915124

FINAL SUPPLEMENTAL RI/FS REPORT FOR

NY STATE SUPERFUND STANDBY CONTRACT
DIARSENOL COMPANY - KINGSLEY PARK SITE
City of Buffalo, Erie County

WORK ASSIGNMENT NO. D002478-23
SITE NO. 9-15-124

PREPARED FOR

Prepared for:

New York State Department of Environmental Conservation

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PREPARED BY

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Liverpool, New York

FEBRUARY 1994

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NEW YORK STATE SUPERFUND STANDBY CONTRACT

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CITY OF BUFFALO, ERIE COUNTY

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NEW YORK STATE

DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DIVISION OF HAZARDOUS WASTE REMEDIATION

Prepared By:

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FEBRUARY 1994

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SECTION 1

INTRODUCTION

1.1 PROJECT BACKGROUND

1.1.1 Site Location and Description

The Diarsenol Company, Kingsley Park site (Kingsley Park) is located at 60 to 86 Kingsley Street in the City of Buffalo, Erie County, New York (Figure 1.1). The Diarsenol Company operated a pharmaceutical manufacturing facility at 72 Kingsley Street which produced an arsenic-based medication from the 1920s until about 1940. From the 1940s until 1967, various owners were listed as occupying the site. The City of Buffalo acquired the property in 1967, and by 1972 all the site buildings were removed and Kingsley Park was in place. The City maintained the park until 1988 when it was closed due to concerns about potential threat to public health.

While no specific incidences can be documented, it is suspected that manufacturing waste and/or product containing arsenic was disposed by the Company around the plant site. Additional materials may have been spread about the site during the demolition of the plant structures.

The site is located in an urban residential area with homes bordering the park on the north and east sides (Figure 1.2). Investigations indicated that there was arsenic contamination in soil in the park and surrounding yards.

Soil conditions at the site consist of fill material ranging from less than a foot to eight feet in thickness. Fill is underlain by a silty clay of undetermined thickness which acts as a barrier to vertical fluid migration. This results in a perched groundwater condition which varies with transient precipitation events and fluctuates greatly. At various times, water levels have varied from less than a foot to seven feet below grade.

1.1.2 Remedial History

A number of sampling efforts and environmental investigations have been conducted at the Kingsley Park site. Previous activities include sampling by the Erie County Department of Environmental Planning (1983), NUS Corp. (1986), Ecology & Environment (NYSDEC Phase II Study - 1989), and the New York State Department of Health (NYS DOH) (June and July, 1990). The Phase II report conducted at the site by E&E recommended that a work plan for the removal and disposal of contaminated material from the site be developed (E&E, 1990).

In September 1990, the New York State Department of Environmental Conservation (NYSDEC) requested that Engineering-Science, Inc. (ES) conduct an Interim Remedial Investigation (IRI) of the Kingsley Park site. The IRI consisted of the collection and analysis of surface and shallow subsurface soil samples from the park and surrounding properties, installation of 14 soil borings, and construction of one groundwater monitoring well, which was later sampled. Arsenic contamination detected in soils ranged from background, which was determined to be 10-20 parts per million (ppm), to 7,090 ppm.

The ES IRI Report was completed in February 1991. In March 1991, the NYSDEC approved the report, prepared a bid package, and procurred a contractor for an Interim Remedial Measure (IRM). The IRM consisted of the excavation and removal of soils containing elevated arsenic levels from the park and surrounding properties, backfilling and restoration, and the installation of four groundwater monitoring wells. During the IRM, a total of 11,549 tons of arsenic contaminated soil were removed from the site. Of this total, 1,981 tons of soil were disposed of as hazardous waste and 9,568 tons as non-hazardous waste. The construction phase of the IRM was completed in June 1992.

Following completion of the IRM, the new wells were sampled and arsenic was detected at levels exceeding groundwater standards. Two additional rounds of groundwater sampling were conducted by ES in 1992 at the Kingsley Park site. Arsenic was detected at levels exceeding groundwater standards in three of the five site wells. In order to address this contamination, the NYSDEC issued a work assignment to ES in June 1993 to conduct a Supplemental Remedial Investigation/Feasibility Study (RI/FS). ES completed the field investigation in December 1993. The results of this investigation are summarized in this report.

1.2 PROJECT OBJECTIVES

The objectives of this RI/FS project for the Kingsley Park site are as follows:

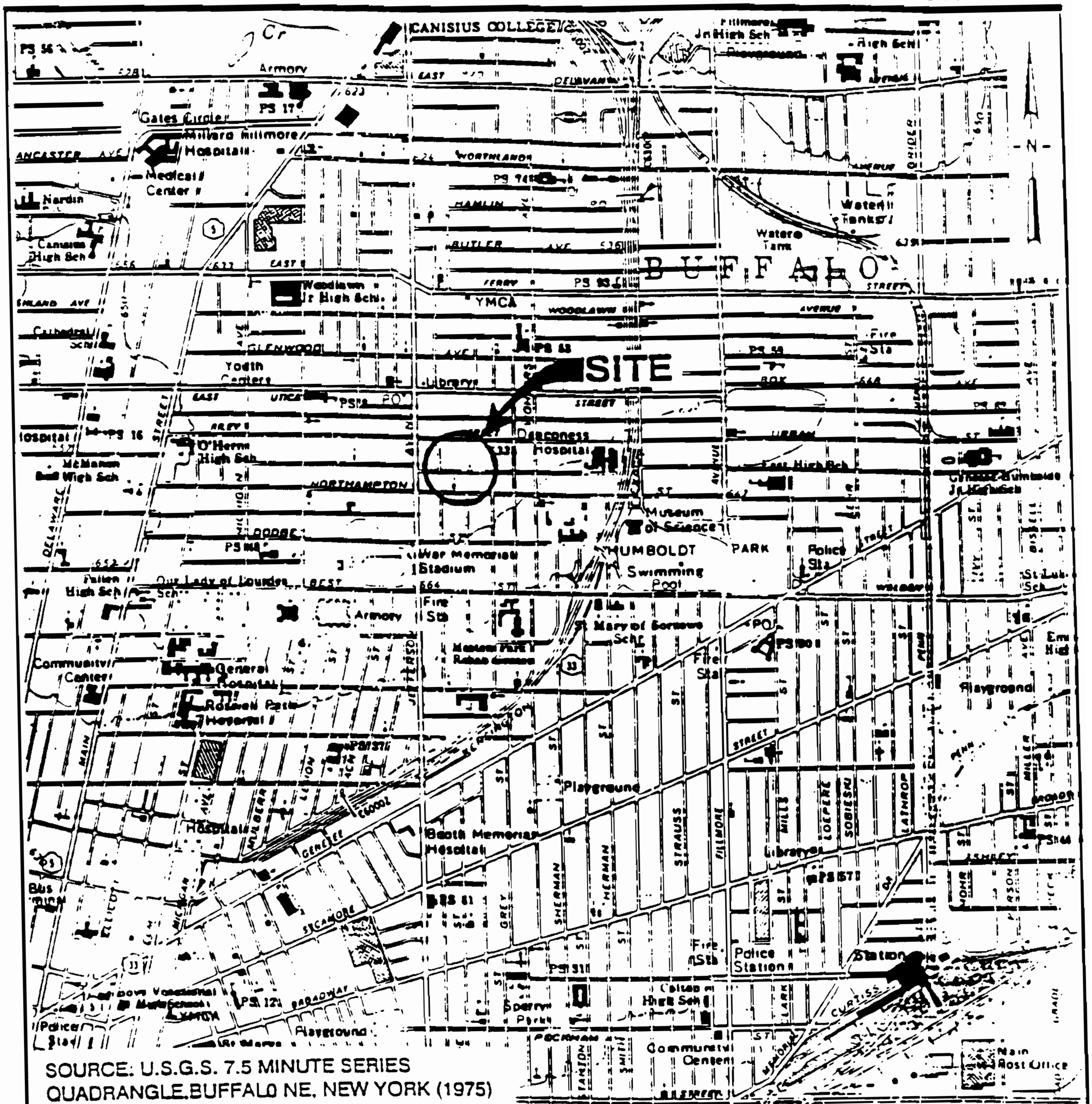
- To define the extent of arsenic contamination in groundwater;
- To determine any potential impacts of groundwater contamination at the site;
- To identify and evaluate technically feasible supplemental remedial alternatives.

1.3 REPORT ORGANIZATION

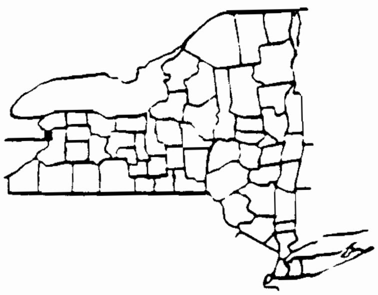
This report describes the site Supplemental Remedial Investigation (SRI) and remedial alternatives considered for the Kingsley Park site. This report includes the following:

- **Section 1** - Provides an introductory secion giving the background of the project, site history, project objectives, and report organization.
- **Section 2** - Contains a summary of the activites and methods used during the SRI, including monitoring well installation, geotechnical soil sampling, and groundwater sampling.
- **Section 3** - Presents the results of the data collected during the SRI and previous groundwater investigations at the site. The data from the SRI are used to further define the site subsurface conditions and extent of contamination.

- **Section 4** - Discusses the remedial alternatives for the site based on the SRI results. Suggested remedial objectives are established, and the alternatives to meet these objectives are presented.
- **Section 5** - Presents the conceptual plan for the recommended alternative.



SOURCE: U.S.G.S. 7.5 MINUTE SERIES
QUADRANGLE BUFFALO NE, NEW YORK (1975)



QUADRANGLE LOCATION

SITE LOCATION MAP
DIARSENOL COMPANY
KINGSLEY PARK SITE
BUFFALO, NEW YORK

2,000 0 2,000 FEET

SCALE: 1" = 2,000'

FIGURE 1.2

FIGURE 1.2
SITE MAP WITH FORMER STRUCTURES
DIARSENOL-KINGSLEY PARK SITE
City of Buffalo, Erie County

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SECTION 2

REMEDIAL INVESTIGATION METHODS

This section describes the site activities and methodology that constituted this Supplemental Remedial Investigation (SRI). These tasks were based on a NYSDEC State Superfund Standby Work Assignment #D00278-23 (NYSDEC, 1993) and were described in the SRI Work Plan submitted in September 1993 (ES, 1993). Geoprobe® groundwater sampling, the first field task described in the SRI work plan, was unsuccessful due to difficulties in recovering groundwater caused by the low permeability soils. A description of the subsequent phases of the study follow.

2.1 MONITORING WELL INSTALLATION

Four shallow monitoring wells were installed by American Auger and Ditching, Inc. under the supervision of an ES geologist from December 20 through December 23, 1993. The wells were drilled to characterize the shallow site geology and hydrogeology and to obtain soil samples for geotechnical analysis. The monitoring well locations are shown on Figure 2.1, and the boring logs are presented in Appendix B. The well borings were drilled using an ATV-mounted drill rig and advanced with 4.25-inch inside diameter (ID) hollow stem augers. Continuous split-spoon samples were collected for the full length of borings, and shelby tube samples were collected from three of the four well borings. All drilling equipment was steam cleaned prior to the start of the project, between each boring, and at the conclusion of the site investigation. All drill cuttings, washings, and decon water were contained in 12 drums at the site.

All four monitoring wells were constructed using two-inch ID .010-slot threaded flush joint PVC, casing and screen. Monitoring well depths ranged from 12 to 15 feet with 8 to 10 feet of screen. The top of all well casings were installed at ground level (flush mounted). The annulus around the outside of the screen was backfilled with silica sand, and a bentonite pellet seal was placed above the sand pack. The seal was allowed to hydrate for at least 30 minutes before placing the grout above the seal. Each monitoring well has a vented cap and locking cap. A flush-mounted protective well casing was cemented in place, and the cement pad was sloped to channel water away from the well. All monitoring well installations were supervised by the field geologist and notes were recorded in the field book. Monitoring wells were developed by bailing to remove sediment from the well screen and sand pack. All development water was contained in two drums at the site.

2.2 GEOTECHICAL SOIL SAMPLING

Six soil samples were collected during well installation to test physical parameters to assist in the development of remedial alternatives. One shelby tube sample and one grab soil sample was taken from each of three monitoring wells (MW-6, MW-7, and

MW-9). The three shelby tube samples were collected from the screened interval between 4 and 10.5 feet below ground surface. Grab soil samples were collected from the screened interval between 5 and 12 feet below ground surface. All samples were submitted to Advanced Geotechnical Investigations, Inc. for analysis. Each Shelby tube was tested for triaxial permeability, bulk density, Atterburg Limits, and moisture content. Grab soil samples were tested for Atterburg Limits and moisture content.

2.3 GROUNDWATER SAMPLING

Groundwater samples including one duplicate and one matrix spike were collected from the nine monitoring wells and one residential sump and analyzed for total and dissolved arsenic. Monitoring well sampling consisted of four procedures, including well evacuation, analytical field tests, sample collection, and filtering. Each of these procedures were in accordance with the QAPP developed for this project (ES, 1993).

Prior to sampling a monitoring well, the static water level was measured from the rim of the PVC well with a Slope Model 51453 electric water level indicator to the nearest 0.01 feet and recorded. The wells were evacuated to assure that the water was representative of the groundwater in the surrounding formation. All well data were recorded in the field book. The monitoring wells were purged of at least three volumes of water (two volumes if purged dry). Prior to filling the sample bottles, the samples were analyzed for temperature (°C), specific conductance (umhos/cm), and pH. Samples for dissolved arsenic analysis were filtered in the field utilizing a 0.45 μm filter and a Buchner Funnel kit.

All samples were delivered to the RECRA Environmental, Inc. laboratory for filtering and analysis according to NYSDEC ASP (September, 1989) procedures for total and dissolved metals analysis. RECRA is ELAP-approved for all categories of solid and hazardous waste analyses. Sample custody, laboratory procedures, and other QA/QC requirements were specified in the QAPP (ES, 1993).

In addition to groundwater samples, two rounds of groundwater elevations were also collected, and new and existing wells were surveyed by Modi Associates, a licensed land surveyor.

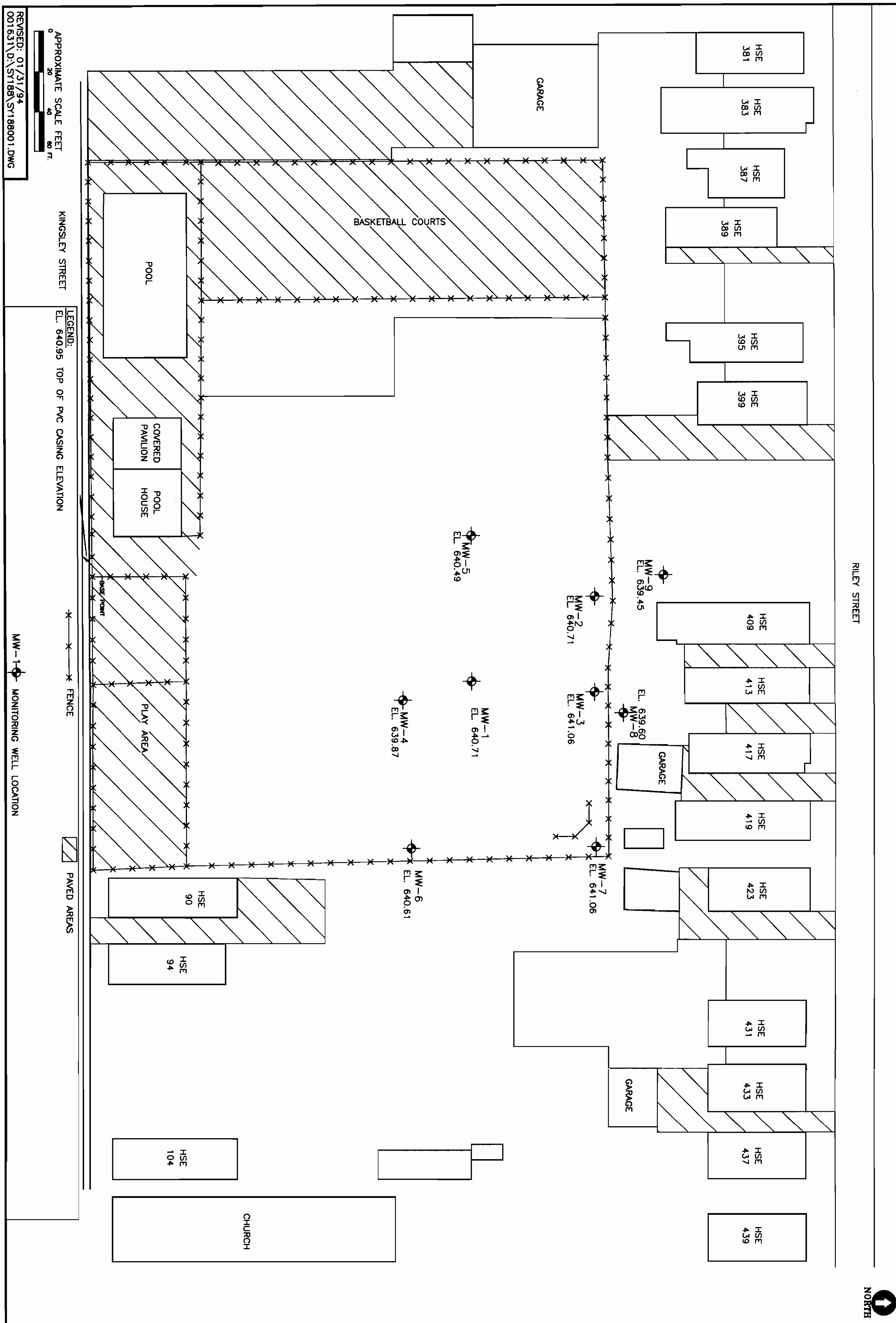

FIGURE 2.1

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MONITORING WELL LOCATION MAP

DIARSENOL-KINGSLEY PARK SITE

City of Buffalo, Erie County

SECTION 3

SUBSURFACE CONDITIONS AND GROUNDWATER CONTAMINATION

This section presents the results of the data collected during the Supplemental Remedial Investigation and previous groundwater investigations at the site.

3.1 SITE GEOLOGY AND HYDROGEOLOGY

Geologic conditions at the site consist of zero to eight feet of fill and unknown thickness of glacial silty clay to clayey silt with sand lenses, underlain by bedrock. The fill includes clean soil imported to regrade the excavation left from soil removal during the IRM and some old fill left from historic site demolition and grading. Most of the unpaved areas are covered with two feet of clean fill. Four to eight feet of clean fill exists in an area roughly bounded by MW-2, MW-3, MW-4, and MW-5. The new fill is a fine to medium sand with relatively high permeability.

There are two hydrogeological units at the site: the overburden soil and the bedrock. It appears that the shallow groundwater may be perched in the clayey soil and is recharged by precipitation infiltration. The bedrock aquifer is separated by the clayey glacial soil, and therefore, should not be affected by the shallow water bearing zone.

Four rounds of groundwater level measurements have been taken at the site since July 1992. The depth of site groundwater fluctuates significantly from season to season. During high precipitation months such as December and January, groundwater depths ranged from less than a foot to 4.6 feet below grade, while in the relatively dryer months such as August, groundwater depths ranged from 3.5 feet to more than seven feet below grade.

Based on existing water level data. there is no uniform horizontal groundwater flow direction, and there are no consistent differences in the hydraulic potentials at the different wells. This is probably due to the relatively flat topography and low permeability of the soil. Groundwater level measurement data obtained after the IRM and during the SRI are summarized in Table 3.1, and the 1993 data are presented on Figure 3.1.

3.2 SITE SURFACE WATER DRAINAGE

In general the site is flat, having less than two feet of vertical relief. There is little or no defined lateral drainage pattern. As a result, part of the site is frequently inundated with a few inches of water after a rain or snow melt. The ponding problem is compounded by the subsurface materials which are poorly drained.

3.3 GEOTECHNICAL SOIL SAMPLE RESULTS

A total of five Atterburg Limits, three hydraulic conductivity tests, and three bulk density tests were performed during the SRI. The results are contained in Appendix

C and summarized in Table 3.2. The test data indicate that the native soil is medium plastic, dense clayey-silty soil with low permeability. Therefore, the soil has poor drainage characteristics but is a good hydraulic barrier.

3.4 GROUNDWATER ANALYTICAL RESULTS

All nine monitoring wells located at the site were sampled and analyzed for total and dissolved arsenic. The sampling was conducted on December 28 (MW-1 through MW-5) and on December 29 (MW-6 through MW-9), 1993. The results of these analyses indicated total arsenic above the NYS Class GA groundwater standard of 0.025 mg/l in wells MW-1, MW-2, and MW-3 (0.04, 3.6, and 0.08 mg/l, respectively). Filtered samples from the same three wells also indicated dissolved arsenic above the NYS standard (0.06, 2.6, and 0.06 mg/l, respectively). Light to heavy turbidity was observed in all unfiltered samples. No visible turbidity was observed in filtered samples.

In addition to monitoring well samples, a residential sump sample was also collected and analyzed for total and dissolved arsenic. Results from these analyses indicated total and dissolved arsenic below the NYS standard (0.01 and 0.008 mg/l, respectively). All groundwater analytical results, including those from previous investigations, are presented on Table 3.3.

3.5 COMPARISON WITH RESULTS OF PREVIOUS INVESTIGATIONS

Four previous rounds of groundwater sampling have been conducted by ES at the Kingsley Park site. Sampling results from all four rounds were found to be very similar with the SRI results. The first round, conducted during the IRI in 1990, showed total and dissolved arsenic above the NYS standard in MW-1. Results from the subsequent three rounds conducted in 1992, after the IRM, indicated total and dissolved arsenic consistently above the NYS standard in MW-2 and MW-3. Total arsenic concentrations ranged from 4.9 to 26.5 ppm in MW-2 and from 0.035 to 0.057 ppm in MW-3. Arsenic concentrations in MW-1 had decreased to below the NYS standard by October 1992, but were found to be above the standard in the December 1993 sampling round. Arsenic concentrations in MW-2 appear to be decreasing with time, but are still considerably higher than levels detected in the other site wells.

3.6 CONTAMINATION EXTENT/MIGRATION

Based on the results of the SRI, groundwater contamination appears to be limited to a small portion of the site in the area of wells MW-1, MW-2, and MW-3. Off-site groundwater underneath nearby residences, north of the site, was found to meet the NYS groundwater standard. Arsenic concentrations detected in on-site wells east, south, and west of the contaminated area were also below the NYS standard. Therefore, it does not appear that arsenic contaminated groundwater is migrating off-site. Remedial efforts should focus on groundwater quality at the limits of the area of concern, specifically the area around MW-2.

TABLE 3.1
GROUNDWATER ELEVATION SUMMARY

Diarsenol Company–Kingsley Park Site
Buffalo, New York

			Round 1: 7/16/92		Round 2: 8/25/92		Round 3: 12/28/93 – 12/29/93		Round 4: 1/28/94	
MONITORING WELL	TOC ELEVATION (feet)	GROUND SURFACE ELEVATION (feet)	DEPTH TO WATER (ft. below TOC)	GROUNDWATER ELEVATION (feet)	DEPTH TO WATER (ft. below TOC)	GROUNDWATER ELEVATION (feet)	DEPTH TO WATER (ft. below TOC)	GROUNDWATER ELEVATION (feet)	DEPTH TO WATER (ft. below TOC)	GROUNDWATER ELEVATION (feet)
MW – 1	640.71	641.1	dry	NA	7.44	633.27	4.00	636.40	4.59	636.12
MW – 2	640.71	641.1	3.50	637.20	4.76	635.95	2.50	638.21	1.49	639.22
MW – 3	641.06	641.3	4.90	636.16	6.12	634.94	3.75	637.31	2.35	638.71
MW – 4	639.87	640.9	4.70	635.17	4.90	634.97	3.80	636.07	under water	NA
MW – 5	640.49	640.9	4.50	635.99	3.78	636.71	2.80	637.69	under water	NA
MW – 6	640.61	640.9	– –	– –	– –	– –	1.95	638.66	under water	NA
MW – 7	640.64	640.9	– –	– –	– –	– –	2.35	638.29	0.87	639.77
MW – 8	639.60	640.0	– –	– –	– –	– –	2.48	637.12	1.34	638.26
MW – 9	639.45	639.6	– –	– –	– –	– –	3.44	636.01	3.32	636.13

NA = Not Applicable ; The groundwater elevation could not be calculated as the well was dry or submerged.
– – Well was not yet installed.

TABLE 3.2
SUMMARY OF GEOTECHNICAL DATA

Diarsenol Company – Kingsley Park Site
Buffalo, New York

SAMPLE ID	SAMPLE LOCATION	SAMPLE DEPTH (ft)	ATTERBURG LIMITS			PERMEABILITY (cm/sec)	BULK DRY DENSITY (pcj)	WATER CONTENT (%)	UNIFIED SOIL CLASS.
			LL	PL	PI				
ST–4	MW–4	4–6.5	48	24	24	1.32E–08	108.3	22.1	CL
ST–9	MW–9	6–8.5	31	19	12	1.87E–08	111.5	19.9	CL
ST–7	MW–7	8–10.5	25	17	8	1.07E–06	114.0	18.1	CL
MW–7	MW–7	5–6	46	22	24			25.7	CL
MW–6	MW–6	9–10	27	17	10			18.9	CL
MW–9	MW–9	10–12	– *	– *	– *			– *	– *

* Material was non–plastic and not appropriate for testing.

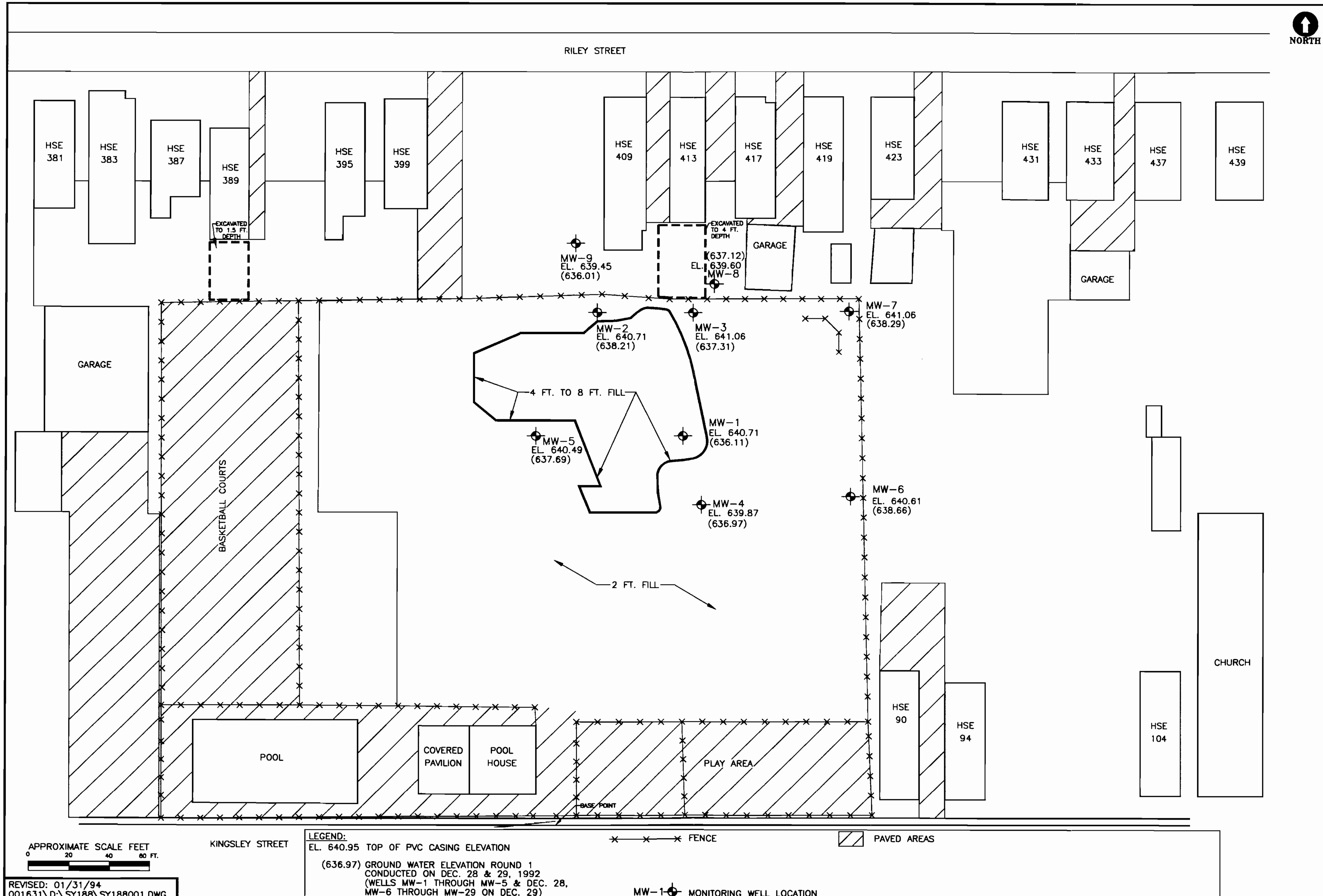
TABLE 3.3
GROUNDWATER ANALYTICAL DATA

Diarsenol Company–Kingsley Park Site
Buffalo, New York

Monitoring Well	Analytical Results – Total and Dissolved Arsenic (mg/ℓ)								
	Round 1: 12/21/90		Round 2: 7/16/92	Round 3: 8/25/92		Round 4: 10/09/92		Round 5: 12/28/93	
	Total	Dissolved	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved
MW – 1	0.045 [1]	0.033 [1]	0.100 [1]	0.030 [1]	0.021	0.011	0.022	0.040 [1]	0.060 [1]
MW – 2	--	--	15.0 [1]	26.5 [1]	7.5 [1]	4.9 [1]	3.3 [1]	3.6 [1]	2.6 [1]
MW – 3	--	--	0.040 [1]	0.035 [1]	0.040 [1]	0.057 [1]	0.052 [1]	0.080 [1]	0.060 [1]
MW – 4	--	--	0.006	0.009	<0.005	<0.005	<0.005	0.005	0.003
MW – 5	--	--	0.020	0.017	<0.005	<0.005	<0.005	0.006	0.004
MW – 6	--	--	--	--	--	--	--	0.004	<0.003
MW – 7	--	--	--	--	--	--	--	<0.003	<0.003
MW – 8	--	--	--	--	--	--	--	<0.003	<0.003
MW – 9	--	--	--	--	--	--	--	0.010	0.010
SUMP–001	--	--	--	--	--	--	--	0.010	0.008

[1] – Indicates that the value is above the New York State limit for a Class GA groundwater (0.025 mg/ℓ).
Reference: Division of Water Technical and Operational Guidance Series (1.1.1): Ambient Water Quality Standards and Guidance Values, revised October 1993.
-- Well was not yet installed.

FIGURE 3.1



GROUNDWATER LEVEL DATA

DIARSENOL-KINGSLEY PARK SITE
City of Buffalo, Erie County

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SECTION 4

REMEDIAL ACTION ALTERNATIVES

The purpose of this section is to establish remedial objectives, to describe and evaluate potentially applicable remedial alternatives, and to recommend the preferred alternative based on its effectiveness in addressing groundwater contamination at the Kingsley Park site.

4.1 REMEDIAL OBJECTIVES

At a minimum, the remedy selected should eliminate or mitigate all significant threats to public health and the environment presented by the contaminated groundwater at the site. The remedial action objectives established for this site are:

- To mitigate the impacts of contaminated groundwater to the environment;
- To provide for long-term attainment of Standards, Criteria, and Guidelines (SCGs) for groundwater quality at the limits of the area of concern (AOC).

4.2 DESCRIPTION OF REMEDIAL ALTERNATIVES

Completion of the IRM addressed soil contamination at the site. Two remedial alternatives have been identified to address groundwater contamination in the AOC. These alternatives are:

1) No Further Action; and
2) Shallow Groundwater Collection System.

Descriptions of these two alternatives are provided in the following sections.

4.2.1 No Further Action

This alternative recognizes the remediation of the site completed under the IRM. Under this alternative, no further remedial action would take place. If this option was followed, the arsenic-contaminated groundwater would remain the same as it is at present. Long-term monitoring consisting of groundwater sampling would be conducted to evaluate the effectiveness of the remediation completed under the IRM and to ensure that site conditions did not deteriorate.

4.2.2 Shallow Groundwater Collection System Alternative

This alternative would consist of the installation of a five to seven foot deep subdrain trench from MW-1, through the vicinity of MW-2 and MW-3, to the city sanitary sewer located on Riley Street (Figure 4.1). This trench system would pull shallow groundwater from the vicinity of MW-1, MW-2, and MW-3 and discharge it to the sanitary sewer. The location of this subdrain would provide an area of drainage influence containing the vicinity of MW-1 through MW-3 which showed slightly elevated levels of arsenic in groundwater. The depth of the subdrain would provide the maximum gravity drainage based on the street sewer elevation.

Based on the description of the clean fill placed during the IRM and the geotechnical data presented in Section 3 for the native soil, the radius of hydraulic influence of the subdrain would be controlled primarily by the depth and permeability of the clean fill. The clean fill is estimated at least five orders of magnitude more permeable than the native soil (i.e., $1x10^{-2}$ vs. $1x10^{-7}$ cm/sec). In the area where the fill thickness is approximately two feet, the effective radius of influence of the subdrain is approximately 20 to 40 feet (Appendix D). In the deeper (4 to 8 feet) fill area, the radius of influence would double to 40 to 80 feet.

4.3 EVALUATION OF REMEDIAL ALTERNATIVES

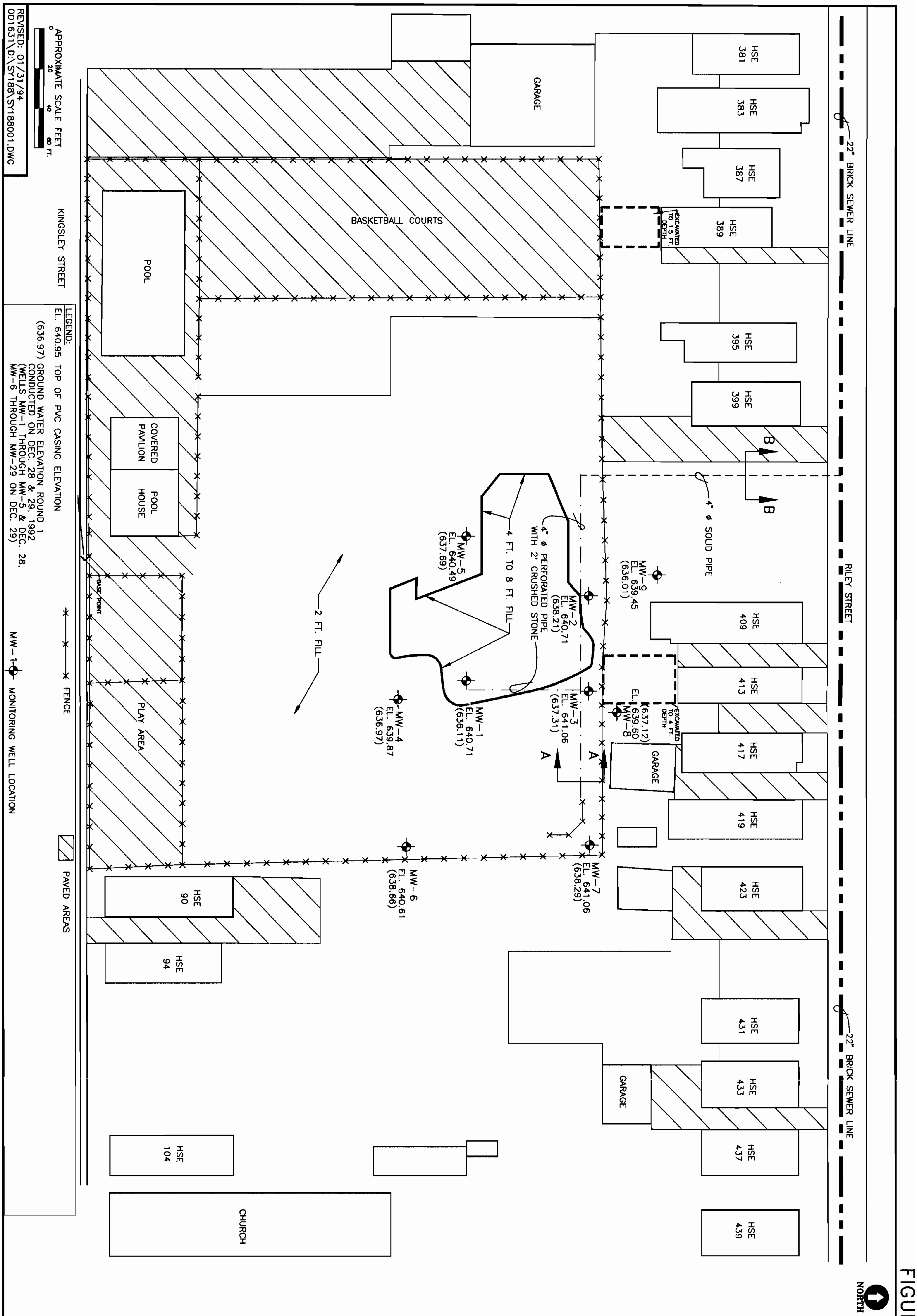
Both the no further action and the shallow groundwater collection system alternatives are protective of human health. With the removal of arsenic contaminated soil from the park and surrounding private yards, and the introduction of clean fill and topsoil to replace contaminated materials, the threat of direct contact has been eliminated.

Although groundwater in a localized area of the site contains arsenic at levels that exceed groundwater standards, the threat to human health and the environment is minimal due to the following factors:

- Groundwater at the site is perched on a low permeability clay layer effectively isolating it from any impact on surrounding groundwater.
- There is no local use of groundwater as a drinking water source.
- A buffer of clean soil exists between the surface and the contaminated groundwater.
- The results of the investigation indicate that there is little movement of site groundwater.
- The physical characteristics of the soils at the site make them a low water producer. As a result, pumping the impacted groundwater would be impractical.

Nevertheless, enhancing the IRM by implementing the shallow groundwater collection system alternatives goes beyond the no further action alternative by directly addressing the groundwater contamination that is present. This is readily implementable, provides an overall greater degree of protectiveness, and would promote drainage of the clean fill brought to the site. This additional drainage may also help alleviate the muddy conditions at the surface that occasionally occur due to rainfall.

Therefore, the Shallow Groundwater Collection System alternative, in conjunction with the completed IRM, more completely attains the remedial goals for the site.



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CONCEPTUAL SHALLOW SUBDRAIN SYSTEM LAYOUT

DIARSENOL–KINGSLEY PARK SITE
City of Buffalo, Erie County

SECTION 5

CONCEPTUAL PLAN FOR THE RECOMMENDED ALTERNATIVE

This section describes the shallow groundwater collection system which is the recommended alternative to supplement the IRM.

5.1 DESCRIPTION OF SHALLOW GROUNDWATER COLLECTION SYSTEM

This Supplemental IRM would consist of the installation of shallow subdrain trench in the vicinity of MW-1, MW-2 and MW-3 (Figure 4.1). The collection sytem would utilize the relatively high permeability fill placed throughout the site during the IRM to work as a blanket drain to collect the contaminated groundwater. Collected groundwater would be discharged to the sanitary sewer system following approval from the Buffalo Sewer Authority.

5.2 DESIGN CONCEPTUAL PLAN

This Supplemental IRM would involve all elements necessary to excavate a shallow trench, install drainage materials, and backfill and restore the excavated area. Construction would start with site preparation including dismantling sections of the site fence, stockpiling all necessary supplies, staking out location and depth of excavation, and installing a temporary orange plastic fencing around the construction areas to exclude random trespassing.

The trench would be excavated to five to seven feet deep and three feet wide with a backhoe. Trench shoring consisting of a three-foot wide trench box would be applied to prevent cave-in and to minimize the size of the excavation. The existing topsoil and clean fill placed during the IRM would be removed and segregated from the subsoil prior to excavating further into the ground. The clean fill can easily be recognized based on its sandy apperance and light brownish color. This clean fill would be stockpiled for later use as a clean backfill and separated from additional excavated soil, which may be contaminated with low levels of arsenic and lead.

After the removal of the clean fill, additional excavation would continue to acheive the required trench depth. This additional excavated soil would be stockpiled on plastic sheeting, clearly separated from the clean fill removed earlier.

Groundwater seepage into the excavation could be controlled with sump pumping. However, if the groundwater elevation is low enough when the construction is completed, this may not be necessary. The collected groundwater would be discharged to the sanitary sewer along Riley Street. After design and prior to the construction, a discharge permit would be received from the Buffalo Sewer Authority for this temporary and future discharge of site groundwater.

The drainage trench, excavated within the current site fence, would be filled with drainage materials to construct a subdrain as shown in Figure 5.1. To provide self-cleaning, the perforated pipe would be sloped at least 0.5% towards the discharge direction. Therefore, the depth of the trench and the thickness of the crushed stone would vary. In general, the depth of the trench should be limited to a maximum of five to seven feet based on the elevation of the top of the sanitary sewer, reported at 631$\pm$ ft.

The conduit trench, excavated outside the fence, would be used to install a 4-inch diameter solid pipe to form a conduit line to conduct groundwater collected by the subdrain to the sanitary sewer (Figure 5.1). It is estimated that the discharge rate of this subdrain would be 150,000 to 450,000 gallons per year, with a maximum daily discharge rate of 26,500 gallons (Appendix D).

Tie-in of the conduit pipe to the street sewer would require excavation to the center of the street and down to the sewer located approximately 8 feet below grade. The tie-in would be at the top of the sewer which is reported to be of brick construction. The tie-in construction would follow Buffalo Sewer Authority requirements.

Upon completion of the subdrain system installation, there would be excess excavated soil left from the construction. The soil might contain slightly elevated levels of arsenic and lead and would need to be disposed of in an off-site landfill permited to receive this type of waste. The Laidlaw landfill in Bellfontaine, Ohio, was used during the IRM for non-hazardous soil disposal.

Before the contractor leaves the site, the disturbed work areas would be restored to their original condition. The restoration work would include seeding and mulching, fence reinstallation, repaving of disturbed street pavement, and street sweeping.

5.3 REMEDIATION COST AND SCHEDULE

The total construction cost is estimated at $48,000 for the subdrain installation with disposal of soil to a non-hazardous waste landfill ($39,000 for disposal to a municipal landfill). These costs are itemized in Tables 5.1 and Table 5.2. There are no annual operation and maintenance costs as the site will be maintained as a park, and the subdrain is designed to be maintenance free.

The actual installation of the subdrain system would take approximately four weeks. Due to the seasonal fluctuations in the site groundwater level, construction in the Fall or Summer would be preferred to minimize groundwater seepage into the trench excavation during the instalation.

TABLE 5.1

COST ESTIMATE

Subdrain System Installation
Soil Disposal at Non-Hazardous Landfill

Diarsenol Company – Kingsley Park Site
Buffalo, New York

Capital Costs

CSI Section	Cost Estimate Section		Description	Source of Unit Cost	Unit	Quantity	Unit Cost	Total Cost
01000	I		MOBILIZATION/DEMOBILIZATION					
		a.	Excavation Equipment (excavator, loader, vibratory roller, paver)	Means, ES	LS	1	$3,000	$3,000
		b.	Misc. Construction Expenses (coordination, travel, physical exams)	ES	Months	1	$1,000	$1,000
			Subtotal					$4,000
02100	II		SITE PREPARATION					
		a.	Personnel Decon. Area (tapwater, 20–mil geomembrane, brushes, etc.)	ES	LS	1	$200	$200
		b.	Health & Safety Equip./Disposal (Level "D") (dust monitor, boots, gloves, etc.)	ES	Months	1	$1,000	$1,000
		c.	Security Fencing (4' high plastic)	ES	LF	200	$2	$400
		d.	Utilities (electricity, water, sanitary, etc)	ES	Months	1	$250	$250
		e.	Temporary Soil Storage Facility (tarps)	ES	LS	1	$200	$200
		f.	Fence Removal / Re–installation	ES	LS	1	$500	$500
		g.	Work/H&S Plans	ES	LS	1	$1,000	$1,000
		h.	Performance Bond	Means, ES	LS	1	$500	$500
		i.	Permits (soil disposal, transportation, sewer connection)	ES	LS	1	$1,500	$1,500
		j.	Insurance	Means, ES	LS	1	$500	$500
			Subtotal					$6,050
02200	III		EARTHWORK					
		a.	Excavation (in–place volume)	Means, ES	CY	300	$15	$4,500
		b.	Trench Box	ES	Weeks	2	$400	$800
		c.	Backfill – Material (delivered) (Crushed Stone)	Means	Tons	225	$12	$2,700
		d.	Backfill / Compaction – Labor	Means	CY	300	$4	$1,200
		e.	Topsoil (delivered)	Vendor	CY	50	$15	$750
		f.	Topsoil installation (spread & light comp.)	ES	CY	50	$8	$400
		g.	Seed / Fertilize (mechanical)	Means	Acre	0.5	$2,500	$1,250
		h.	Hay Mulching (w/ a power mulcher)	Means	1000 SF	20	$30	$600
		i.	Filter Fabric	ES	SF	5000	$1	$5,000
		j.	Pavement – Saw cut & repair	ES	SF	120	$10	$1,200
		k.	Curb – Saw cut & repair	ES	LF	6	$50	$300
		l.	Sidewalk – Saw cut & repair	ES	SF	30	$10	$300
		m.	Dewatering (pump to sewer system)	ES	Weeks	2	$100	$200
			Subtotal					$13,900
02080	IV		OFF–SITE LANDFILL / TRANSPORTATION					
		a.	Landfill – Non–Hazardous Waste	Vendor	Tons	225	$55	$12,375
		b.	Transportation – Non–Hazardous Waste (approx. 500 miles)	Vendor	Tons	225	incl	$0
			Subtotal					$12,375
15000	V		MECHANICAL					
		a.	SDR 35 PVC Pipe – 4" (Perf & Solid)		LF	400	$3	$1,200
		b.	SDR 35 PVC Fittings		EA	5	$25	$125
		c.	Cast Iron Hub		EA	1	$200	$200
		d.	Core Bore / Grout		LS	1	$200	$200
			Subtotal					$1,725
			SUBTOTAL CAPITAL COSTS					$38,050
			Engineering (for design and construction mgmt.)		15.0 %			$5,708
			Contingency		10.0 %			$3,805
			TOTAL CAPITAL COSTS (Pc)					$47,563

Annual Operation and Maintenance Costs

Item	Description	Unit	Quantity	Unit Cost	Total Cost
I	NO O & M IS REQUIRED				$0
	TOTAL PW COSTS (Pt = Pc)				$47,563

TABLE 5.2

COST ESTIMATE

Subdrain System Installation
Soil Disposal at Municipal Landfill

Diarsenol Company -- Kingsley Park Site
Buffalo, New York

Capital Costs

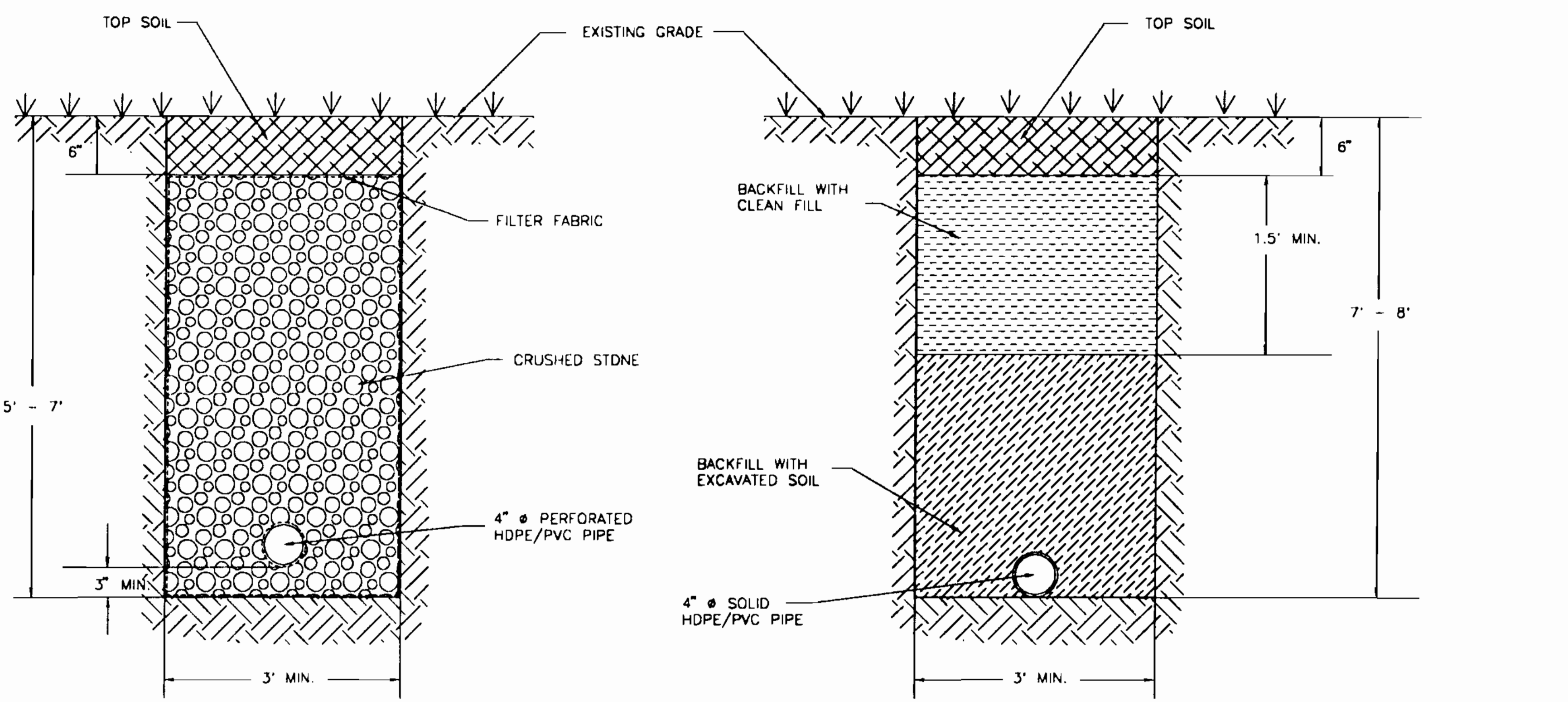
CSI Section	Cost Estimate Section		Description	Source of Unit Cost	Unit	Quantity	Unit Cost	Total Cost
01000	I		MOBILIZATION/DEMOBILIZATION					
		a.	Excavation Equipment (excavator, loader, vibratory roller, paver)	Means, ES	LS	1	$3,000	$3,000
		b.	Misc. Construction Expenses (coordination, travel, physical exams)	ES	Months	1	$1,000	$1,000
			Subtotal					$4,000
02100	II		SITE PREPARATION					
		a.	Personnel Decon. Area (tapwater, 20-mil geomembrane, brushes, etc.)	ES	LS	1	$200	$200
		b.	Health & Safety Equip./Disposal (Level "D") (dust monitor, boots, gloves, etc.)	ES	Months	1	$1,000	$1,000
		c.	Security Fencing (4' high plastic)	ES	LF	200	$2	$400
		d.	Utilities (electricity, water, sanitary, etc)	ES	Months	1	$250	$250
		e.	Temporary Soil Storage Facility (tarps)	ES	LS	1	$200	$200
		f.	Fence Removal / Re-installation	ES	LS	1	$500	$500
		g.	Work/H&S Plans	ES	LS	1	$1,000	$1,000
		h.	Performance Bond	Means, ES	LS	1	$500	$500
		i.	Permits (soil disposal, transportation, sewer connection)	ES	LS	1	$1,500	$1,500
		j.	Insurance	Means, ES	LS	1	$500	$500
			Subtotal					$6,050
02200	III		EARTHWORK					
		a.	Excavation (in-place volume)	Means, ES	CY	300	$15	$4,500
		b.	Trench Box	ES	Weeks	2	$400	$800
		c.	Backfill -- Material (delivered) (Crushed Stone)	Means	Tons	225	$12	$2,700
		d.	Backfill / Compaction -- Labor	Means	CY	300	$4	$1,200
		e.	Topsoil (delivered)	Vendor	CY	50	$15	$750
		f.	Topsoil installation (spread & light comp.)	ES	CY	50	$8	$400
		g.	Seed / Fertilize (mechanical)	Means	Acre	0.5	$2,500	$1,250
		h.	Hay Mulching (w/ a power mulcher)	Means	1000 SF	20	$30	$600
		i.	Filter Fabric	ES	SF	5000	$1	$5,000
		j.	Pavement -- Saw cut & repair	ES	SF	120	$10	$1,200
		k.	Curb -- Saw cut & repair	ES	LF	6	$50	$300
		l.	Sidewalk -- Saw cut & repair	ES	SF	30	$10	$300
		m.	Dewatering (pump to sewer system)	ES	Weeks	2	$100	$200
			Subtotal					$13,900
02080	IV		OFF-SITE LANDFILL / TRANSPORTATION					
		a.	Landfill -- Municipal Waste	Vendor	Tons	225	$25	$5,625
		b.	Transportation -- Municipal Waste (approx. 25 miles)	Vendor	Tons	225	Incl	$0
			Subtotal					$5,625
15000	V		MECHANICAL					
		a.	SDR 35 PVC Pipe -- 4" (Perf & Solid)		LF	400	$3	$1,200
		b.	SDR 35 PVC Fittings		EA	5	$25	$125
		c.	Cast Iron Hub		EA	1	$200	$200
		d.	Core Bore / Grout		LS	1	$200	$200
			Subtotal					$1,725

SUBTOTAL CAPITAL COSTS		$31,300
Engineering (for design and construction mgmt.)	15.0 %	$4,695
Contingency	10.0 %	$3,130
TOTAL CAPITAL COSTS (Pc)		$39,125

Annual Operation and Maintenance Costs

Item	Description	Unit	Quantity	Unit Cost	Total Cost
I	NO O & M IS REQUIRED				$0
	TOTAL PW COSTS (Pt = Pc)				$39,125

FIGURE 5.1



A SUBDRAIN DETAIL
NOT TO SCALE

B TRANSMISSION LINE DETAIL
NOT TO SCALE

APPENDIX A

REFERENCES

APPENDIX A

REFERENCES

E&E, 1990. Ecology and Environment Engineering, P.C. Phase II Investigations, Diarsenol Company, Kingsley Park, Site No. 9-15-124, Draft for NYSDEC, June 1990.

ES, 1993. Work Plan for the NY State Superfund Standby Contract Diarsenol Company, Kingsley Park Site, City of Buffalo, Erie County, Work Assignment No. D002478-23, Site No. 9-15-124, Engineering-Science, Inc., Liverpool, NY, September 1993.

NYSDEC, 1993. Superfund Standby Contract Work Assignment No. D002478-23, Diarsenol Company, Kingsley Park, Site No. 9-15-124, Michael DiPietro, NYS Department of Environmental Conservation, June 1993.

APPENDIX B

BORING LOGS

ENGINEERING–SCIENCE DRILLING RECORD

BORING MW–6

Contractor: American Auger
Driller: Lee Penrod
Inspector: Anne George
Rig Type: Mobil, ATV

PROJECT NAME Kingsley/Dirsenal, NYSDEC
PROJECT NUMBER SY410.02 723867 02000

Sheet 1 of 1
Location: Eastern Fence Line

GROUNDWATER OBSERVATIONS

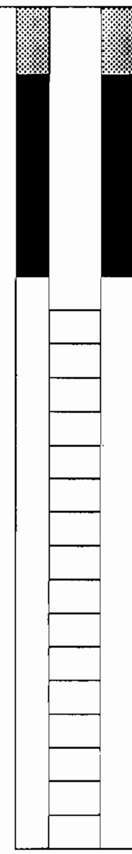
Water Level				
Date				
Time				
Meas. From				

Weather Very Cold 20 F, dropping, windy
Date/Time Start 12/22/93 @ 1500
Date/Time Finish 12/22/93 @1725

Plot Plan

Microtip Reading	Sample I.D.	Sample Depth	Percent Recovery	SPT	FIELD IDENTIFICATION OF MATERIAL	COMMENTS
		0				
				6	0–4" topsoil, change to brown fine to medium sand, (Fill)	Flush mt and locking
		1	80	6	little silt, moist, loose	well cap
				9		Grout 1.0' to surface
		2		6		
				7	Fill to 3.8', then brown silt, some fine sand, trace clay, stiff, damp	Bentonite Seal
		3	70	7		4.0'–1.0'
				8		
		4		14		
					4–6.5' shelby tube (ST–6)	
		5				
		6				
		7		9	Red clay, minor gray laminae, stiff	PVC Screen # 10 slot
			100	13		12.5 to 4.5'
		8		21		
				8	Red clay, some silt, softer, damp, 1.5' layer of sand and clay	
		9	80	8	moist, soft	
				10	Jar sample, 9–10'	Morey0 sand
		10		19		12.5 to 4.0'
				7	as above to 11.1', change to red clay and fine sand, some silt	
		11		10	soft, moldable, wet	
				11		
		12		15		
					Total depth 12.5'	
		13				
		14				

WELL SCHEMATIC



STANDARD PENETRATION TEST
SS = SPLIT SPOON
A = AUGER CUTTINGS
C = CORED

Shelby tube ST–6, 4.0 to 6.5', approx 18.5" recovery, Jar sample 9–10'.

ENGINEERING–SCIENCE DRILLING RECORD

BORING MW–7

Contractor: American Auger
Driller: Lee Penrod
Inspector: Anne George
Rig Type: Mobil, ATV

PROJECT NAME Kingsley/Diarsenol, NYSDEC
PROJECT NUMBER SY410.02 723867 02000

Sheet 1 of 1
Location:
North east corner of site

GROUNDWATER OBSERVATIONS

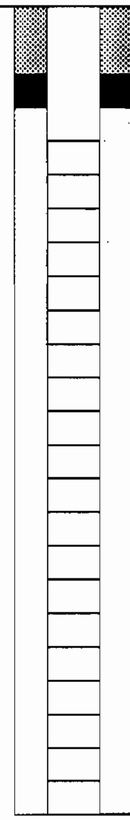
Water Level				
Date				
Time				
Meas. From				

Weather Sunny, 20 F, 20 mph wind
Date/Time Start 12/22/93 @ 0945
Date/Time Finish 12/22/93 @1315

Plot Plan

Microtip Reading	Sample I.D.	Sample Depth	Percent Recovery	Blow Cts.	FIELD IDENTIFICATION OF MATERIAL	COMMENTS
		0				Flush mt. curb box
					Augered through top two feet	locking cap
		1			Sand, top soils, damp	Grout 1' to surface
						Bent seal, 1' to 1.5'
		2				
				3	Brown Sand and silt, dry to 3'	
		3	75	4		
				3	Red/Brown sand and silt, little clay, little gravel, wet	
		4		3		Morey0 sand
				3	Red clay with discontinuous grey laminae, very stiff, dense, dry	12'–1.5'
		5	55	7		
				7		
		6		11		
				11	as above	PVC 10 slot screen
		7	100	13		12'–2'
				12		
		8		15		
					from 8' to 10.5' shelby tube	
		9			approx. 22" recovery	
		10				
				8		
		11		7	Red silt and fine sand, come clay, saturated, sticky	
			100	13		
		12		9		
					Total depth 12'	
		13				
		14				

WELL SCHEMATIC



STANDARD PENETRATION TEST
SS = SPLIT SPOON
A = AUGER CUTTINGS
C = CORED

Jar sample, 5–6', for Atterburg limits and moisture content Shelby tube (ST–7) from 8–10.5'
Lost spoon tip at 6–8' interval.

Contractor:	American Auger
Driller:	Lee Penrod
Inspector:	Anne George
Rig Type:	Mobil, ATV

ENGINEERING–SCIENCE DRILLING RECORD

BORING MW-8

PROJECT NAME Kingsley/Dirsenal, NYSDEC
PROJECT NUMBER SY410.02

Sheet 1 of 1
Location:
House 413 yard

Weather Cold, wet rain/snow 30 F
Date/Time Start 12/21/93 1405
Date/Time Finish 12/21/93 1720

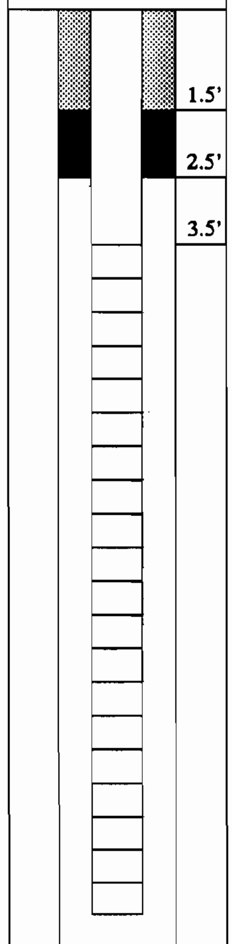
Plot Plan

GROUNDWATER OBSERVATIONS

Water Level				
Date				
Time				
Meas. From				

Microtip Reading	Sample I.D.	Sample Depth	Percent Recovery	Blow Cts	FIELD IDENTIFICATION OF MATERIAL	COMMENTS
		0				
					Augered through top two feet	Grout from surface to 1.5'
		1			assumed fill	
					drill cuttings indicated fill	
		2				Bent. seal 1.5'-2.5'
				4	Red/Brown clay and silt, trace sand, some rounded gravel, stiff, moist to wet	
		3	55	7	to 5.8'	
				5		
		4		6		
				3		Morey 0 sand 2.5'-13'
		5	45	4		
				3		
		6		9	Red clay with gray laminae, some silt, hard, dense, damp	
				3		Sched 40 PVC #10
		7	75	9	as above, grading to all red clay at base	screen, 3.5' to 13.5'
				9		
		8		14		
				7	as above, with intermittant layers of soft, wet silt and clay	
		9	100	9		
				13		
		10		11		
				3	increasing silt content in layers .2' thick	
		11	80	5		
				4		
		12		10		
				5	as above to 13.2', read brown clay and silt, some fine sand	
		13	100	9	dilatant, plastic, saturated.	
				6		
		14		7	Total depth 14'	Total depth 14'

WELL SCHEMATIC



STANDARD PENETRATION TEST
SS = SPLIT SPOON
A = AUGER CUTTINGS
C = CORED

No samples taken
Screen from 13.5' to 3.5', sand to 2.5', seal to 1.5', grout to surface

ENGINEERING–SCIENCE DRILLING RECORD

BORING MW–9

Contractor: American Auger
Driller: Lee Penrod
Inspector: Anne George
Rig Type: Mobil, ATV

PROJECT NAME Kingsley/Dirsenal, NYSDEC
PROJECT NUMBER SY410.02

Sheet 1 of 1
Location:
Vacant lot north of site

GROUNDWATER OBSERVATIONS

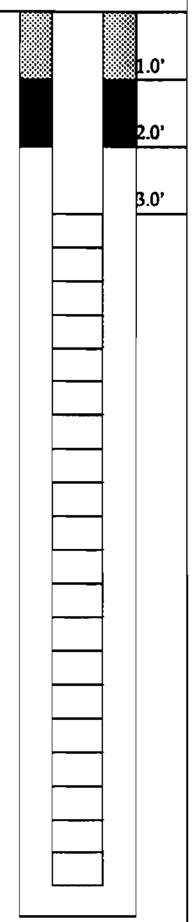
Water Level				
Date				
Time				
Meas. From				

Weather Cold, 32 F, rain/snow, wet
Date/Time Start 12/21/93 0850
Date/Time Finish 12/21/93 1200

Plot Plan

Microtip Reading	Sample I.D.	Sample Depth	Percent Recovery	Blow Cts	FIELD IDENTIFICATION OF MATERIAL	COMMENTS
		0				
				4	Red/Brown clay and silt, some sand, trace– gravel, moist, stiff	
		1	45	8		
				11		Bentonite Seal, 1–2'
		2		10		
				3	Red clay with gray laminae, some silt, very stiff, damp, to 6'	
		3	45	5		
				4		
		4		4		
				5		Morey 0 sand pack
		5	75	6		2 – 13.5'
				11		
		6		10		
					from 6–8.5', shelby tube ST9	
		7				Sched. 40 PVC #10
						Screen, 3 – 13'
		8				
		9		5	Red/Brown clay, little silt, very hard, stiff, dense, to 10.5'	
			70	8		
		10		13		
				6		
		11	100	7	at 10.5', red silt, some fine sand, some clay, soft, saturated	
				5	jar sample, 10–12'	
		12		8		
				4	red/brown fine sand and silt, some clay, dilatant, soft, coarsness increasing with	
		13		4	depth. saturated.	
				3	total depth, 13.5'	TD 13.5'
		14		7		

WELL SCHEMATIC



STANDARD PENETRATION TEST
SS = SPLIT SPOON
A = AUGER CUTTINGS
C = CORED

Shelby tube sample, 6–8.5', jar sample, 10–12'
Screen, 13–3', sand to 2', bentonite seal to 1', grout to surface

APPENDIX C

GEOTECHNICAL SOIL SAMPLE RESULTS

ADVANCED GEOTECHNICAL INVESTIGATIONS
(716) 283-7645

January 10, 1994

Ms. Karen Peluso
Engineering Science, Inc.
290 Elwood Davis Road
Suite 312
Liverpool, New York 13088

Re: Geotechnical Test Results for Diarsenal / Kingsley Park
ADI Project No.: HG-101

Dear Ms. Peluso:

Transmitted herewith are test results for the above referenced project. Testing included Atterberg Limits, Moisture Content, and Permeabilitity determinations. As agreed upon, the bulk density testing was not performed as a seperate test but is included in the test results on the permeability results.

Please note that the testing arm of Advanced Drilling Investigations (ADI) is known as Advanced Geotechnical Investigations (AGI). We are the same firm.

Thank you for the opportunity to provide our services to you. Should you have any questions, or if I may be of further service to you, please do not hesitate to give me a call.

Sincerely,

ADVANCED GEOTECHNICAL INVESTIGATIONS

Joseph R. Boyles
Director of Testing Services

/jrb

c2000/letters/esi1-10
enclosures

SUMMARY OF FLEXIBLE WALL PERMEABILITY TEST RESULTS

PROJECT NAME: DIARSENAL/KINGSLEY PARK	FILE NO.: HG-101
PROJECT LOCATION: BUFFALO, NEW YORK	PROJECT NO.: HG-101
SAMPLE IDENTIFICATION: ST-4 / 4-6.5'	LAB NO.: 033.005
DESCRIPTION:	SAMPLE TYPE: SHELBY TUBE

MAX. DRY DENS.: OPT. WATER CONTENT: DATE: 1/5/93

SPECIMEN DATA

INITIAL PARAMETERS:	FINAL PARAMETERS:
HEIGHT: 6.93 cm	HEIGHT: 6.92 cm
DIAMETER: 7.13 cm	DIAMETER: 7.15 cm
WET WEIGHT: 585.7 g	WET WEIGHT: 588.6 g
MOISTURE CONTENT: 22.1 %	MOISTURE CONTENT: 22.7 %
DRY DENSITY: 108.3 pcf	DRY DENSITY: 107.9 pcf
PERCENT COMPACTION:	

TEST PARAMETERS

CELL NO.: 5 PANEL NO.: 2 POSITIONS: 3 & 4

	RUN NO. 1	RUN NO. 2
CELL PRESSURE:	95.0 psi	95.0 psi
TEST PRESSURE:	85.3 psi	89.9 psi
BACK PRESSURE:	79.8 psi	79.9 psi
DIFFERENTIAL HEAD:	5.5 psi	10.0 psi

PERMEABILITY DATA

	RUN NO. 1	RUN NO. 2
AVERAGE FLOW RATE:	2.81E-05 cc/sec	5.60E-05 cc/sec
COEFFICIENT OF CORRELATION:	0.99988	0.99978
AVERAGE GRADIENT:	55.9	101.62
TEMPERATURE:	20.0 deg C	20.0 deg C
PERMEABILITY, K, at 20 deg C:	1.26E-08 cm/sec	1.38E-08 cm/sec

SUMMARY OF FLEXIBLE WALL PERMEABILITY TEST RESULTS

PROJECT NAME: DIARSENAL/KINGSLEY PARK | FILE NO.: HG-101
PROJECT LOCATION: BUFFALO, NEW YORK | PROJECT NO.: HG-101
SAMPLE IDENTIFICATION: ST-9 / 6-8.5' | LAB NO.: 033.001

DESCRIPTION: | SAMPLE TYPE: SHELBY TUBE

MAX. DRY DENS.: | OPT. WATER CONTENT: | DATE: 1/5/93

SPECIMEN DATA

INITIAL PARAMETERS:	FINAL PARAMETERS:
HEIGHT: 6.95 cm	HEIGHT: 6.93 cm
DIAMETER: 7.07 cm	DIAMETER: 7.00 cm
WET WEIGHT: 585.0 g	WET WEIGHT: 585.0 g
MOISTURE CONTENT: 19.9 %	MOISTURE CONTENT: 20.0 %
DRY DENSITY: 111.5 pcf	DRY DENSITY: 114.2 pcf
PERCENT COMPACTION:	

TEST PARAMETERS

CELL NO.: 6 | PANEL NO.: 2 | POSITIONS: 5 & 6

	RUN NO. 1	RUN NO. 2
CELL PRESSURE:	95.0 psi	95.0 psi
TEST PRESSURE:	85.1 psi	90.0 psi
BACK PRESSURE:	80.0 psi	80.0 psi
DIFFERENTIAL HEAD:	5.1 psi	10.0 psi

PERMEABILITY DATA

	RUN NO. 1	RUN NO. 2
AVERAGE FLOW RATE:	3.76E-05 cc/sec	7.58E-05 cc/sec
COEFFICIENT OF CORRELATION:	0.99965	0.99983
AVERAGE GRADIENT:	51.9	101.29
TEMPERATURE:	20.0 deg C	20.0 deg C
PERMEABILITY, K, at 20 deg C:	1.84E-08 cm/sec	1.90E-08 cm/sec

SUMMARY OF FLEXIBLE WALL PERMEABILITY TEST RESULTS

PROJECT NAME: DIARSENAL/KINGSLEY PARK — FILE NO.: HG-101
PROJECT LOCATION: BUFFALO, NEW YORK — PROJECT NO.: HG-101
SAMPLE IDENTIFICATION: ST-7 / 8-10.5' — LAB NO.: 033.003

DESCRIPTION: — SAMPLE TYPE: SHELBY TUBE

MAX. DRY DENS.: — OPT. WATER CONTENT: — DATE: 1/5/93

SPECIMEN DATA

INITIAL PARAMETERS:		FINAL PARAMETERS:	
HEIGHT:	7.01 cm	HEIGHT:	6.97 cm
DIAMETER:	7.14 cm	DIAMETER:	7.15 cm
WET WEIGHT:	605.6 g	WET WEIGHT:	605.2 g
MOISTURE CONTENT:	18.1 %	MOISTURE CONTENT:	18.0 %
DRY DENSITY:	114.0 pcf	DRY DENSITY:	114.5 pcf
PERCENT COMPACTION:			

TEST PARAMETERS

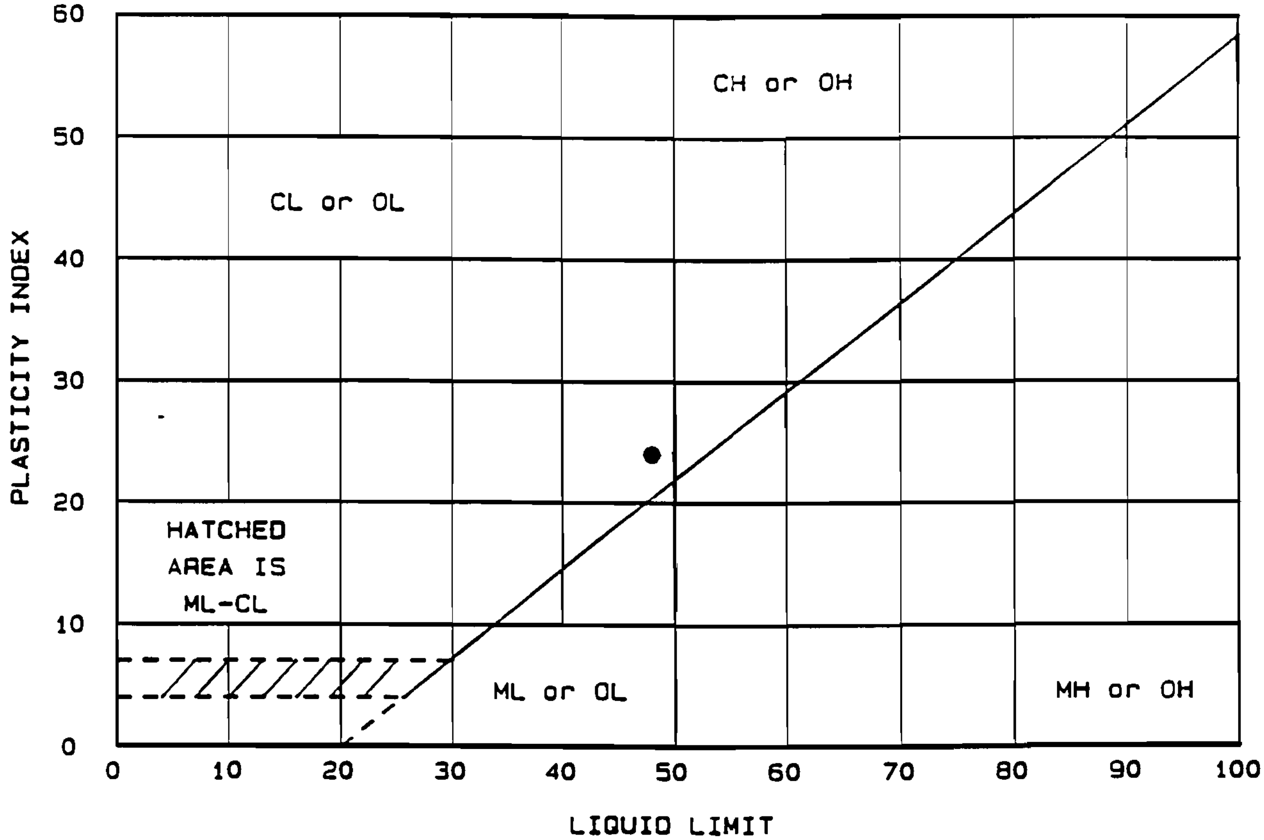
CELL NO.: 4 — PANEL NO.: 2 — POSITIONS: 1 & 2

	RUN NO. 1	RUN NO. 2
CELL PRESSURE:	95.0 psi	95.0 psi
TEST PRESSURE:	85.0 psi	82.5 psi
BACK PRESSURE:	80.0 psi	79.9 psi
DIFFERENTIAL HEAD:	5.0 psi	2.6 psi

PERMEABILITY DATA

	RUN NO. 1	RUN NO. 2
AVERAGE FLOW RATE:	2.20E-03 cc/sec	1.10E-03 cc/sec
COEFFICIENT OF CORRELATION:	0.99979	0.99940
AVERAGE GRADIENT:	50.5	26.5
TEMPERATURE:	20.0 deg C	20.0 deg C
PERMEABILITY, K, at 20 deg C:	1.09E-06 cm/sec	1.04E-06 cm/sec

LIQUID AND PLASTIC LIMITS TEST REPORT



	Location + Description	LL	PL	PI	-200	ASTM D 2487-90
●	ST-~~6~~ 4 / 4-6.5'	48	24	24		

Project No.: HG-101
Project: DIARSENAL / KINGSLEY PARK

Client: ENGINEERING SCIENCE. INC.
Location: BUFFALO. NEW YORK

Date: JAN. 10. 1994

LIQUID AND PLASTIC LIMITS TEST REPORT

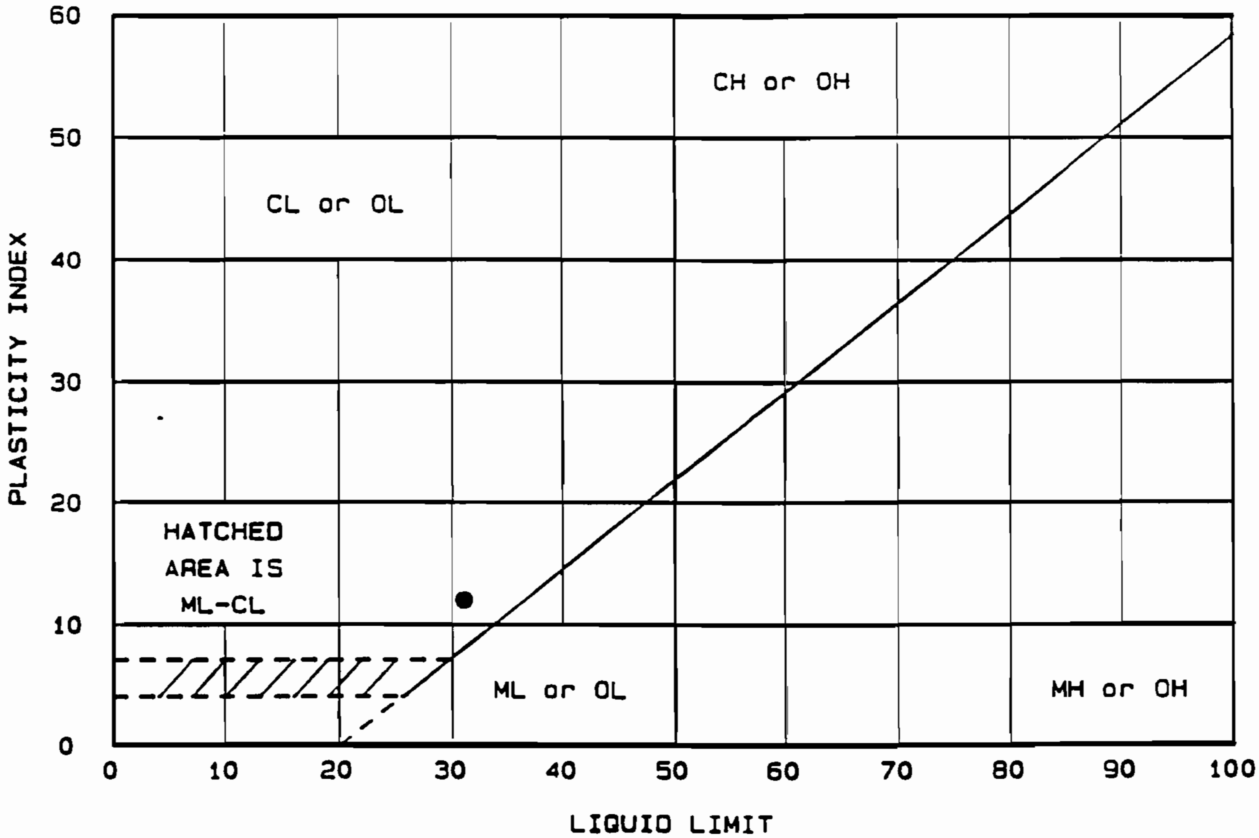
ADVANCED GEOTECHNICAL INVESTIGATIONS

Remarks:

LAB NO. 033.005

Fig. No. ______

LIQUID AND PLASTIC LIMITS TEST REPORT



	Location + Description	LL	PL	PI	-200	ASTM D 2487-90
●	ST-9 / 6-8.5'	31	19	12		

Project No.: HG-101
Project: DIARSENAL / KINGSLEY PARK

Client: ENGINEERING SCIENCE, INC.
Location: BUFFALO, NEW YORK

Date: JAN. 10, 1994

Remarks:

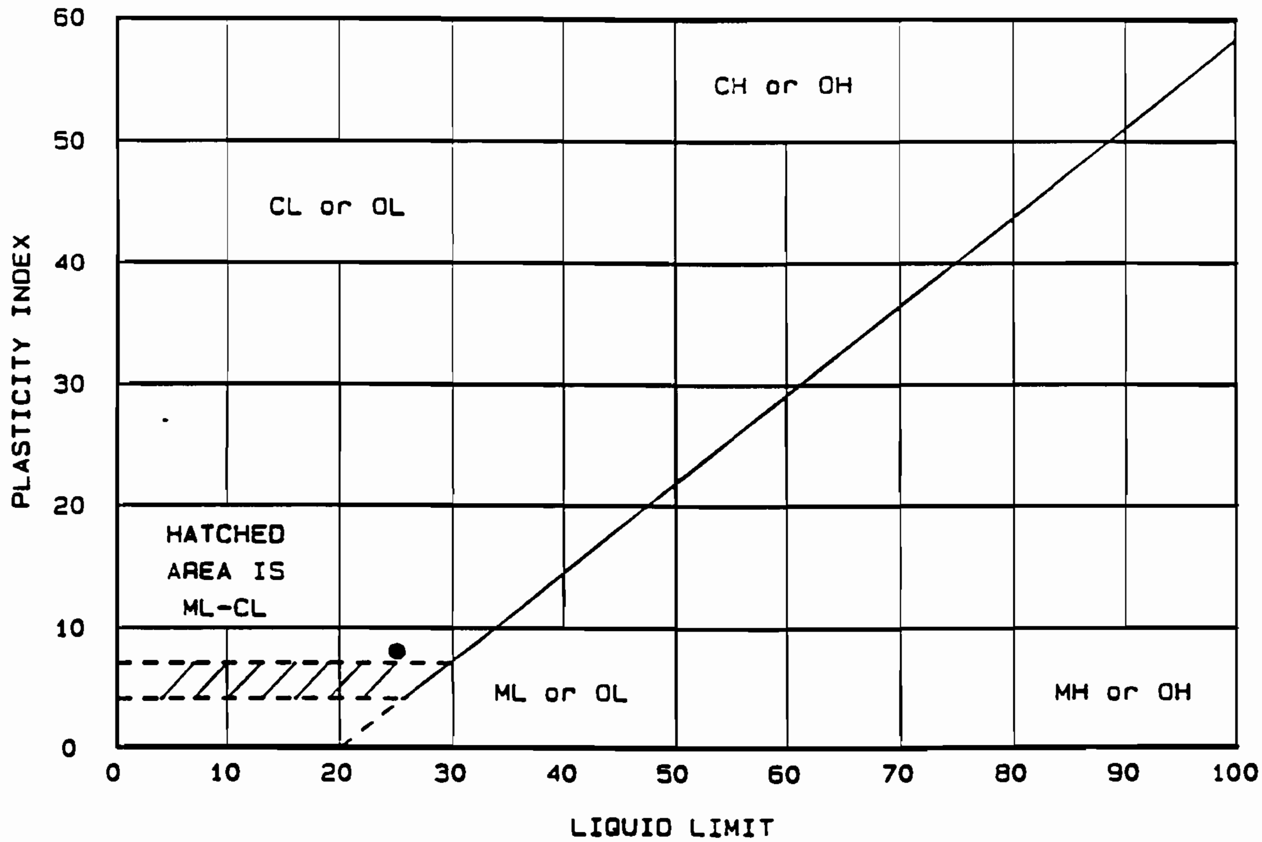
LAB NO. 033.001

LIQUID AND PLASTIC LIMITS TEST REPORT

ADVANCED GEOTECHNICAL INVESTIGATIONS

Fig. No. ______

LIQUID AND PLASTIC LIMITS TEST REPORT



Location + Description	LL	PL	PI	-200	ASTM D 2487-90
● ST-7 / 8-10.5'	25	17	8		

Project No.: HG-101
Project: DIARSENAL / KINGSLEY PARK

Client: ENGINEERING SCIENCE, INC.
Location: BUFFALO, NEW YORK

Date: JAN. 10, 1994

LIQUID AND PLASTIC LIMITS TEST REPORT

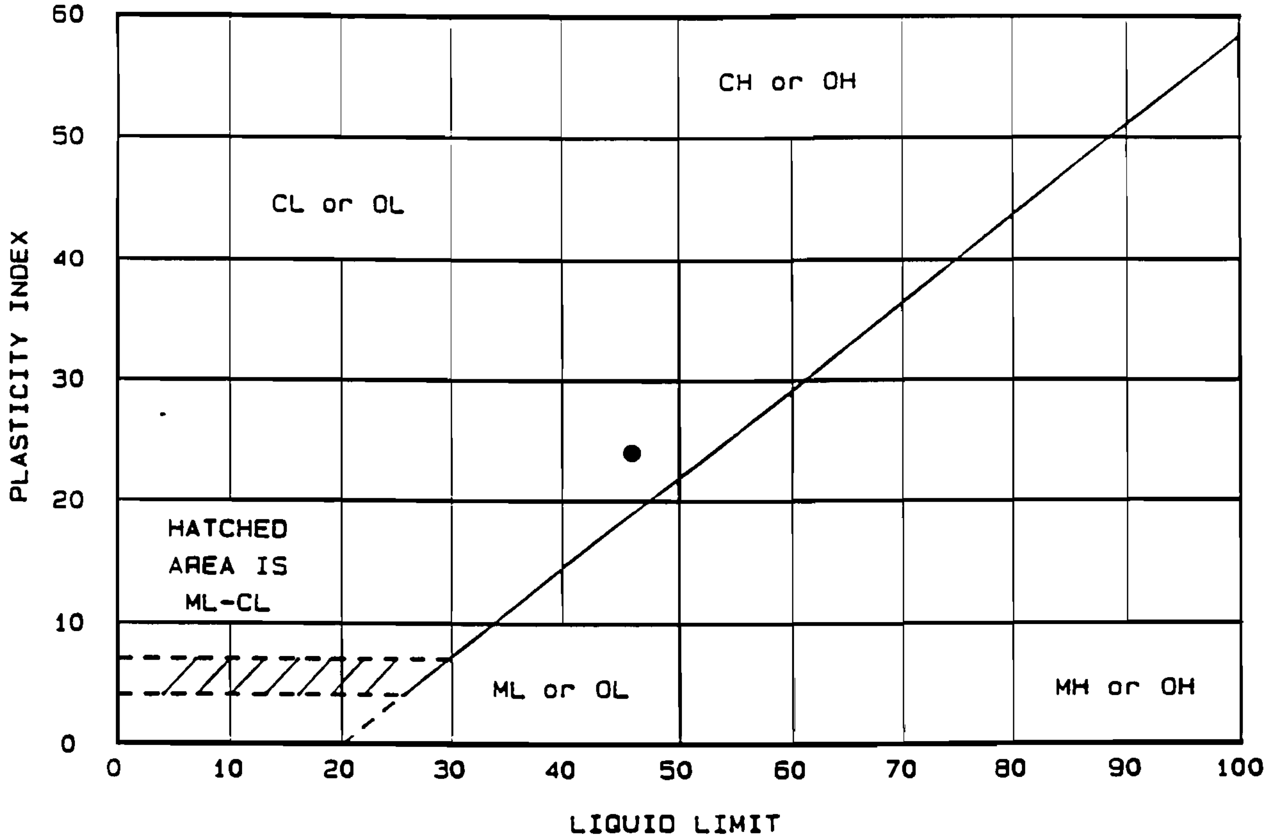
ADVANCED GEOTECHNICAL INVESTIGATIONS

Remarks:

LAB NO. 033.003

Fig. No. ______

LIQUID AND PLASTIC LIMITS TEST REPORT



	Location + Description	LL	PL	PI	-200	ASTM D 2487-90
●	MW-7 / 5-6'	46	22	24		

Project No.: HG-101
Project: DIARSENAL / KINGSLEY PARK

Client: ENGINEERING SCIENCE, INC.
Location: BUFFALO, NEW YORK

Date: JAN. 10, 1994

Remarks:
MOISTURE CONTENT: 25.7%

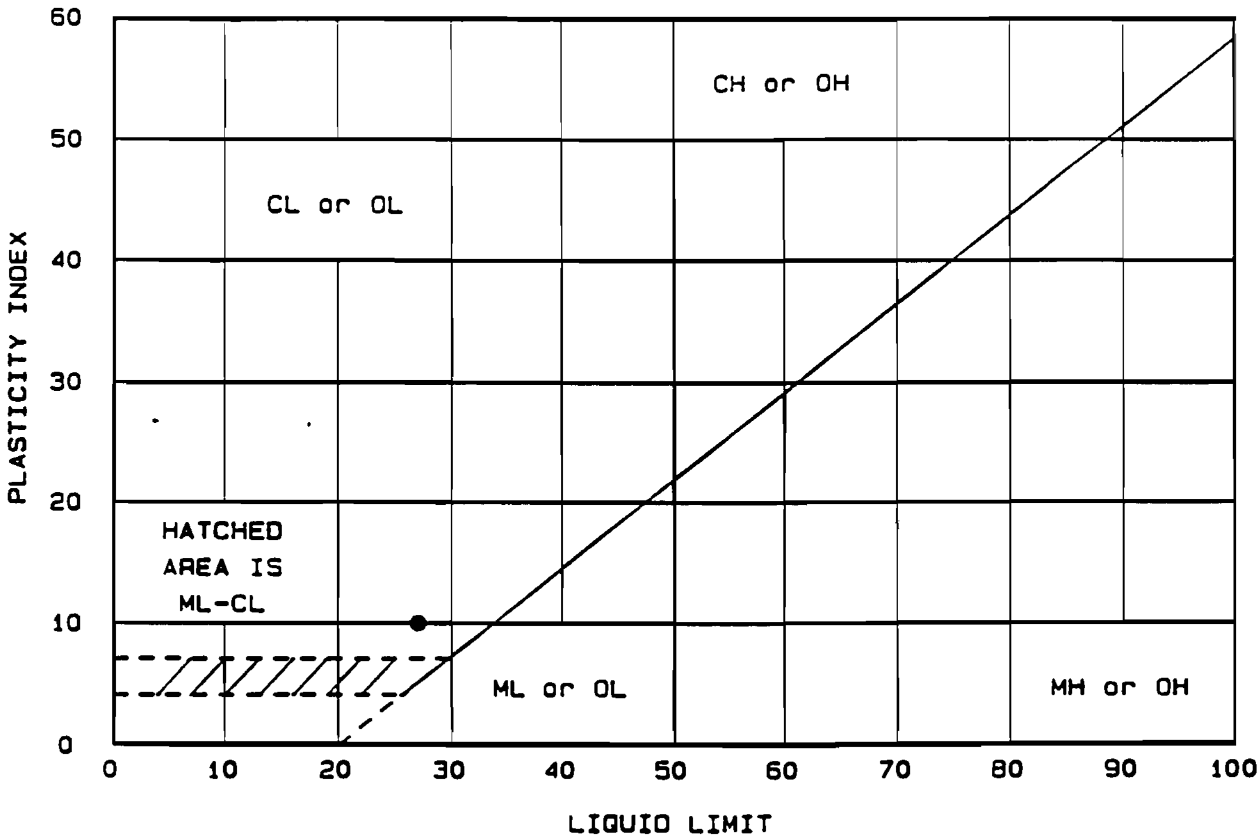
LAB NO. 033.004

LIQUID AND PLASTIC LIMITS TEST REPORT

ADVANCED GEOTECHNICAL INVESTIGATIONS

Fig. No. ______

LIQUID AND PLASTIC LIMITS TEST REPORT



Location + Description	LL	PL	PI	-200	ASTM D 2487-90
● MW-6 / 9-10'	27	17	10		

Project No.: HG-101
Project: DIARSENAL / KINGSLEY PARK

Client: ENGINEERING SCIENCE, INC.
Location: BUFFALO, NEW YORK

Date: JAN. 10, 1994

Remarks:
MOISTURE CONTENT: 18.9%

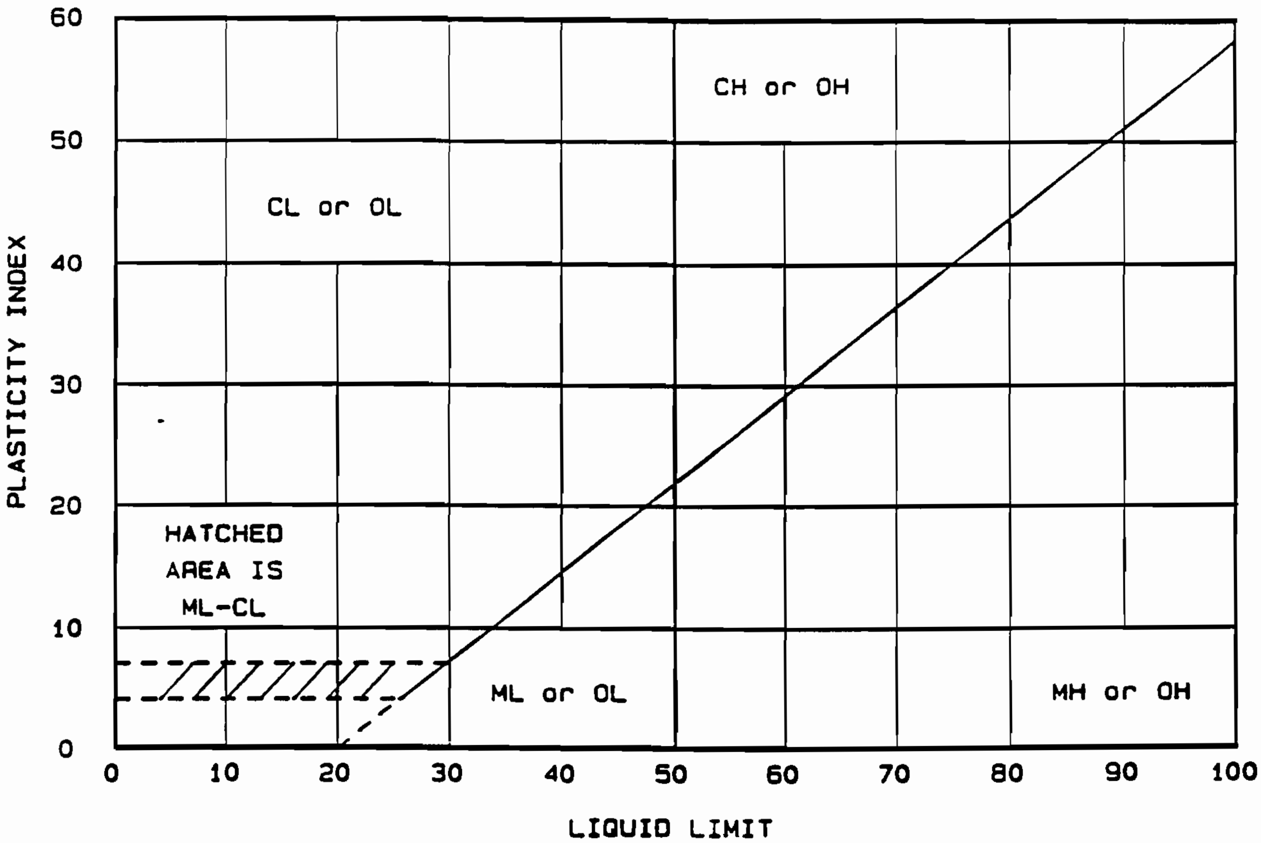
LAB NO. 033.006

LIQUID AND PLASTIC LIMITS TEST REPORT

ADVANCED GEOTECHNICAL INVESTIGATIONS

Fig. No. ______

LIQUID AND PLASTIC LIMITS TEST REPORT



Location + Description	LL	PL	PI	-200	ASTM D 2487-90
● MW-9 / 10-12'					

NV - Non-Viscous NP - Non-Plastic

Project No.: HG-101
Project: DIARSENAL / KINGSLEY PARK

Client: ENGINEERING SCIENCE, INC.
Location: BUFFALO, NEW YORK

Date: JAN. 10, 1994

Remarks:
MOISTURE CONTENT: 18.1%
MATERIAL IS NONPLASTIC-
UNABLE TO ROLL

LAB NO. 033.002

LIQUID AND PLASTIC LIMITS TEST REPORT

ADVANCED GEOTECHNICAL INVESTIGATIONS

Fig. No. ______

APPENDIX D

SUBDRAIN DISCHARGE VOLUME ESTIMATE

ES ENGINEERING-SCIENCE, INC.

Client	NYSDEC	Job No.	723867.03000	Sheet	1 of 7
Subject	Diarsenol - Kingsley Park Subdrain Flow Quantity Est.	By	WX	Date	2/2/94
		Checked	WJL 2/2/94	Rev.	

Assumptions:

1. The drainage flow rate will be determined by:

   Q = Precipitation − Evaporation − Runoff − Leakage into Deeper Soil

2. Area of drainage influence is determined by:

   a. 30 feet from the drain if fill is 2 ft thick (beyond this distance, the hydraulic gradient is too small for flow)

   b. 60 feet from the drain if fill > 2 ft thick

   (see attached map, total area = 16,000 ft^2 = 0.38 acre)

3. Practical evapotranspiration = 70% Lake evaporation or ideal evapotranspiration (w/ sufficient water supply)

Solution:

1. The average annual precipitation for Buffalo area is approximately 35" (see attached Fig. 2-5)

2. The average annual lake evaporation for the same area is approximately 27" (see attached Fig. 2-16) which is about the same as evapotranspiration (see attached reference PP 32).

3. Runoff ≈ 0 based on the near zero drainage grade at the site.

4. Leakage into deep soil

Assume $K = 10^{-8}$ cm/sec $= 2.8 \times 10^{-5}$ ft/day (based on test data)

$i = 1$ (to be conservative)

The vertical flow velocity in the deep soil is:

$$V = Ki = 2.8 \times 10^{-5} \times 1 = 2.8 \times 10^{-5} \text{ ft/day}$$

$$= 2.8 \times 10^{-5} \times 365 \text{ ft/yr}$$

$$= 0.1 \text{ ft/yr} \approx 1''/\text{yr}.$$

(The flow rate is

$$Q_i = KiA = 0.1 \times A = 0.1 \times 16{,}000 \text{ ft}^3/\text{yr}$$

$$= 1{,}600 \text{ ft}^3/\text{yr}$$)

Therefore, the subdrain flow rate is

Precipitation − Evaporation − Runoff − Leakage

$= 35'' - 27'' \times 70\% - 0 - 1''$

$= 15''/\text{yr}$

The total annual flow is

$$Q = 15'' \times A = \frac{15}{12} \times 16{,}000 = 20{,}000 \text{ ft}^3/\text{yr}$$

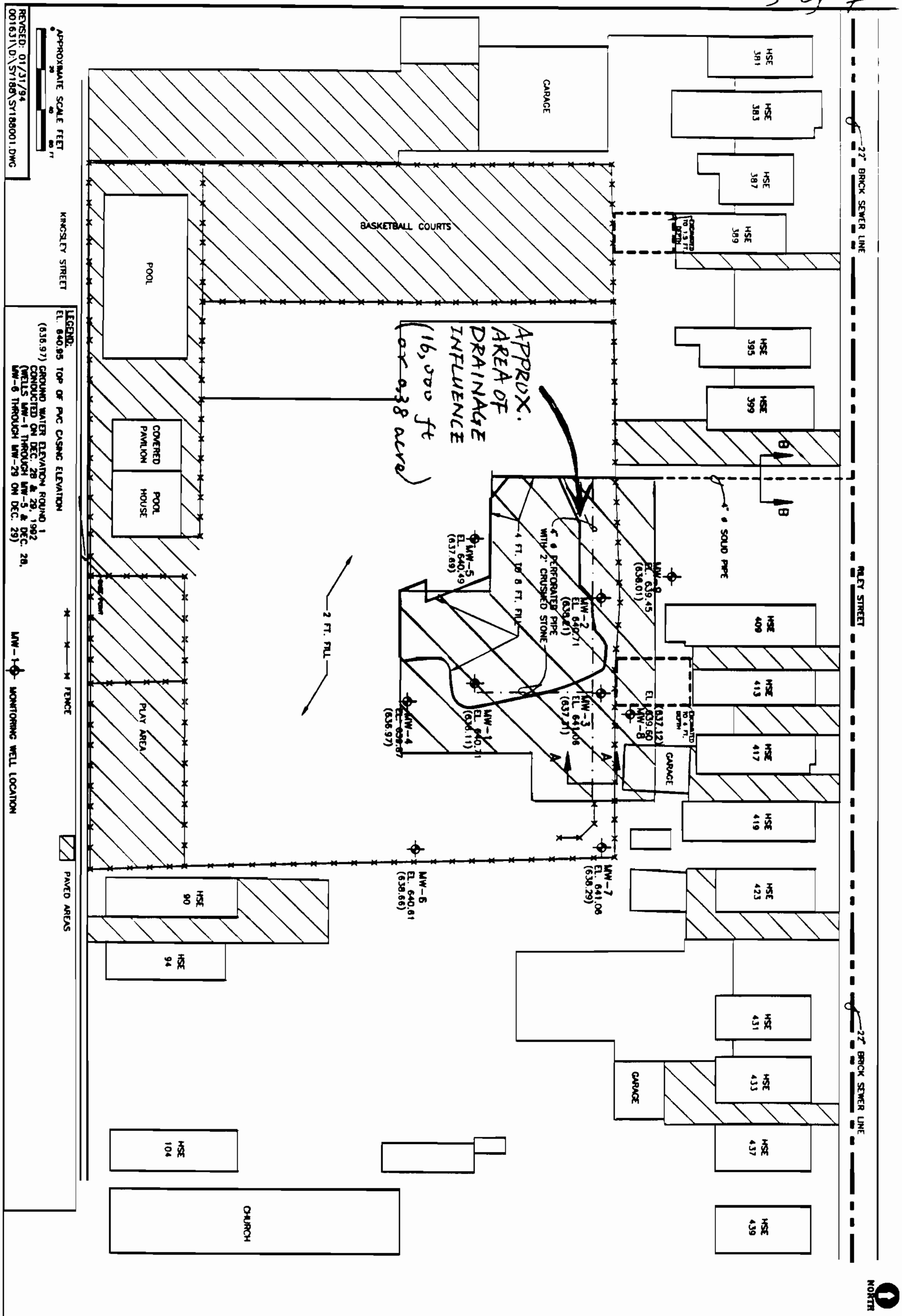
$$\doteq 150{,}000 \text{ gal/yr}$$

$$\doteq 400 \text{ gal/day}$$

Use a factor of safety of 3,

the design flow is $3 \times 150{,}000 = 450{,}000$ gal/yr.

$= 1{,}200$ gal/day



ENGINEERING-SCIENCE
DESIGN • RESEARCH • PLANNING

ES

SHALLOW CONCEPTUAL SUBDRAIN SYSTEM LAYOUT
DIARSENOL-KINGSLEY PARK SITE
City of Buffalo, Erie County

Water-Resources Engineering

RAY K. LINSLEY

Professor of Hydraulic Engineering
Stanford University

JOSEPH B. FRANZINI

Professor of Civil Engineering
Associate Chairman, Department of Civil Engineering
Stanford University

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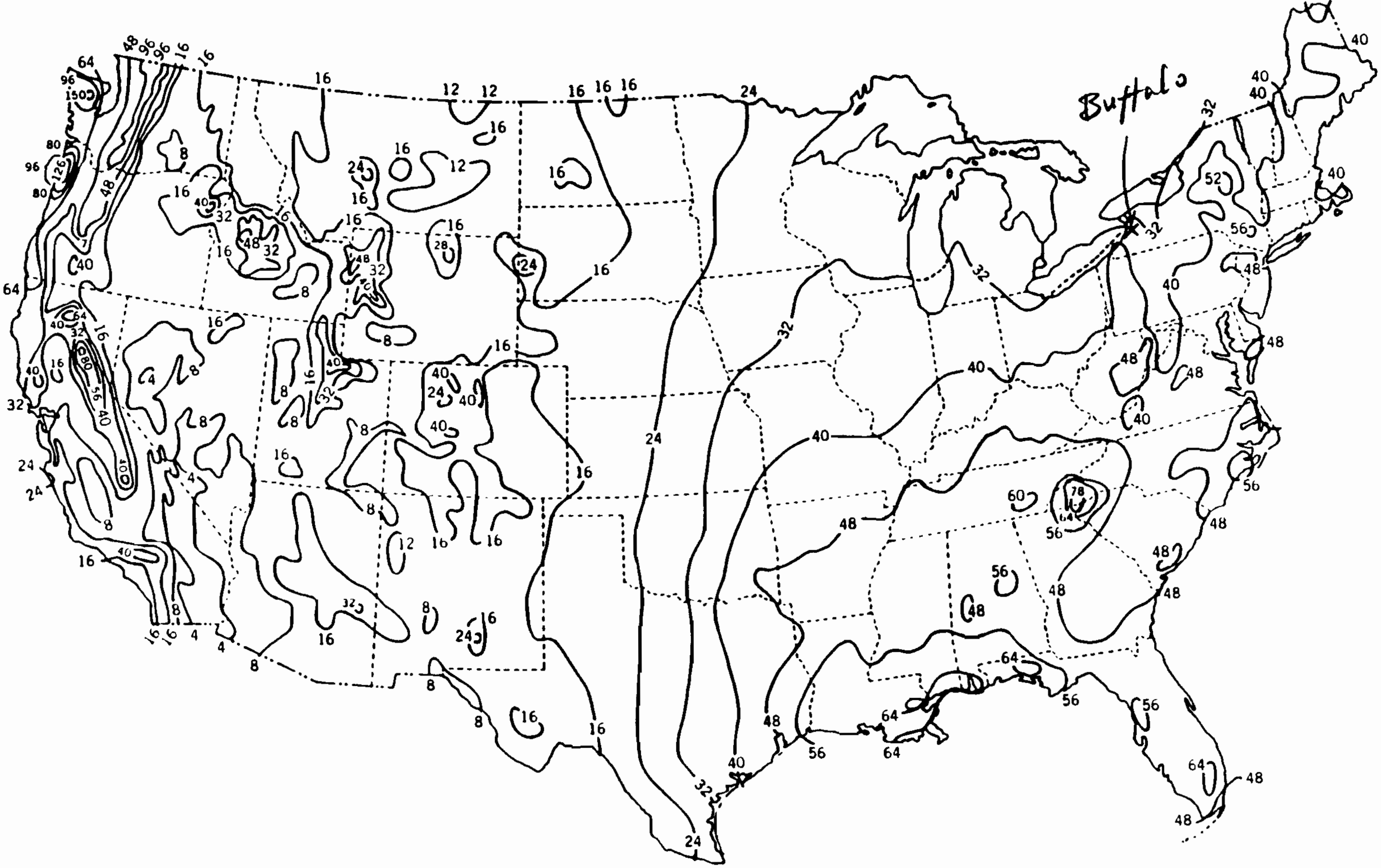

FIG. 2-5 Average annual precipitation in the United States. (National Weather Service)

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(2-8)

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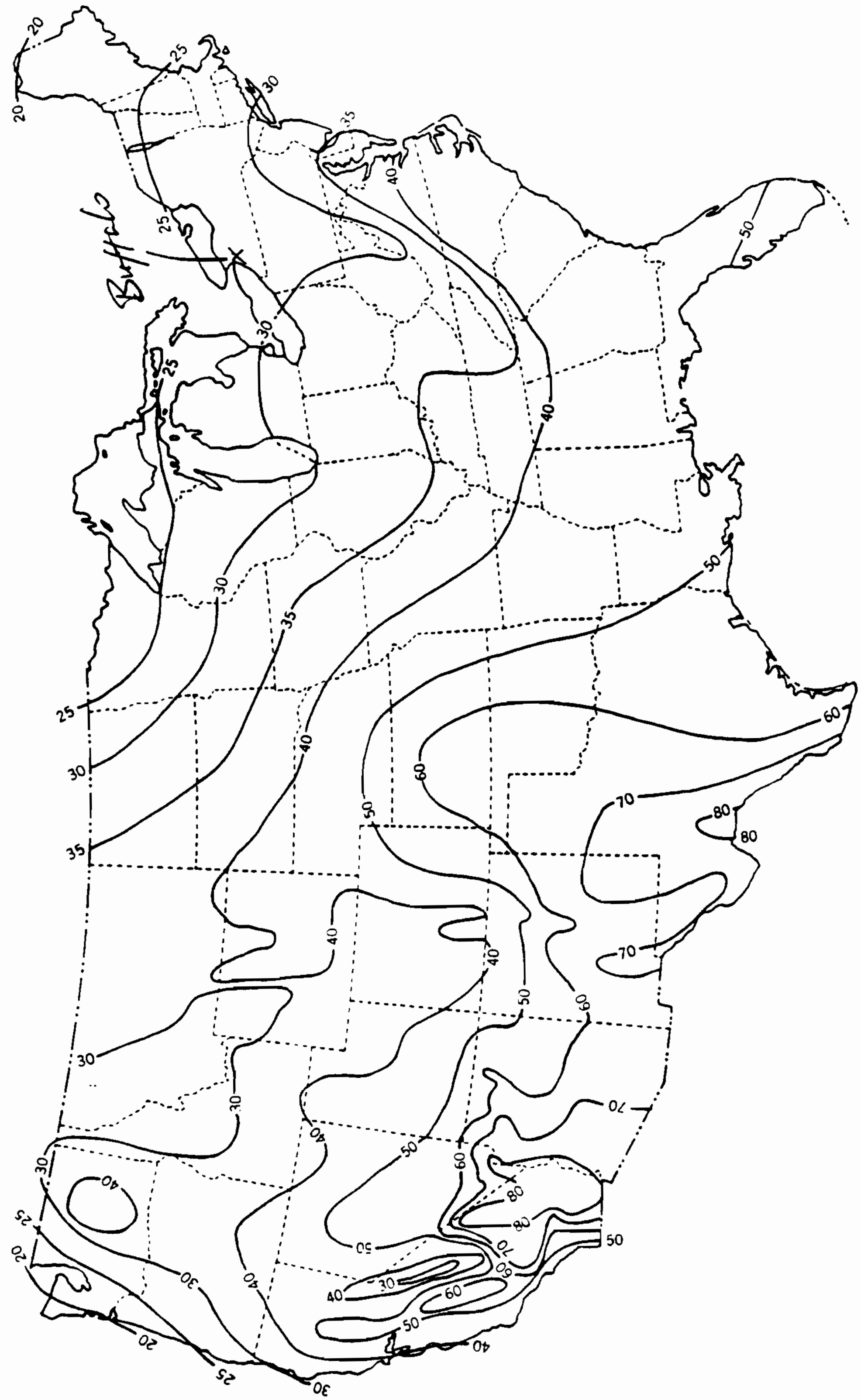


FIG. 2-16 Average annual lake evaporation in inches. (National Weather Service)

not permit the reproduction of the necessary charts, but they can be obtained from the original reference.[1]

There is no simple solution for estimates of evaporation from a proposed reservoir. Field measurements at the site will not yield data which can be used in Eq. (2-3) or Eq. (2-4) since the completion of the reservoir will considerably alter the microclimate of the site. Until further study is complete, there seems no better solution than to use pan data reduced by the coefficient appropriate to the pan.

2-15 Transpiration Plants remove water from soil through their roots, transport the water through the plant, and eventually discharge it through pores (stomata) in their leaves. The *transpiration ratio* (Table 2-3) is determined by dividing the weight of water transpired by a plant during its growth by the weight of dry matter produced by the plant exclusive of roots.

TABLE 2-3 Transpiration Ratios

Plant	*Ratio*
Corn*	349
Wheat*	557
Rice*	682
Flax*	783
Fir trees†	145
Oak trees†	220
Birch trees†	375

*From H. L. Shantz and L. N. Piemeisel. The Water Requirements of Plants at Akron, Colo., *J. Agr. Research*, Vol. 34, pp. 1093–1190, 1927.
†From O. Raber, Water Utilization by Trees with Special Reference to the Economic Forest Species of the North Temperate Zone, *U.S. Dept. Agr. Misc. Pub.* 257, pp. 1–97, 1937.

Transpiration[2] is essentially the evaporation of water from the leaves of plants. Rates of transpiration will, therefore, be about the same as rates of evaporation from a free water surface if the supply of water to the plant is not limited. Estimated free-water evaporation may, therefore, be assumed to indicate the *potential evapotranspiration* from a vegetated soil surface.

The total quantity of transpiration by plants over a long period of time is limited primarily by the availability of water. In areas of abundant rainfall

[1] M. A. Kohler, T. J. Nordensen, and W. E. Fox, Evaporation from Pans and Lakes, *U.S. Weather Bur. Res. Paper* 38, May, 1955.

[2] D. W. Hendricks and V. E. Hansen, Mechanics of Evapotranspiration, *J. Irrigation and Drainage Div., ASCE*, Vol. 88, No. IR2, pp. 67–82, June, 1962.

ES ENGINEERING-SCIENCE, INC.

Client: NYSDEC
Job No.: 723867.03000
Sheet 1 of 1

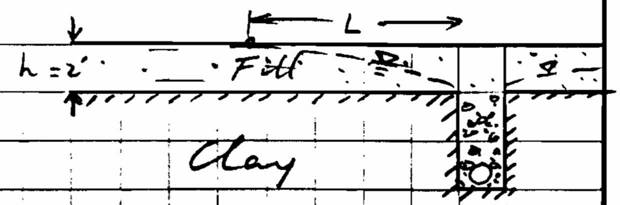
Subject: Diarsenol-Kingsley Park Subdrain Radius of Influence Est.
By: WX
Date: 2/2/94

Checked: WJL 2/2/94
Rev.

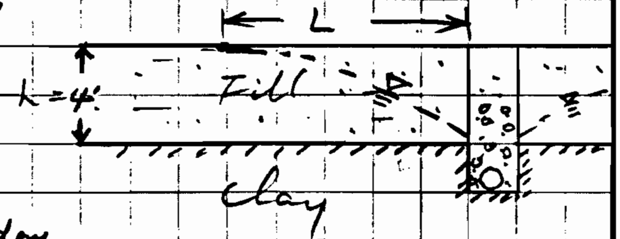
Assumptions:

1. Subsurface conditions A & B as shown.
2. $K_{fill} = 10^{-2}$ cm/sec $= 28$ ft/day
3. $K_{clay} = 10^{-7}$ cm/sec $= 2.8 \times 10^{-4}$ ft/day and therefore the flow in the clay layer is neglegible.
4. Lateral flow velocity $V \geq 1$ ft/day if within the radius of influence (for practical purposes).

Condition A:



Condition B:



Solution:

The lateral flow velocity is determined by Darcy's equation: $V = K \cdot i =$

where, i = hydraulic gradient $\approx \frac{1}{2} \cdot \frac{h}{L}$ (at L distance away from drain)

Thus, $V = K \cdot \frac{h}{2L} = 14 \frac{h}{L}$ L = Effective Radius of Influence.

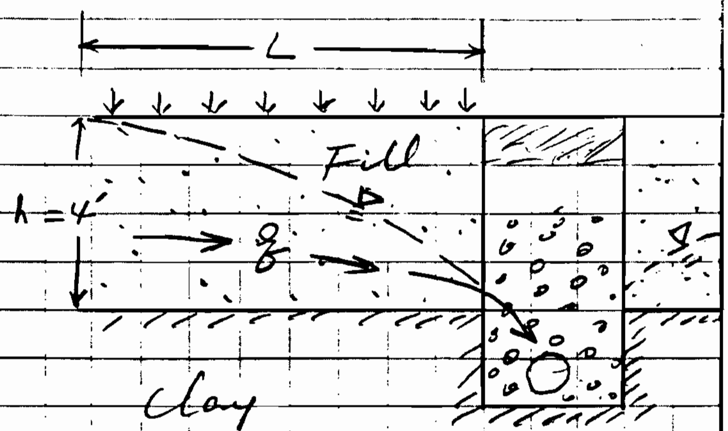
For "Condition A", $h_A = 2$ ft. $V_A = 14 \times \frac{2}{L_A} =$

If $V_A \geq 1$ ft/day, $14 \frac{2}{L_A} \geq 1 \Rightarrow L_A \leq 28$ feet

Similarly, for "Condition B",

$h_B = 4$ ft, $14 \frac{4}{L_B} \geq 1 \Rightarrow L_B \leq 56$ feet

Assumptions:



1. Rainfall intencity is based on 2-year frequency, 24-hour precipitation. $I = 2.5''/24\text{-hr}$
2. $K_{fill} = 1 \times 10^{-2}$ cm/sec $= 28$ ft/day
3. Average fill thickness $h = 4$ ft.
4. Flow from clay is negligible due to its low permeability.

Solution:

Consider 1 ft wide plan area perpendicular to drain:

A. The lateral flow (Darcy's equation)

$$q_L \doteq KiA = K \times \frac{h+0}{L} \times \left(\frac{h}{2} \times 1\right)$$
$$= 28 \times \frac{h}{L} \times \frac{h}{2}$$
$$= 14 \frac{h^2}{L}$$
$$= 14 \times \frac{4^2}{L}$$
$$= 224 \frac{1}{L}$$

B. Precipitation infiltration

$$q_p = I \cdot A'$$
$$= \frac{2.5}{12} \times (L \times 1) = \frac{2.5}{12} L = q_L$$

$\Rightarrow L = 32.8$ ft

ES ENGINEERING-SCIENCE, INC.

Client	NYSDEC	Job No.	723867.03000	Sheet	2 of 3
Subject	Diarsenol-Kingsley Park Peak Daily Flow	By	WX	Date	2/2/94
		Checked	WJL 2/2/94	Rev.	

Therefore, the peak daily flow is

$$q_p = q_L = \frac{2.5}{12} \times 32.8 = 6.83 \text{ ft}^3/\text{day/ft}$$

$= 51$ gal/day/ft of drain.
(for one side only)

Since the subdrain drains from both sides and is 260 linear feet long, the total flow is:

$$Q = 260 \times 2 \times q = 260 \times 2 \times 51$$

$= 26,520$ gal/day

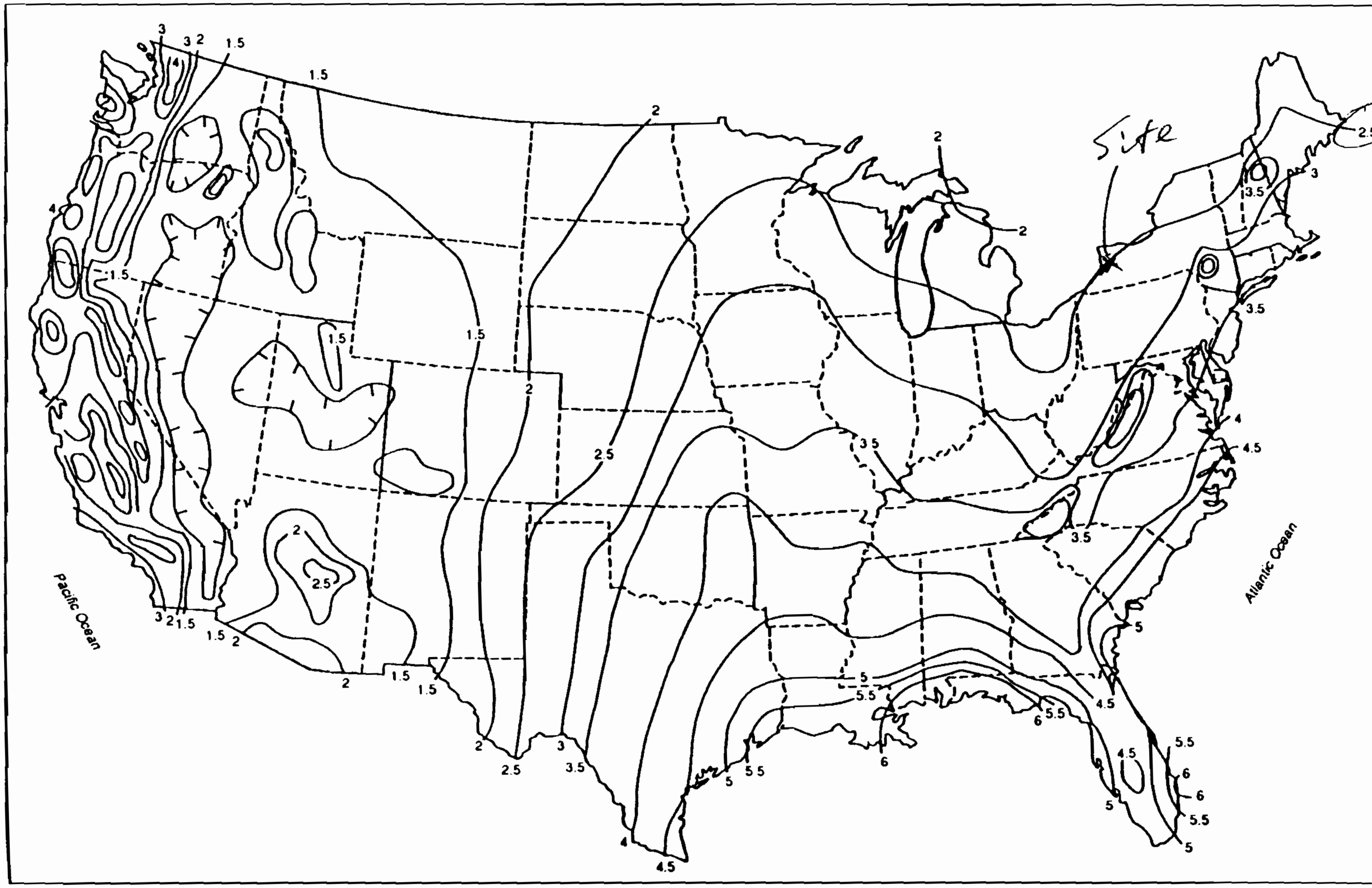


FIG. 7.4 2-year, 24-h precipitation (inches; 1 in = 2.54 cm) (7).