

Site: Industrial
Drawn: C.Y.
Sheet: 33591

CHAPTER 6
SITE GEOLOGY AND HYDROGEOLOGY

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CHAPTER 6
SITE GEOLOGY AND HYDROGEOLOGY

6.1 INTRODUCTION

The geologic and hydrogeologic setting of the Industri-Plex Site has been investigated by various Remedial Investigation and Feasibility Study (RI/FS) tasks, Pre-Design Investigation (PDI) tasks, the GSIP Phase I Remedial Investigation, and the on-Site Aquifer Pumping Test as discussed in Chapter 5. The following description of the geologic and hydrogeologic conditions at the Site is summarized from the data collected during those studies.

6.2 GEOLOGY

6.2.1 Regional Geology

The Site is located within a suite of metamorphic and igneous rocks which are part of the Upper Proterozoic age "Avalon" zone. The Avalon zone is a distinctive group of rocks that were accreted onto Eastern North America during the late Paleozoic (270-320 Ma) Alleghanian orogeny (Hatcher et al., 1989). The rocks underlying the Site belong to the Esmond-Dedham terrane, a part of the Avalon zone, consisting of an extensive suite of compositionally variable 600 to 650 Ma granitic plutons, a younger metamorphosed and infolded suite of Proterozoic and Cambrian age marine sediments intruded by variably alkalic Ordovician and Devonian age androgenic plutons (Gromet, 1989). The bedrock is overlain by Cenozoic age glaciogenic sediments and Recent alluvium.

The late Paleozoic orogeny imparted a strong northeasterly trending structural grain to the bedrock, including folds, foliation and faults. The Site is located between the North Boundary and the Blood Bluff fault zones which divide the Boston area into a series of northeast trending blocks. The blocks are further dissected by north-south trending faults. This structural fabric is apparent in the topographic grain consisting of ridges and valleys that follow the structures. Differential weathering and erosion of the weaker rocks along the faults produced north-south trending preglacial valleys on the bedrock surface. Glacial erosion locally modified the topography by depositing Glacial Till which is thicker in the valleys and thinner along the topographic highs. A predominant preglacial valley system in the region, which also occurs beneath the Site, is referred to as the Fresh Pond Buried Valley (Chute, 1959). Glacial retreat resulted in

fluvioglacial outwash selectively occupying and partially infilling the valley system.

6.2.2 Site Geology

Two main buried valleys are present at the Site divided by a centrally located bedrock ridge. The first buried valley is present on the eastern portion of the Site and trends in an approximately north-northeast direction. A second buried valley, formed by the confluence of two tributary valleys to the north and west, is present in the western portion of the Site, trending approximately north-northwest. These two main buried valleys converge close to the southern boundary of the Site in the vicinity of the Boston Edison Right-of-Way No. 9. The buried valleys cut across bedrock ridges and swales. As is typical of the region, the valleys are generally narrow, and are partially filled with stratified drift. The two buried valleys cutting through the Site, are part of the regional buried valley system, called the Fresh Pond Buried Valley which continues south of the Site.

Four geologic cross-sections have been drawn through different areas of the Site. The cross-section location map and the cross-sections are presented on Figures 6-1, 6-2, and 6-3. The general geologic succession at the Site is described in the following paragraphs.

6.2.2.1 Bedrock

Bedrock as mapped and described in the published literature and recovered from boreholes on-Site consists of granite gneisses, granodiorite, gabbros, nepheline syenite and an assortment of schistose and phyllitic rocks. Bedrock at the Site strikes northeast-southwest to north northeast-south southwest.

The ground surface topography generally reflects the bedrock topography. Bedrock elevations at the Site vary from less than 0 feet on the Boston Edison Right-of-Way No. 9 to between 80 and 110 feet along the northern upland for an overall relief on the top of bedrock of roughly 80 to 110 feet. Bedrock outcrops become more numerous in the northern portion of the Site. Bedrock is close to ground surface along the northern upland and in a former quarry area north of Phillips Pond between Interstate 93 and Commerce Way.

Fractures within bedrock are generally widely spaced although localized zones of intense fracturing (10 fractures or more per foot) are present within the upper 10 feet of bedrock at some locations.

6.2.2.2 Glacial Till

The bedrock is overlain by a mantle of irregularly thick and locally discontinuous Glacial Till interrupted by bedrock outcrops. The Glacial Till is typically an unsorted, poorly-graded, coarse-textured mixture of particles varying in size from clay to boulders. This is interpreted as a lodgement till which was deposited at the base of the glacier. Geologic studies (Lapham and Maevsky, 1990) report three widespread, discontinuous Glacial Till facies, the youngest of which is weakly consolidated. The older tills are well consolidated and weathered. This and other evidence point to deposition from several phases of glacial advance and retreat.

The Glacial Till is typically 5 to 10 feet thick, but beneath the stratified drift in lowlands and in the southern area of the Site, it is generally thinner or absent altogether. Bedrock ridges are commonly stripped of Glacial Till. The proportion of Glacial Till generally

increases to the north where large areas of the bedrock are covered by as much as 32 feet of till. The maximum till thickness (32 feet) was encountered in Borehole RB18 in the northeast part of the Site. Glaciofluvial erosion has left patches of Glacial Till on the sides of the buried valleys. In boreholes that penetrated the axis (deepest part) of the valleys, Glacial Till appears to have been eroded or substantially thinned and the stratified drift lies directly on top of bedrock or on a thin layer of the till. The till thickness generally increases towards the sides of the valleys. The variable thickness of the Glacial Till that occurs at the Site suggests that glacial erosion only locally altered the pre-existing topography.

6.2.2.3 Glacial Outwash Deposits

Stratified drift, consisting mainly of well to poorly sorted sand and gravel with interbedded boulders, cobbles, silt, and clay, was transported by glacial meltwater and deposited in bodies of standing water and along the preglacial valleys. Therefore, stratified drift is found chiefly in buried valleys or lowlands. Most of these sediments contain similar types of deposits that formed successively as the ice melted, such as ice-contact gravel and sand typically along valley sides (Anderson, 1989). Fine-grained deposits, predominantly clay, silt and very fine sand overlie the ice contact deposits. Coarse-grained sand and gravel of outwash and alluvium, in general, overlie the fine grained deposits. These layers of stratified drift have partially filled the large preglacial valleys resulting in the smoothing of the original topography.

The stratified drift deposits are generally less than 60 feet thick at the Site. The stratified drift encountered in the southern portion of the Site during the aquifer pumping test, was thicker, coarser, and cleaner than that previously encountered elsewhere on-Site. The stratified drift forms an unconfined (water table) aquifer at the Site. The aquifer thickness decreases to the north, east and west, where bedrock ridges are closer to the land surface and emerge from beneath the drift and dominate the landscape. The thickest part of the aquifer occurs at the axis of the confluence of the two main buried valleys along the Boston Edison Right-of-Way No. 9.

6.2.2.4 Postglacial Deposits

The postglacial or recent deposits consist of sand and silt which is interbedded with gravel, organic matter, and clay. The postglacial deposits occur in topographic low areas occupied by streams and wetlands. Postglacial deposits which were described as "peat" in PDI Task GW-1 and in the Phase I GSIP Remedial Investigation (Roux Associates et al, 1991) report are referred to as "soils with organic inclusions" in the PDI reports for Tasks S-2 and S-4. Fill occurs over much of the Site west of Commerce Way. The fill consists of silty sands, demolition debris, and chemical manufacturing wastes including animal hide residue.

6.3 SITE HYDROGEOLOGY

The stratified drift at the Site forms an unconfined aquifer which is underlain by either Glacial Till or bedrock and is generally contained within the north-northeast and north-northwest trending preglacial valleys. The stratified drift, subsequently referred to as Outwash Sand, is comprised of sands, silts, and gravel, with the dominant lithologic element being sand. Lateral facies variations are quite common within the Outwash Sand but these variations cannot be traced over great distances.

A contour map of the bottom of the unconfined aquifer is presented as Figure 6-4. Information utilized to construct the map includes RI/FS borehole data (Stauffer, 1983, 1984, 1985), PDI borehole data (Golder, 1990a, 1990b, 1990c, 1990d, 1991a, 1991d), borehole data from previous investigations at the Site (Goldberg-Zoino 1981, 1982a, 1982b, 1983), U.S. Geologic Survey topographic maps of the area (USGS, 1979 and 1985), various aerial photographs (see Reference list), bedrock outcrop locations and, most recently, borehole data from the on-Site pumping test (Golder, 1991c). A description of the previous investigations providing this information is presented in Chapter 5. Since Glacial Till is significantly less permeable than the overlying deposits and occurs as a variably thick, discontinuous mantle over the bedrock beneath the Site, the bottom of the aquifer was considered to be at the top of the Glacial Till mantle in areas where Glacial Till is present. While the Glacial Till was considerably thinner than the stratified drift in the main areas of the buried valleys, not all boreholes intercepted the entire thickness of the stratified drift. Hence, in portions of the Site, the extent of Glacial Till has not been completely defined. In areas where Glacial Till was

absent, the top of bedrock was assumed to be the bottom of the aquifer.

Topographic maps were also utilized to interpret the bottom of aquifer in the following manner. From topographic maps of the area predating recent major modifications of topography (City of Woburn, 1966), drainage lines were drawn and the stream divides and interfluvial areas were delineated. In this manner, an interpretative map of the locations of bedrock "ledges" or "ridges" that cut across the Aberjona River Valley was obtained. A large number of these bedrock ledges acted as the interfluvial areas between low order streams. It was therefore considered that bedrock would be shallow in these localities. These areas of "shallow" bedrock were confirmed from the borehole data. In this manner, a map of topographic high areas (ridges) and topographic low areas (valleys) was prepared. By utilizing available borehole data, the topographic elevation of the bottom of aquifer was determined. In areas where such control was lacking, the elevation was estimated from the topographic interpretation.

The areal extent of the unconfined aquifer is limited in an east-west direction by the presence of numerous bedrock ledges and ridges that underlie the Site and emerge to within a few feet of, or extend above, the ground surface (Figure 6-4). The bedrock elevation in these areas is also generally higher than the phreatic surface. The unconfined aquifer generally thickens along the axis of the buried valleys and is thickest (approximately 60 feet) at the southern portion of the Site where the two valleys converge. As the aquifer is traced upgradient toward the heads of the buried valleys, the thickness of the aquifer generally decreases with a corresponding increase in thickness of the Glacial Till and bedrock elevation.

Farther to the north of the Site, Glacial Till and bedrock are present at the ground surface. The aquifer extends to the northern margin of the Site as narrower bands surrounded by topographically higher bedrock/Glacial Till ridges.

The direction of groundwater flow at the Site is controlled by the geometry of the buried valleys and the glacial Outwash Sand contained therein. Consequently, the overall direction of groundwater flow is towards the south with local variations occurring as much as 90 degrees towards the east and the west. A phreatic surface contour map was produced from the most recent synoptic groundwater elevation measurements conducted on October 6 and 7, 1991 (Golder, 1991c) as shown on Figure 6-5. The depth to groundwater ranges from about 4 feet to 20 feet beneath the land surface and generally increases towards the south.

Horizontal gradients on-Site generally range from 0.002 ft/ft to 0.009 ft/ft (Figure 6-5). Horizontal gradients within the north-northeast trending valley range from 0.004 ft/ft to 0.006 ft/ft. In the tributaries of the north-northwest trending valley, horizontal gradients are higher and range from 0.008 ft/ft to 0.009 ft/ft.

Vertical hydraulic gradients within the Outwash Sand range from -0.006 ft/ft (downward) to +0.028 ft/ft (upward) (Golder, 1991c). The areal distribution of these vertical gradients appears to show some evidence of a trend with upward vertical gradients in the vicinity of Hall's Brook Holding Pond (a probable discharge zone of the unconfined aquifer) and downward vertical gradients north of the Boston Edison Right-of-Way No. 9 (a probable recharge zone of the unconfined aquifer). Small vertical gradients between the Outwash Sand and bedrock were measured in two

well clusters along the Boston Edison Right-of-Way No. 9 and were downward (-0.006 ft/ft) at one location and upward (+0.015 and +0.029) at the other location (Golder, 1991c).

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Lockwood, Kessler and Bartlett Inc., 1966 6533-7-41 through 7-43, Date April 19, 1966.

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James W. Sewall Co., 1974, K858-1-1 though 1-9, Date December 11, 1974. Scale 1"=200'.

James W. Sewall Co., 1974, K858-3-1 through 3-8, Dated December 11, 1974. Scale 1"=200'.

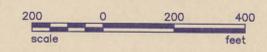
James W. Sewall Co., 1974, K761-6-4 through 6-6, Date April 7, 1974, Scale 1"=500'



LEGEND

	SITE BOUNDARY
	GRID LINE
	SOIL PILES
	STREAMS AND WATERCOURSES
	RAILROAD TRACKS
	E-5 EXTRACTION WELL INSTALLED FOR ON-SITE PUMPING TEST
	P-2S PIEZOMETER INSTALLED FOR ON-SITE PUMPING TEST
	2731 EXISTING BORING OR TEST PIT USED IN GEOLOGIC INTERPRETATION
	OW-39 EXISTING MONITORING WELL (LOCATION SURVEYED)
	OW-15 EXISTING MONITORING WELL (LOCATION UNSURVEYED)
	HIDE PILES BASED ON CONSENT DECREE
	CROSS SECTION DESIGNATION FIGURE No. WHERE CROSS SECTION IS PRESENTED

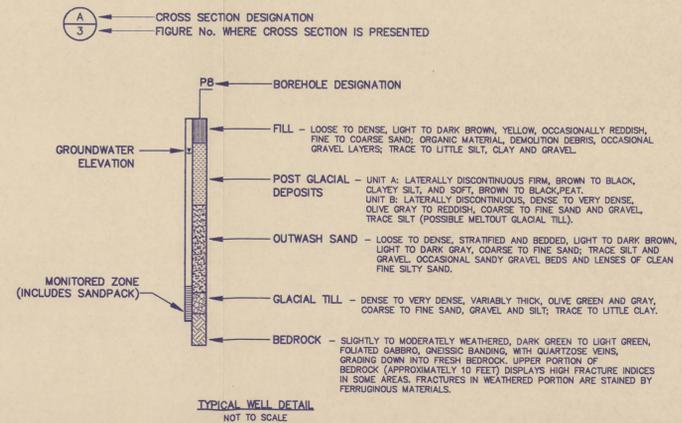
- NOTES**
- 1.) TOPOGRAPHY FROM PHOTOGRAMMETRIC MAP COMPILED BY LIU AERIAL SURVEYS 15 APRIL 90, FOR SAIC ENGINEERING, INC. AT 1 IN. TO 100 FT. AERIAL PHOTOS TAKEN 22 NOVEMBER 89, SCALE 1 IN. TO 800 FT.
 - 2.) SITE BOUNDARY SURVEY BY SAIC ENGINEERING, INC. APRIL, 1990 AND JANUARY, 1991.
 - 3.) ELEVATIONS TO NATIONAL GEODETIC VERTICAL DATUM OF 1929. GRID COORDINATES BASED ON MASSACHUSETTS COORDINATE SYSTEM.
 - 4.) TOPOGRAPHIC CONTOUR INTERVAL 2 FEET.



APR 25 1992

REV	DATE	DESCRIPTION	DR BY	RVW BY
SCALE: AS SHOWN		PROJECT: INDUSTRI-PLEX SITE REMEDIAL TRUST WOBURN, MASSACHUSETTS		
PROJECT No. 903-6400		SHEET TITLE: GEOLOGIC CROSS-SECTION LOCATION MAP		
DES BY	RMC	10/25/91		
DR BY	JSG	12/20/91		
CHK BY	KSJ	12/20/91		
RVW BY				
Golder Associates Mt. Laurel, New Jersey.		SHEET 1 OF 1 FILE No. MAD1-952 FIGURE 6-1		

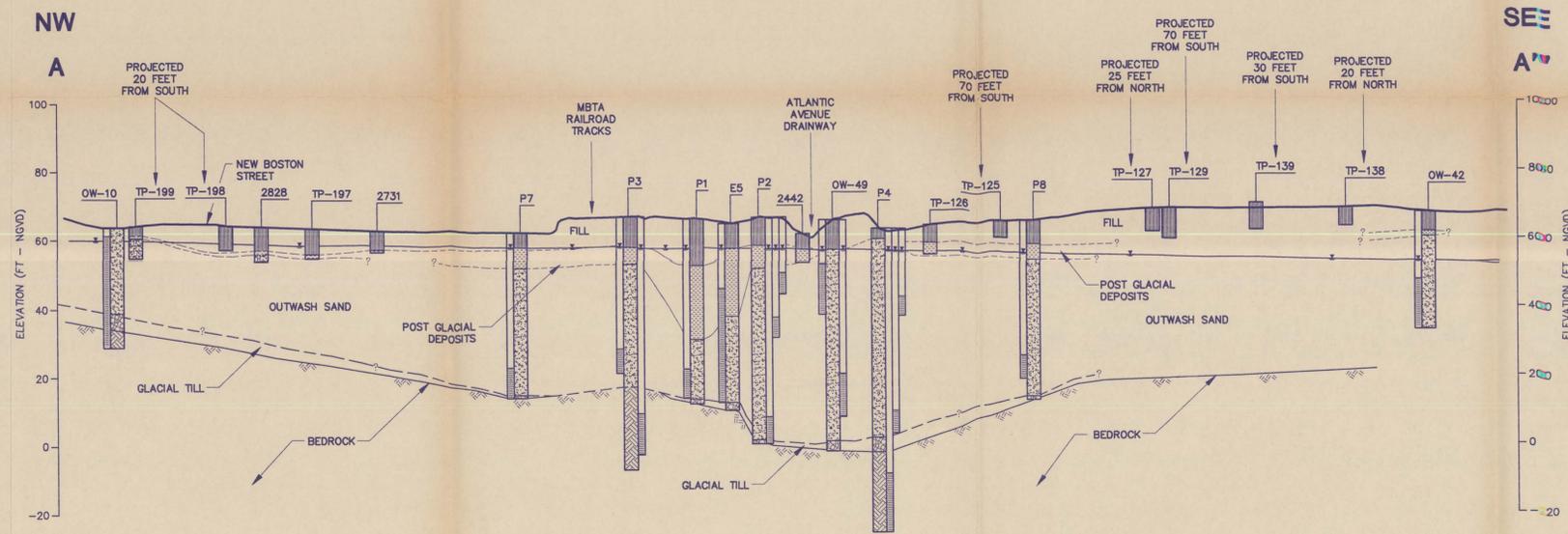
LEGEND



--- GEOLOGIC CONTACT BETWEEN UNITS IS INTERPRETED FROM, AND BASED UPON BOREHOLES LOGS. CONTACT IS DASHED AND QUERIED WHERE UNCERTAIN AND WHERE INTERPRETATION IS NOT POSSIBLE.
 --- GROUNDWATER ELEVATION

NOTES

- ELEVATIONS BASED ON NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.
- GROUNDWATER MEASUREMENTS TAKEN ON 10/06/91 TO 10/07/91.

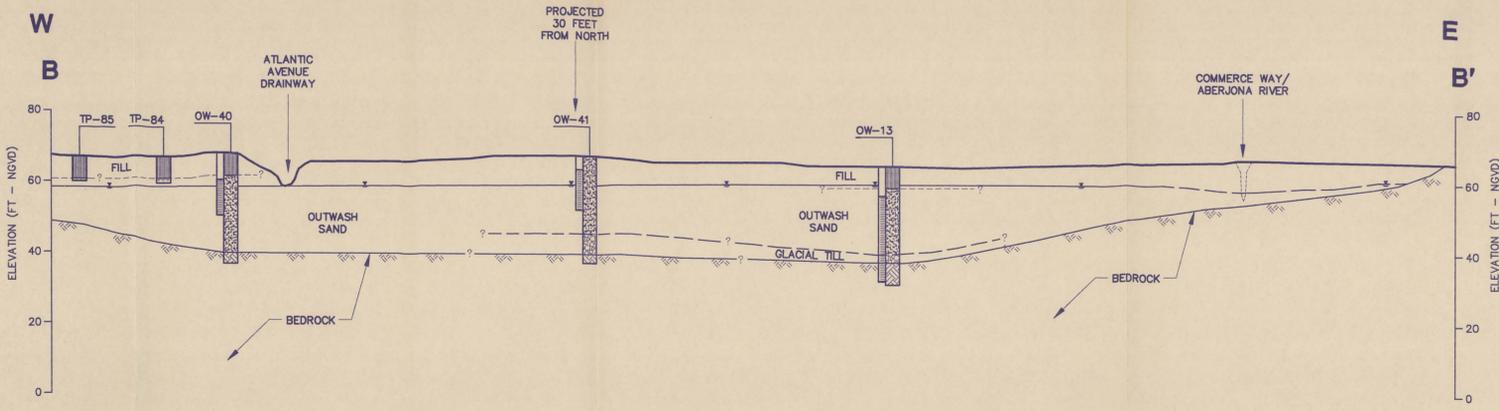


A
6-2 **CROSS SECTION A-A'**

100 0 200
 horizontal scale feet
 20 0 20 40
 vertical scale feet

APR 25 1992

REV	DATE	DESCRIPTION	DR BY	RW BY
SCALE:	AS SHOWN	PROJECT:	INDUSTRI-PLEX SITE REMEDIAL TRUST WOBURN, MASSACHUSETTS	
PROJECT No.	903-6400	DESIGNED BY:	RMG	10/28/91
DR BY:	RDH	12/20/91	SHEET TITLE:	
CHK BY:	RSW	12/20/91	GEOLOGIC CROSS SECTION A-A'	
RW BY:	RSW	12/20/91	SHEET 1 OF 2	
Golder Associates Mt. Laurel, New Jersey			FILE No. MA01-953	
			FIGURE 6-2	



B
6-3
CROSS SECTION B-B'

100 0 100 200
horizontal scale feet

20 0 20 40
vertical scale feet

LEGEND

⊙ B
4 ← CROSS SECTION DESIGNATION
FIGURE No. WHERE CROSS SECTION IS PRESENTED

PB ← BOREHOLE DESIGNATION

GROUNDWATER ELEVATION

FILL - LOOSE TO DENSE, LIGHT TO DARK BROWN, YELLOW, OCCASIONALLY REDDISH, FINE TO COARSE SAND; ORGANIC MATERIAL, DEMOLITION DEBRIS, OCCASIONAL GRAVEL LAYERS, TRACE TO LITTLE SILT, CLAY AND GRAVEL.

POST GLACIAL - UNIT A: LATERALLY DISCONTINUOUS FIRM, BROWN TO BLACK, CLAYEY SILT, AND SOFT, BROWN TO BLACK PEAT. UNIT B: LATERALLY DISCONTINUOUS, DENSE TO VERY DENSE, OLIVE GRAY TO REDDISH, COARSE TO FINE SAND AND GRAVEL, TRACE SILT (POSSIBLE MELTOUT GLACIAL TILL).

OUTWASH SAND - LOOSE TO DENSE, STRATIFIED AND BEDDED, LIGHT TO DARK BROWN, LIGHT TO DARK GRAY, COARSE TO FINE SAND; TRACE SILT AND GRAVEL, OCCASIONAL SANDY GRAVEL BEDS AND LENSES OF CLEAN FINE SILTY SAND.

GLACIAL TILL - DENSE TO VERY DENSE, VARIABLY THICK, OLIVE GREEN AND GRAY, COARSE TO FINE SAND, GRAVEL AND SILT; TRACE TO LITTLE CLAY.

BEDROCK - SLIGHTLY TO MODERATELY WEATHERED, DARK GREEN TO LIGHT GREEN, FOLIATED GABBRO, GNESSIC BANDING, WITH QUARTZOSE VEINS, GRADING DOWN INTO FRESH BEDROCK. UPPER PORTION OF BEDROCK (APPROXIMATELY 10 FEET) DISPLAYS HIGH FRACTURE INDICES IN SOME AREAS. FRACTURES IN WEATHERED PORTION ARE STAINED BY FERROUS MATERIALS.

TYPICAL WELL DETAIL
NOT TO SCALE

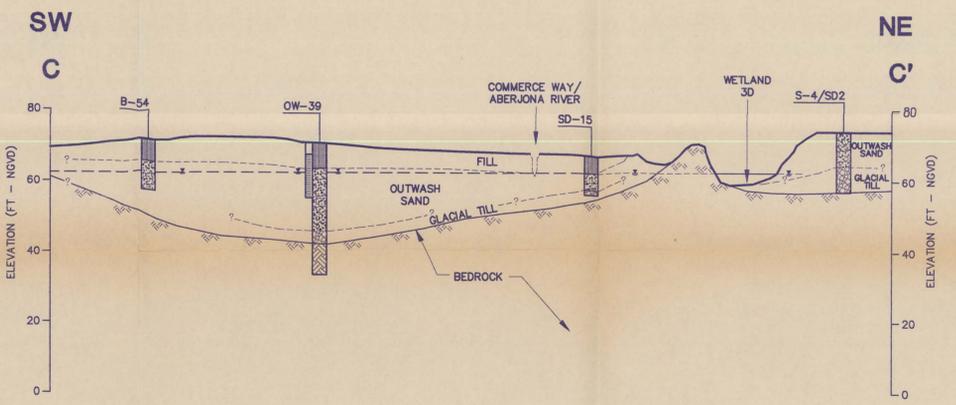
---? GEOLGIC CONTACT BETWEEN UNITS IS INTERPRETED FROM, AND BASED UPON BOREHOLES LOGS. CONTACT IS DASHED AND QUERIED WHERE UNCERTAIN AND WHERE INTERPRETATION IS NOT POSSIBLE.

— GROUNDWATER ELEVATION

NOTES

1.) ELEVATIONS BASED ON NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.

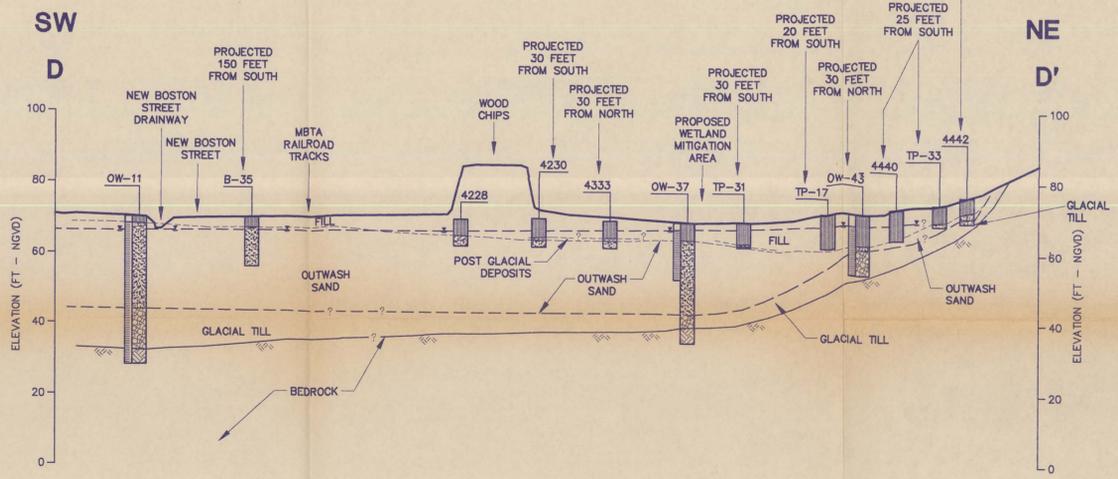
2.) GROUNDWATER MEASUREMENTS TAKEN ON 10/06/91 TO 10/07/91.



C
6-3
CROSS SECTION C-C'

100 0 100 200
horizontal scale feet

20 0 20 40
vertical scale feet



D
6-3
CROSS SECTION D-D'

100 0 100 200
horizontal scale feet

20 0 20 40
vertical scale feet

APR 20 1992

REV	DATE	DESCRIPTION	DR BY	RW BY

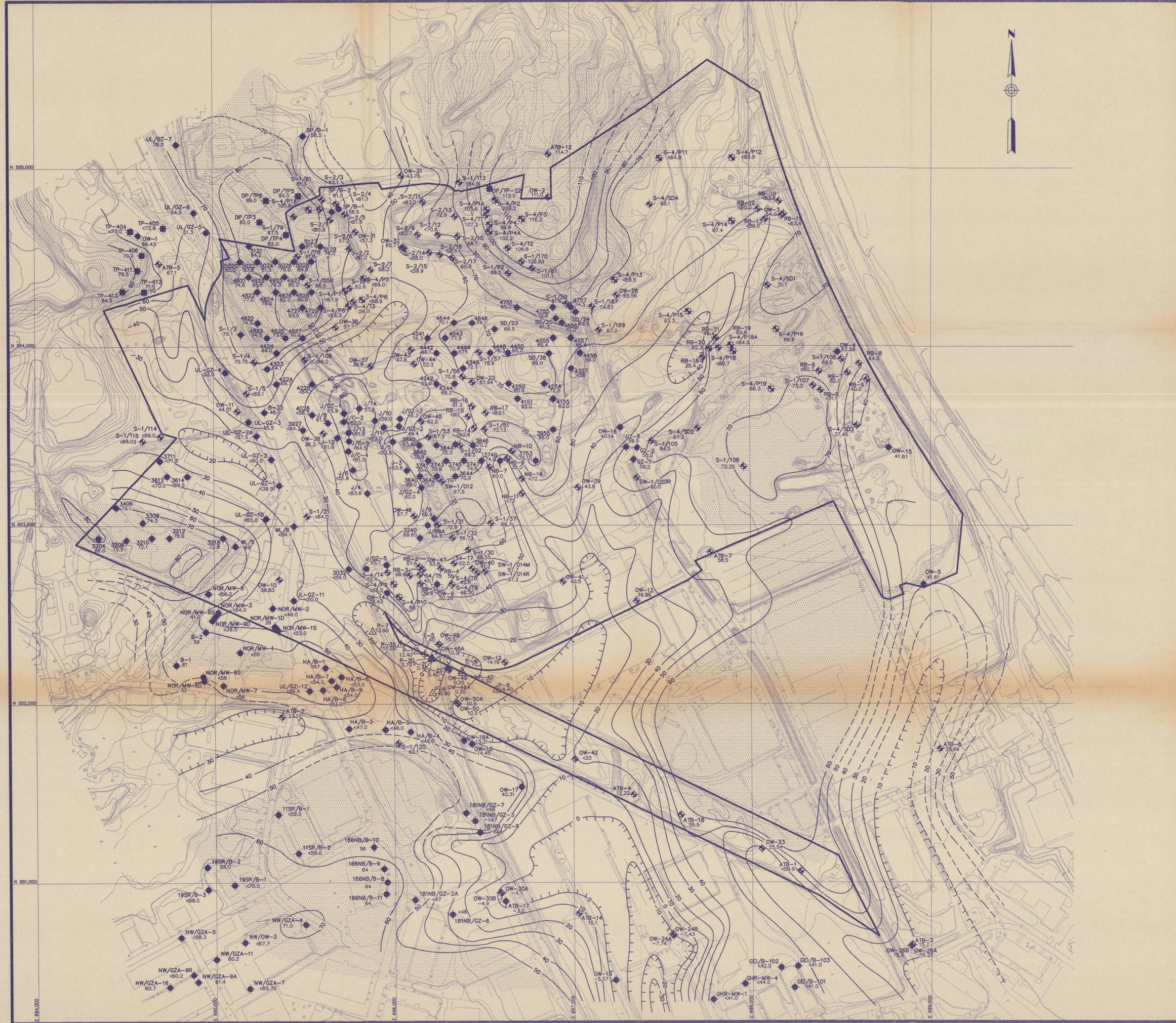
SCALE: AS SHOWN PROJECT: INDUSTRI-PLEX SITE REMEDIAL TRUST WOBURN, MASSACHUSETTS

PROJECT No. 903-8400

DES BY: RMG 10/28/91
DR BY: RDH 12/20/91
CHK BY: RSW 12/20/91
RWV BY: JCR 12-20-91

SHEET TITLE: GEOLGIC CROSS SECTIONS B-B', C-C' AND D-D'

SHEET 2 OF 2
FILE No. MA01-954
Golder Associates
Mt. Laurel, New Jersey
FIGURE 6-3



LEGEND

- SITE BOUNDARY
- GRID LINE
- SOIL PILES
- STREAMS AND WATERCOURSES
- RAILROAD TRACKS
- 50 INTERPRETED ELEVATION CONTOUR OF BOTTOM OF AQUIFER (DASHED WHERE INTERPRETATION IS TENTATIVE)
- 0 INTERPRETED DEPRESSION ELEVATION CONTOUR
- OW-40 BOREHOLE LOCATION (LOCATION SURVEYED) ELEVATION AT BOTTOM OF AQUIFER 41.2
- S-4/P2 TEST PIT LOCATION (LOCATION SURVEYED) ELEVATION AT BOTTOM OF AQUIFER 109.2
- 4622 BORE HOLE LOCATION (LOCATION UNSURVEYED) ELEVATION AT BOTTOM OF AQUIFER 74.5
- TP-404 TEST PIT LOCATION (LOCATION UNSURVEYED) ELEVATION AT BOTTOM OF AQUIFER <73.0
- P-7 PIEZOMETER INSTALLED FOR PUMPING TEST ELEVATION AT BOTTOM OF AQUIFER 13.90
- E-5 EXTRACTION WELL INSTALLED FOR PUMP TEST ELEVATION AT BOTTOM OF AQUIFER 11.40
- APPROXIMATE AREAS WHERE TOP OF GLACIAL TILL OR BEDROCK ELEVATION IS HIGHER THAN GROUNDWATER ELEVATION

- ### NOTES
- 1.) TOPOGRAPHY FROM PHOTOGRAMMETRIC MAP COMPILED BY LIU AERIAL SURVEYS APRIL 15, 1990 FOR SAIC ENGINEERING, INC. AT 1 IN. TO 100 FT. AERIAL PHOTOS TAKEN 22 NOVEMBER 89, SCALE 1 IN. TO 800 FT.
 - 2.) SITE BOUNDARY SURVEY BY SAIC ENGINEERING, INC. APRIL 1990 AND JANUARY 1991.
 - 3.) ELEVATIONS TO NATIONAL GEODETIC VERTICAL DATUM OF 1929. GRID COORDINATES BASED ON MASSACHUSETTS COORDINATE SYSTEM.
 - 4.) CONTOUR INTERVAL 10 FEET
 - 5.) THE BOTTOM OF AQUIFER WAS CONSIDERED TOP OF THE GLACIAL TILL OR TOP OF BEDROCK WHERE GLACIAL TILL WAS NOT RECORDED IN THE LOG.
 - 6.) INTERPRETED BOTTOM OF AQUIFER CONTOURS ARE BASED UPON INTERPOLATIONS BETWEEN BOREHOLE LOCATIONS AND SHOULD BE CONSIDERED APPROXIMATE ONLY. ACTUAL ELEVATIONS OF BOTTOM OF AQUIFER MAY VARY.

APR 25 1992

200 0 200 400
scale feet

REV	DATE	DESCRIPTION	DR BY	RW BY
SCALE:	AS SHOWN	PROJECT:	INDUSTRI-PLEX SITE REMEDIATION TRUST WOBUEN, MASSACHUSETTS	
PROJECT No.	903-6400	SHEET TITLE:	INTERPRETED CONTOUR MAP OF BOTTOM OF AQUIFER	
DES BY	RV	06/19/91		
DR BY	JSG	12/20/91		
CHK BY	QSL	12/20/91		
RW BY	PCR	12/20/91		
Golder Associates Mt. Laurel, New Jersey			SHEET	1 OF 1
			FILE No.	MA01-955
			FIGURE 6-4	



- ### LEGEND
- SITE BOUNDARY
 - GRID LINE
 - SOIL PILES
 - STREAMS AND WATERCOURSES
 - RAILROAD TRACKS
 - INTERPRETED GROUNDWATER ELEVATION CONTOUR (DASHED WHERE INTERPRETATION IS TENTATIVE)
 - INTERPRETED EDGE OF AQUIFER
 - PIEZOMETER INSTALLED FOR PUMPING TEST GROUNDWATER ELEVATION (OCTOBER 6 & 7, 1991)
 - MONITORING WELL (LOCATION SURVEYED) GROUNDWATER ELEVATION (OCTOBER 6 & 7, 1991)
 - MONITORING WELL (LOCATION UNSURVEYED) GROUNDWATER ELEVATION (OCTOBER 6 & 7, 1991)
 - HIDE PILES BASED ON CONSENT DECREE
 - APPROXIMATE AREAS WHERE TOP OF GLACIAL TILL OR BEDROCK ELEVATION IS HIGHER THAN GROUNDWATER ELEVATION
 - 1986 DELINEATED WETLANDS (W.M.S.)

- ### NOTES
- 1.) TOPOGRAPHY FROM PHOTOGRAMMETRIC MAP COMPILED BY LIU AERIAL SURVEYS 15 APRIL 90, FOR SAIC ENGINEERING, INC. AT 1 IN. TO 100 FT. AERIAL PHOTOS TAKEN 22 NOVEMBER 1989, SCALE 1 IN. TO 800 FT.
 - 2.) SITE BOUNDARY SURVEY BY SAIC ENGINEERING, INC. APRIL, 1990 AND JANUARY, 1991.
 - 3.) ELEVATIONS TO NATIONAL GEODETIC VERTICAL DATUM OF 1929. GRID COORDINATES BASED ON MASSACHUSETTS COORDINATE SYSTEM.
 - 4.) TOPOGRAPHIC CONTOUR INTERVAL 2 FEET.
 - 5.) GROUNDWATER ELEVATION CONTOUR INTERVAL 2 FEET.
 - 6.) GROUNDWATER ELEVATION DATA FROM WELLS SCREENED IN THE OUTWASH DEPOSITS AND ACROSS THE CONTACT BETWEEN THE OUTWASH-TILL DEPOSITS WERE USED IN THE INTERPRETATION. GROUNDWATER ELEVATION DATA FROM THE WELLS SCREENED IN BEDROCK OR TILL DEPOSITS (WITH THE EXCEPTION OF OW-1) AS WELL AS INTERMEDIATE AND DEEP PIEZOMETERS WERE NOT INCLUDED IN THE INTERPRETATION.
 - 7.) THE CONTOURS DEPICTED ON THIS DRAWING ARE INTERPRETED. ACTUAL CONDITIONS MAY VARY.

APR 25 1992

200 0 200 400
scale feet

REV	DATE	DESCRIPTION	DR BY	RW BY

SCALE: AS SHOWN		PROJECT: INDUSTRI-PLEX SITE REMEDIAL TRUST WOBURN, MASSACHUSETTS	
PROJECT No. 903-6400		SHEET TITLE: INTERPRETED PHREATIC SURFACE CONTOUR MAP 10/6/91 TO 10/7/91	
DES BY: DSL	10/29/91	DR BY: JSG	12/20/91
CHK BY: RSW	12/20/91	RW BY: JCR	12-20-91

	Golder Associates Mt. Laurel, New Jersey	SHEET 1 OF 1 FILE No. MA01-956 FIGURE 6-5
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CHAPTER 7
GROUNDWATER EXTRACTION SYSTEM

This Chapter has been deferred consistent with
instructions from the Agencies

CHAPTER 8
GROUNDWATER TREATMENT SYSTEM

This Chapter has been deferred consistent with
instructions from the Agencies

CHAPTER 9
GROUNDWATER RECHARGE SYSTEM

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CHAPTER 9
GROUNDWATER RECHARGE SYSTEM

9.1 REMEDIAL DESIGN WORK PLAN REQUIREMENTS

The Remedial Design Work Plan (RDWP; Golder, 1990) establishes that the 100% Design Report shall include the final recharge basin design, pump sizing, recharge system capacity and soil infiltration capacity.

9.2 INTRODUCTION

In accordance with the RDAP (USEPA, 1989) requirements, the recharge basin must be placed in an upgradient portion of the aquifer. Potential recharge basin locations and configurations were evaluated by weighing the following considerations:

- Thickness and hydraulic conductivity of the aquifer beneath the proposed location;
- Presence of existing structures such as buildings and roads;
- Presence of hides beneath or immediately downgradient of the recharge basin; and,
- Proximity to outcrops or areas underlain by till.

The above listed constraints limited the areas where the recharge basin could be located. However, a suitable location for the recharge basin was identified which, on the basis of the thickness and hydraulic conductivity of the aquifer, is expected to allow a reasonable amount of recharge to an upgradient portion of the aquifer. The location for the recharge basin is shown on Sheet 9-1. This location was selected due to the following favorable conditions:

- Located upstream of the extraction system;
- Located within the area of one of the plumes;
- Sufficient thickness and hydraulic conductivity of the aquifer;
- Located immediately upstream of a very large water body (Halls Brook Holding Area), therefore avoiding affecting surface water quality for wildlife support downstream;
- Limited presence of existing structures such as buildings and roads;

- Limited presence of hides immediately downstream of the recharge basin; and,
- Distance from downstream outcrops and areas underlain by till.

The recharge basin will occupy the position of an existing intermittent drainway (the Atlantic Avenue Drainway or Wetland 7C). The available surface area in the Drainway is approximately 20,000 square feet. By adding permanent flow, the functional value of the stream recharge will be enhanced and, at the same time, the effect on Wetland 7C will be minimal.

A preliminary computer simulation for the design of the groundwater extraction and recharge systems for the Site was submitted in Chapter 7 of the 60% Design Report. This analysis modelled the operation of an extraction system with the influence of the recharge basin at the selected location.

The results of the computer simulation indicated that the recharge basin in the proposed location could return 50 gpm to the groundwater system. At this rate of recharge, less than 1 foot of groundwater mounding could occur, which would not interfere with the extraction system performance.

9.3 RECHARGE BASIN DESIGN

The recharge basin will be created within the Atlantic Avenue Drainway, between Atlantic Avenue and the Boston Edison Right-of-Way No. 9. The existing drainway has a longitudinal gradient of 0.5 percent, side slopes approximately 1H:1V and a varying width of 10 feet to 40 feet. The location and layout of the recharge basin are shown on Sheet 9-1.

The drainway will function as a recharge basin by creating four 185-foot long water impoundment areas along its length. Before the impoundment areas are created, the bottom of the drainway will be excavated to remove 16 inches of sediment. Side slopes flatter than 1H:1V will also be excavated 16 inches, while side slopes steeper than 1H:1V will be excavated 16 inches at the toe and then cut to a 1H:1V slope.

The individual impoundment areas will be created by constructing four small compacted clay berms into the base of the drainway. Each clay berm will have a total thickness of 2 feet, with one foot extending above the surface of the excavated Drainway. After construction of the clay berms has been completed, a 16 inch thick gravel/cobble layer will be placed on the berms and on the excavated bottom and sides of the drainway. Underlying the gravel/cobble lining will be a 16 ounce non-woven geotextile. Details of the berms and gravel/cobble layer are shown on Sheet 9-1.

The water impoundments created will have a maximum depth of one foot along the upstream face of each clay berm. During rainfall events, the location and size of the clay berms will not interfere with the ability of the channel to safely convey storm flows. During the 100 year storm

event, which will produce an anticipated 93 cfs to this Drainway (see Chapter 10), the Drainway, which is approximately 4 feet deep, will have a stormwater flow depth of approximately 2 feet, maintaining a freeboard of 2 feet which is more than the 1 foot minimum freeboard typically required. Flow analysis for this channel is presented in Appendix 9-A and summarized in Table 9-1.

REFERENCES

Golder Associates Inc., 1990. Remedial Design Work Plan, Industri-Plex Site, Woburn, Massachusetts, July.

Golder Associates Inc., 1991. 60% Design Report, Industri-Plex Site, Woburn, Massachusetts, April.

U.S. Environmental Protection Agency, 1989. Remedial Design/Action Plan, Industri-Plex Site, Woburn, MA.

TABLE 9-1 ATLANTIC AVENUE DRAINWAY, RECHARGE BASIN, 100 YEAR STORM FLOW ANALYSIS

<i>CHANNEL</i>	<i>CHANNEL SLOPE (ft/ft)</i>	<i>BASE WIDTH (ft.)</i>	<i>SIDE SLOPE L</i>	<i>SIDE SLOPE R</i>	<i>MATERIAL</i>	<i>'n</i>	<i>DESIGN Q (cfs)</i>	<i>FLOW DEPTH (ft)</i>	<i>VELOCITY (fps)</i>
<i>ATLANTIC</i>	<i>0.005</i>	<i>10.00</i>	<i>1.0</i>	<i>1.0</i>	<i>GRAV/CBBL</i>	<i>0.031</i>	<i>93.0</i>	<i>1.84</i>	<i>4.27</i>
<i>DRAINWAY</i>	<i>0.005</i>	<i>40.00</i>	<i>1.0</i>	<i>1.0</i>	<i>GRAV/CBBL</i>	<i>0.031</i>	<i>93.0</i>	<i>0.80</i>	<i>2.85</i>

APPENDIX 9-A
100 Year Storm Flow Calculations

Golder Associates

SUBJECT 100 YR STORM ANALYSIS		
Job No. 903-6400	Made by CRM	Date 4-14-92
Rel. 100% +	Checked VEF	Sheet 1 of 2
	Reviewed JBS. BF	

OBJECTIVE DETERMINE 100 YEAR STORM EVENT DEPTH OF FLOW IN THE ATLANTIC AVENUE DRAINWAY.

METHOD USE MANNINGS EQUATION TO DETERMINE DEPTH OF FLOW. $Q = A \cdot \frac{1.486}{n} \cdot R^{4/3} \cdot S^{1/2}$
CHANNEL WIDTH VARIES FROM 10 TO 40 FEET. ANALYZE AT WIDTHS OF 10' + 40'

REFERENCES: SHEET 9-1, 100% DESIGN REPORT. FIGURE 10-9, 100% ADDENDUM 'LOTUS' SPREADSHEET (TABLE 9-1)

CALCULATION

100 YEAR Q = 93 C.F.S. (FIGURE 10-9)

$$Q = A \cdot \frac{1.486}{n} \cdot R^{4/3} \cdot S^{1/2}$$

R ⇒ Hydraulic Radius

Surface condition: Gravel/Cobble
'n' value determined using $n = 0.0395 \cdot d_{50}^{1/6}$. National Cooperative Highway Research Program, Report 108
 $d_{50} = 3''$, $n = 0.031$

ANALYZE 10" CHANNEL WIDTH

Q = 93 C.F.S.
side slope = 1:1
channel slope = 0.5%

INPUT VALUES INTO TABLE 9-1
SPREAD SHEET RESULTS: depth = 1.84'
Velocity = 4.27 FPS

**Golder
Associates**

SUBJECT 100 YEAR STORM ANALYSIS		
Job No. 903-6400	Made by CRM	Date 4-14-92
Ref. 100% +	Checked JEF	Sheet 2 of 2
	Reviewed JBS RSP	

ANALYZE 40' CHANNEL WIDTH

INPUT PREVIOUS VALUES INTO
TABLE 9-1 SPREADSHEET

RESULTS: depth = 0.80'
velocity = 2.85 f.p.s.

CONCLUSION: THE DEPTH OF THE
ATLANTIC AVENUE DRAINWAY
IS ON THE AVERAGE; 4 FEET
DEEP. WITH THIS DEPTH,
A MINIMUM OF 2' OF
FREEBOARD WILL BE
MAINTAINED

THIS EXCEEDS THE 'TYPICAL'
ONE FOOT OF FREEBOARD
REQUIREMENT