Chapter III

NON-POINT SOURCE DISCHARGES

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

3.1 Introduction

To assess the potential migration of toxic substances from non-point sources along the Niagara River, a site assessment program was initiated. On the U.S. (New York) side, the program was a joint undertaking by the United States Geological Survey (USGS), United States Environmental Protection Agency (EPA), and the New York State Department of Environmental Conservation (DEC). On the Canadian (Ontario) side, the Ontario Ministry of the Environment (MOE) and Environment Canada (DOE) shared the activities.

The program objective was to characterize toxic contaminants and determine the potential for contaminant migration from hazardous waste landfills on the U.S. side and closed and active landfills on the Canadian side. On the U.S. side, significant landfills within 5 kilometres (3 miles) of the Niagara River are discussed. On the Canadian side all landfills within the Niagara and Welland River drainage basin are discussed. Figure 3.1 illustrates the location of the sites having a significant potential for contaminant migration along the Niagara River in both New York and Ontario. Sixty-one sites have been designated as significant on the New York side based on U.S. criteria, and five sites on the Ontario side have been so designated, based on Canadian criteria. These sites are different and not directly comparable. Table 3.1 identifies the sites by the site numbers listed in Figure 3.1.

This chapter summarizes the results of the site investigation programs. More detailed descriptions of the significant sites grouped by sub-area and river segment are presented in Appendix B.

Detailed information on each of the sites investigated, analytical results, and details of remediation programs now underway are cited in separate reference documents issued by the U.S. and Canadian agencies.

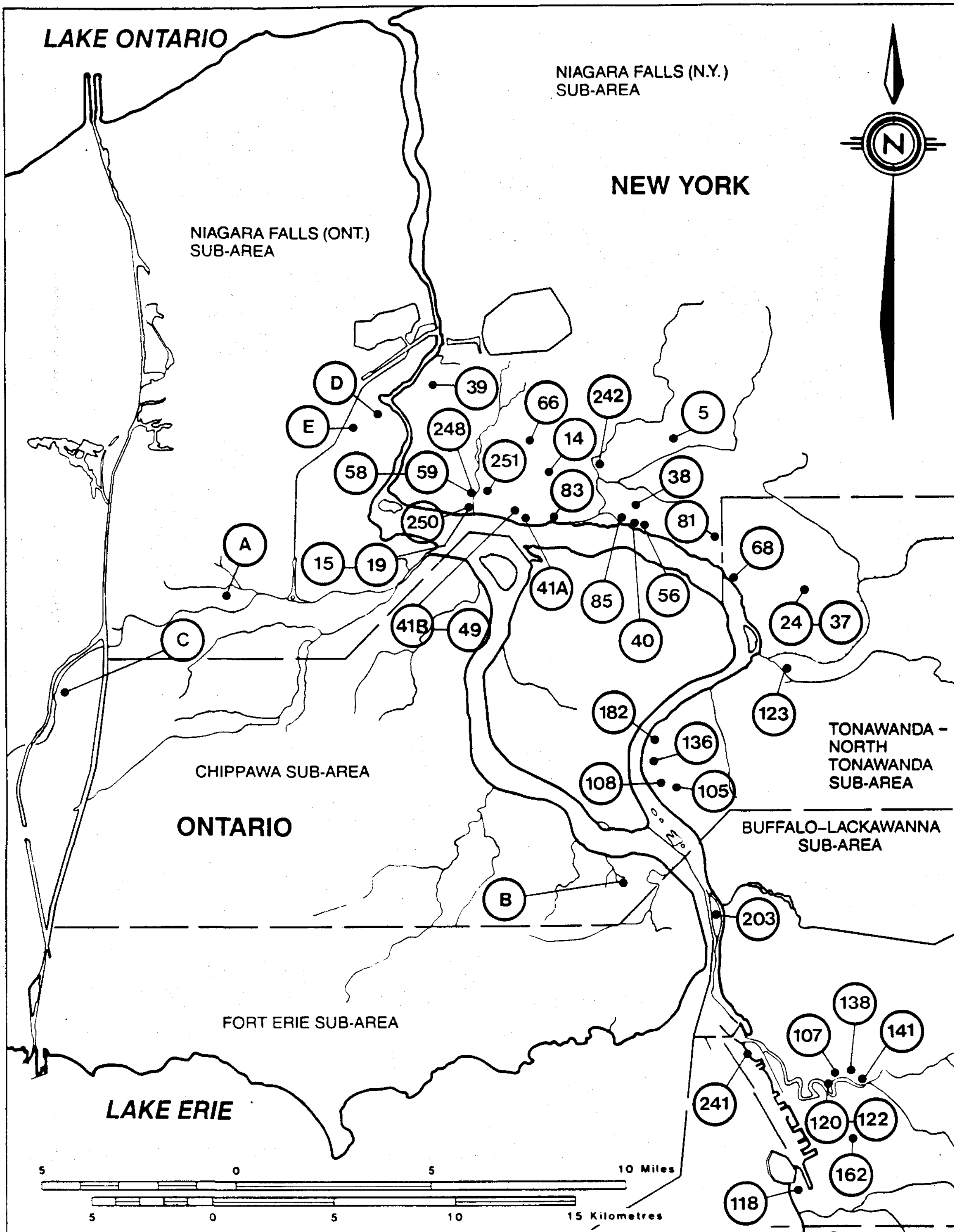

FIGURE 3.1 SITES HAVING A SIGNIFICANT POTENTIAL FOR CONTAMINANT MIGRATION

TABLE 3.1

IDENTIFICATION OF SITES SHOWN ON FIGURE 3.1

SITE NO.	SITE NAME	SITE NO.	SITE NAME
	NEW YORK		Niagara Falls, New York Sub-Area (Continued)
	Buffalo-Lackawanna Sub-Area		
118	Bethlehem Steel	83	Buffalo Avenue
162	Alltift	14	DuPont, Necco Park
241	Times Beach	66	Reichhold-Varcum Chemical Division
141	Mobil Oil Corporation	41A	Occidental Chemical, Buffalo Ave., S-Area
138	McNaughton-Brooks, Incorporated		
107	Allied Chemical	41B-49	Occidental Chemical, Buffalo Ave., Plant (9 sites)
120-122	Buffalo Color (3 sites)		
203	Squaw Island	251	Solvent Chemical
		250	DuPont, Buffalo Avenue Plant (6 sites)
	Tonawanda-North Tonawanda Sub-Area	248	Olin, Buffalo Avenue Plant (3 sites)
105	Allied Chemical	39	Occidental Chemical, Hyde Park
108	Tonawanda Coke		
136	INS Equipment Corporation		
182	Huntley Power Station		ONTARIO
123	Columbus-McKinnon Corporation		
24-37	Occidental Chemical, Durez Division (14 sites)		Fort Erie Sub-Area
68	Gratwick-Riverside Park		None
	Niagara Falls, New York Sub-Area		Chippawa Sub-Area
81	Niagara County Refuse Disposal	B	Fort Erie
56	Olin 102nd Street		
38	Occidental Chemical, Love Canal		
40	Occidental Chemical, 102nd Street		
85	Griffon Park		Niagara Falls, Ontario Sub-Area
5	Bell Aerospace Textron		
242	Charles Gibson	C	Atlas Steels
		A	Cyanamid, Welland
		E	Cyanamid, Niagara Falls
		D	CNR, Victoria Avenue

3.2 Niagara River Site Investigation Program: New York

In 1979, an Interagency Task Force on Hazardous Waste, composed of representatives of DEC, EPA, and the New York State Department of Health, identified 215 hazardous waste disposal sites in Erie and Niagara Counties. Of these and other sites identified since 1979, 164 are within three miles of the Niagara River and include sites used by major industries along the river for the disposal of large quantities and a wide variety of hazardous wastes. Prior to the Niagara River Toxics Project, 59 of the sites had subsurface hydro-geologic and chemical contaminant investigation undertaken. It was determined that 24 of the sites did not warrant an investigations based on the nature of the materials deposited, which generally consisted of slag, rubble, or general refuse. Two sites could not be investigated because the site locations could not be specifically identified. Seventy-nine sites required subsurface hydrogeological and chemical contaminant transport assessment to identify which were possible sources of groundwater contamination. The non-point source assessment program was undertaken to characterize the hydrogeological features and groundwater quality of each of three sub-areas along the Niagara River, to evaluate the hazardous waste disposal sites within each of those sub-areas, and to assess the impact of contaminants from the sites on the groundwater and on the Niagara River.

3.2.1 Determination of Significant Potential for Contaminant Migration to the Niagara River

To determine if a site had a significant potential for off-site contaminant migration, all geological, hydrological, and chemical data available for each site were used. A site designated as having significant potential for contaminant migration to the Niagara River met one or more of the following criteria:

1. geologic data collected on- and off-site indicated that permeable material conducive for contaminant migration exists.

2. hydrologic data collected on- and off-site indicated sufficient groundwater gradients (vertical and horizontal) for contaminant migration to occur.

3. chemical data collected on- and off-site indicated contaminant migration exits.

3.2.2 Hazardous Waste Sites Investigated by USGS

At each of 79 identified hazardous waste disposal sites, test holes were drilled in the unconsolidated deposits at each deposition area using a truck-mounted auger rig. The depth of the holes varied depending upon the thickness of a saturated zone if encountered, the top of the glaciolacustrine clay, the known depth of burial, or the depth determined necessary to describe hydrogeologic conditions at the site. An attempt was made to position the holes at the periphery of each site; however, in some instances the exact dimensions of the sites were unknown.

Core samples were collected where possible, and the cores were used to define site geology and determine zones of potential contaminant migration. Each of the test holes that intercepted the water table had a monitoring well installed to facilitate future sampling. Wells consisted of a 3.8-centimetre (1.5-inch) iron casing with a 0.6-metre x 3.2-centimetre (2-foot x 1.25-inch) diameter stainless steel well screen. For those sites where the water table was not encountered, a substrate sample was collected in the potential zone of contaminant migration. When saturated thickness was 6.1 metres (20 feet) or more, two additional holes were drilled, and wells were installed at intermediate and shallow depths.

All samples collected were analyzed for specific heavy metals and organic compounds. The parameters were selected by DEC based upon known chemicals disposed on the site and an assessment of historical disposal operations.

A summary of sites, test holes, and chemical constituents analyzed is given in Table B.1 in Appendix B. Drilling and sampling of the sites was undertaken from June 1982 through August 1982. Thirty sites were resampled in May 1983. The data from both sets of analyses are also included in this report.

3.2.3 Hazardous Waste Sites Not Investigated by the USGS

At the remaining 85 sites, information from EPA, DEC, USGS, consultant reports, and open literature was compiled to describe hydrogeology, water quality, types of material contained, and other site characteristics which could influence the impact of the site on water resources.

3.2.4 Sub-Area Hydrogeology Investigation

To define the hydrogeology of each sub-area, eleven locations were selected to drill test holes to the top of bedrock (Figure 3.2). This was accomplished with a conventional truck-mounted auger rig using hollow-stem augers. Core samples were collected using a split spoon assembly at five-foot intervals or where feasible. The cores were used to describe the local geology.

Upon reaching bedrock, monitoring wells were installed. Each well was surveyed for elevation in reference to National Geodetic Vertical Datum of 1929 (NGVD).

A water sample was collected from the deepest well at each of nine sites and analyzed for EPA priority pollutants. The remaining two wells were dry. The water sample was collected by evacuating the water within the casing three times using a peristaltic pump and then sampling with a stainless steel teflon-coated bailer.

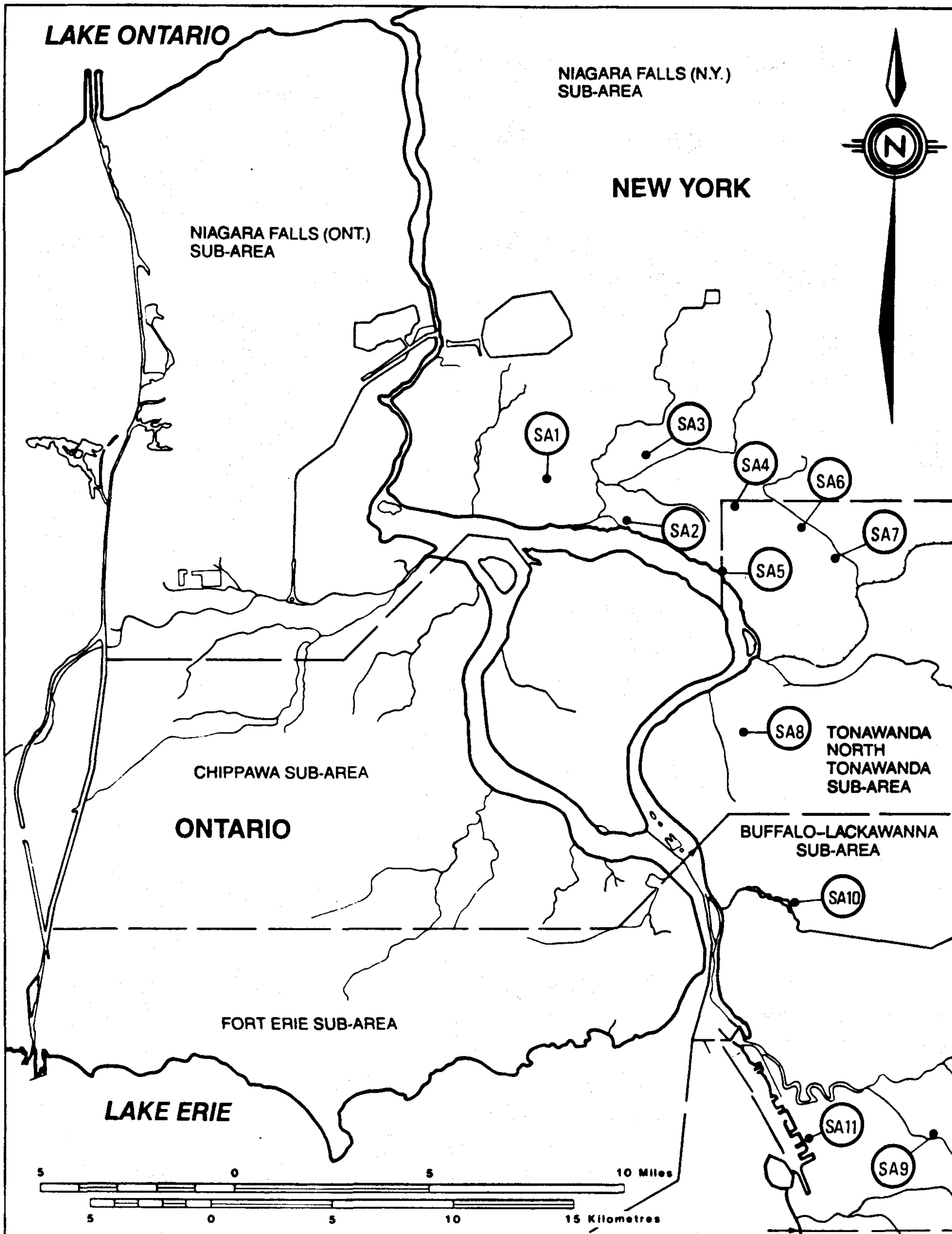

FIGURE 3.2 SUB-AREA WELLS DRILLED IN UNCONSOLIDATED DEPOSITS TO BEDROCK CONTACT

3.2.5 Upper Niagara River Investigation

Six monitoring wells were installed along the Robert Moses Parkway by a contract drilling company according to design specifications. The wells, 244 metres (800 feet) apart, were drilled to bedrock or to the top of a confining layer if present. Upon completion, 5 wells were evacuated and a sample of recharged water was analyzed for EPA priority pollutants. One well yielded insufficient water to obtain a sample.

3.2.6 Lower Niagara River Investigation

Four wells were drilled along the gorge of the Niagara River by a contract drilling company. Two were installed to the Rochester Shale and two in the first permeable zone in the Lockport Dolomite. Each well was sampled for EPA priority pollutants.

3.2.7 Bedrock Drilling

Eleven wells were installed in the Lockport Dolomite at five sites along the Falls Streel Tunnel (an unlined tunnel in the dolomite running in an east-west direction under the City of Niagara Falls, N.Y.). At each site at least two shallow wells were installed, one to the north and one to the south of the east-west trending tunnel. The shallow wells were screened at 1.5-4.6 metres (5-15 feet) below the water table in order to measure the piezometric surface of groundwater in the upper part of the Lockport Dolomite. Four deeper wells were installed at three of the sites in order to determine the piezometric surface of deeper water-bearing zones of the dolomite. Groundwater samples were collected from 9 wells and analyzed for the EPA priority pollutants.

3.2.8 Electromagnetic Conductivity Survey

An electromagnetic conductivity technique was employed at fifteen hazardous waste sites to determine the existence and extent of leachate plumes. The sites were traversed on a grid of approximately equal spacing. The variation in observed values can indicate changes in groundwater conductivity. This technique was also used to determine the areal extent of disposal sites.

3.2.9 Dredge Spoil Containment Sites

One nested piezometer was installed, consisting of three wells screened at approximately 1.5, 3.0, and 4.6 metres (5, 10, and 15 feet) below the fill surface at each of three dredge spoil containment sites near the head of the Niagara River. The deep well was screened at 4.6 metres (15 feet) or at the bottom of the fill material, whichever was less. Each well was sampled, and a surface water sample was taken from each site. Each sample was analyzed for EPA priority pollutants.

3.3 Niagara River Site Investigation Program: Ontario

In 1979, the Ontario Ministry of the Environment began province-wide waste site identification studies to catalogue all waste sites and to determine size and content of the sites. Monenco (Ontario) Ltd. carried out a more detailed Industrial Waste Site Identification Study for the Ministry in 1980 for industrial sites identified in the 1979 study in the West Central Region, which incorporates the entire Niagara Peninsula. Although some sites were identified by Monenco as potential problems, none of these was located in the Niagara-Welland River basin. In early 1982, it was decided that an evaluation should be made of waste sites in Ontario with the potential to contaminate ground and surface waters in the Niagara basin. This study was designed to provide an assessment of landfill sites in Ontario for inclusion in this report.

All landfill sites in Ontario located in the drainage basin of the Niagara and Welland Rivers were considered. Of the seventeen landfill sites under review, five were identified as having significant potential to leach contaminants and are hereafter described as "significant" sites. They were deemed to require further investigation. Investigations are currently underway by MOE and DOE at these five sites to assess whether leaching of contaminants is occurring from each site, and to determine the exact contents of the sites. Independent hydrogeological investigations are underway or are being planned at most sites. In addition, routine monitoring of leachate, runoff, or groundwater is underway.

3.3.1 Determination of Significant Potential For Contaminant Migration

A site was classified as having a significant potential for contaminant migration if it met either or both of the following criteria:

1) The site was known or suspected to contain solid or liquid wastes which contained chemicals on the EPA priority pollutants list.

2) The local terrain or geology associated with the site indicated that there was the potential for contaminants to migrate from the site to either the surface water system or the local groundwater aquifer.

3.4 Data Quality

The quantity and quality of data available for each landfill site varied considerably. On the U.S. side, the USGS conducted a site assessment program involving field investigations at 79 sites. For those sites where the organic samples were analyzed by the USGS laboratory, a GC/MS acid-base neutral scan was used as a screening test for the identification and quantification of organic compounds. At 59 of the sites previous investigations had been undertaken by site owners. These analyzes were carried out by numerous independent laboratories. Therefore levels of quality assurance and quality control vary.

Data from the USGS investigations are based upon a single sampling at each monitoring station. Where groundwater was encountered (20% of the borings) the USGS collected the sample at the top of the glaciolacustrine clay. Otherwise, soil samples just above the clay layer were analyzed. The interpretation of soil data is more difficult than that of groundwater data due to the attenuation characteristics of the soil.

In Canada, historical information for each non-point source was obtained by reviewing Ministry of the Environment files, air photo interpretation, and reviews of company records.

Canadian data are based primarily on the collection of one or two surface leachate samples per year. This may not completely account for seasonal and other variations, nor can the use of surface leachate samples by themselves give a complete picture of off-site chemical migration. Subsurface investigations of chemical migration have been done at 12 of the 17 Canadian sites.

On both the Canadian and U.S. sides of the river, site specific contaminant migration patterns have not been fully established. The usefulness of regional soil permeability values is limited for estimating site specific flows required for the calculation of loadings. Unlike point sources, contaminant migration from non-point sources cannot be quantified by the collection of "effluent" quality and flow data at a point of discharge. In almost every case, a non-point source presents a much more complex flow regime. Therefore, information regarding the non-point source contribution to Niagara River contamination tends to be qualitative and not suitable for the calculation of loadings. The calculation of loadings from non-point sources may be possible in the future, but to do this, the collection of site specific data will have to be expanded and integrated with regional drainage patterns.

3.5 Area Characterization

Landfill sites in the U.S. sub-areas are concentrated south of the City of Buffalo, in the middle third of the Tonawanda sub-area and in and around the City of Niagara Falls. Landfill sites on the Canadian side are not concentrated in any particular geographical area.

3.6 New York Sub-areas

3.6.1 Buffalo-Lackawanna Sub-area

Thirty-three disposal sites were investigated in the Buffalo-Lackawanna sub-area. Nineteen of these sites were involved in the USGS test drilling and sampling program. For the remaining 14 sites, existing data and consultant reports were reviewed to determine if a given site had a significant potential for groundwater contamination and off-site migration.

3.6.1.1 Hydrogeology

The hydrogeology of the sub-area is described relative to the bedrock type and characteristics, composition and permeability of unconsolidated deposits, direction and rate of groundwater movement, and groundwater quality.

The groundwater system within the Buffalo sub-area is a fractured bedrock aquifer and an overlying aquifer in the unconsolidated deposits.

The bedrock is composed of shales, limestones and dolomites. A stratigraphic column of the bedrock units is shown in Figure 3.3. The main sources of water are joints or fractures and solution cavities.

The hydrologic properties of the bedrock aquifer vary considerably. LaSala[1] reported that transmissivity (the rate at which water moves through a unit width of the aquifer under a unit hydraulic gradient) ranged from 0.0006 to 0.0105 metres^2/second (4,000 to 70,000 gallons per day per foot). This range reflects the amount and size of the fracturing and solution cavities.

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1 LaSala, A.M. Jr., Groundwater Resources of the Erie-Niagara Basin, New York, 1968.

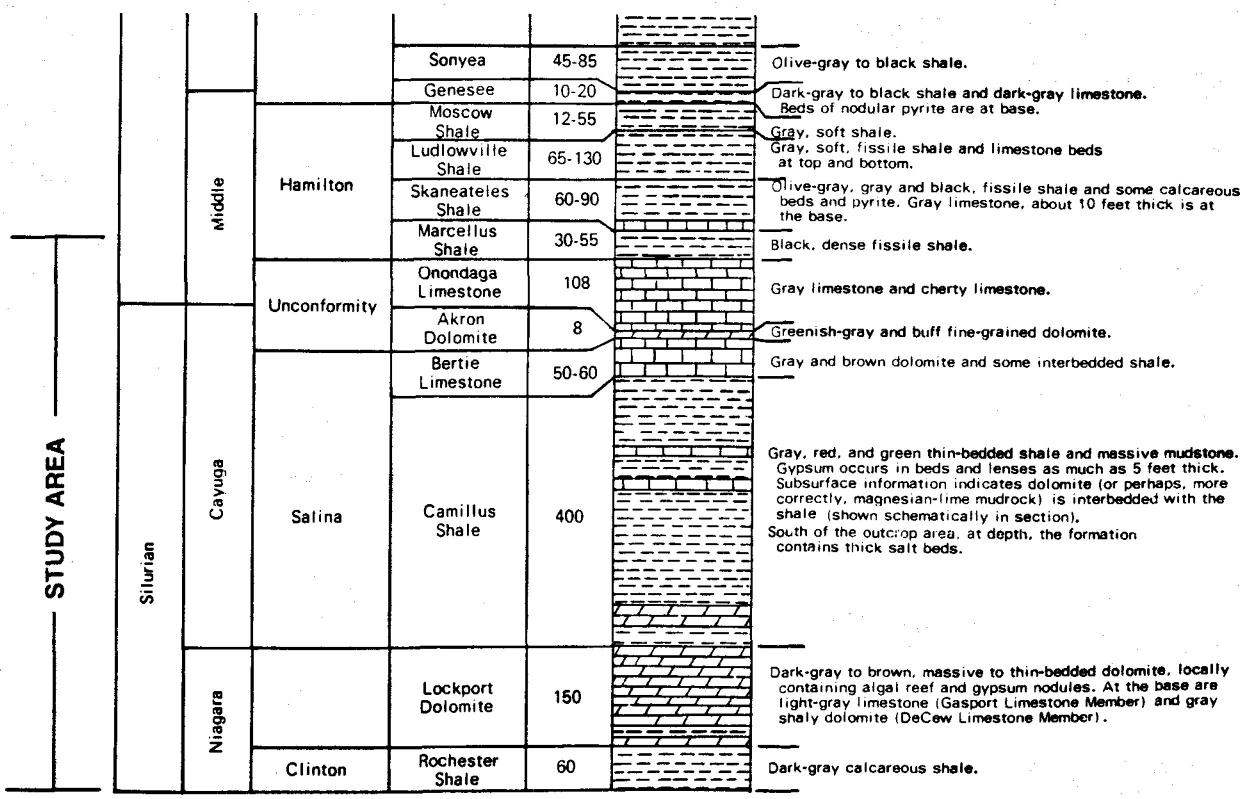
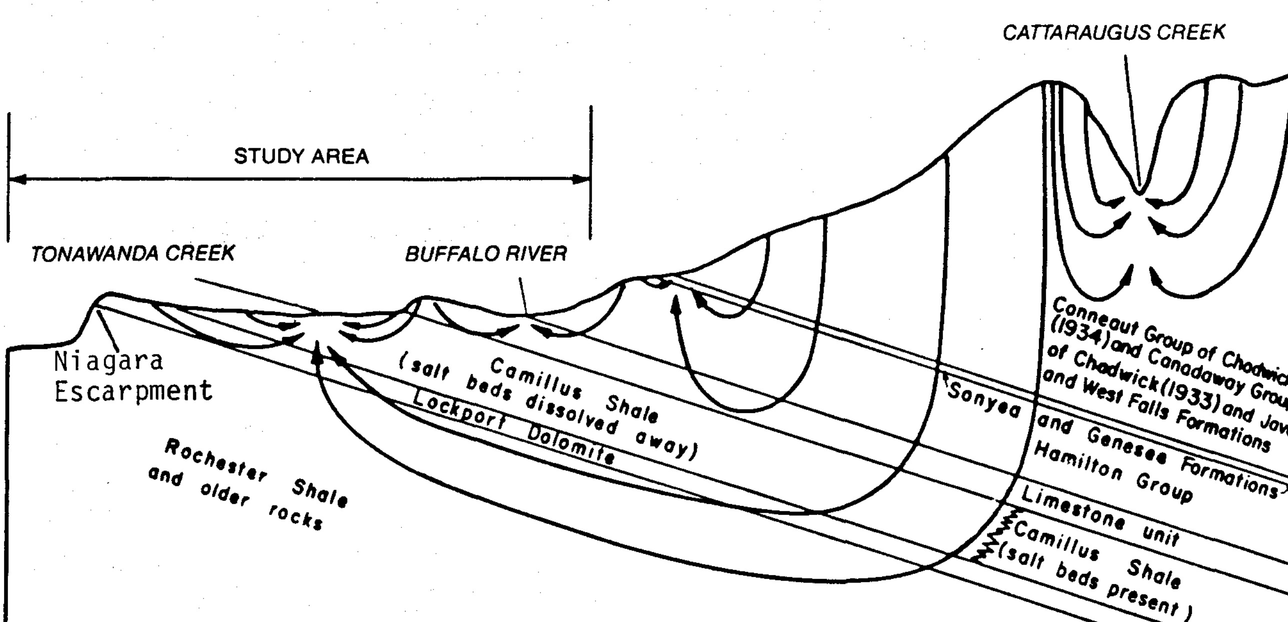


FIGURE 3.3 BEDROCK UNITS OF THE ERIE-NIAGARA BASIN (Adapted from La Sala, 1968)



Ground water circulates through a regional flow system from the Appalchian Uplands to the Erie-Ontario Lowlands and discharges near Tonawanda Creek and through less extensive but nevertheless major flow systems. Probable flow lines are shown. The deepest circulating water may move upward toward Tonawanda Creek through bedding joints in the Camillus Shale and Lockport Dolomite rather than through the underlying rocks.

FIGURE 3.4 INFERRED REGIONAL CIRCULATION OF GROUNDWATER (Adapted from La Sala, 1968)

The direction of groundwater flow is generally northward; a regional cross-section showing the direction of groundwater flow is shown in Figure 3.4. LaSala (1968) inferred a regional flow system exists from the Appalachian Uplands to the Erie-Ontario Lowlands.

Within the regional flow system, intermediate flow systems exist as indicated in Figure 3.4. In the Buffalo-Lackawanna sub-area, an intermediate flow system probably exists between the bedrock aquifer and Lake Erie, causing the direction of groundwater movement to be towards Lake Erie. The rate of movement would be dependent upon the size and amount of fractures in the bedrock.

The unconsolidated deposits consist of a glaciolacustrine clay and sand and gravel deposits. The main unit of these deposits is the glaciolacustrine clay. The 1982 drilling encountered the water table at various depths within the clay. Saturated sand stringers up to 7.6 centimetres (3 inches) thick were commonly found in the clay unit. These stringers were not extensive and often thinned out at short distances.

A seasonal water table exists above the clay unit during the wet seasons but not during the summer months. It is formed by the ponding of percolated precipitation above the relatively impermeable clay. As the water mounds, gradients toward natural or man-made topographic lows develop. Eventually the groundwater discharges to nearby surface water bodies. As the seasons become drier and hotter, vegetation increases and takes up the remaining groundwater through transpiration.

The general range for the permeability of the unconsolidated deposits is from 10^{-4} to 10^{-8} centimetres per second (2.8×10^{-1} to 2.8×10^{-5} feet/day). The larger value can be attributed to sands and silty materials which have a considerably greater permeability than that of the natural glaciolacustrine clay.

The direction of groundwater movement in the unconsolidated deposits is generally toward the major surface water bodies: Lake Erie, the Niagara River, and the Buffalo River. The groundwater flow pattern is bisected in the northern part of the sub-area, where bedrock is less than 1.5 metres (5 feet) below land surface. This zone diverts flow northward and southward.

3.6.1.2 Groundwater Quality

The quality of groundwater in the bedrock aquifer has been documented by LaSala (1968). Concentration ranges for sulfate, hardness, and chloride were mapped for the sub-area. Sulfate concentrations ranged from 100-500 mg/L and hardness (as $CaCO_3$) ranged from 150-1000 mg/L. Chloride concentrations ranged from 100-1500 mg/L, and specific conductance ranged from 1000-9000 micromhos per centimetre at 25°C.

Two sub-area wells (SA-10 and SA-11) drilled in the unconsolidated deposits to the bedrock contact were dry. A water sample was collected in the fall of 1982 from an observation well (SA-9) screened above the bedrock contact in the eastern portion of the sub-area just east of the Buffalo city line. This sample was analyzed for EPA priority pollutants. The results are shown in Table 3.2. Elevated levels of cadmium (22 ug/L), lead (400 ug/L), nickel (210 ug/L), and zinc (53000 ug/L) were observed. Minor amounts of some organic compounds were also quantified.

3.6.1.3 Summary of Significant Sites

Of the 33 sites investigated in the Buffalo sub-area, 10 sites were designated as having a significant potential for contaminant migration (Table 3.3).

3.6.2 Tonawanda-North Tonawanda Sub-area

3.6.2.1 Hydrogeology

The groundwater hydrogeology of the Tonawanda-North Tonawanda sub-area is similar to that of the Buffalo-Lackawanna sub-area. A bedrock

TABLE 3.2

CHEMICAL DATA FROM UNCONSOLIDATED DEPOSITS AT BEDROCK CONTACT
SUB-AREAS ALONG THE NIAGARA RIVER
(ug/L)

PARAMETER	BUFFALO-LACKAWANNA SUB-AREA		TONAWANDA-NORTH TONAWANDA SUB-AREA		NIAGARA FALLS, N.Y. SUB-AREA	
	Maximum 2/	Mean 2/	Maximum	Mean	Maximum	Mean
Antimony 1/	2	2		ND	4	1.3
Arsenic 1/	17	17	7	2.8	4	2.3
Beryllium 1/	ND	ND	ND	ND	ND	ND
Cadmium 1/	22	22	22	14.8	100	43.3
Chromium 1/	1	1	2	1.2	8	3.3
Copper 1/	160	160	65	29.6	800	290
Lead 1/	440	440	290	204	2,200	853
Mercury 1/	ND	ND	ND	ND	ND	ND
Nickel 1/	210	210	33	20	980	341
Selenium 1/	1	1	ND	ND	ND	ND
Zinc 1/	53,000	53,000	16,000	4,054	640,000	217,000
Methylene chloride 1/	3.2	3.2	210	79	375	174
Toluene 1/	3.9	3.9	410	128	230	130
Ethyl benzene 1/	0.4	0.4	25	6.8	5.9	3.7
DDT 1/	0.17	0.17	ND	ND	ND	ND
Chlordane 1/	0.19	0.19	1.6	0.36	0.08	0.03
Naphthalene 1/	1	1	ND	ND	ND	ND
Dimethyl phthalate 1/	4.2	4.2	ND	ND	ND	ND
Diethyl phthalate 1/	19	19	ND	ND	7.7	3.4
Dibutyl phthalate	4.1	4.1	ND	ND	12	4.7
Butyl-2-methylpropyl phthalate	ND	ND	ND	ND	ND	ND
Phenol 1/	4.2	4.2	ND	ND	ND	ND
Benzene propanioc acid	ND	ND	ND	ND	ND	ND
2,3,3,4-Tetramethylpentane	ND	ND	ND	ND	ND	ND
2-Methyl-1-propene	ND	ND	5.6	1.9	ND	ND
Hexane	ND	ND	41	27	12	4
Alpha chlordane	ND	ND	1.08	0.36	ND	ND
1,4-Dimethylbenzene	ND	ND	ND	ND	ND	ND
1,2-Dimethylbenzene	ND	ND	ND	ND	ND	ND
2-Heptanone	ND	ND	ND	ND	ND	ND
Mirex	ND	ND	ND	ND	0.21 3/	0.07 3/
2-6-Dimethylheptane	ND	ND	ND	ND	18	6
2-Decanone	ND	ND	ND	ND	57	19
1-(2-Butoxyethoxy)ethanol	ND	ND	ND	ND	8	2.7
1-Chloro-2-ethenyl-1-methylcyclopropane	ND	ND	ND	ND	4.7	1.6

1/ EPA-priority pollutant.
2/ One sample.
3/ Detected in one sample at Griffon Park.
ND = Not Detected.

TABLE 3.3

SIGNIFICANT HAZARDOUS WASTE SITES
BUFFALO-LACKAWANNA SUB-AREA

Site No.	Site Name	Operational Dates	Area (Acres)	Contents
118	Bethlehem Steel	1920's-1984	750 (Fill Area)	Spent pickle liquor, tar sludge, ammonia still lime sludge and metal sludge
162	Alltift	1950's-1070's	25	Dye, oil sludge, phenolic compounds, chrome sludge, copper sulfate, nitrobenzene, monochlorobenzene, naphthalene, auto demolition waste, core sands, fly ash and foundry sand
241	Times Beach	1971-1876	46	Dredge spoils from Buffalo River, Buffalo Harbor and Black Rock Canal
141	Mobil Oil	1950's-1076	3	Cooling waste silt, separator floats and sediments, tetraethyl lead, lube sludges, spent catalysts, soil contaminated with asphalt and fuel oil
138	McNaughton-Brooks	1960-1066	1	Xytol, toluol, and paint sludge
107	Allied Chemical	1930-1977	1	Vanadium pentoxide catalyst, sulfate sludges, sulfuric and nitric acids, salts, slag and polymerized sulphan
120-122	Buffalo Color	1930-1933	3	Iron oxide sludge, metal sludge which may contain trace organics, ammonium sulfate (well injection)
203	Squaw Island	1954-1970	60	Foundry sand, incinerator residue, trace oils, resins and municipal waste

aquifer exists in the Camillus Shale which is overlain by an aquifer in the unconsolidated deposits.

The main sources of water within the bedrock aquifer are joints or fractures and solution cavities found within the unit. The Camillus Shale is estimated to have a transmissivity value that ranges from 0.00105 to 0.0105 $metres^2$/second (7,000 to 70,000 gallons per day per foot) (LaSala, 1968). Regionally, groundwater in the shale is projected to discharge into Tonawanda Creek and the Niagara River.

The unconsolidated deposits consist of morainal and clay materials. The morainal material is generally a clay-like till with a low permeability. During the test drilling program, groundwater was encountered at various depths within the clayey units. Also encountered were thin stringers of very permeable sand which initially yielded considerable amounts of water. The yield diminished as the stringers became dewatered.

A seasonal water table exists in this sub-area in the overlying clay deposits similar to that found in the Buffalo sub-area during periods of high precipitation. The water table discharges into areas of low topography and eventually into nearby surface water bodies.

Permeability tests were performed on several clay samples taken from disposal sites. The vertical permeability was about 10^{-8} cm per second (2.8×10^{-5} ft/d). This low permeability is probably the cause of the small fluctuation of water levels in monitoring wells screened in this stratum. The reported fluctuations are generally less than 0.9 metres (3 feet) throughout the year.

The direction of groundwater movement in the unconsolidated deposits is generally toward the major surface-water bodies: the Niagara River and Ellicott and Tonawanda Creeks.

3.6.2.2 Groundwater Quality

The quality of groundwater in the bedrock aquifer has been investigated by LaSala (1968). Concentrations for sulfate ranged from 100-1000 mg/L, and hardness (as $CaCO_3$) ranged from 1500-3000 mg/L. Chloride concentrations ranged from 100 to 1500 mg/L and specific conductance ranged from 1500-9000 micromhos per centimetre at 25°C.

Water samples were collected in the fall of 1982 from five observation wells (SA-4, 5, 6, 7 and 8) screened in the unconsolidated deposits above the bedrock contact, and analyzed for priority pollutants. (Figure 3.2). Four of the wells were located along the eastern edge of the sub-area and one was located adjacent to the Niagara River. The results of the analyses (Table 3.2) indicated elevated concentrations of cadmium (22 ug/L maximum, 14.8 ug/L mean), lead (290 ug/L maximum, 204 ug/L mean), nickel (33 ug/L maximum, 20 ug/L mean), and zinc (16,000 ug/L maximum, 4,504 ug/L mean). Methylene chloride (210 ug/L maximum, 79 ug/L mean) and toluene (410 ug/L maximum, 128 ug/L mean) were detected, along with a limited number of other organic compounds at minimal levels. Chlordane (1.6 ug/L) was quantified along the eastern edge of the sub-area. Alpha-chlordane (1.08 ug/L) was detected at one well adjacent to the Gratwick-Riverside Park site along the Niagara River.

3.6.2.3 Summary of Significant Sites

Sixty disposal sites were investigated in the Tonawanda-North Tonawanda sub-area. Twenty-nine of these sites were involved in the USGS test drilling and sampling program. Existing data and consultants' reports were reviewed for the remaining 31 sites to determine if a given site had a significant potential for groundwater contamination and off-site migration.

Of the 60 sites investigated in the Tonawanda sub-area, 20 sites were designated as having a significant potential for contaminant migration. (These are listed in Table 3.4).

TABLE 3.4

SIGNIFICANT HAZARDOUS WASTE SITES
TONAWANDA-NORTH TONAWANDA SUB-AREA

Site No.	Site Name	Operational Dates	Area (Acres)	Contents
105	Allied Chemical	1950-1960	1	Scrap chlorinated and non-chlorinated polyethylene and spent catalyst
108	Tonawanda Coke	1930-1979	5	Fly ash, cinders and tar sludges
136	INS Equipment	1960's-1970's	55	Pit sludge, cutting oils, grinding waste and foundry sand
182	Huntley Power Station	1958-1970's	55	Phenol tars, chlorinated benzenes, foundry sand and slag
123	Columbus-McKinnon	1930-1965	1	Waste cutting oils
24-37	Occidental Chemical, Durez Division (14 sites)	1930-1973	40 (Plant Area)	Phenol tar, chlorobenzenes, phenol-bearing material, calcium-aluminum oxide, calcium phosphate
68	Gratwick-Riverside Park	1962-1968	45	Phenolic resin, phenolic molding compounds,oil, grease and municipal waste

3.6.3 Niagara Falls, New York Sub-area

3.6.3.1 Hydrogeology

The groundwater hydrogeology of the Niagara Falls sub-area is similar to that of the Buffalo-Lackawanna and Tonawanda-North Tonawanda sub-areas. A bedrock aquifer in the Lockport Dolomite is overlain by an aquifer in the unconsolidated deposits.

The Lockport Dolomite consists of a predominately fine crystalline matrix with some poorly connected solution cavities in the upper portion. There are few primary openings for groundwater to move through the unit. Significant groundwater movement occurs in secondary openings such as joints and fractures, which may be slightly widened by solution. It is the secondary openings that make the Lockport Dolomite a significant aquifer in the area. Some joints have formed in the underlying Rochester Shale, but not nearly to the extent of the dolomite because the shale is not as brittle. Little hydrogeologic information is available for the deeper rock units.

Most of the groundwater movement occurs in the horizontal bedding joints in which Johnston (1964)[1] identified seven major zones. Some movement of the groundwater probably occurs in other fine-bedded zones 1.3 to 10.2 centimetres (0.5 to 4 inches) thick, which would tend to be weaker and more likely to fracture than thicker massive beds 0.6 to 3.0 metres (2 to 10 feet) thick. Johnston noted that the major water-bearing zones occur most commonly in thin bedded zones underlying thick massive beds.

Significant movement of groundwater in vertical joints is common in the upper 3.0 to 4.8 metres (10 to 15 feet) of the dolomite (weathered zone), and in the vicinity of the gorge wall. Movement also occurs landward for approximately 61 metres (200 feet) where tension release joints were formed by the removal of the supporting rock mass that has been eroded away in the

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1 Johnston, Richard H., Groundwater in the Niagara Falls Area, New York, 1964.

gorge. The tension release joints in the Lockport Dolomite and Rochester Shale are believed to be significant avenues for groundwater to flow downward into the Niagara River. The vertical joints near the gorge wall may explain the lack of occurrence of seepage springs along the gorge. Groundwater may move downward in the vertical tension release joints and seep out to the river from deeper rock units which are covered by talus.

A potentiometric surface map of the upper water-bearing zone is shown in Figure 3.5. The directions of groundwater movement are shown with arrows perpendicular to the equal-potential lines. The potentiometric surfaces of deeper water-bearing zones could not be defined due to a lack of data.

The unconsolidated deposits consist of glacial and lacustrine material overlying bedrock. The glacial deposits are generally a clayey till with low permeability. During the test drilling program, groundwater was encountered at various depths within this unit. In some parts of the sub-area, particularly to the north and along the gorge where the unconsolidated material was very thin, no groundwater was encountered.

Due to the low permeability of the deposits, a seasonal water table exists in the sub-area, particularly in the fill and coarse-grained material overlying the more impermeable deposits. This water table usually forms mounds which discharge radially from the site into topographic lows, drainage ditches, and streams.

The direction of groundwater movement in the unconsolidated deposits is generally toward the major surface-water bodies: the Niagara River, Cayuga Creek, and Gill Creek.

3.6.3.2 Groundwater Quality

Groundwater samples were collected in the fall of 1982 and analyzed for priority pollutants from three wells (SA-1, 2, and 3) located in the

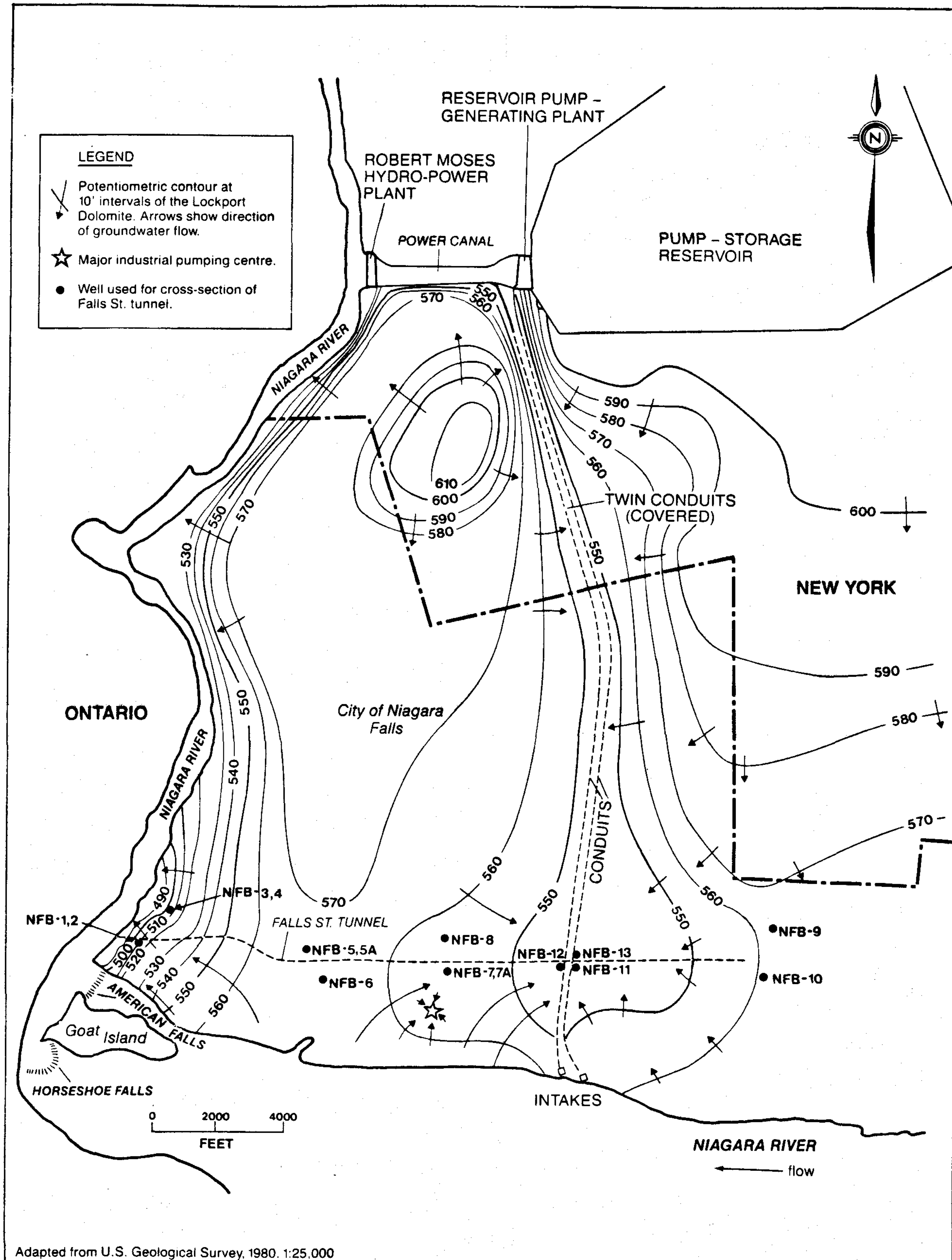

FIGURE 3.5 POTENTIOMETRIC SURFACE OF THE UPPER LOCKPORT (Contours approximate)

eastern portion of the Niagara Falls, New York sub-area (Figure 3.2). These wells were screened in the unconsolidated deposits above the bedrock contact. The results (Table 3.2) indicated elevated levels of cadmium (100 ug/L maximum, 43.3 ug/L mean), lead (2,200 ug/L maximum, 853 ug/L mean), nickel (980 ug/L maximum, 341 ug/L mean), and zinc (640,000 ug/L maximum, 217,000 ug/L mean). Minor amounts of organic compounds were quantified with the exception of methylene chloride (375 ug/L maximum, 174 ug/L mean) and toluene (230 ug/L maximum, 130 ug/L mean). Mirex (0.21 ug/L) was detected in one well adjacent to Griffon Park along the Niagara River.

Groundwater samples were also collected in the fall of 1982 from the western portion of the sub-area in the City of Niagara Falls and analyzed for priority pollutants. Five wells were screened above the bedrock contact along the Robert Moses Parkway. The results of these analyses are presented with the description of the DuPont Buffalo Avenue site (Appendix B) and in Table 3.2.

Four wells (NFB 1, 2 and NFB 3, 4) were drilled into bedrock along the lower Niagara River immediately downstream of the Falls, (Figure 3.5). Two were drilled to the top of the Rochester Shale and the samples collected represent a composite of the groundwater entering the Lower Niagara River through the horizontal bedrock zones in the dolomite at the City of Niagara Falls. The other two wells were drilled to the uppermost major zone in the dolomite. The results of the analyses are shown in Table 3.5.

The analyses representing the composite of the groundwater zones in the dolomite indicated elevated levels of mercury (6.8 ug/L maximum, 3.6 ug/L mean) and nickel (120 ug/L maximum, 76 ug/L mean). Tetrachloroethylene was detected at 58 ug/L maximum, 29.9 ug/L mean, along with minor amounts of other organic compounds.

Analysis of the wells drilled to the uppermost major water-bearing zones in the dolomite indicated elevated levels of cadmium (66 ug/L maximum, 36 ug/L mean), lead (3,600 ug/L maximum, 2,115 ug/L mean), nickel (460 ug/L

TABLE 3.5

CHEMICAL DATA FROM BEDROCK WELLS
NIAGARA FALLS, NEW YORK, SUB-AREA
(ug/L)

PARAMETER	LOWER NIAGARA RIVER GORGE All Dolomite Zones Maximum	LOWER NIAGARA RIVER GORGE All Dolomite Zones Mean	LOWER NIAGARA RIVER GORGE Upper Zone Maximum	LOWER NIAGARA RIVER GORGE Upper Zone Mean	FALLS STREET TUNNEL Upper Zone Maximum	FALLS STREET TUNNEL Upper Zone Mean	POWER AUTHORITY CONDUITS Upper Zone Maximum	POWER AUTHORITY CONDUITS Upper Zone Mean
Antimony 1/							1.5	1.3
Arsenic 1/	6	3.5	7	7			4	3.7
Beryllium 1/	0	0	10	5	0	0	0	0
Cadmium 1/	0	0	66	36	89	31.8	5	3.7
Chromium 1/	0	0	0	0	44	19.3	20	16
Copper 1/	26	19	580	385	800	230	92	72
Lead 1/	24	13.5	3600	2115	3500	966	420	407
Mercury 1/	6.8	3.6	1.2	1.2			0.9	0.6
Nickel 1/	120	76	460	235	200	148	43	26.3
Selenium 1/	1	0.5	2	2	760	128	0	0
Silver 1/	4	3	5	3.5	2	1.3	0	0
Zinc 1/	250	240	8700	4950	30000	5583	3500	1496
Chloroform 1/	1.7	0.9	0	0				
Trichloroethylene 1/	6.2	3.1	0	0	33	8.3	26	14
Tetrachloroethylene 1/	58	29.9	6.0	3.0	8.8	2.2	8.8	4.1
Toluene 1/	0	0	3.7	1.9	7.8	2.5	34	14
Alpha-BHC 1/	0	0	0.2	0.1			1.4	0.87
Heptachlor 1/	0.04	0.03	0.03	0.02			0.01	0.01
Endosulfan 1/	0	0	0.04	0.02				
Bis(2-ethylhexyl) phthalate 1/	15	7.5			9.4	4.7	13	10.8
Di-n-octyl phthalate 1/	13	6.5						
Trans-1,2-dichloroethylene 1/					80	20	1400	941
Benzene 1/							250	143
Chlorobenzene 1/							35	16.7
Hexachlorobenzene 1/							0.47	0.19
Beta-BHC 1/							1.4	0.64
Gamma-BHC (Lindane) 1/							0.13	0.05
1,4-Dichlorobenzene 1/							65	25
1,3-Dichlorobenzene 1/							30	16
1,2-Dichlorobenzene 1/							33	16
Nitrobenzene 1/							8.5	2.8
1,2,4-Trichlorobenzene 1/							27	12.7
Naphthalene 1/							31	11.5
Di-n-butyl phthalate 1/							18	11.7
Diethyl phthalate 1/							12	5.5
Butylbenzyl phthalate 1/							61	32.3

1/ EPA priority pollutant
For metals - blank spaces = NA
For organics - blank spaces = 0 = ND

maximum, 235 ug/L mean), and zinc (8,700 ug/L maximum, 4,950 ug/L mean). Only minor amounts of organic compounds were detected.

Within the western portion of the sub-area in the City of Niagara Falls, samples were collected from three sets of wells. One set of three wells was drilled in the upper dolomite along the east-west Falls Street Tunnel. Analytical results from samples collected from the three pair of wells identified as NFB-5 and 6, NFB-7 and 8, and NFB 9 and 10 in Figure 3.5 are shown in Table 3.5. While these wells were drilled to determine if the Falls Street Tunnel was receiving or discharging contaminants to the groundwater, the analytical results are summarized to reflect the groundwater quality in the upper bedrock zone in this area. Elevated levels of cadmium (89 ug/L maximum, 31.8 ug/L mean), lead (3,500 ug/L maximum, 966 ug/L mean), nickel (200 ug/L maximum, 148 ug/L mean), selenium (760 ug/L maximum, 128 ug/L mean), and zinc (30,000 ug/L maximum, 5,583 ug/L mean) were observed. Minor amounts of organic compounds were detected. Water level data indicate the tunnel is receiving significant groundwater inflow. Groundwater infiltration is the subject of a further investigation by the City of Niagara Falls.

Analytical results from samples collected at the set of three wells identified as NFB-11, 12, and 13 on Figure 3.5 are shown in Table 3.5. These wells are located where the Falls Street Tunnel passes over the New York State Power Authority conduits leading to the forebay and pumped storage reservoir of the State Power Authority's Robert Moses Power Plant adjacent to the Lower Niagara River. Elevated levels of lead (420 ug/L maximum, 407 ug/L mean) and nickel (43 ug/L maximum, 26.3 ug/L mean), were observed. Elevated levels of a number of organic compounds were also found.

Sediment samples were collected from the New York State Power Authority pumped storage reservoir. The results are pending.

3.6.3.3 Summary of Significant Sites

Seventy-one disposal sites were investigated in the Niagara Falls, New York sub-area. Thirty-one of the sites were involved in the USGS test drilling and sampling program. For the remaining 40 sites, existing data and consultant reports were reviewed to determine if a given site had significant potential for groundwater contamination and offsite migration.

Of the 71 sites investigated in the Niagara Falls sub-area, 31 were designated as having a significant potential for contaminant migration (Table 3.6).

3.7 Ontario Non-Point Sources

3.7.1 Fort Erie Sub-area

This sub-area includes all land which drains to the Niagara River on the Ontario side from Lake Erie up to and including Frenchman's Creek.

3.7.1.1 Hydrogeology

The Fort Erie sub-area exhibits a much thinner overburden layer than the other two sub-areas on the Ontario side. Surface deposits range from 2 to 12 metres (7 to 39 feet) and consist of a lacustrine clay material with occasional gravel deposits.

The bedrock is close to the surface throughout most of this area, and dominates the hydrogeology. The bedrock is composed of limestone and dolomite with a permeability estimated at 10^{-4} to 10^{-5} cm/s (2.8×10^{-1} to 2.8×10^{-2} ft/d). The bedrock forms a local aquifer which has a good yield potential.

3.7.1.2 Summary of Significant Sites

There was one site in this sub-area. After reviewing existing data and consultants' reports, this site was considered not significant.

TABLE 3.6

SIGNIFICANT HAZARDOUS WASTE SITES NIAGARA FALL, NEW YORK SUB-AREA

Site No.	Site Name	Operational Dates	Area (Acres)	Contents
81	Niagara County Refuse Disposal	1968-1976	50	Heat treatment salts, plating tank sludge, PVC skins and emulsion, thiazole polymer blends, polyvinyl alcohol, phenolic resins and brine sludge with mercury
56	Olin, 102nd Street	1948-1970	6	"Black Cake", graphite, benzene hexachloride, and tetrachlorophenol mixture, trichlorobenzene, alpha and beta BHC cake, tetrachlorobenzene, lime sludge, brine sludge, hexachlorobenzene, trichloroanisole and concrete
38	Occidental Chemical, Love Canal	1942-1953	16	Wide variety of chlorinated organics, metals, sulfides, miscellaneous chemicals and municipal waste
40	Occidental Chemical, 102nd Street	1943-1971	14	Organic and inorganic phosphates and hypophosphites, BHC cake, chlorobenzenes and miscellaneous chemicals
85	Griffon Park	1950's-1979	7	Incinerator residue and municipal waste
5	Bell Aerospace Textron	1950's-present	1	Rocket fuels, nitric acid, sodium hydroxide and plating wastes

TABLE 3.6 (Continued)

Site No.	Site Name	Operational Dates	Area (Acres)	Contents
242	Charles Gibson	1955-1957	4	Hexachlorobenzene and BHC cake
83	Buffalo Avenue	1930-1950	45	Non-combustibles and incinerator residue
14	DuPont, Necco Park	1930-1977	25	Sodium cell brick, graphite scrap and butts, brine plant salt dissolver sludge, furnace brick and rubble, scrap polyvinyl alcohol, chlorinolysis residues and other chemicals
66	Reichhold-Varcum Chemical Division	1940's-1979	4	Phenolic waste sludge
41A	Occidental Chemical, Buffalo Avenue, S-Area	1947-1975	16	Organic phosphates, acid chlorides, phenol tars, liquid disulfides, monochlorotoluene, metal chlorides, thiodan, chlorobenzenes and miscellaneous chlorinated organics
41B-49	Occidental Chemical, Buffalo Avenue Plant (9 sites)	1930-1978	95 (Plant Area)	Organic chemicals, metals chlorides, sulfides and phosphorus compounds
251	Solvent Chemical	1974-1978	2	Chlorinated benzenes
15-19 250	DuPont, Buffalo Avenue Plant (6 sites)	1925-1972	90 (Plant Area)	Sodium cyanide, metal cyanide, chloroethylenes, polychlorinated biphenyls, cell bricks, demolition debris
58-59 248	Olin, Buffalo Avenue Plant (3 sites)	1947-1960	12 (Plant Area)	Brine sludge containing mercury and possibly PCBs
39	Occidental Chemical, Hyde Park	1953-1975	15	Chlorinated organics, phosphates, sulfides, fluorides, sludges and miscellaneous chemicals

3.7.2 Chippawa Sub-area

3.7.2.1 Hydrogeology

The Chippawa sub-area includes two distinct geological formations which are designated the Bertie and Welland sections. The Bertie section consists of the land on the southern boundary, which is underlain by the Bertie Formation and has characteristics identical to those previously discussed in the Fort Erie sub-area.

The remaining lands, known as the Welland section, are underlain by a massive glaciolacustrine clay formation, the Haldimand Clay Plain. This laminated glaciolacustrine clay overlies Halton clay till. The Haldimand clay layer varies in depth from 12 metres (39 feet) to more than 30 metres (98 feet) and generally exceeds 25 metres (82 feet) in thickness, although the upper 5 metres (16 feet) of the clay is highly weathered.

The Haldimand clay exhibits a permeability estimated at 10^{-7} to 10^{-8} cm/s ($2.8x10^{-4}$ to $2.8x10^{-5}$ ft/d). The underlying till has a permeability in the range of 10^{-5} to 10^{-6} cm/s ($2.8x10^{-2}$ to $2.8x10^{-3}$ ft/d).

The western portion of the sub-area is dominated by a dolomitic limestone bedrock. Bedrock changes to dolomite, shale, and gypsum in an eastward direction toward the Niagara River.

3.7.2.2 Groundwater Quality

Pockets of gravel and sand lenses in the overburden are used as a source of potable water throughout this sub-area. The underlying Guelph-Lockport Dolomite aquifer exhibits high carbonate and sulphate concentrations and is not extensively used as a source of potable water in this basin. These naturally occurring high chemical levels are the only substances identified in this water source. No man-made chemical contaminants have been identified and none are anticipated.

3.7.2.3 Summary of Significant Sites

The Fort Erie Municipal Landfill was the only site in the Chippawa sub-area. A hydrogeological investigation of this site led to its classification as having significant potential for contaminant migration (Table 3.7).

3.7.3 Niagara Falls, Ontario Sub-area

The Niagara Falls, Ontario sub-area represents the majority of the drainage basin under consideration on the Ontario side and consists of all land draining into the Niagara River between the northern tip of Navy Island and Lake Ontario. This includes the entire Welland River Basin which drains through the Queenston-Chippawa Power Canal to the Niagara River at Queenston.

3.7.3.1 Hydrogeology

The hydrogeology of this extensive sub-area is varied. Three distinct geological units are represented. They have been identified here as separate sections: Lower Niagara, Welland, and Niagara Falls.

The Lower Niagara section is bounded by Lake Ontario to the north, and the Niagara Escarpment to the south. The area is covered by up to 30 metres (100 feet) of lacustrine silt and clay, which overlies fine grained sands. The thickness of the overburden decreases sharply in the western district of this section. The overburden is underlain by the Queenston Formation (red shale) in the northern portion and by the sandstones and dolomite of the Niagara Escarpment in the south. The hydraulic conductivity of the material in this section is variable. The upper clay unit has a conductivity of about 10^{-6} cm/s (2.8×10^{-3} ft/d) and the shale bedrock about 10^{-5} cm/s (2.8×10^{-2} ft/d). Weathered dessication cracks in the surface weathered zone, which is 3 - 4 metres (10-12 feet) thick, can increase the hydraulic conductivity by as much as five orders of magnitude.

TABLE 3.7

ONTARIO LANDFILL SITES WITHIN WELLAND AND NIAGARA RIVERS DRAINAGE BASIN

SUB-AREA	LANDFILL	OPERATIONAL DATES	CONTENTS	PRESENT STATUS
Ft. Erie	Ft. Erie Municipal	1972-Present	Municipal wastes, sewage sludge, non-hazardous solid industrial wastes	Leachage plume in aquifer, hydrogeologic & monitoring studies in progress.
Niagara Falls	Atlas Steels	1930-Present	Electric furnace slag, excavated rubble, baghouse dust, sludge, grinding swarf	Remedial measures as part of waste acid solidification process.
	CNR (Victoria Ave.)	1968-1982	Metal waste, wood scrap, car cleaning debris vessels and materials	Closed, not yet capped site on west face of swale, seepage to surface waters.
	Cyanamid (Welland)	1940-Present	Calcium carbonate-graphite carbon slurry, cyanide-bearing waste, scrap vessels and materials	Slurry lagoon (#11) still operational, solid waste disposal sites permitted to west and north of plant.
	Cyanamid (Niagara (Falls)	1940s	Waste cyanide-bearing process rock (0.16% total cyanide)	Site was mostly excavated in 1974 but some still remains in gully area draining to power canal.

The Welland section is the largest in this sub-area. It extends south and west from the City of Niagara Falls to the headwaters of the Welland River. The hydrogeology is identical to that described for the Welland portion of the Chippawa sub-area. In the western portion of the Welland section, the overburden consists of laminated glaciolacustrine clay, overlying Halton clay till. This layer generally exceeds 25 metres (82 feet) in thickness; however, the upper 5 metres (16 feet) of the clay is highly weathered. This clay plain extends to the east, varying in depth from 12 metres (39 feet) to more than 30 metres (98 feet).

The Niagara Falls section covers the area from the top of the escarpment southwards to approximately the southerly limit of the City of Niagara Falls, and runs in a band laterally westward to the watershed boundary. The overburden in the Niagara Falls section, consisting of stratified clay, silt, and sand, varies in depth from 10-15 metres (33-49 feet) at the east end to 17-30 metres (56-98 feet) at the west end. The lacustrine clays have a hydraulic conductivity in the 10^{-5} to 10^{-7} cm/s (2.8×10^{-2} to 2.8×10^{-4} ft/d) range. Variation due to weathered dessication cracks can increase the hydraulic conductivity from 2 to 5 orders of magnitude.

Two localized zones exist in this sub-area which are substantially different from the surrounding clay plain. The first is the Fonthill Kame, where drift sand extends to a depth of 60 metres (200 feet). This kame acts as a drainage divide. Hydraulic conductivities in this deposit are approximately 10^{-3} cm/s (2.8 ft/d).

The second anomaly is a naturally eroded gorge running from the whirlpool to St. Davids. This gorge represents the original channel of the Niagara River prior to the last ice age. The gorge is known to be at least 60 metres (200 feet) deep and entirely filled with stratified sands, gravels, lacustrine silt, clay, and tills. This complex deposit exhibits extremely variable hydraulic conductivities. The permeable surface sands in this gorge act as major paths for the groundwater flow system. The buried bedrock gorge also creates a regional discharge of groundwater from the deeper bedrock aquifer.

Two distinct bedrock formations are found in the Niagara Falls, Ontario sub-area: the Lockport and Guelph Dolomite Formations. They are found in thicknesses up to 35 metres (115 feet). These formations are underlain by Queenston Shale. The upper 5 metres (16 feet) of the dolomite is very fractured; solutioned cavities are suspected. This upper portion would allow the passage of groundwater at a rapid rate. Below this weathered zone, vertical fractures are present. Based on information collected from the U.S. side of the river, this fractured zone may extend inland a short distance.

3.7.3.2 Summary of Significant Sites

15 sites were reviewed in the Niagara Falls, Ontario sub-area. Hydrogeological investigations for three sites and existing data and consultants' reports for the remaining 12 sites were reviewed. Of these 15 sites, four were considered to have significant potential for contaminant migration (Table 3.7).

3.8 Summary of Results of Non-Point Source Investigations

3.8.1 General

Figure 3.1 illustrates the location of the sites having a major potential for contaminant migration along the Niagara River in both New York and Ontario. Sixty-one sites have been designated as significant on the New York side and five sites on the Ontario side. Table 3.8 summarizes the contaminant migration concerns for the sites by sub-area and also indicates the current site remediation status.

TABLE 3.8

SITES HAVING A SIGNIFICANT POTENTIAL FOR CONTAMINANT MIGRATION
ALONG THE NIAGARA RIVER (NEW YORK AND ONTARIO)

SITE NO.	SITE NAME	CONTAMINANT MIGRATION CONCERNS	REMEDIATION STATUS
	NEW YORK		
	Buffalo-Lackawanna Sub Area		
118	Bethlehem Steel	Elevated levels of organics and inorganics in wells along Lake Erie shore. Contaminant migration to Lake Erie is indicated.	Investigation Underway
162	Alltift	Elevated levels of indicator parameters above clay. Potential for horizontal migration.	Preliminary Investigation Complete
241	Times Beach	Barrier in place does not prevent water from entering and leaving site. Any leachate produced at site could enter Lake Erie and Niagara River.	Investigation Underway
141	Mobil Oil Corporation	Material underlying site is sand; contaminant migration to Buffalo River is expected.	No Action to Date
138	McNaughton-Brooks, Incorporated	Soil samples indicate significant potential for horizontal migration off the site.	No Action to Date
107	Allied Chemical	Low pH values found in monitoring wells could enhance mobilization and seepage of heavy metal contaminants to Buffalo River.	Preliminary Investigation Complete
120-122	Buffalo Color (3 sites)	Proximity of sites to Buffalo River and concentrations of organic and inorganic compounds indicate significant potential for contaminant movement to river.	Investigation Underway
203	Squaw Island	Location of site between the Niagara River and Black Rock Canal would allow any leachate to percolate to these water bodies.	No Action to Date
	Tonawanda-North Tonawanda Sub-Area		
105	Allied Chemical	Organic and inorganic compounds found in soil samples. Additional information needed to confirm contaminant migration from site to Niagara River.	No Action to Date
108	Tonawanda Coke	Organic contaminants identified in soil samples. Additional information needed to confirm contaminant migration from this site to Niagara River.	No Action to Date
136	INS Equipment Corporation	Proximity of site to river and former presence of wetlands suggest that contaminant migration is occurring.	No Action to Date

TABLE 3.8 (Continued)

SITE NO.	SITE NAME	CONTAMINANT MIGRATION CONCERNS	REMEDIATION STATUS
	Tonawanda-North Tonawanda Sub-Area (Cont'd)		
182	Huntley Power Station	Organic and inorganic contaminants found in soil samples. Inorganic contaminants found in surface water. Potential for migration into Niagara.	No Action to Date
123	Columbus-McKinnon Corporation	PCBs and halogenated organics found in soil samples. Silt and sand underlying site; contaminant migration to Ellicott Creek is indicated.	Investigation Underway
24-37	Occidental Chemical, Durez Division (14 sites)	Analyses from monitoring wells in unconsolidated deposits indicate substantial contamination. Total dioxin found in on-site residues.	Under Litigation/Investigation Underway
68	Gratwick-Riverside Park	Fill is fairly permeable, enabling free groundwater movement from site to Niagara River. Contaminant migration is expected.	No Action to Date
	Niagara Falls, New York Sub-Area		
81	Niagara County Refuse Disposal	Seasonal water table and groundwater flow direction indicate potential for contaminant movement off site.	Investigation Underway/"Superfund Site"
56	Olin 102nd Street	Recent study indicates plume of contaminated groundwater intruding alluvial deposits of Niagara River and discharging into river.	Under Litigation
38	Occidental Chemical, Love Canal	2,3,7,8, dioxin isomer identified in sediment of storm sewers at Love Canal and in surface water sediment samples where these storm sewers discharge. Potential contamination in Black, Bergholtz, and Cayuga Creeks and in 102nd St. delta of Niagara River indicated.	Under Litigation/"Superfund Site"
40	Occidental Chemical, 102nd Street	Potential for contaminant migration off the site. Fill overlies alluvial river deposit which is probably hydrologically connected to Niagara River.	Under Litigation
85	Griffon Park	Priority pollutant inorganics detected in on-site water and soils samples. Mirex detected in off-site well sample along river. Additional information needed to confirm contaminant migration.	No Action to Date
5	Bell Aerospace Textron	Layer of mixed silts, sands, and clays conducive to movement of groundwater. Volatile organic contaminants found in downgradient well.	Investigation Underway
242	Charles Gibson	Additional information need to confirm contaminant migration.	Investigation Program Developed

TABLE 3.8 (Continued)

SITE NO.	SITE NAME	CONTAMINANT MIGRATION CONCERNS	REMEDIATION STATUS
	Niagara Falls, New York Sub-Area (Cont'd)		
83	Buffalo Avenue	Formerly wetland area, unconsolidated material 9.1 metres (30 feet) deep. Additional information required to confirm extent of contaminant migration.	No Action to Date
14	duPont, Necco Park	Data indicate leachate plume migrating south-southeast from site. Plume has migrated into top 6.1 metres (20 feet) of the Lockport Dolomite.	Remediation Undertaken/ Investigation Underway
66	Reichhold-Varcum Chemical Division	Monitoring wells on-site show phenols below clay layer and near perimeter of site. Additional information needed to confirm contaminant migration.	Investigation Underway
41A	Occidental Chemical, Buffalo Ave., S-Area	Based on known groundwater flow pattern in this area, and information on organic chemical levels, chemical migration is very likely from this site.	Under Litigation
41B-49	Occidental Chemical, Buffalo Ave. Plant (9 sites)	Information on geology of sites and analyses of wells installed in unconsolidated deposits indicate significant potential of contamination migration to the Niagara River.	Under Litigation
251	Solvent Chemical	High levels of ammonia, zinc, and organic compounds found in on-site wells. Additional information needed to confirm contaminant migration.	Under Litigation
15-19,250	duPont, Buffalo Avenue Plant (6 sites)	Information on groundwater movement in unconsolidated deposits and analyses of samples from wells adjacent to site indicate high concentrations of contaminants migrating towards Niagara River.	Remediation Undertaken/ Investigation Underway
58,59,248	Olin, Buffalo Avenue Plant (3 sites)	Downgradient well in southeastern area of plant indicated concentrations of mercury and organic contaminants. Additional information needed to confirm contaminant migration.	Investigation Underway
39	Occidental Chemical, Hyde Park	Data collected indicate that leachate from landfill has infiltrated in some places through the unconsolidated deposits and the Lockport Dolomite.	Court Approved Consent Agreement/ Investigation Underway
	ONTARIO		
	Fort Erie Sub-Area		
	None		

TABLE 3.8 (Continued)

SITE NO.	SITE NAME	CONTAMINANT MIGRATION CONCERNS	REMEDIATION STATUS
	ONTARIO		
	Chippawa Sub-Area		
B	Fort Erie	Conventional parameters indicate contamination of local aquifer. Plume definition study underway.	Investigation Underway
	Niagara Falls, Ontario Sub-Area		
C	Atlas Steels	Leachate springs contaminated with heavy metals are reaching the Welland River via surface flow.	Remediation Underway
A	Cyanamid, Welland	Surface migration of inorganic contaminants occurring.	Investigation Underway
E	Cyanamid, Niagara Falls	Potential leachate migration along surface of old gully to the Queenston-Chippawa Power Canal.	No Action to Date
D	CNR, Victoria Avenue	Potential significance due to proximity of site to Niagara River and nature of waste materials in site.	No Action to Date

3.8.2 New York

The main unit of the unconsolidated deposits in each of the sub-areas is glaciolacustrine clay which has a permeability of about 10^{-9} cm per second (2.8×10^{-5} ft/d). The thickness of this impermeable clay varies from about 18.3 metres (60 feet) in the Buffalo-Lackawanna sub-area to about 4.6 to 6.1 metres (15 to 20 feet) in the Niagara Falls, New York sub-area. The presence of this glaciolacustrine clay generally precludes significant vertical and horizontal migration of water.

The silt material which overlies the glaciolacustrine clay has a higher permeability of 10^{-5} cm/s (2.8×10^{-2} ft/d), which is also restrictive to groundwater movement due to the flat gradients in the three mile band along the Niagara River.

Disposal sites located in the fill areas along the river, in general, are the sites having the greatest potential for contaminant migration due to the nature of the geologic materials and the short contaminant travel distance to the river.

Table B.2 in Appendix B summarizes the sites having a significant potential for contaminant migration and the level of their priority pollutant contaminants in groundwater by sub-area and river segment in greater detail. In some instances, water was not encountered in the site or assessment drilling and groundwater quality data are not available.

The sub-area with the greatest potential for contaminant migration to the Niagara River is the Niagara Falls, New York sub-area due to the number of sites along the river, the nature of the materials disposed, and the levels of contaminants observed in the groundwater at the sites.

While some elevated levels of inorganic compounds were observed in all of the sub-area wells drilled in the unconsolidated deposits at the bedrock contact, generally few organic compounds were found in these wells, and concentrations were low.

Wells drilled in the unconsolidated deposits along the Wheatfield-Upper River segment of the Niagara Falls sub-area reflected high levels of organic contaminants associated with the significant sites in this segment. Groundwater movement in the bedrock is northeast (away from the Niagara River) along the lower reach of this segment.

Wells drilled in the bedrock along the lower Niagara River just downstream of the Falls indicated elevated levels of some inorganic constituents and a limited number of organic compounds in minor amounts. The composite samples from the wells drilled through the total depth of the Lockport Dolomite along the gorge wall indicated minor concentrations of both inorganic and organic parameters with the exception of mercury (6.8 ug/L maximum, 3.6 ug/L mean) and tetrachloroethylene (58 ug/L maximum, 29.9 ug/L mean).

Wells drilled in the top zone of the bedrock in the vicinity of the State Power Authority conduits and the Falls Street Tunnel indicated elevated levels of some inorganic constituents and organic compounds particularly trans-1,2-dichloroethylene (1400 ug/L maximum, 941 ug/L mean) and benzene (250 ug/L maximum, 143 ug/L mean).

Much of the discussion in this chapter has been limited to addressing the significant potential for contaminant migration from specific landfill sites and contamination of the Niagara River based on the three chosen criteria outlined at the beginning of the chapter. To a large extent, this reflects the limitations of the present data base, which in turn is related to the number of sites along the river and the associated costs of the extensive investigations necessary to define the extent of the real or potential problems. While the presently available data base may appear limited in this regard, the results generated as a part of the Niagara River Toxics Project are a signifcant step forward in addressing the question of non-point source contributions to the contamination of the Niagara River. Despite these limitations, it is possible to draw some general as well as specific conclusions regarding contamination of the Niagara River and surrounding area from non-point sources.

General overall groundwater contamination covers a large areal extent in the three mile band along the river dealt with in this study (Table 3.2). Chemical analyses from exploratory wells indicate that there is some contamination of the groundwater by both metals and synthetic organic contaminants. Comparison of concentrations of several parameters presented in Table 3.2 (cadmium, copper, lead, zinc, methylene chloride, toluene) indicates that the groundwater in the Niagara Falls (NY) sub-area (with the exception of the Lower River segment where no general data are available), is more highly contaminated than the two areas upstream. To some extent, this reflects the relative densities of known landfill sites in this sub-area and the proximity of the exploratory wells to these sites.

The horizontal direction of groundwater movement in the unconsolidated deposits is generally toward major surface water bodies: Lake Erie, the Niagara River, and the Buffalo River in the Buffalo-Lackawanna sub-area; the Niagara River, Ellicott Creek and Tonawanda Creeks in the Tonawanda-North Tonawanda sub-area; and the Niagara River, Cayuga Creek, and Gill Creek in the Niagara Falls, NY Sub-area. In the Niagara Falls, NY sub-area, significant vertical movement of groundwater also occurs in the Lockport Dolomite and Rochester Shale through tension release joints adjacent to the Niagara River. The joints are believed to be significant avenues for groundwater to flow downward into the Niagara River. In some cases, migration of contaminants into the dolomite and contamination of the groundwater by metals and synthetic organics has been demonstrated (eg. lower Niagara River immediately downstream of the falls, DuPont Necco Park Site, Hyde Park Site).

164 sites were investigated, and 103 were judged to have little potential for affecting the Niagara River. 61 sites were judged to have a

significant potential for contributing contamination to the Niagara River. Of these sites, the following (Table 3.9) have, in the best judgement of the Committee, contributed or are contributing contaminants to the Niagara River.

TABLE 3.9

SITES BELIEVED TO HAVE CONTRIBUTED, OR BE CONTRIBUTING, CONTAMINANTS TO THE NIAGARA RIVER

Bethlehem Steel	Occidental Durez
DuPont Buffalo Avenue (6 sites)	Occidental 102nd Street
Gratwick-Riverside Park	Occidental S area
Hyde Park	Olin Buffalo Avenue (3 sites)
Love Canal	Olin 102nd Street
Occidental, Buffalo Avenue plant area (9 sites)	Squaw Island
	Times Beach

3.8.3 Ontario

Data have been collected from seventeen disposal sites in the Niagara-Welland drainage basin. Twelve of the seventeen sites have been determined to be insignificant. Since these sites have little or no impact or potential impact on the local groundwater regime and the Niagara River, they have not been included in this summary report.

The remaining five sites, for the purposes of this report, have been classified as significant. Data for these sites show that for the most part, the significance lies in their potential to impact on the water system. A significant classification does not necessarily imply that offsite contamination is actually occurring.

At the sites in the Welland section of the Niagara Falls, Ontario sub-area, the overburden is thick enough and exhibits sufficiently low permeability to preclude any downward migration of contaminants to the underlying aquifer. Any potential migration of contaminants from the two sites in this section, is more likely to occur via surface drainage or through the heavily weathered upper clay zone to the Welland River. In the

Committee's opinion, the Atlas Steels landfill is contributing contaminants to the Niagara River via the Welland River.

At the sites in the Niagara Falls section, the underlying soils are shallower and more stratified than in the Welland section. The location and local topography at the two sites in this section, Cyanamid's Niagara Falls landfill and CNR's Victoria Avenue landfill, would indicate that movement of contaminants would likely occur via surface runoff or migration through the upper weathered clay zone to the surface waters. It should also be noted that the majority of Cyanamid's Niagara Falls landfill was removed from this site in 1974.

The remaining site, Fort Erie's Bridge Street landfill, is a municipal disposal site. Due to the nature of the wastes deposited here, no hazardous chemical contamination as defined by EPA's priority pollutant list is anticipated. However, contamination of the underlying aquifer by conventional pollutants has been detected. The low attenuative capacity of a shallow overburden in this area has been compounded by an extremely high water table at this site. No assessment of the extent of contaminant migration has yet been made, although hydrogeologic investigations are underway. It is believed, however, that contamination via groundwater transport is localized and does not at present have a significant impact on the Niagara River.

The five significant sites on the Ontario side of the Niagara River have been classified as such due to their potential to contaminate the Niagara River, rather than due to any detected impact. Programs are underway by the provincial and federal environmental agencies to investigate and determine the extent of contamination, if any.