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CHARACTERIZATION AND ABATEMENT OF GROUNDWATER POLLUTION FROM LOVE CANAL CHEMICAL LAND FILL, NIAGARA FALLS, N.Y.

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SECTION I

BACKGROUND

For some 25 to 30 years the Hooker Chemical Company utilized an excavated area (shown in Figure 1) known as the "Love Canal" for the disposal of drummed chemical residues, process sludges (i.e., HCI cake) fly ash and other residues. The ~16 acre Love Canal is located in the southeast corner of the City of Niagara Falls known as the "Lasalle" area. It is bordered on the north by Colvin Boulevard; on the south by Frontior Avenue; on the west by 97th Street and on the east by 99th Street. The southermost portion of the site is about 1/4 mile from the Niagara River near Cayuga Island. Records of the exact contents of disposed drummed residues are not available, although it appears that chlorinated hydrocarbon residues are present.

The chronological transfers of property ownership will not be traced in this report. At the present time ownership of the 16 acre site is as follows:

6.58 acres between Read Avenue and Colvin Blvd. - City of Niagara Falls

3.53 acres between Read Avenue and Wheatfield Avenue - City of Niagara Falls Board of Education

5.98 acres between Wheatfield Avenue and Frontier Avenue - L. C. Armstrong, Kane Pa.

Except in the vicinity of the school property, the canal site is bordered by single family homes on 97th and 99th Streets. The dump site is used as a "short cut" crossing by children, as well as an unofficial playground in the areas between Frontier Avenue and Wheatfield and Read Avenue and Colvin Boulevard. The area to the west of the 99th Street Grammar School between Wheatfield Avenue and Read Avenue has been graded and is used as an official playground by the school children.

Over the many years which have elapsed since the drummed chemicals were landfilled and covered with soil, many of the drums have corroded or otherwise deteriorated. Drum contents have been exposed to percolating waters and in many instances to the atmosphere. There is evidence such as irregular depressions and potholes which indicate that as the drums closer to the ground surface became increasingly corroded or otherwise deteriorated the overlying soil cover sunk into the drums. Fume odors from the site are evident at all times, but are particularly oppressive on hot humid days.

Information on the general horizontal placement of drummed chemicals, sludges, and fly ash was provided to the City of Niagara Falls according to the map given previously. The placement of municipal landfill is also shown in Figure 1.

Field checking of the landfill using hand augur probes indicates that the horizontal distribution of drummed material may be more widespread than shown. Hand augur probes in the school playground between Read Avenue and Wheatfield Avenue indicate that this area does contain drummed materials. It is also evident that drummed material has been placed throughout the area between Wheatfield Avenue and Frontier Avenue.

Hand augur borings and visual observation show that the depths of soil cover over drums range from zero cover to about 6 feet. Generally, drums occur between 3 1/2 to 4 feet below the ground surface.

Using a hand auger it was not possible to ascertain the depths to which drummed and other residues were placed in the canal. The use of power equipment at this time for deep depth probes was deemed unwise since release of possibly toxic or explosive drum contents was feared. It was stated by some local residents that the canal was about 10' deep. However, it was stated by other residents that pits were later dug as deep as 35 feet about 1957 in 3 locations between Wheatfield Avenue and Frontier Avenue and filled with drums. (There reportedly was a large fire in one of these pits on one occasion).

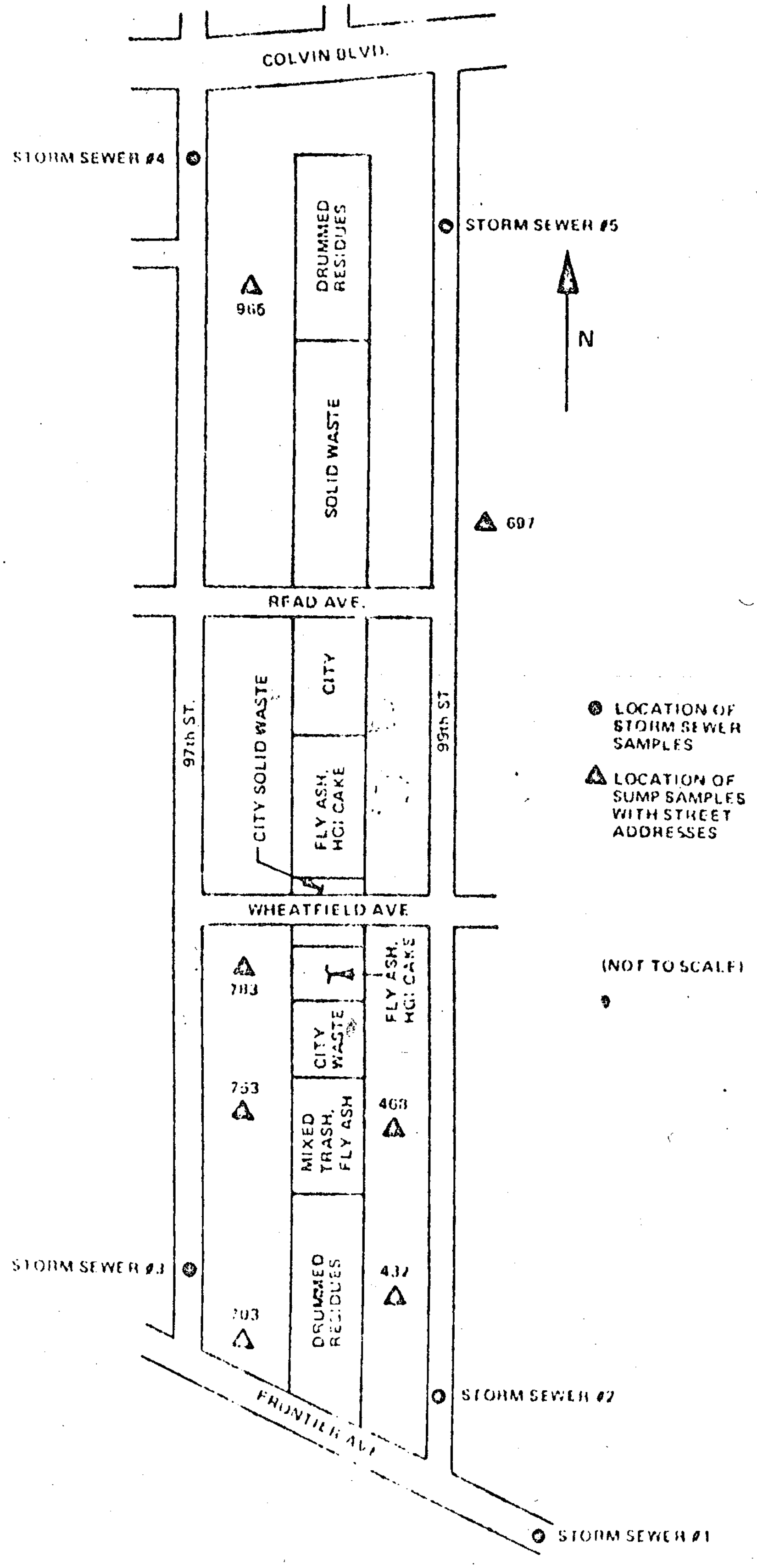

Figure 1 LOVE CANAL LOCATION AND SAMPLING POINTS

At this time the vertical distribution of drummed and other residues throughout the landfill is not adequately characterized. Recommendations for obtaining this information through seismic and/or resistivity measurements, supported by limited drilling, will be discussed in a later report section.

The Calspan Corporation was retained by the City of Niagara Falls to obtain more information on the nature and extent of the leachate problem from the Love Canal, and provide recommendations regarding interim and possibly permanent abatement of cotnaminated leachate from reaching home sump pumps, storm sewers, and ground water. Recommendations for abatement of fumes from individual sump pumps were also to be made. Calspan was to further assist the City of Niagara Falls in efforts to obtain federal Environmental Protection Agency (EPA) funds for demonstration or full scale application of control measures.

SECTION II

HYDROLOGY AND WATER QUALITY INVESTIGATIONS

The purpose of hydrologic and water quality investigations were to ascertain the following:

- Location and description of seasonal (i.e., "perched") water tables and permanent ground water tables
- Direction of contaminated groundwater flow
- Quality of shallow ground water and deep ground water

In order to obtain information on the above, a number of steps were taken. In the Spring (April 12, 1977) samples of water and solids were taken from sumps of selected homes bordering the landfill on 97th and 99th Streets. At the same time, samples of water were taken from sotrm sewers on 97th and 99th Streets and the main storm sewer pipe on 100th Street. Figure 1 shows the locations of the home sumps and storm sewers which were sampled. At the time samples were taken pH's were recorded, odors if present were described, and visual observations made. The locations, pH's and visual observations of sump samples and storm sewers are summarized in Tables 1 and 2 respectively.

Liquid and solid samples collected from sewers and sumps were analyzed by gas chromatography for chlorinated hydrocarbons. Samples from homeowner's sumps and from the storm sewers near the canal area collected on 12 April 1977 were extracted with hexane. The hexane was concentrated using a kuderna-danish evaporator to a small volume (5 ml) and a small aliquot injected into a gas chromatograph. An electron capture detector was utilized to detect amounts of chlorinated materials. Primary emphasis was placed on analyzing for polychlorinated biphenyls (PCB's) and hexachlorocyclopentadiene (C-56).

Results of these analyses are contained in Table 3. The chemical analyses along with visual observations, odor detection, and records of complaints to the city sewer authorities strongly support the

TABLE 1

SUMMARY OF SUMP PUMP
SAMPLING SURVEY

LOCATION OF SAMPLE SITE	DESCRIPTION OF SAMPLE	DATE OF SAMPLE
703 97th St.	Viscous oil-like substance floating on surface and coating the sides and bottom of sump. Antiseptic odor, pH = 7.2. One gallon grab sample obtained.	4/12/77
753 97th St.	A solid sample of black tar-like material was collected from the sides and bottom of sump. One gal. water sample also grabbed. Strong antiseptic odor. pH = 8.4.	4/12/77
[illegible]83 97th St.	Chemicals had been added to sump to keep odor down. Crust had formed on water surface. pH = 7.1.	4/12/77
[illegible]65 97th St.	Very little water in sump. One quart sample of solidified material collected. Odor is a problem only on occasions.	4/12/77
[illegible]7 99th St.	No residue or floating material. Water was turbid (may be water softener backwash). Very little odor. pH = 8.0.	4/12/77
[illegible]68 99th St.	Brownish solids on bottom of sump. Very little floating solids. Reddish-brown water ponds on surface of back-yard. Ponded surface water has strong chemical odor. pH = 7.2.	4/12/77
[illegible]32 99th St.	Relatively clear water, no residue or odor. pH = 7.4.	4/12/77

TABLE 2

SUMMARY OF STORM SEWER
SAMPLING SURVEY

LOCATION OF SAMPLE SITE	DESCRIPTION OF SAMPLE	DATE OF SAMPLE COLLECTION
Sewer #1 Manhole on Frontier Ave. (100th St. Outfall)	Moderate odor	4/12/77
Sewer #2 South end of 99th St. near house #401	Appears clean with no chemical odor. Water flowing south	4/12/77
Sewer #3 South end of 97th St. near house #721	Reddish color and residue present. Strong chemical odor. Water flowing south.	4/12/77
Sewer #4 North end of 97th St. near house #990	Red color, slight odor. Water flowing north.	4/12/77
Sewer #5 North end of 99th St. near house #754	No odor or surface sheen, appears clean. Water flowing north.	4/12/77

TABLE 3

CHEMICAL ANALYSES OF SUMP AND STORM SEWER SAMPLES

Sample Description	Components	Concentration
Sump water, 703 97th St.	PCB	2,700 μg/l
Sump solids, 703 97th St.	PCB	64,000 μg/g
Sump water, 753 97th St.	C56 or hexachlorobenzene	61,700 μg/l
Sump solids, 753 97th St.	PCB	8,060 μg/g
Sump water, 783 97th St.	PCB	1,260 μg/l
Sump solids, 468 99th St.	*	130 μg/g
Water, Sewer #1-100th St. outfall	C56 or hexachlorobenzene	700 μg/l
Water, Sewer #2-south end 99th St.	---	<20 μg/l
Water, Sewer #5-north end 99th St.	---	<20 μg/l
Water, Sewer #3-south end 97th St.	PCB	660 μg/l
Water, Sewer #4-north end 97th St.	PCB	3,200 μg/l

* unidentifiable - calculated using PCB standard.

general belief that the problem of contaminated leachate movement into sumps and storm sewers is far more serious on the 97th Street side of the landfill, and more particularly on 97th Street between Wheatfield Avenue and Frontier Avenue.

The data from the storm sewer samples strongly implies east to west movement of contaminated leachate. Both of the storm sewers to the east of the landfill (i.e., 99th Street) had <20 ug/l of chlorinated hydrocarbons, while the storm sewers to the west of the landfill (i.e., 97th Street) had high concentrations of PCB's. The sump solids from the residence sampled on 99th Street also had a much lower concentration of chlorinated hydrocarbons than did the solids and water from sumps on 97th Street.

During field investigation of the landfill, some samples of materials were taken directly from drums or from the soil above the drums which had become saturated with residues of viscous tar-like consistency and, in some cases, oil-like consistency. Three of these samples were analyzed using infrared spectroscopy rather than gas chromatography because of the possibility of gross contamination to analytical equipment from these samples. A summary of infrared analyses of samples is as follows:

1. An oil-like dark brown liquid which drained from a viscous sludge found ~3 feet below ground surface above a drum; strong chemical odor. Infrared scan shows this is an aliphatic-aromatic hydrocarbon.

2. A tan colored crystalline solid taken from a broken cardboard drum exposed at ground surface. Infrared scan shows this is an aromatic or chloroaromatic residue.

3. A brown black odorous viscous material found 2.5 [4.5] feet below ground surface. Drums encountered at 3.5 feet. Infrared shows this to be an organic acid residue.

The infrared spectra of the above materials differ significantly from the sludges taken from sumps on 97th Street. The migrating materials are not the same as those collected in the test borings. The samples collected on April 12 and May 28, 1977 show a widely different composition. These samples lead to the belief that the dump area must contain a large variety of waste constituents, some of which are being carried by percolating waters and others which are not. The most important fact, is however, that PCB's are actively being leached from the Love Canal area. PCB's

Data from monitoring wells to be described later, the flow directions in storm sewers, and field observation show that the direction of surface and shallow ground water flow is in a northeast to southwest direction towards the Niagara River from about Read Avenue which includes about two-thirds of the site. From about Read Avenue, north the direction of surface water and shallow ground water movement is towards the northwest. It is also clear from monitoring well data and field observation that the occurrence of perched water tables close to the ground surface or at the ground surface is far more frequent and persistent in the southern sector of the landfill from Wheatfield Avenue south to Frontier Avenue. The influence of microtopography on the collection of ponded surface water and high perched water is particularly evident to the east of the landfill behind a residence at 460 99th Street.

Although data collected from monitoring wells thus far is insufficient to definitely establish the direction of deep permanent ground water flow through and from the landfill, data from a U.S. Geological Survey report (Reference 1) indicates that flow will be almost directly west at least in the southernmost portion of the landfill rather than southwest to the Niagara River which is only one-fourth of a mile away. This is because of possible infiltration of water from the Niagara River into the deep permanent water table. In this case, it appears that deep groundwater from this vicinity is entering the industrial groundwater pumping complex located west of the Niagara Power Project conduit 4 miles west of the dump site.

Groundwater Monitoring Wells

In order to observe and measure shallow and deep ground water level depths in the vicinity of the Love Canal landfill and to measure ground water quality, a number of 6 inch diameter monitoring wells have been installed as shown in Figure 2. These wells were installed between May 27 and May 31, 1977. In order to compare water levels in the wells it was necessary to survey the well casings and tie them to a common reference elevation. This survey was completed by the City of Niagara Falls, Division of Engineering. Table 4 summarizes groundwater level monitoring data.

The data from the shallow monitoring wells confirm the presence of perched water tables in the southern portion of the landfill between Wheatfield Avenue and Frontier Avenue (monitoring wells #3,4). In this area free water is probably within two to three feet of the ground surface for all but the driest weather periods. During extended wet periods such as early Spring and late Fall the ground is probably saturated to the ground surface.

In the northern sector of the landfill between Read Avenue and Colvin Boulevard, shallow monitoring wells placed at 3.3 and 10 feet were dry at each sampling period. It is clear therefore, that this sector is much drier than the southern sector. Soil profile characteristics indicate that in wet seasons perched water tables will occur however. Continued monitoring of the shallow wells is needed to ascertain when a perched water table is present in the northern sector, and to what extent this perched water may become contaminated by chemical leachate.

The slope of the permanent groundwater table appears to be in the general direction of east to west with a corresponding flow in that direction. This observation correlates with the overall groundwater flow pattern for the southeastern corner of the City of Niagara Falls, but once again this determination is not a final one because the water levels in the deep wells have not yet reached their static elevations. To more accurately determine the direction of groundwater flow would require the installation of a third deep well near the landfill.

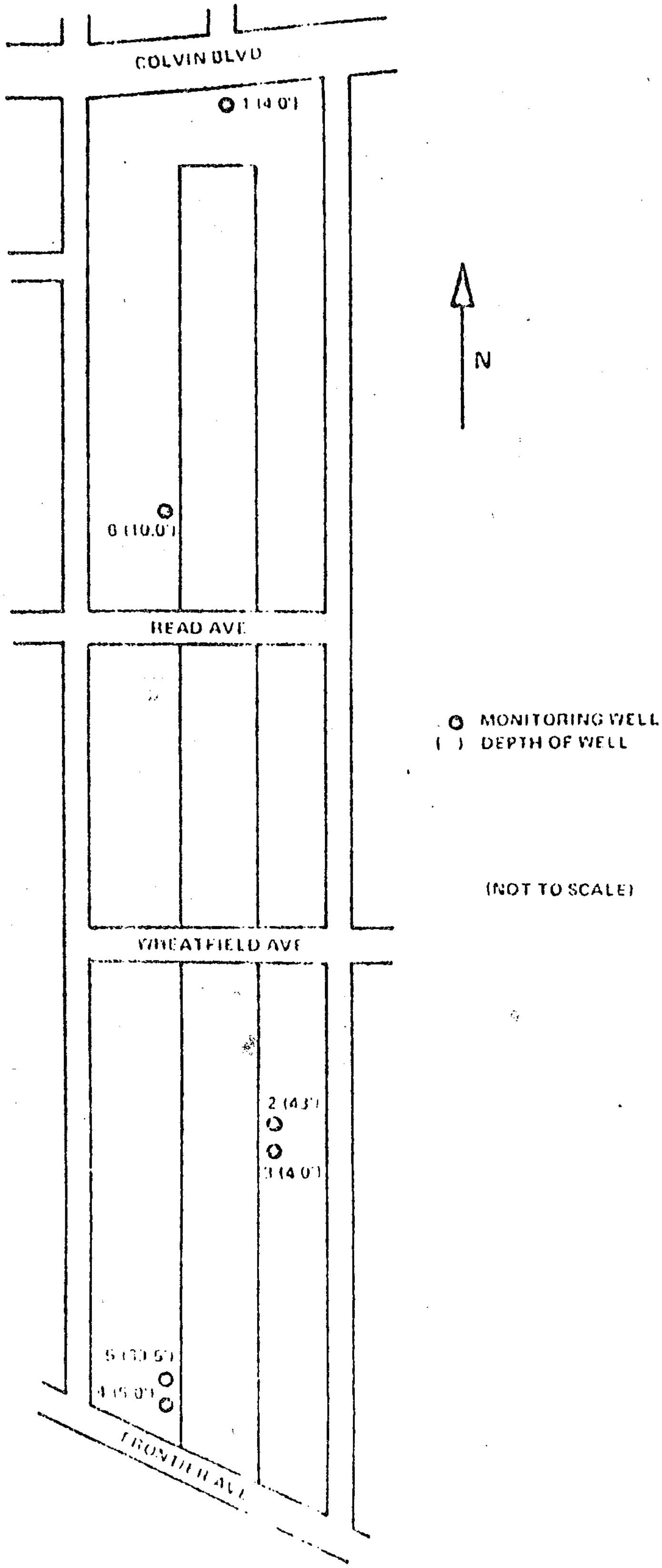

Figure 2 GROUNDWATER MONITORING WELL LOCATIONS

The direction of groundwater flow in the shallow or perched water table (assuming it does exist) cannot be established from the limited data in Table 4. However, the data from storm sewers as discussed previously strongly indicates overall east to west movement of both shallow groundwater and contained leachate contaminants. The two shallow wells are separated by a considerable distance with irregular surface topography and disturbed soil conditions in the landfill. In general, groundwater flow in a shallow aquifer follows the surface topography and may be influenced significantly by climatological conditions. Table 1 shows the water level in well #3 to be much more dependent upon rainfall than is well #4. This can be explained by the existence of a low area located adjacent to well #4, where surface runoff collects forming a groundwater recharge mound during wet periods (i.e., the week of 7/1-7/10).

Monitoring Well Water Quality

Samples of water obtained from both shallow and deep monitoring wells were analyzed for chlorinated hydrocarbon contamination. Results of these chemical analyses performed by gas chromatography are contained in Table 5. Positive identification of specific components including C-56, PCB's or hexachlorobenzene was not possible from data interpretation. Chlorinated hydrocarbons are reported as μg/l chlorine using lindane as a standard. This should not be interpreted as positive identification of lindane.

The limited monitoring well water quality data indicates that although there may be some contamination of the permanent ground water with chlorinated hydrocarbons (wells 4,5) the degree of contamination is far less than the shallow perched water (wells 3,4). Continued monitoring and analysis on a monthly basis at least through the Spring of 1978 should be conducted to definitely establish the relative degree of shallow and deep ground water contamination.

TABLE 4

Summary of Groundwater Level Monitoring Data

Observation Well No.	Depth of Well Casing	Elevation of Water Surface (Feet Above Sea Level) 6/9/77	6/20/77	7/11/77	7/27/77
2	43 ft. (to bedrock)	537.3	541.4	545.3	548.9
5	39.5 ft. (to bedrock)	538.8	541.3	543.0	544.2
3	4 ft.	571.54	570.33	573.17	571.83
4	5 ft.	570.63	570.32	570.24	569.67
1	3.3 ft.	Dry	Dry	Dry	Dry
6	10 ft.	Dry	Dry	Dry	Dry

TABLE 5

GROUNDWATER WATER QUALITY IN VICINITY OF LOVE CANAL

Sampling Date	Monitoring Well Number	Chlorinated Hydrocarbons as μg/l Chlorine*	Comments
6/20	2 (deep well)	1.2	All components early
7/06	2	1.0	in chromatogram
6/20	3 (shallow well)	9.7	Similar to a low
7/06	3	6.2	molecular weight PCB
6/20	4 (shallow well)	196.	Same column election
7/06	4	90.	range as above (#3)
			but different patterns
6/20	5 (deep well)	2.4	Most peaks early-but
7/06	5	0.6	different than in #2

* Lindane standard

In the samples analyzed no components could be identified as C-56, PCB's (1242), lindane, hexachlorobenzene.

SECTION III
SOIL INVESTIGATIONS

At the time that monitoring wells were installed, observations were made regarding the type of soils bordering the landfill. Hand augur borings were also made at a number of other locations on the perimeter of the landfill. In addition, records of soil borings made by the New York State Department of Transportation (DOT) when constructing the Lasalle Expressway just to the south of the landfill were examined.

These combined data sources show that from the ground surface to a depth of 4 to 6 feet the soils consist of silts and very fine sands originating from glacial lake deposits (i.e., lacustrine). Directly beneath the silts and very fine sands there is a thick compact layer of reddish lake laid sediments of low permeability. These silty clay sediments are estimated to contain about 60% silt and 40% clay. This layer of red clayey sediments is estimated to range from 15 to 20 feet in thickness throughout the landfill perimeter.

4-6' silt & sand

15'-20' silt c 40% clay

15'-20' Till

Compact glacial till of a silt loam to loamy texture lies beneath the lake laid clay deposits. The glacial till layer will range in thickness from 15 to 20 feet. The glacial till lies on top of limestone bedrock occurring at ~40 feet. In summary the sequence of soil layers on the perimeter of the Love Canal dump site is as follows:

0 to 4-6' - silts and fine sands
low permeability

4-6' to 19-26' - silts and clays of very low permeability

19-26' to 40' - compact loamy glacial till of low permeability

40'+ - limestone bedrock

The fact that the highly impermeabile clayey soil layer occurs beneath the more permeable silt and fine sand layer, along with the occurrence of contaminants in sumps suggests that leachate tends to move more easily laterally through the more permeable top layer rather than vertically through the clay. The limited data from monitoring wells discussed previously also supports the suggestion of preferential horizontal movement.

Therefore, interception of lateral flow of contaminated leachate is viewed as viable control alternative and is discussed in more detail in Calspan recommendations

SECTION IV

RECOMMENDATIONS

Based upon analysis of the data which is available to date on the nature and extent of the Love Canal leachate problem and the desire to effect immediate relief to homeowners in the area, a number of measures are recommended by Calspan for implementation during the current year (1977). In addition, Calspan recommends a number of monitoring activities and investigations aimed at further definition of the problem and feasibility of control.

A. Measures Recommended for Early Implementation

Fume Abatement--The appearance of leachate from the Love Canal chemical landfill in the sump pumps of homes in the vicinity of the landfill has resulted in the emanation of fumes from sumps into homes. It is recommended that in those homes which are significantly affected by fumes from sumps, the sumps be sealed such that fumes from the leachate-contaminated sumps are not released to the house interior. Figure 3 gives design of sump pump modifications which will vent fumes to the outdoors without escape from the sumps into house interiors. In a house to house survey conducted by the City of Niagara Falls Utility Department (Ref. 2), 21 houses were identified as having a sump residue and/or odor problem. These residences listed in Enclosure I constitute potential locations for installation of sump fume evacuation and water diversion systems.

The use of submersible pumps is preferred since more effective isolation of vapors is achieved. The use of any of the sump fume evacuation systems is contingent on assurance that an explosion hazard cannot be created in the sealed sumps. Although chlorinated hydrocarbons such as have been identified thus far in sump water samples are not very flammable or explosive, there may be other as yet unidentified fume constituents which could be more flammable. Before installation of sump fume evacuation systems, it is recommended that further testing and evaluation be conducted to assure that danger of fume explosion is negligible.

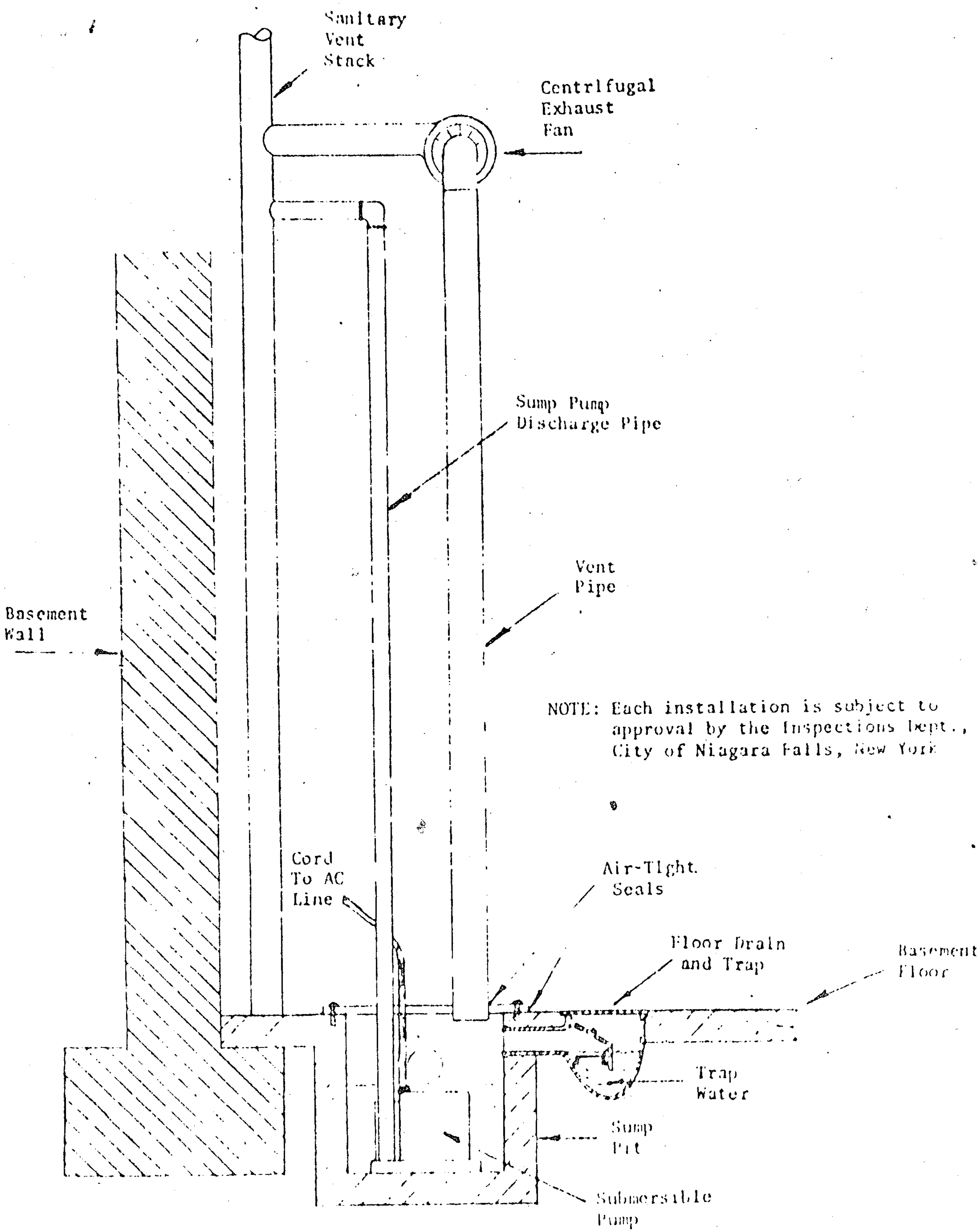

Figure 3 System for Containing Sump Pit

It is also recommended that sump pumps be tied into sanitary sewers rather than storm sewers. In this way, contaminated sump water will receive activated carbon treatment at the new treatment plant.

The cost of installing a new sump with an air sealed fume evacuation system in an individual home is estimated as ~$940 (see Table 6 for cost breakdown). In most homes, tie-in to the sanitary sewer will only involve addition of a small length of pipe and associated fittings. Data collected by the City of Niagara Falls on contaminated sumps adjacent to the Love Canal indicate that ~20 homes would require air sealed pump systems.

Increased Ground Cover--Field investigations have revealed that areas of the Love Canal containing drummed residues have corroded drums at depths of 3 feet or less with many being exposed at the surface. Organic material from the drums is sometimes visible at the surface or is encountered within a few feet of the surface. In addition, malodorous fumes from the leaked material are perceptible at all times and more acute on warm, humid days.

There is no doubt that increased cover over all or most of the land fill will improve protection of humans (especially children) and animals from direct exposure to leaked materials and also reduce fume emanation to a large extent. In a laboratory study* conducted by U.S. EPA, it was found that addition of compacted soil cover of less than one inch reduced release of hexachlorobenzene fumes by over 98% over a 55 day period.

It is therefore recommended that at least 12 inches of soil cover be added to the Love Canal site. Eight to 10 inches of the cover material should be of a high clay composition (i.e., silty clay) such as is found in subsoils of the Niagara Falls area. The added clayey soil should be compacted with a sheepsfoot roller or similar equipment and graded such

24"

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*"Problems Associated with the Land Disposal of An Organic Industrial Hazardous Waste Containing HCB," W. J. Farmer et al. In Residual Management by Land Disposal, Proceedings of the Hazardous Waste Research Symposium, Cincinnati, Ohio USEPA-600/9-76-015, July 1976

TABLE 6

ESTIMATED COST OF VAPOR CONTAINMENT SYSTEM

Sump pump	$130
Fan...............................	25
Floor Drain	70
Other Materials	200
Labor.............................	360
SUBTOTAL........	$785
Contingency (Tax) 20%......	155
TOTAL...............	$940

that a crown effect and impermeable condition is created. In this way surface water will run off to the sides of the site rather than permeate into the ground and become contaminated. Tests conducted by Calspan on clayey subsoils in this region indicate that permeability of compacted soil should be in the order of 10^{-8} cm/sec.

After grading and compacting of subsoil (~0.5 to 1% slope to each side of landfill) ~4 inches of top soil (silt loam, loam) should be added and seeded with a fast growing, hardy grass such as perennial rye.

The estimated costs of adding sufficient cover to the Love Canal site for fume suppression and human and animal protection is estimated as $363,000. This includes the cost of gutter drains for routing runoff to storm sewers. Details of this cost estimate are given in Table 7. Detailed inventory of the horizontal distribution of landfilled chemicals and drums may enable exclusion of a few acres for increased cover.

Tile Drain System--Investigation of the soil layering adjacent to the Love Canal revealed that approximately the top 5 to 6 feet of soil is a silt loam to fine sandy loam material of moderate permeability. This layer is in turn underlain by a 20 to 25 foot heavy silty clay layer of very low permeability. Significant quantities of materials leaked from the drums are being carried laterally through the upper 5 to 6 foot soil layer to sump pumps and storm sewers especially on the 97th Street side of the landfill.

It is believed feasible and beneficial to intercept this lateral movement by the installation of a tile drainage system placed just above the impermeable clay layer or at about a 7 foot depth. After placement of perforated tile in the bottom of the 7 foot trench, the trench is backfilled with small gravel to enhance movement of leachate to the tile. The tile system would be tied in with sanitary sewers for treatment of contaminated leachate.

Since data on water quality and visual observations indicated that contamination of storm sewers and sump pumps is most acute to the west of the landfill and in the southern sector (i.e. from Wheatfield Ave. to Frontier Ave.), it is recommended that tile be installed on these perimeters

TABLE 7

COST SUMMARY FOR COVER AND SURFACE DRAINAGE OF LOVE CANAL

1. Deliver, grade, and compact with sheepsfoot roller 10" of subsoil (high clay content); cover with 4" of top soil, grade, and seed to grass.

Affected area = 16 acres = 77,400 yd^2

Subsoil - deliver and spread	
21,500 yd^3 at \$4.50/yd^3	\$ 96,800
Subsoil - compact	
21,500 yd^3 at \$1.05/yd^3	22,600
Topsoil - deliver and place; fine grade, seed, and fertilize	
77,400 yd^2 at \$1.90/yd^2	147,100
TOTAL	\$266,500
Contingency (10%)	26,700
TOTAL FOR LAND COVER	\$293,200

2. Install 18" concrete gutter along surface perimeter of area.

Gutter length = 7,500 ft.

Evacuation	
840 yd^3 at \$2/yd^3	\$ 1,700
Gravel	
280 yd^3 at \$6/yd^3	1,700
Concrete gutter	
7,500 ft. at \$8/ft	60,000
TOTAL	\$ 63,400
Contingency (10%)	6,300
TOTAL FOR DRAINAGE GUTTERS	\$ 69,700
TOTAL FOR COVER AND SURFACE DRAINAGE	\$362,900

NOTE: If concrete gutter is installed in connection with drain tile, excavation and gravel costs become negligible resulting in a cost of \$66,000.

initially. At this time, data indicates that a tile drainage system is not needed on the 99th Street side from Wheatfield Ave. north to Colvin Blvd.

The estimated costs of the limited tile drainage system as described above is $40,200. The estimated costs of a tile drainage system completely encompassing the landfill is estimated as $57,200. Details of cost estimates are summarized in Table 8. The combined cost of cover, surface drainage, and subsurface drainage is estimated as $399,000.

It should be pointed out that the tile drainage system could be installed underneath the runoff gutter system and can be more economically done at the same time the gutter system is installed. If done at a later date, a separate trench would need to be installed or the existing gutter system removed and replaced after tile installation. In addition, the ~2500 yd^3 of soil removed during tile installation can be used as augmented cover on the landfill. In either case, uncontaminated surface runoff water should be segregated from contaminated subsurface flow.

Serious consideration was given to installation of an impermeable clay barrier between the drain tile systems and residences (i.e., on the outside perimeter of the tile drain trench) to further prevent lateral movement of contaminated leachate. However, such a measure would prevent movement of already contaminated water from the houseward sides into the tile drains and also increase costs considerably. For this reason, the implementation of clay barriers should be deferred for further evaluation and field study.

Monitoring--The installed wells should continue to be monitored and sampled periodically. Groundwater levels should be recorded on a once monthly basis. Sampling for analyses of organic constituents should be done every 2 - 3 months. It is recommended that monitoring, sampling and analyses be continued through a one year period or perhaps indefinitely until the problem is satisfactorily resolved.

TABLE 8

COST SUMMARY FOR SUBSURFACE TILE DRAINAGE OF LOVE CANAL

Install 6" perforated tile drain in 7 ft. deep trench; backfill with gravel within 1 ft. of ground surface; backfill remaining foot with compacted subsoil. (Hook-up to sanitary sewer not included)

Minimum/Maximum Lengths = 4,770 ft./6,770 ft.

	Minimum	Maximum
Excavation		
2500/3500 yd^3 at $\$4/yd^3$	\$ 10,000	\$ 14,000
Tile drain		
4770 ft/6770 ft at \$2.85/ft	13,600	19,300
Gravel		
2085/2960 yd^3 at $\$6/yd^3$	12,500	17,800
Backfill and compact subsoil		
355/500 yd^3 at $\$1.50/yd^3$	\$ 500	\$ 800
TOTAL	\$36,600	\$51,900
Contingency (10%)	3,600	5,200
GRAND TOTAL	\$40,200	\$57,200

supported by careful borings in selected locations. Discussions of this possibility with personnel from the Geology Department at SUNYAB have been initiated with the tentative expectation that their participatior in such measurements in further investigations which may be arranged.

Clay Barriers--Although the use of clay barriers to prevent lateral movement of contaminated water is not recommended on a full scale basis at this time, it is suggested that limited investigation of this technique be initiated in the event that such controls may later be desirable.

Such a limited investigation would involve the isolation of perhaps one residence or other area from lateral movement of contaminated leachate by installation of a clay barrier and evaluation of effectiveness through sump pump and/or well monitoring. The clay barrier would be place such that it goes through the more permeable upper six feet of soil into the heavy impermeable lower clay layer. The thickness of the clay barrier would be 2 feet and it would go to a depth of 7 to 8 feet.

Drawdown Wells--On the basis of available data thus far from shallow monitoring wells, the Calspan hydrology consultant does not believe that drawdown wells would be effective in reducing shallow ground water levels because of apparent very slow recharge of drawdown and the attendant necessity for close well spacing. To date, no monitoring or drawdown wells have been installed in the landfill itself. Two or three small (2" - 4" diameter) combined monitoring and test drawdown wells could be installed at various locations in the landfill to directly ascertain the nature of unattenuated leakage and leachate as well as ascertain drawdown potential.

Full scale drawn down wells cannot be recommended at this time in the absence of adequate information on the nature of drummed and leaked material and their horizontal and vertical distribution. In addition, expected drawdown cones of depression and treatability of evacuated liquids or slurries cannot be ascertained at this time.

It is cautioned that direct drilling into the landfill material with power equipment could puncture drums with release of possibly toxic or flammable liquids and gases. At the time that test drawdown and monitoring wells are installed, there must be fire fighting, anti-gas (i.e., gas masks) and other safety equipment on site. Drilled holes must be sealed with bentonite to prevent fume escape. Gases which are vented to the atmosphere from the well cap must be detoxified (possibly by venting through carbon filter) before release.

Air Pollution Investigations--Although the addition of soil cover is expected to eliminate or substantially reduce the release of fumes from the landfill, monitoring of air quality should be done to verify that an air pollution hazard no longer exists or the extent to which it may still exist.

(The initial step will be to determine the composition and concentration of air pollutants above and near the landfill through a reconnaissance air sampling program. Consideration is now being given to the nature and extent of this program (i.e., use of on-site mobile instrumentation vs grab sampling, meteorological conditions of sampling, ground moisture conditions during sampling, etc.).

If the reconnaissance program shows that the landfill continues to pose an air pollution problem, three additional steps will be required.

1. A permanent monitoring system must be established. The design of such a system must await completion of the initial survey.

2. A system must be developed to determine the (air pollution) source strength of the landfill so that atmospheric dispersion models can be applied for estimating the overall extent of the problem.

3. Control measures for reducing source strength must be considered.

Measures which may be investigated, given that an air pollution problem still exists after increased cover, are the use of activated carbon or other artificial barriers to prevent fume release.

In-situ Detoxification--The greatest potential for complete and final solution to the Love's Canal landfill problem rests in removal of drums from the landfill and detoxification of their contents, probably by incineration. This is also probably the most costly and the most dangerous to field personnel.

Without complete knowledge of the composition of materials in the drums, their toxicity, pyrotechnical properties, volatility, etc., or of the mechanical integrity of the drums themselves, it seems that excavation of the landfill will have to be approached with archeological caution. Furthermore, because of the vast quantity of material involved and the unknown hazards, it seems best to assemble the detoxification equipment on site rather than risk transportation through crowded industrial and residential districts surrounding the canal. To eliminate potentially hazardous atmospheric contamination in these same areas, we can even visualize housing the excavation itself in large air supported structures, with air discharged from the structure through activated carbon filters, or perhaps to provide oxygen to incinerators constructed on site to detoxify liquids.

Substantial investigation will be required to determine if such precautions are necessary or sufficient, and to provide a reasonably accurate estimate of the cost of these procedures. That investigation may be initiated by attempting a small scale, experimental excavation.

Following determination of the volumetric distribution of the drums within the landfill, a relatively small area with easy access could be selected for the investigation. Using hand tools, personnel equipped with suitable protective clothing and breathing apparatus would remove the soil cover and sufficient soil from the side of the landfill to permit inspection of the drums. During these operations, air pollution sampling and monitoring equipment would be used to determine the extent of atmospheric problems being created. Harnesses would be placed on the uppermost drums and a crane used to remove them. Samples would be taken from each drum to be tested for composition, combustion properties and explosive, including energy content, and possible detoxification procedures. The experiment would continue in this way, with removal of successively lower layers of drums to the clay substrate and until perhaps 100 drums had been excavated.

This kind of pilot operation represents the first step in the eventual solution of the Love Canal problem if recovery and decontamination of the landfilled pollutants is required.

REFERENCES

1. "Ground Water in The Niagara Falls Area, New York," Richard H. Johnston, U.S. Geological Survey, State of New York Conservation Department, Water Resources Commission, Bulletin GW-53, 1964.

2. Letter from John J. Burnett, Director of Utilities, City of Niagara Falls to John McMahon, Regional Engineer For Environmental Quality, New York State Department of Environmental Conservation, Buffalo, New York, dated February 18, 1977.

ENCLOSURE 1 - SUMP SURVEY

97th STREET

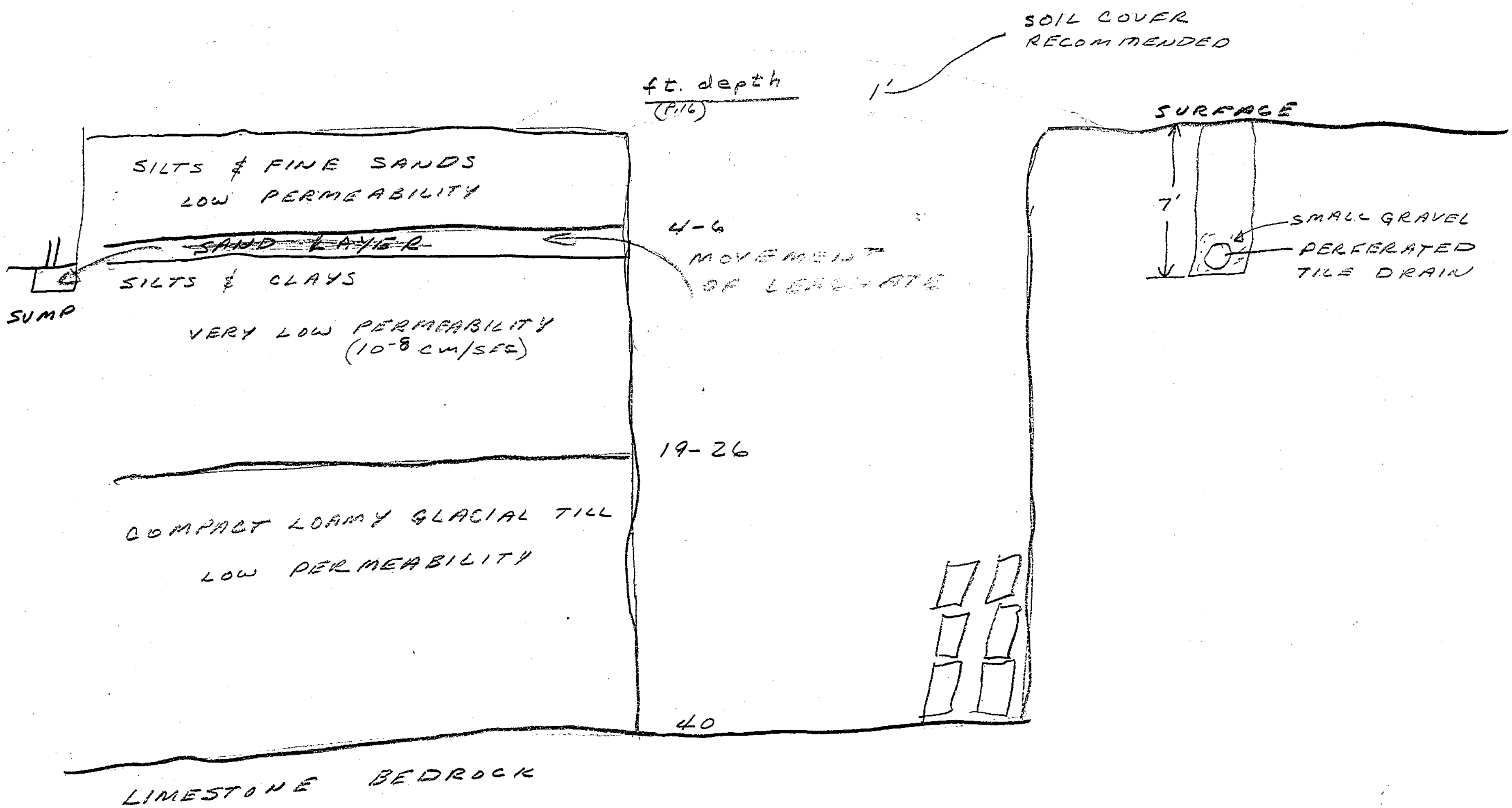
ADDRESS	OWNER	RESIDUE	ODOR	COMMENT
703	N.Y.S. Dept. of Transportation	Moderate	Light	
753	Peter P. Bulka, Jr.	Heavy	Moderate	
763	Edward Benns & Tuesday Lake	Heavy	Heavy	
767	Robert M. Huryn, Sr.	Moderate	Light	
779	James F. Masterson	Light	Light	
783	Henry P. Krzyskoski	Light	Light	Floor Drain
791	Arthur C. Phillips	Light	Light	
965	John R. Pietkiewicz, Jr.	Light	Light	
977	Russell F. Taylor	Light	Light	
983	James W. Phillips	Light	Light	

99th STREET

ADDRESS	OWNER	RESIDUE	ODOR	COMMENT
429	Paul E. Stott	Light	No Trace	
432	Pearl I. Crotzer	Light	No Trace	
468	Timothy Moriarty	Moderate	Moderate	
474	James A. Gizzarelli	No Trace	Heavy	
476	Aileen R. Voorhees	Light	Light	
[illegible]	Ronald Kowaleski		Moderate	Floor Drain
502	Mike Bakaysa		Moderate	Floor Drain
510	Robert J. Ridgeway		Moderate	Floor Drain
514	Joyce N. LaPolice		Moderate	Floor Drain
603	Edward F. Niedzielek	Moderate		
697	William MacPherson	Light	Light	

7/17/81
J.F.K.

SECTION THROUGH LOVE CANAL BETWEEN
WHEATFIELD AVE. & FRONTIER AVE.
(CALSPAN) (p.16)



The Fred C. Hart report was provided to the Environmental Protection Agency in fulfillment of its contract obligations. The report generally summarizes all information available on the landfill site, provides some new data on soil samples taken on and in the vicinity, and makes a number of general recommendations. The evaluation contained in the report will provide essential information for the actual engineering project on the site.