prepared in duplicate, 5 percent spiked, and a blank prepared each time samples were extracted. Calibration multipoint standards were analyzed prior to initiating work, and at least one standard per 8-hour shift was run on each instrument used during the study. Each instrument met a tuning calibration specification each 8-hour shift. The spike compound recoveries and duplicate precision were monitored for each fraction. Surrogate compounds in 100 percent of all sample fractions were spiked prior to preparation for analysis; surrogate recoveries were evaluated to monitor the extraction efficiencies of these and similar classes of compounds from the samples. Recoveries could be effected by sample matrix type, or other extraction conditions. Those fractions with recoveries or precision outside control limits were examined for such effects and possible repeat analysis to confirm the causes of such recoveries or precision.

5.4.2.3 QC Programs for Inorganic Priority Pollutants Analyses

Inorganic samples were prepared as described in the above-referenced methods. Blanks were prepared with each batch of samples. Spikes were prepared at the rate of 5 percent. Standards were analyzed (at least 3 levels) before and after each set of samples to establish a calibration curve. Known values of reference standards (EPA or NBS) were compared to those obtained and prepared by CompuChem to document accuracy.

5.4.2.4 QC Programs for TCDD (Dioxin) Analyses

Dioxin samples were analyzed using the most recent EPA methodologies. Standards were obtained from and/or referenced against EPA solutions, whose levels had been established from interlaboratory studies. Blanks were prepared with each set of samples. Spikes and duplicates were prepared at the rate of 5 percent each. Each instrument was required to be calibrated each 8-hour shift, following initial multipoint calibration at at least three levels of standards. Criteria for calibration and analytical acceptability applied were those in the EPA methodology.

5.4.3 Summary of Acceptability of QC Results

The quality control data generated from the screen, organics, inorganics, and TCDD analyses demonstrated that the analytical performance was within acceptance criteria limits, and that the analytical systems were operating as desired to produce data of appropriate quality.

6.0 CONTAMINATION ASSESSMENT

The contamination assessment is a crucial element of the investigation since it provides the basis for selection of remedial action. Priority areas have been mapped based on the results of the contamination assessment. A "hot spot" map identifying dioxin contamination has also been prepared.

The contamination assessment provides an approach whereby a large number of samples containing a range of compounds at varying concentrations and with differing toxicities and persistence characteristics can be numerically evaluated. The results of these evaluations are considered in light of the potential for human exposure on a site-specific basis and other contaminant-related considerations to arrive at an estimate of the relative contamination at one sample site compared to another.

6.1 Objective

The objective of the contamination assessment is to serve as a decision-making tool for the selection of remedial action alternatives. The intent is to rank or prioritize areas so that appropriate remedial action can be recommended and not to make an absolute determination of the risk to human health. The utility of the approach is as a method for organizing the large amount of analytical information, as an aid in interpreting the significance of the analytical results and as a basis for evaluating remedial action alternatives.

6.2 Discussion of Approach

6.2.1 Overall Concept

The contamination assessment examines, for each sample site, the following factors:

- Contaminants detected
- Concentrations of individual contaminants
- Toxicity of individual contaminants, represented primarily by drinking water standards or water quality criteria for the protection of human health
- Persistence of individual contaminants, as indicated by physical/chemical/biological properties
- Factors affecting potential exposure pathways

The two conceptual components of the contamination assessment are a toxicity assessment and an exposure assessment. Toxicity is the ability of a chemical to affect living orgamisms adversely and, as such, is an intrinsic property of a contaminant. Exposure (the actual contact with a chemical) is affected by properties of the contaminant(s) in question (nonsite-specific factors) which determine persistence and mobility and by site-specific factors (noncontaminant-specific) which determine potential pathways of exposure. Intrinsic properties of the contaminant(s) which determine toxicity and persistence have been expressed in a quantitative manner in a "matrix" (Table 6-1). Input to the matrix consists, for each sample, of the contaminants identified and their concentrations. The calculations in the matrix are completed (to account for toxicity and persistence) resulting in a "score" for the sample. The "scores" are then indicated on the intermediate "work maps." The exposure pathway factors and a discussion of other considerations related to specific contaminants are integrated

SAMPLE MATRIX

TABLE 6-1
LOVE CANAL CONTAMINATION ASSESSMENT FOR HYPOTHETICAL SAMPLE SITE

CONTAMINANT	CONCENTRATION ug/KG or ug/L	CRITERION ug/L	PERSISTENCE SCORE	PRODUCT = conc./crit. x pers.
CARCINOGENS				
A.BHC isomers				
alpha-BHC	1000	.092	11	119565
beta-BHC	1000	.163	11	67485
delta-BHC	1000	.147	11	81633
gamma-BHC	1000	.186	12	59140
		A.Subtotal		327822
B.PAH				
phenanthrene	1000	.028	9	321429
anthracene	1000	.028	9	321429
pyrene	1000	.028	11	392857
chrysene	1000	.028	12	428571
benzo(a)anthracene	1000	.028	12	428571
		B.Subtotal		1892857
C.Monocyclic aromatics				
benzene	100	6.6	6	909
hexachlorobenzene	1000	.0072	12	1666667
2,4,6-trichlorphenol	1000	12	9	750
		C.Subtotal		1668326
D.Halogenated aliphatics				
1,2-dichloroethane	100	9.4	6	638
1,1,1-trichloroethane	1000	2	7	3500
1,1,2,2-tetrachloroethane	100	1.7	9	5294
trichloroethylene	1000	27	7	259
tetrachloroethylene		8	7	875
carbon tetraclhloride	1	4	7	1750
chloroform	100	1.9	7	3684
bromoform	100	1.9	8	4211
trichlorofluoromethane	100	1.9	7	3684
methylene chloride	100	1.9	6	3158
hexachlorobutadiene	100	4.5	9	2000
		D.Subtotal		29054
E.Miscellaneous				
1,2-diphenylhydrazine	1000	.422	10	23697
bis(2-chloroethyl)ether	1000	.3	8	26667
		E.Subtotal		23697
CARCINOGEN SCORE: (Sum A-E Subtotals)				3941756

TABLE 6-1 (Cont'd)
LOVE CANAL CONTAMINATION ASSESSMENT
FOR HYPOTHETICAL SAMPLE SITE

SAMPLE MATRIX

CONTAMINANT	CONCENTRATION ug/KG or ug/L	CRITERION ug/L	PERSISTENCE SCORE	PRODUCT = conc./crit. x pers.
NON-CARCINOGENS				
F.PAH				
naphthalene	1000	1000	8	8
fluoranthene	1000	42	12	286
			F.Subtotal	294
G.Metals				
arsenic	1000	50	12	240
chromium	1000	50	14	280
cadmium.	1000	10	15	1500
antimony	1000	146	13	89
mercury	100	.146	11	75342
lead	10	50	12	240
nickel	1000	13	12	896
thallium	1000	13	15	1154
copper	1000	1000	14	14
zinc	1000	5000	15	3
			G.Subtotal	79758
H.Monocyclic aromatics				
chlorobenzene	1000	480	7	15
1,4-dichlorobenzene	1000	400	9	23
1,2-dichlorbenzene	1000	400	9	23
1,3-dichlorbenzene	1000	400	9	23
1,2,4-trichlorobenzene	1000	100	10	100
1,2,3-trichlorobenzene	1000	100	10	100
1,2,3,4-tetrachlorobenzene	1000	38	10	263
1,2,4,5-tetrachlorobenzene	1000	38	10	263
pentachlorobenzene	1000	74	11	149
ethylbenzene	1000	1400	6	4
toluene	1000	1350	6	4
phenol	1000	3500	7	2
2,4-dichlorophenol	1000	3090	8	3
pentachlorophenol	1000	1010	13	13
p-chloro-m-cresol	1000	1010	9	9
			H.Subtotal	992
I.Phthalates				
dimethyl phthalate	1000	313000	10	0
diethyl phthalate	1000	350000	11	0
dibutyl phthalate	1000	34000	13	0
bis-2-ethylhexylphthalate	1000	15000	13	1
butylbenzyl phthalate	1000	15000	12	1
di-n-octyl phthalate	1000	15000	14	1
			I.Subtotal	3
J.Miscellaneous				
2-chloronaphthalene	1000	15	10	667
			J.Subtotal	667
NON-CARCINOGEN SCORE: (Sum F-J Subtotals)				81714
TOTAL SCORE (carcinogen + non-carcinogen)				4023470

with the maps to identify the relative hazard at each site (or groups of sites). The final output is task area contamination assessment maps which reflect the integration of exposure pathway factors, sample scores and other contaminant-related considerations. Additionally, a "hot spot" map is created by plotting concentration data for dioxin, a contaminant of special concern. In conjunction, the contamination assessment map and the "hot spot" map serve as the basis for determining levels of remedial action. Figure 6-1 depicts the overall approach of the contamination assessment.

6.2.2 The Matrix

A matrix has been developed to organize and interpret the extensive amount of analytical data. It is used to evaluate contaminant concentrations in terms of toxicity and persistence in order to provide an overall numerical value for each sampling site. An example of the matrix is attached as Table 6-1. The individual components of the matrix, as indicated by the column headings, are explained below.

6.2.2.1 Contaminants

The left hand column is the list of "CONTAMINANTS." Under the column heading, the word "CARCINOGENS" appears. On the second page of the table is the heading "NONCARCINOGENS." Contaminants are classified into either category based upon their classification in the EPA's 1980 Water Quality Criteria (discussed further in 6.2.2.3); these classifications were reviewed by consultants from the Department of

OVERVIEW OF CONTAMINATION ASSESSMENT METHODOLGY

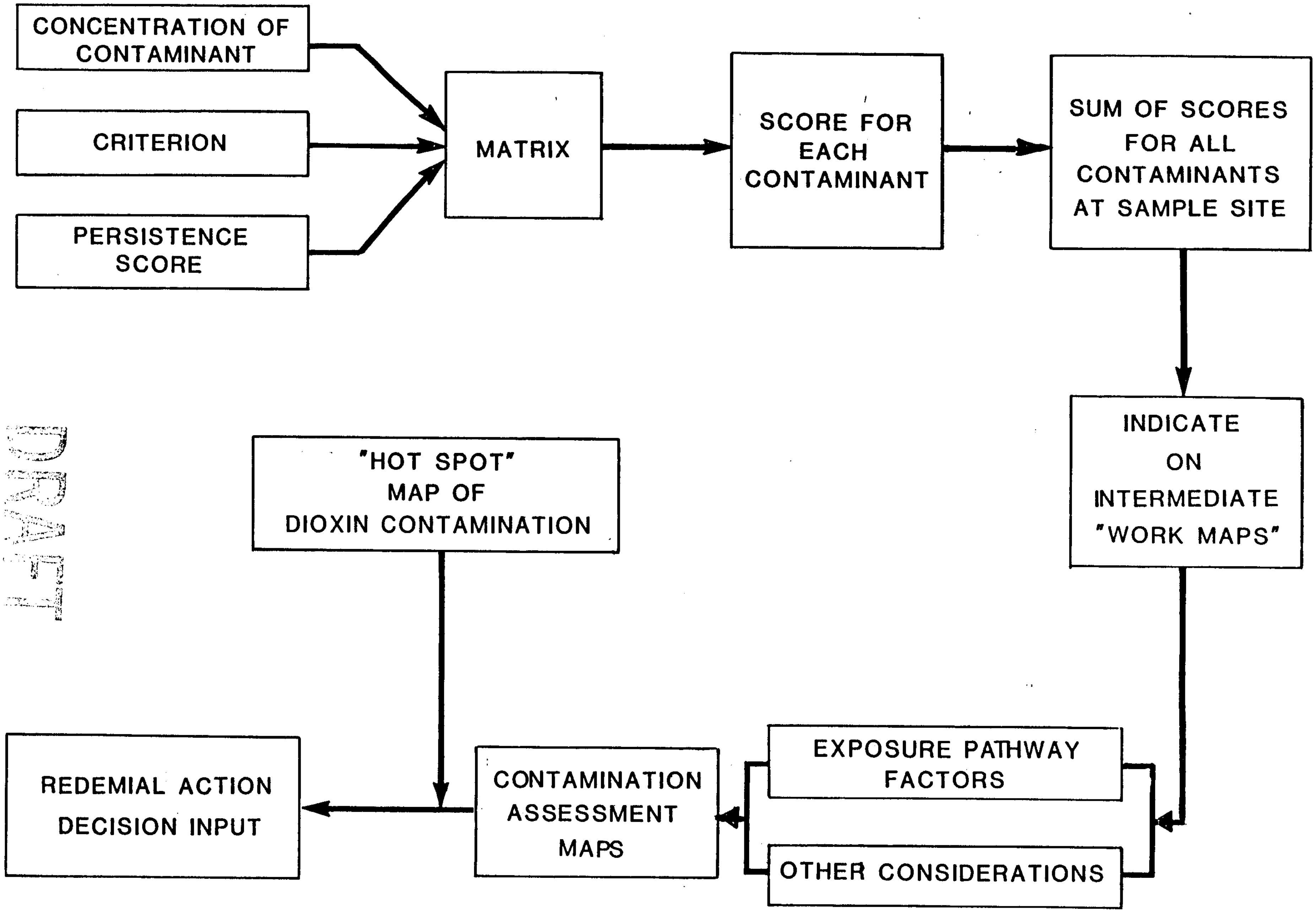

FIGURE 6-1

Environmental Medicine at the Mt. Sinai Medical Center. Scores are computed separately for the carcinogens and the non-carcinogens since the Water Quality Criteria are derived differently for these two types of contaminants.

Within each group (carcinogens and non-carcinogens), related contaminants are placed in groups designated by alphabetic letters, such as "A. BHC isomers," "B. PAH (Polynuclear Aromatic Hydrocarbons)," etc. The matrix contains the names of all the contaminants detected in the samples taken in the five task areas. Only those compounds which were identified to a confidence level of 80 percent or greater were included in the matrix. Compounds which were identified by a "library search" but for which the confidence level was less than 80 percent were not included, since contaminant identification was less certain and the concentrations measured were only estimates.

The resultant carcinogen and non-carcinogen scores are added to yield a total score for the sample. Because the criteria values for the carcinogens are lower than for the non-carcinogens, the carcinogen score invariably dominates the total score. The purpose of grouping related contaminants within the two larger categories and calculating subtotals is to provide a clear picture of which contaminants are contributing most to the total score.

6.2.2.2 Concentration

The concentration data, in ug/kg (ppb) or ug/L (ppb), is entered into the matrix. On the example attached, all concentrations have been arbitrarily set at 1000 for illustrative purposes.

6.2.2.3 Criterion

The third column heading, "CRITERION," refers, in most cases, to the available water quality criterion for each contaminant. Units are ug/L (ppb). For organic contaminants, these values were taken from:

> USEPA
> Water Quality Criteria Documents:
> Availability. Federal Register,
> Vol. 45, No. 231, Nov. 28, 1980

This publication refers to criteria developed for 64 toxic pollutants or pollutant categories pursuant to Section 304(a)(1) of the Clean Water Act. A separate document exists for each pollutant (or pollutant category) describing recommended maximum permissible pollutant concentrations consistent with the protection of aquatic organisms and human health. These criteria are not rules and have no regulatory impact.

The values entered in the "CRITERION" column are taken directly from the EPA publication. "Criteria for suspect or proven carcinogens are presented as concentrations in water associated with a range of incremental cancer risks to man...(since) there is no scientific basis for estimating "safe" levels for carcinogens." "Criteria for non-carcinogens represent levels at which exposure to a single chemical is not anticipated to produce adverse effects in man" (USEPA, Water Quality Criteria Documents; Availability, 1980).

The inclusion of the criterion value serves two purposes. First, it takes into consideration the relative toxicity of the various contaminants; the criteria values were derived based upon the best toxicity information available at the time. Second, dividing the concentration data by the criteria values serves to "normalize" the concentrations, insuring that the significance of a highly toxic contaminant does not get obscured by virtue of a detected low concentration, or, conversely, the significance of a minimally toxic contaminant does not get over-emphasized by virtue of a detected high concentration. The EPA's Water Quality Criteria were chosen to "normalize" the concentration data for the following reasons:

- They are fairly recent (1980).
- They are most applicable to exposure via water, as opposed to Threshold Limit Values for occupational exposure via inhalation.
- They are most comprehensive in that criteria exist for a majority of the contaminants detected. SNARLs (Suggested No Adverse Response Level) or ADIs (Acceptable Daily Intakes) exist for a much more limited list of substances, and it was necessary to have consistency in the normalization procedure.

For most of the inorganics (heavy metals) EPA Interim Primary Drinking Water Standards exist. These are generally identical to the EPA Water Quality Criteria.

However, where these values differed, the drinking water standards, which are enforceable regulations, were selected. Drinking water standards were not available for antimony, nickel or thallium; water quality criteria were used for these contaminants.

It is acknowledged that the criteria used in the matrix are for water and not sediment; however, there are no recognized criteria or guidelines for contaminants in sediment.

As stated, the EPA has expressed the criteria for carcinogens as concentrations associated with an increase in cancer risk of 10^{-7}, 10^{-6} or 10^{-5}, meaning one additional cancer in a population of ten million, one million and 100,000, respectively. The value entered in the matrix for each contaminant is the criterion corresponding to an incremental cancer risk of 10^{-5}. This was arbitrarily chosen, and could just as well have been the criterion for a 10^{-6} or 10^{-7} increase in risk, since the objective is to compare the contaminants <u>relative</u> to one another. This is <u>not</u> an attempt to establish a level of acceptable risk, which is a matter of policy.

The human health criteria for non-carcinogens are presented as concentrations not expected to cause adverse effects in man. Derivation of both

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no-effect (non-carcinogen) and specified risk (carcinogen) concentrations are based upon extrapolation from animal toxicity or human epidemiology studies; details of the methods used to derive the criteria are given in "Guidelines and Methodology Used in the Preparation of Health Effect Assessment Chapters of the Consent Decree Water Criteria Documents, Appendix C, Federal Register, Vol. 45, No. 231, Friday, November 1980, pp. 79347-79357.

For each contaminant (carcinogen or non-carcinogen), the EPA has expressed the criterion for the protection of human health in two ways: 1) based upon ingestion of contaminated water and aquatic organisms, and 2) based upon consumption of aquatic organisms only. The former value was selected.

There were no EPA Water Quality Criteria for the following compounds:

- naphthalene
- acenaphthene
- p-chloro-m-cresol
- butylbenzyl phthalate
- di-n-octyl phthalate
- 2-chloronaphthalene

The procedures used to determine appropriate criteria for these compounds are discussed in the Supporting Documents. These derived criteria values were reviewed by consultants from the Department of Environmental Medicine at Mt. Sinai Medical Center. The Mt. Sinai team also recommended the use of more rigorous criteria than the EPA's Water Quality

Criteria for two compounds, as discussed in the Supporting Documents.

6.2.2.4 Persistence Score

The next column heading, "PERSISTENCE SCORE," refers to the persistence score calculated for each contaminant. This score represents the relative environmental persistence of each contaminant based upon its partitioning between air and water (expressed as Henry's Law Constant), partitioning between water and sediment/soil (expressed as the log of the octanol: water partition coefficient) and biodegradability.

Each contaminant is rated for each of these three factors and the ratings are summed. The lowest possible score (least persistent contaminant) is a 3, while the highest possible score (most persistent contaminant) is a 15.

Various literature sources were searched for information on the Henry's Law Constant, octanol:water partition coefficient and biodegradability of each contaminant. These values were calculated and/or recorded for each contaminant, and rated as detailed below.

- Volatility was expressed in terms of H, the Henry's Law Constant, where

  $$H = \frac{\text{Partial Pressure in atmosphere, Pa}}{\text{water solubility, gm}^{-3}\text{/molecular weight}}$$

  The values were rated as follows, with a 1 representing the most volatile (least persistent) contaminant:

Value of H	Rating
≥1000	1
100-999	2
10-99	3
1-9	4
<1	5

- A high octanol:water partition coefficient indicates a high tendency to adsorb onto sediments (particularly sediments high in organic content) and a high tendency to bioaccumulate. The most common expression of this value is as a logarithm, log Kow. The values were rated as follows, with a 1 representing the least tendency to adsorb onto sediment (least persistent):

Value of log Kow	Rating
≥6	6
5-5.99	5
4-4.99	4
3-3.99	3
2-2.99	2
<2	1

- Biodegradability scores are based primarily upon scores given in "Methodology for Rating the Hazard Potential for Waste Disposal Sites," JRB Associates, which appears in the "National Oil and Hazardous Substances Contingency Plan," USEPA, 1982. Information from other sources (Callahan, et al., 1979, Water Related Environmental Fate of 129 Priority Pollutants, and Geating, 1981, Literature Study of Biodegradability of Chemicals in Water) was also used. The ratings are on a scale of 1 to 4, as follows:

	Rating
Highly resistant to biodegradation	4
Resistant, but biodegradation is known or believed to occur in some cases	3
Amenable to biodegradation	2
Readily biodegradable	1

The ratings in each of the three categories are added together to yield the persistence score. Persistence scores are presented in Table 6-2.

6.2.2.5 Subtotals and Totals

As indicated on the sample matrix, subtotals are calculated for the individual contaminant groups. The subtotals for the carcinogen groups are added, yielding the CARCINOGEN SCORE. The same procedure is applied to the non-carcinogens, yielding a NON-CARCINOGEN SCORE. These two scores are added, yielding the TOTAL SCORE.

6.2.2.6 Matrix Output

The calculated TOTAL SCORES are represented visually on intermediate "work maps" to provide a pictorial indication of the matrix results. In the next step, the potential pathways for contaminant exposure are examined and of other considerations related to various contaminants in the study area are discussed.

TABLE 6-2

CALCULATION OF PERSISTENCE SCORES

Contaminant	H	H Rating	Log Kow	Log Kow Rating	Biodegradability Rating	Sum of Ratings
Alpha-BHC	0.595	5	3.81	3	3	11
Beta-BHC	0.016	5	3.80	3	3	11
Delta-BHC	0.031	5	4.14	4	3	12
Gamma-BHC	0.05	5	3.72	3	3	11
phenanthrene	12.52	3	4.46	4	2	9
anthracene	63.5	3	4.45	4	2	9
pyrene	0.13	5	4.92	4	2	11
chrysene	est. 0.015	5	5.61	5	2	12
benzo(a)anthracene	0.011	5	5.61	5	2	12
benzene	555.2	2	2.13	2	2	6
hexachlorobenzene	172.3	2	6.18	6	4	12
2,4,6-trichlorophenol	32.9	3	3.38	3	3	9
1,2-dichloroethane	92.6	3	1.48	1	2	6
1,1,1-trichloroethane	3557	1	2.17	2	4	7
1,1,2,2-tetrachloroethane	38.6	3	2.56	2	4	9
trichloroethylene	922	2	2.29	2	3	7
tetrachloroethylene	2063	1	2.88	2	4	7
carbon tetrachloride	2351	1	2.64	2	4	7
bromoform	use 106	est. 2	2.30	2	est. 4	8
chloroform	343	2	1.97	1	4	7
trichlorofluoromethane	11114	1	2.53	2	4	7
hexachlorobutadiene	1044	1	3.74	3	4	8
methylene chloride	323	2	1.25	1	3	6
1,2-diphenylhydrazine	"low"	est. 4	3.03	3	est. 3	10
bis(2-chloroethyl) ether	1.34	4	1.58	1	3	8
naphthalene	24.41	3	3.31	3	2	8
fluoranthene	1.03	4	5.33	5	3	12
arsenic	can be impt. in reducing envir.	4	4.35 calc	4	4	12
chromium	not impt.	5	5.23	5	4	14
cadmium	not impt.	5	6.68	6	4	15
lead	vol. poss. in	4	4.17	4	4	12
nickel	not impt.	5	3.93	3	4	12
thallium	not impt.	5	6.50	6	4	15
copper	not impt.	5	5.93	5	4	14
antimony	vol. poss.	4	5.71	5	4	13
mercury	1155	1	6.36	6	4	11
zinc	not imp.	5	6.03	6	4	15
chlorobenzene	398	2	2.84	2	3	7
1,4-dichlorobenzene	276	2	3.38	3	4	9
1,2-dichlorobenzene	197	2	3.38	3	4	9

TABLE 6-2 (Cont'd)

CALCULATION OF PERSISTENCE SCORES

Contaminant	H	H Rating	Log Kow	Log Kow Rating	Biodegrad-ability Rating	Sum of Ratings
1,3-dichlorobenzene	267	2	3.38	3	4	9
1,2,4-trichlorobenzene	144	2	4.18	4	4	10
1,2,3-trichlorobenzene	approx. 144	est. 2	est. 4.18	est. 4	4	10
1,2,3,4-tetrachlorobenzene	approx. 567	est. 2	est. 4.93	est. 4	est. 4	10
1,2,4,5-tetrachlorobenzene	567	2	4.93	4	est. 4	10
pentachlorobenzene	no data	est. 2	5.63	est. 5	est. 4	11
ethylbenzene	652	2	3.15	2	2	6
toluene	601	2	2.49	2	2	6
phenol	0.132	5	1.46	1	1	7
2,4-dichlorophenol	0.58	5	2.75	2	3	13
pentachlorophenol	0.026	5	5.01	5	3	13
p-chloro-m-cresol	low	est. 5	2.95	2	2	9
dimethyl phthalate		est. 5	2.12	2	3	10
diethyl phthalate		est. 5	3.22	3	3	11
dibutyl phthalate		est. 5	5.2	5	3	13
bis (2-ethyhexyl) phthalate	0.026	5	5.3	5	3	13
butyl benzyl phthalate	0.108	5	4.8	4	3	12
di-n-octyl phthalate		est. 5		est. 6	3	14
2-chloronaphthalene	54.7	3	4.01	4	3	10
bis (2-chloroethyl) ether	1.34	4	1.58	1	3	8

6.2.3 Exposure Pathways

This subsection describes potential pathways for human exposure to contaminants originating from the Love Canal area and identifies which of these potential pathways appear to be active based on the sampling results. An active pathway indicates that the Love Canal-related contaminants are presently found there and that the transport of contaminants through this medium appears to occur. In terms of the potential for actual human exposure to contamination via the active pathways, this discussion considers the theoretical worst-case potential, assuming no remedial action is taken.

In Task Area III, Black and Bergholtz Creeks and Cayuga Creek are potential pathways for human exposure to contaminants. The Black Creek flows east to west on the north side of the Love Canal area and receives flows from areas immediately east and west of the Love Canal. Black Creek joins Bergholtz Creek just north of 96th Street. From there, Bergholtz Creek flows west to its confluence with Cayuga Creek, a tributary of the Little Niagara River to the south. Flows ultimately discharge into the Niagara River which serves as a water supply for the City of Niagara Falls. Intakes are located approximately 2.5 and 3.5 miles downstream of the Love Canal area.

The sampling results indicte that the sediments and surface waters in Cayuga Creek contain Love Canal-related contaminants and, therefore, Cayuga Creek is not an active pathway for transport of such contaminants and potential human exposure. Contamination was found primarily in creek sediments, but the chemicals detected (inorganics and phthalate esters) are not Love Canal related. In

Black and Bergholtz Creeks, however, the presence of dioxin indicates that the sediments in these creeks present an active pathway for human exposure to contaminants originating from the Canal area.

The degree to which contaminated sediments are transported from the creeks into downstream surface waters is dependent upon stream flows. High flows tend to scour stream sediments and carry them downstream, while during low flows, less sediment transport occurs. Ocassional flow reversals resulting from weather-dependent conditions are also known ot occur in Black, Bergholtz and Cayuga Creeks. During these periods, upstream sediment transport may be possible. Limited recreational use of the area occurs, and human exposure to contaminants in the creeks could result from direct or indirect skin contact with contaminated sediments or surface waters or from the inhalation of volatile compounds subsequent to their partitioning from the sediment to the water column. However, only a few samples were found to contain contaminants considered volatile. Another possibility for exposure is from the accidental ingestion of contaminants in water. This exposure pathway is less likely than the pathways mentioned previously because of the preferential partitioning of the majority of contaminants detected into sediment versus water, the distance to the water supply intake and the fact that the water is treated prior to consumption.

6.2.4 Other Considerations

Two groups of contaminants, the phthalate esters and the inorganics, were found consistently in the sampling area, including samples taken outside of the influence of

Love Canal ("upstream" samples on Black and Bergholtz Creeks). In some samples, the only compounds detected were inorganics and phthalate esters. It was not felt that, in the absence of other organic contaminants which are more likely of Love Canal origin, and considering the potential exposure pathways, such samples would necessitate remedial action. An explanation of the rationale for this decision follows.

6.2.4.1 Phthalate Esters

Two compounds belonging to a class of chemicals known as phthalate esters or phthalic acid esters were detected in the samples taken in the Task Area III. These were bis(2-ethylhexyl) phthalate and di-n-octyl phthalate. They were detected fairly consistently throughout the study area, but never in concentrations exceeding the criteria values used in the matrix for these compounds. These two compounds were also found in the "upstream" samples taken in Black Creek and Bergholtz Creek at concentrations similar to those found in sampling areas potentially influenced by Love Canal.

It is not surprising that phthalate esters were found throughout the sampling area. They are recognized to be ubiquitious in the environment. They are used as plasticizers in building and construction, home furnishings, clothing, cars, food wrappings and medical supplies, and as nonplasticizers in pesticides, cosmetics, fragrances and oils. Phthalate ester residues in foods such as margarine, cheese and milk may, in fact, reach 50 ppm (EPA, Ambient Water Quality Criteria for Phthalate Esters, 1980).

Phthalate sters have also been detected in soil, water, and air and in fish flesh and animal and human tissue. They have been detected in varied matrices and in areas remote from industrial sites, including the Sargasso Sea (EPA Ambient Water Quality Criteria for Phthalate Esters, 1980).

Several factors contributed to a decision that the presence of phthalate esters at a sampling location did not in and of itself warrant remedial action. These factors are:

- Presence of phthalate esters in upstream sediment samples in Black and Bergholtz Creeks at concentrations similar to those found in sampling areas potentially influenced by Love Canal.

- Ubiquitous occurrence of phthalate esters in the environment in general.

- Phthalate esters were detected in only eight of the 155 liquid samples analyzed in the investigation of all task areas. Therefore, the potential exposure route via ingestion of contaminated water does not appear to be of major concern.

- Phthalate esters are believed to be capable of absorption through the skin, which is a potential route of exposure for the sediment. However, phthalate esters are considered to be of a low order of toxicity (EPA, Ambient Water Quality Criteria for Phthalate Esters, 1980).

6.2.4.2 Inorganics (Heavy Metals)

Inorganics were found in the majority of the samples throughout the Task III Study Area. Concentrations of inorganics detected in study area sediment samples are comparable, to a large degree, with levels found in samples collected "upstream" on the Black and Bergholtz Creeks and with levels found in sediments in "control" areas during the EPA Monitoring Study (EPA 1982).

Several factors contributed to a decision that the presence of inorganic constituents at a sampling location did not in and of itself warrant remedial action. These factors were:

- Presence of inorganics in upstream sediment samples in Black and Bergholtz Creeks at concentrations similar to those found in sampling areas potentially influenced by Love Canal.
- Ubiquitous and natural occurrence of heavy metals in the environment in general.
- Heavy metals were detected in only one of the eight liquid samples from the investigations of the various task areas for which inorganics analyses were performed. Therefore, the potential exposure route via ingestion of contaminated water, which would be of most concern, does not appear to be very likely. Further sampling to ascertain water concentrations would be required to confirm this assumption.

- Heavy metals, in the forms in which they are likely to occur in the sediments, do not present a significant concern via the most likely exposure routes for sediment (direct or indirect skin contact).

6.2.5 Contamination Assessment Maps

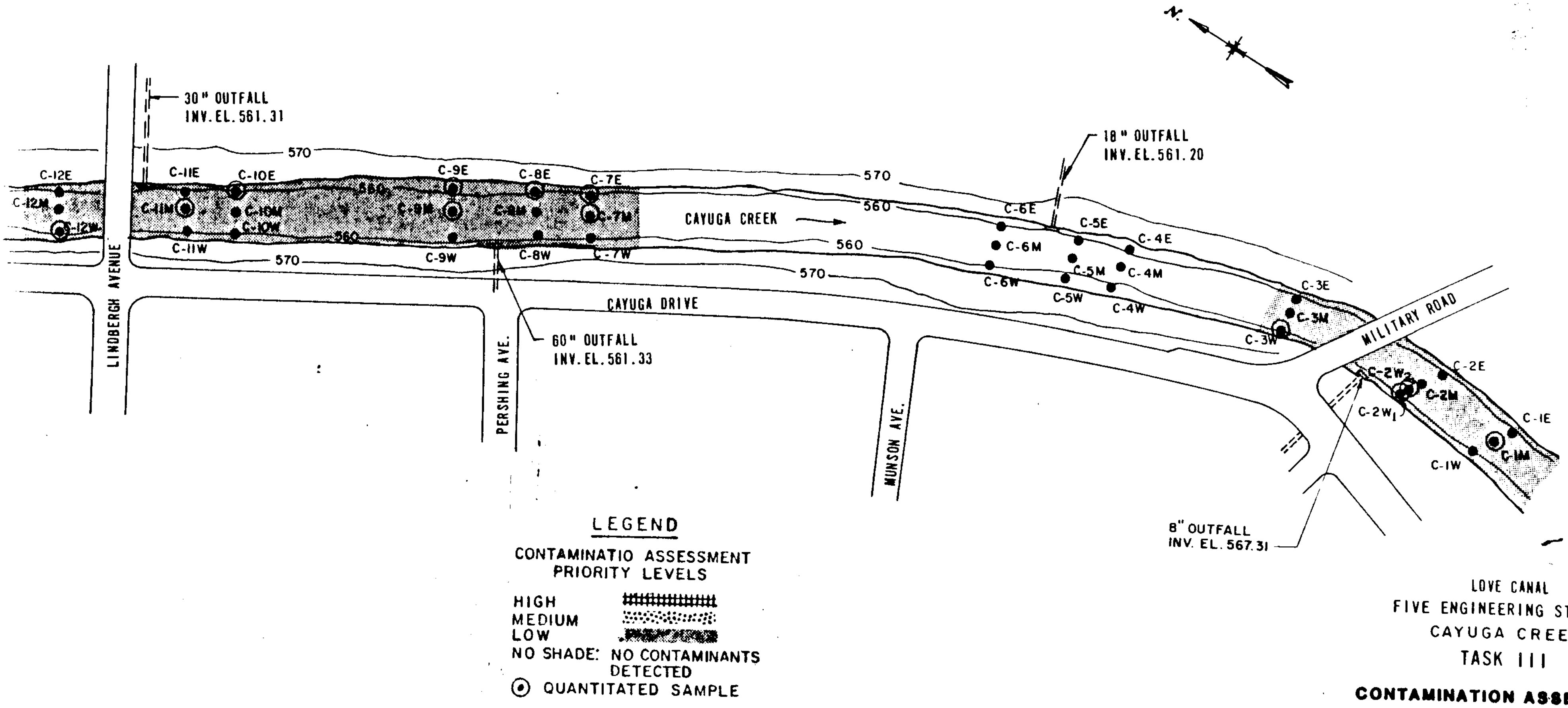
The product of the contamination assessment is a set of contamination assessment maps for the Task III Study Area. These maps depict areas of relative low, medium and high priority and are shown in Figures 6-2 and 6-3. These rankings were determined by evaluating the matrix results, the work maps, the potential exposure pathways and other considerations. The lows, mediums and highs are relative rankings and are used to identify areas where some form of remedial action should be considered.

The low, medium and high rankings are defined as follows:

- Low: Low matrix score, indicating inorganic compounds occurring at or near "upstream" concentrations; organic compounds, if any, not specifically Love Canal-related; and/or existing contaminants appear to have minimum potential for human exposure.

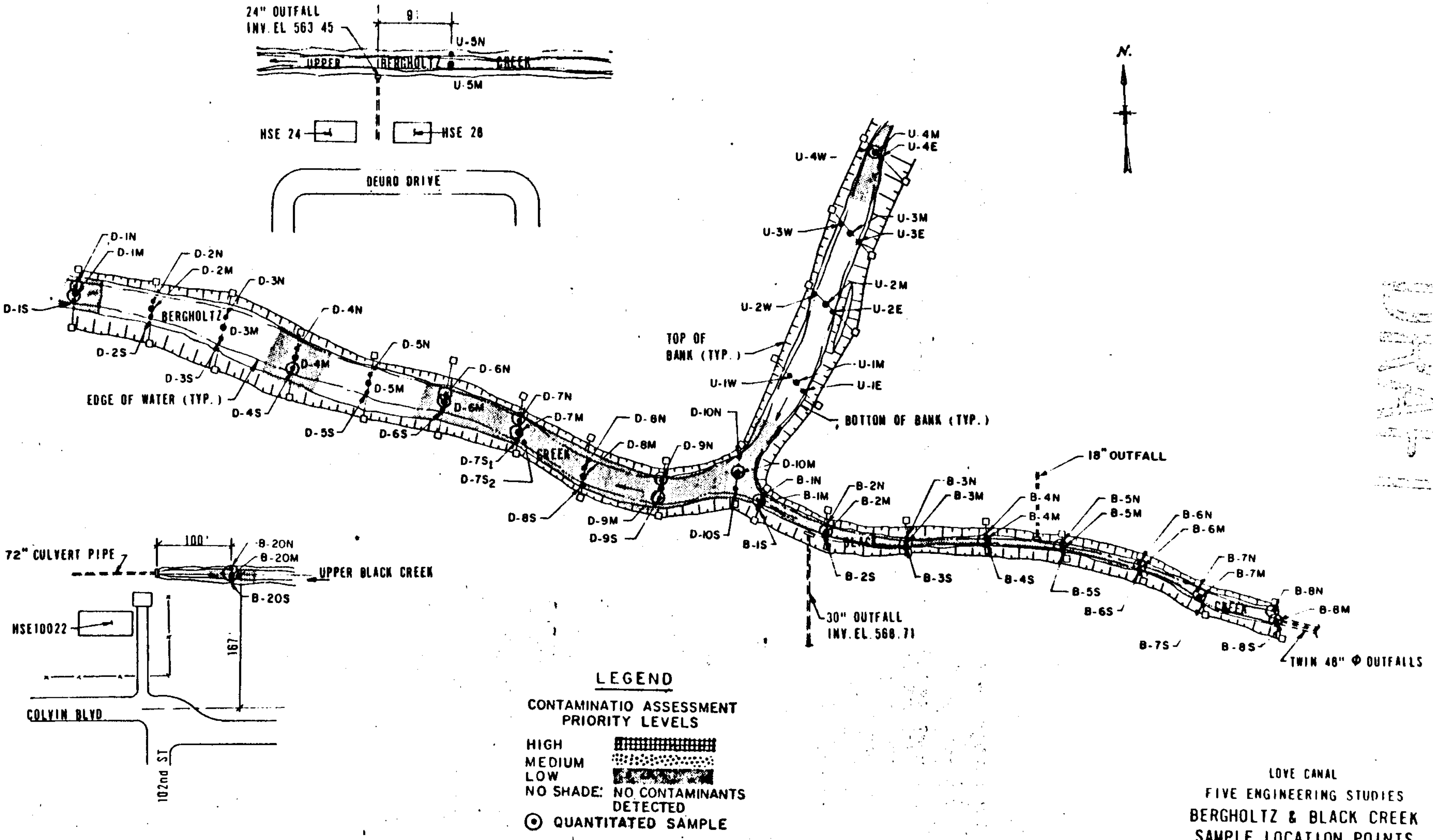
- Medium: Intermediate matrix score, indicating a limited number of Love Canal-related compounds occurring at low to moderate concentrations; and/or existing contaminants appear to have moderate potential for human exposure.

FIGURE 6-2



LOVE CANAL
FIVE ENGINEERING STUDIES
CAYUGA CREEK
TASK III

CONTAMINATION ASSESSM
MAP



LOVE CANAL
FIVE ENGINEERING STUDIES
BERGHOLTZ & BLACK CREEK
SAMPLE LOCATION POINTS
TASK III
CONTAMINATION ASSESSMENT MAP

- High: High matrix score, indicating several or numerous Love Canal-related compounds occurring at significant concentrations; and/or existing contaminants appear to have a high potential for human exposure.

6.2.6 Hot Spot Map

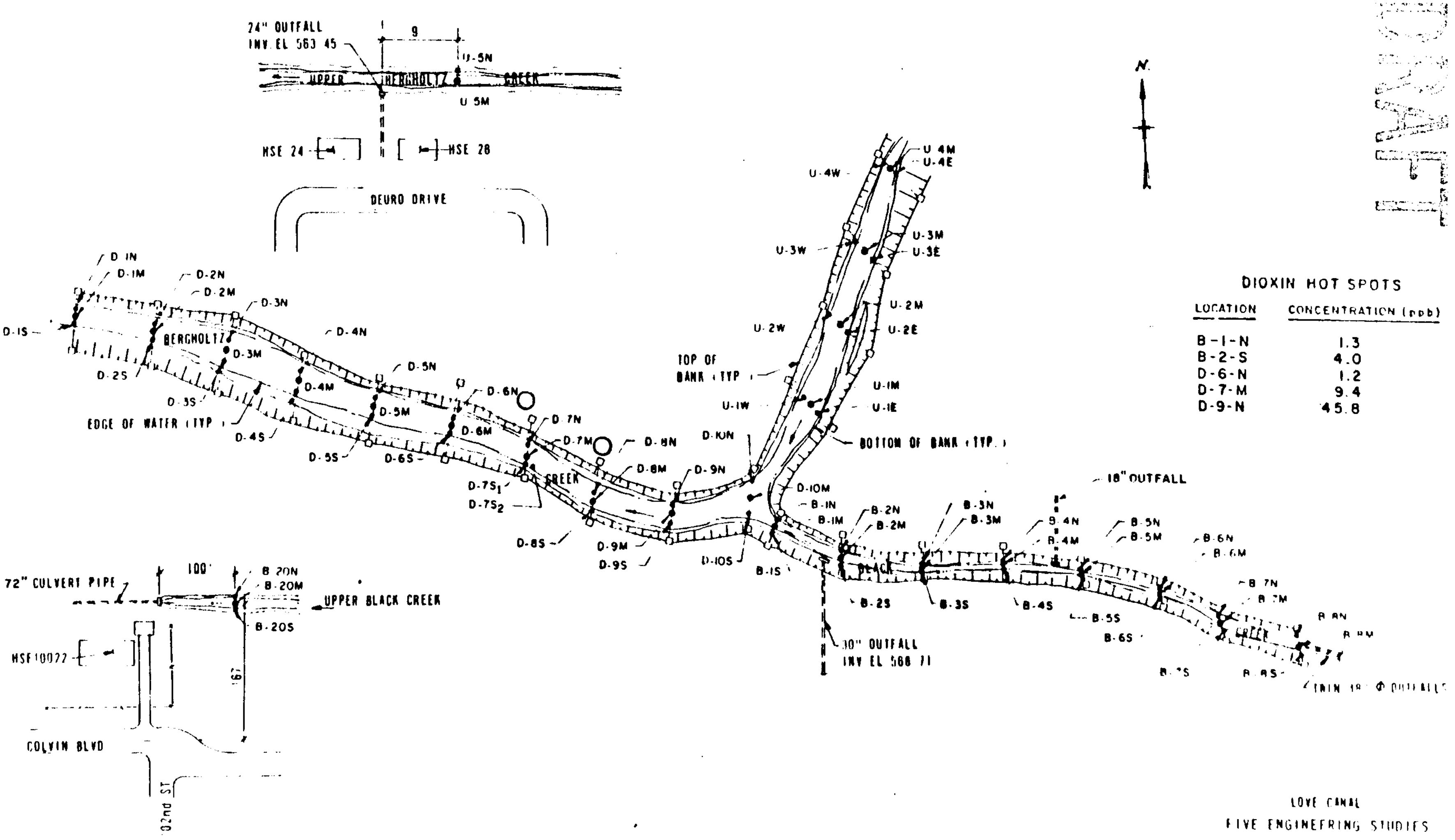
A separate "hot spot" map has been prepared for dioxin, a contaminant of particular concern. The map identifies the sampling locations where this compounds was found and the concentrations detected. The "hot spot" maps have been used in conjunction with the contamination assessment maps in determining appropriate remedial measures for the task area. The map is presented in Figure 6-4.

6.3 Discussion of Results

6.3.1 Black and Bergholtz Creeks

Dioxin (2,3,7,8-TCDD) and a limited number other organic compounds and inorganic constituents (arsenic, chromium, cadmium, copper, lead, nickel, zinc, thallium) characterized the contamination detected in Black and Bergholtz Creeks. Phthalate esters, di-n-octyl phthalate and bis(2-ethylhexyl) phthalate were present singly or in combination, throughout Black and Bergholtz Creeks. Other than 2,3,7,8-TCDD and phthalate esters, only two incidences of contamination by synthetic organic chemical occurred: methylene chloride was detected at sample site B-1N and 3-chloronaphthalene at sample site D-9N. Contaminants were detected in all sediment levels sampled with no apparent pattern.

FIGURE 6-4



DIOXIN HOT SPOTS

LOCATION	CONCENTRATION (ppb)
B-1-N	1.3
B-2-S	4.0
D-6-N	1.2
D-7-M	9.4
D-9-N	45.8

LOVE CANAL
FIVE ENGINEERING STUDIES
BERGHOLTZ & BLACK CREEK
SAMPLE LOCATION POINTS
TASK III

2,3,7,8-TCDD was not included in the scoring matrix, but was assessed independently. Concentrations of 2,3,7,8-TCDD are plotted on the "hot spot" map of Black and Bergholtz Creek. The pattern of dioxin contamination suggests that the storm sewer outfall near the confluence of Black and Bergholtz Creeks is present or has been the source of the contamination. Dioxin was not found further upstream than sample location B-2, indicating that the storm water entering the piped portion of Black Creek at 98th Street does not appear to be an active pathway of contaminant transport.

Investigations of the storm sewers in Task Area VII indicated dioxin contamination at the 93rd Street outfall into Black Creek. Black Creek itself was not sampled in the vicinity of this outfall and the extent of the dioxin contamination is unknown.

The potential pathways for human exposure have been discussed in Section 6.2.3 Human exposure to contaminated sediments could result from direct or indirect skin contact. Since only part of the area is fenced (Black Creek from 98th Street to the confluence of Bergholtz Creek), and the creeks are shallow, the potential for human exposure is of definite concern.

The potential for human exposure via ingestion of contaminated water seems less likely, due to the distance to the water intakes in the Niagara River and the treatment of water prior to consumption. Accidental ingestion of creek water would still be possible; however, contamination of water by organic chemicals did not occur (with the exception of bis(2-ethylhexyl phthalate at B-6).

Because of the high priority assigned to dioxin contamination, the nature and extent of remedial action in Black and Bergholtz Creek is defined by locations where 2,3,7,8-TCDD was found. Regardless of the concentrations detected, remediation of areas of dioxin contamination is recommended as a result of the extremely toxic and presistent nature of 2,3,7,8-TCDD and the public perception surrounding this compound.

Concentrations of heavy metals and phthalate esters in samples taken in areas potentially influenced by Love Canal were similar to concentrations of these contaminants detected in upstream areas (sample sites B-20 and U-4), indicating that sources other than Love Canal may be contributing these contaminants to the creeks. Based upon the contamination by the organics, phthalate esters and the few other organics, a low priority designation would be given to Black and Bergholtz Creeks as indicated in the contamination assessment map. The rationale for this designation is the same as that detailed for Cayuga Creek. The "hot spot" map for 2,3,7,8-TCDD, however, imposes a designation of high priority on the area delineated in the "hot spot" map. Remedial action is recommended in this area of Black and Bergholtz Creeks.

6.3.2 Cayuga Creek

No contaminants which could be specifically classified as Love Canal-related compounds were found in Cayuga Creek. Inorganic constituents (arsenic, chromium, cadmium, copper, lead, nickel, zinc, and thallium) were detected. The phthalate esters di-n-octyl phthalate and bis(2-ethylhexyl) phthalate were present, singly or in combination, throughout Cayuga Creek. Other than the phthalate esters, only one incidence of contamination by synthetic organic chemicals occurred; methylene chloride was detected at sample location C-2-E. No 2,3,7,8-TCDD (dioxin) was found in Cayuga Creek.

With one exception, concentrations of heavy metals and phthalate esters were similar to concentrations of these contaminants detected in samples taken upstream of the influence of Love Canal (sample sites B-20 and U-4). The exception was sample site C-7-M where the concentration of arsenic was 170 and 160 ppm, in the upper and middle sediment layers, respectively. (By comparison, "upstream" concentrations of arsenic were 22-43 ppm.) The potential source and significance of the arsenic contamination at C-7-M is detectable. The overall pattern of contamination suggests that the sanitary sewer outfalls at Pershing Avenue and Military Road are active pathways of contaminant transport. These sewer outfalls can convey sanitary sewage from the Love Canal area. However, transport of Love Canal-related contaminants via the storm sewer outfalls on the east bank is more likely and contamination attributable to at least one of these outfalls (the 18-inch outfall north of Military Road) was not evident. This, coupled with the "upstream" concentrations of arsenic, suggests that sources other than Love Canal may be contributing to the contamination in Cayuga Creek.

The potential pathways for human exposure have been discussed in Section 6.2.3. Human exposure to contaminated sediments could result from direct or indirect skin contact. However, considering the nature and concentrations of the contaminants detected, skin contact is unlikely to be of significant concern of potentially more concern is contamination of the water. However, only one water sample (at C-3W) was found to contain detectable levels of organic contamination [pecifically bis(2-ethylhexyl) phthalate]. No organics were found in this sample. No other liquid samples from Cayuga Creek were analyzed for inorganics, so it is not possible to make definitive conclusions about the concentrations of inorganics (such as arsenic) in the water. However, of the seven liquid samples taken in the various task areas that were analyzed for inorganics, non were found to contain detectable concentrations. In addition, due to the nature of the detected contaminants (both inorganics and phthalates) to partition preferentially into sediment rather than water, it is likely that water concentrations would be substantially lower than sediment concentrations. Some evidence for this assumption is afforded by the data: the water concentration of bis(2-ethylhexyl) phthalate was 330 ppm at C-3W, while the sediment concentration of this compound was 600 and 5,300 ppm in samples taken at C-2W.

All samples which passed the screening analysis are indicated on the contamination assessment map for Cayuga Creek. Samples that did not pass or exceed the qualitative screen are assumed not to be contaminated. This map reflects a "low priority" designation at all sample sites. Limited or no remedial action is indicated, based upon the nature of the contaminants that were detected (inorganics, phthalate esters, one sample containing methylene chloride), the concentrations detected (similar to "upstream" concentrations with the exception of an isolated sample site with elevated arsenic levels), and the pattern of contamination (possibly related to sewer outfalls but apparently fairly well-distributed throughout the creek). However, potential pathways of human exposure are fairly significant, since the creek is an open area and is used to a certain extent for recreation. The significance of skin contact with the sediment appears to be low; the significance of accidental ingestion of water would be greater. However, further investigation is necessary to ascertain the concentrations of contaminants in the water column.

7.0 REMEDIAL ALTERNATIVES

7.1 General

The Contamination Assessment presented in Chapter 6 identified specific portions of Black, Bergholtz, and Cayuga Creeks requiring remedial action. The specific remedial alternatives which will be considered are included in the following major categories:

- No Action.
- Restrict Access.
- Stabilization In-Situ.
- Removal and Disposal.

These categories are listed in order of increasing level of effort. The actual remedial alternatives are a combination of the above dependent on the contamination assessment for each specific portion of the creek. Each specific alternative is described in the following sections. An evaluation of the various possible courses of action is presented in Chapter 8. Chapter 9 consists of detailed engineering descriptions and cost information for the primary and secondary recommendations for remedial action.

It has been assumed that any contaminated storm sewers or sanitary sewer overflows discharging to the creeks will be cleaned or plugged prior to the implementation of any remedial alternative. Attempts should also be made to identify and eliminate any other possible sources of contamination further upstream.

Common to all of the following alternatives is the immediate implementation of a monitoring program on the creeks. This program would consist of flow measurement and periodic collection and analysis of both sediment and water column samples. This would provide much needed information concerning flow patterns and sediment transport in the creeks. These are critical considerations in the final design and implementation of any remedial action alternative.

7.2 No Action

A true 'No Action' remedial alternative would consist of no remedial actions and a cessation of all monitoring activities on the creeks. Due to the high visibility of this project and previous findings of contamination in the creeks, this is not a feasible alternative. A more appropriate 'Modified No Action' would include a limited program of periodic water and sediment sampling. This would serve to verify the selection of no action and provide a warning of any change in the contaminant level present in the creeks or any downstream movement of contaminants. Such a change would require review of the situation and renewed consideration of alternative remedial actions.

7.2.1 Alternative 1 - No Action

The no action alternative would involve no remedial actions and consist of merely a continuation of the creek monitoring program previously outlined. The program would target those specific areas of Black, Bergholtz, and Cayuga Creeks previously shown to have contaminated sediments. Under this alternative, the monitoring program would be gradually reduced in scope. Ultimately, the program would entail infrequent sampling or it would be phased out entirely, dependent on accumulated findings of the program. This alternative could precede a more extensive remedial action if warranted based on the results of the monitoring program.

7.3 Restrict Access

Restricting access to the creeks is another remedial alternative. This would be done by a combination of the following:

- Increasing Public Awareness.
- Posting of Signs.
- Fencing the Creeks.

The general public must be informed through public meetings of the extent of the problem and the importance of restricting access to the creeks. The posting of informational signs along the banks of the creeks would further assist in this effort. The fencing of the creeks along the banks would serve to physically restrict those not previously deterred.

7.3.1 Alternative 2 - Restrict Access

An organized program of public meetings and news releases would be structured to heighten public awareness concerning the importance of restricting access to the creeks. This would include presentations at local schools, since children are the primary recreational users of the creeks.

Currently access to Black Creek is restricted by a 6 foot high chain link fence along both the north and south banks. This extends from 98th Street west to the confluence with Bergholtz Creek.

Construction of new fencing would be necessary to restrict access to contaminated sediments in Bergholtz Creek from 150 feet above to 500 feet below the confluence with Black Creek. This would require clearing and grubbing along both banks and erecting 1,300 feet of 6 foot high chain link fence. Easement arrangements with the abutting property owners would be necessary for permanent siting of the fencing and to allow access for construction and maintenance purposes. Informational signs would be posted along the length of the fencing to explain its importance and further discourage accessing the creeks. Access points would be provided along the fencing to allow for sampling and any clearing needed to maintain a free flowing creek.

Restricting access to the 300 foot stretch of Cayuga Creek with contaminated sediments is not considered a feasible alternative. In this portion, the creek is over 85 feet wide and is subject to heavy recreational use. To effectively restrict access, it would be necessary to fence across the channel at both ends of this stretch. It would be difficult to do this without resulting in flow restrictions especially during high flow periods.

7.4 Stabilization In-Situ

Stabilization in-situ remedial alternatives are defined as those methods which secure contaminated sediments in place to prevent or minimize further transport of contamination downstream. These alternatives are applicable primarily where contaminant levels are not perceived to warrant extensive removal methods but simple access restrictions are deemed insufficient. Stabilization in-situ methods applicable to creek sediments consist of the following:

- Placement of small stone.
- Placement of filter fabric.
- Piping the creek.
- Treatment in place.

Placement of small stone along creek channels is widely used to prevent erosion of small creeks during high flow periods. The stone must be sized to prevent movement during all flow conditions. The effectiveness of the small stone could be enhanced by underlying it with filter fabric material. This would further stabilize the sediments by decreasing the entrainment of fines. In addition, the filter fabric would decrease the volume of small stone needed in areas of unstable sediments.

Piping the creek would involve the placement of a large culvert pipe in the creek channel. The culvert would be placed in suitable bedding material and would be sized to accommodate peak run-off flows. This would be done by evaluating the size of the drainage basin and monitoring flow by gauging the creek. The creek channel would be filled, graded, and seeded. This would convert the creek to an underground storm sewer similar to the portion of Black Creek between

102nd Street and 98th Street. This would stabilize the contaminated sediments by effectively burying them in place and removing the stream flow as a transport mechanism.

Treatment in place refers to the use of chemical or biological agents which are mixed with the contaminated sediments to produce a relatively innocuous material. The two major types of this remedial method are fixation and destruction. Fixation or solidification involves the use of a solidifying agent which physically surrounds the sediment material and creates a stable, cement-like mass. However, this new material is porous and subject to erosion and must therefore still be removed. Destruction involves the use of specific chemical compounds or microorganisms that interact with the contaminants to render them relatively inert.

While treatment in place methods hold much promise for the future, their practical use to date has been extremely limited. The agitation of the sediments necessary for these two approaches would aggravate transport of the contaminants. The practical application of these methods to free flowing creeks, subject to wide fluctuations in flow, has yet to be proven. Furthermore, the destruction agents require a specificity of contaminant which is not possible in this situation. Therefore, treatment in place remedial alternatives are not considered viable.

7.4.1 Alternative 3 - Stabilize Sediments

For the 200 foot stretch of contaminated sediments in Black Creek, this would involve removal of the existing fencing and cleaning and grubbing the entire channel. Large sheets of filter fabric would be placed in the channel and small stone dumped and hand spread to a depth of 8 inches. Access to Black Creek would be from a haul road constructed along the south bank.

For the 650 foot stretch of contaminated sediments in Bergholtz Creek, the channel would be lined with filter fabric and covered with small stone as described above. Access to Bergholtz Creek would be from a haul road constructed along the south bank on the 93rd Street School property. For the limited portion upstream of the confluence with Black Creek, an access road from Mason Court to the southeast bank would be constructed. Annual inspections would be conducted to identify exposure or curling of the filter fabric and specific areas requiring additional quantities of small stone.

For the 300 foot stretch of contaminated sediments in Cayuga Creek, stabilization of sediments by placement of filter fabric and small stone is not considered feasible. In this area, the channel is over 85 feet wide with water depth exceeding 6 feet. Because of the limited length of this stretch in relation to its width, migration of the stone and curling of the filter fabric would be a constant problem.

7.4.2 Alternative 4 - Resitrict Access and Stabilize Sediments

This alternative combines restrictions of access (7.3.1 Alternative 2) with stabilization of the sediments (7.4.1 Alternative 3). The stabilization would minimize further downstream transport of the contaminated sediments while access restrictions would minimize recreational usage of the stabilized area. Because of the difficulties involved with stabilizing the contaminated sediments in place on Cayuga Creek, this alternative was considered only for Black and Bergholtz Creeks.

7.4.3 Alternative 5 - Piping the Creeks

The Black Creek is currently piped from 102nd Street to 98th Street. The remaining 700 foot stretch to Bergholtz Creek would be piped through twin 43 inch by 68 inch elliptical culvert pipes. This would appear adequate to accommodate the flow from the twin 48 inch pipes upstream and the two storm sewer outfalls. The actual sizing would be determined during design based on specific drainage and flow calculations. The existing fencing would be removed, an access road would be constructed along the south bank, and the entire channel would be cleared and grubbed. The creek channel sediments would be excavated to a depth of 24 inches and backfilled 12 inches with compacted granular bedding material and graded. Connections would be made for the two storm sewer outfalls on the creek and a grating would be placed at the downstream end to prevent access. The entire channel would be backfilled with gravel providing a minimum of 12 inches of cover over the crown of the culvert. The surface would be graded to a swale over the culvert pipes with drop inlet catch basins every 200 feet. The construction area would then be covered with topsoil and seeded to minimize erosion. Maintenance would involve occasional inspections to detect any erosion of the cover material and to remove any debris accumulated at the grating or the catch basins. A limited piping approach was also considered, which would involve piping only the contaminated portion of Black Creek.

Piping is not considered a feasible alternative for Bergholtz and Cayuga Creeks. The dimensions of the creeks and their associated drainage areas are extensive enough to render piping infeasible. Piping the creeks would require numerous culvert pipes and increase the possibility of flooding in developed areas.

7.5 Removal and Disposal

The most extensive remedial alternatives involve the removal and disposal of contaminated sediments. This removal could be proposed immediately or follow one of the previously discussed alternatives based on results of the contaminant monitoring program. The two major methods for creek sediment removal are:

- Hydraulic Dredging.
- Mechanical Excavation.

Regardless of the method used, the sediment would be excavated to a depth of at least four feet below the existing creek bed. Additional sediment sampling would be conducted during design to determine the maximum depth of penetration of contaminants. Following any sediment removal, it would be necessary to stabilize the creek bed with four feet of coarse fill material.

Hydraulic dredging of contaminated sediments in the Task III Area creeks would require the use of a mud cat dredge. This type of dredge is readily available and portable, minimizes turbidity, and operates well in shallow waters. The dredge slurry would be pumped to a secure location for settling of solids and treatment of return water. A mud cat dredge is capable of pumping a slurry for a maximum of 1,500 feet and would therefore require that the settling basin be sited nearby. Depending on this location, the sediments could be permanently contained or rehandled for shipment to a local waste disposal facility. To minimize downstream transport of suspended contaminated sediments during dredging, a sediment barrier, such as a silt curtain, would be erected at the downstream limit of sediment removal. The dredging operation would work downstream to this barrier and upon completion it would be removed and treated as contaminated material.

The handling of dredge return water would require the construction of a treatment facility at or near the disposal site. In order to keep the sediments in suspension in the dredge piping, flow velocities of 16 to 18 feet per second must be maintained. Assuming a 6 inch diameter discharge line, a slurry consisting of 15 percent solids and 85 percent water, and a flow velocity of 17 feet per second, approximately 1,300 gallons per minute of return water would have to be treated while the dredge is operating. Alternatively, storage facilities could be used to permit treatment of the water pumped during one shift over a 24 hour period. No studies have been made of the type or degree of return water treatment required for this project, but reports on pilot plant work for similar, fine-grained and silty sediments indicate that at a minimum, chemical flocculation and clarification will be needed to assist in separating the suspended solids from the water stream. If granular activated carbon filtration is required to remove organic contaminants from the return water, sand filtration may also be needed prior to carbon filtration to avoid plugging the carbon filters.

Mechanical excavation of contaminated sediments in the Task III Area creeks could be readily accomplished by land-based equipment. The maximum digging reach of a clamshell is approximately 80 feet, for a dragline 68 feet, and for a backhoe 30 feet. Access roads would be constructed along the banks to accommodate excavation equipment and watertight transport trucks. A station would be provided for washing down the trucks before they departed the restricted work area. To minimize downstream transport of contaminated sediments during excavation, a sediment barrier, such as a silt curtain, would be erected at the downstream limit of sediment removal. The excavation would proceed downstream to this barrier and upon completion it would be removed and treated as contaminated material.

Disposal of contaminated sediments generated by any removal method would ultimately be at a local hazardous waste facility such as CECOS. The material would be transported by watertight trucks to the facility where dewatering would be necessary before final disposal. The liquid fraction would be treated at the facility by carbon filters before discharge into the sanitary sewer system.

Consideration was given to final deposition of the material at the 93rd Street School. This property is reported to be filled with contaminated sludge material. However, the proximity of the property to the creek and the need to permanently dedicate it as a waste disposal site, rendered this approach unacceptable.

7.5.1 Alternative 6 - Hydraulic Dredging

Hydraulic dredging of the 850 foot stretch of Black and Bergholtz Creeks containing contaminated sediments would be done using a small mud cat dredge. A sediment barrier would be erected about 500 feet downstream from the confluence. Access to the creeks would be from the south bank of the Bergholtz at the 93rd Street School. A large earthen impoundment would be constructed on the school property for the dredge spoil and return water treatment. The impoundment would have an impermeable liner and would have multiple cells to allow for coagulant aided flocculation of the dredge water. Further study is necessary to determine the level of treatment that will be required. If warranted, a small package carbon filtration plant would be temporarily sited on the same property. Upon completion of the dredging, the treated water would be discharged to either the creek or the sanitary sewer system dependent on the results of testing. The remaining dredge solids will be excavated from the impoundment and transported by watertight trucks to a hazardous waste disposal facility. All access roads and the entire earthen basin including the liner and 2 feet of original topsoil would be excavated and disposed at the same facility. The school property would be filled with 2 feet of clean topsoil, graded and seeded.

Hydraulic dredging of the Cayuga Creek was not considered to be feasible. The area is densely developed and there is no available open area of sufficient size to locate an impoundment basin for the dredged material. Pumping the dredge slurry through crowded neighborhoods for long distances would be necessary to obtain an adequately sized site. This would needlessly escalate the costs and implementation difficulties associated with the project.

7.5.2 Alternative 7 - Mechanical Excavation

Mechanical excavation of the 850 foot stretch of Black and Bergholtz Creeks containing contaminated sediments would be done primarily using a clamshell. The small portion of Black Creek would be excavated using a backhoe. A sediment barrier would be erected 500 feet downstream from the confluence. Access to the creeks would be from a haul road constructed along the south bank from the 93rd Street School to a point about 200 feet upstream from Bergholtz Creek. A temporary stream crossing at the mouth of Black Creek would be needed to excavate Bergholtz above the confluence. Clearing and grubbing would be needed in the creek channels and along the bank access points. The excavated sediments would be deposited in watertight trucks for transport to a hazardous waste disposal facility. At the downstream limit of the excavation a decontamination station would be established for washing down the trucks before they departed the restricted work area. The runoff would be collected and sealed in drums for disposal at a suitable facility. Upon completion of each portion of the sediment excavation, the access road would be excavated and disposed along with the contaminated sediments. The bank areas would then be graded and seeded as part of final site restoration.

Mechanical excavation of the 300 foot stretch of Cayuga Creek containing contaminated sediments would be done using a barge-mounted clamshell. The width of the channel would otherwise require excavation from both banks. Accessing Cayuga Creek from Cayuga Drive for wet excavation would create problems resulting from the spillage of material. This problem would be minimized by only utilizing a haul road constructed along the eastern bank of the Cayuga. A sediment barrier would be erected about 200 feet downstream of Pershing Avenue. The clamshell would progress down the center of the channel depositing excavated sediment in watertight trucks on the access road. At the upstream limit of the excavation a decontamination station would be established for washing down the trucks before they departed the restricted work area. The runoff would be collected and sealed in drums for disposal at a suitable facility. The excavated sediment would then be transported to a local hazardous waste facility for disposal. Upon completion of the sediment removal, the access road would be excavated and disposed at the same facility. The bank areas would then be graded and seeded as part of final site restoration.

7.5.3 Alternative 8 - Mechanical Excavation and Sediment Trap

A refinement of Alternative 7 would be the widening of a portion of the creek to create a permanent sediment trap. During the excavation of Bergholtz Creek, the channel would be widened and deepened at the downstream limit of the contaminated sediments. A submerged concrete wall would be placed at the downstream end where the bottom would abruptly revert to original grade. The significant increase in the cross sectional area of the channel should cause a marked decrease in flow velocity. As a result, this area should settle outor trap sediment particles suspended in the water. This area could then be periodically sampled and excavated when necessary to remove contaminants. Excavation would be minimized on the south bank because the school property is reported to contain contaminants. Regardless, any material excavated during this project would be considered contaminated and require disposal at an approved facility.

A sediment trap is not warranted at Cayuga Creek since the contamination is not as acute. The contamination is resulting from inorganic compounds and has been identified only over a limited portion of the creek.

8.0 EVALUATION OF ALTERNATIVES

8.1 Summary of Alternatives

The remedial alternatives described in Chapter 7 have been evaluated for inclusion in an overall remedial action program for the Task III area. A summary of the feasible remedial alternatives is presented below:

- No Action
- Restrict Access to Bergholtz Creek
- Stabilize Sediments in Black and Bergholtz Creeks
- Restrict Access and Stabilize Sediments in Black and Bergholtz Creeks
- Piping the Black Creek
- Hydraulic Dredging of Black and Bergholtz Creeks
- Mechanical Excavation of Black, Bergholtz, and Cayuga Creeks
- Mechanical Excavation and Sediment Trap in Bergholtz Creek

8.2 Preliminary Evaluation of Alternatives

In order to remove from the list of possible alternatives those which are least practical or acceptable, a preliminary screening of alternatives has been undertaken. In this preliminary screening, each alternative has been evaluated and given a rank or score from 1 to 10 for each of the 6 different parameters. The parameters included in this screening are: effectiveness, reliability, worker safety, ease of implementation, minimal environmental impacts during implementation, and public acceptance.

- <u>Effectiveness</u> - This parameter refers to the applicability of the alternative as an action which reduces the potential for direct contact or migration of the contaminated sediments. "Will it do the job" is addressed here.

- <u>Reliability</u> - This parameter refers to the continued effectiveness of the alternative. "Will it continue to do the job" is addressed here.

- <u>Worker Safety</u> - This parameter refers to the potential of workers contacting contaminated material during the remedial action.

- <u>Ease of Implementation</u> - This parameter refers to the perceived level of difficulty involved in initiating the remedial action. This would address property acquisition, easements, permits, phasing, etc.

- <u>Environmental Impacts During Construction</u> - This parameters refers to the short-term impacts resulting from implementation of the alternative. This addresses the release of contaminants due to disturbance of the sediments.

- <u>Public Acceptance</u> - This parameter refers to the overall perception of the remedial action by the general public.

A high score for a given parameter indicates that the alternative meets the criteria described by the parameter, while a lower score indicates that the alternative is less acceptable as regards to the same parameter. A worksheet which includes each numerical score and supporting comments has been been prepared for each remedial alternative. The individual worksheets have been composited into the evaluation matrix shown in Table 8-1 for comparison purposes.

Preliminary Screening Worksheet

Alternative 1

No Action

Parameter	Score by Location B	Score by Location D	Score by Location C	Comments
Effectiveness	2	1	3	B - Currently fenced D - No change in current status C - Contamination is limited
Reliability	3	1	1	B - Currently fenced D, C - No change in current status
Worker Safety	10	10	10	B,D,C - No workers involved
Ease of Implementation	10	10	10	B,D,C - Only monitoring program requires implementation
Environmental Impacts During Implementation	10	10	10	B,D,C - No adverse impacts during implementation
Public Acceptance	3	1	5	B,D - Contamination includes Dioxin C - Contamination mainly inorganic compounds
	38	33	39	

B - Black Creek
D - Bergholtz Creek
C - Cayuga Creek

Preliminary Screening Worksheet

Alternative 2

Restrict Access

Parameter	Score by Location		Comments
	B	D	
Effectiveness	3	3	B - Currently restricted, appears effective D - Subject to recreational use
Reliability	3	3	B - Current fencing appears reliable D - Restricting channel could create problems
Worker Safety	9	9	B,D - Minimal worker contact
Ease of Implementation	10	9	B - Currently fenced D - Clearing and grubbing banks required
Environmental Impacts During Implementation	10	9	B - Currently fenced D - Bank clearing could cause erosion
Public Acceptance	3	3	B,D - Contamination includes Dioxin
	38	36	

B - Black Creek
D - Bergholtz Creek

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Preliminary Screening Worksheet

Alternative 3

Stabilize Sediments

Parameter	Score by Location B	Score by Location D	Comments
Effectiveness	6	4	B - Fencing would be maintained D - Subject to recreational use
Reliability	4	4	B,D - Some loss of stone possible
Worker Safety	6	6	B,D - Direct contact with sediments
Ease of Implementation	5	6	B - Requires temporary removal of fencing B,D - Access road must be built
Environmental Impacts During Implementation	8	8	B,D - Limited disturbance of sediments
Public Acceptance	7	6	B - Fencing reduces accessibility D - Subject to recreational use
	36	34	

B - Black Creek
D - Bergholtz Creek

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Preliminary Screening Worksheet

Alternative 4

Restrict Access and Stabilize Sediments

Parameter	Score by Location		Comments
	B	D	
Effectiveness	6	5	B - No recreational use D - Subject to recreational use
Reliability	4	4	B,D - Some loss of stone possible
Worker Safety	6	6	B,D - Direct contact with sediments
Ease of Implementation	5	5	B - Banks cleared and access road built
Environmental Impacts During Implementation	8	7	B - Currently fenced D - Bank clearing could cause erosion B,D - Limited disturbance of sediments
Public Acceptance	7	7	B,D - Contamination not removed
	36	34	

B - Black Creek
D - Bergholtz Creek

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Preliminary Screening Worksheet

Alternative 5

Piping the Creeks

Parameter	Score by Location B	Comments
Effectiveness	7	B - Contaminants not removed
Reliability	7	B - Blockages may occur
Worker Safety	5	B - Direct contact with sediments
Ease of Implementation	5	B - Banks cleared and access road built
Environmental Impacts During Implementation	6	B - Disturbance of sediments during construction
Public Acceptance	8	B - Burial of sediments
	38	

B - Black Creek

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Preliminary Screening Worksheet

Alternative 6

Hydraulic Dredging

Parameter	Score by Location		Comments
	B	D	
Effectiveness	9	9	B,D - Contaminated sediments removed
Reliability	8	8	B,D - Potential water treatment problems
Worker Safety	3	3	B,D - Contact with contaminated sediment slurry and rehandling dredge solids
Ease of Implementation	3	3	B,D - Settling basins location and return water treatment
Environmental Impacts During Implementation	3	3	B,D - Disturbance of sediments during removal and rehandling
Public Acceptance	6	6	B,D - Settling basins and rehandling at 93rd Street School
	32	32	

B - Black Creek
D - Bergholtz Creek

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Preliminary Screening Worksheet

Alternative 7

Mechanical Excavation

Parameter	Score by Location B	Score by Location D	Score by Location C	Comments
Effectiveness	9	9	9	B,D,C - Contaminated sediments removed
Reliability	10	10	10	B,D,C - Contaminated sediments removed
Worker Safety	5	5	5	B,D,C - Contact with excavated sediments
Ease of Implementation	4	4	4	B,D,C - Major excavation and hauling operation
Environmental Impacts During Implementation	5	5	5	B,D,C - Disturbance of sediments during removal
Public Acceptance	9	9	9	B,D,C - Contaminated sediments removed
	42	42	42	

B - Black Creek
D - Bergholtz Creek
C - Cayuga Creek

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Preliminary Screening Worksheet

Alternative 8

Mechanical Excavation and Sediment Trap

Parameter	Score by Location D	Comments
Effectiveness	10	D - Contaminated sediments removed periodically
Reliability	9	D - Contaminated sediments removed periodically
Worker Safety	4	D - Periodic contact with contaminated sediments
Ease of Implementation	4	D - Major excavation and hauling operation
Environmental Impacts During Implementation	4	D - Disturbance of sediments during removal
Public Acceptance	10	D - Contaminated sediments removed periodically
	41	

D - Bergholtz Creek

TABLE 8-1

ALTERNATIVE EVALUATION MATRIX

	Alternative Score By Location														
	(B) Black Creek						(D) Bergholtz Creek							(C) Cayuga Creek	
Parameter	1	3	4	5	6	7	1	2	3	4	6	7	8	1	7
Effectiveness	2	6	6	7	9	9	1	3	4	5	9	9	10	3	9
Reliability	3	4	4	7	8	10	1	3	4	4	8	10	9	1	10
Worker Safety	10	6	6	5	3	5	10	9	6	6	3	5	4	10	5
Ease of Implementation	10	5	5	5	3	4	10	9	6	5	3	4	4	10	4
Environmental Impacts During Implementation	10	8	8	6	3	5	10	9	8	7	3	5	4	10	5
Public Acceptance	3	7	7	8	6	9	1	3	6	7	6	9	10	5	9
	38	36	36	38	32	42	33	36	34	34	32	42	41	39	42

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8.3 Summary of Evaluation Matrix

The alternative evaluation matrix, Table 8-1, has ranked each of the proposed remedial actions on a comparative basis to aid in the selection process. For Cayuga Creek the alternative evaluation matrix has ranked mechanical excavation slightly higher than "no action." The selection of the recommended alternative remedial action for Cayuga Creek has been dependent on the contamination assessment presented in Section 6. The area of concern has been defined by an elevated level of arsenic at one particular sampling location. This has not seemed sufficient to warrant a major excavation effort on the creek. Therefore, a no action approach has been selected with a recommendation for further sampling to determine the source and extent of the arsenic contamination. Should these studies indicate that the sediment requires removal, the mechanical excavation outlined in Section 7 could be implemented. A preliminary construction cost estimate for the mechanical excavation of a 300-foot reach of Cayuga Creek is shown in Table 8-4.

Based on the alternative evaluation matrix, hydraulic dredging of Black and Bergholtz Creeks has been effectively eliminated from consideration as a feasible alternative. The difficulties involved with siting and constructing a settling basin, rehandling of dredge solids, and treating the return water were deemed formidable obstacles to the selection of this alternative. In-situ stabilization of the contaminated sediments in Black and Bergholtz Creeks utilizing filter fabric and small stone has also been eliminated from consideration based on rankings in the matrix. While this approach would have decreased the potential for direct contact, the contamination would remain and migration through solubilization would be possible. The ranking of the remaining alternatives for Black and Bergholtz Creeks has not differentiated them sufficiently to select a recommended remedial action. Therefore, the following specific alternatives are compared in detail on the basis of the previously discussed evaluation parameters:

- Limit access to Black and Bergholtz Creek
- Mechanical excavation of Bergholtz Creek and piping of Black Creek
- Mechanical excavation of Black and Bergholtz Creek
- Mechanical excavation of Black and Bergholtz Creek with sediment trap

8.3.1 Effectiveness

Mechanical excavation with a sediment trap would be the most effective remedial action. The contaminated sediments would be immediately removed and periodic excavation would remove additional contamination if it migrated downstream into the sediment trap. Mechanical excavation alone would be similarly effective by removing the contaminated sediments. Under this approach it is believed that additional excavations would not be warranted since the contaminant source is no longer active. Piping the creek would be effective in limiting direct contact and preventing migration via sediment transport of the contaminated sediments. However, since the contaminants would not be removed, migration via solubilization could occur. Limiting access to the creeks would be effective somewhat in limiting direct contact with the contaminated sediments. However, direct contact is possible and migration probable via both sediment transport and solubilization.

8.3.2 <u>Reliability</u>

Mechanical excavation alone would be the most reliable remedial action since it would involve no permanent structures and would not require any additional operation or maintenance considerations. Mechanical excavation with the sediment trap would have a high degree of reliability with some maintenance requirements necessary to ensure that the sediment trap and the associated overflow structure function adequately. Piping the creek would also have a high degree of reliability. Blockages, erosion, surcharging resulting in upstream flooding, and the eventual replacement of the pipe would be potential problems. Limiting access to the creeks would be the least reliable alternative. The significance of the fencing would be gradually reduced and it would require maintenance and eventual replacement.

8.3.3 <u>Worker Safety</u>

Limiting access to the creeks would afford workers a higher degree of safety. The workers would not contact the contaminated sediments and there would be no disturbance of the same. Mechanical excavation alone and piping the creek would involve a decreased level of worker safety. Both would involve a significant disturbance of the contaminated sediments and the potential for direct contact. Mechanical excavation with the sediment trap would afford the worker a lower level of safety due to possible direct contact with contaminated sediments during periodic excavations of the trap.

8.3.4 Ease of Implementation

Limiting access to the creeks would be relatively easy to implement requiring only a fencing contractor. Much of the property is publicly owned and permanent easements would be obtained from adjacent homeowners. The remaining alternatives requiring mechanical excavation or piping the creek would be more difficult to implement. It would be necessary to develop a detailed design, obtain construction easements, and coordinate the excavation of sediments with an approved hazardous waste disposal facility for dewatering and ultimate disposal.

8.3.5 Environmental Impacts During Implementation

Limiting access to the creeks would result in no significant environmental impacts during implementation. Piping the Black Creek would require removal of existing stream bank vegetation and excavation of the stream bed, prior to emplacing the pipe. This would remove habitat for common wildlife species and aquatic organisms. Disturbance of the sediments during excavation would result in temporary downstream water quality, degradation, siltation, and the possible migration of contaminants in suspended sediments.

Mechanical excavation of the creeks would also require vegetation removal and stream bed sediment disturbances. Temporary water quality impacts would be expected as well as downstream siltation and some transport of contaminants associated with entrained sediments. Although existing habitat would be temporarily destroyed, following excavation and stabilization, vegetation would become

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re-established in and along the stream beds and recolonization of the creeks by benthic species and other aquatic organisms would be expected.

Construction of a silt trap in addition to mechanical excavation would have similar, but somewhat greater impacts than excavation alone. Themore extensive excavation required for construction of the silt trap, would temporarily increase water quality impacts; however, once in place, the silt trap would improve downstream water quality by reducing suspended sediment levels in stream flows.

8.3.6 Public Acceptance

Mechanical excavation with a sediment trap would be the most publicly acceptable remedial action. This approach would remove all currently identified contaminated sediments and allow for the collection and periodic removal of any future contamination that might migrate downstream. Mechanical excavation alone would be only slightly less acceptable to the general public. Removal of the identified contaminated sediments would be considered an appropriate remedial response. Piping the creek would also garner support from the general public. Much of the contaminated sediments would be removed and the remaining sediments would be buried under the newly piped portion of the creek. However, there would be some concern raised over the potential for the contaminated material left behind to migrate and cause problems at a later date. Limiting access to the creeks would be a relatively unacceptable alternative to the general public. The presence of dioxin in the sediment of the creeks would be a major issue and would require the recommendation of a more extensive remedial action.

8.3.7 Conclusion

The detailed discussion of the alternative remedial actions with respect to the evaluation parameters has served to further limit those actions under consideration. Limiting access has been shown to be both publicly unacceptable and relatively ineffective as a long-term remedial approach. Mechanical excavation has been selected as the recommended remedial action for Bergholtz Creek. The installation of a sediment trap would provide additional long-term protection against downstream migration of contamination. However, the results of the contamination assessment do not justify this additional level of protection. A cost breakdown for the installation of a sediment trap on Bergholtz Creek has been included in Table 8-3. Mechanical excavation has been selected as the recommended remedial action for Bergholtz Creek. The installation of a sediment trap would provide additional long-term protection against downstream migration of contamination. However, the results of the contamination assessment do not justify the additional expense for the sediment trap.

It has not been possible to clearly differentiate between piping and excavating Black Creek. Both alternatives have been shown to be fairly comparable and therefore require further consideration on a cost basis.

8.4 Cost Evaluation

In evaluating the remedial actions based on the aforementioned parameters, a clear cut choice cannot be made between piping Black Creek or mechanical excavation. Therefore, preliminary cost estimates have been developed for the evaluation of the following three remedial alternatives:

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- Piping the entire 700 feet of Black Creek
- Piping only 200 feet of Black Creek
- Mechanical excavation of 200 feet of Black Creek

For the purposes of these estimates it has been assumed that all work would be performed concurrent with mechanical excavation of Bergholtz Creek.

Based on the cost information presented in Table 8-2, piping 200 feet of Black Creek has been estimated to be 20 percent costlier than mechanically excavating the same reach. Piping the entire 700 feet is many times more expensive and would not be justifiable based on the absence of contaminated sediments in the upstream reach. Therefore, mechanical excavation has been selected as the recommended remedial action for Black and Bergholtz Creeks.

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TABLE 8-2

PIPING OR MECHANICAL EXCAVATION OF BLACK CREEK PRELIMINARY CONSTRUCTION COST ESTIMATES*

	Piping 700 Feet	Piping 200 Feet	Excavating 200 Feet
Clearing and Grubbing	$ 2,000	$ 500	$ 500
Access Road	10,500	3,800	3,800
Excavation	3,100	900	1,800
Culvert Piping	126,000	36,000	-
Inlet, Outlet Structures	12,000	10,000	-
Catch Basins	3,000	1,000	-
Backfill	11,500	3,300	4,500
Removal of Access Road	4,200	1,500	1,500
Transport Material	18,280	5,970	8,190
Disposal at Waste Facility	182,800	59,700	81,900
Subtotal	$373,380	$122,670	$102,190
Contingencies (15%)	56,010	18,400	15,330
Total Construction Cost	$429,390	$141,070	$117,520

*Assumes all work concurrent with remedial action on Bergholtz Creek.

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TABLE 8-3

MECHANICAL EXCAVATION OF BLACK AND BERGHOLTZ CREEKS WITH INSTALLATION OF SEDIMENT TRAP ON BERGHOLTZ CREEK PRELIMINARY CONSTRUCTION COST ESTIMATE

	Quantity	Unit Cost	Total
Sediment Trap Installation			
Excavation	325 c.y.	$ 7 c.y.	$ 2,275
Overflow Structure	Lump Sum	$1,500	1,500
Grading and Seeding	Lump Sum	$ 500	500
Rip Rap - small stone	90 c.y.	$ 10 c.y.	900
Transport Material	325 c.y.	$ 10 c.y.	3,250
Disposal at Waste Facility	325 c.y.	$ 100 c.y.	32,500
Sediment Trap Cost			$40,925

Mechanical Excavation With Sediment Trap	
Mechanical Excavation Cost (see Table 9-1)	$ 852,540
Reduction in Backfill (1045 c.y. at 10/c.y.)	(10,450)
Revised Excavation Cost	$ 842,090
Sediment Trap Cost	132,450
Total Construction Cost	$1,015,465
Total Construction Cost - Mechanical Excavation alone	(980,420)
Additional Cost of Sediment Trap	$ 35,045
Say	$ 35,000

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TABLE 8-4

MECHANICAL EXCAVATION OF CAYUGA CREEK PRELIMINARY CONSTRUCTION COST ESTIMATE

	Quantity	Unit Cost	Total
Fencing and Gates	1,370	$ 12/l.f.	$ 16,440
Clearing and Grubbing	Lump Sum	$ 500	500
Sediment Barrier	Lump Sum	$ 3,000	3,000
Access Road	625 l.f.	$ 15	9,375
Mobilization	Lump Sum	$ 5,000	5,000
Excavation	3,870 c.y.	$ 6	23,220
Backfill	3,870 c.y.	$ 10	38,700
Removal of Access Road	925 c.y.	$ 5,000	5,000
Washdown Station Transport Material	Lump Sum	$10,000 c.y.	47,950
Disposal at Waste Facility	4,795 c.y.	100 c.y.	479,500
Total Construction Cost			$632,385
Contingencies (15 percent)			94,860
Engineering and Legal (30 percent)			189,720
Total Estimated Project Cost			$916,625
Say			$917,000

9.0 RECOMMENDATIONS

9.1 Remedial Action for Black and Bergholtz Creeks

As a result of the contamination assessment presented in Chapter 6, as specific reach of Black and Bergholtz Creeks, as shown on Figure 9-1, is targeted for remedial action. This area encompasses Bergholtz Creek extending from 500 feet below to 150 feet above the confluence with Black Creek. It also includes the portion of Black Creek extending from Bergholtz Creek to a point 200 feet upstream. The major source of concern is the detection of dioxin in the creek sediments. Based on these findings, it is recommended that this specific area can be immediately fenced to restrict access. The fencing should be set back as shown on Figure 9-1 to allow for a controlled work area. The recommended remedial action is mechanical excavation of the contaminated sediments and transport via watertight trucks to a nearby hazardous waste disposal facility.

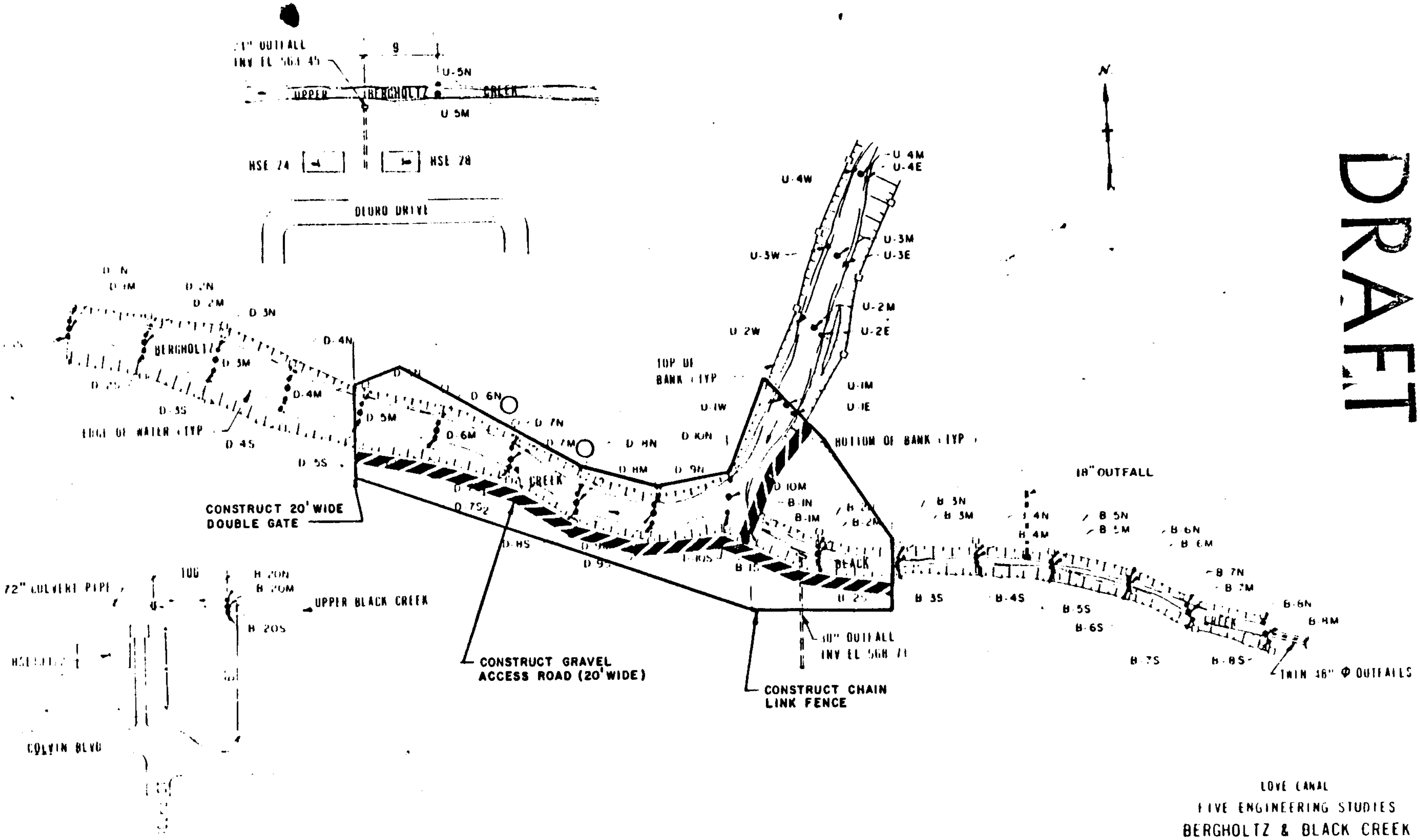
The total project cost is estimated to be $1,236,000. The installation of a permanent sediment trap is estimated to cost an additional $44,200. However, the results of the contamination assessment do not justify the additional expense.

9.1.1 Description

- Erect 1,950 lf of 6-foot high chain link fence surrounding the remedial area, set back to allow a working area for excavation equipment.

- Obtain all units and easements, both temporary and permanent, necessary to begin the project.

FIGURE 9-1



LOVE CANAL
FIVE ENGINEERING STUDIES
BERGHOLTZ & BLACK CREEK
MECHANICAL EXCAVATION
TASK III

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- Clear and grub both the channels and the bank from which excavation is to be done.
- Construct a gravel fill access road 20 feet wide along the south bank of Black and Bergholtz Creeks.
- Erect a sediment barrier such as a silt curtain at the downstream limit of the excavation.
- Construct a temporary stream crossing consisting of a large culvert pipe and gravel fill at the mouth of Black Creek.
- Extend the access road along the east bank of the upper Bergholtz Creek.
- Construct a truck washdown station consisting of a pad with underdrains, a storage tank with a pump, and water service from the 93rd Street school building.
- Excavate the sediments using a crane mounted clamshell and deposit the material into watertight trucks.
- Backfill the creeks with clean fill material returning to the original grade.
- Transport the excavated material via watertight trucks, after washdown, to a nearby approved waste disposal facility.

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- Excavation will proceed downstream and the access road will be continually removed and disposed along with the sediments.

- Upon completion of the excavation the sediment barriers will be removed and disposed along with the sediments.

9.1.2 Implementation

It is important that stream gauging is established on Black and Bergholtz Creeks as soon as possible to allow for the accumulation of seasonal flow data. This data would be used for the development of sediment transport models for the creeks. This is vital in assessing long-term contaminant migration and short-term impacts to be expected during remedial actions. Consideration should also be given to the collection and analysis of additional sediment samples to further refine the limits of the remedial action. Reductons in the area to be excavated would result in significant cost savings which would most likely justify the additional sampling expense. The additiona sampling results and flow data are critical information necessary for the effective design and implementation of the remedial action. The time required to prepare construction plans and specifications, obtain permits and easements, advertise for and receive bids, and award a construction contract is estimated to be approximately six months. Excavation and removal of the sediments should be completed in five months. The entire remedial project from design to final completion should require a one year period.

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Under Task Area VII, a sample was collected at the outfall to Bergholtz Creek of the 93rd Street storm sewer. Analysis of the sample indicated the presence of dioxin. This location, at the 93rd Street pedestrian bridge is below the lower limit of the sampling program conducted on Bergholtz Creek. Prior to the implementation of the proposed remedial action, further sediment samples and water column samples should be taken in the vicinity of this outfall. The samples should be analyzed specifically for dioxin, but also for a wide range of organic and inorganic compounds. An investigative samplingg program for this area of Bergholtz Creek would require about one week of field operations for sample collection. However, the amount of time required for analysis of the samples is difficult to estimate. Analysis for dioxin is time consuming due to its complexity and the limited number of capable laboratories. A three-month time frame for the entire investigative program would be feasible.

9.2 Remedial Action for Cayuga Creek

As a result of the contamination assessment of Cayuga Creek presented in Chapter 6, an area of concern has been identified. This area is defined by an elevated level of arsenic at one particular sampling location (C-7M). This location was selected due to the presence of a 60-inch, pumped, sanitary sewer overflow outfall. The sanitary sewer carries flows originating from the Love Canal area and could convey contamination to Cayuga Creek. Analysis of other samples taken in the vicinity indicated lower levels of arsenic. The detection of one sample with elevated levels or arsenic does not warrant a major excavation effort on the creek.

During the field investigations, the portion of the creek under the Military Road Bridge was found to have several feet of unconsolidated sediment mixed with organic material. The sediments in this area were unstable and, when disturbed, produced a very strong odor. A sanitary sewage pump station with an overflow to the creek is located just south of this bridge and may be a source of this material.

A no action approach is recommended with provisions for further sampling in the two areas of Cayuga Creek identified above. An investigative sampling program should be conducted to determine the source, extent, and mobility of any identified contaminants. Should this study indicate that sediment removal is required, the mechanical excavation approach described in Chapter 7 could be implemented. This description and the cost estimate presented in Chapter 8 assume the removal of contaminated sediments in a 300-foot reach in the area of the 60-inch outfall (C-7 to C-9).

9.2.1 Description

- Establish stream gauging on Cayuga Creek below the areas to be sampled to allow for the development of seasonal flow data.

- Collect sediment and water column samples from locations on the pumped sanitary sewer overflow line which discharges into Cayuga Creek at Pershing Avenue.

- Collect sediment and water samples both upstream and downstream from sampling location C-7.

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- Collect sediment and water samples in the unconsolidated sediments located under the Military Road Bridge.
- Analyze all samples for a wide range of organic and inorganic (specifically arsenic) compounds.
- Review the results of the sampling program an determine the source, extent, and mobility of any detected contamination.

9.2.2 Implementation

It is important that stream gauging be established on Cayuga Creek as soon as possible to allow for the accumulation of seasonal flow data. This data would be used for the development of sediment transport models for the creek. This would aid in identifying the source and evaluating the mobility of contaminants. The investigative sampling program outlined for Cayuga Creek would require about one week of field operations for sample collection. A boat would be necessary to collect samples in the center of the channel. The amount of time required for analysis of the samples is difficult to estimate. Analysis for dioxin is time consuming due to its complexity and the limited number of capable laboratories. A three-month time frame for the entire investigative program would be feasible.

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TABLE 9-1

MECHANICAL EXCAVATION OF BLACK AND BERGHOLTZ CREEK COST ESTIMATE

	Quanity	Unit Cost	Total
Fencing and Gates	1,950 lf	$12/lf	$ 23,400
Clearing and Grubbing	Lump Sum	$3,000	3,000
Access Road	1,350 lf	$15/lf	20,250
Sediment Barrier	Lump Sum	$1,000	1,000
Temporary Stream Crossing	Lump Sum	$3,000	3,000
Excavation	4,515 cy	$ 6/cy	27,090
Backfill	4,515 cy	$10/cy	45,150
Removal of Access Road	2,000 cy	$ 4/cy	8,000
Washdown Station	Lump Sum	$5,000	5,000
Transport Material	6,515 cy	$10/cy	65,150
Disposal at Waste Facility	6,515 cy	$100/cy	651,500
Total Construction Cost			$ 852,540
Contingencies (15%)			127,880
Engineering and Legal (30%)			255,760
Total Estimated Project Cost			$1,236,180
		Say	$1,236,000

APPENDIX A
SUMMARY OF ANALYSIS

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-014S-A
Location ID: B-1-N
CompuChem #: 2713

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	222	Methylene Chloride	2,300	2,000	170
Acid	LS	Heneicosane	500	EC	1564
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	440	200	1488
	429	Di-N-Octyl Phthalate	420	200	1647
	LS	Pentacosane	8,000	EC	1387
	LS	Pentacosane	8,600	EC	1446
	LS	Tricosane	8,400	EC	1514
	LS	Pentacosane	8,000	EC	1597
	LS	Tricosane	7,600	EC	1694

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	17	1.0
105	Chromium, Total	6.8	1.0
106	Copper, Total	13	1.0
107	Lead, Total	15	1.0
109	Nickel, Total	7.1	1.0
112	Thallium, Total	8.6	1.0
113	Zinc, Total	39	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-018S-A
Location ID: B-2-S
CompuChem #: 2701

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	1,300	EC	1256
	LS	Eicosane	3,200	EC	1464
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	5,200	EC	1551
	LS	Pentacosane	37,000	EC	1325
	LS	Tricosane	38,000	EC	1375
	LS	Pentacosane	37,000	EC	1430
	LS	Pentacosane	36,000	EC	1495
	LS	Pentacosane	35,000	EC	1572

INORGANICS

INSUFFICIENT SAMPLE MATERIAL AVAILABLE TO PERFORM INORGANICS ANALYSIS.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-021S-A
Location ID: B-3-S
CompuChem #: 2710

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid		None Detected			
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	4,500	2,000 [1]	1524
	LS	Tricosane	110,000	EC	1356
	LS	Pentacosane	150,000	EC	1409
	LS	Pentacosane	190,000	EC	1471
	LS	Pentacosane	110,000	EC	1543
	LS	Pentacosane	180,000	EC	1628

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	28	1.0
104	Cadmium, Total	1.7	1.0
105	Chromium, Total	13	1.0
106	Copper, Total	16	1.0
107	Lead, Total	62	1.0
109	Nickel, Total	13	1.0
112	Thallium, Total	12	1.0
113	Zinc, Total	44	1.0

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-024S-B
Location ID: B-4-N
CompuChem #: 2640

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Cyclotrisiloxane, Hexamethyl-	390	EC	525
	LS	Cyclotetrasiloxane, Octamethyl-	320	EC	719
	LS	Unknown	660	EC	1257
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	1,700	200	1523
	LS	Unknown	620	EC	1037

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	35	1.0
104	Cadmium, Total	1.6	1.0
105	Chromium, Total	10	1.0
106	Copper, Total	18	1.0
107	Lead, Total	20	1.0
109	Nickel, Total	13	1.0
112	Thallium, Total	14	1.0
113	Zinc, Total	38	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-027S-A
Location ID: B-5-N
CompuChem #: 2648

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	52,000	EC	1020
	LS	Unknown	130,000	EC	1461
	LS	Heneicosane	120,000	EC	1540
	LS	Unknown	25,000	EC	1575
	LS	Pentacosane	310,000	EC	1594
Base/Neutral/ Pesticide		None Detected			

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	27	1.0
105	Chromium, Total	18	1.0
106	Copper, Total	16	1.0
107	Lead, Total	48	1.0
109	Nickel, Total	11	1.0
112	Thallium, Total	2.5	1.0
113	Zinc, Total	91	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-027S-C
Location ID: B-5-N
CompuChem #: 2650

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	4,400	EC	1110
	LS	Unknown	12,000	EC	1292
	LS	Pentacosane	56,000	EC	1442
	LS	Unknown	19,000	EC	1457
	LS	Unknown	44,000	EC	1592
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	220	200	1736

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	17	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	10	1.0
106	Copper, Total	15	1.0
107	Lead, Total	21	1.0
109	Nickel, Total	13	1.0
112	Thallium, Total	7.4	1.0
113	Zinc, Total	42	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-016L
Location ID: B-6
CompuChem #: 2004

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/l)	Detection Limit (ug/l)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	10	EC	666
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	220	10	1529

INORGANICS

Compound Number	Compound	Conc. (mg/l)	Detection Limit (mg/l)
	None Detected		

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-028S-A
Location ID: B-6-M
CompuChem #: 2651

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Eicosane	4,800	EC	1424
	LS	Eicosane	80,000	EC	1484
	LS	Heneicosane	270,000	EC	1541
	LS	Pentacosane	12,000	EC	1578
	LS	Pentacosane	38,000	EC	1595
Base/Neutral/ Pesticide	LS	Tricosane	58,000	EC	1374
	LS	Eicosane	72,000	EC	1430
	LS	Pentacosane	84,000	EC	1496
	LS	Pentacosane	96,000	EC	1574
	LS	Tricosane	96,000	EC	1674

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	32	1.0
105	Chromium, Total	13	1.0
106	Copper, Total	17	1.0
107	Lead, Total	25	1.0
109	Nickel, Total	11	1.0
112	Thallium, Total	8.8	1.0
113	Zinc, Total	49	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-033S-A
Location ID: B-7-S
CompuChem #: 2686

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Eicosane	1,600	EC	1512
	LS	Heneicosane	7,400	EC	1569
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	4,800	2,000 [1]	1552
	LS	Heneicosane	83,000	EC	1279
	LS	Eicosane	39,000	EC	1237
	LS	Pentacosane	98,000	EC	1323
	LS	Heneicosane	110,000	EC	1372
	LS	Pentacosane	110,000	EC	1427

INORGANICS

INSUFFICIENT SAMPLE MATERIAL AVAILABLE TO PERFORM INORGANICS ANALYSIS.

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[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-034S-B
Location ID: B-8-M
CompuChem #: 2690

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	12,000	EC	1242
Base/Neutral/ Pesticide		None Detected			

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	24	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	8.7	1.0
106	Copper, Total	11	1.0
107	Lead, Total	15	1.0
109	Nickel, Total	9.0	1.0
112	Thallium, Total	9.2	1.0
113	Zinc, Total	28	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-035S-B
Location ID: B-8-S
CompuChem #: 2693

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	1,600	EC	1580
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	260	200	1646

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	27	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	13	1.0
106	Copper, Total	15	1.0
107	Lead, Total	25	1.0
109	Nickel, Total	12	1.0
112	Thallium, Total	6.6	1.0
113	Zinc, Total	52	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-109S-A
Location ID: B-20-M
CompuChem #: 2820

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Tricosane	8,000	EC	1405
	LS	Cyclohexane,Eicosyl-	210	EC	1443
	LS	Eicosane	330	EC	1504
	LS	Heneicosane	2,000	EC	1561
	LS	Unknown	613	EC	1595
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	1,400	400 [1]	1550
	LS	Pentacosane	7,600	EC	1323
	LS	Pentacosane	7,200	EC	1371
	LS	Pentacosane	7,200	EC	1427
	LS	Pentacosane	7,200	EC	1491
	LS	Pentacosane	6,800	EC	1568

INORGANICS

INSUFFICIENT SAMPLE MATERIAL AVAILABLE TO PERFORM INORGANICS ANALYSIS.

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[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ADALYSIS

Malcolm-Pirnie ID#: III-0-109S-B
Location ID: B-20-M
CompuChem #: 2821

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	6,500	EC	863
	LS	Unknown	1,400	EC	1024
	LS	Unknown	5,400	EC	1380
	LS	Unknown	2,200	EC	1442
	LS	Unknown	720	EC	1562
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	680	200	1549
	LS	Pentacosane	11,000	EC	1372
	LS	Pentacosane	13,000	EC	1427
	LS	Unknown	15,000	EC	1570
	LS	Pentacosane	15,000	EC	1662
	LS	Pentacosane	14,000	EC	1772

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-109S-B
Location ID: B-20-M
CompuChem #: 2821

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	35	1.0
104	Cadmium, Total	1.3	1.0
105	Chromium, Total	9.9	1.0
106	Copper, Total	12	1.0
107	Lead, Total	18	1.0
109	Nickel, Total	14	1.0
112	Thallium, Total	13	1.0
113	Zinc, Total	31	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-109S-C
Location ID: B-20-M
CompuChem #: 2822

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Eicosane	1,400	EC	1506
	LS	Heneicosane	6,700	EC	1564
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	8,000	2,000 [1]	1528
	LS	Unknown	780,000	EC	1416
	LS	Unknown	900,000	EC	1478
	LS	Pentatriacontane	940,000	EC	1551
	LS	Pentatriacontane	1,800,000	EC	1638
	LS	Pentatriacontane	740,000	EC	1868

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[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#:	III-0-109S-C
Location ID:	B-20-M
CompuChem #:	2822

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	32	1.0
104	Cadmium, Total	1.8	1.0
105	Chromium, Total	12	1.0
106	Copper, Total	15	1.0
107	Lead, Total	21	1.0
109	Nickel, Total	15	1.0
112	Thallium, Total	17	1.0
113	Zinc, Total	38	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-107S-B
Location ID: B-20-N
CompuChem #: 2818

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	180	EC	641
	LS	Unknown	160	EC	1377
	LS	Eicosane	300	EC	1501
	LS	heneicosane	1,260	EC	1559
	LS	Pentatriacontane	560	EC	1596
Base/Neutral/ Pesticide	LS	Pentacosane	20,000	EC	1567
	LS	Unknown	120	EC	1677
	LS	Unknown	21,000	EC	1770
	LS	Pentane,2,2,3,3-Tetramethyl-	21,000	EC	1908
	LS	Pentacosane	19,000	EC	2072

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	43	1.0
104	Cadmium, Total	2.2	1.0
105	Chromium, Total	16	1.0
106	Copper, Total	22	1.0
107	Lead, Total	21	1.0
109	Nickel, Total	16	1.0
112	Thallium, Total	13	1.0
113	Zinc, Total	42	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-108S-A
Location ID: B-20-S
CompuChem #: 2819

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	LS	2-Propanone	6,500	EC	149
	LS	Unknown	5,600	EC	388
Acid	LS	Unknown	960	EC	1256
	LS	Unknown	530	EC	1380
	LS	Pentacosane	1,300	EC	1445
	LS	Eicosane	6,300	EC	1505
	LS	Heneicosane	16,000	EC	1565
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	1,100	4,000 [1]	1493
	LS	Heneicosane	36,000	EC	1249
	LS	Pentacosane	32,000	EC	1290
	LS	Pentacosane	57,000	EC	1511
	LS	Pentacosane	68,000	EC	1593
	LS	Pentacosane	67,000	EC	1694

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-108S-A
Location ID: B-20-S
CompuChem #: 2819

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	22	1.0
104	Cadmium, Total	1.3	1.0
105	Chromium, Total	9.5	1.0
106	Copper, Total	9.9	1.0
107	Lead, Total	15	1.0
109	Nickel, Total	10	1.0
112	Thallium, Total	14	1.0
113	Zinc, Total	28	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-072S-C
Location ID: C-1-M
CompuChem #: 3018

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Cyclotrisiloxane, Hexamethyl-	1,160	EC	526
	LS	Cyclotetrasiloxane, Octamethyl-	770	EC	720
	LS	Unknown	400	EC	1554
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	400	200	1646
	LS	Unknown	200	EC	1443
	LS	Unknown	180	EC	1487
	LS	Unknown	140	EC	1587
	LS	Unknown	220	EC	1646
	LS	Unknown	120	EC	1881

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-072S-C
Location ID: C-1-M
CompuChem #: 3018

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	34	1.0
104	Cadmium, Total	1.2	1.0
105	Chromium, Total	10	1.0
106	Copper, Total	15	1.0
107	Lead, Total	23	1.0
109	Nickel, Total	12	1.0
112	Thallium, Total	16	1.0
113	Zinc, Total	68	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-075S-B
Location ID: C-2-E
CompuChem #: 3024

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	222	Methylene Chloride	2,100	2,000	152
Acid	LS	Unknown	1,900	EC	709
	LS	Unknown	740	EC	872
	LS	Unknown	181	EC	1380
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	260	200	1731

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	13	1.0
105	Chromium, Total	5.1	1.0
106	Copper, Total	7.7	1.0
107	Lead, Total	12	1.0
109	Nickel, Total	5.5	1.0
112	Thallium, Total	6.8	1.0
113	Zinc, Total	21	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-073S-A
Location ID: C-2-W
CompuChem #: 3019

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	2,000	EC	1458
	LS	Unknown	3,400	EC	1570
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	5,300	200	1525

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	30	1.0
104	Cadmium, Total	2.4	1.0
105	Chromium, Total	9.9	1.0
106	Copper, Total	20	1.0
107	Lead, Total	20	1.0
112	Thallium, Total	8.6	1.0
113	Zinc, Total	35	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-074S-A
Location ID: C-2-W_2
CompuChem #: 3020

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Cyclotrisiloxane, Hexamethyl-	600	EC	523
	LS	Cyclotetrasiloxane, Octamethyl-	280	EC	719
	LS	Eicosane	1,000	EC	1505
	LS	Unknown	160	EC	1549
	LS	Heneicosane	7,400	EC	1563
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	600	200	1551
	429	Di-N-Octyl Phthalate	1,800	200	1730
	LS	Tricosane	26,000	EC	1374
	LS	Pentacosane	30,000	EC	1430
	LS	Pentacosane	36,000	EC	1494
	LS	Pentacosane	34,000	EC	1570
	LS	Pentacosane	30,000	EC	1662

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-074S-A
Location ID: C-2-W_2
CompuChem #: 3020

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	21	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	5.8	1.0
106	Copper, Total	14	1.0
107	Lead, Total	17	1.0
109	Nickel, Total	7.4	1.0
112	Thallium, Total	8.4	1.0
113	Zinc, Total	36	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-027L
Location ID: C-3W
CompuChem #: 2060

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/l)	Detection Limit (ug/l)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	10	EC	1408
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	330	10	1524

INORGANICS

Compound Number	Compound	Conc. (mg/l)	Detection Limit (mg/l)
	None Detected		

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-090S-C
Location ID: C-7-E
CompuChem #: 2879

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid		None Detected			
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	260	200	1648
	LS	Tricosane	340	EC	1336
	LS	Pentacosane	460	EC	1386
	LS	Pentacosane	560	EC	1443
	LS	Pentacosane	400	EC	1510
	LS	Unknown	350	EC	1590

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	30	1.0
104	Cadmium, Total	1.4	1.0
105	Chromium, Total	9.2	1.0
106	Copper, Total	16	1.0
107	Lead, Total	22	1.0
109	Nickel, Total	10	1.0
112	Thallium, Total	12	1.0
113	Zinc, Total	33	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-091S-A
Location ID: C-7-M
CompuChem #: 2850

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	320	EC	1372
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	360	200	1555

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	170	1.0
104	Cadmium, Total	1.9	1.0
105	Chromium, Total	13	1.0
106	Copper, Total	18	1.0
107	Lead, Total	23	1.0
109	Nickel, Total	13	1.0
112	Thallium, Total	15	1.0
113	Zinc, Total	98	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-091S-B
Location ID: C-7-M
CompuChem #: 2851

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Pentacosane	3,200	EC	1470
	LS	Unknown	550	EC	1477
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	220	200	1730
	LS	Pentacosane	380	EC	1493
	LS	Unknown	440	EC	1660
	LS	Unknown	360	EC	1675
	LS	Eicosane	340	EC	1906
	LS	Unknown	420	EC	2276

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	160	1.0
104	Cadmium, Total	1.9	1.0
105	Chromium, Total	12	1.0
106	Copper, Total	17	1.0
107	Lead, Total	25	1.0
109	Nickel, Total	14	1.0
112	Thallium, Total	15	1.0
113	Zinc, Total	71	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-093S-B
Location ID: C-8-E
CompuChem #: 2857

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	1,600	EC	1335
	LS	Unknown	720	EC	1348
	LS	Pentatriacontane	3,400	EC	1366
	LS	Unknown	940	EC	1564
	LS	Unknown	2,400	EC	1574
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	5,300	200	1494
	LS	Unknown	2,400	EC	1024

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	23	1.0
104	Cadmium, Total	1.8	1.0
105	Chromium, Total	10	1.0
106	Copper, Total	18	1.0
107	Lead, Total	18	1.0
109	Nickel	12	1.0
112	Thallium, Total	13	1.0
113	Zinc, Total	34	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-096S-C
Location ID: C-9-E
CompuChem #: 2837

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	130	EC	625
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	460	200	1738
	LS	Unknown	320	EC	643
	LS	Unknown	240	EC	1504
	LS	Unknown	540	EC	1553
	LS	Unknown	280	EC	1885
	LS	Unknown	580	EC	2013

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	30	1.0
105	Chromium, Total	12	1.0
106	Copper, Total	16	1.0
107	Lead, Total	20	1.0
109	Nickel, Total	12	1.0
112	Thallium, Total	5.3	1.0
113	Zinc, Total	36	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-097S-A
Location ID: C-9-M
CompuChem #: 2838

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Eicosane	440	EC	1525
	LS	Unknown	340	EC	1538
	LS	Unknown	340	EC	1545
	LS	Unknown	1,480	EC	1567
	LS	Unknown	560	EC	1571
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	320	200	1731
	LS	Pentacosane	380	EC	1429
	LS	Pentacosane	680	EC	1493
	LS	Unknown	360	EC	1546
	LS	Pentacosane	420	EC	1569
	LS	Unknown	440	EC	1661

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-097S-A
Location ID: C-9-M
CompuChem #: 2838

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	22	1.0
105	Chromium, Total	7.5	1.0
106	Copper, Total	12	1.0
107	Lead, Total	16	1.0
109	Nickel, Total	8.1	1.0
112	Thallium, Total	13	1.0
113	Zinc, Total	100	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-099S-A
Location ID: C-10-E
CompuChem #: 2844

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Phenanthrene	450	EC	1394
	LS	Unknown	330	EC	1485
	LS	Heneicosane	1,400	EC	1542
	LS	Fluoranthene	450	EC	1572
	LS	Pentacosane	3,600	EC	1596
Base/Neutral/ Pesticide	LS	Tricosane	10,000	EC	1431
	LS	Tricosane	12,000	EC	1496
	LS	Heptacosane	13,000	EC	1665
	LS	Pentacosane	13,000	EC	1776
	LS	Pentacosane	12,000	EC	1913

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-099S-A
Location ID: C-10-E
CompuChem #: 2844

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	13	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	4.5	1.0
106	Copper, Total	8.4	1.0
107	Lead, Total	14	1.0
109	Nickel, Total	4.1	1.0
112	Thallium, Total	3.8	1.0
113	Zinc, Total	68	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-103S-B
Location ID: C-11-M
CompuChem #: 2830

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	LS	1,4-Dioxane	5,300	EC	388
Acid	LS	Pentatriacontane	17,000	EC	1350
	LS	Unknown	2,000	EC	1547
	LS	Unknown	2,700	EC	1561
	LS	Unknown	3,500	EC	1585
	LS	Unknown	2,100	EC	1530
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	2,600	4,000 [1]	1548
	LS	2-Pentanone,4-Hydroxy-4-Methyl-	10,000	EC	516
	LS	Eicosane	6,000	EC	1426
	LS	Eicosane	7,600	EC	1490
	LS	Eicosane	7,200	EC	1566
	LS	Pentacosane	6,400	EC	1657

[1] Sample extract could not be concentrated to 0.5 ml, thus the detection limits are higher than normal.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-103S-B
Location ID: C-11-M
CompuChem #: 2830

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	27	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	14	1.0
106	Copper, Total	16	1.0
107	Lead, Total	22	1.0
109	Nickel, Total	12	1.0
112	Thallium, Total	5.6	1.0
113	Zinc, Total	62	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-104S-B
Location ID: C-12-W
CompuChem #: 2833

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	LS	2-Propanone	390	EC	151
Acid	LS	Pentatriacontane	6,000	EC	1372
	LS	Tridecane,2-Methyl-	3,800	EC	1383
	LS	Unknown	12,600	EC	1401
	LS	Heneicosane	1,620	EC	1567
	LS	Unknown	1,600	EC	1572
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	200	200	1731
	LS	Pentacosane	920	EC	1373
	LS	Pentacosane	1,100	EC	876
	LS	Pentacosane	1,200	EC	1493
	LS	Pentacosane	1,000	EC	1569
	LS	Eicosane	840	EC	1661

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-O-104S-B
Location ID: C-12-W
CompuChem #: 2833

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	25	1.0
104	Cadmium, Total	1.1	1.0
105	Chromium, Total	11	1.0
106	Copper, Total	17	1.0
107	Lead, Total	16	1.0
109	Nickel, Total	12	1.0
112	Thallium, Total	12	1.0
113	Zinc, Total	36	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-002S-C
Location ID: D-1-M
CompuChem #: 2547

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid		None Detected			
Base/Neutral/ Pesticide	LS	Pentacosane	8,400	EC	1567
	LS	Pentacosane	9,600	EC	1659
	LS	Pentacosane	10,000	EC	1770
	LS	Pentacosane	9,800	EC	1905
	LS	Pentacosane	7,400	EC	2069

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	40	1.0
104	Cadmium, Total	1.2	1.0
105	Chromium, Total	13	1.0
106	Copper, Total	18	1.0
107	Lead, Total	18	1.0
109	Nickel, Total	15	1.0
112	Thallium, Total	6.9	1.0
113	Zinc, Total	42	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-003S-B
Location ID: D-1-N
CompuChem #: 2549

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Pentacosane	580	EC	1329
	LS	Tricosane	2,000	EC	1513
Base/Neutral/ Pesticide	LS	Unknown	380	EC	1291
	LS	Pentacosane	260	EC	1489
	LS	Unknown	260	EC	1655
	LS	Pentacosane	400	EC	1765
	LS	Eicosane	240	EC	1900

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	37	1.0
104	Cadmium, Total	2.2	1.0
105	Chromium, Total	13	1.0
106	Copper, Total	14	1.0
107	Lead, Total	20	1.0
109	Nickel, Total	14	1.0
112	Thallium, Total	15	1.0
113	Zinc, Total	69	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-010S-C
Location ID: D-4-S
CompuChem #: 2481

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	180	EC	1261
	LS	Unknown	100	EC	1273
	LS	Pentacosane	680	EC	1303
	LS	Unknown	200	EC	1378
	LS	Unknown	200	EC	1549
Base/Neutral/ Pesticide		None Detected			

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	7.2	1.0
105	Chromium, Total	8.5	1.0
106	Copper, Total	11	1.0
107	Lead, Total	9.4	1.0
109	Nickel, Total	8.1	1.0
112	Thallium, Total	8.5	1.0
113	Zinc, Total	38	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-041S-A
Location ID: D-6-M
CompuChem #: 2672

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	2,200	EC	1271
	LS	Pentacosane	420	EC	1435
	LS	Pentacosane	9,200	EC	1572
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	1,700	200	1490

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	14	1.0
105	Chromium, Total	6.0	1.0
106	Copper, Total	9.9	1.0
107	Lead, Total	13	1.0
109	Nickel, Total	6.8	1.0
112	Thallium, Total	11	1.0
113	Zinc, Total	23	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-041S-C
Location ID: D-6-M
CompuChem #: 2674

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Pentacosane	4,300	EC	1119
	LS	Pentacosane	4,600	EC	1444
	LS	Pentacosane	18,000	EC	1470
	LS	Pentacosane	14,000	EC	1482
Base/Neutral/ Pesticide	LS	Pentacosane	2,400	EC	1493
	LS	Pentacosane	2,800	EC	1569
	LS	Eicosane	2,600	EC	1660
	LS	Eicosane	2,400	EC	1770
	LS	Pentacosane	2,000	EC	1905

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	29	1.0
105	Chromium, Total	13	1.0
106	Copper, Total	17	1.0
107	Lead, Total	17	1.0
109	Nickel, Total	11	1.0
112	Thallium, Total	9.1	1.0
113	Zinc, Total	42	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-042S-A
Location ID: D-6-N
CompuChem #: 2675

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	LS	1,4-Dioxane	20,000	EC	384
Acid	LS	Pentacosane	72,000	EC	1254
	LS	Pentacosane	40,000	EC	1332
	LS	Heneicosane,1-Cyclopentyl-	15,000	EC	1383
	LS	Pentacosane	20,000	EC	1444
	LS	Cyclohexane,Eicosyl-	56,000	EC	1508
Base/Neutral/ Pesticide	413	BIS (2-Ethylhexyl) Phthalate	220	200	1491
	LS	Unknown	220	EC	1688

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	20	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	11	1.0
106	Copper, Total	17	1.0
107	Lead, Total	13	1.0
109	Nickel, Total	10	1.0
112	Thallium, Total	6.3	1.0
113	Zinc, Total	35	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-042S-C
Location ID: D-6-N
CompuChem #: 2677

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	1,300	EC	1583
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	520	200	1722
	LS	Unknown	540	EC	1537
	LS	Unknown	320	EC	1640
	LS	Unknown	2,800	EC	1772
	LS	Unknown	340	EC	1868
	LS	Unknown	780	EC	1995

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	33	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	8.9	1.0
106	Copper, Total	16	1.0
107	Lead, Total	15	1.0
109	Nickel, Total	12	1.0
112	Thallium, Total	13	1.0
113	Zinc, Total	73	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-044S-A
Location ID: D-7-M
CompuChem #: 2630

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	LS	1,4-Dioxane	5,100	EC	388
Acid	LS	Unknown	1,100	EC	1379
Base/Neutral/ Pesticide	LS	Unknown	3,600	EC	1364
	LS	Unknown	2,800	EC	1399
	LS	Unknown	4,400	EC	1410
	LS	Unknown	2,700	EC	1444

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	13	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	36	1.0
106	Copper, Total	20	1.0
107	Lead, Total	49	1.0
109	Nickel, Total	5.3	1.0
112	Thallium, Total	4.3	1.0
113	Zinc, Total	110	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-043S-B
Location ID: D-7-N
CompuChem #: 2628

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Pentacosane	520	EC	1470
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	320	200	1646

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	31	1.0
104	Cadmium, Total	1.2	1.0
105	Chromium, Total	8.8	1.0
106	Copper, Total	18	1.0
107	Lead, Total	20	1.0
109	Nickel, Total	9.5	1.0
112	Thallium, Total	12	1.0
113	Zinc, Total	32	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-046S-A
Location ID: D-7-S_2
CompuChem #: 2800

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	1,800	EC	1562
Base/Neutral/ Pesticide	LS	Pentacosane	260,000	EC	1372
	LS	Pentacosane	300,000	EC	1427
	LS	Pentacosane	370,000	EC	1568
	LS	Unknown	370,000	EC	1662
	LS	Pentacosane	330,000	EC	1774

INORGANICS

INSUFFICIENT SAMPLE MATERIAL AVAILABLE TO PERFORM INORGANICS ANALYSIS.

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-051S-A
Location ID: D-9-N
CompuChem #: 2782

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Benzene,1-Chloro-2-Methyl-	250	EC	675
	LS	Naphthalene,1-Chloro-	320	EC	1096
	LS	Unknown	260	EC	1239
	LS	Unknown	160	EC	1350
	LS	Unknown	340	EC	1358
Base/Neutral/ Pesticide	416	2-Chloronaphthalene	340	200	916
	429	Di-N-Octyl Phthalate	360	200	1646
	LS	Unknown	220	EC	1587
	LS	Pentacosane	250	EC	1683
	LS	Pentacosane	350	EC	1799
	LS	Pentacosane	340	EC	1940
	LS	Pentacosane	350	EC	2114

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-051S-A
Location ID: D-9-N
CompuChem #: 2782

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	32	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	13	1.0
106	Copper, Total	18	1.0
107	Lead, Total	17	1.0
109	Nickel, Total	12	1.0
112	Thallium, Total	22	1.0
113	Zinc, Total	42	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-052S-C
Location ID: D-9-S
CompuChem #: 2787

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile	222	Methylene Chloride	5,900	2,000	151
Acid		None Detected			
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	260	200	1648
	LS	Unknown	1,200	EC	848
	LS	Unknown	1,100	EC	952
	LS	Unknown	900	EC	1116
	LS	Unknown	620	EC	1162
	LS	Unknown	1,400	EC	1292

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	13	1.0
105	Chromium, Total	3.5	1.0
106	Copper, Total	8.4	1.0
107	Lead, Total	9.6	1.0
109	Nickel, Total	4.7	1.0
112	Thallium, Total	4.0	1.0
113	Zinc, Total	17	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-053S-C
Location ID: D-10-M
CompuChem #: 2790

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid		None Detected			
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	500	200	1649
	LS	Unknown	480	EC	1489
	LS	Unknown	280	EC	1579
	LS	Unknown	260	EC	1774
	LS	Unknown	640	EC	1884
	LS	Unknown	300	EC	2216

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	17	1.0
105	Chromium, Total	4.8	1.0
106	Copper, Total	13	1.0
107	Lead, Total	12	1.0
109	Nickel, Total	6.8	1.0
112	Thallium, Total	6.2	1.0
113	Zinc, Total	26	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-066S-A
Location ID: U-4-M
CompuChem #: 2951

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid	LS	Unknown	400	EC	512
	LS	Cyclotrisiloxane, Hexamethyl-	420	EC	523
	LS	Unknown	280	EC	533
	LS	Cyclotetrasiloxane, Octamethyl-	460	EC	719
	LS	Unknown	110	EC	873
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	600	200	1731
	LS	Unknown	600	EC	1546
	LS	Unknown	360	EC	1650
	LS	Unknown	400	EC	1877
	LS	Unknown	920	EC	2005
	LS	Unknown	400	EC	2399

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-066S-A
Location ID: U-4-M
CompuChem #: 2951

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	35	1.0
105	Chromium, Total	8.6	1.0
106	Copper, Total	14	1.0
107	Lead, Total	20	1.0
109	Nickel, Total	9.8	1.0
112	Thallium, Total	5.8	1.0
113	Zinc, Total	34	1.0

MALCOLM-PIRNIE
SUMMARY OF ANALYSIS

Malcolm-Pirnie ID#: III-0-066S-B
Location ID: U-4-M
CompuChem #: 2952

ORGANICS

Fraction	Compound Number	Compound	Conc. (ug/kg)	Detection Limit (ug/kg)	Scan Number
Volatile		None Detected			
Acid		None Detected			
Base/Neutral/ Pesticide	429	Di-N-Octyl Phthalate	240	200	1731
	LS	Unknown	200	EC	1534
	LS	Unknown	200	EC	1546

INORGANICS

Compound Number	Compound	Conc. (ug/g)	Detection Limit (ug/g)
102	Arsenic, Total	34	1.0
104	Cadmium, Total	1.0	1.0
105	Chromium, Total	7.6	1.0
106	Copper, Total	15	1.0
107	Lead, Total	17	1.0
109	Nickel, Total	10	1.0
112	Thallium, Total	9.7	1.0
113	Zinc, Total	32	1.0

APPENDIX B
REFERENCES

APPENDIX B

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"B" - Fred Hart Associates Report-Ground Water Contamation

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