PROPOSED REMEDIAL ACTION PLAN
Frontier Chemical Royal Avenue
Operable Unit No. 1
Niagara Falls, Niagara County, New York
Site No. 9-32-110

January 2006

Prepared by:

Division of Environmental Remediation
New York State Department of Environmental Conservation

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FRONTIER CHEMICAL ROYAL AVENUE
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SECTION 1: <u>SUMMARY AND PURPOSE OF THE PROPOSED PLAN</u>

The New York State Department of Environmental Conservation (NYSDEC), in consultation with the New York State Department of Health (NYSDOH), is proposing a remedy for Operable Unit No. 1 of the Frontier Chemical Royal Avenue site to address soils, overburden groundwater, and upper bedrock groundwater which have been contaminated with volatile and semi-volatile organic compounds. The presence of hazardous waste has created significant threats to human health and/or the environment that are addressed by this proposed remedy. As more fully described in Sections 3 and 5 of this document, on site disposal, spills, and leaks during waste treatment and storage activities have resulted in the disposal of hazardous wastes, including volatile and semi-volatile organic compounds. These wastes have contaminated the site soils and groundwater, and have resulted in:

- a significant threat to human health associated with potential direct exposure to contaminated site soils and groundwater;
- a significant environmental threat associated with the impacts of contaminants to regional bedrock groundwater and the Niagara River.

To eliminate or mitigate these threats, the NYSDEC proposes the following remedy:

- A remedial design program would be implemented to provide the details necessary for the construction, operation, maintenance, and monitoring of the remedial program.
- Removal of existing site buildings, above grade structures, and demolition debris from the site.
- Excavation and off-site treatment/disposal of contaminated soil source areas (generally defined as soils with total VOCs>100ppm).
- The backfill of soil removal areas with clean soil or other suitable material.
- Completion of a clean soil or asphalt pavement cover over areas of site which do not have concrete or asphalt pavement.
- Improved storm water collection with permitted discharge to the Niagara Falls Water Board sewer system.
- Site groundwater controlled/treated in one of two ways: either an agreement with the Niagara Falls Water Board for use of Water Board utilities to provide site groundwater control/treatment; or, a groundwater control/treatment system constructed on site, with permitted

discharge of effluent to the Water Board's sewer system.

- Development of a site management plan to address residual contamination and any use restrictions.

- Imposition of an institutional control in the form of an environmental easement.

- Periodic certification of the institutional and engineering controls.

- Operation of components of the remedy until remedial objectives have been achieved, or until a NYSDEC/NYSDOH determination that continued operation is not feasible.

- A long term monitoring program to evaluate effectiveness of the cover and groundwater control/treatment system.

The proposed remedy, discussed in detail in Section 8, is intended to attain the remediation goals identified for this site in Section 6. The remedy must conform with officially promulgated standards and criteria that are directly applicable, or that are relevant and appropriate. The selection of a remedy must also take into consideration guidance, as appropriate. Standards, criteria and guidance are hereafter called SCGs.

This Proposed Remedial Action Plan (PRAP) identifies the preferred remedy, summarizes the other alternatives considered, and discusses the reasons for this preference. The NYSDEC will select a final remedy for the site only after careful consideration of all comments received during the public comment period.

The NYSDEC has issued this PRAP as a component of the Citizen Participation Plan developed pursuant to the New York State Environmental Conservation Law and Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York (6 NYCRR) Part 375. This document is a summary of the information that can be found in greater detail in the November 2002 "Supplemental Remedial Investigation (RI) Report for the Former Frontier Chemical Waste Process, Inc. Site", the April 2004 "Feasibility Study (FS) for the Former Frontier Chemical Waste Process, Inc. Site", and other relevant documents. The public is encouraged to review the project documents, which are available at the following repositories:

Earl Brydges Memorial Library
1425 Main Street
Niagara Falls, NY 14304
Hours: Mon, Tues, Wed: 9am-9pm
Thurs: 9am-6pm; Fri, Sat: 9am-5pm

NYSDEC Region 9 Office
270 Michigan Avenue
Buffalo, NY 14203
Hours: Mon-Fri: 8:30am-4:45pm
Contact Mr. Jeff Konsella at (716) 851-7220 for an appointment

NYSDEC Central Office
625 Broadway
Albany, NY 12233
Hours: Mon-Fri: 8:30am-4:45pm
Contact Mr. Edward Belmore at (518) 402-9669 for appointment

The NYSDEC seeks input from the community on all PRAPs. A public comment period has been set from January 23, 2006 - February 21, 2006 to provide an opportunity for public participation in the remedy selection process. A public meeting is scheduled for February 7, 2006 at the Earl Brydges Memorial Library in Niagara Falls, beginning at 6:30 pm.

At the meeting, the results of the RI/FS will be presented along with a summary of the proposed remedy. After the presentation, a question-and-answer period will be held, during which verbal or written comments may be submitted on the PRAP. Written comments may also be sent to

Mr. Konsella at the above address through February 21, 2006.

The NYSDEC may modify the preferred alternative or select another of the alternatives presented in this PRAP, based on new information or public comments. Therefore, the public is encouraged to review and comment on all of the alternatives identified here.

Comments will be summarized and addressed in the responsiveness summary section of the Record of Decision (ROD). The ROD is the NYSDEC's final selection of the remedy for this site.

SECTION 2: SITE LOCATION AND DESCRIPTION

The Frontier Chemical Royal Avenue site is approximately 9 acres in size and is located on the northwestern corner of the intersection of Royal Avenue and 47th Street in Niagara Falls (see Figure 1). A residential neighborhood is approximately ½ mile west of the site. The Frontier Chemical site is in the heavily industrialized area of Niagara Falls bounded on the north by Niagara Falls Blvd., on the south by the Niagara River, and on the west by Hyde Park Blvd. Numerous other inactive hazardous waste sites are within 1 mile of the site. These include several Occidental Chemical waste and plant sites, as well as DuPont Chemical, Olin Chemical, and the Solvent Chemical sites.

The majority of the buildings on the site have been demolished, although some smaller buildings and structures remain. The site is completely fenced and the majority of the surface of the site covered by either concrete or blacktop. Several large areas of demolition debris also occupy areas on the surface of the site.

Operable Unit (OU) No. 1, which is the subject of this document, consists of the overburden soils, as well as overburden and upper (defined in Section 5.1.1 as the A-zone and B-zone) bedrock groundwater. An operable unit represents a portion of the site remedy that for technical or administrative reasons can be addressed separately to eliminate or mitigate a release, threat of release or exposure pathway resulting from the site contamination. The remaining operable unit for the this site is Operable Unit No. 2, and is defined as the deeper (defined in Section 5.1.1 as the C-zone and lower) bedrock groundwater.

SECTION 3: SITE HISTORY

3.1: Operational/Disposal History

The Frontier Chemical Waste Process Corporation operated a permitted waste treatment, storage, and disposal (TSD) facility at the Royal Avenue site from 1974 to December 1992. While operating, this facility treated or stored approximately 25,000 tons of chemical wastes per year. Figure 2 shows the TSD facility layout in 1984. Several major spills were documented during site operations, and in December 1992, following documented releases of hazardous waste from numerous drums, the site was ordered closed by the NYSDEC.

3.2: Remedial History

Several investigations of the site have been performed between 1981-1990. These investigations were primarily focused on identifying areas of groundwater contamination, and were required under terms of the facility's operating permit. In 1992, the bankruptcy of the company's management firm ended the company's preliminary plans to implement corrective actions to address the identified groundwater contamination.

Following closure of the facility in December 1992, an emergency removal action was initiated by the US Environmental Protection Agency (EPA) to remove the stored hazardous wastes from the site. During 1993-1994, under a voluntary agreement with the EPA, a group of potentially responsible parties (PRPs) removed over 4,000 drums of waste from the site. In a subsequent agreement with the EPA, a second phase was conducted by the PRPs during 1994-1995 which resulted in the removal of wastes from the 45 storage tanks on the property.

In 1995, the NYSDEC listed the site as a Class 2 site in the Registry of Inactive Hazardous Waste Disposal Sites in New York State. A Class 2 site is a site where hazardous waste presents a significant threat to the public health or the environment and action is required.

In January 2001 the site was referred to the NYSDEC for action using State Superfund monies. In the summer of 2001, a work plan was prepared to perform a Supplemental Remedial Investigation (Supplemental RI) and Feasibility Study (FS) of the site. The Supplemental RI was completed in 2002, and the Feasibility Study was completed in 2004.

SECTION 4: <u>ENFORCEMENT STATUS</u>

Potentially Responsible Parties (PRPs) are those who may be legally liable for contamination at a site. This may include past or present owners and operators, waste generators, and haulers.

As a result of previous litigation resulting from the drum and tank removal actions, several hundred PRPs have been identified. These PRPs, as well as the current property owner- "5335 River Road, Inc.", may be legally liable for contamination at the site.

The PRPs declined to implement the RI/FS at the site when requested by the NYSDEC. After the remedy is selected, the PRPs will again be contacted to assume responsibility for the remedial program. If an agreement cannot be reached with the PRPs, the NYSDEC will evaluate the site for further action under the State Superfund. The PRPs are subject to legal actions by the state for recovery of all response costs the state has incurred.

SECTION 5: <u>SITE CONTAMINATION</u>

A remedial investigation/feasibility study (RI/FS) has been conducted to evaluate the alternatives for addressing the significant threats to human health and the environment.

5.1: <u>Summary of the Remedial Investigation</u>

The purpose of the RI was to define the nature and extent of any contamination resulting from previous activities at the site. The RI consisted of data collected from the previous site investigations (conducted from 1981-1990), as well as data collected from the Supplemental RI (conducted between October 2001 and July 2002). The field activities and findings of the investigations are described in detail in the November 2002 Supplemental RI report.

The following is a summary of major site activities conducted from 1981-1990:

- 1982: To define site geology and groundwater flow direction, a hydrogeologic investigation was performed which included the installation of 8 groundwater monitoring wells.

- 1984-1985: To assess groundwater quality, a hydrogeologic investigation was conducted which included the installation and sampling of 9 additional groundwater monitoring wells.

- 1987-1988: A soil and groundwater investigation was performed which included the installation and sampling of 17 additional groundwater monitoring wells. The investigation included the organic vapor screening of soils from 28 overburden boreholes to access contaminant source areas.

- 1989-1990: A groundwater investigation was performed which included the installation and sampling of 42 additional groundwater monitoring wells.

- 1991-1992: An Interim Remedial Measures (IRM) Design Report was developed by Frontier Chemical Waste Process, Inc. and submitted to the NYSDEC. The proposed IRM included the installation of a new bedrock groundwater pumping well to reduce groundwater contaminant migration, with the use of existing chemical treatment processes to treat the captured groundwater prior to discharge to adjacent Niagara FallsWater Board sewers. The IRM was never implemented by Frontier.

The following activities were conducted during the Supplemental RI conducted during 2001-2002:

- Record search of historical site information;
- Evaluation of previous investigation data and reports to identify and focus Supplemental RI scope of work;
- Excavation of 4 test pits to verify reported site utility connections along Royal Avenue;
- Collection and analysis of soil samples taken from 26 soil borings installed as part of hydrogeologic investigations;
- Installation of 11 new (replacement) groundwater monitoring wells and 11 new piezometers; and
- Sampling of 69 new and existing groundwater monitoring wells and piezometers;

To determine whether the soil and groundwater contain contamination at levels of concern, data from the investigation were compared to the following SCGs:

- Groundwater, drinking water, and surface water SCGs are based on NYSDEC "Ambient Water Quality Standards and Guidance Values" and Part 5 of the New York State Sanitary Code.
- Soil SCGs are based on the NYSDEC "Technical and Administrative Guidance Memorandum (TAGM) 4046; Determination of Soil Cleanup Objectives and Cleanup Levels".

Based on the RI results, in comparison to the SCGs and potential public health and environmental exposure routes, certain media and areas of the site require remediation. These are summarized below. More complete information can be found in the 2002 Supplemental RI report.

5.1.1: <u>Site Geology and Hydrogeology</u>

<u>Geology</u>

The surface of the site is mostly covered by either asphalt or concrete. Up to 2 feet of fill material (generally gravel with some cinder, glass, wood, slag, bricks, etc.) overlies an overburden mostly comprised of a silty-clay, with some discontinuous seams of silty sand and clay. The total depth of the overburden is 14 to 17 feet.

The bedrock immediately beneath the overburden is Lockport Dolomite. Distinct horizontal fracture systems have been characterized during the RI. The upper 35 feet of bedrock has been characterized as follows: the A-zone is identified as the fracture system consisting of the upper several feet of weathered bedrock; the B-zone is identified as the fracture system approximately 8-10 feet below the A-zone; and the C-zone is identified as the fracture system approximately 20 feet below the B-zone. While no previous Frontier Chemical investigations have targeted bedrock beneath the C-zone, numerous deeper bedrock fracture systems have been confirmed and described at other locations within the region. The bedrock A-zone, B-zone, and C-zone are described in greater detail in the Site Hydrogeology discussion.

Regional Hydrogeology

Regionally, bedrock groundwater is recharged by water from the upper Niagara River (above the Falls), transmitted through fractures in the rock, and discharged to the lower Niagara River (at the gorge downstream from the falls). There are two man-made structures which exert a significant influence on the flow of bedrock groundwater in the region: the New York Power Authority (NYPA) conduits and the Falls Street Tunnel. These structures and their effects on regional groundwater are discussed below.

NYPA Conduits

The NYPA conduits are two parallel reinforced concrete lined tunnels which were installed within the upper bedrock to convey upper Niagara River water to the Robert Moses power generating station in Lewiston, NY. They are each approximately 65 feet wide by 46 feet high and run 4 miles in length in a south (river intake end) to north (power plant location) direction. The conduits pass approximately 1/4 mile to the west of the Frontier Chemical site (see Figure 1 for location).

The NYPA conduits were constructed with a series of continuous drains along the outside of the concrete walls and floors. These drains are connected to the inside of the conduits at two locations and were designed to regulate the bedrock groundwater height around the exterior of the conduits. Given the length and depth of the NYPA conduits, the drain systems intersect and influence a significant portion of the upper bedrock groundwater in the Niagara Falls area. The drain systems essentially create a preferential pathway for upper bedrock groundwater, and the result is a groundwater “sink” along the length of the conduits. It has been estimated that the conduits influence on the bedrock groundwater extends approximately 3,000 - 4,000 feet to the east and west of the alignment.

The NYPA conduits pass under the unlined bedrock Falls Street Tunnel (described in detail below) near Royal Avenue. A significant amount of bedrock groundwater transmitted along the NYPA conduit drain system discharges upward into the Falls Street Tunnel at this crossing. A 2003 estimate performed on behalf of NYPA calculated a discharge of approximately 6.5 million gallons of bedrock groundwater per day into the Falls Street Tunnel from the NYPA conduit drain system.

Falls Street Tunnel

The Falls Street Tunnel (FST) is an unlined bedrock sewer tunnel which passes along the south side of the Frontier Chemical site. It runs east to west for approximately 3.5 miles from 56th Street to the Niagara Gorge (see Figure 3). The FST is approximately 7 feet wide by 6 feet high (in the vicinity of Royal Ave.) and it intersects the site B-zone bedrock fracture system. The FST has drop shafts constructed at all major street intersections. These drop shafts are brick lined within the overburden and unlined within the bedrock.

Other Local Sewers

In the local vicinity of the site, there are several sewers which either influence site hydrogeology or play a role in the collection and discharge of local groundwater and storm water. The major Water Board sewers and corresponding flow paths are shown in Figure 3. As discussed above, the

FST is a major sewer which runs under Royal Avenue along the south side of the site. Running parallel, and also located beneath Royal Avenue just south of the FST, is the South Side Interceptor. In addition, the New Road Tunnel runs along the eastern side of the site under 47th street. The South Side Interceptor and the New Road Tunnel are discussed in detail below.

<u>South Side Interceptor</u>

The FST was originally constructed as a combined storm and sanitary sewer. However, most of the waters from east of 47th Street were diverted after 1972, when the concrete lined South Side Interceptor (SSI) sanitary sewer was constructed. The SSI is located slightly south of the FST and runs from near 47th street and Royal Avenue to its discharge point at the Water Board's waste water treatment plant (WWTP). The SSI sewer serves various industrial waste dischargers with connections between its origin and its termination at the WWTP. Regulating weirs constructed in the FST just west of 47th street (and adjacent to the Royal Avenue site) and at 38th street (about ½ mile to the west) divert normal FST flows to the SSI. High water flows within the FST (such as those accompanying significant storm events) result in an "over topping" of the diversion weirs, and allow flow to continue along the FST to the west instead of being by diverted to the SSI.

<u>New Road Tunnel</u>

The New Road Tunnel is an unlined bedrock sewer tunnel which passes along the eastern side of the site. It runs from north to south under 47th street, and discharges to the FST. The New Road tunnel is approximately 6 feet wide by 5 feet high, and like the FST, the tunnel intersects the site B-zone bedrock fracture system.

<u>Site Hydrogeology</u>

Depth to groundwater within the overburden ranges from about 2 to 10 feet below ground surface. There is a horizontal overburden groundwater gradient to the southeast, with a localized overburden "sink" (inwardly directed groundwater depression) in the south-central portion of the site. A downward vertical groundwater gradient exists between the overburden and the top of the bedrock.

Within the upper 35 feet of bedrock, 3 distinct horizontal fracture zones have been identified. The A-zone consists of the highly weathered upper 3 to 5 feet of bedrock. The B-zone is a fracture system which is up to 2 feet thick and is located approximately 8 to 10 feet below the A-zone. A downward vertical groundwater gradient exists from the A-zone to the B-zone. The C-zone is a fracture system approximately 20 feet below the B-zone. Although the C-zone has not been fully characterized, a slight upward vertical groundwater gradient has been calculated from the C-zone to the B-zone. The bedrock between the three defined horizontal fracture zones contain some vertical fractures which provide some groundwater communication between the zones.

The FST and the New Road Tunnel run along the south and east sides of the site, respectively. As both of these tunnels intersect the bedrock B-zone fracture system, site bedrock groundwater from the B-zone directly infiltrates into these tunnels. This infiltration in turn promotes a downward groundwater gradient from the site overburden and upper weathered bedrock into the B-zone. The construction of the drop shafts to the FST also promotes overburden groundwater drainage to the bedrock. The influence of these tunnels may also impart an upward groundwater gradient from the lower C-zone fracture system toward the B-zone. The effect of the Falls Street tunnel as an upper bedrock groundwater interceptor has been well documented in numerous hydrogeologic studies of the area. The location, depth, and hydraulic influence of the tunnels has effectively intercepted site overburden and upper bedrock groundwater and prevented it from migrating beyond the Royal Avenue and 47th street tunnel alignments.

At the Frontier Chemical site, groundwater within the bedrock C-zone and some of the lower bedrock fracture systems are also likely influenced by the NYPA conduit drain system. Site groundwater flow within some of these lower bedrock fracture zones is most likely toward the NYPA conduits. Since significant amounts of conduit water discharges into the Falls Street Tunnel, it appears likely that at least some of the C-zone and lower site bedrock groundwater is discharged to the FST.

5.1.2 Niagara Falls Water Board Treatment of Waste Water and Storm Water Flows

The Water Board's WWTP ordinarily treats all discharges into the sanitary and storm water sewers. Treated waters from the WWTP are discharged to the lower Niagara River via the Adams Tailrace Tunnel (see Figure 3). However, during extended storm events or during those with very intense precipitation, the storage capacities of the utilities may be exceeded, resulting in the discharge of untreated waters directly to the lower Niagara River. The major components of the Water Board's storm water management system are discussed below.

Routine Handling and Treatment of Stormwater

Under normal weather conditions, all water entering the FST is ultimately discharged to the WWTP for treatment. Flows in the FST to the east of 38th street (including industrial waste water discharge and contributions from the new road tunnel) are diverted to the SSI, which transmits flow directly to the WWTP. Flow in the FST downstream of a diversion weir at 38th street (storm water, groundwater infiltration, etc.) is discharged to the South Gorge Interceptor, which conveys the flow along the river gorge to the Gorge Pumping station, where it is pumped to the WWTP for treatment.

Handling and Treatment during Significant Storm Water Events

During significant storm events, flows within the FST can bypass the SSI diversion weir and continue down the FST to the South Gorge Interceptor. During such storm events, flows in the South Gorge Interceptor may exceed the capacity of the pumping station. When the storm water holding capacities of the South Gorge Interceptor and FST are exceeded, flows are discharged without treatment to the Lower Niagara River via one or more permitted combined sewer overflow outfalls.

5.1.3: Nature of Contamination

As described in the Supplemental RI report, many soil and groundwater samples were collected to characterize the nature and extent of contamination. Figure 4 depicts a site base map with locations of soil and groundwater samples indicated. The main categories of contaminants that exceed their SCGs are volatile organic compounds (VOCs), and semivolatile organic compounds (SVOCs). The VOCs of concern include (but are not limited to) such compounds as acetone, trichloroethane, trichloroethene, dichloroethane, dichloroethene, tetrachloroethene, trichlorobenzene, dichlorobenzene, benzene, chlorobenzene, toluene, xylene, vinyl chloride, etc. The SVOCs of concern include (but are not limited to) such compounds as monochlorotoluene, phenol, trichlorophenol, dichlorophenol, etc.

5.1.4: Extent of Contamination

This section describes the findings of the investigation for all environmental media that were investigated.

Chemical concentrations are reported in parts per billion (ppb) for water and parts per million (ppm) for soil. For comparison purposes, where applicable, SCGs are provided for each medium.

Table 1 summarizes the degree of contamination for the contaminants of concern in subsurface soils and compares the data with the soil SCGs for the site. Tables 2, 3, 4, and 5 summarize the degree of contamination for the contaminants of concern in the site overburden, A-zone bedrock, B-zone bedrock, and C-zone bedrock groundwaters, respectively, and provides comparisons with groundwater SCGs for the site. The following are the media which were investigated and a summary of the findings of the investigation.

Surface Soil

The majority of the site is currently covered with either concrete or asphalt pavement. As such, surface soil samples were not collected as part of the Supplemental RI sampling program.

Subsurface Soil

Volatile organic contamination is widespread in overburden soils in the central and south-central portions of the site. Figure 5 is a two-dimensional depiction of monchlorotoluene (MCT) and total VOCs (without MCT) concentrations within subsurface soils. MCT is a tentatively identified compound which can be identified in VOC and SVOC sample analysis. MCT is present in very high concentrations at the site, and is also considered a contaminant of concern at several other hazardous waste sites in the Niagara Falls area. There appears to be an overburden source area of MCT in the south-western quadrant of the site, with MCT concentrations detected as high as 7,884 ppm. There is an equally large area of soil with very high concentrations of total VOCs (as high as 2,089 ppm) in the central and southern portion of the site.

It should be noted that VOC concentrations within the source areas vary with depth, and maximum VOC concentrations were detected at depths from 3 and 13 feet below ground surface. The heterogeneous nature of the overburden contributes to the vertical and horizontal distribution of contaminants in the source areas. The extremely high concentrations of VOCs and MCT detected within overburden soils suggest that non-aqueous phase liquid (NAPL) exists within the soil matrix. Since many of the VOCs are more dense than water, it is also likely that dense NAPLs (i.e. DNAPL) are more prevalent near the bottom of the overburden soils, on or near the surface of the bedrock.

Toxicity Characteristic Leaching Procedure (TCLP) analysis, which indicates whether a media must be treated as a hazardous waste, was performed on soil samples from 3 boreholes located within the central part of the site. One of the soil samples in this area exceeded the regulatory limit for trichloroethene (2.32 ppm vs. criteria of 0.5 ppm). Given the magnitude of organic contaminant concentrations in soils at other site locations, it is likely that there is a significant area of subsurface soil which would also exceed TCLP criteria, and therefore be considered hazardous waste.

Groundwater

Site groundwater has been contaminated from previous spills and releases during waste storage, treatment and disposal activities. As a large percentage of the overburden soils have been contaminated by various VOCs and SVOCs, associated overburden groundwater has been similarly effected. Due to the influence of the adjacent unlined bedrock tunnels on the overburden groundwater (drawing it downward into the fractured bedrock aquifer), the majority of site contamination (both dissolved phase and NAPL) has likely migrated downward into the fractured bedrock. Groundwater impacts to each zone are discussed below. As discussed in Section 5.1.1, the location and influence of the Falls Street and New Road Tunnels has effectively intercepted the lateral movement of overburden and upper bedrock groundwater and prevented it from migrating off site beyond the Royal Avenue and 47th Street tunnel alignments. The effects of the Falls Street Tunnel (and the

NYPA Conduits) on upper bedrock groundwater in the area has been well documented. USGS studies (1987 and 1991) and the 1992 "Niagara Falls Regional Groundwater Assessment" (performed jointly on behalf of DuPont, Olin, and Occidental) fully detail the effects summarized in Section 5.1.1.

Overburden Groundwater

Very high concentrations of VOCs are distributed over a large area of the site from the center to the southwestern corner. A sample of DNAPL containing mostly MCT was taken during a 1988 sampling event from overburden well BH-4B, located in the southwestern quadrant of the site, immediately down gradient of a former sludge settler lagoon. The highest concentrations of VOCs within overburden groundwater were detected in the center of the site. MCT was detected at 264,000 ppb at BH87-4B(R) and total VOCs (not including MCT) were detected at 394,300 ppb at PZ-01-4. Table 2 lists contaminants of concern in the overburden groundwater and Figures 6 and 7 present a conceptual view of total VOCs and MCT concentrations.

Bedrock Groundwater

The nature and extent of bedrock groundwater contamination is discussed below. As discussed in Section 2, Operable Unit No. 1 includes only the upper portion of the bedrock groundwater (i.e. A-zone and B-zone). The limited data related to Operable Unit No. 2 (i.e. deeper bedrock groundwater- C-zone and below) has been included in this discussion since an attempt was made to obtain C-zone bedrock groundwater quality data in the RI. Tables 3, 4, and 5 list contaminants of concern in the bedrock groundwater and Figures 6 and 7 present a conceptual view of total VOCs and MCT concentrations detected in the various upper bedrock zones.

A-zone Bedrock Groundwater

The distribution of groundwater contamination within the A-zone is widespread throughout the center, southern and southwestern portions of the site (see Figures 6 and 7). The highest concentrations of VOCs within the A-zone groundwater unit are located in the same proximity as the overburden groundwater VOC highs. MCT was detected at 42,900 ppb at MW88-3A(R) and total VOCs (without MCT) were detected at up to 354,064 ppb at MW-88-8A.

B-Zone Bedrock Groundwater

B-zone groundwater contamination is generally less widespread than the A-zone. The influence of the Falls Street Tunnel is apparent as the highest concentrations of VOCs and MCT are present along the southern side of the site near Royal Avenue (see Figures 6 and 7). MCT was detected at 47,400 ppb at MW-11 and total VOCs (without MCT) were detected at 93,271 ppb, also at MW-11. Samples of DNAPL were obtained in 1988 from B-zone fracture wells MW-11 and MW-87-1A. The DNAPL from MW-11 contained mostly MCT, di-chlorobenzenes, tri-chlorobenzenes, tetrachloroethene, and trichloroethene. The DNAPL from MW-87-1A was almost entirely MCT.

C-Zone Bedrock Groundwater

Three groundwater monitoring wells were installed in the C-zone as part of the previous investigations. One of the three wells was damaged and therefore was not sampled during the Supplemental RI. One of the two remaining C-zone bedrock wells sampled (near the eastern site boundary) in the Supplemental RI did not contain VOCs at detectable concentrations. The other well (in the south-central area) contained concentrations of MCT at 4,410 ppb and total VOCs (without MCT) at 3,590 ppb. This south central site location corresponded to an area of very high B-zone contaminant concentrations. It is therefore likely that there is also extensive C-zone groundwater contamination present in the southern portion of the site. However, the magnitude and extent of C-zone contamination cannot be assessed without additional groundwater investigations. Appropriate investigations of Operable Unit No. 2 will be necessary to characterize the nature and extent of deeper bedrock groundwater contamination.

5.2: Interim Remedial Measures

An interim remedial measure (IRM) is conducted at a site when a source of contamination or exposure pathway can be effectively addressed before completion of the RI/FS. There were no IRMs performed at this site during the RI/FS. A previous removal action was initiated by the US EPA and is discussed in Section 3.2.

5.3: Summary of Human Exposure Pathways:

This section describes the types of human exposures that may present added health risks to persons at or around the site. A more detailed discussion of the human exposure pathways can be found in Section 7 of the November 2002 Supplemental RI report.

An exposure pathway describes the means by which an individual may be exposed to contaminants originating from a site. An exposure pathway has five elements: [1] a contaminant source, [2] contaminant release and transport mechanisms, [3] a point of exposure, [4] a route of exposure, and [5] a receptor population.

The source of contamination is the location where contaminants were released to the environment (any waste disposal area or point of discharge). Contaminant release and transport mechanisms carry contaminants from the source to a point where people may be exposed. The exposure point is a location where actual or potential human contact with a contaminated medium may occur. The route of exposure is the manner in which a contaminant actually enters or contacts the body (e.g., ingestion, inhalation, or direct contact). The receptor population is the people who are, or may be, exposed to contaminants at a point of exposure.

An exposure pathway is complete when all five elements of an exposure pathway exist. An exposure pathway is considered a potential pathway when one or more of the elements currently does not exist, but could in the future.

At this site, contamination exists in subsurface soils and groundwater, and in soil vapor. For a complete exposure pathway to occur, persons would have to come into contact with the contaminated soil or groundwater, or inhale organic vapors. Exposure to these media could occur through trespassing or utility maintenance activities in and around the site. Currently, the only potential pathways of exposure are for utility workers entering adjacent or on-site utilities and structures. These potential pathways are:

- Dermal (skin) contact with contaminated subsurface soils and groundwater; and
- Inhalation of organic vapors.

The site is located in an industrial area and is not readily accessible to the public or workers at adjacent businesses. All occupied structures in the area are served by public water. Completed pathways may occur in the future for utility workers or site workers during subsurface construction activities and routine work.

5.4: Summary of Environmental Impacts

This section summarizes the existing and potential future environmental impacts presented by the site. Environmental impacts include existing and potential future exposure pathways to fish and wildlife receptors, as well as damage to natural resources such as aquifers and wetlands.

Site contamination has impacted the groundwater resource in the bedrock. However, a City ordinance currently prohibits the use of groundwater for drinking water purposes.

Under certain wet weather conditions, the off-site migration of contaminants within the overburden and upper bedrock may be directly discharged to the lower Niagara River (which in turn flows into Lake Ontario). The potential exists for aquatic resources to be effected by site contaminants. Some organic contaminants may bio-accumulate in Niagara River or Lake Ontario aquatic resources.

SECTION 6: SUMMARY OF THE REMEDIATION GOALS

Goals for the remedial program have been established through the remedy selection process stated in 6 NYCRR Part 375-1.10. At a minimum, the remedy selected must eliminate or mitigate all significant threats to public health and/or the environment presented by the hazardous waste disposed at the site through the proper application of scientific and engineering principles.

The remediation goals for this site are to eliminate, reduce, or control to the extent practicable:

- exposures of persons at or around the site to VOCs and SVOCs in soils, groundwater, or air;
- the release of contaminants from soil into groundwater that may create exceedances of groundwater quality standards;
- the release of VOC vapors from soils or groundwater into ambient air within site structures or subsurface utilities; and
- the off-site migration of VOCs and SVOCs within the overburden groundwater and within the bedrock groundwater zones of concern.

Further, the remediation goals for the site include attaining to the extent practicable:

- ambient groundwater quality standards and
- NYSDEC TAGM 4046 Recommended Soil Cleanup Objectives

SECTION 7: SUMMARY OF THE EVALUATION OF ALTERNATIVES

The selected remedy must be protective of human health and the environment, be cost-effective, comply with other statutory requirements, and utilize permanent solutions, alternative technologies or resource recovery technologies to the maximum extent practicable. Potential remedial alternatives for the Frontier Chemical Royal Avenue Site were identified, screened and evaluated in the FS report which is available at the document repositories identified in Section 1.

The FS utilized a select, focused group of general response actions and remedial technologies for site soil and groundwater contamination. This focused approach was appropriate given the nature and extent of site contamination. Both the magnitude of site contamination (including the presence of NAPL) and the practical limitations posed by the fractured bedrock aquifer were taken into consideration. Appropriate guidance, including EPA's "*Presumptive Response Strategy and Ex-Situ Treatment Technologies for*

Contaminated Ground Water at CERCLA Sites" and *"Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration"* were considered. Due to the composition of the overburden (silty-clay with discontinuous seams of silty sand), various in-situ technologies (such as vapor extraction and chemical oxidation) were deemed infeasible and screened out of consideration in the FS.

A summary of the remedial alternatives that were considered for this site are discussed below. The present worth represents the amount of money invested in the current year that would be sufficient to cover all present and future costs associated with the alternative. This enables the costs of remedial alternatives to be compared on a common basis. As a convention, a time frame of 30 years is used to evaluate present worth costs for alternatives with an indefinite duration. This does not imply that operation, maintenance, or monitoring would cease after 30 years if remediation goals are not achieved.

7.1: Description of Remedial Alternatives

The following potential remedies were considered to address the contaminated soils and groundwater at the site.

Alternative 1: No Action

The No Action Alternative is evaluated as a procedural requirement and as a basis for comparison. This alternative would leave the site in its present condition and would not provide any additional protection to human health or the environment.

Present Worth: *$0*
Capital Cost: *$0*
Annual OM&M:
(Years 1-5): *$0*
(Years 5-30): *$0*

Alternative 2: Institutional Controls

Institutional controls would be implemented to restrict site access and prevent human exposures to site contaminants within the soils and groundwater. Site access would be physically controlled by long term maintenance of the perimeter fence. An environmental easement would be implemented to prevent future site uses which may be incompatible with the site remedy. A site management plan would be developed to ensure that any future site use be limited to commercial or industrial uses and that any future construction include appropriate mitigation efforts to deal with contaminated site soils, soil vapors, and groundwater. Periodic certification would be required from the property owner that the institutional controls are still in place and that nothing has occurred that would impair the ability of the controls to protect public health or the environment.

This alternative would also include an annual groundwater monitoring program to assess long term site contamination and the effectiveness of the institutional controls at achieving the remedial objectives. Overburden and bedrock groundwater samples would be collected and analyzed from selected existing wells. It is assumed that the number of wells included in the monitoring program would be reduced by approximately 50% after the fifth year of data collection.

The implementation of the environmental easement and development of an Operation, Monitoring, and Maintenance (OM&M) plan for the institutional controls could be completed and finalized in 3-6 months.

Present Worth: *$989,000*
Capital Cost: *$26,000*
Annual OM&M:
(Years 1-5): *$101,000*
(Years 5-30): *$50,000*

Alternative 3: Cover System with Control/Treatment of Overburden and Upper Bedrock Groundwater

This alternative would include the removal of above grade structures and debris, with placement of a clean soil or asphalt pavement cover over areas of the site which are not currently paved. It would also include the control/treatment of contaminated site groundwater by either employing the existing Water Board utilities or through the design and construction of an on-site groundwater control/treatment system. The objective of this alternative would be to eliminate potential human exposures to contaminated vapors, soils, and groundwater, and to effectively and reliably control and treat the contaminated overburden and upper bedrock groundwater.

The cover system would be accomplished by either placing at least a one foot layer of clean soil over the unpaved areas of the site (approximately 20% of the site), or by grading and paving those areas with asphalt. If clean soil was used as the cover material, a layer of geotextile material would be included in those areas below the clean soil for future "demarcation" of potentially contaminated soils. It is recognized this type of cover system would not completely prevent infiltration of precipitation into the site soils. Any surface depressions or below grade building foundations on the site would be filled with clean soil and properly graded, or filled with an appropriate sub-base layer and paved with asphalt. In order to construct and maintain the cover system, the existing demolition debris would be removed from the site. Additional storm water collection manholes and sewer lines would be installed on the site to facilitate proper drainage. The storm water collection system would be connected to one of the existing Niagara Falls Water Board sewers for discharge under a permit with the Water Board.

Overburden and upper bedrock groundwater would either be intercepted and treated utilizing existing Water Board utilities or through the design, construction, and operation of an on-site groundwater control/treatment system. Use of existing Water Board utilities for the long term collection and treatment of contaminated site groundwater would require an agreement with the Water Board and would include reasonable compensation for providing such services. If the Water Board were to undertake future modifications to the existing utilities which diminished their control/treatment effectiveness, or should the Water Board be unwilling to provide for the continued collection and treatment of contaminated site groundwater, then an on-site groundwater control/treatment system would be required.

An environmental easement would be implemented to prevent future site uses which may be incompatible with the site remedy. A site management plan would be developed to ensure that any future site use be limited to commercial or industrial uses and that any future construction include appropriate mitigation efforts to deal with contaminated site soils, soil vapors, and groundwater. Periodic certification would be required from the property owner that the institutional controls are still in place and that nothing has occurred that would impair the ability of the controls to protect public health or the environment.

This alternative would also include an annual groundwater monitoring program to assess long term site contamination and the effectiveness of the remedy at achieving the remedial objectives. Overburden and bedrock groundwater samples would be collected and analyzed from selected existing wells. It is assumed that the number of wells included in the monitoring program would be reduced by approximately 50% after the fifth year of data collection.

The design for this alternative would depend on the choice of groundwater control/treatment system and could be completed and finalized in 6-18 months. An on-site groundwater control/treatment system would likely require pre-design pump tests and groundwater treatability studies to determine effective groundwater control/treatment system parameters. The construction time to implement this alternative is estimated at approximately 6-12 months. Costs below include a range with the lower estimates assuming groundwater control/treatment utilizing existing Water Board utilities (but do not include Water Board charges for such services), and the upper estimates assuming the design, construction, an operation of an on-site groundwater control/treatment system.

Present Worth: . . . . . . *$1,861,000 - $4,671,000*
Capital Cost: . . . . *$873,000 - $2,635,000*
Annual OM&M:
(Years 1-5): . . . . *$101,000 - $169,000*
(Years 5-30): . . . . *$50,000 - $118,000*

Alternative 4: Excavation and Treatment/Disposal of Soil "Source Areas" (Total VOCs >100ppm), Installation of a Cover System, with Overburden and Upper Bedrock Groundwater Control/Treatment

This alternative would remove the above grade structures and debris from the site as well as excavate and treat/dispose of the contaminated soils with total VOCs>100 ppm. Following removal of the contaminated soil >100 ppm, a clean soil or asphalt pavement cover would be completed over areas of the site which are not currently paved. This alternative would also include the control/treatment of contaminated site groundwater by either employing the existing Water Board utilities or thru the design and construction of an on-site groundwater control/treatment system. The objective of this alternative would be to reduce contaminant soil source areas, while effectively and reliably controlling the highly contaminated overburden and upper bedrock groundwater.

A pre-design soil investigation would be conducted to more accurately identify the lateral and vertical extent of soil "source areas". These areas would be excavated and treated/disposed at a permitted off site location. On-site de-watering of contaminated soils would be necessary for soils below the water table. Excavation waters would either be treated on-site with permitted discharge to the sewers, or would be sent off site for treatment and disposal. Soil excavation would use engineering controls to prevent potential on and off-site exposures to particulates and volatile organic vapors. In order to conduct the pre-design investigation and excavate the contaminant "source areas", all remaining structures and demolition debris would be removed from the site with proper disposal of the material at an off-site facility.

The removal of the soil contaminant source areas >100 ppm total VOCs would eliminate much of the potential future contaminant loadings to the bedrock. These areas likely contain NAPL and are the most highly contaminated overburden areas. It is estimated that removal of these soils would reduce the overall contaminant mass within the soils by about 36%.

Similar to Alternative 3, a cover system would be constructed after removal of the soil contaminant "source areas". The cover system would include the placement of at least one foot of clean soil over the unpaved areas of the site (approximately 20% of the site), or by grading and paving those areas with asphalt. If clean soil was used as the cover material, a layer of geotextile material would be included in those areas below the clean soil for future "demarcation" of potentially contaminated soils. Any surface depressions or below grade building foundations on the site would be filled with clean soil and properly graded prior to being covered. Additional storm water collection manholes and sewer lines would be installed on the site to facilitate proper drainage. The storm water collection system would be connected to one of the existing Water Board sewers for discharge under a permit with the Water Board.

Site groundwater would be controlled and treated either utilizing the existing Water Board utilities, or by design, construction, and operation of an on-site groundwater control/treatment system. Either groundwater control/treatment option would require Water Board agreement and/or permits for discharge of either raw or treated site groundwater to the Water Board's sewer system.

An environmental easement would be implemented to prevent future site uses which may be incompatible with the site remedy. A site management plan would be developed to ensure that any future site use be limited to commercial or industrial uses and that any future construction include appropriate mitigation efforts to deal with contaminated site soils, soil vapors, and groundwater. Periodic certification would be required from the property owner that the institutional controls are still in place and that nothing has occurred that would impair the ability of the controls to protect public health or the environment.

This alternative would also include an annual groundwater monitoring program to assess long term site contamination and the effectiveness of the remedy at achieving the remedial objectives. Overburden and bedrock groundwater samples would be collected and analyzed from selected existing wells. It is assumed that the number of wells included in the monitoring program would be reduced by approximately 50% after the fifth year of data collection.

As with Alternative 3, the design for this alternative would depend on the choice of groundwater control/treatment system and could be completed and finalized in 6-18 months. Pump tests and treatability studies would likely be required if design of an on-site groundwater treatment system is necessary. In addition, a pre-design soil investigation would be required to further define the soil contaminant "source areas". Treatability studies may also be required for soil disposal. The construction time to implement this alternative is estimated at approximately 12-24 months. Costs below include a range with lower estimates assuming groundwater control/treatment utilizing existing Water Board utilities (but do not include Water Board charges for such services) and upper estimates assuming the design, construction, and operation of an on-site groundwater control/treatment system.

Present Worth: . . . . $10,892,000 - $13,701,000
Capital Cost: . . . . . . $9,903,000 - $11,665,000
Annual OM&M:
(Years 1-5): . . . . $101,000 - $169,000
(Years 5-30): . . . . $50,000 - $118,000

Alternative 5: Excavation and Treatment/Disposal of all Contaminated Soils with Upper Bedrock Groundwater Control/Treatment

This alternative would include the excavation and off-site treatment/disposal of all soils containing total VOCs greater than 10ppm. It would also include the control/treatment of the contaminated upper bedrock groundwater by either employing the existing Water Board utilities or thru the design, construction, and operation of an on-site groundwater control/treatment system. The objective of this alternative would be to eliminate contaminant soil source areas, while effectively controlling the highly contaminated upper bedrock groundwater.

On-site de-watering of contaminated soils would be necessary for soils below the water table. Excavation waters would either be treated on-site with permitted discharge to the sewers, or would be sent off site for treatment and disposal. Similar to Alternative 4, soil excavation would use engineering controls to prevent potential on and off-site exposures to particulates and volatile organic vapors. In order to gain access to all excavation areas, all remaining demolition debris would be removed from the site. Any remaining site buildings or structures located in the soil removal areas would be demolished with proper disposal of the material at an off-site facility.

The removal of the soil contaminant source areas >10 ppm total VOCs would eliminate most of the potential future contaminant loadings to the bedrock. It is estimated that removal of these soils would reduce the overall contaminant mass within the soils by at least 90%.

Upper bedrock groundwater would be controlled and treated either utilizing the existing Water Board utilities, or by design, construction, and operation of an on-site groundwater control/treatment. Either groundwater collection/treatment option would require Water Board agreement and/or permits for discharge of either raw or treated site groundwater to the Water Board's sewer system.

An environmental easement would be implemented to prevent future site uses which may be incompatible with the site remedy. A site management plan would be developed to ensure that any future site use be limited to commercial or industrial uses and that any future construction include appropriate mitigation efforts to deal with contaminated site soils, soil vapors, and groundwater. Periodic certification would be required from the property owner that the institutional controls are still in place and that nothing has occurred that would impair the ability of the controls to protect public health or the environment.

This alternative would also include an annual groundwater monitoring program to assess long term site contamination and the effectiveness of the remedy at achieving the remedial objectives. Overburden and bedrock groundwater samples would be collected and analyzed from selected existing wells. It is assumed that the number of wells included in the monitoring program would be reduced by approximately 50% after the fifth year of data collection.

As with Alternatives 3 and 4, the design for this alternative would depend on the choice of groundwater control/treatment system, and could be completed and finalized in 12-18 months. Pump tests and treatability studies would likely be required if design of an on-site groundwater treatment system is necessary. In addition, a pre-design soil investigation would be required to delineate the extent of the soil removal areas. Treatability studies may also be required for soil disposal. The construction time to implement this alternative is estimated at approximately 18-36 months. Costs below include a range with lower estimates assuming bedrock groundwater control/treatment utilizing existing Water Board utilities (but do not include Water Board charges for such services), and upper estimates assuming the design, construction, and operation of an on-site bedrock groundwater control/treatment system.

Present Worth: . . . . $23,765,000 - $26,574,000
Capital Cost: . . . . . $22,777,000 - $24,539,000
Annual OM&M:
(Years 1-5): . . . . $101,000 - $169,000
(Years 5-30): . . . . $50,000 - $118,000

7.2 Evaluation of Remedial Alternatives

The criteria to which potential remedial alternatives are compared are defined in 6 NYCRR Part 375, which governs the remediation of inactive hazardous waste disposal sites in New York State. A detailed discussion of the evaluation criteria and comparative analysis is included in the FS report.

The first two evaluation criteria are termed "threshold criteria" and must be satisfied in order for an alternative to be considered for selection.

1. Protection of Human Health and the Environment. This criterion is an overall evaluation of each alternative's ability to protect public health and the environment.

2. Compliance with New York State Standards, Criteria, and Guidance (SCGs). Compliance with SCGs addresses whether a remedy will meet environmental laws, regulations, and other standards and criteria. In addition, this criterion includes the consideration of guidance which the NYSDEC has determined to be applicable on a case-specific basis.

The next five "primary balancing criteria" are used to compare the positive and negative aspects of each of the remedial strategies.

3. Short-term Effectiveness. The potential short-term adverse impacts of the remedial action upon the community, the workers, and the environment during the construction and/or implementation are evaluated. The length of time needed to achieve the remedial objectives is also estimated and compared against the other alternatives.

4. Long-term Effectiveness and Permanence. This criterion evaluates the long-term effectiveness of the remedial alternatives after implementation. If wastes or treated residuals remain on-site after the selected remedy has been implemented, the following items are evaluated: 1) the magnitude of the remaining risks, 2) the adequacy of the engineering and/or institutional controls intended to limit the risk, and 3) the reliability of these controls.

5. Reduction of Toxicity, Mobility or Volume. Preference is given to alternatives that permanently and significantly reduce the toxicity, mobility or volume of the wastes at the site.

6. Implementability. The technical and administrative feasibility of implementing each alternative are evaluated. Technical feasibility includes the difficulties associated with the construction of the remedy and the ability to monitor its effectiveness. For administrative feasibility, the availability of the necessary personnel and materials is evaluated along with potential difficulties in obtaining specific operating approvals, access for construction, institutional controls, and so forth.

7. Cost-Effectivness. Capital costs and operation, maintenance, and monitoring costs are estimated for each alternative and compared on a present worth basis. Although cost-effectiveness is the last balancing criterion evaluated, where two or more alternatives have met the requirements of the other criteria, it can be used as the basis for the final decision. The costs for each alternative are presented in Table 6.

This final criterion is considered a "modifying criterion" and is taken into account after evaluating those above. It is evaluated after public comments on the Proposed Remedial Action Plan have been received.

8. Community Acceptance - Concerns of the community regarding the RI/FS reports and the PRAP are evaluated. A responsiveness summary will be prepared that describes public comments received and the manner in which the NYSDEC will address the concerns raised. If the selected remedy differs significantly from the proposed remedy, notices to the public will be issued describing the differences and reasons for the changes.

SECTION 8: SUMMARY OF THE PROPOSED REMEDY

The NYSDEC is proposing Alternative 4, excavation and treatment/disposal of soil "source areas" (with Total VOCs>100ppm), installation of a cover system, with overburden and upper bedrock groundwater control/treatment as the remedy for Operable Unit No. 1 at this site. The elements of this remedy are described at the end of this section.

The proposed remedy is based on the results of the RI and the evaluation of alternatives presented in the FS. Alternative 4 is being proposed because, as described below, it satisfies the threshold criteria and provides the best balance of the primary balancing criteria described in Section 7.2. It would achieve the remediation goals for the site by: removing the remaining soil contaminant source areas from the site, preventing direct human contact with contaminated site soils, vapors, and groundwater by completing a cover system over the surface of the site; and ensure the long term control and treatment of contaminated site groundwater by either utilizing existing Water Board utilities (per an agreement with the Water

Board), or by the design and construction of an on-site groundwater control/treatment system. Figure 8 is a conceptual representation of cover system additions with an on-site groundwater control/treatment system.

Due to the extremely high concentrations of organic contaminants within the site groundwater, and the presence of DNAPL within the bedrock (which will serve as a continuing source of contamination and cannot be readily extracted from bedrock fractures), achievement of groundwater standards on site within a reasonable time frame is considered technically impracticable. As such, pursuant to U.S. Environmental Protection Agency guidance Evaluating the Technical impracticability of Ground-Water Restoration, Interim Final, Directive 9234.2-25, September 1993, the NYSDEC has determined that the SCGs for bedrock groundwater will not be met.

Alternatives 3, 4, and 5 would offer similar protection of human health and the environment, through either containment and/or soil source area removal and treatment. Alternative 1 would not offer any protection of human health and the environment, and Alternative 2 would offer limited protection by means of site access restrictions.

None of the five alternatives would achieve SCGs for both soil and groundwater. Alternative 5 is the only alternative that would achieve soil SCGs, through excavation and off site treatment/disposal of all soils above SCGs. Alternative 4 would remove and treat some of the soil contaminant "source areas", however a large volume of contaminated soil above SCGs would remain. None of the alternatives would achieve groundwater SCGs.

Because alternatives 3, 4, and 5 all satisfy the threshold criteria, the five balancing criteria are particularly important in selecting a final remedy for the site.

Alternatives 3, 4, and 5 all have short term impacts which could be controlled. Alternatives 4 and 5 would require significant engineering controls in order to control releases of organic vapors during soil excavation activities. Erection of temporary containment structures would likely be required to prevent releases of volatile organic contaminants during soil excavations and/or staging activities. Workers involved in excavations and/or contaminated soil handling activities associated with Alternatives 3, 4, and 5 would require respiratory protection. Since Alternative 3 (containment) could be implemented the quickest, the time needed to achieve the remediation goals would generally be the shortest for alternative 3.

Alternative 5 would offer the greatest long term effectiveness since this alternative would remove/treat/dispose of all contaminated soils above SCGs. Alternative 4 would offer more long term effectiveness than Alternative 3, since it would involve the removal/treatment/disposal of the soil contaminant "source areas". However, while alternatives 4 and 5 would remove either some or all of the contaminant source soils, such a removal would not result in the achievement of groundwater standards within a reasonable or predictable time frame. This is due to the presence of DNAPL within the bedrock, which will continue to serve as a source of future bedrock groundwater contamination. Alternatives 3 and 4 would both offer long term effectiveness by providing a reliable means (a cover system) of preventing contact with contaminated soils. Alternative 4's effectiveness would be enhanced by the removal and treatment/disposal of soil contaminant source areas. Alternatives 3 and 4 would also rely on a site management plan to ensure that any future site use or development adequately addressed the remaining soil and soil vapor contamination. Alternatives 3, 4, and 5 would equally provide for long term control and treatment of contaminated site groundwater. Alternatives 1 and 2 would offer little, if any, long term effectiveness for existing soil and groundwater contamination.

Alternative 5 would offer the greatest reduction in contaminant volume. It is estimated that Alternative 5 would remove at least 90% of contamination within site soils. Alternative 4 would offer some reduction in soil contaminant volume. It is estimated that Alternative 4 would reduce approximately 36% of the soil contamination. Alternatives 1, 2, and 3 would not offer any reduction of contamination within site soils. Alternatives 3, 4, and 5 would all control groundwater contaminant mobility within the overburden and upper bedrock groundwater.

Alternatives 1 and 2 are easily implementable. Alternative 3 is also easily implementable, but would require some additional controls (e.g. minor dust and vapor suppression and monitoring) during construction of the cover system and/or the groundwater control/treatment system. Alternatives 4 and 5 are implementable, but would require extensive engineering controls for the excavation and transport of the contaminated soils. Extensive pre-design soil sampling would need to be conducted to delineate the extent of the soil contaminant "source areas" in Alternatives 4 and 5. Treatability studies would likely be required for the off-site treatment/disposal of contaminated soils in Alternatives 4 and 5.

The cost of the alternatives varies significantly. Due to the costs of soil excavation and treatment/disposal, alternatives 4 and 5 would cost substantially more than alternatives 1,2, or 3. The costs for removal and treatment of "source area" soils in Alternatives 4 and 5 would depend upon the source area soil volume estimates determined in a pre-design sampling program. Alternatives 3, 4, and 5 all require groundwater control/treatment. Significant cost savings may be realized if an agreement were reached with the Water Board to provide long term site groundwater control/treatment. Such an agreement could eliminate the expenses associated with the design, construction, and operation of an on-site groundwater control/treatment system.

The estimated present worth cost to implement the remedy is estimated at between $10,892,000 - $13,701,000. The cost to construct the remedy is estimated at between $9,903,000 - $11,665,000 and the estimated average annual operation, maintenance, and monitoring costs for 30 years is estimated at between $50,000 - $169,000 (not including appropriate Niagara Falls Water Board charges). The significant range of costs is due to a lower cost estimate which assumes use of the existing Water Board utilities for groundwater control/treatment, and a higher cost estimate which assumes the construction and operation of an on site groundwater control/treatment system.

The elements of the proposed remedy are as follows:

1. A remedial design program would be implemented to provide the details necessary for the construction, operation, maintenance, and monitoring of the remedial program.

2. Existing site buildings, above grade structures, and demolition debris would be removed from the site.

3. Contaminant source area soils (those containing total VOCs > 100ppm) would be excavated and treated/disposed off-site at an appropriate disposal facility. Soil removal areas would be backfilled with clean materials.

4. The site surface would be covered through placement of clean soil or asphalt pavement over the unpaved portions of the site. If clean soil was used as the cover material, a layer of geotextile material would be included in those areas below the clean soil for future "demarcation" of potentially contaminated soils.

5. Appropriate storm sewers would be constructed to collect and discharge site storm water to the Niagara Falls Water

Board's sewers under appropriate permit requirements.

6. Site groundwater would be controlled/treated in one of two ways. Either an agreement with the Niagara Falls Water Board would be reached which allows for site groundwater control/treatment utilizing City utilities, or a site groundwater control/treatment system would be constructed on site, with permitted discharge of effluent to the Water Board's sewer system.

7. Development of a site management plan to: (a) address contaminated soils that may be excavated from the site during future redevelopment. The plan would require soil characterization and, where applicable, disposal/reuse in accordance with NYSDEC regulations; (b) evaluate the potential for vapor intrusion for any buildings constructed on the site, including provisions for mitigation of any impacts; (c) identify any use restrictions; and (d) provide for the operation and maintenance of the components of the remedy.

8. Imposition of an institutional control in the form of an environmental easement that would (a) require compliance with the approved site management plan; (b) limit use and development of the property to commercial or industrial uses only; (c) restrict the use of groundwater as a source of potable water; and (d) require the property owner to complete and submit to the NYSDEC a periodic certification.

9. The property owner would provide a periodic certification, prepared and submitted by a professional engineer or such other expert acceptable to the NYSDEC, until the NYSDEC notifies the property owner in writing that this certification is no longer needed. This submittal would contain certification that the institutional controls and engineering controls are still in place, allow the NYSDEC access to the site, and that nothing has occurred that would impair the ability of the control to protect public health or the environment, or constitute a violation or failure to comply with the site management plan.

10. The operation of the components of the remedy would continue until the remedial objectives have been achieved, or until the NYSDEC determines that continued operation is technically impracticable or not feasible.

11. Since the remedy results in untreated hazardous waste remaining at the site, a long term monitoring program would be instituted. The monitoring program would include evaluations of the integrity of the cover system and the magnitude of remaining site groundwater contamination. This program would allow the effectiveness of the cover system and groundwater control/treatment system to be monitored and would be a component of the operation, maintenance, and monitoring for the site.

TABLE 1
Nature and Extent of Subsurface[1] Soil Contamination
2001 Sampling

SOILS	Contaminants of Concern	Concentration Range Detected (ppm)[a]	SCG[b] (ppm)[a]	Frequency of Exceeding SCG
Volatile Organic Compounds (VOCs)	1,1,1 trichloroethane	0.002 - 510	0.8	5 of 31
	1,1 dichloroethane	0.002 - 45	0.2	5 of 31
	1,2,4 trichlorobenzene	0.002 - 140	3.4	8 of 31
	1,2 dichlorobenzene	0.002 - 680	7.9	8 of 31
	1,3 dichlorobenzene	0.002 - 210	1.6	11 of 31
	1,4 dichlorobenzene	0.002 - 430	8.5	8 of 31
	acetone	0.005 - 48	0.2	3 of 31
	benzene	0.003 - 9.8	0.06	4 of 31
	chlorobenzene	0.002 - 830	1.7	7 of 31
	tetrachloroethene	0.003 - 2700	1.4	9 of 31
	toluene	0.001 - 56	1.5	8 of 31
	trichloroethene	0.002 - 150	0.7	10 of 31
	xylenes (total)	0.001 - 40	1.2	4 of 31
Semivolatile Organic Compounds (SVOCs)	phenol	0.037 - 8.7	0.03	13 of 31
	benzo(a)anthracene	0.043 - 1.3	0.224	4 of 31
	benzo(a)pyrene	0.072 - 2.4	0.061	9 of 31
	chrysene	0.049 - 3	0.4	4 of 31
	dibenzo(a,h)anthracene	0.038 - 0.39	0.014	6 of 31
Tentatively Identified Compounds (TICs)	total monochlorotoluene	ND[c] - 7884	NA[d]	NA[d]
PCB/Pesticides	heptachlor epoxide	0.00027 - 0.22	0.02	3 of 31

Notes: [1]Only subsurface soil data available- surface soils were not sampled.
[a] ppm = parts per million, which is equivalent to milligrams per kilogram, mg/kg, in soil;
[b] SCG = standards, criteria, and guidance values;
[c]ND = non-detect
[d]NA = No SCG available for total MCT

TABLE 2

Nature and Extent of Overburden Groundwater Contamination
2001 Sampling

OVERBURDEN GW	Contaminants of Concern	Concentration Range Detected (ppb)[a]	SCG[b] (ppb)[a]	Frequency of Exceeding SCG
Volatile Organic Compounds (VOCs)	1,1,1 trichloroethane	4 - 8500	5	11 of 29
	1,1 dichloroethane	2 - 7000	5	14 of 29
	1,2,4 trichlorobenzene	9 - 7600	5	7 of 29
	1,2 dichlorobenzene	2 - 69000	3	14 of 29
	1,2 dichloroethane	1 - 460	0.6	5 of 29
	1,3 dichlorobenzene	2 - 41000	3	12 of 29
	1,4 dichlorobenzene	2 - 43000	3	13 of 29
	acetone	6 - 5500	50	9 of 29
	benzene	2 -30000	1	9 of 29
	chlorobenzene	1 - 36000	5	13 of 29
	cis- 1,2 dichloroethene	1 - 120000	5	19 of 29
	methylene chloride	220 - 19000	5	6 of 29
	tetrachloroethene	3 - 74000	5	17 of 29
	toluene	2 - 6700	5	10 of 29
	trichloroethene	2 - 250000	5	21 of 29
	vinyl chloride	22 - 6300	2	12 of 29
	xylenes (total)	4 - 720	5	6 of 29
Semivolatile Organic Compounds (SVOCs)	phenol	6 - 4600	1[c]	7 of 12
	2,4 dichlorophenol	3 - 42	5	4 of 12
Tentatively Identified Compounds (TICs)	total monochlorotoluene	ND[d] - 135	NA[e]	NA[e]

Notes: [a] ppb = parts per billion, which is equivalent to micrograms per liter, ug/L, in water;
[b] SCG = standards, criteria, and guidance values;
[c]1 ppb= standard applies to sum of phenolic compounds (i.e. Total Phenols)
[d]ND = non-detect
[e]NA = No SCG available for total MCT

TABLE 3
Nature and Extent of A-Zone Bedrock Groundwater Contamination
2001 Sampling

Bedrock A-Zone GW	Contaminants of Concern	Concentration Range Detected (ppb)[a]	SCG[b] (ppb)[a]	Frequency of Exceeding SCG
Volatile Organic Compounds (VOCs)	1,1,1 trichloroethane	47 - 18000	5	7 of 23
	1,1 dichloroethane	1 - 4300	5	12 of 23
	1,1 dichloroethene	5 - 1300	5	4 of 23
	1,2,4 trichlorobenzene	1 - 4200	5	7 of 23
	1,2 dichlorobenzene	1 - 61000	3	15 of 23
	1,2 dichloroethane	20 - 140	0.6	2 of 23
	1,3 dichlorobenzene	1 - 19000	3	14 of 23
	1,4 dichlorobenzene	2 - 26000	3	13 of 23
	acetone	13 - 3500	50	9 of 23
	benzene	4 -15000	1	15 of 23
	chlorobenzene	1 - 21000	5	16 of 23
	cis- 1,2 dichloroethene	2 - 270000	5	16 of 23
	methylene chloride	130 - 13000	5	7 of 23
	tetrachloroethene	2 - 47000	5	10 of 23
	toluene	1 - 3900	5	12 of 23
	trichloroethene	2 - 22000	5	17 of 23
	vinyl chloride	3 - 26000	2	8 of 23
	xylenes (total)	1 - 240	5	4 of 23
Semivolatile Organic Compounds (SVOCs)	phenol	1 - 4400	1[c]	13 of 18
	2,4 dichlorophenol	7 - 85	5	6 of 18
	2,4,6 trichlorophenol	1 - 64	1	5 of 18
Tentatively Identified Compounds (TICs)	total monochlorotoluene	ND[d] - 27600	NA[e]	NA[e]

Notes: [a] ppb = parts per billion, which is equivalent to micrograms per liter, ug/L, in water;
[b] SCG = standards, criteria, and guidance values;
[c] 1 ppb= standard applies to sum of phenolic compounds (i.e. Total Phenols)
[d] ND = non-detect
[e] NA = No SCG available for total MCT

TABLE 4
Nature and Extent of B-Zone Bedrock Groundwater Contamination
2001 Sampling

Bedrock B-Zone GW	Contaminants of Concern	Concentration Range Detected (ppb)[a]	SCG[b] (ppb)[a]	Frequency of Exceeding SCG
Volatile Organic Compounds (VOCs)	1,1,1 trichloroethane	4 - 10000	5	7 of 18
	1,1 dichloroethane	1 - 2800	5	10 of 18
	1,2,4 trichlorobenzene	1 - 1100	5	6 of 18
	1,2 dichlorobenzene	4 - 12000	3	12 of 18
	1,3 dichlorobenzene	4 - 8400	3	12 of 18
	1,4 dichlorobenzene	7 - 9600	3	12 of 18
	acetone	3 - 8700	50	6 of 18
	benzene	5 -5100	1	12 of 18
	chlorobenzene	1 - 13000	5	13 of 18
	cis- 1,2 dichloroethene	1 - 1600	5	13 of 18
	methylene chloride	11 - 8600	5	6 of 18
	tetrachloroethene	12 - 6000	5	10 of 18
	toluene	2 - 2500	5	8 of 18
	trichloroethene	3 - 10000	5	10 of 18
	vinyl chloride	28 - 400	2	8 of 18
	xylenes (total)	2 - 360	5	2 of 18
Semivolatile Organic Compounds (SVOCs)	phenol	7 - 11000	1[c]	8 of 14
	2,4,6 trichlorophenol	1 - 170	1	4 of 14
Tentatively Identified Compounds (TICs)	total monochlorotoluene	Nd[d] - 47000	NA[e]	NA[e]

Notes: [a] ppb = parts per billion, which is equivalent to micrograms per liter, ug/L, in water;
[b] SCG = standards, criteria, and guidance values;
[c] 1 ppb= standard applies to sum of phenolic compounds (i.e. Total Phenols)
[d] ND = non-detect
[e] NA = No SCG available for total MCT

TABLE 5
Summary of C-Zone Bedrock Groundwater Contamination
2001 Sampling

Bedrock C-Zone GW	Contaminants of Concern	Concentration Range Detected (ppb)[a]	SCG[b] (ppb)[a]	Frequency of Exceeding SCG
Volatile Organic Compounds (VOCs)	1,1,1 trichloroethane	ND[c] - 910	5	1 of 2
	1,1 dichloroethane	ND - 77	5	1 of 2
	1,2,4 trichlorobenzene	ND - 57	5	1 of 2
	1,2 dichlorobenzene	ND - 210	3	1 of 2
	1,3 dichlorobenzene	ND - 210	3	1 of 2
	1,4 dichlorobenzene	ND - 210	3	1 of 2
	benzene	4 -440	1	2 of 2
	chlorobenzene	ND - 680	5	1 of 2
	cis- 1,2 dichloroethene	ND - 11	5	1 of 2
	methylene chloride	ND - 100	5	1 of 2
	tetrachloroethene	ND - 95	5	1 of 2
	toluene	ND - 170	5	1 of 2
	trichloroethene	ND - 420	5	1 of 2
Semivolatile Organic Compounds (SVOCs)	phenol	ND - 31	1[d]	1 of 2
Tentatively Identified Compounds (TICs)	total monochlorotoluene	ND - 2600	NA[e]	NA[e]

Notes: [a] ppb = parts per billion, which is equivalent to micrograms per liter, ug/L, in water;
[b] SCG = standards, criteria, and guidance values;
[c]ND = non-detect
[d]1 ppb= standard applies to sum of phenolic compounds (i.e. Total Phenols)
[e]NA = No SCG available for total MCT

Table 6
Remedial Alternative Costs

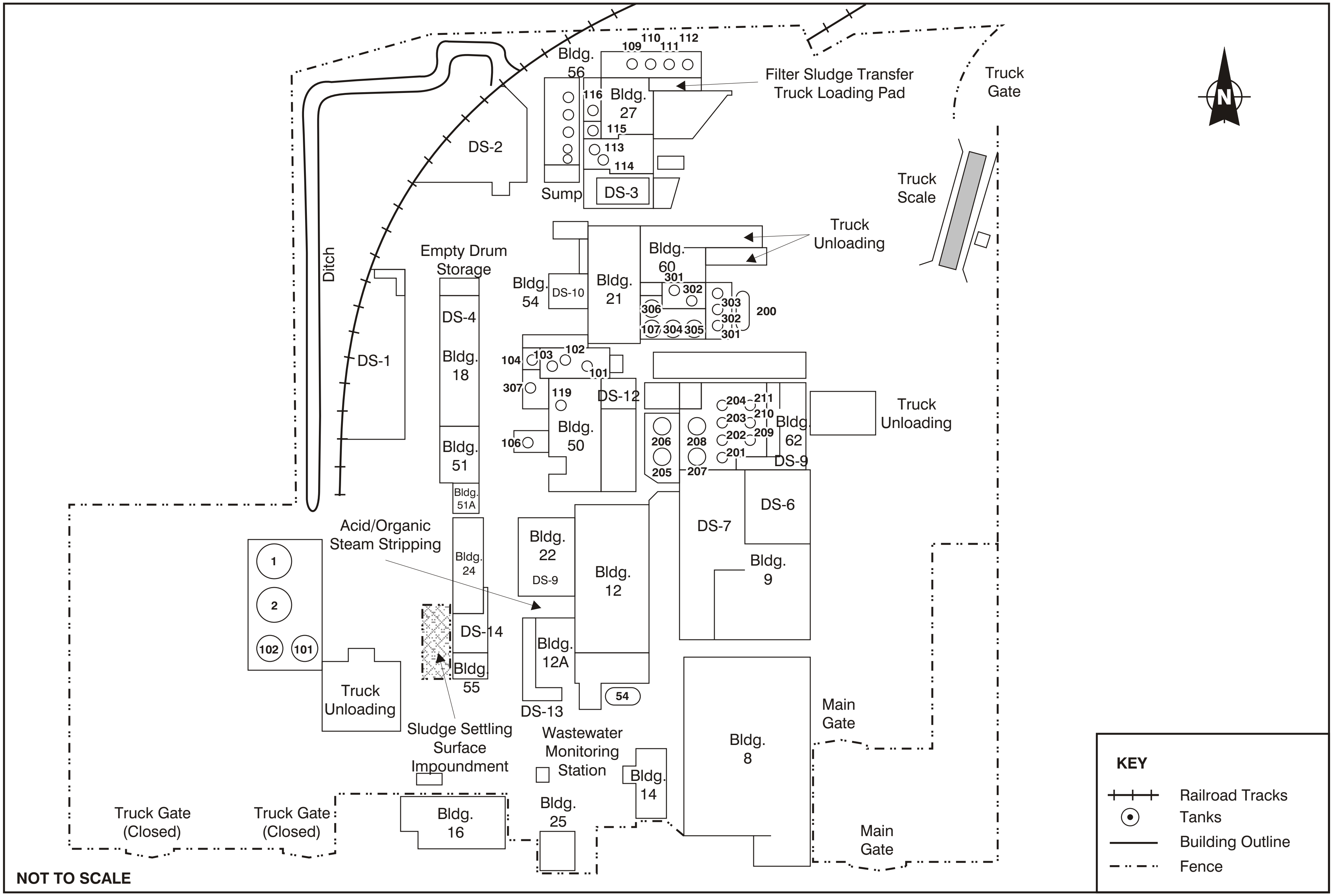
Remedial Alternative	Capital Cost	Annual OM&M	Total Present Worth
1. No Action	$0	$0	$0
2. Institutional Controls	$26,000	$50,000 - $101,000	$989,000
3. Cover System/GW Control/Treatment	$873,000 - $2,635,000	$50,000 - $169,000	$1,861,000 - $4,671,000
4. Excavation/Treatment of Soil "Source Areas"(>100ppm)/Cover System/`GW Control/Treatment	$9,903,000 - $11,665,000	$50,000 - $169,000	$10,892,000 - $13,701,000
5. Excavation/Treatment of Contaminated Soils (>10ppm)/ GW Control/Treatment	$22,777,000 - $24,539,000	$50,000 - $169,000	$23,765,000 - $26,574,000

SOURCE: Niagara Falls Quadrangle, 7.5 Minute Series Topographic Map 1980.

SCALE

0 0.5 1 Mile

Figure 1 - SITE LOCATION MAP
Frontier Chemical Royal Avenue Site (#9-32-110)



SOURCE: Frontier Waste Process, Inc. historical drawings.

Figure 2 - 1984 Site Map - Frontier Chemical Royal Avenue Site (#9-32-110)

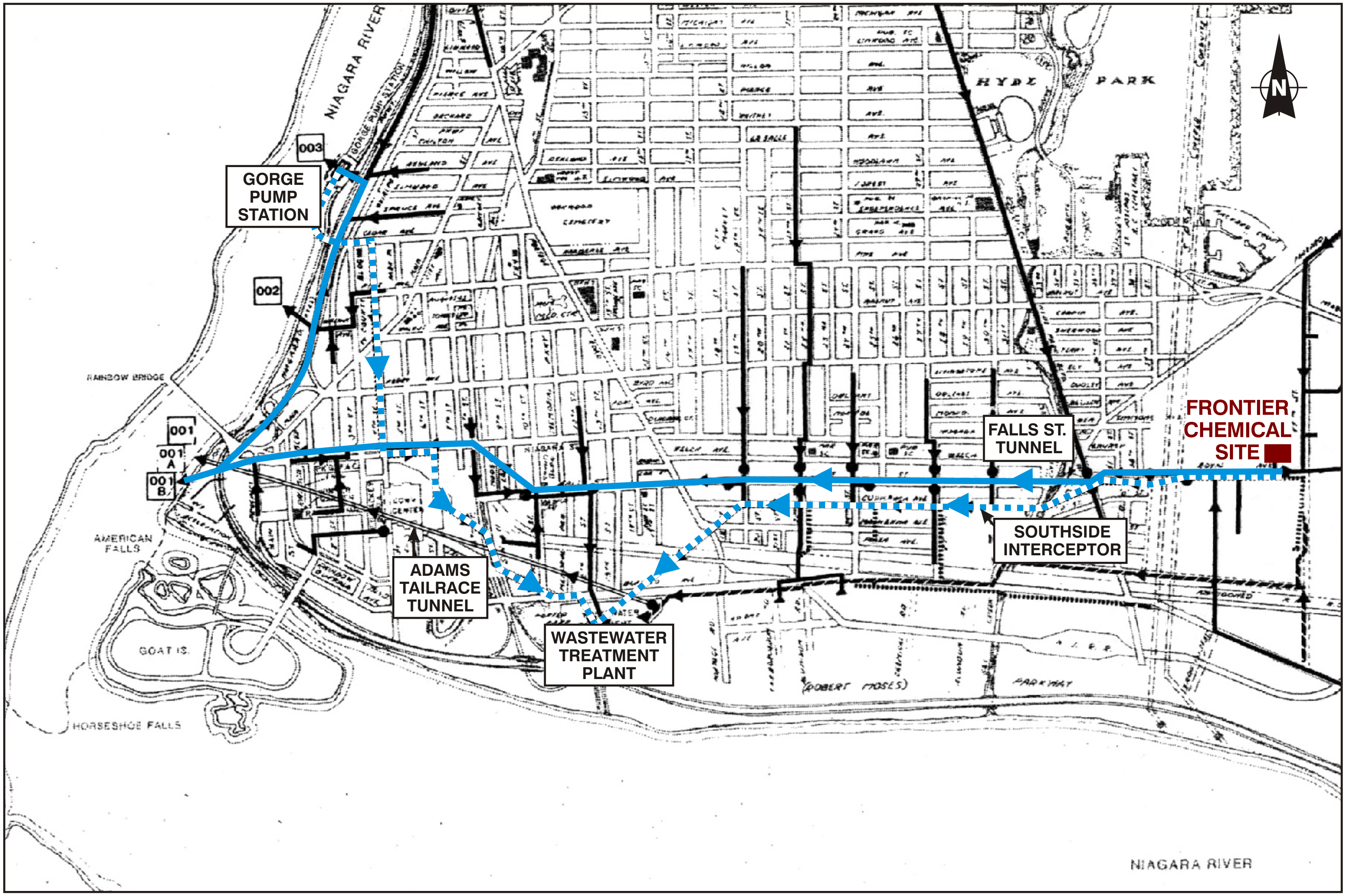
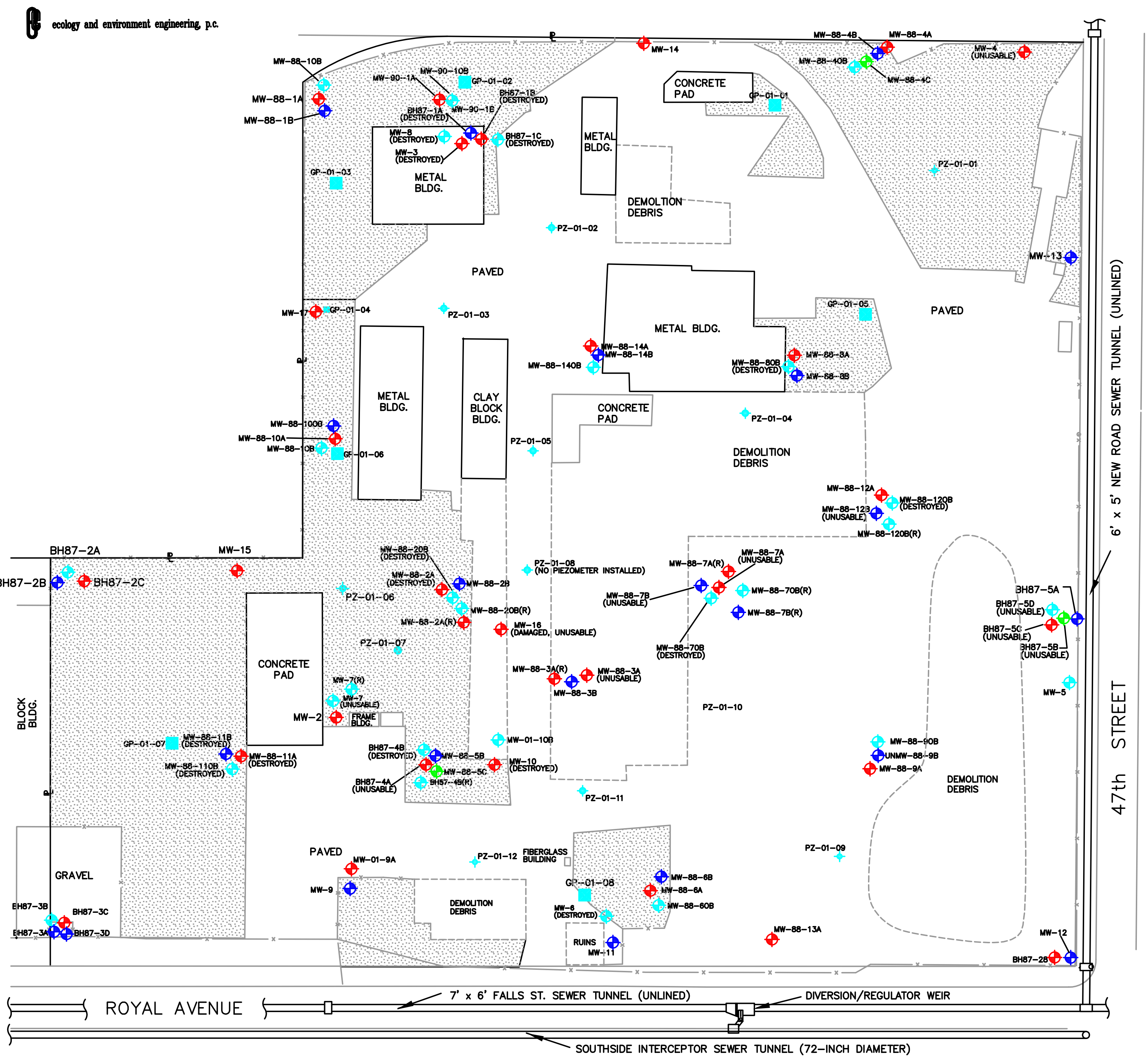


Figure Adapted by NYSDEC from E&E May 2004 Frontier Chemical Royal Avenue Feasibility Study Report

Figure 3 - Major Sewer Flows in the Vicinity of the Frontier Chemical Royal Avenue Site (#9-32-110)

ecology and environment engineering, p.c.



LEGEND

- UNPAVED AREAS
- OVERBURDEN WELL
- A-ZONE BEDROCK WELL
- B-ZONE BEDROCK WELL
- C-ZONE BEDROCK WELL
- SRI PIEZOMETER LOCATION
- SRI SOIL BORING LOCATION
- OUTLINE OF DEMOLISHED STRUCTURES/DEBRIS PILE
- OUTLINE OF BUILDING OR CONCRETE PAD

SCALE IN FEET

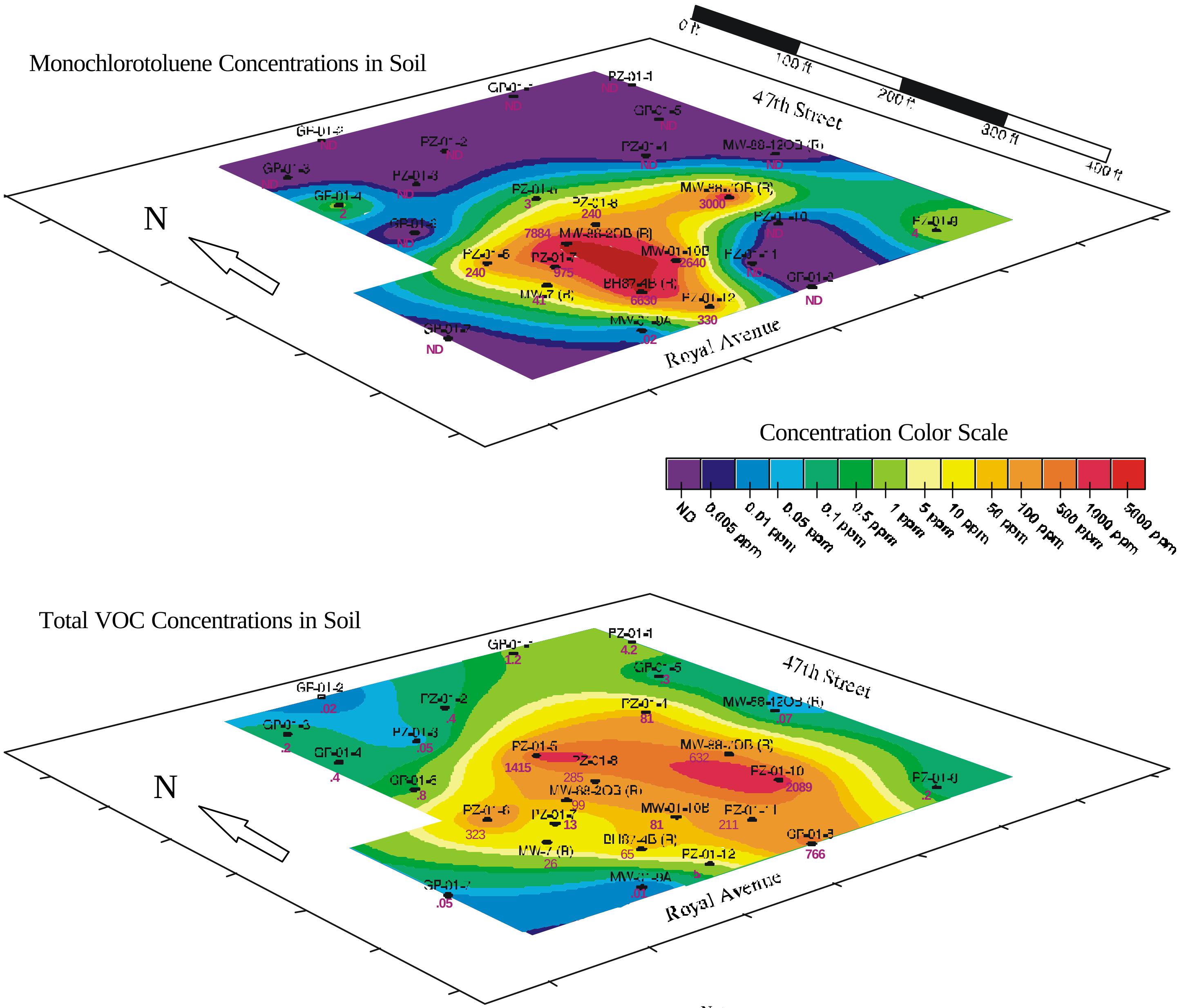
0 40 80 120

FRONTIER CHEMICAL
ROYAL AVENUE SITE

Niagara Falls, NY | SITE # 9-32-110

SITE BASE MAP

FIGURE 4



ecology and environment engineering, p.c.

Notes:

1. Figures adapted from E&E Nov. 2002 Supplemental RI Report.
2. Monochlorotoluene (MCT) is a tenatively identified compound.
3. Samples collected November 2001.
4. Distance scale is approximate.

Figure 5 - Two-Dimensional Contour Plots of MCT and Total VOCs (minus MCT) in Soils
Frontier Chemical Royal Avenue Site (#9-32-110)

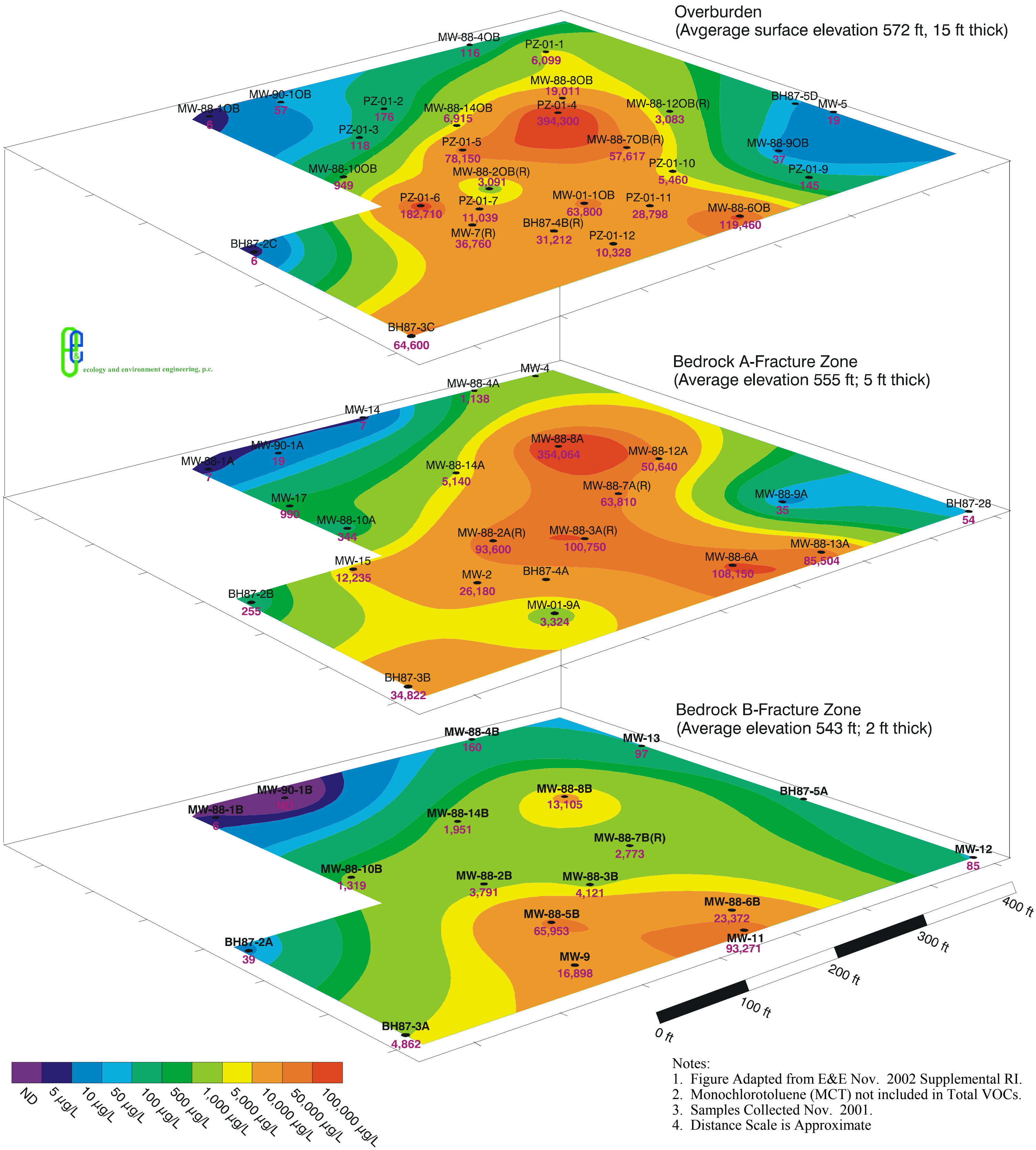


Figure 6 - Three Dimensional View of Total VOC Concentrations (Minus MCT) in Groundwater
Frontier Chemical Royal Avenue Site (#9-32-110)

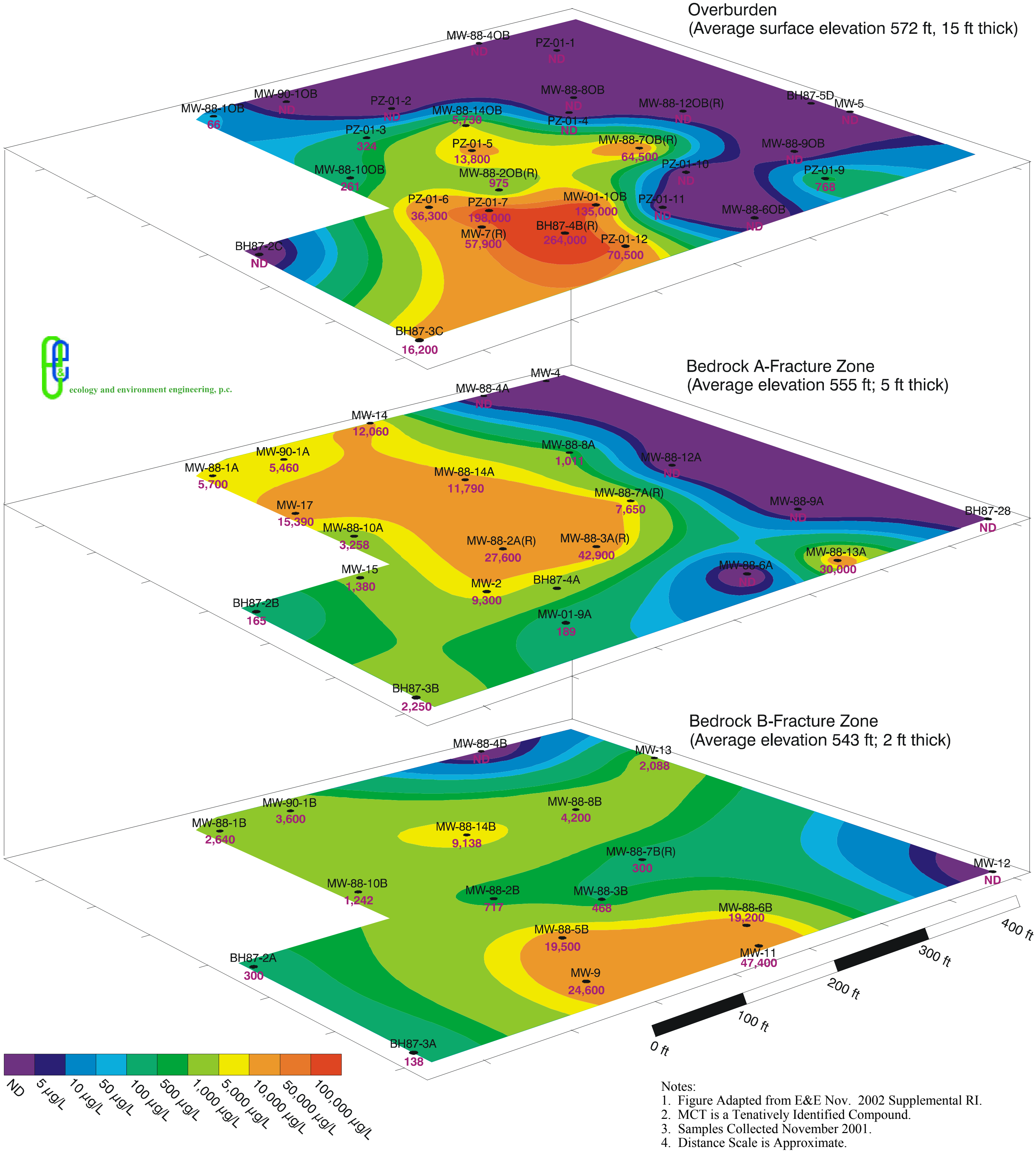
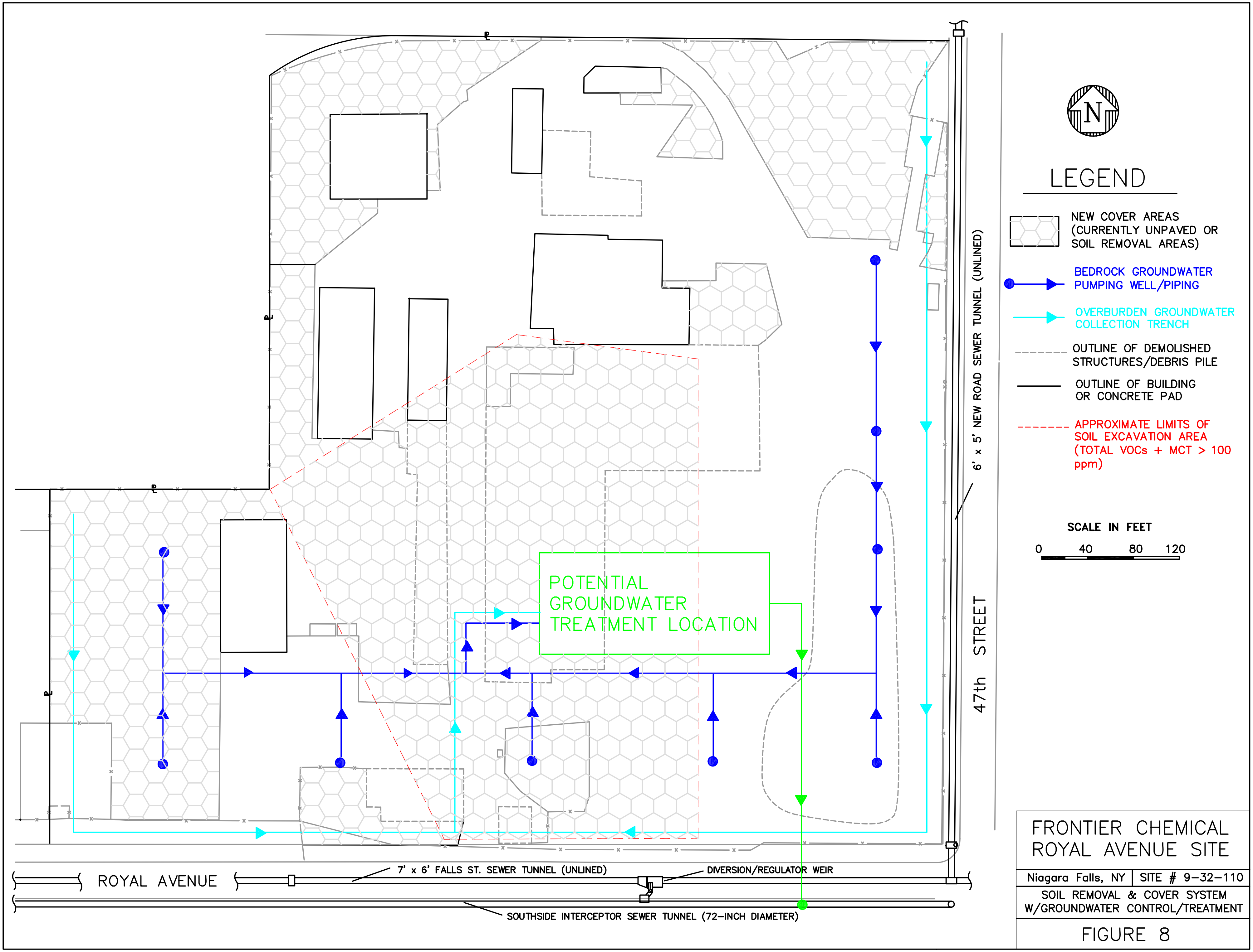


Figure 7 - Three Dimensional View of Monochlorotoluene (MCT) Concentrations in Groundwater
Frontier Chemical Royal Avenue Site (#9-32-110)


LEGEND
NEW COVER AREAS (CURRENTLY UNPAVED OR SOIL REMOVAL AREAS)
BEDROCK GROUNDWATER PUMPING WELL/PIPING
OVERBURDEN GROUNDWATER COLLECTION TRENCH
OUTLINE OF DEMOLISHED STRUCTURES/DEBRIS PILE
OUTLINE OF BUILDING OR CONCRETE PAD
APPROXIMATE LIMITS OF SOIL EXCAVATION AREA (TOTAL VOCs + MCT > 100 ppm)
SCALE IN FEET
0
40
80
120
POTENTIAL GROUNDWATER TREATMENT LOCATION
6' x 5' NEW ROAD SEWER TUNNEL (UNLINED)
47th STREET
ROYAL AVENUE
7' x 6' FALLS ST. SEWER TUNNEL (UNLINED)
DIVERSION/REGULATOR WEIR
SOUTHSIDE INTERCEPTOR SEWER TUNNEL (72-INCH DIAMETER)
FRONTIER CHEMICAL
ROYAL AVENUE SITE
Niagara Falls, NY
SITE # 9-32-110
SOIL REMOVAL & COVER SYSTEM W/GROUNDWATER CONTROL/TREATMENT
FIGURE 8