LOVE CANAL REMEDIAL PROJECT

BOREHOLE INVESTIGATION

VOLUME I: TEXT

OCTOBER 1983

FINAL REPORT

prepared by
E.C. JORDAN CO.
for
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF SOLID WASTE
ALBANY, NEW YORK

E.C. JORDAN CO.
CONSULTING ENGINEERS

4166-05
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October 21, 1983

Mr. Norman H. Nosenchuck, P.E.
Director
Department of Environmental Conservation
Division of Solid Waste
50 Wolf Road
Albany, New York 12233-001

Dear Mr. Nosenchuck:

Subject: Final Report
Love Canal Remedial Project; Task V
Borehole Investigation, Task VA

Enclosed are ten copies of the revised final report on the Borehole Investigation, Task V-A of the Love Canal Remedial Project. Review comments provided by Mr. Joseph Slack, P.E., were incorporated.

The objectives of the borehole investigation have been fulfilled and the results are reported herein. The results include information on the geologic setting and the distribution of chemicals in the vicinity of the proposed wall alignment.

Laboratory protocols followed and chemicals found in the selected soil samples are reported. Assessment of the geologic and chemical data indicates that New York State Department of Environmental Conservation should consider limiting the depth of the proposed wall in certain areas. The proposed wall location should be reviewed in areas where chemicals have been found in the soil at levels greater than water quality criteria. Several chemicals were also detected for which no numerical standards have been developed by the Environmental Protection Agency or New York State. Chemicals found along the proposed alignment do not exceed OSHA standards but precautions are recommended for construction workers to avoid contact with the skin and eyes and inhalation of airborne chemicals resulting from construction activities.

Very truly yours,

E.C. JORDAN CO.

E. James Hamilton

E.James Hamilton, P.E.
Project Manager

EJH:jrg

cc: J. Slack, P.E., NYSDEC
W. Coakley, EPA Region II, w/enclosure

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LOVE CANAL REMEDIAL PROJECT

TASK V-A
BOREHOLE INVESTIGATION
VOLUME I-TEXT

by

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Portland, Maine 04112

October 1983

Project Manager

Norman H. Nosenchuck, P.E.
Department of Environmental Conservation
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Albany, New York 12233-0001

DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF SOLID WASTE
ALBANY, NEW YORK 12233-0001

PREFACE

The New York State Department of Environmental Conservation and the U.S. Environmental Protection Agency have undertaken a cooperative project to identify and implement measures to remedy problems caused by disposal of hazardous wastes at the Love Canal Site in Niagara Falls, New York. The Love Canal Remedial Project consists of the following tasks:

I. Expanded Leachate Collection System and Other Containment Options;

II. North End Storm and Sanitary Sewers;

III. Black and Bergholtz Creek;

IV. South End Sewers;

V. Long-Term Monitoring Program;

VI. Delta Area Remediation; and

VII. Lift Stations and Sanitary Sewers West of Site.

Task I includes the construction of a containment or cutoff wall in addition to other modifications to contain the chemicals in Love Canal and to reduce the operating costs of the existing treatment plant by reducing the volume of groundwater collected by the barrier drain. Task V-A consisted of a borehole investigation to explore the subsurface chemical conditions along the alignment of the proposed cutoff wall. The purpose of this report is to provide the NYSDEC with detailed information on the chemicals and soil types found along the proposed wall alignment obtained during Task V-A. Task V-B is to design a monitoring plan to measure the effectiveness of the remedial actions already installed or to be installed pending the results of Task II, III, IV VI and VII. Task V-C is to implement the monitoring plan.

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SECTION 1

INTRODUCTION

1.1 PROPOSED WALL CONSTRUCTION

In accordance with its cooperative agreement with the U.S. Environmental Protection Agency (EPA), the New York State Department of Environmental Conservation (NYSDEC) has initiated the construction of a containment system around the Love Canal chemical waste repository. The proposed location, configuration, and details of the containment system are described in Volumes I and II of the Contract Documents for the Construction of the Site Containment System (CH2M Hill, 1982). The proposed system is to consist of an approximately 15-foot (4.6 m) deep, 2-foot (0.6 m) thick unreinforced concrete wall, extending into the soft clay which underlies the site. Construction of the cutoff wall at the utility crossing locations was started in December 1982 and completed in March 1983.

The principal purpose of the proposed containment system is to reduce inflow of groundwater and surface water to the existing leachate collection (barrier drain) and treatment system. The presence of sporadic zones of coarser-grained soils, fill materials and desiccated clay zones within 8 to 12 feet (2.4 to 3.7 m) of the surface provides avenues for groundwater seepage into the collector system. The soft lacustrine clay deposits into which the concrete wall is to be keyed and the underlying glacial till is presumed to provide adequate hydraulic protection for the collector system.

Previous exploration by USEPA, NYSDEC and other investigators have indicated that there are two groundwater regimes underlying the Love Canal area which are of particular relevance to the Love Canal containment and leachate collection system: 1) a confined aquifer of significant magnitude within the fractured upper 20 feet (6.1 m) of the bedrock (Lockport Dolomite); and 2) the near-surface groundwater regime which consists of a complex and seasonably variable combination of natural and man-made pathways for groundwater infiltration and migration. It is the latter, near-surface groundwater regime that is of particular concern in addressing the appropriateness of the proposed location of the wall and considerations of health and safety during its construction. The concerns which arise with regard to wall location and construction are as follows: 1) have hazardous materials migrated from the canal to areas or zones outside the proposed wall; and 2) are there chemical or physical conditions present within the required excavations which, through exposure or contact, pose a threat to the construction personnel?

1.1.1 Proposed Wall Alignment

The fenced area enclosing Love Canal (designated the "Canal Area") is bounded by Colvin Boulevard on the north, Frontier Avenue to the south, 95th and 96th Streets to the west and 100th Street to the east (Figure 1). The alignment of the proposed wall is within the fenced area on the north, east and western perimeter and extends beyond the fenced enclosure to the south along Frontier Avenue. The alignment of the proposed wall was marked in the field by NYSDEC by staking all corners and turning points. These markings were used to establish the borehole locations.

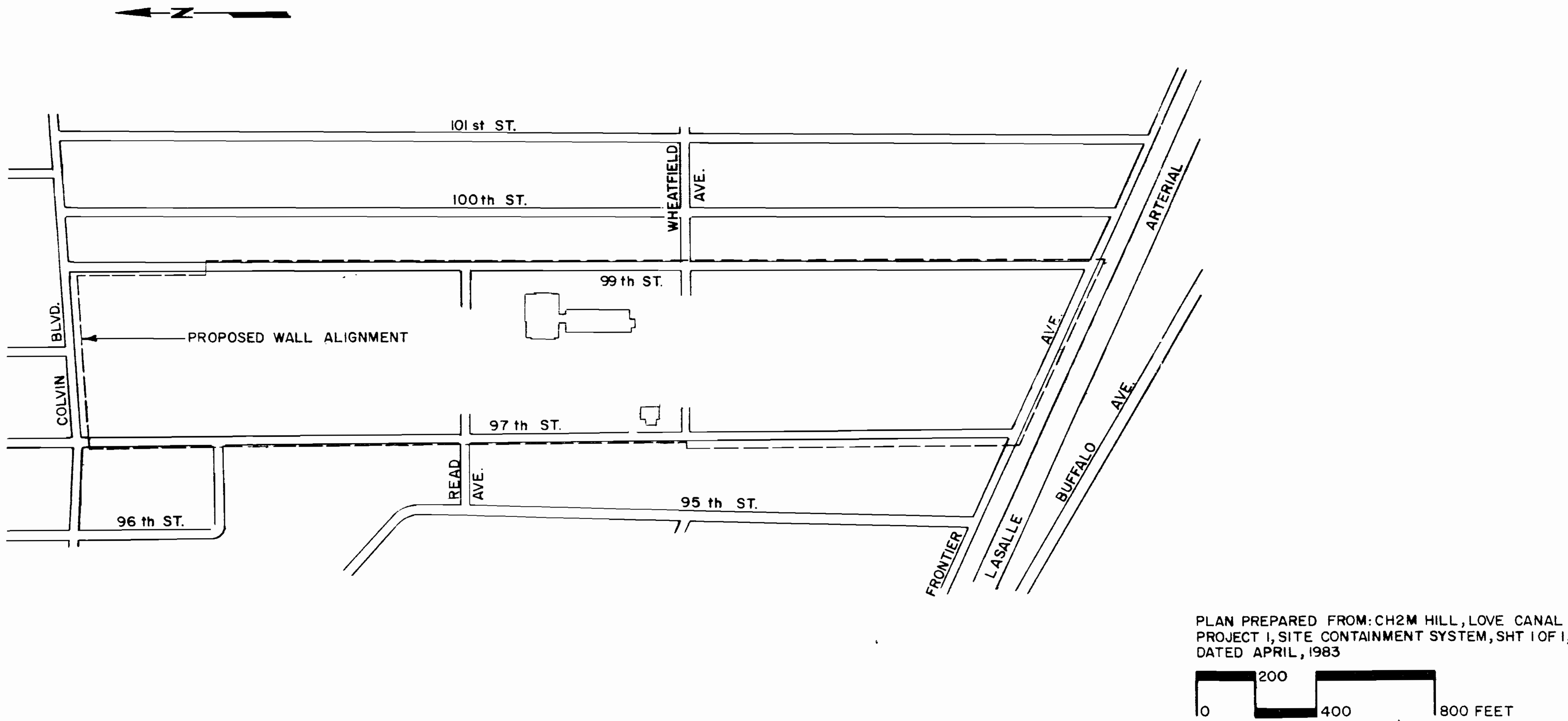

Figure 1
Proposed Wall Alignment
Love Canal Remedial Project (Task V-A)

1.1.2 Field Facilities

A field office was established at 1004 98th Street. Occupancy was established March 18, 1983, after the previous occupant vacated. This office, obtained through the Urban Development Corporation, served as the field headquarters. The office building served as a field laboratory for Flame Ionization Detector (FID) gas chromatography (GC) analysis and as temporary sample storage for the duration of field activities. Storage of soil record samples during the field investigation was provided in a secured garage at 9712 Colvin Boulevard.

A decontamination trailer was maintained onsite and had been used by prior investigators of Love Canal. The trailer was retained for use by field personnel in compliance with the project health and safety plan.

1.2 EXISTING GEOTECHNICAL AND CHEMICAL INFORMATION

Hydrogeologic assessment and chemical assay of the soils in the vicinity of the containment wall at Love Canal have been the subject of previous investigations:

- Borings were conducted on 10 and 20 ft (3.0 and 6.1 m) centers around the perimeter of the canal prior to the construction of the leachate drain system in 1979 (Earth Dimensions, 1979a and 1979b).

- Soil sampling and monitoring well installation were done as part of the EPA environmental monitoring program in 1980 (EPA, 1982).

- Monitoring wells have been installed by the NYSDEC and the New York State Attorney General's office (NYSAG) along the western side of the canal (Earth Dimensions, 1982).

All of these studies provided valuable information concerning the soil properties and stratigraphy. However, only the USEPA study provided chemical assay of the soils. Inferences about the chemicals in soils were, however, made on the basis of data from the groundwater assays in the NYSDEC, USEPA and NYSAG wells.

1.2.1 Hydrogeologic Setting

A preliminary understanding of the hydrogeologic setting at the Love Canal site was prepared based on existing information. Characteristics of each strata are given below. The strata are listed from youngest to oldest:

- Sand and silt fill (highly to moderately permeable)

  3×10^{-4} to 3×10^{1} ft/day (1×10^{-7} to 1×10^{-2} cm/sec)

- Hard silty clay (Lake Tonawanda deposits, marginally permeable)

  3×10^{-4} to 3×10^{-1} ft/day (1×10^{-7} to 1×10^{-4} cm/sec)

- Soft silty clay (glacial Lake Dana deposits, very low permeability)

  3×10^{-5} to 3×10^{-4} ft/day (1×10^{-8} to 1×10^{-7} cm/sec)

- Glacial till (low permeability)

  3×10^{-5} to 3×10^{-4} ft/day (1×10^{-8} to 1×10^{-7} cm/sec) o Lockport dolomite (bedrock, permeable)

$>3 \times 10^{1}$ ft/day ($>1 \times 10^{-2}$ cm/sec)

o Rochester shale (bedrock, low permeability)

$\leq 10^{-4}$ ft/day ($\leq 4 \times 10^{-8}$ cm/sec)

As proposed, the wall is to be keyed into the soft silty clay (Lake Dana deposits) at a depth of approximately 15 feet (4.6 m). The sand and silt fill and the underlying hard silty clay (Lake Tonawanda deposits) provide avenues for groundwater seepage which the wall is intended to block.

1.2.2 Chemical Assay of Soil

The EPA study of the upper 6 feet (1.8 m) of soils near the alignment of the containment wall (Figure 2) provides an understanding of the distribution and quantities of chemicals present. Soil samples were composited from the entire depth of the shallow 6-foot (1.8 m) borings and, therefore, were not likely to indicate the highest concentrations present in the profile. Extractable or semi-volatile (SV) organics, polynuclear aromatic hydrocarbons (PNA's) and pesticides (PEST) were typically found at µg/kg (ppb) levels in the vicinity of the proposed wall. Volatile organics (VOA) were infrequently detected and were present only at low µg/kg levels.

1.2.3 Chemical Assay of Groundwater

A wider variety of both volatile and extractable organic chemicals were found in the groundwater samples (Figure 3) than in the soil samples (EPA, 1982).

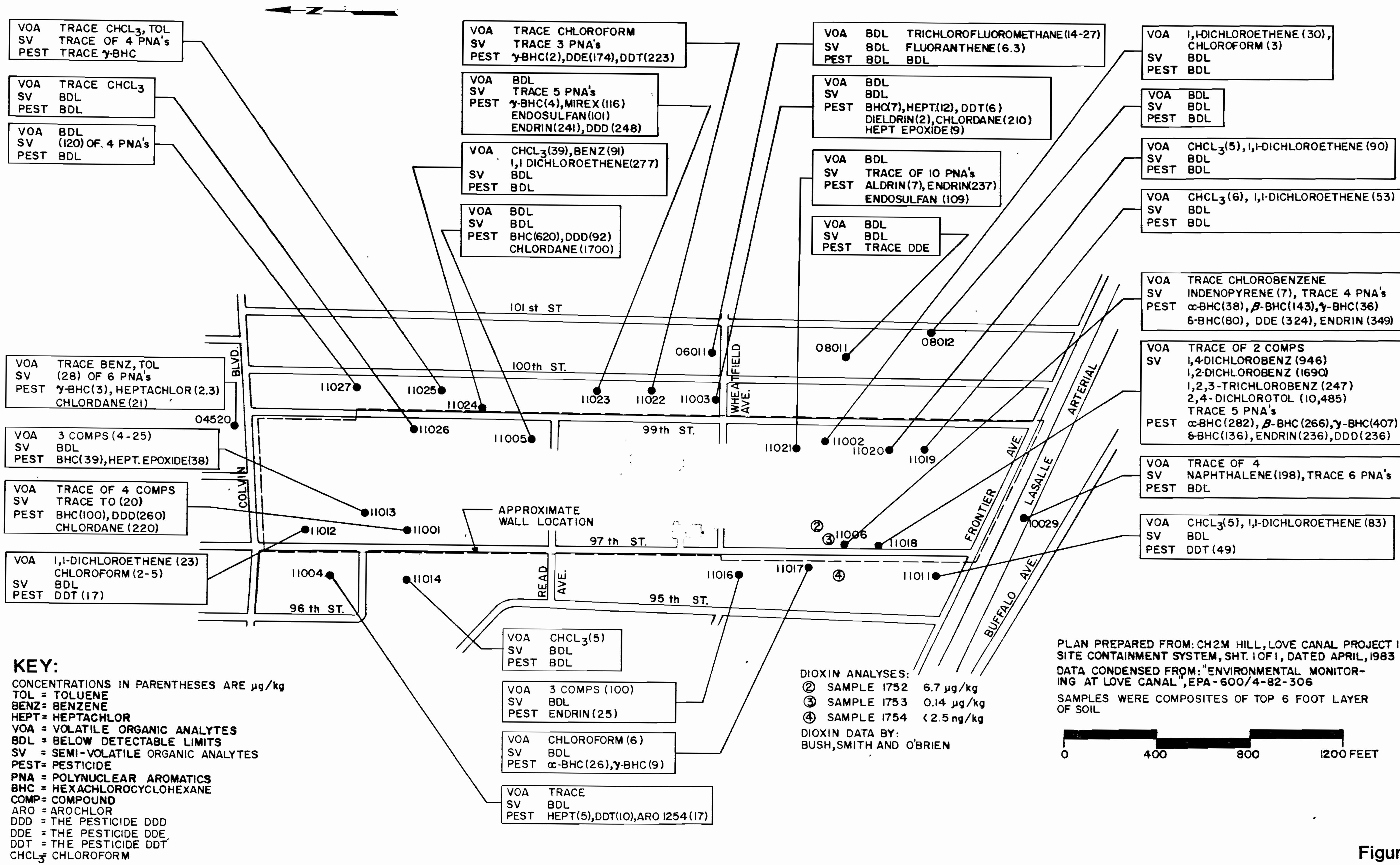

Figure 2

Summary of chemicals in soil near proposed wall through 1982

Love Canal Remedial Project (Task V-A)

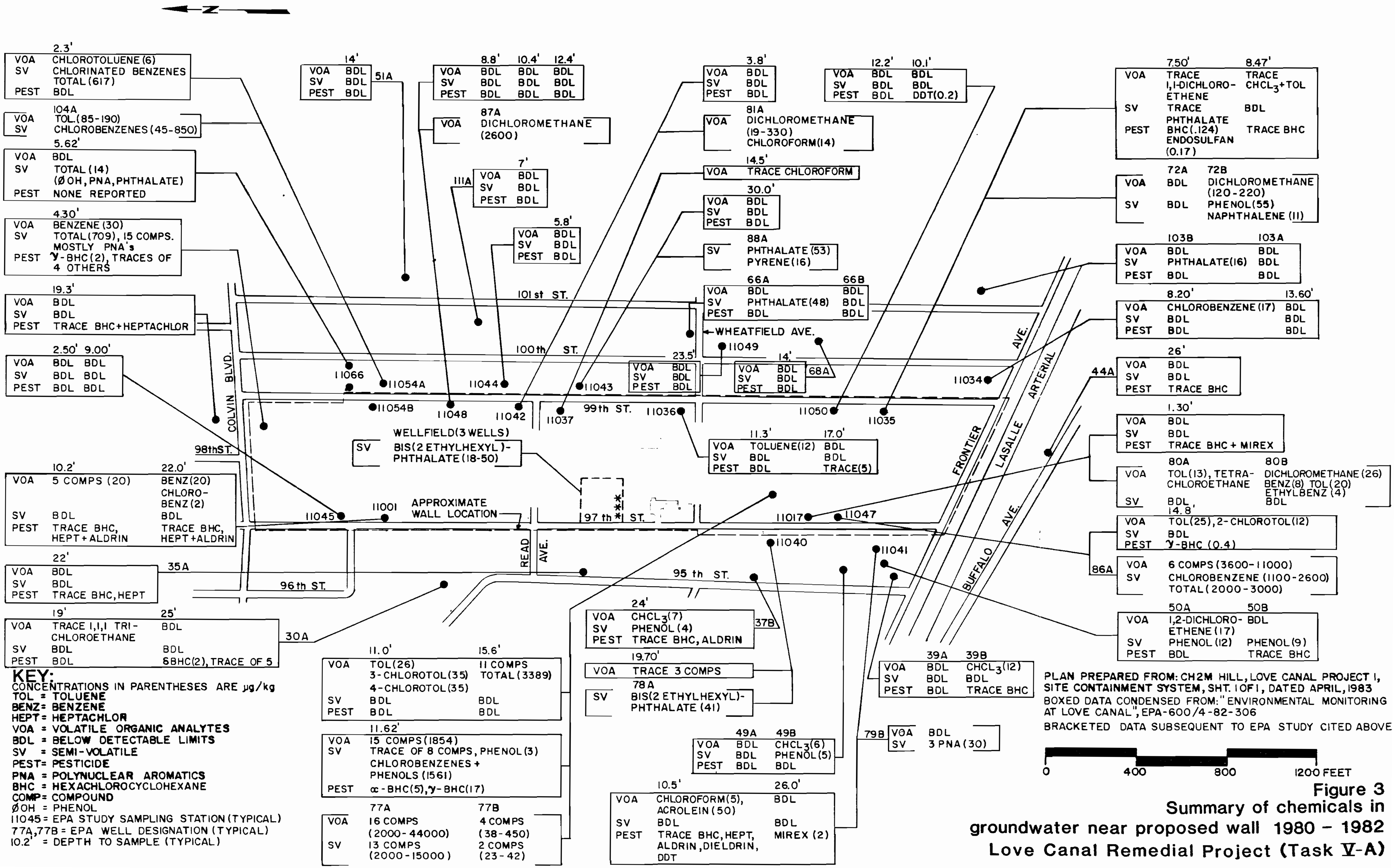

Figure 3
Summary of chemicals in groundwater near proposed wall 1980 – 1982
Love Canal Remedial Project (Task V-A)

Confidential data collected by NYSDEC and NYSAG in anticipation of litigation were not available to supplement the USEPA information. In general, the groundwater regime to the east of Love Canal appears to contain very few organic compounds. Those that were present were in concentrations of a few µg/l (ppb). The variety and concentrations of chemicals in the groundwater appeared to be greater in the area to the west of the canal. The regional flow of groundwater in the vicinity of Love Canal is toward the southwest (EPA, 1982).

1.2.4 Proposed Wall Design

The contract documents for the construction of the site containment system (Love Canal Remedial Project, Task I) were prepared under contract to the NYSDEC and were published in August 1982 (CH2M Hill, 1982). The contract documents consist of two volumes: Volume 1, Specifications; and Volume 2, Drawings. The drawings were used to select locations for boreholes with respect to the proposed wall alignment and the in-place utilities.

1.3 TASK V-A WORK OBJECTIVES

The principal work objective of the borehole investigation was to obtain soil samples along the proposed wall alignment. Examination of these samples was intended to provide a detailed understanding of the geology along the proposed wall line to a depth slightly below the proposed wall depth of 15 feet (4.6 m). Samples showing the greatest indications of chemical presence or greatest potential for chemical migration were selected for further screening from among carefully collected sets of specimen vials at each 2-foot (0.6 m) depth increment. On the basis of visual examination and chemical screenings by means of photo-ionization measurements and FID GC analyses for volatile organics, selected specimens were analyzed by GC-MS methods for extractable organic priority pollutants. Some of the specimens selected were also analyzed by GC-MS methods for volatile organic priority pollutants and dioxin. In addition, where chemicals were detected, contingency holes were drilled (with the concurrence of the NYSDEC) for the purpose of identifying and defining the extent of contamination.

The resultant body of data, compiled and presented in tabular and graphical form are contained in this report. Existing health and safety criteria for detected compounds are also included to allow the NYSDEC to make an informed judgment concerning the appropriateness of the proposed wall alignment and to make any necessary alignment adjustments prior to construction.

SECTION 2

SUMMARY

In accordance with the terms of its Agreement of January 25, 1982 with the State of New York Department of Environmental Conservation, E.C. Jordan Co. has conducted a borehole investigation along the alignment of the proposed cutoff wall at Love Canal in Niagara Falls.

2.1 ACTIVITIES

Under direction and full-time monitoring by E.C. Jordan Co. personnel, fifty-nine continuously sampled hollow-stem auger borings were drilled to depths of 16 to 24 feet (4.9 to 7.3 m) by Empire Soils Investigations, Inc. during the period of March 23 to April 11, 1983. Five hundred and seven 1 3/8-inch diameter split-spoon samples were taken during the advancing of the boreholes. Each sample was examined, scanned with a photoionization meter for detection of volatile organic substances and logged by the field sampling team. Specimens were selected from each sample and secured for laboratory testing and as a physical record. Specimens from each sample were scanned again in the field laboratory with a photoionization meter for volatile organic substances.

Based on the visual examination and chemical scanning, the field sample coordinator selected specimens from two soil samples of each borehole which most likely contained chemicals for further field and laboratory analysis or selected specimens for laboratory analysis from the utility crossings and other locations of particular concern for further field and laboratory analysis. Twenty-two of these specimens, one from each of the seven utility crossings and fifteen from other locations along the proposed wall alignment were shipped to Gulf South Research Institute (GSRI) for volatile and extractable organic priority pollutant analyses. Seventeen of the GSRI specimens were subsequently forwarded to Wright State University (EPA designated laboratory) for dioxin analysis. The remaining specimens were assayed in the field laboratory for volatile organic concentrations using a gas chromatograph equipped with flame ionization detectors. Based on the results of the foregoing procedures 39 specimens were forwarded to the E.C. Jordan Co. laboratory for organic priority pollutant analyses. The results of the field and laboratory measurements and analyses are tabulated in this report and summarized below.

2.2 CONCLUSIONS AND RECOMMENDATIONS

The borehole investigation consisted of the collection and compilation of soil and chemical data from 59 continuously sampled boreholes drilled along the proposed wall alignment and in specified adjacent areas. Five hundred and seven soil samples were examined and 61 assays for volatile and extractable organic priority pollutants were conducted. Seventeen assays for dioxin were also conducted. Interpretation of these data lead to the following conclusions:

1. Special attention should be given to the depth of the proposed wall if its functional effectiveness requires keying into the soft clay. Areas for special attention include the southeast, northwest, and northeast corners of the proposed wall alignment. In these areas, the clay layer is thin, 4 feet (1.2 m), and therefore excavation should be controlled to prevent penetration of the clay layer.

2. The boreholes encountered undisturbed soils and no evidence of chemical deposits indicating that the Love Canal excavation or subsequent chemical waste disposal did not extend to the proposed wall alignment.

3. Organic priority pollutant chemicals are present in the soils along the proposed wall alignment. The levels of nine of these chemicals at eleven locations exceed existing state and/or Federal criteria for groundwater used as a drinking water source. It should be noted that five chemicals detected were phthalates; two exceeded New York State drinking water criteria. Since the phthalates are not known constituents of wastes deposited at Love Canal, the results should be used with caution in determining the appropriateness of the proposed wall alignment.

   The area of greatest concern is the southern portion of the proposed wall alignment. The levels and types of chemicals, the potential for groundwater use and impact and the potential for long-term extraction by the barrier drain system need to be reviewed by NYSDEC to determine if wall relocation is appropriate.

4. The safety and health of construction personnel are not expected to be adversely affected based on comparison of contaminant concentrations found in the borehole soil specimens with current OSHA air quality requirements. Precautions should be taken to avoid contact with the skin and eyes or inhalation of aerosols from soils containing hazardous chemicals.

SECTION 3

FIELD EXPLORATIONS

3.1 LOCATIONS OF BOREHOLES

The original 44 borehole locations (Figure 4) were selected to characterize the alignment of the proposed wall. Although a nominal spacing of 200 feet (61 m) was used, there was a higher density of boreholes across the north and south ends of the canal because of past indications that a greater concentration of chemicals might be found in these areas. Boreholes were also located where the proposed wall alignment crossed utility lines. A greater potential for the presence of chemicals was considered to exist at utility crossings due to the possibly greater permeability of backfilled soil materials in the utility trenches (Monitoring data (EPA, 1982) suggested that the sewers may have served as conduits of chemical transport). An effort was also made to locate boreholes in areas along the east and west sides of the proposed alignment so as to intersect locations of buried swales.

The locations of the original 44 boreholes (Table 1) were established in the field prior to drilling in cooperation with the NYSDEC. Locations for 15 supplemental boreholes (Table 1) were selected on the basis of the field observations and other data and were selected to define areas of suspected contamination. These additional holes were located with the assistance and concurrence of the NYSDEC.

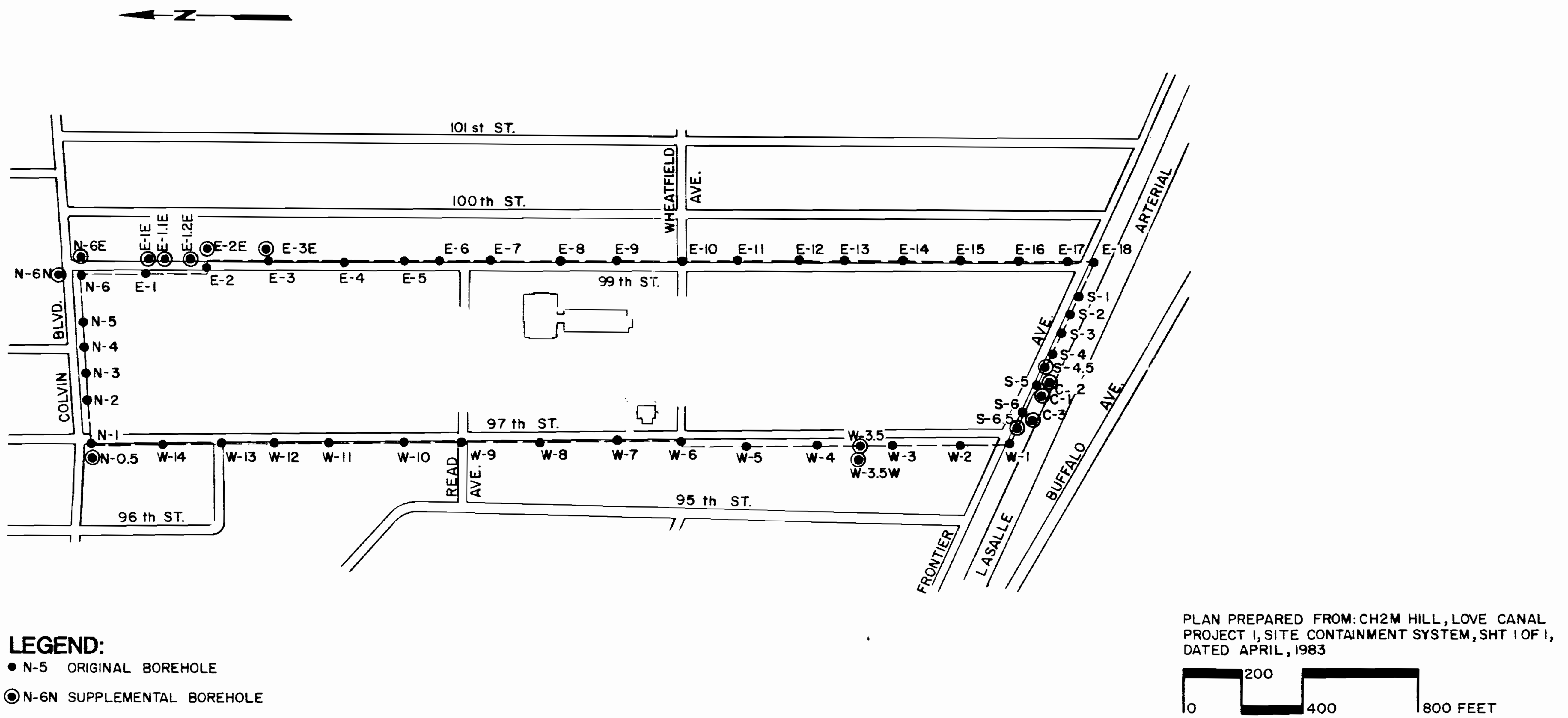

Figure 4
Location of Boreholes
Love Canal Remedial Project (Task V-A)

TABLE 1. BOREHOLE LOCATIONS AND DEPTHS

Line	Borehole	Depth (ft)[a]	Purpose
North	N-0.5[b]	20.0	Lateral transect[c]
	N-1	16.0	Utility crossing
	N-2	16.0	Canal crossing
	N-3	16.0	Canal crossing
	N-4	20.0	Canal crossing
	N-5	16.0	Canal crossing
	N-6	20.0	Past data showed SV in groundwater
	N-6E	16.0	Lateral transect[d]
East	N-6N	16.0	Lateral transect[d]
	E-1	19.4	Line hole
	E-1E	20.0	Lateral transect[c]
	E-1.1E	16.0	Lateral transect[e]
	E-1.2E	16.0	Lateral transect[e]
	E-2	15.0	Utility crossing
	E-2E	16.0	Lateral transect[f]
	E-3	16.0	Line hole; past GW data showed VOA
	E-3E	20.0	Lateral transect[c]
	E-4	16.0	Line hole
	E-5	16.0	Line hole
	E-6	20.0	Line hole
	E-7	16.0	Line hole
	E-8	16.0	Past soils data showed DDT
	E-9	16.0	Line hole
	E-10	16.0	Utility crossing
	E-11	20.0	Line hole
	E-12	16.0	Line hole
	E-13	16.0	Line hole
	E-14	16.7	Line hole
	E-15	16.0	Line hole
	E-16	20.0	Line hole
	E-17	16.0	Line hole
	E-18	16.0	Utility crossing
South	S-1	16.0	Line hole
	S-2	16.0	Canal crossing
	S-3	16.0	Canal crossing
	S-4	16.0	Canal crossing
	S-4.5	16.0	Define contaminant extent[c]
	S-5	20.0	Canal crossing
	S-6	16.0	Line hole
	S-6.5	20.0	Define contaminant extent[c]
	C-1	24.0	Lateral transect[g]
	C-2	24.0	Lateral transect[g]
	C-3	24.0	Lateral transect[g]

TABLE 1 (continued)

Line	Borehole	Depth(ft)[a]	Purpose
West	W-1	16.0	Line hole
	W-2	16.0	Line hole; past soils data showed VOA
	W-3	16.0	Line hole; past soils data showed SV
	W-3.5	20.0	Define contaminant extent[h]
	W-3.5W	16.0	Lateral transect[c]
	W-4	16.0	Line hole
	W-5	16.0	Line hole
	W-6	16.0	Line hole
	W-7	16.0	Line hole
	W-8	16.0	Line hole
	W-9	16.0	Utility crossing
	W-10	16.0	Line hole
	W-11	16.0	Line hole
	W-12	20.0	Line hole; past soils data showed DDD
	W-13	20.0	Utility crossing
	W-14	16.0	Line hole

[a] 1 foot = 0.305 meters

[b] Alphanumeric designation which identifies each borehole

[c] Additional borehole selected as volatile organics were detected with a photoionization meter in related alignment borehole.

[d] Additional borehole selected as late eluting organics were detected with a gas chromatograph in related borehole.

[e] Additional borehole selected as late eluting organics were detected with a gas chromatograph in N-6 and E-3E and volatiles detected by photoionization meter in E-1.

[f] Additional borehole selected as volatile organics were detected with a photoionization meter in E-3.

[g] Additional borehole selected to define southerly extent of chemical movement.

[h] Additional borehole selected based on earlier data of chemicals and swales in the area.

VOA = Volatile Organic Priority Pollutant Analytes
SV = Semivolatile (Extractable) Organic Priority Pollutant Analytes
GW = Groundwater
DDT = The pesticide DDT.
DDD = The pesticide DDD and a degradation product of DDT.

The emphasis of the program was placed on collecting discrete soil samples for geologic classification and chemical characterization. During the course of the program, five hundred seven soil sample sets were collected and subjected to a screening procedure which was used to identify samples for detailed chemical analysis. The borehole sample which was judged to contain the greatest amount of chemicals was selected for detailed chemical analysis. This screening was accomplished through careful selection of borehole locations, rigorous and methodical sampling procedures, visual observations, measurement of volatile organic compounds and field laboratory analysis. Additional details of the specimen selection protocol are provided in Appendix A (Volume II). The program was specifically designed to identify the soil samples containing the greatest amount of chemicals in each borehole.

3.2 DRILLING PROCEDURES

3.2.1 General

The boreholes were drilled using hollow-stem augers. This method was selected because it allowed the timely completion of individual boreholes, reduction of cross-contamination of soil samples, avoidance of washwater disposal problems and was the least costly of the methods considered appropriate for the project. In the event that unstable soils had been encountered, cased boreholes would have been used to advance the hole. Details of the development of the borehole and required decontamination procedures are provided in Appendix A and the Task V-A Work Plan (E.C. Jordan Co., 1983a).

Drilling and sampling procedures were selected to avoid cross-contamination of sampling locations and individual samples by means of the following methods:

1. obtaining split spoon samples immediately after advancing the augers to the appropriate depth for sampling;

2. using decontaminated split spoons for each sample; and

3. completing each borehole on the same day it was started to avoid potential migration of contaminants from higher portions of the borehole if drilling operations are shut down for an extended length of time (e.g., overnight).

Each drill rig was assigned a drilling monitor who observed drilling operations, provided sampling criteria for the driller and assisted in collecting the soil samples from the split spoon. The drilling monitor had the authority to stop advancement of the borehole if the technical specifications were not met. In addition, a drilling coordinator was present at the site to assure proper coordination between drill rigs, adherence to safety and health requirements, adherence to drilling specifications, uniformity in documentation and adherence to decontamination procedures.

Documentation of the drilling and sampling of each borehole was the joint responsibility of the drilling monitor and the driller. Borehole logs are provided in Appendix B.

3.2.2 Advancing Holes

As part of the drilling procedure, the area around each hole was first prepared by placing a clean sheet of plastic on the ground. This surface was covered with a 4- by 8-foot (1.2 by 2.4 m) sheet of plywood. All drilling was made through a cutout in the plywood and plastic sheets. Soil cuttings were retained on the plastic sheeting for subsequent disposal. Surface samples (S-1, 0 to 2 feet (0 to 0.6 m)) were obtained by split spoon sampling prior to initiating the hollow-stem auger drilling. Subsequent sampling at 2-foot (0.6 m) intervals was made after advancing the hollow-stem augers, with plugged end, to the top of the next sample interval. The holes were terminated at 15 to 16 feet (4.6 to 4.9) if at least 2 feet (0.6 m) of soft reddish gray clay was encountered. Fifteen holes were extended to depths of between 16 and 20 feet (4.9 and 6.1 m) for one or more of the following reasons: (1) granular soils were encountered in the 14 to 16 foot (4.3 to 4.9 m) sample; (2) elevated PI readings were obtained in the lower samples; (3) the borehole was selected to provide geologic and chemical information at greater depths. Three borings, C-1 through C-3, along LaSalle Arterial were extended to 24 feet (7.3 m) because of the additional embankment height of 3 to 4 feet (.9 to 1.2 m).

3.2.3 Backfilling Holes

All holes were backfilled to within 8 feet (2.4 m) of the ground surface with bentonite powder or pellets. The remaining space was backfilled with cuttings from the hole or residue from the samples. Materials were tamped down firmly. Stakes indicating hole locations were inserted into the filled holes to preserve locations at non-roadway locations on-site and along the southern wall alignment. Excess cuttings or sample residue were containerized for subsequent disposal at the toe of the clay cap as had been directed by the NYSDEC.

3.2.4 Decontamination of Drilling Equipment

Each drilling rig was equipped with a set of six 2-foot (0.6 m) long split-spoon samplers. Since boreholes were drilled to a minimum of 16 feet (4.9 m), a decontamination station was established at each rig to clean the samplers. A series of buckets and brushes was set up to accomplish the following decontamination protocol:

1. The sampler was first brushed clean of residual soil.

2. It was then placed in a bucket of tap water and brushed clean.

3. The sampler was then washed with 5- to 10-percent methanol in water and a methanol rinse (squeeze bottle application) occurred in a separate bucket.

4. A third wash was done with a mild detergent.

5. A final rinse was done in a bucket using tap water.

Cleaning solutions were collected and disposed of in accordance with instructions of the NYSDEC at the completion of each hole and new solutions prepared for the next hole.

Augers and any other equipment going into the hole or contacting cuttings were taken to a decontamination station and decontaminated in a similar manner. The main wash station for the augers was a 100-gallon (380 ℓ) tank which permitted the settling out and collection of solids for disposal in accordance with NYSDEC requirements.

SECTION 4

GEOLOGIC SETTING

4.1 REGIONAL GEOLOGY

4.1.1 Surficial Deposits

The surficial soils in the Niagara Falls area consists of unconsolidated glacial deposits overlying Silurian age sedimentary rocks. The glacial deposits range from glacial till to lacustrine clay-silt to fine sand. The unconsolidated sediments south of the Niagara escarpment thicken gradually from north to south and range from 5 to 15 feet (1.5 to 4.6 m) to nearly 45 feet (13.7 m) thick in the Love Canal area. (EPA, 1982)

The glacial till consists of a reddish, well graded gravel with a sandy to clayey silt matrix directly overlying bedrock. The overlying lacustrine materials were deposited by glacial Lake Dana and post glacial Lake Tonawanda. These lake sediments grade upward from a reddish gray varved clay sequence with thin "till-like" layers at the lower contact. A uniform reddish brown, slightly varved, clayey silt underlies a thin surface stratum of silty fine sand representing the waning stages of Lake Tonawanda.

4.1.2 Bedrock Geology

The bedrock underlying the unconsoldiated sediments consists of the Lockport dolomite. This formation, consisting of layers of limestone and shaley dolomite, dips gently toward the south at less than one degree (EPA, 1982). In places, the formation exhibits prominent open bedding joints. Regionally, the thickness varies from as little as 20 feet (6.1 m) along the escarpment to as much as 180 feet (54.9 m) near Love Canal. The Lockport dolomite, forming the prominent Escarpment and cap rock of the Niagara Falls area is resistant and structurally sound. The underlying Rochester shale is weaker and less durable.

4.2 LOVE CANAL SURFICIAL GEOLOGY

The description of the site geology, presented herein, is based on an interpretation of the materials encountered in the 59 continuously sampled test borings made as part of this investigation. The borings, from 15 to 24 feet (4.6 to 7.3 m) deep, encountered unconsolidated sediments consisting of surface fill, moderately thick sequences of lacustrine silt and clay and glacial till. A continuous geologic profile (Figure 5) was interpreted from these data. The groundwater table appears to fluctuate in the reddish brown clay and to remain consistently above the soft gray clay.

4.2.1 Fill

In general, the fill consists of disturbed native soils, utility trench backfill, roadway subgrade, demolition debris, and railroad bed materials and

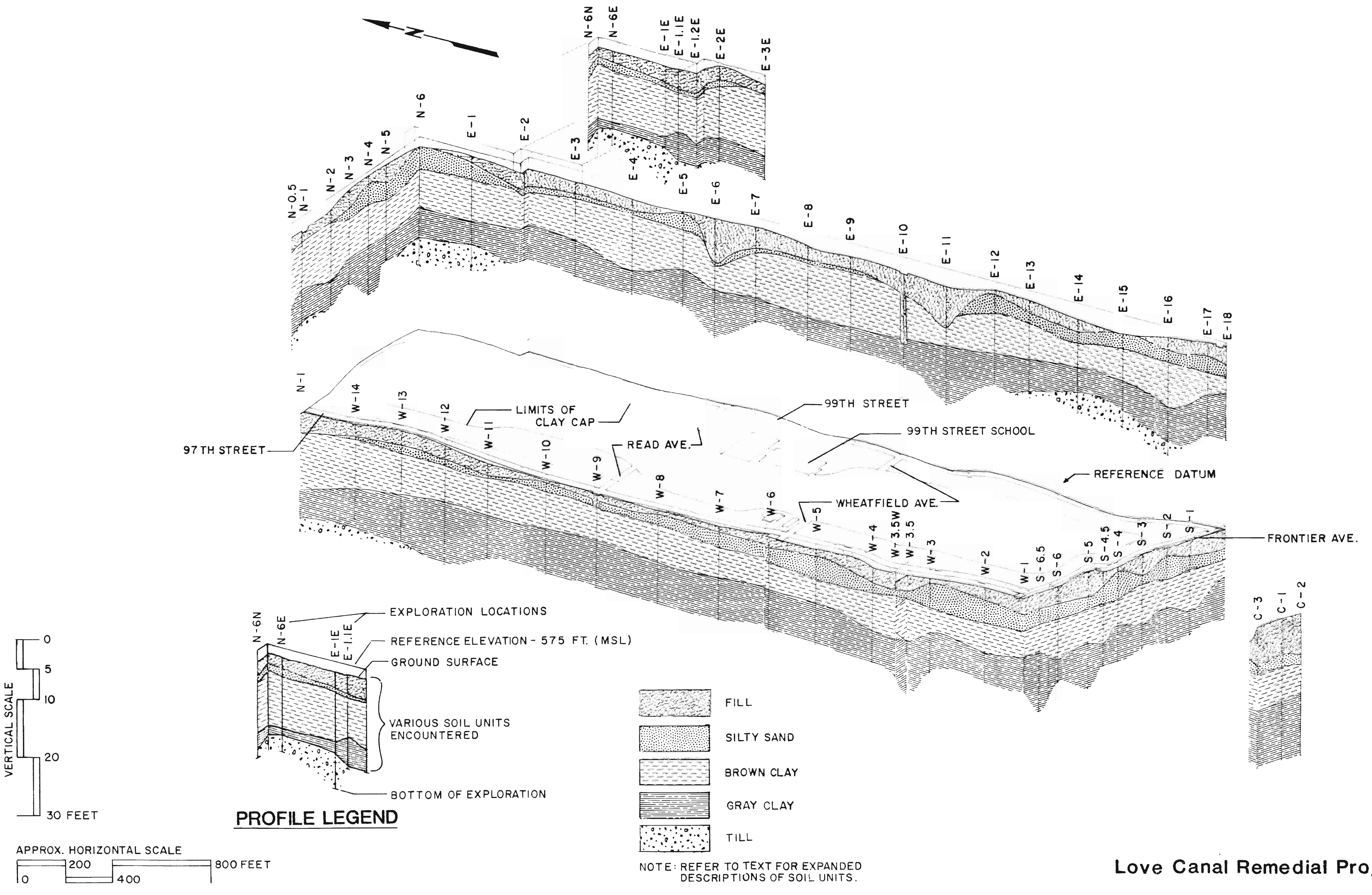

Figure 5
Fence diagram
Love Canal Remedial Project (Task V-A)

ranges in depth from less than 1 foot (0.3 m) to more than 11 feet (3.4 m). The fill along the north alignment ranged from 1 foot (0.3 m) to 6 feet (1.8 m) deep and represents the edge of the existing clay cap. Along the west alignment the fills averaged 2.3 feet (0.7 m) and, in general, represent disturbed native soil materials. The fill along the south alignment averaged nearly 4 feet (1.2 m) and consisted of silt, sand and gravel. The explorations C-1 through C-3, made along the north side of the LaSalle Arterial, encountered a uniform sequence of fill averaging nearly seven feet (2.1 m) thick. These fills consisted of "till-like" highway embankment fill over miscellaneous soil and rubble fill associated with an old railroad bed. Fill depths along the east alignment are the most variable. While averaging 3.3 feet (1.0 m), the depth ranges from less than 1 foot (0.3 m) to nearly 12 feet (3.7 m). The deepest fill was encountered in sewer line backfill at the intersection of 99th Street and Wheatfield Avenue.

4.2.2 Sand

A surficial stratum of mottled brown silty fine sand was encountered over much of the site. Portions of the sand horizon appear to be transitional with the overlying fill. In general, where encountered, the sands range from 2 to 4 feet (0.6 to 1.2 m) thick and appear to be widespread along the southern portions of the east and west proposed wall alignment (near Frontier Avenue).

4.2.3 Brown Clay

This stratum consists of a brown to reddish brown varved silty clay with fine sand and silt partings. While prominent vertical fractures were encountered in some explorations, it appears that minor fractures are uniformly distributed throughout the upper portion of this unit. Fine sand and silt was encountered along the fracture surfaces. As inferred from the standard penetration resistance, the brown clays range from a hard to medium consistency. In general, where undisturbed by construction activities, this stratum ranges from four to nine feet (1.2 to 2.7 m) thick. The upper contact with the overlying fill and native sand stratum is generally sharp and well defined.

4.2.4 Gray Clay

This stratum consists of a reddish gray to gray varved silty clay with occasional fine sand and silt partings. Based on the standard penetration resistances indicates the consistency of the gray clay ranges from medium to very soft. Along the alignment, the stratum ranged in thickness from approximately 4 feet (1.2 m) in the northeast corner to greater than 12 feet (3.7 m) at the southwest corner. While most of the borings terminated in the soft gray clay, granular soil (glacial till) was encountered below the clay at some locations.

4.2.5 Glacial Till

A stratum of granular soil ranging from alternating thin layers of glacial "till-like" material and reddish gray silty clay to a uniform glacial till was encountered beneath the gray clay in several boreholes. The glacial tills varied from a soft to a stiff consistency. Where encountered, the depth of penetration into the till ranged from less than 1 foot (0.3 m) to more than 6 feet (1.8 m). The till soils were encountered in the northeast and northwest corners of the alignment and along the east side between boreholes E-13 and

E-16. In general, the upper contact with the overlying gray clay appears to be transitional and consists of 2 to 4 feet (0.6 to 1.2 m) of a stratified sequence of alternating layers of silty clay and granular material gradually becoming more "till-like" with depth. The upper portions of the till appear water saturated and soft.

SECTION 5

FIELD ASSAYS

5.1 SPECIMEN COLLECTION AND MANAGEMENT

The objective of specimen collection was to select for analysis specimens of soil strata from subsurface locations where chemicals were most likely to be found, e.g., sand lenses in clay soils. Specimen collection was conducted in accordance with the Task V-A Work Plan (E.C. Jordan Co., 1983a). A brief description of the specimen collection protocol is provided here.

A sampling team, consisting of two geoscientists, was assigned to each drill rig. Operating from a mobile field work station, the team visually observed and recorded soil characteristics (including color, texture and photoionization (PI) meter readings for volatile organics) of each 2-foot (0.6 m) soil sample. This information was used to identify the most probable zones where chemicals may be found.

Specimens were collected from the identified soil zones with a clean spatula and gloves and placed in 40-ml volatile organic analyte (VOA) vials which were specifically prepared in accordance with procedures recommended by the EPA. Also, a representative specimen of the remaining strata was placed in a half-pint (0.5 ℓ) sample jar with a Teflon seal cap for retention as a soil record specimen. This record specimen of the soil profile and was also used for headspace photoionization measurements in the field laboratory.

Recorded information included: names of drilling and monitoring personnel; chain-of-custody; date and time; sample number; penetration resistance; recovery and descriptions of the soil; interpretation of the soil stratification throughout the exploration; and PI measurements of the soil sample. Borehole logs are provided in Appendix B. Photographs (35 mm color slides) were also taken showing specimen locations in the soil sample. Additional details of the specimen collection protocol are provided in Appendix A.

Custody of the specimens transferred from the sampling team to the sample coordinator in the field office for secure storage and subsequent analysis in the field laboratory. Specimen handling and storage procedures were in accordance with those specified in Love Canal Remedial Project Task V-A Quality Assurance Plan (E.C. Jordan Co., 1983b). These procedures included establishment of specimen refrigeration and transportation chain-of-custody logs and provision for locked storage at 0 to 4°C. Custody of all specimens not transported to laboratories were transferred at the completion of the field activities to Jean Dubois, P.E., NYSDEC Field Project Engineer. Subsequent to the transfer, it was necessary to analyze two soil specimens (C-2 S3 and W-3.5W S5), which were stored at an estimated maximum temperature of 5.6°C. An assessment of the analytical results for these two specimens is presented in Appendix D (Volume II).

5.2 SELECTION PROTOCOL FOR SPECIMEN ASSAY

5.2.1 Field Geologist's Recommendation

Field decision criteria were established for selecting the most contaminated samples from the soil column obtained from the borehole. These criteria were based on:

- visual observation of any soil discolorations or chemical deposits;
- volatile organic screening of the soil sample using a photoionization (PI) meter.
- textural variations in the soil column which might indicate probable pathways for chemical migration (sand lenses, fractures or contact surfaces).

These criteria were further augmented by the requirement that, lacking any indications of sample preference, the sample would be selected from the saturated zone. Based on this guidance, the field geologist selected two or three sample depths for each hole which he recommended for further screening and assay by field GC.

5.2.2 Organic Screening of Soil

Volatile organics were screened using an HNU PI model 101 photoionization (PI) meter equipped with an 11.7 ev source lamp. This lamp provides the widest

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TABLE 2. VOLATILE ORGANIC LEVELS OF BOREHOLE SOIL SAMPLES[a,b,c,d]

	Borehole										
Specimen	N-0.5	N-1	N-2	N-3	N-4	N-5	N-6	N-6E	N-6N	E-1	E-1E
S-1	0		0	0	0	0	0	0	0	0	0
S-2	0	1.5	2.0	0	0	0	0	0	0	0	0
S-3	0	0	0	0	0	0	0	0	0	0	0
S-4	0	1.0	0	1.0	0	0	0	0	0	0	0
S-5	0	0	0	0	0	0	0	0	0	0	0
S-6	0	0	0	0	0	0	0	0	0	0	0
S-7	0	0	0	2.0	0	2.0	0	0	0	0	0
S-8	0	0	0	3.0	0	0	0	0	0	0	0
S-9	0				0		0			0	0
S-10	0				0		0			0	0

	Borehole										
Specimen	E-1.1E	E-1.2E	E-2	E-2E	E-3	E-3E	E-4	E-5	E-6	E-7	E-8
S-1	0	0	0	0	0	0	0	0	0	NS	0
S-2		0	0	0	0	0	0	0	0	0	0
S-3	0	0	0	0	0	0	0	0	0	0	0
S-4	0	0	0	0	0	0	0	0	NS	0	0
S-5	0	0	0	0	0	0	0	0.5	0	0	0
S-6	0	0	0	0	0	0	0	0.3	0	0	0
S-7	0	0	0	0	0	0	0	0	0	0	0
S-8	0	0	0	0	0	0	0	1.0	0	0	0
S-9						0			0		
S-10						0			0		

	Borehole										
Specimen	E-9	E-10	E-11	E-12	E-13	E-14	E-15	E-16	E-17	E-18	S-1
S-1	NS	0	NS	0	0	0	0	0	NS	0	0
S-2	NS	0	NS	0	0	0	0	0	NS	0	0
S-3	0	0	NS	0	0	0	0	0	NS	0	0
S-4	5.0	0	NS	0	0	0	0	0	NS	0	0
S-5	NS	0	NS	0	0	0	0	0	NS	0	0
S-6	>10	0	NS	0	0	0	0	0	NS	0	0
S-7	NS	0	NS	0	0	0	0	0	NS	0	0
S-8	NS	0	NS	NS	NS	0	0	0	NS	0	0
S-9			0					0			
S-10			0					0			

TABLE 2 (continued)

Specimen	Borehole S-2	S-3	S-4	S-4.5	S-5	S-6	S-6.5	C-1	C-2	C-3	W-1
S-1	0	0	0	0	0	0	0	0		0	0
S-2	0	0	0	0	0	0	0	0	0	0	0
S-3	0	0	0	0	0	0	0	1.5	1.5	0	0
S-4	0	0	0	7.5	10	0	0	0	0	0	0
S-5	0	0	0	7.5	5	3	0	0	0	0	0
S-6	0	0	2	0	150	2	0	0	0	0	0
S-7	0	0	0	0	3	0	0	0	0	0	0
S-8	0	0	0	3	0	6	0	0	0	0	0
S-9					0		0	1.0	0.5	0	
S-10					0		0	0	0	0.6	
S-11								0	0	1.0	
S-12								0	0	0.5	

Specimen	Borehole W-2	W-3	W-3.5	W-3.5W	W-4	W-5	W-6	W-7	W-8	W-9	W-10
S-1	0	1.0	0	0	0	0	0	0	0	0	0
S-2	0	1.0	0.2	0	1.0	0	0	0	0	0	0
S-3	0	0	0	0	0	0	0	0	0	0	0
S-4	0	4	0	0	0	0	0	0	0	0	0
S-5	0	0	25	0	0	0	0	0	0	0	0
S-6	NS	0	0	0	1.0	0	0	0	0	0	0
S-7	NS	0	0	0	0	0	0	0	0	0	0
S-8	NS	0	0	0	0	0	0	0	0	0	0
S-9			0								
S-10			0								

Specimen	Borehole W-11	W-12	W-13	W-14
S-1	0	0	0	0
S-2	0	0	0	0
S-3	0	0	0	0
S-4	0	0	0	0
S-5	0	0	3.0	NS
S-6	0	0	2.0	NS
S-7	0	0	0	NS
S-8	0	0	0	NS
S-9		0	0	
S-10		0	0	

[a] All readings are in parts per million (ppm). The HNU PI model 101 meter was fitted with an 11.7ev source lamp, factory calibrated against benzene and field standardized daily with a reference gas.

[b] 0 indicates that the sample was screened and no volatile organics were detected.

[c] NS indicates that the sample was not screened because of instrument malfunctions or human error.

[d] No entry means sample not obtained.

TABLE 3. VOLATILE ORGANIC LEVELS OF RECORD SPECIMEN HEADSPACE[a,b,c,d]

Specimen	Borehole										
	N-0.5	N-1	N-2	N-3	N-4	N-5	N-6	N-6E	N-6N	E-1	E-1E
S-1	0.7			0	0	0	0	1.0	0.9	2.4	0.7
S-2	0.4	4.9		0	0	0.6	0.1	0.6	0.6	2.1	0.6
S-3	0.9	4.2		0	0		0	0.7	0.9	2.0	1.0
S-4	1.1	2.4	4.0	0	0	0	0	1.1	1.0	3.1	1.0
S-5	0.8	3.2	6.4	0	0	0.2	0	1.1	0.9	2.2	0.9
S-6	0.4	2.6	7.0	0	0	0.1	0	0.9	0.4	10.0	1.1
S-7	0.7	2.5	7.2	0	0	0.6	0	1.2	1.1	9.0	1.2
S-8	1.1	2.5	7.2	0	0	0	0	1.7	1.2	6.2	1.0
S-9	0.8		6.9	0.1	0		0.2			6.4	0.9
S-10	1.3				0		0			5.3	0.5

Specimen	Borehole										
	E-1.1E	E-1.2E	E-2	E-2E	E-3	E-3E	E-4	E-5	E-6	E-7	E-8
S-1	0	0	0.6	0	6.1	0	0.4	0	0.2	2.1	1.4
S-2		0.1	0.5	0	6.6	0	0.4	0	0.4	1.8	1.7
S-3	0	0	0.5	0	7.0	0	0.3	0	0.4	1.9	1.6
S-4	0	0	0	0	4.4	0	0.3	0	0.5	1.7	1.7
S-5	0	0	0	0	6.0	0	0.5	0	0.3	1.7	1.4
S-6	0	0	0	0	5.2	0	0.3	0	0.3	1.7	1.7
S-7	0	0	0	0	5.6	0	0.3	0.1	0.4	1.7	1.8
S-8	0	0		0	4.8	0	0.5	0	0.5	1.6	1.7
S-9									0.4		
S-10									0.5		

Specimen	Borehole										
	E-9	E-10	E-11	E-12	E-13	E-14	E-15	E-16	E-17	E-18	S-1
S-1	1.4	2.6	1.4	0.4	0.6	0	0.4	0.5	0	0	0
S-2	1.6	2.4	1.4	0.4	0.5		0.7	0.7	0	0.3	0
S-3	1.5	2.7	1.5	0.2	0.2	0	0.8	0.4	0	0	0
S-4	1.6	3.5	1.7	0.2	0.2	0	0.7	0.6	0	0	0
S-5	1.7	2.5	1.7	0.5	0.5	0.1	0.7	0.7	0	0	0
S-6	1.7	18	1.7	0.5	0.3	0	0.6	0.6	0	0	0
S-7	1.7	3.8	1.4	0.4	0.2	0	0.6	0.5	0	0.2	0
S-8	1.7	1.4	1.6	0.5	0.4	0	0.6	0.8	0	0	0
S-9			1.7					0.6			
S-10			1.4					0.6			

TABLE 3 (continued)

Specimen	Borehole S-2	S-3	S-4	S-4.5	S-5	S-6	S-6.5	C-1	C-2	C-3	W-1
S-1	0	0.1	0.5	1.9	0	0	1.3	1.9		1.4	0
S-2	0	0	0	1.5	0	0	1.4	1.9	1.1	3.4	0
S-3	0	0	0	2.5	0.1	0	1.4	2.0	12	2.3	0
S-4	0	0	0.5	11	1.1	0.3	1.5	1.7	3.0	1.3	0
S-5	0	0	0.4	20	40	28	1.8	1.6	1.4	1.2	0
S-6	0	0	0		5.0	46	1.5	1.8	1.0	1.2	0
S-7	0	0	0	14	2.2	36	1.3	1.4	0.8	1.0	0
S-8	0	0	0	7	0.6	16	1.4	2.3	1.0	0.8	0
S-9					0		1.2	1.4	1.2	0.9	
S-10					0		1.0	1.3	1.0	0.9	
S-11								1.4	0.8	0.8	
S-12								1.4	0.8	0.9	

Specimen	Borehole W-2	W-3	W-3.5	W-3.5W	W-4	W-5	W-6	W-7	W-8	W-9	W-10
S-1	0	0	1.0	0	0	0	0	0	0	1.8	0
S-2	0	0	0.8	0	0	0	0	0	0	0.2	0
S-3	0	0.2	0.8	0	0	0	0	0	0.1	0	0
S-4	0	0.2	0.7	0	0.1	0	0	0	0	0	0
S-5	0	0	0.7	0	0	0	0	0	0	0	0
S-6	0	0	0.9	0	0	0	0	0	0	0	0
S-7	0	0.1	0.9	0	0.1	0	0	0	0.2	0	0
S-8	0	0.1	0.9	0	0	0	0	0	0	0	0
S-9			1.0	0							
S-10			0.8	0							

Specimen	Borehole W-11	W-12	W-13	W-14
S-1	0	0	2.2	0
S-2	0	0	0	0
S-3	0	0	0	0
S-4	0	0	0	0
S-5	0	0	0	0
S-6	0	0	0	0
S-7	0	0	0	0
S-8	0	0	0	0
S-9		0	0	
S-10		0	0	

[a] All readings are in parts per million (ppm). The HNU PI model 101 meter was fitted with an 11.7ev source lamp, factory calibrated against benzene and field standardized daily with a reference gas.

[b] 0 indicates that the sample was screened and no volatile organics were detected.

[c] NS indicates that the sample was not screened because of malfunction or human error.

[d] No entry means sample not obtained.

geoscientists, and the specimen selection criteria stated in Sections 5.2.1 and 5.3 to select specimens for FID GC analysis and subsequent GC-MS analysis. Specimens selected for analysis did not necessarily exhibit the greatest PI meter reading. Alternative selection criteria that were used are as follows: certain boreholes had a previously designated specimen depth (e.g., utility crossings), greater weight was placed on visual observation and the recommendations of the geoscientist for some samples, and, in some cases, a vertical distribution was desired to improve the understanding of chemical distribution in the soils strata present. Also, saturated soils tended to receive greater priority than unsaturated soils in specimen selection.

The photoionization meter was useful in screening soil samples for the presence of volatile organics at the parts per million levels. At lower concentrations (parts ber billion level), the PI meter failed to detect the presence of volatile priority pollutants in 30 percent of the specimens. This finding is consistent with the sensitivity (1 ppm) of the instrument. Measurements of the headspace of specimens held overnight at room temperature were more effective than screening of soil samples in a split spoon prior to specimen collection. In addition, the PI meter was found to be sensitive to moisture variations, providing higher readings on humid, rainy days. In summary, the PI meter was found to be a useful screening tool for volatile organics at the ppm level. Meter readings were used in conjunction with other observations of site and sample conditions when selecting specimens for detailed analysis.

5.2.3 Specimen Volatile Organic Analyses

The field laboratory analysis for volatile priority pollutants was conducted with a Perkin-Elmer Sigma IIIB Gas Chromatograph equipped with dual flame ionization detectors (FIDs) and glass columns packed with SP-1000 substrate using an analytical protocol based on EPA methods 601 and 602. The purge and trap device was manufactured by Tekmar (Model LSC-2). The resultant chromatograms were recorded on 8-inch width chart paper. An analytical protocol was developed (see Appendix C) to provide confirmatory evidence of the absence of volatile priority pollutants and to assist in selecting specimens for more detailed chemical analysis. Reference standards and spiked additions were routinely used during the field laboratory analyses. Specimens showing the presence of volatile priority pollutants by field GC were submitted for confirmation by GC-MS using EPA Method 624.

Most field GC analyses indicated the absence of volatile priority pollutants. Only seven samples from five boreholes (Table 4) yielded tentative identification of volatile priority pollutants. A total of 9 different volatile priority pollutants were tentatively identified. The presence of dichloromethane (methylene chloride) was indicated only at W-3.5W, which is located approximately 60 feet (18 m) west of the proposed western wall alignment. Two other boreholes where volatiles were detected by FID GC were S-6 located on the proposed southern wall alignment and C-2 located on the northern shoulder of the LaSalle Arterial. These two boreholes tentatively (requiring confirmation by GC-MS) contained toluene, 1,1,1-trichloroethane and benzene. Tentative identification of trichloroethene and tetrachloroethene was made only at bore-

TABLE 4. VOLATILE PRIORITY POLLUTANTS TENTATIVELY IDENTIFIED BY FID GC

Borehole	Sample	Analyte[a]	Concentration[b]
N-6	S-2	late eluting compounds not specified by methods 601, 602	---
E-2E	S-3	late eluting compounds not specified by methods 601, 602	---
E-2E	S-5	late eluting compounds not specified by methods 601, 602	---
S-6	S-5	1,1,1-trichloroethane	> 320
		benzene	> 320
		toluene	> 320
		chlorobenzene	> 320
		ethylbenzene	< 1.8
		late eluting compounds not specified by methods 601, 602	---
S-6	S-8	1,1,1-trichloroethane	> 320
		benzene	> 320
		tetrachloroethane	> 320
		toluene	> 320
		late eluting compounds not specified by methods 601, 602	---
C-2	S-3	1,1,1-trichloroethane	> 320
		trichloroethene	54
		benzene	46
		tetrachloroethene	47
		toluene	> 320
		chlorobenzene	> 320
		ethylbenzene	> 320
		late eluting compounds not specified by methods 601, 602	---
W-3.5W	S-5	dichloromethane	> 320

All other samples showed no volatile priority pollutants.

[a] Analytical protocol based on EPA Methods 601 and 602 for volatile priority pollutant analysis. Volatiles tentatively identified by FID GC were submitted for confirmation with GC-MS according to EPA method 624.

[b] Concentration reported as µg/kg (ppb).

hole C-2. Late eluting compounds were observed in six of the specimens analyzed. The late eluting compounds could potentially be some of the more volatile extractable organic priority pollutants, i.e., dichlorobenzenes. The quantity of volatile priority pollutants tentatively shown to be present exceeded the dynamic range of the field GC analytical protocol in several instances. However, the subsequent analysis (EPA Method 624) of all samples that were found to tentatively contain volatile organic priority pollutants during field screening provided quantitative results for the validated compounds. Comparison of FID GC and GC-MS analyses is provided in Appendix D.

5.3 SPECIMENS SELECTED FOR ADDITIONAL ANALYSIS

The selection of specimens for additional analysis was made according to preceeding selection protocol unless the borehole was at a utility crossing. Specimen selection protocol for utility crossings are described subsequently. Further, the selection was influenced by the following requirements:

1. Submit one specimen suspected of containing the greatest amount of chemicals from each borehole;

2. Confirm field GC tentative detection of volatile priority pollutants;

3. Attain a distribution of specimens for dioxin analysis for the complete wall alignment but with an emphasis on the canal and utility crossings;

4. Preferentially select specimens in the groundwater saturated zone; and

5. To the extent that specimen selection protocol based on visual observations, PI meter measurements and volatile priority pollutant analysis by field GC allows, attain a distribution of specimens for extractable priority pollutant analyses throughout the geologic profile.

Based on the selection protocol for specimen assay, one specimen was selected (Figure 6) from each borehole for additional chemical analysis.

Dioxin analyses were scheduled for selected boreholes because the presence of dioxins in sewer sediments at the site was determined during prior surveys. Other dioxin analyses were specified at selected canal crossing boreholes (north and south wall alignments) because of the anticipated close proximity of these areas to the limits of the canal and known buried wastes.

Specimen selection for utility crossings (Boreholes N-1, E-2, E-10, E-18, W-9 and W-13) was limited to the soil sample interval immediately below the sewer, or water utility line. Where more than one utility line was present at a utility crossing, the specimen selected was based on the sampling team's observations and PI measurements of the soil sample and record specimen head-space. Specimen selection at the canal crossings (Boreholes N-2 through N-5, S-2 through S-5) was also based on the sampling team's observations and PI measurements for all of the soil sample intervals of the borehole. Specimen selection for all other boreholes was based on the sampling team's recommendations, PI measurements, field GC analyses and the requirements described above.

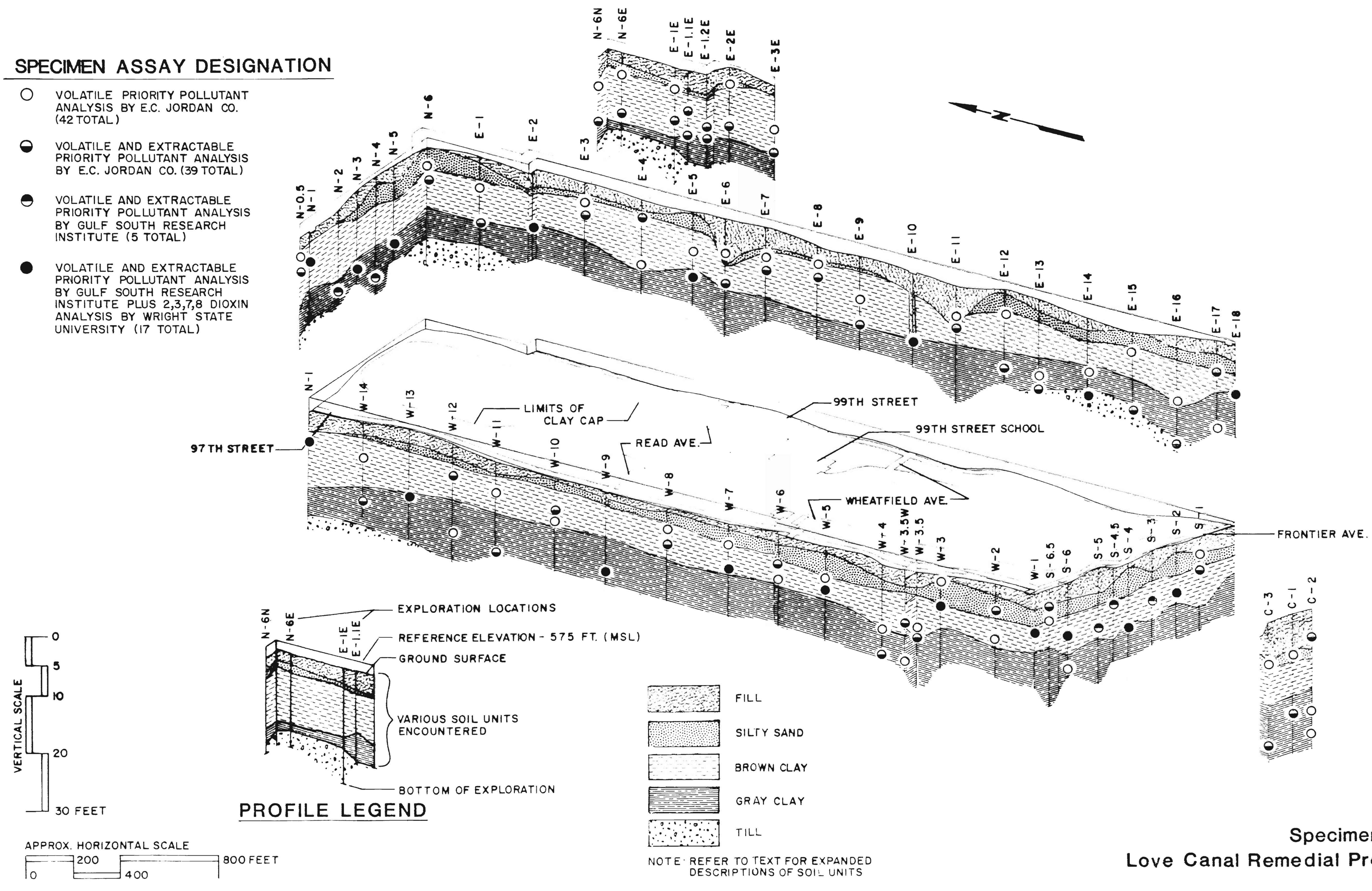


Figure 6
Specimen assay schedule
Love Canal Remedial Project (Task V-A)

5.4 SPECIMEN SHIPMENT

Seventeen specimens selected for organic priority pollutant and dioxin analysis and five specimens selected for organic priority pollutant analysis from areas where dioxin was suspected to be present were sent to Gulf South Research Institute (GSRI). Following organic priority pollutant analysis, the seventeen specimens were sent to Wright State University (an EPA contract laboratory) for dioxin analysis. All other specimens were sent to the E.C. Jordan Co. laboratory for organic priority pollutant analysis. All specimens were placed in special packaging materials and shipped by air cargo carriers.

SECTION 6

LABORATORY ASSAYS

6.1 SELECTION OF ANALYTES

Based on available information, constituents of wastes deposited at Love Canal include the organic priority pollutants. Although other chemicals have been found in the soils and groundwater at Love Canal, the organic chemicals present are of greater concern with regard to the safety of workers constructing the wall and potential health effects of mobile substances in the groundwater. Because they possess a wide range of transport and fate characteristics, organic priority pollutants are expected to be constituents of chemical migration from Love Canal. The analytes selected, therefore, were organic priority pollutants. These analytes included most chemical species of potential health concern known to be present in the canal area.

Volatile organics were considered important for several reasons:

1. Volatiles are, in general, more soluble and mobile than other organic priority pollutants,

2. their presence may indicate probable pathways for migration of other species that may be more persistent or toxic in the environment (e.g., pesticides), and

3. they were found in previous samplings of composites of the top 6 feet (1.8 m) of soil.

The EPA study (EPA, 1982) indicated volatiles were present in low concentrations in the 6-foot (1.8 m) composite samples. However, volatiles may have been present only at one location (e.g., contact zone between the sand lenses and the underlying brown silty clay) in the composite sample. The low concentrations in the surficial soils may also be a result of loss to the atmosphere. Pathways for migration in the deeper soils may contain, and therefore be detected by analysis of, volatile priority pollutants. Since the depth of sampling was greater than in the EPA study and specific zones of soil rather than composites were to be analyzed, volatile organic priority pollutant analytes were selected.

Semi-volatile organics of concern at the site include the pesticides and polynuclear aromatic hydrocarbons. Pesticides were reported by EPA to be present at the site, being concentrated in the southwest and northeasterly sections of the canal area. Concerns about lack of data for the volatiles at depths greater than 6 feet (1.8 m) also apply for the semi-volatiles.

The other analyte of concern was dioxin. More specifically, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) was selected as the specific dioxin compound to be analyzed for due to its toxicity. This compound was reported to be present at the site, principally concentrated in storm sewer sediments, stream beds and an occasional house sump. It had not been identified in any of the eight EPA near surface soil samplings for dioxin. However, there remained a concern about the extent of dioxin migration across the proposed wall alignment. To address this question, 2,3,7,8-TCDD was selected as an analyte and several borehole locations representing projections of the canal to the north and south, utility crossings and a random distribution along the proposed wall alignment were selected to provide specimens for analysis.

6.2 ASSAY PROTOCOLS

At least one specimen from each borehole was analyzed for volatile and extractable organic priority pollutants. Volatile priority pollutants were determined by the following protocols:

- o adaptations of EPA GC Methods 602 and 603 with confirmation of tentative identifications by adaptation of EPA GC-MS Method 624 (Jordan); or

- o adaptation of EPA GC-MS Method 625 (Jordan and Gulf South Research Institute).

Extractable priority pollutants were determined by Jordan and Gulf South Research Institute using an adaptation of EPA GC-MS Method 625. The analysis for 2,3,7,8-TCDD (dioxin) was conducted by Wright State University, an EPA contract laboratory. The protocol for dioxin analysis established 10 to 100 ng/kg as the quantifiable detection limit goal.

Details of the analytical protocols (except for 2,3,7,8-TCDD) are described in the Quality Assurance Plan (E.C. Jordan Co., 1983b) prepared for this project. The quality control program included analysis of reference samples, field quality control duplicates, the use of internal standards and, where appropriate, at least 10 percent replication of all samples analyzed. Quality control performance is reported in Appendix D.

6.3 CHEMICALS DETECTED

The laboratory chemical analysis program assayed the most highly suspected zone of contamination from each of the 59 boreholes. Assay results are tabulated in Appendix E. Several chemicals were only detected in the three boreholes located in the LaSalle Arterial. Both volatile (purgeable) and extractable (semi-volatile) priority pollutants were detected along certain portions of the proposed wall alignment.

The volatile compounds found included nine priority pollutants:

- dichloromethane (methylene chloride)
- trans-1,2-dichloroethene
- chloroform
- carbon tetrachloride
- trichloroethene
- benzene
- tetrachloroethene
- toluene
- chlorobenzene

In general, all of these compounds except trichloroethene were found along the proposed southern wall alignment and in the LaSalle Arterial. Only a few of the nine compounds were found along other portions of the proposed wall alignment. The following is a brief summary of where the volatile priority pollutants were found:

- Dichloromethane was detected in three adjacent boreholes along the northern (N-3, N-4, N-5) and southern (S-4.5, S-5, S-6) wall alignment and was also detected at three locations along the eastern (E-5, E-14, E-18) and five locations along the western (W-1, W-3.5W, W-5, W-7, W-9) proposed wall alignments.

- Trans-1,2-dichloroethene was found at detectable quantities at W-3.5W. It's presence at less than quantifiable levels was reported at S-6.

- Chloroform was detected only at S-4 along the southern wall alignment.

- Carbon tetrachloride was detected only at S-4 on the southern wall alignment.

- Trichloroethene was detected only along the proposed eastern wall alignment (E-2, E-10).

- Benzene was detected along the proposed southern wall alignment (S-5, S-6) and at E-10 on the eastern alignment.

- Tetrachloroethene was detected only at S-6.

- Toluene was detected in the LaSalle Arterial right-of-way, along the proposed southern alignment (S-5, S-6) and along the eastern alignment (E-1.2E, E-5, E-10).

- Chlorobenzene was detected in greatest quantity at C-2 in the LaSalle Arterial; it was also found along the southern alignment (S-3, S4.5, S-5, S6), the eastern alignment (E-5, E-10, E-14, E-18) and the northern alignment (N-1, N-4).

Greater quantities of volatile priority pollutants were found at N-4, N-5, E-10, E-18, S-5, S-6, W-3.5, W-9 and C-2 than at other sections of the proposed wall alignment.

The extractable priority pollutants detected along the proposed wall alignment included the following twelve chemicals:

α - BHC	diethyl phthalate
γ - BHC (Lindane)	hexachlorobenzene
1,3-dichlorobenzene	di-n-butyl phthalate
1,4-dichlorobenzene	butyl benzyl phthalate
1,2,4-trichlorobenzene	bis(2-ethylhexyl) phthalate
2-chloronaphthalene	di-n-octyl phthalate

In general, the phthalates were detected along all four portions of the proposed wall alignment in the following descending order of frequency of occurrence: bis(2-ethylhexyl), di-n-octyl, diethyl, butyl benzyl and di-n-butyl.

Extractable priority pollutants detected in the LaSalle Arterial right-of-way also included the following additional compounds:

β - BHC	fluoranthene
anthracene	pyrene
chrysene	1,2-dichlorobenzene

All of these compounds were found in a specimen from C-2 collected at the location of a former railroad roadbed. The compounds listed above include pesticides and base/neutral extractable compounds. No acid extractable compounds were detected.

The remaining extractable compounds were detected in one or more of the following locations: E-10, S-5, S-6, and/or C-2. Polynuclear aromatic hydrocarbons were detected only at C-2 and hexachlorobenzene was detected only at S-5. Preliminary results of the assays for 2,3,7,8-tetrachlorodibenzo-p-dioxin indicated that dioxin was not present in the 17 selected specimens (Figure 6).

SECTION 7

ASSESSMENT OF FINDINGS

7.1 SOILS

Based on interpretation of the samples retrieved from the 59 continuously sampled borings, the bottom of the soft clay stratum along the proposed alignment appears to range from approximately 12 to more than 24 feet (3.7 to 7.3 m) deep. The explorations encountered underlying granular soils, including glacial till, within 12 to 16 feet (3.7 to 4.9 m) of the surface in several areas. In addition, the soft clay stratum in these same areas thins to between 4 and 5 feet (1.2 and 1.5 m). These potentially critical areas of soft clay thickness and shallow depths to the underlying granular soils are located as follows:

- the explorations along the alignment between E-14 and E-15 (southern part of eastern wall) encountered 12 to 13 feet (3.7 to 4.0 m) of soil above the underlying till with 4 to 5 feet (1.2 to 1.5 m) of soft clay;

- the exploration at N-1 (northwest corner of wall) encountered 15 to 16 feet (4.6 to 4.9 m) of soil overlying the glacial till with 5 feet (1.5 m) of soft clay; and

- the explorations at N-6 and E-1 (northeast corner of wall) encountered 15 to 16 feet (4.6 to 4.9 m) of soils overlying the glacial till with 4 feet (1.2 m) of soft clay.

In addition, the contingency borings N-6E and E-1E (east of northeast corner of wall) encountered 13 to 14 feet (4.0 to 4.3 m) of soils overlying the glacial till with only 1 to 2 feet (0.3 to 0.6 m) of soft clay.

If the thickness of the soft clay layer and the depth to the upper more granular portion of the glacial till are important in determining the effectiveness of the proposed wall, then special attention may be required during detailed design and construction in these areas. The thin clay layer of 4 feet (1.4 m) and shallow depth 12.3 ft (4.2 m) to the underlying glacial till in the identified areas may require modification of the nominal 15-foot (4.6 m) depth of the wall and precautions during excavation to avoid penetrating the clay.

7.2 CHEMICALS

The assessment of chemicals found in the soils along the proposed wall alignment was conducted by:

1. compiling pre-existing chemical data collected in the vicinity of the proposed wall alignment;

2. comparing chemical data obtained from this borehole investigation with the pre-existing data to identify sections of the wall where quantities of chemicals differ;

3. assessing the significance of the data to the appropriateness of the proposed wall alignment; and

4. assessing the significance of the data to environmental health and safety of construction personnel during emplacement of the wall.

7.2.1 Comparison of Pre-existing and New Chemical Data

Prior to this borehole program, the majority of chemicals found in soils in the vicinity of the proposed wall alignment (Figure 2) were identified during the EPA monitoring program in 1980 (EPA, 1982). A direct comparison of some of these data with selected chemical assays of this borehole investigation (Figure 7) indicates a change in the chemicals detected in the soil.

The samples compared were within 75 feet (22.9 m) of each other. In general, the 1980 samples were reported to contain mostly volatiles, insecticides and polynuclear aromatic hydrocarbons whereas the 1983 samples contained several phthalates, some pesticides, and a few volatile compounds.

Differences in the protocols used during the two studies are important in making the comparison:

1. Soil assays were made on composite samples of the top 6 feet (1.8 m) of soils at each EPA sampling location; in the borehole investigation, chemical assay was made of a specimen of a 2-foot (0.6 m) sample.

2. The protocol used for sample selection during the borehole investigation preferentially favored deeper samples whereas some contaminants such as pesticides may be present only through surficial deposition.

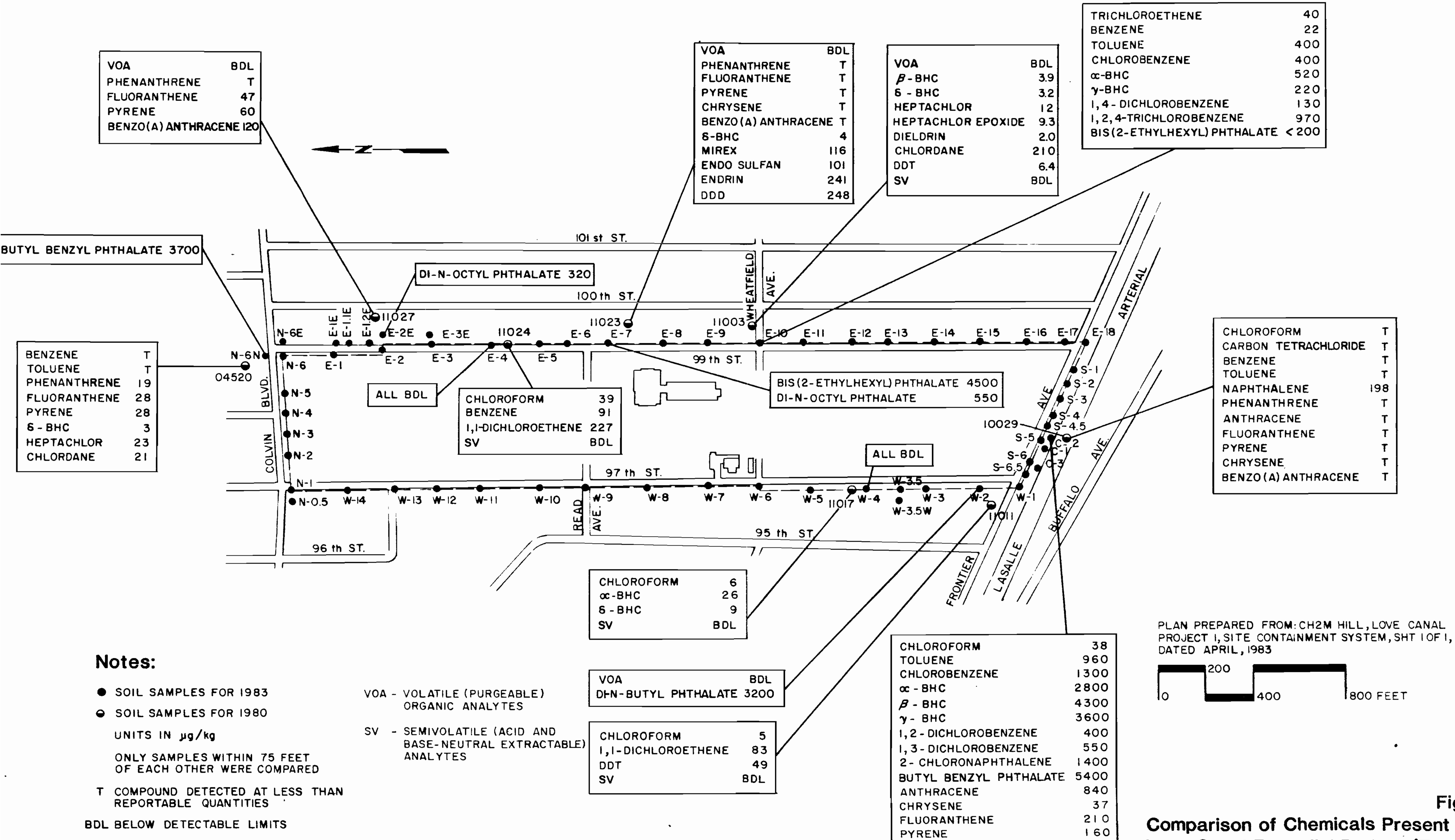


Figure 7
Comparison of Chemicals Present in Soil
Love Canal Remedial Project (Task V-A)

3. Analytical detection limits of the EPA study were generally lower for semi-volatile compounds (including pesticides) than in the borehole investigation which relied on detection limits achievable when using EPA Method 625.

In addition, the two studies did not collect samples from exactly the same vertical or areal locations. Significant differences may occur, even over the 75-foot (23 m) distance or up to 18-foot (5.4 m) vertical dislocations used in making this comparison.

Comparison of the selected data (Figure 7) leads to the following observations:

1. A general reduction of volatile compounds to less than quantifiable or detectable levels were found except at boreholes C-2 and E-10. The specimen taken at borehole E-10 was below the sanitary sewer on Wheatfield Avenue near 99th Street. The results at this location may have been influenced by exfiltration of chemicals from the sewer or flow through the sewer bedding material. At borehole C-2, the LaSalle Arterial was constructed above the historic location of a railroad right-of-way and the dirt- and gravel-paved Frontier Avenue. The chemicals found there may have originated from maintenance and use of these roadbeds.

   The extent of reduction in volatile compounds over the period from 1980 to 1983 may be determined by comparing borehole sample E-4 with EPA soil sample 11024 on the eastern alignment, 350 feet (107 m) north of Read Avenue. No volatiles were found in borehole E-4, but if the reportable quantity detection limit is compared to quantities reported in 1980, the volatiles decreased to 1/3 to 1/30 of their levels in 1980.

2. Semi-volatile chemicals detected in the recent assays are limited to the phthalates except at boreholes E-10 and C-2. Pesticides, in general, were not present at detectable levels in the recent assays, whereas, several pesticides were previously reported. Natural processes which may lead to reductions in these compounds include removal by solution into the groundwater, volatilization, or degradation on the soil substrate through a number of chemical and bio-chemical mechanisms.

7.2.2 Health and Environmental Criteria

The chemical data base obtained during the borehole investigation indicates the presence of nine volatile priority pollutants and eighteen extractable priority pollutants. It is important to place into proper perspective the significance of the levels of compounds present in the soils. Criteria to evaluate the significance of quantities of chemicals are not available for all priority pollutants. Several criteria considered pertinent to the assessments of wall location and worker exposure were identified:

- New York State Ground Water Quality Criteria (NYGWQ);
- National Interim Primary Drinking Water Standards (NIPDWS);
- EPA Draft Health Advisories (SNARL); and
- Occupational Safety and Health Criteria (OSHA).

The criteria (Table 5) do not specify limits for chemicals in soils, but rather for the air or water media. It is important to recognize that the basis for chemical level criteria are daily ingestion of water or inhalation/skin contact over an 8-hour workplace environment. The chemicals in the soil are subject to many natural chemical and physical processes which tend to establish an equilibrium for a particular set of environmental conditions. Only a fraction of each compound is available for transfer to the air or water media at any given time. Thus, direct comparison of the criteria with concentrations of chemicals present in the soil would overestimate the potential for adverse impact.

Three sets of criteria, NYGWQ, NIPDWS, and SNARLS, were established to provide goals or guidance regarding the quality of drinking water. The OSHA set of criteria were established to protect the worker during a typical 8-hour day exposure.

TABLE 5. SELECTED ENVIRONMENTAL AND HEALTH CRITERIA AND PHYSICAL PROPERTIES[a]

CHEMICAL	NYGWQ	NIPDWS	SNARLS Long Term	OSHA[b]	VOLATILITY
dichloromethane			150	500	438
trans-1,2-dichloroethene			270	200	326
chloroform	100	100		50	192
carbon tetrachloride	5		20	10	91
trichloroethene	10		75	100	74
benzene	ND[c]		70	10	95
tetrachloroethene			40	100	19
toluene			340	200	28
chlorobenzene				75	15
α BHC	ND				0.06
β BHC	ND				0.17
γ BHC	ND	4		$0.5 mg/m^3$	0.94×10^{-5}
1,3-dichlorobenzene					2.0
1,4-dichlorobenzene					1.0
1,2,4-trichlorobenzene					0.42
2-chloronaphthalene					
diethyl phthalate					0.05
hexachlorobenzene		0.35			1×10^{-5}
di-n-butylphthalate	770			$5 mg/M^3$	0.1
bis (2-ethylhexyl) phthalate	4200				2×10^{-7}
di-n-octyl phthalate					1.2
anthracene			25		
chrysene			25	$0.2 mg/M^3$	
fluoranthene			25		
pyrene			25		
1,2 dichlorobenzene	4.7			50	1.0

a values in µg/l or ppb unless otherwise noted.
b New York State groundwater criteria - class GA waters.
c National Interim Primary Drinking Water Standards.
d U.S. Environmental Protection Agency draft health advisories.
e Occupational Safety and Health Act workplace air standards.
f values in ppm unless otherwise noted.
g mm of mercury at 25°C unless otherwise noted.
h 10-day exposure
i not detectable.

7.2.2.1 Water Quality Criteria. Comparison of the criteria with the concentrations of chemicals found in the borehole program indicates only a few chemicals are present in the soil at concentrations greater than the water quality criteria listed:

Chemical	Borehole
dichloromethane	N-5, E-18, W-3.5W and W-9
chloroform	S-5
trichloroethene	E-10
benzene	E-10, S-5, S-6
toluene	E-10, S-5, S-6, C-2
α-BHC	E-10, C-2
β-BHC	C-2
γ-BHC	E-10, C-2
1,2-dichlorobenzene	C-2
di-n-butyl phthalate	W-2, W-6, W-8, W-10
bis (2-ethylhexyl) phthalate	E-7

All of the chemicals determined to be above the criteria used in this assessment (Figure 8) were found along the proposed wall alignment except β-BHC which was only found at borehole C-2 in the La Salle Arterial right of way.

New York State has established a nondetectable criterion for four of the chemicals listed above (α, β, and γ-BHC and benzene). The EPA has established an acceptable level of 4 μg/l for γ-BHC (also known as Lindane) and has suggested in draft form that 70 μg/l may be an appropriate health advisory

CRITERIA CHEMICALS
NON-CRITERIA CHEMICALS

NOTES:

1. NUMBERS IN PARENTHESES INDICATE CHEMICAL QUANTITY IN µg/kg (ppb)
2. CHEMICALS SHOWN ARE PRESENT IN QUANTITIES GREATER THAN THE FOLLOWING CRITERIA:
   a. NEW YORK STATE GROUNDWATER QUALITITY FOR PROTECTION OF DRINKING WATER RESOURCES: (GA CLASSIFICATION)

DI-N-BUTYL PHTHALATE	770 µg/l
CHLOROFORM	100 µg/l
TRICHLOROETHENE	10 µg/l
α-BHC	NOT DETECTED
β-BHC	NOT DETECTED
γ-BHC	NOT DETECTED
BENZENE	NOT DETECTED
BIS-(2 ETHYLHEXYL)-PHTHALATE	4200 µg/l
1,2 DICHLOROBENZENE	4.7 µg/l

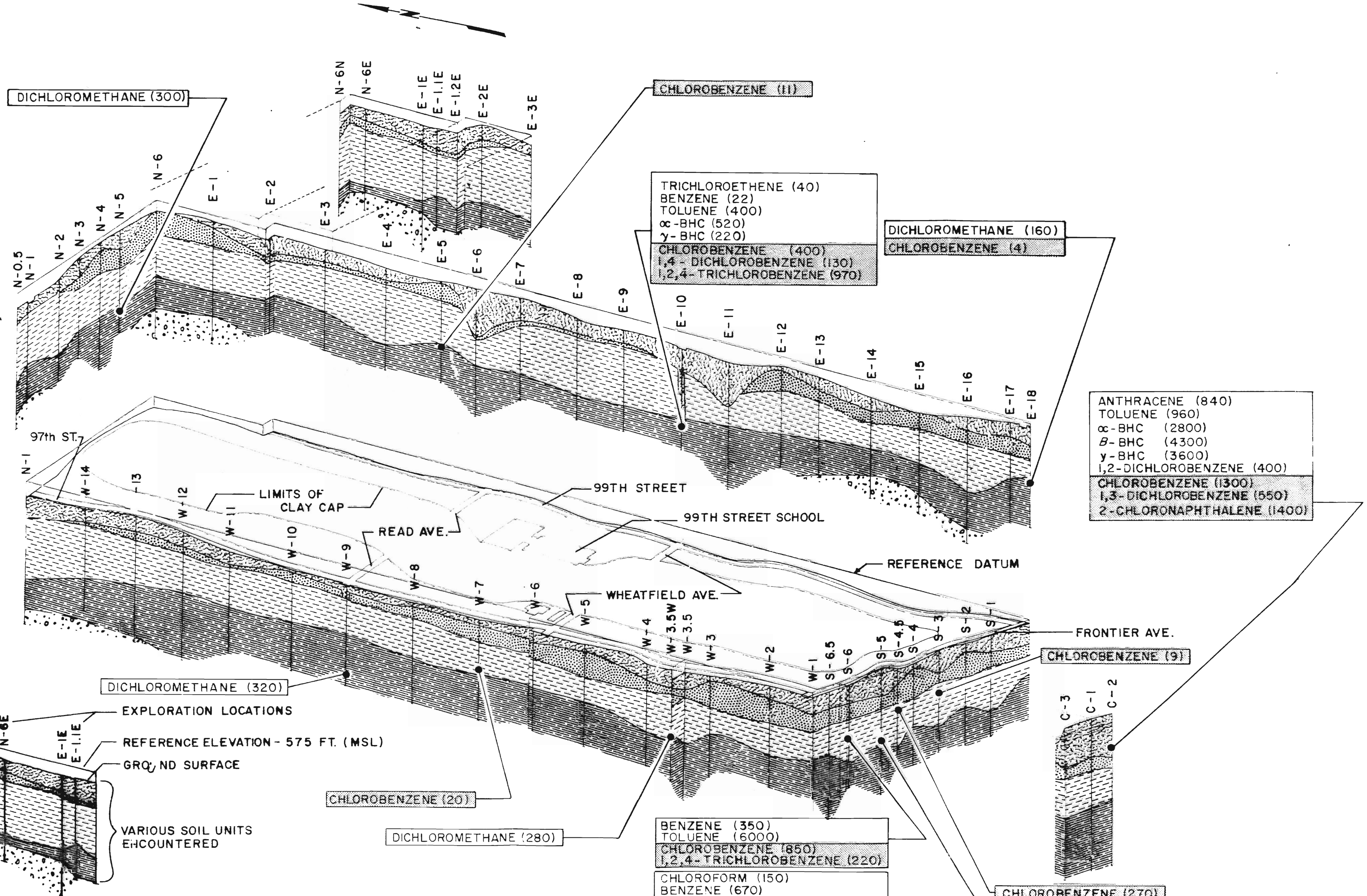
   b. U.S. ENVIRONMENTAL PROTECTION AGENCY DRAFT HEALTH ADVISORY (SNARL) FOR LONG TERM EXPOSURE IN DRINKING WATER:

DICHLOROMETHANE	150 µg/l
TOLUENE	340 µg/l
BENZENE	70 µg/l
ANTHRACENE	25 µg/l

   c. U.S. ENVIRONMENTAL PROTECTION AGENCY NATIONAL INTERIM PRIMARY DRINKING WATER STANDARD:

γ-BHC	4 µg/l

3. PHTHALATES DETECTED ARE NOT SHOWN.



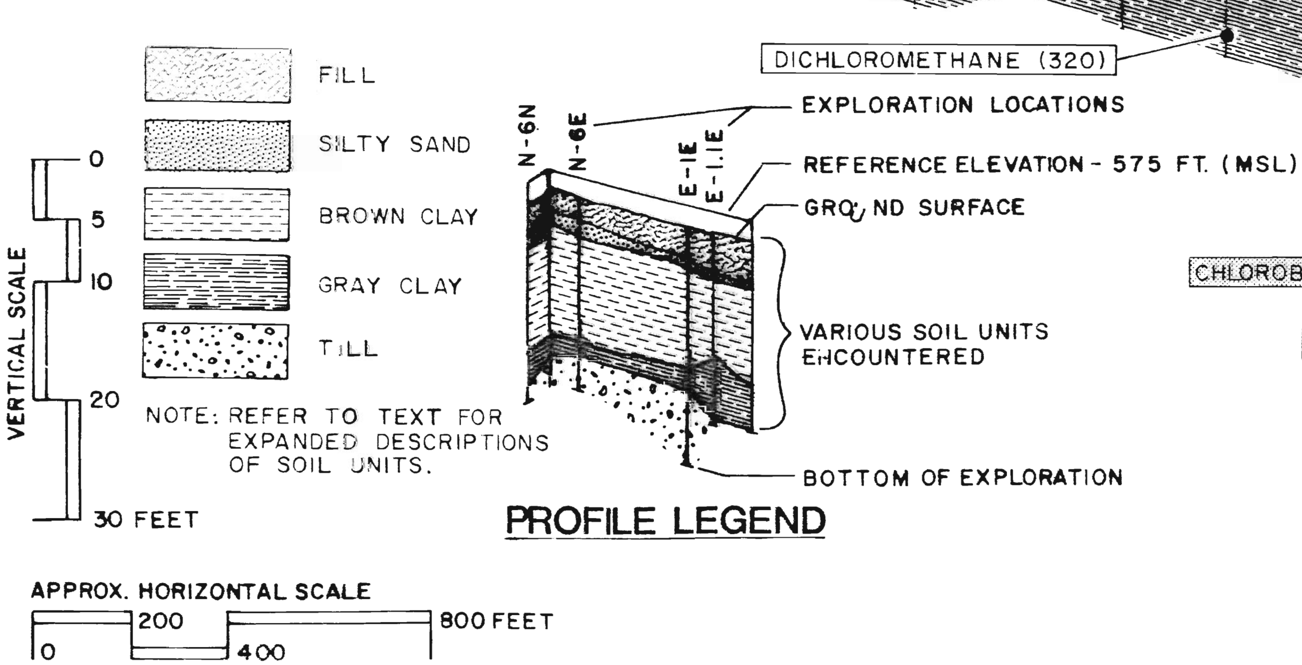


Figure 8
Selected Chemicals present in Soil
Love Canal Remedial Project (Task V-A)

level for benzene. Detection of γ-BHC in the borehole investigation was in each instance in concentrations greater than the EPA criterion. Benzene was detected at boreholes, S-5 and S-6 in concentrations greater than the EPA criterion.

The concentrations of chemicals detected along the proposed northern, eastern and western wall alignments were less than 5 times the criteria for drinking water supplies (except for the NYS benzene and BHC criteria). Chemicals along the southern alignment were present at relatively greater levels (up to 23 times greater than criteria). Chemical assay of the former roadbed underlying the LaSalle Arterial indicated the EPA criterion for γ-BHC was exceeded by a factor of 900. The southern alignment is the portion of the proposed wall which contains chemicals in soil which most exceed drinking water criteria.

The chemicals present in excess of water quality criteria warrant further evaluation. This may include estimating the potential impact on uses and discharge of groundwater, the potential for the identified chemicals to partition between the soil and groundwater to be transported to the barrier drain or other users and discharge points, and an assessment of the costs and risks associated with alternative wall alignments. A brief summary of health risks is provided in Appendix F.

Eight chemicals were detected (Figure 8) at quantifiable levels for which no numerical standards have been developed by EPA or NYS:

Chemical	Borehole
chlorobenzene	E-5,E-10,E-18,S-3,S-4.5,S-5,S-6,W-7
1,4-dichlorobenzene	E-10,S-5
1,2,4-trichlorobenzene	E-10,S-5,S-6
1,3-dichlorobenzene	S-5,C-2
2-chloronaphthalene	S-5,C-2
diethyl phthalate	E-2,E-18,S-2,S-3,S-4,S-4.5,S-5,S-6
butyl benzl phthalate	N-5,N-6,N-6N,N-6E,E-17,S-1,S-5,W-3.5, C-2,C-3
di-n-octyl phthalate	N-0.5,N-6,E-1,E-2E,E-7,E-8,E-12,W-3.5, W-7,W-8

Extensive scientific investigation and assessment of each chemical and public review and comment are part of the formal administrative procedures required to establish numerical standards. In the absence of such standrads, decisions regarding the signficiance of chemicals detected are subjective.

The origin of phthalates along the proposed wall alignment is not known. Phthalates are not known to be consituents of wastes deposited in Love Canal. Phthalates are commonly used as a plasticizer to provide flexibility to plastic materials such as polyvinyl chloride. Sampling and laboratory sources of potential specimen contamination were examined. Reagent blanks used during Soxhlet extraction and analysis of the soil specimens provided control of potential laboratory sources of contamination. No quantitative basis exists for assessing potential specimen contamination from plastic protective gloves used during specimen collection.

7.2.2.2 Air Quality Criteria. Comparison of the OSHA criteria with the concentrations of chemicals found in soils which may be excavated during construction of the proposed wall indicates that no OSHA criterion will be exceeded.

A number of chemicals present in the soils along the proposed wall alignment are sufficiently volatile, however, to cause a detectable odor at ambient conditions. An Odor Index (Verschueren, 1977) was developed as a tool to assess the potential for odors under certain evaporative conditions. The Odor Index is defined as a ratio of the vapor pressure (the driving force to introduce an odorant into the air) to the ability of an odorant to create a recognized response by 100 percent of the people exposed.

$$\text{Odor Index (OI)} = \frac{\text{vapor pressure (ppm)}}{\text{odor recognition threshold (ppm)}}$$

The odor index values were grouped into three categories:

Category I > 1,000,000 (high odor potential)

Category II 1,000,000 - 100,000 (medium odor potential)

Category III < 100,000 (low odor potential)

Of the chemicals detected during the borehole soil sampling program in 1983, none exceed the 100,000 limit for Category III (Table 6.)

TABLE 6. ODOR INDEX OF CHEMICALS DETECTED IN SOILS ALONG THE PROPOSED WALL ALIGNMENT.

CHEMICAL DETECTED	ODOR INDEX	ODOR POTENTIAL
chloroform	70	Low
carbon tetrachloride	540	Low
chlorobenzene	52,600	Low
benzene	300	Low
1,2-dichlorobenzene plus and 1,4-dichlorobenzene	26	Low
dichloromethane	2,100	Low
tetrachloroethene	370	Low
toluene	720	Low
trichloroethene	300	Low

NOTE: chemicals not listed, but detected, in the the March-April 1983 borehole investigation do not have a listed odor index.

Even where the detected concentrations are greatest, in the vicinity of the southern wall alignment (S-4.5 through S-6, and C-2) and the sanitary sewer at Wheatfield Avenue, they have a low odor potential. In addition, the level of worker exposure to these volatile compounds is expected to be lower than allowable OSHA criteria.

7.2.3 Proposed Wall Alignment

The significance of the geologic and volatile and extractable organic priority pollutant data collected during the borehole investigation (2,3,7,8 TCDD analyses not available for this report) and other data previously collected along the proposed wall alignment is that nine chemicals present in seven of the boreholes are in excess of water quality criteria established to protect drinking water supplies. Exceeding the water quality criteria, in and of itself, may not be the appropriate basis for any decision to relocate the wall. However, the levels of chemicals do suggest that further evaluation of the potential for extracting these chemicals through operation of the barrier drain and thus altering the location of the proposed wall is warranted. Particular areas of concern (Figure 8) are in the vicinity of the following boreholes:

- northern wall alignment (N-5);
- eastern wall alignment (E-10 and E-18);
- southern wall alignment (S-5 and S-6); and
- western wall alignment (W-9).

Areas outside of the proposed wall alignment which also contain chemicals in excess of the criteria are in the vicinity of the following boreholes:

- southern wall alignment (C-2); and
- western wall alignment (W-3.5W).

The boreholes encountered undisturbed soils and no evidence of chemical deposits indicating that the Love Canal excavation did not extend to the wall alignment.

7.2.4 Health and Safety of Construction Personnel

Assessment of the significance of the chemicals detected in the borehole investigation to worker exposure has been based on the volatile and extractable priority pollutants identified. Results of the 2,3,7,8 tetrachlorodibenzo-p-dioxin analyses were not available for inclusion in this assessment.

The data collected during the borehole investigation has established that concentrations of the chemicals found along the proposed wall alignment are below the limits established by OSHA for air quality in a work place environment. Some of the chemicals present are volatile, particularly in the vicinity of the southern wall alignment and the sanitary sewer under Wheatfield Avenue east of 99th Street where concentrations are greatest. However, it is estimated that the odor intensity will be low. While organic vapor inhalation is not anticipated to be a health problem, precautions should be taken to avoid contact with the skin or eyes or inhalation of dust or airborne chemicals which were detected along the proposed alignment. Selected information regarding the potential health effects of chemicals encountered in the boreholes is provided in Appendix E for use in establishing appropriate precautions. In view of the levels of chemicals detected, acute adverse effects to appropriately protected workers would not be expected.

SECTION 8

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