Department of Environmental Conservation

Division of Environmental Remediation

FOCUSED FEASIBILITY STUDY

Atlas Graphics Site
Hempstead, Nassau County
Site Number 1-30-043B

SEPTEMBER
1999

New York State Department of Environmental Conservation
GEORGE E. PATAKI, *Governor* JOHN P. CAHILL, *Commissioner*

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1.0 INTRODUCTION

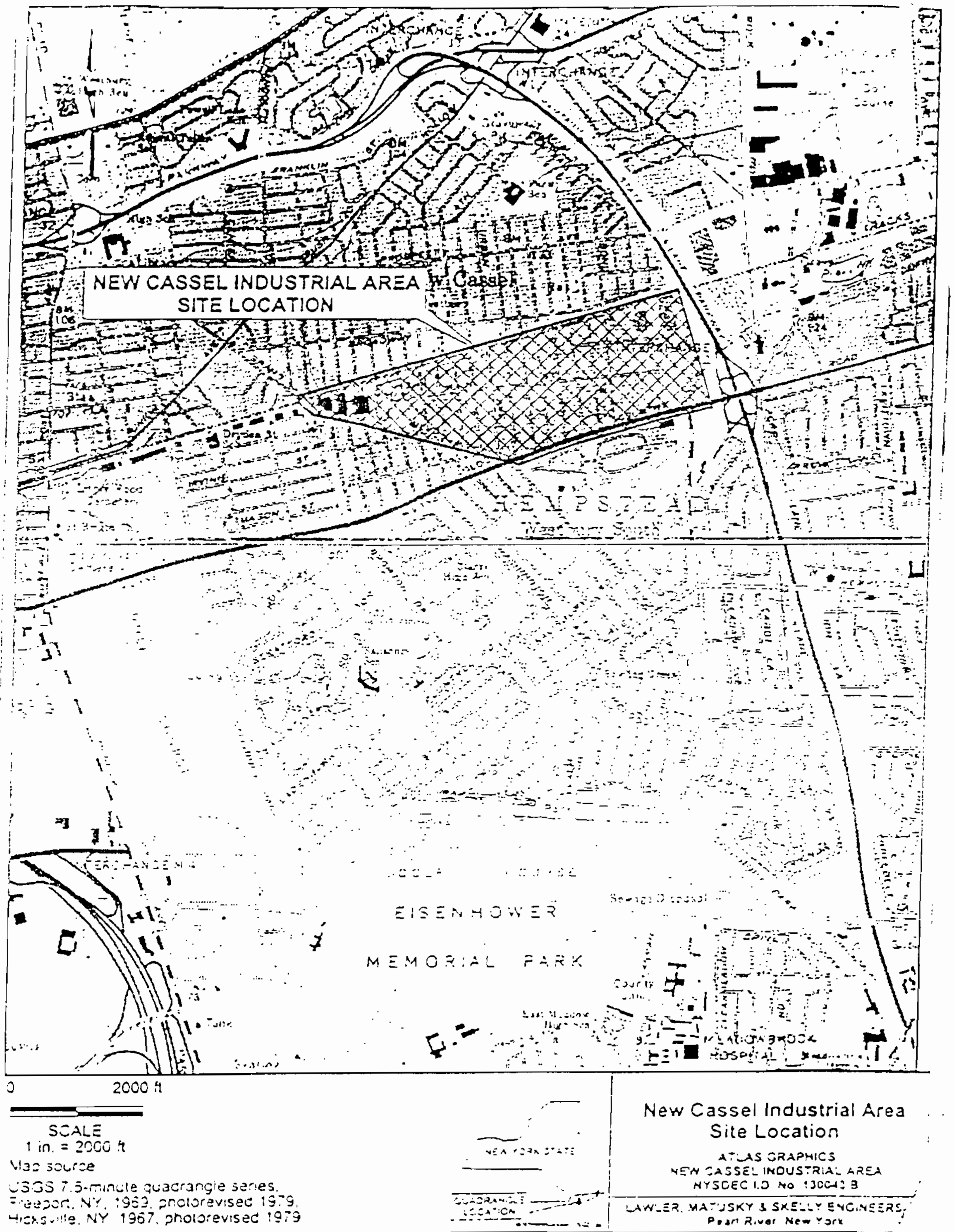
The New Cassel Industrial Area (NCIA) is located in the unincorporated village of Westbury in the Town of North Hempstead, Nassau County, New York (Figure 1). Approximately 200 industrial or commercial businesses occupy this 170-acre site (Figure 2). Due to extensive halogenated volatile organic contamination of groundwater beneath the site, the New York State Department of Environmental Conservation (NYSDEC) classified the entire industrial area as a hazardous waste disposal site in 1988. Based on the results of a Site Investigation (SI) and Preliminary Site Assessment (PSA) conducted by the New York State Department of Environmental Conservation's (NYSDEC) consultant Lawler, Matusky & Skelly Engineers LLP (LMS) seven facilities responsible for the contamination were identified as Class 2 sites on the New York State Registry of Inactive Hazardous Waste Disposal Sites in March of 1995. At this time the NCIA as a whole was delisted. The Atlas Graphics Site was identified as one of these facilities.

The Atlas Graphics Site, (NYSDEC Site No. 1-30-143B on the New York State Registry of Inactive Hazardous Waste Disposal Sites) is located at 567 Main Street in the NCIA. The site is comprised of approximately 8,000 square feet which is bounded by Swalm Avenue to the west, commercial buildings and parking lots to the north and east, and Main Street to the south (Figure 3). The property is currently an active printing and graphics operation that occupies the small two story commercial building on the site.

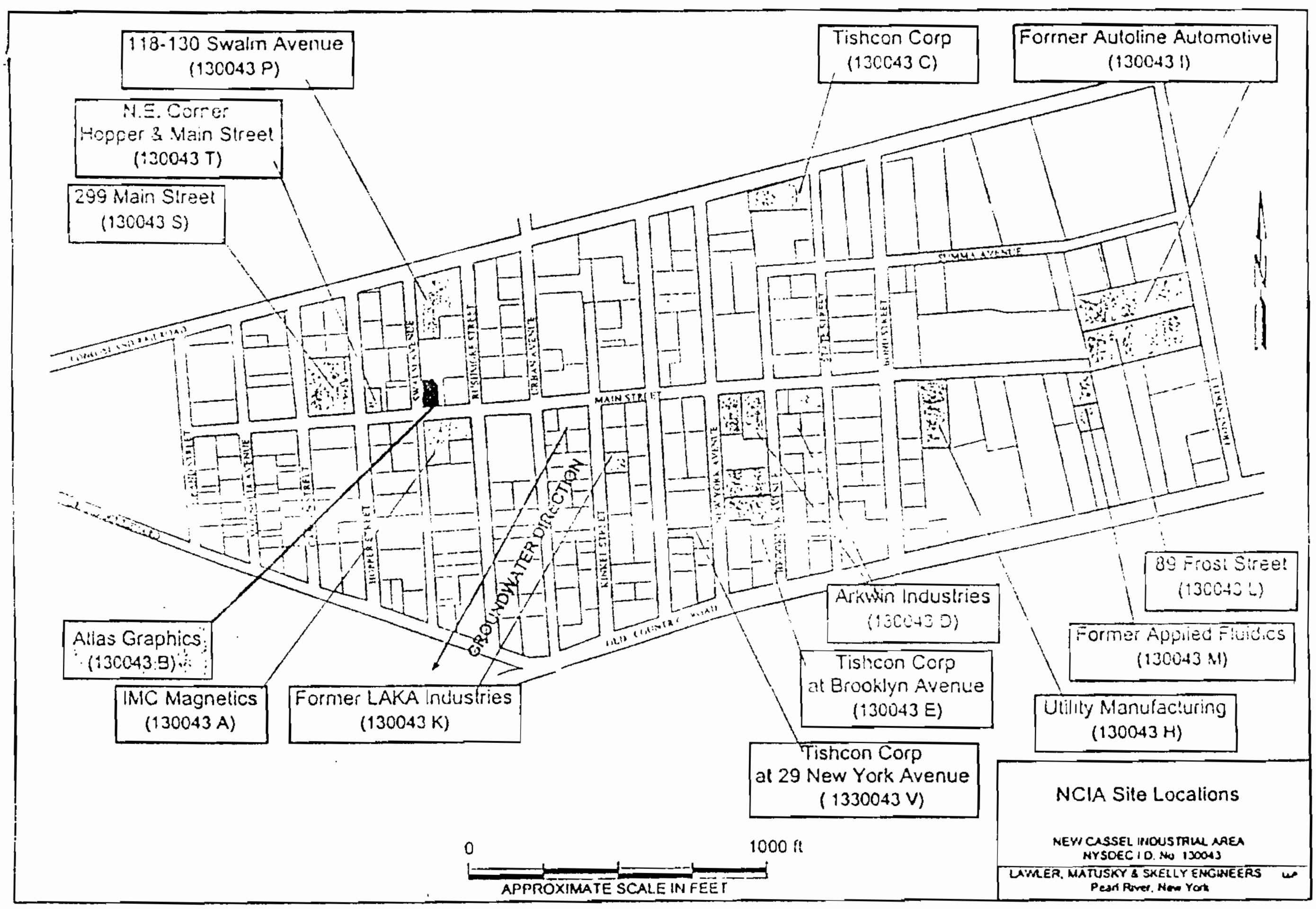
Historic records of the Atlas Graphics site indicate the site was developed prior to 1971. Chemical usage records indicate that Atlas Graphics used 312 gallons of trichloroethylene (TCE) each year for degreasing purposes. The wastewater from this operation was discharged directly into a cesspool off the southwest corner of the building. Investigations conducted by the Nassau County Health Department (NCDOH) in 1978 indicated that the cesspool was heavily contaminated with TCE. In 1978 a sample collected by NCDOH showed 4.5 mg/kg TCE and 0.1 mg/kg of 1.1.1-trichloroethane (1.1.1-TCA), an additional sample collected in 1980 contained 318 mg/kg of TCE. The Atlas Graphics facility was eventually connected to the county sewer system in November 1980. Records pertaining to the cleaning and abandonment of the cesspool when the facility was connected to the county sewer were not located. It is not known if the cesspool was cleaned and removed or if any hazardous wastes were removed from the site at that time.

Previous investigations in the vicinity of the Atlas Graphics site include the SI and PSA conducted by LMS in 1994 to 1997. During the SI concentrations of tetrachloroethylene (PCE) related contaminants were found to be significantly higher in a geoprobe point (GP-20) located downgradient of the Atlas Graphics site than upgradient concentrations.

Atlas Graphics
Site # 1-30-043B
Figure 1 - New Cassel Industrial Area Location



Atlas Graphics
Site # 1-30-043B
Figure 2 - Atlas Graphics location in the New Cassel Industrial Area



Atlas Graphics
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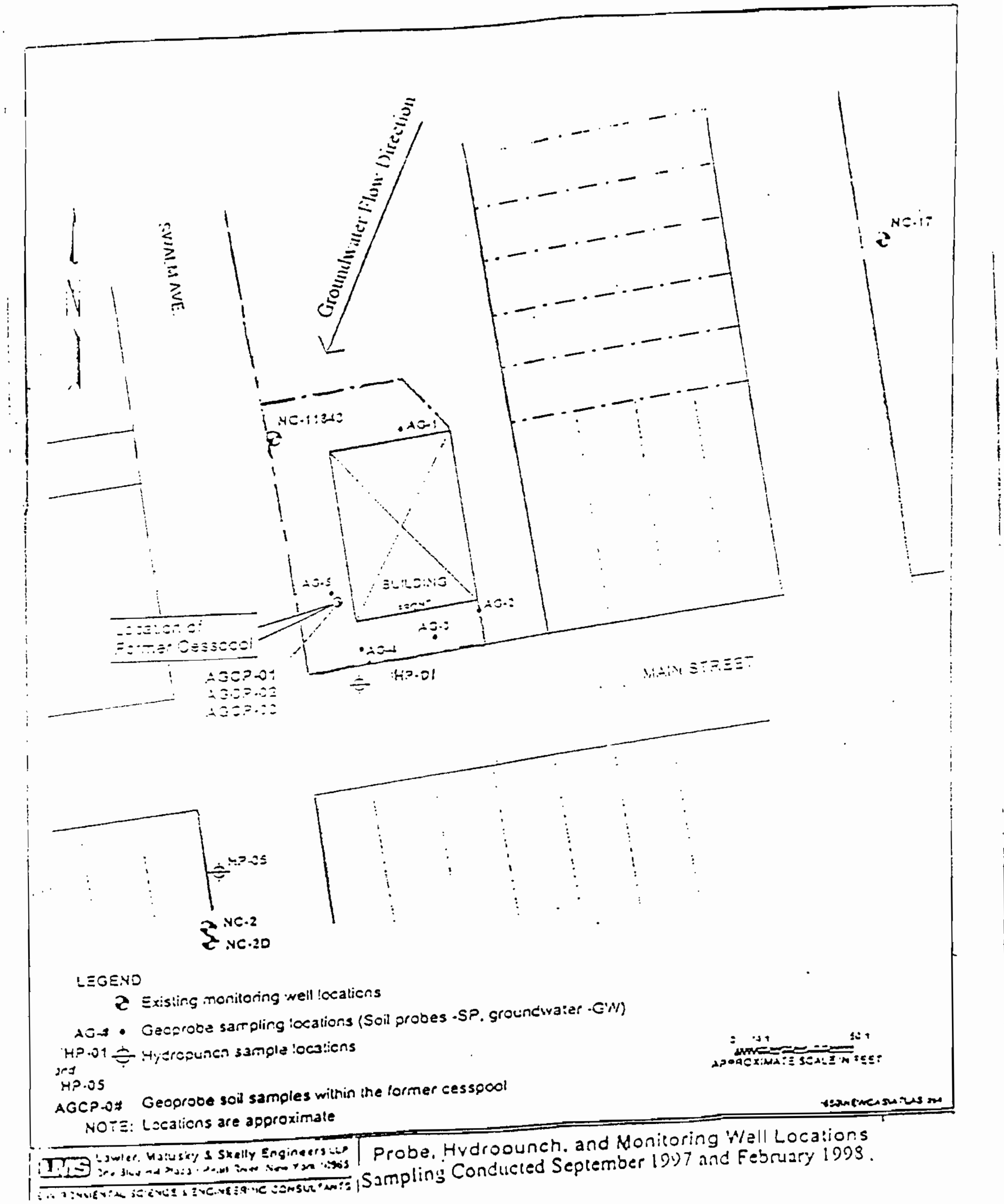
Figure 3 - Atlas Graphics Site Map



2.0 SUMMARY OF THE INVESTIGATION RESULTS

2.1 SOIL PROBE RESULTS

Several of the soil samples collected in 1998 during the RI confirmed that hazardous wastes were disposed of on the site and are present on the site. The source area of this contamination appears to be isolated to the former cesspool location off the southwest corner of the building. Three soil probes inside of the former cesspool (AGCP-01, AGCP-02, and AGCP-03) were completed during the RI. At AGCP-01 soil probe samples were collected at 8-12 ft, 12-16 ft, and 16-20 ft below ground surface (bgs). The analytical data for these soil probe samples did not indicate the presence of any volatile organic compounds above the quantitation limit (Figure 4). At AGCP-02 soil probe samples were also collected at 8-12 ft, 12-16 ft, and 16-20 ft bgs. The analytical data for these soil probe samples did not indicate the presence of any target compounds in the 16-20 ft sample at AGCP-02 (Figure 4). The concentration of TCE exceeded the recommended cleanup objective in the 8-12 ft soil probe sample with a concentration of 2.3 mg/kg. The recommended cleanup objective for TCE is 0.7 mg/kg. Only trace levels of TCE (0.015 mg/kg) were found in the 12-16 ft soil probe sample (Figure 4). At AGCP-03 soil probe samples were collected at 4-8 ft, 8-12 ft, 12-16 ft and 16 to 20 ft bgs. The analytical data for these soil probe samples did not indicate the presence of any target compounds above the quantitation limit in the 4-8 ft sample and the 8-12 ft sample (Figure 4). The concentration of TCE exceeded the recommended cleanup objective in the 12-16 ft soil probe sample with a concentration of 7.6 mg/kg (Figure 4). Trace levels of TCE (.009 mg/kg), PCE (.005 mg/kg), ethylbenzene (.003 mg/kg), and xylene (.006 mg/kg) were also found in the 4-8 ft soil probe sample.

A total of seven soil samples were collected at AG-5. The results of the VOC analysis are shown on Figure 4. No target compounds in excess of the NYSDEC recommended soil cleanup objective were detected in the samples with the exception of acetone at 0.43 mg/kg in the 20-22 ft sample. In addition to acetone, TCE was detected at 0.042 mg/kg in AG-5 (5-7 ft) and at 0.11 mg/kg in the 20-22 ft sample (Figure 4). AG-5 was located adjacent to the former cesspool location and the presence of target compounds in the soil in this area suggests a nearby source area. The results are presented in the Remedial Investigation report dated March 1999.

No metals or SVOC's were detected at concentrations which exceed the recommended soil cleanup objective or the anticipated site background concentrations in an industrialized area.

Several of the soil samples colleted during this investigation confirmed that hazardous wastes were disposed of on the site or are present on the site. The source area of this contamination appears to be isolated to the former cesspool location off the south west corner of the building. The contamination appears to be the result of past disposal practices at the site.

Atlas Graphics
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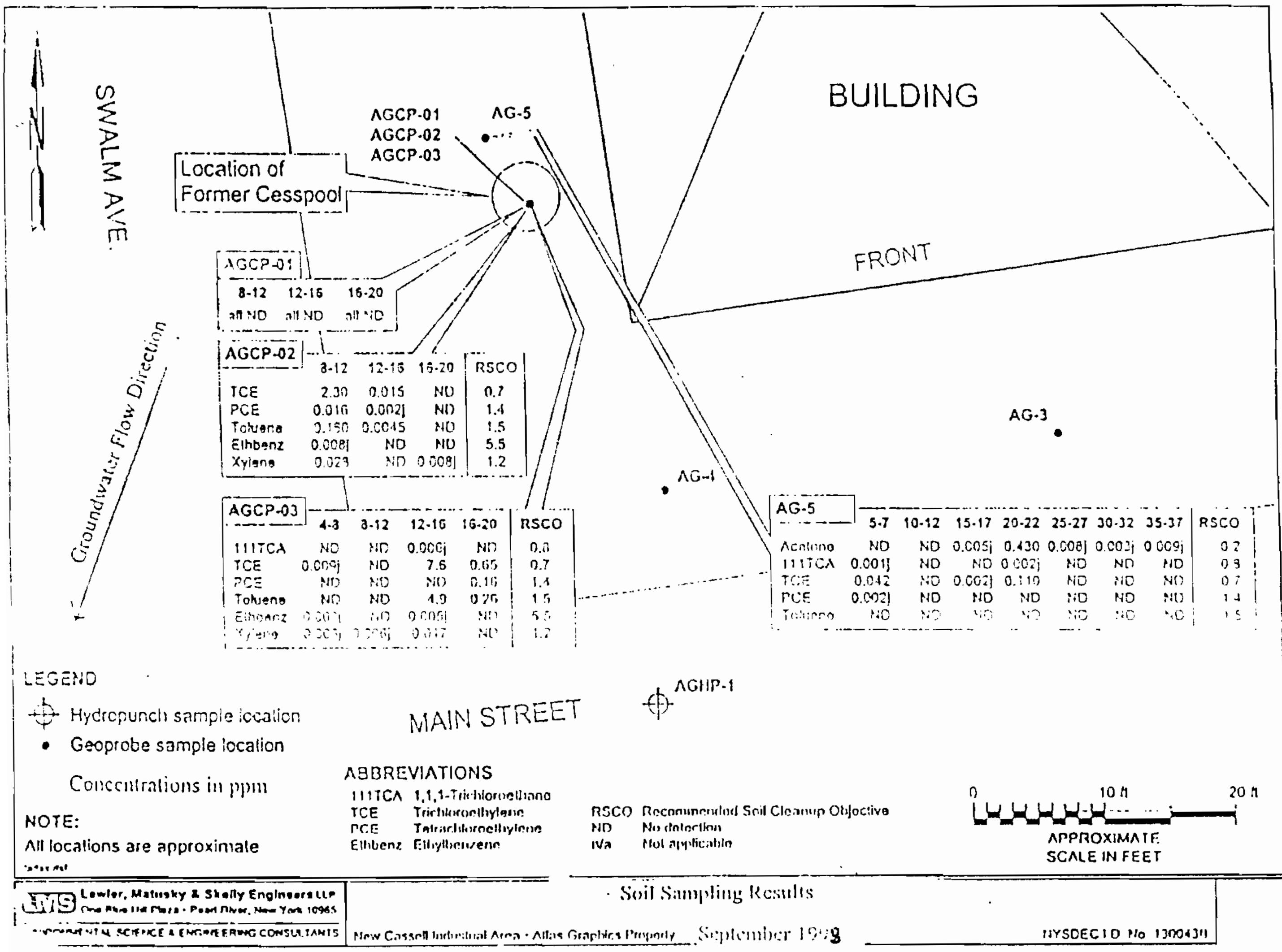
Figure 4 - Soil Sampling Locations and Results



2.2 GROUNDWATER PROBE RESULTS

A total of 5 groundwater probe samples were collected from AG-01, AG-03, and AG-05, the results are summarized in Figure 4.

The results of AG-01 indicate concentrations of VOCs in excess of NYSDEC class GA groundwater standards at the shallow depth (56-60 ft). A groundwater probe sample was not taken at the intermediate depth (66-70 ft) since this zone appeared dry. Target compounds above the quantitation limit were not detected in the deep sample (76-80 ft). The primary target compound which was detected in the 56-60 ft sample was PCE (10µg/l). Other compounds found above the Class GA groundwater standards included acetone (150 µg/l), and benzene (2 µg/l). Trace levels of 1,2-DCE (10 µg/l), 2-butone (40 µg/l), TCE (4 µg/l), toluene (3 µg/l), xylene (2 mg/l), 4-methyl-2-pentanone (9 µg/l), 2-hexanone (5 µg/l), and styrene (1 µg/l) were also detected.

The results of AG-03 indicate concentrations of VOCs in excess of NYSDEC class GA groundwater standards at all three of the depths sampled (56-60, 66-70 ft and 76-80 ft). The primary target compound which was detected is TCE and concentrations are highest at the shallow depth (56-60 ft) (Table 1). Target compounds found at the shallow depth (56-60 ft) in excess of the Class GA groundwater standards include 1,1-DCE (2 µg/l), 1,1-DCA (8 µg/l), 1,1,1-TCA (47 µg/l), TCE (310 µg/l), and PCE (30 µg/l). Other compounds found at the shallow depth include acetone (16 µg/l) and 1,1,2-TCA (3 µg/l). Target compounds found at the intermediate depth (66-70 ft) in excess of the Class GA groundwater standards include TCE (16 µg/l), and PCE (6 µg/l). Other compounds found at the intermediate depth include 1,1,1-TCA (1 µg/l), and 1,2-DCE (3 µg/l). The only target compound found at the deepest depth (76-80 ft) in excess of the Class GA groundwater standards was PCE (40 µg/l). Toluene (3 µg/l) was also detected at the deepest depth. The only trend noted in the data from the AGGW-03 is a decreasing concentration of TCE with depth. The presence of high concentrations of TCE at the shallow depth suggest an on-site source of TCE. However, similar concentrations of TCE were noted in the upgradient sampling point (NC-11843).

The results of AG-05 indicate concentrations of VOCs in excess of NYSDEC class GA groundwater standards at all three of the depths sampled (56-60, 66-70 ft and 76-80 ft). The primary target compound which was detected was TCE and concentrations are highest at the deepest depth (76-80 ft) (Figure 4). Total VOCs at the two shallow depths (56-60 ft and 66-70 ft) were 1010 µg/l and 756 µg/l, respectively. At the deepest depth (76-80 ft) total VOCs were 4819 µg/l including 3900 µg/l of TCE. This geoprobe was located on the Atlas Graphics site just north of the former cesspool location. The presence of high levels of TCE in the vicinity of the former cesspool suggests that the past disposal of TCE into the cesspool has affected the groundwater quality in this area.

2.3 HYDROPUNCH GROUNDWATER SAMPLING RESULTS

The results of HP-01 (see Figure 3 for hydropunch locations) indicate concentrations of VOCs in excess of NYSDEC class GA groundwater standards at 60, and 70 ft below the ground surface (Figure 5). No target compounds were detected at the deepest sampling depth (80 ft). At the 60 ft depth 8 µg/l PCE was detected, total VOC's at the 70 ft depth were 53 µg/l including 18 µg/l TCE and 35 µg/l PCE. This hydropunch was located along the north side of Main Street just south (downgradient) of the former cesspool on the Atlas site. The source of this groundwater contamination cannot be entirely attributed to the Atlas site since the upgradient groundwater contaminant concentrations are similar to those found in HP-01.

The results of HP-05 indicate concentrations of VOCs in excess of NYSDEC class GA groundwater standards at 60, 70, and 80 ft below the ground surface (Figure 5). The primary target compounds are 1,1-DCE, 1,1- DCA, 1,1,1-TCA, TCE, PCE and Toulene. The concentrations reach a peak concentration at 80 ft (Figure 5). The trend of the concentrations with depth below 80 ft is not known as sampling was stopped at 80 ft. Total VOCs peaked at 80 ft where 1599 µg/l was detected including 100 µg/l 1,1,1-TCA, 1400 µg/l TCE, 99 µg/l PCE, and 39 µg/l Toulene. Total VOCs at 70 ft where 907.5 µg/l including 4.9 µg/l 1,1-DCE, 4.6 µg/l 1,1-DCA, 170 µg/l 1,1,1 TCA, 680 µg/l TCE, and 48 µg/l PCE. Total VOCs at 60 ft where 753 µg/l including 130 µg/l 1,1,1 TCA, 570 µg/l TCE, and 53 µg/l PCE. This hydropunch was located along the west side of Swalm Avenue (Figure 3). This location is in a downgradient position of the former cesspool at the Atlas site. However, this sampling location is located immediately west of the IMC Magnetics site. Investigations at the IMC Magnetics site have shown that this site is heavily contaminated with target compounds as a result of past activities at this site. It is believed that most of the contamination detected in the HP-05 groundwater samples can be attributed to the IMC Magnetics site.

2.4 MONITORING WELL SAMPLING RESULTS

A total of four existing monitoring wells were sampled during the September 1998 field sampling. The wells included NC-17, NC-2, NC-2D, and NC-11843 (Figure 3). The analytical results for these groundwater samples are found in Table 1.

The results from the NC-2 and NC-2D well pair showed concentrations of VOCs in excess of NYSDEC class GA groundwater standards in both wells (Table 2). NC-2 is the shallow watertable well of this pair and is screened to a total depth of approximately 72 ft. Target compounds detected in excess of NYSDEC class GA groundwater standards in this well include 1,2-DCE (24 µg/l), TCE (290 µg/l), and PCE (510 µg/l). NC-2D is the deeper well in this well pair with a total depth of approximately 122 ft. Target compounds detected in excess of NYSDEC class GA groundwater standards in this well include 1,2-DCA (7 µg/l), 1,1,1-TCA (29 µg/l), TCE (81 µg/l), and PCE (160 µg/l). The contamination in this area appears to be associated with the plume of TCE/PCE contamination which appears to originate from the

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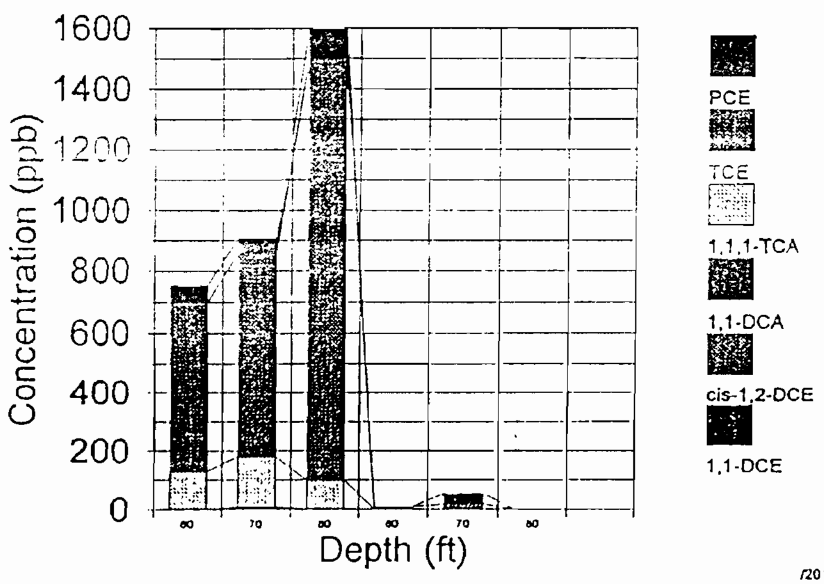
Figure 5 - Hydropunch Results

Hydropunch:	HP-05	9/22/97		HP-01		2/24/98
Depth	60	70	80	60	70	80
1,1-DCE	0	4.9	0	0	0	0
cis-1,2-DCE	0	0	0	0	0	0
1,1-DCA	0	4.6	0	0	0	0
1,1,1-TCA	130	170	100	0	0	0
TCE	570	680	1400	8	18	0
PCE	53	48	99	0	35	0
Toulene	0	0	39			
Total VOC's	**753**	**807.5**	**1599**	**8**	**53**	**0**



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Hydropunch Results

ATLAS GRAPHICS SITE
NEW CASSEL INDUSTRIAL AREA
NYSDEC I.D. No. 130043

LAWLER, MATUSKY & SKELLY ENGINEERS LLP
Pearl River, New York

Former IMC Magnetics site which is located just east of the NC-2 well pair. The maximum downgradient extent of this contamination is unknown.

The results from N-11843 also showed concentrations of VOCs in excess of NYSDEC class GA groundwater standards (Table 1). Target compounds detected in excess of NYSDEC class GA groundwater standards in this well include 1,2-DCE (7 μg/l), TCE (19 μg/l), and PCE (20 μg/l). This well is located approximately 22 ft from the center line of Swalm Street in the northwest corner of the Atlas property. It is in a upgradient position of the Atlas cesspool and the NC-2 well pair and is completed to a total depth of 59 ft. NC-17 has a total depth of approximately 64 ft. PCE (41μg/l) was the only target compound detected in excess of NYSDEC class GA groundwater standards (Table 1).

2.5 ANALYSIS OF GROUNDWATER RESULTS

The groundwater probe, hydropunch groundwater samples, and the monitoring well groundwater samples were analyzed for the site to determine upgradient and downgradient contaminant concentrations. The upgradient groundwater sampling points included NC-17, AG-01, and NC-11843. The noted concentrations in the three upgradient points are significantly less than the downgradient groundwater sampling points (AG-03, AG-05, HP-01, HP-05, and NC-2 well cluster). The AG-05 was the closest groundwater sampling point to the former cesspool location which received the TCE contaminated wastewater. This sampling point showed the highest concentrations measured during this investigation. At AG-05 the concentrations of TCE were 710 mg/l in the 56-60 ft sample, 550 mg/l in the 66-70 ft sample, and 3900 mg/l in the 76-80 ft sample. The concentrations appear to be increasing with depth and the concentrations below 80 feet are not known as deeper sampling was not conducted. The vertical distribution of TCE suggests that the main body of contamination has migrated downward from the watertable.

The overall nature and extent of the groundwater contamination which has migrated from the Atlas site is difficult to determine since the the Former IMC Magnetics site located directly south of the Atlas site on Main Street. Past investigations at the Former IMC Magnetics site indicate that the soil and groundwater at this site were heavily contaminated with similar contaminants as those used at the Atlas site.

3.0 REMEDIAL ACTION OBJECTIVES AND QUANTITIES OF CONTAMINATED MEDIA

The sampling and analysis conducted during the RI identified limited subsurface soils contamination at concentrations greater than the NYSDEC soil cleanup objectives. Based on the groundwater sampling data the contamination in the soils appears to have migrated downward through the soil column to the watertable. Once the contamination reached the watertable it appears to be migrating vertically and horizontally from the source area to off-site locations. Residual contamination in site soils are a source of continued groundwater contamination through leaching. Establishment of remedial action objectives for the on-site soils will be based on the prevention of the continued migration of the contaminants present in the soils to the groundwater

MONITORING WELL SAMPLING RESULTS

Atlas Graphics

LMS Sample # / NYSDEC Sample Designation	NC-2D B60226	NC-2 B60227	N-11843 B60228	NC-17 B60229	TRIP BLANK	NYSDEC CLASS GA STANDARDS(a)
VOLATILE ORGANICS (µg/l)						
Methylene chloride	ND	ND	ND	ND	1 j b	5
Acetone	ND	ND	ND	10 j	ND	50
1,1-Dichloroethene	ND	ND	ND	ND	ND	5
1,1-Dichloroethane	ND	2 j	ND	ND	ND	5
1,2-Dichloroethylene (total)	ND	24	7 j	3 j	ND	N/A
1,2-Dichloroethane	7 j	ND	ND	ND	ND	0.8
2-Butanone	ND	ND	ND	ND	ND	N/A
1,1,1-Trichloroethane	29	100	3 j	ND	ND	5
Trichloroethylene	81	290 d	19	5 j	ND	5
Benzene	ND	ND	ND	ND	ND	0.7
4-Methyl-2-pentanone	ND	ND	ND	ND	ND	N/A
2-Hexanone	ND	ND	ND	ND	ND	50
Tetrachloroethylene	160	510 d	20	41	ND	5
Toluene	3 j	2 j	2 j	3 j	ND	5
Ethylbenzene	ND	ND	ND	ND	ND	5
Styrene	ND	ND	ND	ND	ND	5
Xylene (total)	ND	ND	ND	ND	ND	N/A

(a) - NYSDEC Division Division of Water Technical and Operational Guidance Series (1.1.1) June 1998
d - Concentration recovered from diluted 5:1 sample.
e - Estimated concentration; exceeds GC/MS calibration range.
j - Estimated concentration; compound present below quantitation limit.
N/A - Not available.
ND - Not detected at analytical detection limit.

below the site.

The data from the RI demonstrated that the groundwater underlying the site is contaminated with VOCs. Because of the complexity of the on-site and off-site contaminated groundwater issue, largely due the the presence of the nearby IMC Magnetics site and the possibility of upgradient sources in the NCIA, the remedial action objectives for groundwater will be primarily based on remediation of the near-field (on-site) plume.

3.1 REMEDIAL ACTION OBJECTIVES

Remedial action objectives are developed for a site to determine the levels to which contaminant concentrations must be reduced to protect human health and the environment. The remedial action levels for soils at this site are based on established NYSDEC recommended soil cleanup objectives for each of the contaminants of concern. Please refer to NYSDEC Technical and Administrative Guidance Memorandum (TAGM) 4046. The soil cleanup objectives are intended to provide a measure of contaminant source control to mitigate further migration of the contaminants to the groundwater from the source area. The recommended soil cleanup objectives for the two compounds that were found above the standards are 0.7 mg/kg for TCE, and 1.5 mg/kg for toluene.

In addition to the remedial action objective of preventing further migration of contaminants to the watertable a secondary remedial action objective is to protect the structural integrity of the existing building and utilities which are found in the immediate vicinity of the former cesspool location.

The remedial action objectives for the groundwater medium are established as NYSDEC's Class GA groundwater standards (NYSDEC 1998). These are given for the relevant contaminants in Table 1 and Figure 4. Achievement of these objectives is believed to be protective of human health and the environment.

The primary human exposure concern for the Atlas Graphics site is through ingestion of contaminated groundwater. A secondary concern is exposure through inhalation or dermal contact during any remedial activities involving excavation of soils of groundwater treatment. The remedial methods chosen must adequately deal with these concerns.

3.2 QUANTITIES OF CONTAMINATED MEDIA

Based on the limited amount of soils found in excess of the cleanup objectives approximately 40 cubic yards of contaminated soils are found near the former cesspool area. The total volume of soils requiring excavation and disposal encompasses an area of about 10 feet by 10 feet by 18 feet deep, for a total volume of approximately 67 cubic yards (CY). The cubic 67 yards included approximately 27 cubic yards of soils that contain low levels of the contaminants of concern that are found above the 40 cubic yards of contaminated soils.

The near-field groundwater contamination from this site is concentrated in the vicinity of the cesspool located near the south west corner of the building. The area in which contamination due to the Atlas Graphics site is concentrated is approximately 20,000 sq ft (see Figure 6). Assuming a

Atlas Graphics
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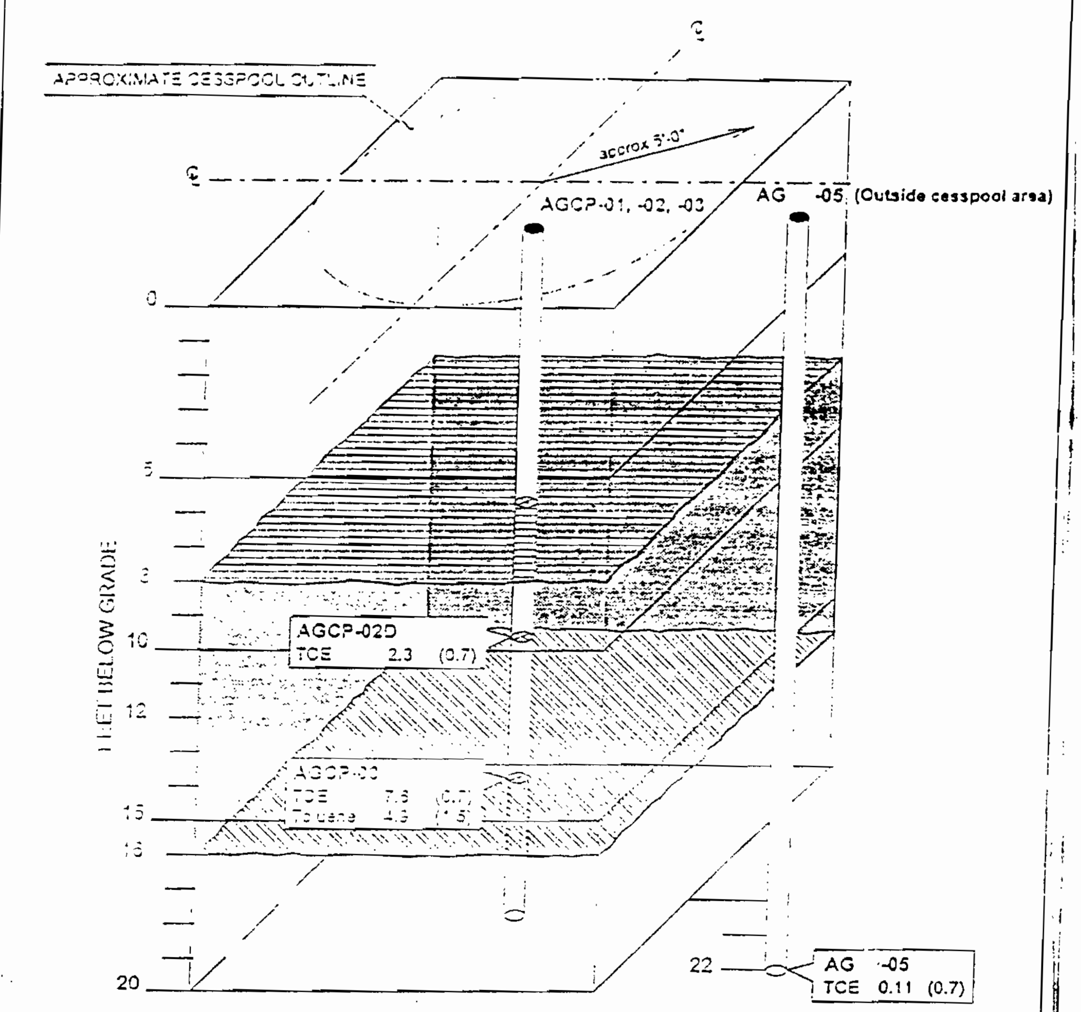
Figure 6 - Location of Contaminated Soils at the Atlas Graphics Site



LEGEND

Compound Concentration (Cleanup objective)
(mg/kg) (mg/kg)

TCE = Trichloroethylene

Shaded area represents area of contamination that exceeds cleanup objectives

NOT TO SCALE

\atlas cesspool results.dsf

LMS Lawler, Matusky & Skelly Engineers LLP
One Blue Hill Plaza • Pearl River, New York 10965
ENVIRONMENTAL SCIENCE & ENGINEERING CONSULTANTS

Former Cesspool Investigation Results

New Cassel Industrial Area • Atlas Graphics Property NYSDEC I.D. No. 130043B plume thickness of 50 ft (approximately the distance from the water table to the first impermeable layers in the Atlas Graphics area) and an effective porosity of approximately 15 percent gives a total estimated quantity of contaminated groundwater of one million gallons.

4.0 IDENTIFICATION AND SCREENING OF REMEDIAL ALTERNATIVES

A large number of remedial options are available for the treatment of soils contaminated with VOCs. Based on the existing site conditions and the quantities of contaminated materials many of them can be immediately screened out from further consideration based on:

Failure to meet remedial action objectives
Implementability

4.1 SOIL REMEDIATION

Containment of the contamination in the vicinity of the former leachpool area would not meet the long term remedial action objective of cleaning up the soils to the recommended soil cleanup objective. A remedial measure which contains the existing contamination would involve some type of soil mixing which would be 4nefficient based on the limited amount of soil to be treated. Several in-situ treatment technologies are also potential options, all of the in-situ treatment options with the exception of soil vapor extraction/bioremediation can be screened out based on iffefficiencies associated with treating the limited amount of contamination found on the site (these technologies are more suitable for larger sites. Excavation and on-site treatment can also be screened out due to the limited available space at the site and the small volume of contaminated soils that would require treatment.

The potential soil IRM options remaining after the screening process include:

1 - Natural attenuation with continued monitoring (no action)
2 - Soil vapor extraction/bioremediation
3 - Excavation and off-site disposal

4.2 GROUNDWATER REMEDIAL ALTERNATIVES

Control measures for the shallow, on-site groundwater contaminant plumes are discussed in the following subsections. General response actions for groundwater contamination include no action, institutional measures, containment, collection, in-situ treatment, on-site ex-situ treatment, and disposal.

4.2.1 No Action/Institutional Measures. The no action option is included as a basis for comparison with active groundwater remedial alternatives in accordance with the NCP and New York State Inactive Hazardous Waste Disposal Site Remedial Program regulations (6 NYCRR Part 375). Contaminants already present in the groundwater will continue to migrate from the Atlas Graphics site with this no action general response action. Public Health and environmental impacts of the contaminated groundwater will not be lessened. This option would also include institutional measures such as deed and development restrictions. Deed and development restrictions are intended to prevent human contact with contaminated media through restricted on-site uses. Deed and development restrictions may restrict future actions involving the groundwater medium at the site. Deed restrictions limit or prohibit certain uses or development of the site in case of a property transfer, and serve to notify prospective owners of the existence of remaining contamination at the site. Development restrictions serve similar purposes to those of deed restrictions, but apply to any new construction initiated by the current property owners. Groundwater use restrictions may be applied to prevent future site users from employing contaminated groundwater as a potable or process water source. Institutional measures are retained for further consideration in the screening process.

4.2.2 **Containment**. Capping, or surface sealing, will prevent the infiltration of storm water thereby minimizing the flow of uncontaminated runoff water into the contaminated groundwater. A portion of the site area (approximately 8,000 sft) is covered with topsoil and landscaped. The majority of the Atlas Graphics site (approximately 90%) is currently covered with pavement or occupied by buildings, which act as a surface cap. Storm water that collects on the pavement and building rooftops is channeled into on-site dry wells where it infiltrates into the ground or is directed toward storm sewer catch basins along local streets. For a cap to be effective, the storm water may need to be rerouted to another area (e.g., rerouted off-site). Rerouting of the on-site stormwater system would negatively impact on-site operations and may be prohibited by the local public works department. Current land use would likely prohibit the installation of a surface cap. Therefore, surface capping and sealing options have been screened out of the evaluation.

Vertical or horizontal barriers are another type of technology for containing contaminated groundwater and/or preventing contaminant migration. Their applicability is dependent on site-specific geological conditions. A number of different subsurface barrier options are available for groundwater containment, including vertical barrier placement options and construction materials. Barriers may be placed downgradient from the area of highest concentration to decrease or prevent the migration of contaminated groundwater into uncontaminated areas. They may also be placed upgradient from the area of highest concentration to decrease or prevent the flow of uncontaminated groundwater into the area of the highest contamination. The most effective method of barrier wall placement is to completely surround the contaminant plume, thereby isolating the area of highest concentration. Vertical barriers must be keyed into a low permeability formation (e.g., bedrock or clay). The use of vertical barriers at the Atlas Graphics site is not recommended because of the impracticality of containing the shallow plumes. The zone of contamination is known to extend to approximately 80 ft bgs, and there is no low permeability formation to key in a barrier at this depth. Horizontal barriers may be installed to form a "floor" beneath the area of highest concentration; this technique is referred to as "bottom sealing". However, construction of a horizontal barrier at depths of over 80 ft and across the two plume areas is impractical. For these reasons, vertical and horizontal barriers were screened out of the technology evaluation.

4.2.3 Collection. Groundwater pumping is the most common collection method and is used to extract contaminated groundwater for subsequent treatment and discharge. Pumping may also be used to lower the water table in specific areas of the site to reduce and/or reverse the direction of groundwater flow. Pumping can be instituted alone or in conjunction with other remedial technologies.

Extraction wells can be used for plume containment, groundwater restoration, or both. Application of this technology is dependent on aquifer characteristics and plume dimensions, as well as extracted groundwater treatment and disposal options. The relatively coarse and unconsolidated nature of the soil at the Atlas Graphics site is such that hollow stemmed auger drilling could be used to install remediation wells.

Injection wells can be used to reinject groundwater to the subsurface after extraction and treatment. They can also be used to inject nutrients, steam, or hot water to the subsurface, if required by a remedial technology. In order to be effective, moderate aquifer transmissivity is desirable. Gravity fed injection wells are usually used for shallow contamination and are placed close together because the injected reagent flows mostly downward and not laterally. To enable more lateral flow, shallow gravity fed injection wells are used in conjunction with extraction wells. Pressurized injections are used for deeper wells, where the reagents are released at the bottom of the well. Shallow groundwater reinjection wells may be needed on the Atlas Graphics site to achieve the remedial objectives.

Another groundwater pumping system option is an innovative technology called pulsed pumping. Pulsed pumping involves the use of a noncontinuous pumping regime to encourage the diffusion of contaminants from stagnation zones into capture zones while reducing the overall volume of recovered groundwater. Additional study of this technology is necessary to determine its suitability on the site.

Subsurface collection systems are effective groundwater collection mechanisms. This technology acts to centralize groundwater collection by increasing hydraulic conductivity locally within the saturated zone, and could be designed to enhance the capture and avoid the escape of contaminants around the collection system. Process options for a subsurface collection system include French drains, interceptor trenches, and pipe drains. Groundwater at the Atlas Graphics site is encountered at depths of over 50 ft making subsurface collection systems impractical to implement. Subsurface collection systems are better implemented at sites where the groundwater table is shallower.

4.2.4 In-Situ Treatment. In-situ treatment technologies include remedial technologies that treat groundwater contaminants in place without bringing them to the surface (via pumping). These techniques are most effective where the contaminant plume is controllable, well-defined, homogeneous, shallow in depth, and relatively small in areal extent. In-situ groundwater treatment technologies that are potentially applicable to the Atlas Graphics site include biological, thermal, and physical/chemical treatment processes.

Biological Treatment. Enhanced biodegradation exploits the ability of indigenous or introduced bacteria to biodegrade organic compounds under favorable soil conditions by optimizing such factors as oxygen content, pH, and temperature of the groundwater. Some chlorinated compounds, such as PCE and TCE, are biodegraded in the environment, but the process is slow and the degradation products may still be toxic. This in-situ technology requires injection of nutrients into the subsurface. Nitrate enhancement has proven to be effective only for gasoline constituents to date. Oxygen enhancement with peroxide is usually used in conjunction with pump and treat systems to enhance the rate of biodegradation of organic contaminants by naturally occurring microbes. Sufficient microbial population is not believed to exist in the subsurface in the vicinity of the site to conduct in-situ bioremediation. Therefore, biological treatment is not evaluated further in this analysis.

Thermal Treatment. In-situ thermal treatment processes strive to enhance the recovery of volatile and semi-volatile organic contaminants by volatilization. In this process, hot water or steam is forced into the aquifer via injection wells. Vaporized contaminants rise to the unsaturated zone where they can be removed by vacuum extraction and then treated. Thermal in-situ treatment techniques are not retained for further consideration as enhancements to groundwater pumping systems due to the potential for low implementability (e.g., public opposition).

Physical/Chemical Treatment. Physical and chemical in-situ treatment technologies include passive treatment walls, funnel and gate systems, bioslurping, hydraulic or pneumatic fracturing, air sparging, surfactants, cosolvents, electrokinetics, dual phase extraction, and in-well vapor stripping.

Passive treatment walls or beds are an innovative technology for the removal of contaminants from groundwater by subsurface beds (commonly called in-situ reactors) filled with adsorptive or reactive media (e.g., ion-exchange resins or limestone) through which contaminated groundwater flows. Within the adsorptive or reactive media, contaminants are captured and degraded over time. Disadvantages of this technology may include saturation of bed materials in a relatively short time and plugging of the bed with precipitates. The system also requires consistent control of pH levels to maintain the effectiveness of the treatment wall. Due to the locations and depths of the contaminant plumes, the configuration of the site, and existing site operations, it may be difficult or impossible to construct and install such in-situ treatment beds.

A funnel and gate system consists of strategically placed in-situ barriers that direct groundwater flow into passive treatment walls, thereby reducing the size of the treatment wall required. The "gate" part of this treatment system, i.e., the passive treatment wall, is subject to the same limitations as described above. For the reasons given, passive treatment walls and the funnel and gate system were eliminated from the screening process.

Bioslurping uses vacuum-enhanced dewatering techniques to minimize the amount of groundwater and air that is extracted via recovery ("slurper") wells. This technology is best suited toward removing light non-aqueous phase liquid (LNAPL). After the free product has been removed, the system can be converted into a conventional bioventing system. Bioslurping has been screened from further discussions because it is typically designed and tested to address contamination from petroleum products with a floating LNAPL layer. Bioslurping does not appear to be a technology that can effectively remediate the contamination found in shallow groundwater at the Atlas Graphics site.

Hydraulic or pneumatic fracturing is usually applied to low permeable formations, such as clays, till, and bedrock. None of these formations are present at the Atlas Graphics site and the technology is screened out of this analysis.

Air sparging (AS) is an in-situ groundwater treatment technology applicable for the removal of VOCs and is applied by forcing compressed air into the subsurface to volatilize the contaminants present. The volatilized contaminants rise to the unsaturated zone where they are typically captured with a soil vapor extraction (SVE) system and brought to the surface for treatment. Air emissions generated must be monitored and treated appropriately. This technology is best suited for sites with coarse-grained materials (e.g., sand). AS/SVE technology can be implemented at the Atlas Graphics site; however, volatilized contaminants may incidentally contaminate soils in the unsaturated zone before being captured by the SVE system. Although additional study of this technology may be necessary to determine its suitability on the site, AS/SVE has been retained for further consideration.

Controlled injection of surfactants or cosolvents into the groundwater is an emerging technology that is used to mobilize or dissolve contaminants. The surfactant and cosolvent flushing methods are used in conjunction with a conventional groundwater pump-and-treat system to increase the removal rate of non-aqueous phase liquids

(NAPL) by increasing the apparent solubility of the contaminant and reducing interfacial tension between the water and the NAPL. The use of surfactants and cosolvents at hazardous waste sites has not been fully demonstrated, and there is the potential for undesirable conditions to develop, such as the degradation of contaminants into more toxic compounds or a plume that is uncontrollable. For these reasons, surfactants and cosolvents were not retained in the screening process.

Dual phase extraction is applied by simultaneously removing liquid and gas from low permeability formations using a vacuum extraction well that is screened in the unsaturated and saturated zones. As the vacuum is applied to the well, soil vapor is extracted and groundwater is entrained by the extracted vapors. Once above grade, the extracted vapors and groundwater are separated and treated. Dual phase extraction is generally combined with other technologies (e.g., air sparging or bioventing) that are intended to extract VOCs and is most effective when both soil and groundwater areal contamination exists. Since soil contamination is minimal at the Atlas Graphics site, dual phase extraction is not given further consideration in this evaluation.

In-well vapor stripping consists of two major components: 1) pressurized air flow generation and delivery and 2) vacuum extraction. Wells are placed in the areas of the highest VOC contaminant concentrations and/or in areas to contain off-site contaminant migration. Vertical wells are installed and connected to a vacuum system. Many types of in-well vapor stripping designs exist that have proven to be effective in treating VOCs. In addition, an in-well vapor stripping groundwater remediation system may be designed to eliminate incidental or temporary contamination of the soil medium at the site. This technology has the best results in sandy soils but has been demonstrated to be effective in soils with a range of geological properties. In-well vapor stripping has been retained in the technology screening process.

4.2.5 Ex-Situ Treatment. A wide variety of technologies are available for the treatment of collected groundwater when it is brought up to the surface, including biological, thermal, physical, and chemical methods. The choice of an appropriate treatment technology is dependent on the nature and concentration of the contaminants present as well as the relative cost and effectiveness of each of the technologies. The presence of more than one type of contaminant in the water stream may require the use of more than one process option in a treatment train. A brief discussion is presented below which describes the available process options for treating collected groundwater via biological, thermal, physical, and chemical technologies.

Biological Treatment. Biological treatment technologies that may be applicable to collected groundwater include treatment in aerobic and anaerobic reactors. Examples of aerobic reactors include activated sludge, trickling filters, and rotating biological contactors. These technologies are generally applicable for the removal of organic constituents (volatile and semi-volatile compounds) only. The applicability of these processes to treating collected groundwater needs to be determined in a treatability study. Rotating biological contactors can handle relatively low-strength wastes as compared to the activated sludge and trickling filter processes. Anaerobic filters are generally used for pretreatment of strong wastes. Biological treatment technologies generally require more operator attention than other types of technologies. Therefore, they are screened out of the evaluation.

Thermal Treatment. Thermal treatment technologies may be effective for removing organic constituents from collected groundwater. Appropriate treatment of air emissions is required to remove any volatilized constituents prior to their release into the atmosphere. Thermal treatment units that have the potential to handle liquids include incinerators (e.g., rotary kiln, fluidized or circulating bed, liquid injection, or infrared), wet air oxidation, and molten salt/plasma arc units. Incineration is an energy-intensive process. Wet-air oxidation and molten glass/plasma arc are both innovative treatment technologies that have not yet been demonstrated at hazardous waste sites to the extent that the other technologies under consideration have been demonstrated, therefore, their reliability and effectiveness are less reliably known. Administrative difficulties, including air emissions permitting requirements and potential public opposition, may make thermal treatment less likely to be implementable than other comparable treatment technologies. For these reasons, none of these thermal technologies have been retained in the screening process.

Physical Treatment. Numerous physical treatment processes are available for removing organic constituents from collected groundwater. Flow equalization (i.e., mixing of waste streams of different strengths) and sedimentation are commonly applied technologies for reducing contaminant concentrations. Sedimentation is a technology that captures settleable solids (such as suspended iron that may impede the operation of a treatment system) from a liquid stream. Sedimentation, in the form of clarification, is retained as a feasible technology option. Activated carbon is a commonly used treatment process for removing organics (through adsorption) and metals (through filtration). Granular activated carbon (GAC) adsorption is a presumptive treatment technology for treatment of dissolved organic contaminants in groundwater at CERCLA sites (EPA 1996). Activated carbon adsorption is also used as an effluent polishing step. Flow equalization, sedimentation, and activated carbon adsorption have all been retained for further evaluation.

Ion exchange can remove dissolved metals and radionuclides from an aqueous solution. Oil, grease, and suspended solids may decrease the efficiency of this technology. A wastewater is produced that would require treatment. This technique has not been retained because it does not effectively treat volatile organics. Reverse osmosis is a separation process that forces water through a membrane. The water containing the contaminants that was not able to pass through the membrane is recirculated back to a treatment unit where organic vapors are extracted by a vacuum and then are condensed, thereby minimizing air releases. This wastewater is a small fraction of the original amount of water that needs to be treated, but will need to be disposed of. Because the membrane is susceptible to chemical attack and being clogged, and because this technology may present more technical difficulties when compared to other technologies, this process has not been considered for further discussion.

Air stripping is a full-scale technology that removes volatile organics from the groundwater by greatly increasing the surface area of the contaminated water that is exposed to the air. Air stripping is a presumptive treatment technology for treatment of dissolved organic contaminants in groundwater at CERCLA sites (EPA 1996). There are many types of aeration techniques that could be utilized (e.g., packed towers, diffused aeration, tray aeration, and spray aeration). This technology has been retained for further study because of its ability to remove volatiles from the groundwater.

Ultrafiltration is a mechanical separation process based on particle size. The particles are separated by forcing liquid through a semipermeable membrane, whereby only the particles that are smaller than the openings in the membrane can fit through. This technology has not been retained. Synthetic sorptive resins are similar to the carbon adsorption process and can be designed to achieve higher degrees of selectivity and adsorption capacity for certain compounds than activated carbon. The synthetic resin process is more suitable for thermally unstable compounds, such as explosives, and is therefore screened from further discussions. Using x-rays to break down organic contaminants into nontoxic compounds is an emerging technology that has not been commercially demonstrated and is, therefore, not continued in the screening processing.

Of the physical treatment technologies, flow equalization, sedimentation, carbon adsorption, and air stripping have been retained for further evaluation.

Chemical Treatment. Chemical treatment technologies that may be applicable at the site in conjunction with other processes include precipitation, oxidation, flocculation/coagulation, reduction, neutralization, chlorination, and ultra-violet (UV) light oxidation/ozonation. Both precipitation and flocculation/coagulation with chemical additions have proved effective for the removal of metals. One or more of these processes may be needed to pretreat the contaminated groundwater to remove iron and manganese prior to VOC removal. Flocculation/coagulation may also be conducted using alternating current electrocoagulation; however, this is not a commonly used or proven technology at hazardous waste sites. These processes are effective primarily in the removal of inorganics; treatability studies may need to be conducted to evaluate their effectiveness and optimum operating conditions. Precipitation, flocculation, and coagulation are retained as feasible technologies. Flocculation/coagulation via alternating current electrocoagulation has not been retained for further evaluation.

Oxidation and reduction may effectively remove inorganics and VOCs when combined with other processes. However, incomplete oxidation or reduction may result in the presence of more toxic constituents. Oxidation using hydrogen peroxide is effective for the removal of organics only, while chlorine dioxide oxidation and chlorination are effective primarily for cyanide removal and do not remove metals or organics. Catalytic oxidation uses metal oxides (e.g., nickel oxide, copper oxide, manganese dioxide, and chromium oxide) to oxidize VOCs. Oxidation with hydrogen peroxide and catalytic oxidation have been retained; chlorine dioxide oxidation has not been retained.

Neutralization is not generally effective for the removal of contaminants, but may be required to meet discharge limitations (if applicable) or as pretreatment for other processes. Chlorination has been shown to treat cyanides, and is not effective for organics removal. UV oxidation or ozonation treatment may be effective in removing organics when used in conjunction with other processes. UV oxidation is a presumptive treatment technology for treatment of dissolved organic contaminants in groundwater of CERCLA sites (EPA 1996). However, UV oxidation may present administrative difficulties (i.e., public opposition), and ozonation requires the use of hazardous chemicals in its operations. Chlorination and UV oxidation/ozonation have been eliminated from further discussions.

4.2.6 **Disposal.** Disposal, or discharge, options for collected groundwater are dependent on the quantities of water for disposal, pretreatment/treatment requirements, and regulatory considerations. Disposal options were divided into off-site and on-site options and discussed below.

Off-site Discharge. Off-site facilities that may potentially accept effluent from the site include the local publicly owned treatment works (POTW), local stormwater collection system, or a treatment, storage, or disposal facility (TSDF). The POTW will likely require pretreatment of the collected groundwater to meet the POTW pretreatment standards prior to being discharged. Conversations with personnel from the Nassau County Department of Public Works (operator of wastewater treatment facilities that service the NCIA) indicate that this agency will not accept a continuous flow of groundwater into the sewer system. Therefore, discharge to the local sewage system was eliminated as an option at the Atlas Graphics site.

Any effluent discharged to the local stormwater collection system would need to satisfy the NYSDEC surface water standards (6 NYCRR Part 700) prior to discharge. The underground piping may need to be upgraded in order to accept a continuous flow from the site. Due to these limitations, discharge to an off-site stormwater collection system is eliminated as an option.

Collected groundwater may also be stored and transported to a TSDF for treatment and disposal. However, this alternative may meet public opposition and other administrative difficulties if there are large volumes of water and/or continuing discharges. Therefore, it has been eliminated as an option.

On-site Discharge. On-site discharge options include deep well injection, infiltration through recharge basins and/or dry wells, or containment in a surface impoundment. On-site discharge would likely require treatment to meet applicable NYSDEC groundwater quality standards. Deep well injection uses injection wells to place liquid waste into geologic formations that have no potential to allow migration of contaminants into potable water aquifers. This alternative is not practical at the Atlas Graphics site due to the site-specific geologic conditions (i.e., sole source aquifers underlie the site). Discharge to dry wells (followed by reinfiltration) is an acceptable discharge option as the effluent is allowed to infiltrate into the ground below the Atlas Graphics site. Appropriate permits or permit equivalents would need to be obtained for this disposal option. Surface impoundments and recharge basins could not be used at the Atlas Graphics site due to space limitations and the current use of the site.

4.3.1 Remaining Groundwater Response Technologies

The groundwater remedial technologies that were retained following the technology screening process are summarized below, based on general response action categories.

4.3.1.1 No Action with Institutional Control Measures. Although the no action alternative does not address the contamination present at the site through remedial measures, it has been retained for comparison with other options in accordance with the NCP. Long-term monitoring of shallow groundwater may be appropriate for this site after other remedial measures have been implemented. This option would also include institutional measures Such as deed, development, and groundwater use restrictions.

4.3.1.2 Containment. No containment technologies were retained as groundwater response controls largely because their implementation at the site is technically impractical.

4.3.1.3 Collection. Of the groundwater collection technologies, extraction and injection wells have been retained for further evaluation. Groundwater pumping via extraction wells has been proven to be an effective contaminant plume control mechanism. Pulsed pumping has also been retained for further discussion as an enhancement to groundwater extraction.

4.3.1.4 In Situ Treatment. Air sparging with soil vapor extraction (AS/SVE) has been retained for further discussion. In-well vapor stripping was also retained as a physical and/or chemical groundwater treatment technology.

4.3.1.5 Ex Situ Treatment. Several of the physical treatment technologies (e.g., flow equalization, sedimentation, carbon adsorption, and air stripping) were retained for further evaluation for use with a groundwater collection technology. Flow equalization can mix low concentrations of contaminants with high concentrations to make the relative concentration that needs treatment about the same. Sedimentation, carbon adsorption, and air stripping were retained for use in a treatment train to remove inorganic and organic contaminants from liquids prior to discharge. Chemical ex-situ treatments that were retained include precipitation, flocculation, coagulation, oxidation, reduction, and neutralization. Precipitation, flocculation, coagulation, and neutralization may be needed to pretreat the contaminated groundwater prior to VOC removal unit processes. Oxidation or reduction technologies may be used to reduce VOC concentrations in the liquid phase.

4.3.1.6 Disposal. No off-site treatment and disposal options were retained. On-site discharge via seepage basins (infiltration galleries or wet wells) is a feasible discharge option. Contaminant concentrations in the effluent of this technology would need to satisfy applicable regulatory requirements. Temporary storage was also retained as a possible option.

5.0 DEVELOPMENT AND EVALUATION OF REMEDIAL ALTERNATIVES

5.0 INTRODUCTION

The purpose of this section is to identify and evaluate various remedial alternatives suitable for the Atlas Graphics site. The intent of this evaluation is not to exhaust all possible treatment alternatives but rather to consider those alternatives that are readily implementable and proven technologies that were identified during the screening process. For simplicity, soil and groundwater treatment alternatives will be assessed separately. Final remedy selection may employ a combination of soil and groundwater remediation technologies.

5.1 DEVELOPMENT AND EVALUATION OF REMEDIAL ALTERNATIVES FOR SOIL MEDIUM

Table 3 presents a technology assessment, which compares in-situ technologies and ex-situ technologies for soil remediation and the advantages and disadvantages of both retained technologies. In order to develop the information necessary to provide comparative cost summaries, assumptions were made regarding the area and volume of soil requiring remediation. The "Immediate Investigation Report, November, 1998" for the Atlas site reveals that soil in the former cesspool area is impacted by various volatile compounds, however, only TCE and toluene were detected at concentrations exceeding the soil cleanup objectives. Figure 5 illustrates the extent of contamination, which is bound by the footprint of the former cesspool. The data indicate that TCE was detected at a maximum concentration of 2.33 mg/kg (clean-up objective = 0.7 mg/kg) at depths between 8 and 12 feet and 7.6 mg/kg at depths between 12 and 16 feet. Toluene was detected at a maximum concentration of 4.9 mg/kg (clean-up objective = 1.5 mg/kg) at a depth between 12 and 16 feet. The investigation revealed other locations and depths that show evidence of volatile organic

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Table 2 - Soils Technology Assessment

Atlas Graphics Technology Assessment

Technology	Advantages	Disadvantages
Alternative 2: Excavation and Disposal of Contaminated Soils	• Eliminates long term liabilities by eliminating source of contamination (assuming a complete delineation was conducted). • No recurring Operation & Maintenance Costs • Effective and Expeditious Remediation, typically favored by local communities • No additional land space required for housing treatment equipment. • Only one post remedial sampling and monitoring event required – no recurring monitoring costs. • No substantive State permits for air monitoring from remedial activities. • Also eliminates any metals and semi-volatile organic contamination bound in subsurface soils.	• Complicated excavation due to proximity to building and potential of subsurface and above ground utility interferences. Will require shoring and bracing down to estimated depth of 25 feet. • Evidence indicates that excavated soils will be non-hazardous, however, may require hazardous soil disposal which may be cost prohibitive. • Greater potential for discovering unknown conditions such as rocks and other variables that may drive up costs. • Exposure pathways during excavation work include inhalation and/or ingestion of soils through exposure to dust and skin contact. Relatively low exposures risks. • May require a fair amount of hand excavation; excavating equipment may be hindered by subsurface utilities and logistics of the site (overhead electrical lines, etc.)
Alternative 3: Soil Vapor Extraction/ Bio-Venting/Bioremediation In-situ technologies for VOC treatment generally induce an air flow across the contaminated media to volatize and physically extract VOC contamination form the site soils. Bioremediation components may revitalize naturally occurring microorganisms. Sometimes, a nutrient source such as nitrogen and/or phosphorus is introduced to further enhance biogrowth (Bioremediation). The thriving microorganisms biodegrade VOC contamination and the extracted soil gas may be treated above ground and then discharged to the atmosphere.	• Proven, effective technologies for VOC treatment. • Depending upon total contaminated volume may be more cost effective than excavation and disposal alternatives. • Minimal disruption to surrounding area, for this application, requires installation of one extraction well and discharge piping. • If soil conditions permit, may be highly effective treatment over a short duration based on the theoretical data gained through desk top modeling.	• Performance is difficult to predict especially without treatability testing or pilot work. • General soil conditions are favorable for vapor extraction, however, air flow will preferentially flow through the more permeable sandy soils and the lower permeable sludge pockets will likely remain stagnant. Pilot test work is required to assess performance. • Recurring Operation and Maintenance Costs – Timeframe difficult to predict w/o treatability study work; will likely require at least two months of operation. • Requires more extensive post remedial activity sampling to ensure performance. • Requires land use to house treatment equipment – due to highly industrialize area, land is limited. Requires a stack installation to discharge treated soil gas – typically Best Engineering Practice (BEP) stack is at 1 ½ times the height of the nearest structure. • Exposure pathways include inhalation of soil vapor off gas. Requires handling, testing and disposal of condensate, although quantities should be low. • In-situ bioremediation components generally require a wetting agent in sandy, dry soils. This requires the installation of a recirculaton system or recurring wetting events.

compounds, however, the concentrations detected were below the soil cleanup objectives. Therefore, the area targeted for remediation is within the former cesspool area. The total estimated impacted depth is 18 ft based on available data that revealed non-detectable concentrations to depths of 37 ft. The cost analysis was conducted assuming 1999 dollars. Present Worth calculations are not applicable (except for alternative 1) since the remedial alternatives under investigation can be completed in less than one year.

5.2 INDIVIDUAL ANALYSIS OF OPTIONS FOR SOILS REMEDIATION

5.2.1 Alternative 1 - No Action

This alternative encompasses no active remediation; however, it would require continuous monitoring to ensure the impacted area does not migrate vertically or horizontally and to assess the changes in the chemistry of the contaminants (due to natural biodegradation, etc.). Institutional control measures such as and development deed restrictions, which prevent human contact with contaminated media through restricted site uses, are also included in this alternative. The cost associated with this alternative was estimated assuming the following:

Semi-annual sampling of three existing groundwater monitoring wells would be carried out for the first two years, followed by annual sampling for an additional 28 years. Table 3 summarizes the estimated cost for Alternative 1: No Action.

5.2.2 Alternative 2: Excavation and Off-site Disposal

This alternative would remove the contaminated soil by excavating the abandoned cesspool source area. Shoring and bracing would be required as the cesspool is adjacent to the on-site building. The total area required for excavation and disposal is estimated as 67 cubic yards (CY) based on a 10 foot square cesspool area to a depth of 18 ft below grade (bg). Hand excavation to depths of about four (4) feet will be required to avoid interference's with (unknown) utilities. It is assumed that the building footings will not interfere with the excavation. Excavation to depths of 18 feet can be achieved using conventional excavation equipment, i.e., no aboveground or below ground utility clearances would be required for the excavation. The excavated material would be staged on-site and analyzed to characterize it for proper off-site disposal. The resulting excavation would be backfilled with clean fill material. Groundwater quality would be monitored annually for a period of ten years by sampling nearby groundwater monitoring wells.

Table 4 summarizes the cost estimate associated with Alternative 2: Excavation and Off-site Disposal.

5.2.3 Alternative 3: Soil Vapor Extraction

This alternative requires the installation of a soil vapor extraction system. Clean air would be forced down an injection well into the area of soil contamination, promoting the volatilization of the contaminants. An extraction well utilizing a vacuum would then draw the contaminated vapors from the soil to the ground surface. The contaminated vapors would pass through a carbon filter prior to being discharged to the atmosphere. At least four months of continuous operation of the system is estimated to complete the removal.

An evaluation of the estimated costs associated with Alternative 3: Soil Vapor Extraction was developed assuming the following:

- The primary constituents are TCE and toluene. The average concentration within the contaminated zone (8-16 feet bgs) is about 5 mg/kg TCE and 2.5 mg/kg toluene. The effectiveness of the treatment will be impacted by soil porosity and moisture. Without pilot test data, assumptions have to be made regarding system performance specifically the radius of influence, mass removal rates and the operating vacuum. To assist in these assumptions, the EPA guidance software Hyperventilate Ver 2.0 was used. The resulting assumptions are as follows:

- Published literature indicates that the maximum extractability of TCE is about 13 lbs./1000 cu ft and toluene is 3 lbs./ 1000 cu ft. Although mass transfer rate information is not provided, it appears that a cleanup would readily progress since boring log data reveals the site soils are composed of mostly sands. A duration of 2 to six months is assumed to be adequate to complete the remediation.

- Based on published literature and the Hyperventilate program, a vapor extraction blower sized to achieve a 5-10 ft radius of influence in medium soils can produce a flow rate of about 150 cfm at a pressure of about 8 in. water column. A blower of this size would have a 5 hp motor (conservatively).

Table 5 summarizes the costs associated with Alternative 3: Soil Vapor Extraction.

5.3 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOILS

Table 2 summarizes the comparative analysis of selected alternatives 2 and 3. The analysis suggests that in the Alternative 2: Excavation and Off-site Disposal offers the overall best technical and cost effective remedy for the Atlas Graphics site, if only soil remediation is necessary, and if all contaminated soil lies within a range of depths conducive to excavation. However, since the site is characterized by generally low level contamination, and has much higher levels of groundwater contamination, other factors may influence the final decision regarding the proposed remedy. Alternative 3, Soil Vapor Extraction, may be more compatable with the proposed groundwater remedy. Soil Vapor Extraction influences a broader area than a

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Table 3

Cost estimate for Alternative 1: No Action/Long Term Monitoring

Items	Unit Cost(s)	Quantity	Cost in 1999
Capital Cost Direct costs for institutional control measures			$10,000
O & M costs for the first two years Semi-Annual sampling of 3 wells for the first 2 years	500	6/yr	$ 3,000/yr
Annual sampling of 3 wells - years 3-30	500	3/yr	$ 1,500/yr
Replacement of one well every 5 years.	4,000	1/5/yr	$ 800/yr
Present worth based on a 30 year life and a 5% Interest Rate			$50,000

Table 4
Atlas Graphics NYSDEC I.D. No. 130043B
Cost Estimate for Soils Alternative 2: Excavation and Off-site Disposal

ITEM	UNIT	UNIT COST	QUANTITY	COST (1999$)
Capital Costs				
Mobilization/Demobiliation	LS	$ 1,000	1	$ 1,200
Utility clearance	LS	$ 1,000	1	1,000
Utility relocation & Interferences	LS	assumed none	0	0
Sidewalk demolition	SF	3	100	300
Sidewalk disposal (non-hazardous concrete)	CY	50	1.2	62
Excavation (Hand)	CY	50	15	742
Excavation (Machine)	CY	12	52	622
Rock Removal	CY	assumed none	0	0
Shorting and Bracing	SF	7	800	5,600
Compaction & Backfilling	CY	10	67	667
Confirmatory Sampling/Waste Characterization (TCLP analysis)	EA	450	2	900
Liners/covers	SF	0.15	2,000	300
Health and Safety Oversight & Plan	HR	65	40	2,600
Personal Protective Equipment	EA/day	30	8	240
Non-hazardous waste transport and disposal	CY	110	67	7,333
Post Excavation Sampling	EA	assumed none	0	0
Site Restoration	SF	4	100	400
Decontamination of Equipment	EA	$ 250	2	500
Total Capital Costs				$22,465
Operation and Maintenance Costs				- $0 -
Engineering and Design @ 15%				3,370
Management and Administrative @ 15%				3,370
Contingency @ 25%				5,616
10 Yr groundwater monitoring program similar to alternative 1				$20,000
Total Cost in Present Dollars				**55,000**

Notes
1. Administrative cost not included in cost estimate.

Table 5
Atlas Graphics - Site 1-30-043B
COST ESTIMATE FOR ALTERNATIVE 2:
AIR SPARGING/SOIL VAPOR EXTRACTION/VAPOR TREATMENT

Item	Unit Cost ($)	Quantity	Cost (1999 $)[a]
Capital Costs			
A. Direct Costs			
Site Preparation			
Contractor mobilization/demobilization	LS		$ 25,000
Pilot Study	LS		$ 30,000
Air Sparging System			
Installation of air sparging points	$ 7,000 /well	1 well	$ 7,000
Underground piping delivery system	$35,000 /lf	1,000 lf	$ 20,000
Pressure blower			5,000
Soil Vapor Extraction System			
Installation of vapor extraction points	$ 6,300 / points	2 points	$ 13,000
Piezometer microwells	$ 2,000 / points	5 points	$ 10,000
Extraction system (piping network (well to treatment plant)	LS		$ 10,000
Moisture separator & blower	LS		$ 4,000
Condensate Storage Container	$1,277 / unit	1 unit	$ 1,000
Electrical controls	LS		$ 10.000
Treatment building	LS		$ 2,000
System assembly & startup	LS		$ 2,000
Asphalt Removal, Disposal, Restoration	$20.94 /lf	1,000 lf	$ 11,000
Soil Disposal (nonhazardous)	$125.00 /cy	12 cy	$ 2,000
Fencing/Signage	LS		$ 4,000
Vapor Treatment System Installation	LS		$ 5.000
			$161,000
B. Indirect Costs			
Engineering and Design @ 15%			$ 21,000
Legal and Administrative @ 10%			$ 14,000
Contingency @ 25%			$ 35,000
			$230,000
O & M Costs Yr. 1-3			$ 30,000
O & M Costs Yr. 4-5			$ 5,000
Present Worth			$400,000

limited excavation of contaminated material, allowing the mitigation of undetected contaminated zones near the cesspool. Since the exposure pathway of greatest concern is through the contamination of groundwater for this site, and since Soil Vapor Extraction makes an efficient combination with groundwater technologies such as Air Sparging, this alternative should be given careful consideration. The AS/SVE treatment system will be considered in detail under groundwater alternatives.

5.4 EVALUATION OF GROUNDWATER TREATMENT OPTIONS

5.4.1 Alternative 1: No Action

Alternative 1 includes institutional controls (e.g., deed, development, and groundwater use restrictions) to minimize contact with the contaminated groundwater. Groundwater use restrictions will be implemented to prevent development of the underlying groundwater as a potable or a process water source. A long-term groundwater monitoring program is included in this alternative to monitor any migration of the contaminant plumes. Three existing groundwater monitoring wells would be sampled semi-annually for the first two years, and semi-annually for the next 28 years. Monitoring wells selected for the long-term monitoring for Alternative 1 will include NC-2 and NC2-D, shown in Figure 2. Two additional existing monitoring wells will be chosen. A 5-yr monitoring program, with sampling conducted on a semi-annual basis has been assumed in order to allow for cost comparisons among the other alternatives. If contaminant levels continue to exceed the remedial action objectives at the end of the 30-yr period, the monitoring program may be extended, or other remedial actions taken. In costing this alternative, it was assumed that the existing wells will be sufficient to assess the long term effects of the groundwater plume.

Records of contaminant concentrations over time will be kept and periodically evaluated to monitor trends. The cost estimate for this long-term groundwater monitoring program assumes replacement of two of the monitoring wells being sampled every five years during the 30 years of monitoring. The replacement cost is necessary because a monitoring well could become plugged, the casing could collapse, or the well could be damaged.

5.4.2 Alternative 2: Air Sparging/Soil Vapor Extraction/Vapor Treatment

Alternative 2 considers the installation of an air sparging/soil vapor extraction (AS/SVE) system to remediate the shallow groundwater contamination at the Atlas Graphics site. Off-gas treatment and long-term groundwater monitoring are also implemented as part of this alternative.

There are several reported advantages of using the air sparging technology over other methods for remediating contaminated groundwater including:

There is no need to pump, handle, and treat groundwater at the surface; only contaminated vapor is extracted and treated in this technology. Integration with other remediation techniques.Flexibility of design. Successful implementation at numerous sites.

Some limitations reported for this technology include:

- Some constituents (such as metal compounds) may form complexes with the soil matrix, which may decrease volatilization rates.
- Heterogeneous soils may cause channeling (the preferential movement of air though high conductivity layers and possibly away from the area of contamination), thus limiting the effectiveness of the treatment.
- Aquifer clogging may occur when increased iron precipitation or biomass accumulation caused by oxygen injection changes subsurface characteristics.
- Soils in the unsaturated zone may become incidentally contaminated during the extraction of contaminated vapors.
- Extra planning and design may be warranted to attain sufficient air delivery to the saturated zone while preventing undesirable effects such as vapor migration and groundwater mounding.

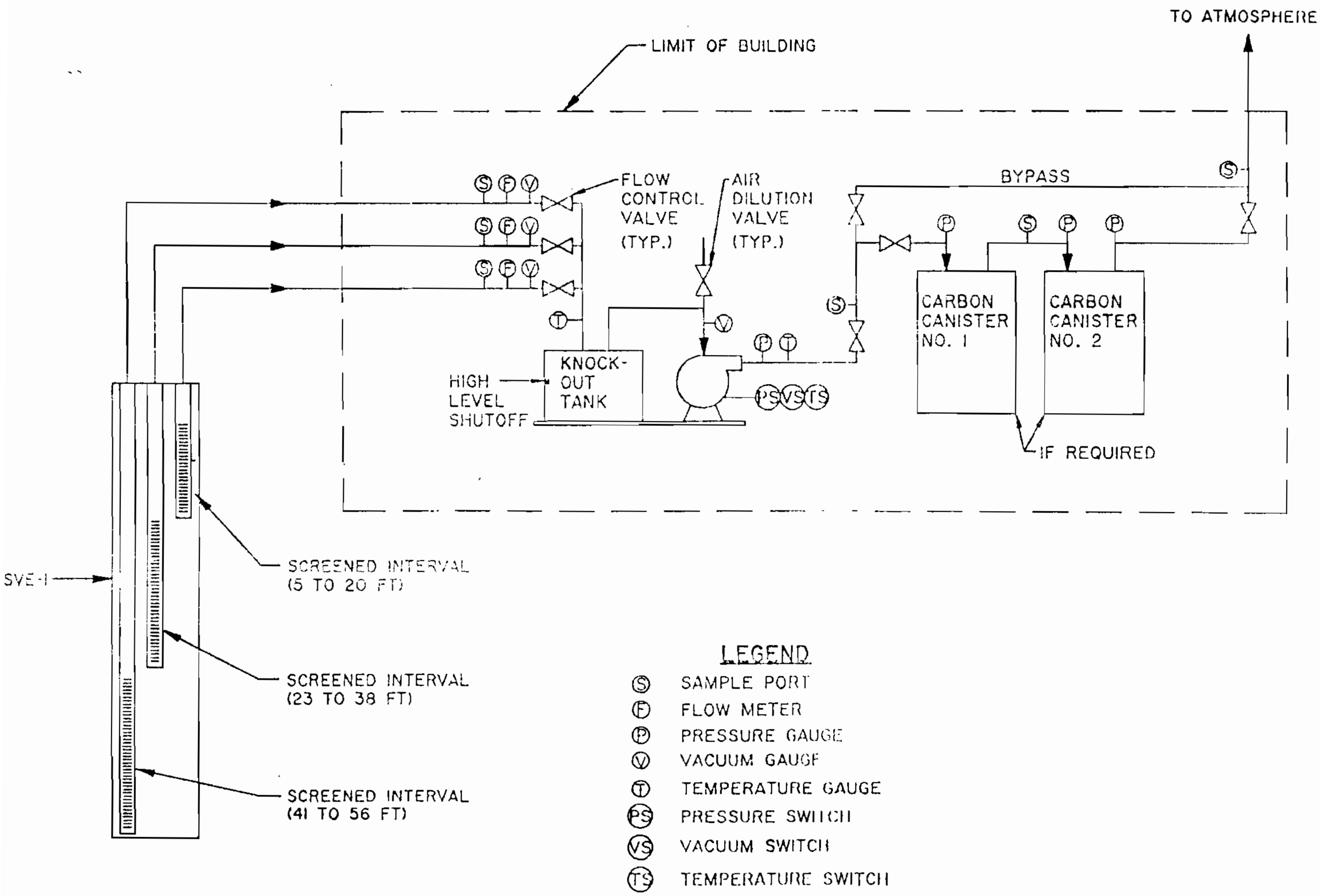
5.4.2.1 AS/SVE. Air sparging/soil vapor extraction is a demonstrated in-situ physical/chemical treatment alternative for remediating contaminated groundwater, as per EPA's Superfund Innovative Technology Evaluation (SITE) program. Air sparging is an in-situ technology employed to volatilize contaminants from the groundwater to the unsaturated zone. SVE then removes the volatilized contamination from the unsaturated zone to the ground surface, typically for vapor-phase treatment. See Figure 6.

In AS/SVE technology, compressed air is injected into air sparge wells at controlled pressures and volumes to introduce air channels into the contaminated saturated zone. The channels induce in-situ air stripping of dissolved VOCs and volatilize trapped and adsorbed phase contamination present in the aquifer. In addition, aerobic biodegradation of the contaminants may also occur, depending on site-specific conditions. The channels containing contaminants travel from the saturated zone up to the unsaturated zone. The injection sparge wells are arranged such that the entire area requiring treatment is effectively aerated, which may involve creating overlapping zones of influence.

An SVE system then collects vapor-phase VOCs and transports them to the surface for subsequent treatment. The SVE system consists of vapor extraction points (VEPs) placed in the unsaturated zone above the contaminated groundwater and a vacuum system at the ground surface to remove vapors from the VEPs.

Unlike conventional groundwater remediation systems, air sparging does not require groundwater to be pumped to and treated at the surface. The technology is most applicable to VOCs, SVOCs, and non-volatile aerobically

Atlas Graphics
Site # 1-30-043B
Figure 6 - SVE Process



biodegradable organic contaminants. Air sparging has been used at sites with high yield aquifers and relatively course-grained (moderate to high permeability) homogeneous material that provides an effective contact between air and the contaminated medium being treated.

Air compressors or blowers are typically used to deliver a stream of air under pressure to the subsurface via the sparging wells, and vacuum pumps are utilized for the removal of contaminants in the vapor phase. The aboveground AS/SVE system components also typically include a vapor treatment system and a process control system to monitor and adjust air delivery and removal equipment for maximum remediation efficiency.

For the purposes of this FS, a preliminary assessment of the AS/SVE system configuration, radii of influence, and air flow rates has been made based on historical application and reported subsurface conditions. At the Atlas Graphics site, the air sparging system would include the installation of one air injection sparging well, located in the south-west corner of the site (see Figure 3), consisting of 2-in diameter Schedule 40 PVC, to address the shallow groundwater contamination plume. The well will be mounted flush with the existing ground surface and installed to approximate depths of 80-85 ft bgs. A 20-hp air compressor unit should be capable of producing a free flow rate of approximately 50 scfm. Pilot testing and field measurements in the design phase of the work will more accurately determine the exact number and placement of each of the air sparging wells, along with specific subsurface air distribution patterns expected to result.

Approximately two vapor extraction points (VEPs) will be necessary to address the removal of VOCs transported though the unsaturated zone. Each well will be mounted flush with the existing ground surface and installed within the unsaturated zone. Each VEP will be 2 inches in diameter, and constructed of Schedule 40 PVC. A vacuum blower (approximately 7.5 hp) with a total system suction flow rate of approximately 300 scfm would be used for the SVE system. Pilot testing and field measurements in the design phase of the work will determine the exact number, placement, and depth of each of the VEPs.

Components of the air sparging/SVE system include air compressor blower(s), inlet filter(s), and associated piping; a vacuum blower(s), filter(s), associated piping, and moisture separator; vapor-phase granulated activated carbon (GAC) units (described below); piping; system control equipment (i.e., valves, meters, electronics, gauges, etc.); and a structure to house system components and vapor treatment equipment. A building will be constructed to house the treatment equipment (i.e., the treatment facility and associated units should be low profile as to blend-in with the surroundings and on-site operations). A part-time operator will be needed to operate and supervise the AS/SVE process and treatment plant.

Operation and maintenance costs include electricity to operate the system; periodic repair and replacement of system parts/components; routine operator inspection of the system; and system monitoring. System inspection and monitoring activities consist of routine visits to the site to inspect the air sparging and SVE components and collect real-time air measurements, as necessary.

Prior to final design, a pilot-scale treatability study will be performed to determine the overall effectiveness of the AS/SVE technology along with configurations (aerial locations and depths) of sparging wells, VEPs, and system piping at the site. Site-specific design parameters, such as zones of air distribution, injection air pressures, injection flow rates, and mass removal efficiency, can be obtained from a pilot test. A pilot scale test can also evaluate vapor phase treatment approaches. In addition, the extent of channeling at the site can be evaluated. The results of the pilot test will also be used to better estimate the run time and power requirements of the system.

For cost estimating purposes, it is assumed that the remedial objectives for the shallow groundwater contaminant plume at the Atlas Graphics site will be met in two years (based on discussion with AS/SVE vendors and review of case studies). The actual cleanup time may be longer than two years; better estimates of cleanup time can be made based on the pilot-scale treatability study. Remedial objectives are considered to be achieved when all compliance monitoring results meet specified criteria in two consecutive sampling episodes. For this FS, a contingency of an additional year is applied to the treatment time. for an assumed active project life of three years.

5.4.2.2 Vapor Phase Treatment. VOCs in the vapor phase are collected from each VEP and pumped with a vacuum extraction blower to a granular activated carbon (GAC) treatment system. This structure will house the blowers, vacuum pumps, controls, and GAC vapor treatment units for the vapor extraction wells. The exact location of the treatment building will be confirmed with Atlas Graphics, Inc. during the design stage. The overall vapor phase flow rate for the two shallow contaminant plumes is expected to be approximately 300 scfm. At the treatment area, the collected vapors containing VOCs are passed through the GAC medium, adsorbed, and then vented to the atmosphere. Initial carbon usage rates were estimated to be approximately 70 lb/day. It is assumed that as VOC concentrations in the groundwater and vapor streams are reduced over time, the carbon usage rates will also decrease. When GAC is spent (i.e., saturated with VOCs), it is transported off-site and replaced with fresh material. High relative humidity of the treated vapor (i.e., above about 50%) reduces the adsorption efficiency of the GAC. In addition, moisture and condensate can accumulate within the vapor extraction piping. To address these issues, vacuum extraction blowers will be specified so that sufficient heat is imparted to the vapor stream and the relative humidity is maintained within satisfactory limits. Any condensate that is created in the system will be collected and periodically disposed of at an approved off-site facility.

A preliminary review of the VOC constituents and respective vapor phase concentrations indicates that an emission stack will probably not be required.

However, the ultimate configuration of the entire vapor recovery/treatment system, including GAC usage rates over time, should be based on the results from the pilot study. Air monitoring and inspection of the vapor treatment system after startup may also determine system requirements. For cost estimating purposes, GAC was the assumed vapor phase treatment option for the air sparging/SVE alternative. However, other vapor phase treatment options (i.e., catalytic oxidation and incineration) should be evaluated during the final design and treatability study.

5.4.2.3 Waste Disposal. It is estimated that approximately 3 yd^3 of uncontaminated, nonhazardous soil will require off-site disposal from the installation of the AS/SVE system. In addition, approximately 500 ft^2 of asphalt will also be excavated and require off-site disposal.

It is conservatively estimated that approximately 25 gallons per month of condensate will accumulate above ground in the vapor extraction treatment area. As noted, condensate will be periodically collected and disposed of at an approved off-site facility. Analytical sampling of the condensate and any other materials generated during remedial activities will be conducted to characterize the wastes and identify disposal options.

5.4.2.4 System Performance Monitoring. To confirm that the AS/SVE system is achieving remedial objectives, groundwater samples will be collected from piezometers installed for system performance monitoring and analyzed for VOCs. The results of these analyses will be used to determine whether remedial action objectives are being satisfied, and whether changes in system design, configuration, and operation are required.

Long-term groundwater monitoring will be conducted twice per year for five years beyond remediation system startup to determine if remedial objectives are being met. The continued need for monitoring can be re-evaluated and possibly discontinued at any time during the 5-yr period. If groundwater contaminant levels remain below the site remedial action objectives for two consecutive sampling events, the monitoring program may be discontinued. If contaminant levels continue to exceed the remedial action objectives at the end of the 5-yr period, the monitoring program and system operation will be extended and/or other remedial actions may be taken. See Table 6 for cost estimates.

5.4.3 Alternative 3: In-Well Vapor Stripping/Vapor Treatment

Alternative 3 includes remediating the shallow, on-site groundwater at the Atlas Graphics site by implementing in-well vapor stripping, an in-situ remediation technology, and off-gas treatment. This alternative also includes long-term monitoring of the groundwater plume.

The reported advantages of using the in-well vapor stripping technology over other methods for remediating contaminated groundwater include:

Cost savings because there is no need to pump, handle, and treat groundwater at the surface; only contaminated vapor is extracted and treated in this technology.

System can be designed so that soils in the unsaturated zone do not become incidentally or temporarily contaminated during groundwater remediation.
Simplicity of design.

Limited maintenance requirements.

Some limitations reported for this technology include:

Possible clogging of well screens due to precipitation of iron or other nutrients present in the subsurface.

Potential to spread contaminants in the subsurface if the system is not properly designed or constructed.

Lower effectiveness in shallow aquifers (due to limited area for groundwater recirculation).

Lower effectiveness in deep confined aquifers due to limited recirculation potential.

High electric operational expense in deep aquifers.

Several commercial variations of the in-well vapor stripping process have been developed. Three main types of in-well vapor stripping systems include the Unterdruck-Verdampfer-Brunnen (UVB) or "vacuum vaporizer well" system, the NoVOCs™ system, and the Density Driven Convection (DDC) system. The UVB in-well vapor stripping system was selected for analysis in this FS because of several reasons:

The large amount of information and research readily available in the literature.

Flexibility of the system to operate under various site conditions.

Decreased moisture content in vapors to be treated.

Lower likelihood of well screens to become clogged by iron precipitates.

Previous demonstration at sites with other physical and contaminant characteristics similar to the Atlas Graphics site.

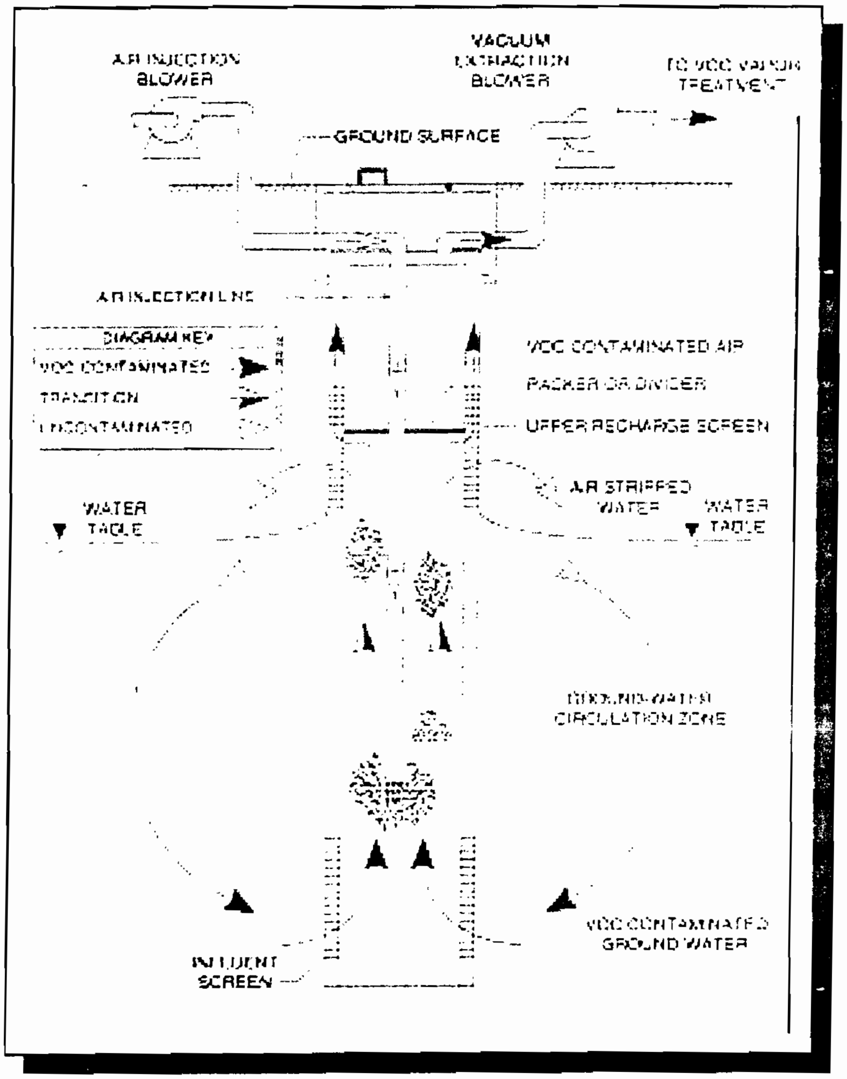
5.4.3.1 ***In-Well Vapor Stripping.*** In-well vapor stripping (also known as in-situ vacuum, vapor, or air stripping) is a demonstrated in-situ physical/chemical treatment alternative for remediating contaminated groundwater, as per EPA's Superfund Innovative Technology Evaluation (SITE) program. The technology involves the creation of groundwater circulation patterns, or "cells", in the subsurface surrounding specially designed wells and simultaneous aeration within the wells to volatilize VOCs from the circulating groundwater. Contaminated vapors are typically extracted from the wells and treated at the surface; however, unlike conventional groundwater remediation systems, in-well vapor stripping does not require groundwater to be pumped to and treated at the surface. This in-well air stripping technology is most applicable to VOCs (such as PCE and TCE); however, modifications of the basic remedial process are proposed for applications to treat SVOCs, pesticides, and inorganics. In-well vapor stripping has been used in unconfined and confined aquifers and applied to geologic materials with a range of characteristics. A schematic of the in-well vapor stripping process is shown in Figure 7.

An in-well stripping well consists of an inner and an outer casing that are hydraulically separated from one another, usually by a packer or divider plate. This separation ensures one-directional flow of groundwater into the well at its base (through a lower screened interval) and out of the well near the water table (through an upper screened interval). Air is injected into the well through a gas injection line and diffuser, releasing bubbles into contaminated groundwater in the well. These bubbles aerate the water and form a type of air-lift pumping system (due to an imparted density gradient) that causes groundwater to flow upward in the well. As the bubbles rise, VOC compounds in the water are transferred from the dissolved state to the vapor state through an air stripping process.

The air/water mixture rises in the well until it encounters the dividing device within the inner casing. The divider is designed and located within the well to maximize volatilization. The air/water mixture flows from the inner casing to the outer casing through the upper screen. A vacuum is applied in the outer casing, and contaminated vapors are drawn upward through the annular space between the two casings and typically treated at the ground surface. The partially treated groundwater, from which some of the VOCs have been removed, re-enters the subsurface through the upper screen and infiltrates back to the aquifer and the zone of contamination where it is eventually cycled back into the well. This pattern of groundwater movement forms a circulation cell in the subsurface around the well that allows groundwater to undergo sequential treatment cycles until remedial objectives are achieved. A continuous VOC-rich vapor stream is created as contaminant concentrations in groundwater are significantly reduced.

At the Atlas Graphics site, the in-well vapor stripping system would include the installation of one groundwater circulation/stripping well (8-in. diameter) to address the shallow, on-site groundwater contamination plume based on contaminant depths and radii of influence expected to be achieved. The well will be mounted flush with the existing ground surface and installed to approximate depths of 80 ft bgs. The estimated groundwater flow rate in each well is 50 gallons per minute (gpm). The stripping well, based on a 30-ft thick zone of contamination (located at approximated depths of 50-80 ft bgs in each plume area), is estimated to produce a radius of influence of approximately 110 ft. The upper screened intervals in the well will be installed at depths ranging from approximately 40-50 ft bgs to provide routes of groundwater reinfiltration to the subsurface. The lower screened intervals are estimated to be at about 70-80 ft bgs in each

Figure 7 - In-Well Stripping



well. Aquifer pump testing and field measurements in the design phase of the work will more accurately determine the construction details and placement of each of the in-well vapor stripping wells, along with specific groundwater circulation/treatment patterns expected to result.

Components of the in-well vapor stripping system include: air injection blowers and associated piping; vacuum extraction blowers (for vapor collection) and associated piping; a moisture separator and condensate storage container; system control equipment (i.e., valves, meters, electronics, gauges, etc.); an iron sequestering/pH control system; and a structure to house system components and vapor treatment equipment. A building will be constructed to house the treatment equipment (i.e., the treatment facility and associated units should be low profile as to blend-in with the surroundings and on-site operations). A part-time operator will be needed to operate and supervise the in-well vapor stripping process and treatment plant.

Operation and maintenance costs include electricity to operate the system; periodic repair and replacement of system parts/components; iron control chemical replenishment; routine operator inspection and maintenance of the system; and system monitoring. System inspection, maintenance, and monitoring activities consist of routine visits to the site to inspect and clean the in-well vapor stripping components and collect real-time air measurements, as necessary.

Prior to final design, a pilot-scale treatability study and aquifer pump test will be performed to determine the overall effectiveness of the in-well vapor stripping technology and well/piping configurations at the site. A pilot scale test can also determine optimal operating pressures and flow rates to remove contaminants from the groundwater and evaluate the airflow distribution and vapor phase treatment approaches. In addition, control of iron and pH in the subsurface can be evaluated. The results of the pilot test will also be used to better estimate the run time and power requirements of the system.

For cost estimating purposes, it is assumed that the remedial objectives for the shallow, on-site groundwater contaminant plume at the Atlas Graphics site will be met in three years (based on discussion with vendors and review of case studies). The actual cleanup time may be longer than three years; better estimates of cleanup time can be made based on a pilot-scale treatability study. Remedial objectives are considered to be achieved when all compliance monitoring results meet specified criteria in two consecutive sampling episodes. For this FS, a contingency of an additional year is applied to the treatment time, for an assumed active project life of four years.

5.4.3.2 Vapor Phase Treatment. VOCs in the vapor phase are collected from the well and pumped with a vacuum extraction blower to a granular activated carbon (GAC) treatment system. The exact location of the treatment building will be confirmed with Atlas Graphics, Inc. during the design stage. The vapor phase flow rate to the GAC treatment system is expected to be approximately 1000 standard cubic feet per minute (scfm), assuming an air-to-water ratio of 75:1. In the treatment area, the vapors containing VOCs are passed through the GAC medium, adsorbed, and then vented to the atmosphere. Initial carbon usage rates were estimated to be approximately 70 lb/day. It is assumed that as VOC concentrations in the groundwater and vapor streams are reduced over time, the carbon usage rates will also decrease. When GAC is spent (i.e., saturated with VOCs), it is transported off-site and replaced with fresh material.

High relative humidity of the treated vapor (i.e., above about 50%) reduces the adsorption efficiency of the GAC. In addition, moisture and condensate can accumulate within the vapor extraction piping. To address these issues, vacuum extraction blowers will be specified so that sufficient heat is imparted to the vapor stream and the relative humidity is maintained within satisfactory limits. Any condensate that is created in the system will be collected and periodically disposed of at an approved off-site facility.

A preliminary review of the VOC constituents and respective vapor phase concentrations indicates that an emission stack will probably not be required. However, the ultimate configuration of the entire vapor recovery/treatment system, including GAC usage rates over time, should be based on the final design and results from the pilot study. Air monitoring and inspection of the vapor treatment system after startup may also determine system requirements. For cost estimating purposes, GAC was the assumed vapor phase treatment option for the in-well vapor stripping alternative. However, other vapor phase treatment options (i.e., catalytic oxidation and incineration) may be evaluated during the final design and treatability study.

5.4.3.3 ***Waste Disposal.*** It is estimated that approximately 5 yd^3 of uncontaminated, nonhazardous soil will require off-site disposal from the installation of the two stripping wells and piping associated with air injection and vapor vacuum extraction. In addition, asphalt will be excavated from an approximately 500 sqft. area and will require off-site disposal.

It is conservatively estimated that approximately 100 gallons per month of condensate will accumulate aboveground in the in-well vapor stripping treatment area. As noted, condensate will be periodically collected and disposed of at an approved off-site facility. Analytical sampling of the condensate and any other materials generated during remedial activities will be conducted to characterize the wastes and identify disposal options. For costing purposes, it is assumed that the condensate would be disposed of as hazardous waste.

5.4.3.4 ***System Performance Monitoring.*** To confirm that the in-well vapor stripping system is achieving remedial objectives, groundwater samples will be collected from three existing monitoring wells at the site and analyzed for VOCs. The results of these analyses will be used to determine whether remedial action objectives are being satisfied, and whether changes in system design, configuration, and operation are required. Groundwater monitoring will be conducted twice per year for five years beyond remediation system startup. The continued need for monitoring can be re-evaluated and possibly discontinued at any time during the 5-yr period. If groundwater contaminant levels remain below the site remedial action objectives for two consecutive sampling events, the monitoring program may be discontinued. If contaminant levels continue to exceed the remedial action objectives at the end of the 5-yr period, the monitoring program, and system operation, will be extended and/or other remedial actions may be taken. Costs for this alternative are summarized in Table 7.

5.4.4 Alternative 4: Groundwater Extraction/Air Stripping/Re-injection

Alternative 4 has been developed to evaluate the feasibility of using a groundwater extraction system at the Atlas Graphics site to capture the shallow VOC-contaminated groundwater and treat it at the surface (i.e., ex situ treatment).

The objective of groundwater extraction is to draw contaminated groundwater into the pumping well's zone of capture. The recovery rate is increased until the capture zone radius is believed to exceed the lateral dimensions of the plume or the area of concern. The recovery well should be located sufficiently downgradient of the highest contaminated point in the plume so that the majority of the contaminated groundwater will naturally flow into the capture zone. This alternative includes an extraction well pattern designed to reduce the VOC concentrations in the shallow groundwater contaminant plume.

An aquifer pump test should be performed prior to the design to verify assumptions made here regarding well spacing, zone of capture, flow rates, and remediation time.

5.4.4.1 Extraction Wells. This alternative includes the installation of an extraction well within the contaminant plume. Prior to final design, a 72-hr aquifer pump test should be completed to precisely determine hydraulic conductivity values. The pump test should be completed at, or near, the area where the remedial pumping is to occur. An existing monitoring well cannot be used for the pump test because a well with a minimum diameter of 6 in. is needed. This new well for the pump test will be made of PVC and have a screen approximately 20-ft in length. A 7.5-15 hp submersible pump with a 4-in. outlet should be used to pump groundwater at a flow rate of 200-500 gpm. It is assumed that the extracted groundwater generated during the aquifer test will be treated with a granular activated carbon filter and the treated effluent discharged to existing stormwater wet wells (a type of re-injection well).

Atlas Graphics - Site #1-30-043B
Table 6
COST ESTIMATE FOR ALTERNATIVE 3:
IN WELL AIR STRIPPING/VAPOR TREATMENT

ITEMS	UNIT COST ($)	QUANTITY	COST (1999 $)[a]
CAPITAL COSTS			
A. Direct Costs			
Pilot/Aquifer Pump Test	LS		$ 65,000
Site Preparation			
Contractor mobilization/demobilization	LS		20,000
Well/Remediation System Installation Start-up			
Stripping Wells	$90,000 /well	1 wells	90,000
includes electrical components of wells			
Iron Control System	$3,000 /well	2 wells	8,000
Equipment Housing	LS		50,000
Instruments, Electrical, and Controls	LS		25,000
Phone Line and Auto Dialer	$700 /unit	1 unit	1,000
Moisture Separator	$2,000 /unit	1 unit	2,000
Condensate Storage Container	$1,277 /unit	1 units	1,000
Fencing	$36.58 /lf	200 lf	$7,000
Signage	LS		$1,000
Asphalt Removal, Disposal, Restoration	$20.94 /lf	500 lf	$10,000
Air Injection Piping/Trenching/Installation	$35.00 /lf	500 lf	$18,000
Vapor Extraction Piping/Installation	$10.00 /lf	500 lf	$ 5,000
pipe installed in same trench as air injection pipe	$125.00 /cy	10 lf	$1,000
Soil Disposal (nonhazardous)	LS		$1,000
Vapor Treatment Installation			
		Subtotal	$311,000
B. Indirect Costs			
Engineering and Design @ 15%			$ 45,000
Legal and Administrative @ 10%			$ 30,000
Contingency @ 25%			$ 75,000
		Total	$460,000
O&M Costs			
Operator Attention (years 1-4)			

ITEMS	UNIT COST ($)	QUANTITY	COST (1999 $)[a]
Iron Control Chemical Replacement			
Year 0-1	LS	6,000	$ 17,000
Year 1-4		9,000	21,000
		Present Worth:	$ 38,000
	Annual cost for	**years 1-4:**	11,000
Condensate Control (years 1-4)	LS		$ 10,000
Vapor Phase Carbon Replacement Year 0-1	$1.20 /lb	$ 13,000 lb	16,000
Year 1-4	$1.20 /lb	4,000 lb	$ 4,000
		Present Worth	$ 20,000
		Annual cost for years 1-4	$ 6,000 /yr
Vapor Monitoring (years 1-4)			
Sampling of air emission (once pe 2 months)	$1,000 /event	6 events	$ 6,000
Long-term groundwater monitoring program			
Semiannual sampling of 3 wells for VOCs	$500 /well	30 wells	$ 13,000
	Annual cost for	**years 1-4 (72**	6,000 /yr $ 2,000
	Annual cost for	**wells**	
		5 (6 wells):	$ 9,000 /yr
Repair/replacement of equipment	LS		
@ 5% per year (years 1-4)			$ 10,000 /yr
	$0.10 /kw-hr		
Electricity (years 1-4)		100,000 kw-hr	$ 51,000
	Annual O&M		
		cost for years	
	Annual O&M	**1-4:**	$ 3,000
	Annual O&M	**cost for year 5**	
		cost for years	
		6-30	$0
Present Worth			
Based on 4 years of operation. 5 years of Groundwater monitoring and a 5% interest rate			$630,000
		SAY	
			$0.63 Million

a - Costs rounded to the nearest $1000
LS -Lump sum.

To facilitate the collection of the contaminated groundwater at the Atlas Graphics site, a minimum of one extraction well will be needed. This well will be installed to approximately 90-ft bgs and have a maximum screened length of about 40-ft. The extraction well will be placed slightly downgradient of the groundwater contaminant concentrations near the abandoned cesspoos shown in Figure 2. This extraction well will be pumping contaminated groundwater at a rate of about 10 gpm based on principles developed by Grubb for determining stagnation point, zone of capture, and the dividing streamline for an unconfined aquifer (Groundwater, 1993). For this extraction well to operate at a pumping rate of 10 gpm, a 1 hp submersible pump with a 1-in. outlet will be needed to fit into the 6-in. diameter well.

The actual remedial pumping rate for the extraction well should be optimized based on the results of the pump test and a comprehensive groundwater flow model of the site. The objective of the optimization process would be to create the required capture zone while minimizing the amount of groundwater which must be extracted.

The contaminated groundwater from the extraction well will travel though a 2-in. pipe to the on-site groundwater treatment plant (described below). Prior to any treatment, the groundwater will be metered. Flow will be controlled inside the treatment building rather than at the extraction well itself. Also, with the meters and flow control devices inside of the facility, the likelihood of vandalism is greatly decreased.

5.4.4.2 Groundwater Treatment and Discharge. In order to satisfy SCGs, specifically groundwater treatment effluent limitations, the extracted groundwater must be treated to remove inorganic and organic compounds. An approximately 1,000-ft^2 groundwater treatment plant is proposed to be constructed, location yet to be determined. The location of the building will be confirmed with Atlas Graphics, Inc. during the design stage. A schematic of the proposed unit operations of this treatment plant is presented in Figure 9. For costing purposes in the FS, a total peak flow of approximately 20 gpm is expected from the extraction well network; therefore, the components of the treatment system have been sized based on a peak flow rate of 20 gpm plus a minimal allowance for a safety factor.

After the pumped groundwater has been metered inside of the treatment facility, it will enter an equalization tank (with a mixer) to equalize the flows from the two pumping wells. The water will then flow via gravity into a pH adjustment/reaction tank. With the addition of a base compound (i.e., sodium hydroxide), the pH will be raised to about 8 to 10, and a coagulant will be added into the reaction tank to help flocculate and precipitate dissolved inorganic constituents. A mixer will ensure that the base and the coagulant become completely mixed before passing (via gravity) into the settling tank/clarifier unit. In the settling tank, a sludge will be produced as the iron, manganese, and other inorganic compounds settle to the bottom of the tank. The sludge will be dewatered to form a sludge cake, which will be disposed of off-site. It is assumed in the cost estimate that this sludge cake will be disposed of as non-hazardous waste; this assumption should be verified in the remedial design phase with a TCLP waste characterization analysis. The filtrate from the dewatering process will be recycled back into the equalization tank.

The contaminated groundwater that passes through the settling tank will then be pumped into a media filter to remove dissolved solids. An acidic compound (i.e., sulfuric acid) will be added to lower the pH to about 6 to 7 before the water is fed into a low profile tray air stripper. The low profile stripper is better suited than an air stripping tower for this site because the surrounding buildings are only one story tall. The vapor phase emitted from the air stripper will undergo treatment via GAC to remove the volatiles. Following vapor phase GAC treatment, air emissions will be discharged to the atmosphere.

The liquid effluent leaving the air stripper will be passed through a cartridge filter to remove any remaining solids before being discharged into an on-site infiltration gallery. The infiltration gallery will consist of four wet wells (injection wells) located near the treatment facility. Each wet well will have a diameter of about 6-ft and an approximate depth of 20 ft bgs. The wet wells will be operated in parallel to handle overflow and maintenance periods.

The discharged effluent is subject to the New York State groundwater effluent limitations - Class GW . The discharge standards will be detailed in a State Pollutant Discharge Elimination System (SPDES) permit or equivalent, as issued by the NYSDEC.

Chemical consumption for these treatment processes include: approximately 160 gal/month (or 2,000 gal/year) sodium hydroxide, about 80 gal/month of sulfuric acid (or 1,000 gal/year), and approximately 2,200 lbs/year of iron chloride ($FeCl_3$).

The estimated amount of sludge production for this treatment system is about 10 lbs/day, or 3,600 lbs/year, assuming a constant total dissolved solids loading. Initial carbon usage was estimated to be approximately 20 lbs/day based on an estimated vapor flow rate of 200 scfm.

Due to the need for a treatment facility at the selected location, a building would be constructed to house the treatment equipment (i.e., the treatment facility and associated units and piping should be low profile as to blend-in with on-site operations and the surroundings). A part-time operator would be needed to operate and supervise the pumping wells and the treatment plant.

A bench-scale treatability study and/or a pilot-scale study would be required prior to the preparation of the detailed design for the groundwater treatment facility. The purpose of these pre-design studies is to confirm chemical dosage rates, as well as to optimize the contact times in the tanks. The treatability studies will also help to evaluate the ability of the treatment processes to meet discharge requirements. If discharge limitations are not satisfied, polishing with carbon adsorption may be necessary. The treated effluent will be periodically monitored (i.e., SPDES permit) to ensure that discharge limits are met (sampling frequencies are described in the next section).

5.4.4.3 System Performance Monitoring. For the purposes of this study, it is assumed that the extraction and treatment system would operate for at least 4 years. This estimate was based on the theoretical time it would take for the furthest contaminant in each of the shallow, on-site plumes to be captured by the groundwater extraction system and on project life contingency factors that were applied. The controlling retardation factor, which affects contaminant transport velocity, was for PCE. A hydraulic conductivity of 70 ft/day was used in the calculation. Many of the parameters used in deriving this estimate can vary widely, which would impact the remediation time. The estimated remediation time of 4 years was used for costing purposes in this FS. Better estimates of cleanup time can be made based on the results from a pilot scale treatability study.

The long-term monitoring program included in this alternative is intended to assess the effectiveness of groundwater extraction and treatment on the contaminant levels in the aquifer over time. Monitoring will consist of system performance monitoring and groundwater quality monitoring. During the first three months that the treatment plant is in operation, VOC samples from both of the influent pipes and the single effluent pipe will be collected once per week to evaluate the efficiency and effectiveness of the treatment plant. The effluent sample analysis will be used to demonstrate that the SPDES requirements are being met. For the remainder of the four year time frame, VOC sampling of the influent and the effluent at the treatment plant would be collected once per month. Samples will be analyzed for conventional parameters (e.g., pH, solids, and alkalinity) as well as VOC content.

Three monitoring wells would have VOC samples taken on a semi-annual basis for five years after system start-up to monitor the contaminant transport and transformation, and response to the remediation system. The continued need for a long-term monitoring program may be re-evaluated and possibly discontinued at any time during the 5-yr period. If groundwater contaminant levels in the monitoring wells remain below the site remedial action objectives for two consecutive sampling events, the remediation system may be evaluated as to be discontinued, although monitoring may be continued to determine if rebounding has occurred (about two more sampling events). If contaminant levels continue to exceed the remedial action objectives at the end of the 5-yr period, the monitoring program, and system operation, will be extended. In costing this alternative, it was assumed that the existing wells will be sufficient to assess the long term effects of the groundwater plume. Cost estimates for this alternative are given in Table 7.

ATLAS GRAPHICS SITE #1-30-043B
TABLE 7
COST ESTIMATE FOR ALTERNATIVE 4: GROUNDWATER EXTRACTION/AIRSTRIPPING/RE-INJECTION

ITEM	UNIT COST($)	QUANTITY	COST (1999$)[a]
CAPITAL COSTS			
A. Direct Costs			
Treatability Study	LS		$ 8,000
Aquifer Pump Test[1] (includes treatment)	LS		60,000
Site Preparation			
Contractor Mobilization/demobilization	LS		40,000
Well Installation			
Drilling and installation of Excavation well	$ 8,000 /well	2 wells	12,000
Disposal of Soil as Nonhazardous	125 /yd^3	3 yd^3	1,000
Pump, Transducer, Concrete Enhancement	5,000 /well	2 wells	10,000
Installation of Connecting Piping			
Trenching, Bedding, Pipe, Conduit	35 /lf	500 lf	18,000
Asphalt Removal, Disposal, Restoration	20.94 /lf	500 lf	10.000
Groundwater Treatment			
Treatment System Equipment	$142,000	-	142.000
Air Stripper	20.997 /unit	1 unit	21,000
Electrical Components and Controls	60,000	-	60,000
Housing for Treatment Operations	90,000	-	90.000
Inflation Gallery			
Wet Well (9-ft diameter, 15-ft deep)	4,000 /well	4 wells	$ 16.000
		Subtotal	$488.000

ITEM	UNIT COST ($)	QUANTITY	COST (1999)[a]
Plant Operator (Part-Time) (years 1-4)	LS		$ 37,000 /yr
System Monitoring			
Total System Monitoring (first year)	LS		20,000
Total System Sampling (years 2 through 4)	LS		30,000
		Present Worth: 4-	50,000
	Annual Cost Over	**yr Period:**	$ 14,000
Long-Term Groundwater Monitoring Program			
Semiannual Sampling of 9 wells for VOCs	500 /well	90 wells	
	Annual cost for	**years 1-4 (72 years)**	
		year 5 (18 wells)	9,000
	Annual cost for		7,000
Repair/Replacement of Equipment/Well Development (years 1-4)			
(5% of all treatment equipment)	LS		$ 11,000
(10% inflation gallery)	LS	**Cost for years 1-4**	2,000
	Annual O & M	**Cost for year 5:**	$110,000
		Cost for years 6-30:	2,000
	Annual O & M		0
	Annual O & M		
Present Worth			
Based on 4 years if operation, 5 years groundwater monitoring, and a 5% interest rate.			$1,127,000
		Say	**$1.13Million**

a - costs rounded to the nearest $1000.
LS- Lump sum.
1 - includes one pilot test well.
2 - Includes system performance, groundwater monitoring, and air emission testing.

Table 8 - Groundwater Alternative Comparison

ALTERNATIVE	OVERALL PROTECTION OF OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH SCGs	REDUCTION OF TOXICITY, MOBILITY OR VOLUME	SHORT-TERM EFFECTIVENESS	LONG-TERM EFFECTIVENESS AND PERMANENCE	IMPLEMENTABILITY	COST
ALTERNATIVE 1 Monitored Natural Attenuation	Minimal prevention of human contact through institutional controls only. Contaminants remain in the environment	Relies solely on natural attenuation to achieve site SCGs. Will not quickly achieve groundwater SCGs	Relies on natural attenuation to reduce toxicity, mobility, or volume of contamination present in site soils	Does not result in disruption of site operations or pose a threat to short term health or the environment	Does not provide long term effectiveness or permanence, contaminants will remain at site	No constraints to implementation of institutional measures and monitoring	Capital $ 0 O&M $15 000/yr Present Worth $0 2 million
ALTERNATIVE 2 Soil Vapor Extraction	Reduces potential for migration of contaminants by extracting VOCs from deep subsurface soils	Applicable NYSDEC soil cleanup objectives achieved through treatment. Relies on natural attenuation for groundwater remediation. Air emissions will be controlled to meet SCGs	Reduces the mobility and volume of VOCs at the site by extraction of contaminants from the soil. Toxicity of collected VOCs is reduced by treatment	Will result in disruption of site operations during implementation. Will generate noise and traffic. Approximately 500 sf is required for chemical storage and treatment equipment	Permanently removes VOCs from subsurface soil. Rebounding may occur but may be monitored	Well, piping and vacuum installation as well as construction of a vapor treatment facility can be readily implemented	Capital $ 188 000 O&M (Yr 1-10) $57,000/yr Present Worth $0 6 million
ALTERNATIVE 3 In Well Vapor Stripping/ Vapor Treatment	Protects human health and the environment by transferring contaminants from the water phase to the vapor phase and treating them ex-situ. Prevents further downgradient migration of contaminants	Achieves applicable groundwater standards. Relies on natural attenuation to achieve soil cleanup objectives. Air emissions will be controlled to meet SCGs	Reduces the mobility and volume of VOCs on the site through in situ treatment of groundwater. Toxicity of VOCs is controlled by treatment	Will result in disruption of site operations during implementation. Will generate some noise and traffic. Approximately 2000 sf is required for chemical storage and treatment equipment	The estimated operating time for the in well vapor stripping system is estimated at 10 to 12 years. Technology permanently removes captured VOCs.	Equipment for in-well air stripping technology is sold by a limited number of vendors. Equipment installation is readily implementable and available	Capital $ 1 309 000 O&M (Yr 1-12) $214 000/yr Present Worth $3 2 million
ALTERNATIVE 4 Extraction/ Air Stripping/ Vapor Treatment/ Re-injection	Protects human health and the environment by extracting contaminated groundwater from aquifer and treating it ex-situ. Prevents further down-gradient migration of contaminants	Achieves applicable groundwater standards. Relies on natural attenuation to achieve soil cleanup objectives. Air emissions and treated effluent discharge will be controlled to meet SCGs	Reduces volume and mobility of contaminants in groundwater through extraction, toxicity of extracted groundwater reduced by treatment	Will result in disruption of site operations during implementation. Will generate noise and traffic. Approximately 2000 sf is required for chemical storage and treatment equipment	The estimated operating time for the pump and treat system is 15 years. Technology permanently removes captured VOCs	Well and piping installation and treatment facility construction can be readily implemented	Capital $1,109 000 O&M (Yr 1-15) $234,000/yr Present Worth $3 5 million

5.5 COMPARATIVE ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES

Table 8 summarizes the comparative analysis of the selected alternatives. The analysis reveals that alternatives 2, 3 and 4 all meet the evaluation criteria. Option 2 has the additional point of addressing soil contamination, removing the necessity for separate measures to address soil contamination at the site (Soil vapor analysis is discussed above in conjunction with soils remediation).

6.0 SUMMARY OF THE EVALUATION OF REMEDIAL ALTERNATIVES FOR SOILS AND GROUNDWATER

Comparative analysis of remedial alternatives has been carried out independently for soils and groundwater. In order to select the most advantageous overall approach, soils and groundwater options will now be evaluated together. The most promising methods for both soil and groundwater remediation have been selected for this final evaluation. A summary of the detailed analysis follows. As presented below, the time to construct does not include the time required to design the remedy, procure contracts for design and construction or to negotiate with responsible parties for implementation of the remedy. The time to implement is the expected time for the alternative to reach remedial objectives.

6.1 DESCRIPTION OF ALTERNATIVES

The potential remedies are intended to address the contaminated soils and groundwater at the site. Groundwater contamination at shallow depth (less than 90 ft bgs) is predominant at the site, however, low levels of VOC contamination may be found at depths greater than 90 ft bgs. Downgradient groundwater contamination and deep groundwater contamination will be addressed as a part of the overall investigation of groundwater contamination that is migrating from all Class 2 sites in the NCIA.

Alternative A: No Action (Soils alternative 1 and Groundwater alternative 1)

Present Worth:	*$ 50,000*
Capitol Cost:	*$ 0*
Annual O&M years 1-2	*$3,000*
Annual O&M years 3-30	*$2,300*
Time to construct	*none*
Time to implement	*30 years*

The no action alternative is evaluated as a procedural requirement and as a basis for comparison. It requires continued monitoring only, allowing the site to remain in an unremediated state. This alternative would leave the site in its present condition and would not provide any additional protection to human health or the environment. The site would remain as a Class 2 site.

Groundwater use restrictions would be implemented to prevent development of the underlying groundwater as a potable or process water source without the necessary water quality treatments. Semi-annual sampling of three existing groundwater monitoring wells would be carried out for the first two years, and annual sampling conducted for the subsequent 28 years. The monitoring program would be extended or discontinued based on new data received during this period.

Alternative B: Excavation and Off-site Disposal of Contaminated Soil (Soils alternative 2)

Present Worth:	*$ 54,000*
Capital Cost:	*$ 23,000*
Annual O&M	*$ 2,300*
Time to Construct	*6 months*
Time to Implement	*10 years*

This alternative would require the excavation and disposal of approximately 67 cubic yards of material in the area of the abandoned cesspool. The depth of the excavation, coupled with the proximity to the building, would make shoring and bracing essential, since sloping the excavation would not be viable. Hand excavation to a depth of 4 feet would be required to avoid (unknown) utilities. Conventional excavation equipment would be employed below 4 feet. This alternative only directly addresses soil contamination. After the removal of the source of the contamination it is expected that it would take a minimum of ten years to achieve the remedial objectives for on-site groundwater. This is based on the fact that in the time since the initial cleanup of the cesspool and connection to the public sewer (1982) groundwater contamination at the site has remained high despite the moderate levels of remaining soil contamination found in the RI. Contamination which has already reached the groundwater and is currently migrating south of the NCIA would not be addressed, however. Annual sampling of three existing groundwater monitoring wells would be conducted for ten years. The monitoring program would be extended or discontinued based on new data received during this period.

Alternative C: Air Sparging/Soil Vapor Extraction for on-site soil and groundwater (soils alternative 2 combined with groundwater alternative 2)

Present Worth:	$ 400,000
Capital Cost:	$ 230,000
Annual O&M (years 1-3):	$ 75,000
Annual O&M (years 4 and 5)	$ 5,000
Time to Construct	6 months
Time to Implement	3 years

AS/SVE is a demonstrated in-situ physical/chemical treatment for remediating contaminated soil and groundwater. The AS/SVE system would require the installation of injection/extraction wells to effectively volatilize and capture contaminants in the soil and groundwater. Off-gas treatment and long-term groundwater monitoring would also be included as part of this alternative.

The air sparging component would consist of one well installed in the upper fifty feet of the aquifer, to about 105 ft bgs. This well would inject compressed air via air blowers or compressors into contaminated groundwater at controlled pressures and volumes to increase groundwater/air contact. The air channels would promote the volatilization of dissolved

VOCs and adsorbed phase contamination. The volatilized contaminants would then travel from the saturated zone into the unsaturated soils. The injection well would be installed to ensure the entire area of concern would be effectively aerated.

The vapor-phase contaminants would be collected with the use of a vacuum pump/extraction wells. These wells would collect all vapor-phase contaminants and transport them to the surface. All vapors would be treated with a granular activated carbon filter before discharge to the atmosphere.

Pilot testing and field measurements would be necessary to determine the exact number of AS/SVE wells necessary to effectively remediate the area of concern. For costing purposes it was assumed that one air sparge and two soil vapor extraction points would be required. These points would be located on the southwest corner of the Atlas Graphics property near the abandoned cesspool.

This system would be expected to stay in operation for three years. To confirm the AS/SVE system is achieving remedial objectives, groundwater quality would be monitored at three monitoring wells semiannually for a period of five years. The monitoring program would be extended or discontinued based on new data received during this period.

Alternative D: In Well Vapor Stripping/Vapor Treatment for on-site groundwater (groundwater alternative 3)

Present Worth:	*$ 630,000*
Capitol Cost	*$ 460,000*
Annual O&M (years 1-4)	*$ 62,000*
Annual O$M (year 5)	*$ 5,000*
Time to Construct	*6 months*
Time to Implement	*4 years*

Under this alternative, the shallow groundwater contaminant plume would be treated in-situ using a series of groundwater circulation wells (or in-well stripping) to capture and re-circulate groundwater within the aquifer. The groundwater circulation well system creates in-situ vertical groundwater circulation cells by drawing groundwater from the aquifer formation through one screen section of a double-screened well and discharging it through a second screen section. While groundwater circulates in and out of the stripping cell, no groundwater is removed from the ground. Air is injected into the well through a gas injection line and diffuser, releasing bubbles into the contaminated groundwater. These bubbles aerate the water and form a type of air-lift pumping system (due to an imparted density gradient) that causes groundwater to flow upward in the well. As the bubbles rise, VOC contamination in the groundwater is transferred from the dissolved state to the vapor state through an air stripping process.

The air/water mixture rises in the well until it encounters the dividing device within the inner casing. The divider is designed to maximize volatilization. The air/water mixture flows from the inner casing to the outer casing through the upper screen. A vacuum is applied to the outer casing, and contaminated vapors are drawn upward through the annular space between the two casings. The partially treated groundwater re-enters the subsurface through the upper screen and infiltrates back to the aquifer and the zone of contamination where it is eventually cycled back into the well. This pattern of groundwater movement forms a circulation cell in the subsurface around the well that allows groundwater to undergo sequential treatment cycles until remedial objectives are met.

Off gas from the stripping system would be collected and treated using granular activated carbon filters.

Aquifer pump testing and field measurements would be necessary to determine the exact number of In Well Vapor Stripping wells necessary to effectively remediate the areas of concern. For costing purposes it was assumed that two (2) groundwater circulation/stripping wells would be required. These points would be located near the southwest corner of the Atlas Graphics property.

This system would remain in operation approximately four years. To ensure the system is achieving remedial objectives, groundwater quality would be monitored at three (3) existing wells semiannually for a period of five years. The monitoring program would be extended or discontinued based on new data received during this period.

Alternative E: Extraction/Air Stripping/Re-Injection of on-site groundwater (groundwater alternative 4)

Present Worth:	*$ 1,127,000*
Capitol Cost:	*$ 732,000*
Annual O&M (years 1-4)	*$ 100,000*
Annual O&M (year 5)	*$ 2,000*
Time to construct	*6 months*
Time to implement	*4 years*

The groundwater extraction system would draw contaminated shallow groundwater from the pumping well's cone of depression. The recovery flow rate is increased until the cone of depression is sufficient to cover the lateral dimensions of the contaminated area. The recovery wells would be located on the south-west (downgradient) portion of the property, in the vicinity of the abandoned cesspool.

The pumped groundwater would be collected at the surface for treatment. First it would enter a flow equalization tank, then a pH adjustment tank. The pH would be raised to about 9, and a coagulant would be added into the reaction tank to help flocculate and precipitate soluble inorganic constituents. Then, after passing through a mixer, the groundwater would enter a settling tank where an iron/manganese sludge would settle to the bottom of the tank. The groundwater then passes through a media filter to remove dissolved solids. An acidic compound would be added to lower the pH to 6 or 7 before the water is fed into a low profile tray air stripper. The low profile stripper would be selected over a stripping tower because the surrounding buildings are typically one story tall.

The vapor phase emitted from the air stripper would be collected and treated with granular activated carbon prior to discharge to the atmosphere.

The liquid effluent leaving the air stripper would be passed through a filter to remove any remaining solids before being discharged to the on-site infiltration gallery. The infiltration gallery would consist of four injection wells.

Aquifer pump testing and field measurements would be necessary to determine the exact number and placement of extraction wells necessary to effectively remediate the areas of concern. For costing purposes it was assumed that two (2) extraction wells would be required.

This system would remain in operation for approximately four years. To ensure the system is achieving remedial objectives, groundwater quality would be monitored at three (3) existing wells semiannually for a period of five years. The monitoring program would be extended or discontinued based on new data received during this five year period.

6.2 EVALUATION OF REMEDIAL ALTERNATIVES

The criteria used to compare the potential remedial alternatives are defined in the regulation that directs the remediation of inactive hazardous waste sites in New York State (6 NYCRR Part 375). For each of the criteria, a brief description is provided, followed by an evaluation of the alternatives against that criterion. A detailed discussion of the evaluation criteria and comparative analysis is included in the Feasibility Study.

1. Compliance with New York State Standards, Criteria, and Guidance (SCGs). Compliance with SCGs addresses whether or not a remedy will meet applicable environmental laws, regulations, standards, and guidance.

   The data for the site shows that SCGs are exceeded for VOCs in on-site soils and groundwater. The remedy selected for this site must remediate the groundwater to Class GA standards, and soils to the cleanup objectives in TAGM #4046-Determination of Soil Cleanup Objectives and Cleanup Levels.

   Since no remedial actions are included in Alternative A, SCGs would not be met and concentrations of soils and groundwater contaminants would remain at unacceptable levels. Alternative B would address soil contamination at the site, but not groundwater. Alternative C would address both soil and groundwater contamination, whereas Alternatives D and E would primarily address groundwater contamination. Overall achievement of SCGs could be obtained by Alternative C, or by combining Alternative B with Alternative D or E.

2. 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.

   Alternative A offers the least protection to human health and the environment because no active remediation would be undertaken. Alternative B would offer some protection because soil contamination would be removed. Alternative C would offer the best overall protection, whereas Alternatives D and E would protect the environment by remediating groundwater contamination only.

Alternative B, in combination with Alternative D or E, would offer sufficient overall protection.

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.

   Alternative A offers no short term effectiveness. Alternative B offers good short term effectiveness for contaminated soils, but no short term effectiveness for groundwater contamination. Additionally, Alternative B may expose on-site workers and the general public to fugitive dust during the excavation process. Alternative C offers good short term effectiveness in that the majority of the contamination would be removed during the early stages of the operation. Alternatives D and E offer good short term effectiveness for groundwater contamination only.

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 controls intended to limit the risk, and 3) the reliability of these controls.

   Alternative A offers little long term effectiveness. VOCs would be bio-degraded over time, however this may increase the levels of the breakdown compounds in the soil and groundwater. Alternative B offers good long-term effectiveness for soil contamination in the excavated area, but would not have any effect on groundwater contamination. Alternative C offers good long term effectiveness for both soils and groundwater contamination. Alternatives D and E offer good long term effectiveness for groundwater contamination, but will have little effect on soil contamination.

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.

   Alternative A offers no reduction in toxicity, mobility or volume. Alternative B offers a reduction in toxicity, mobiliy and volume of soils contamination. Alternative C would reduce toxicity, mobility and volume of both soils and groundwater contamination. Alternatives D and E reduce toxicity and mobility of groundwater contamination.

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

   Alternative A requires no implementation. Due to the proximity of the site building to the area to be excavated, Alternative B would require special precautions during the excavation process. Alternatives C and E are readily implementable with only minor property access issues that would need to be addressed. Alternative D, in-well vapor stripping, requires the use of one of a small number of vendors with specialized experience. This may result in Alternative D being more difficult to implement than the other alternatives.

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

   The estimated present worth costs range from $50,000 (Alternative A) to $1,127,000 (Alternative E). Alternatives B, C and D have estimated present worth costs of $54,000, $400,000 and $630,000 respectively.

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 how the Department 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.

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