SDMS: 159625
08-0076

Corporate Environmental Programs
General Electric Company
100 Woodlawn Avenue, Pittsfield, MA 01201

Transmitted Via FedEx

November 28, 2001

Bryan Olson
EPA Project Coordinator
U.S. Environmental Protection Agency
One Congress Street, Suite 1100
Boston, MA 02214-2023

**Re: GE-Pittsfield/Housatonic River Site
Upper ½-Mile Reach Removal Action *(GECD800)*
Results of Cell J1 DNAPL Investigation and Proposal to Address
Presence of DNAPL in Cell J1**

Dear Mr. Olson:

Enclosed is a document titled *Results of Cell J1 DNAPL Investigation and Proposal to Address Presence of DNAPL in Cell J1*. This document presents the results of recent investigations and excavations to delineate the extent of dense non-aqueous phase liquid (DNAPL) encountered in Cell J1 during the Upper ½-Mile Reach Removal Action. This submittal additionally sets forth General Electric Company's (GE's) proposal and schedule for further response actions to address the DNAPL encountered in the upstream and downstream portion of Cell J1. In general, this proposal involves additional excavation and installation of a new sheetpile barrier wall and DNAPL monitoring/recovery wells.

Please feel free to call me with any questions.

Sincerely,

Andrew T. Silfer/nos

Andrew T. Silfer, P.E.
GE Project Coordinator

Enclosure

cc: R. Bell, MDEP
J. Bernstein, Bernstein, Cushner & Kimmel
J. Bieke, Shea & Gardner
M. Carroll, GE*
T. Conway, EPA
J.L. Cutler, MDEP (2 copies)
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C. Fredette, CDEP
R. Goff, USACE
N. Harper, MA AG*
H. Inglis, EPA
D. Jamros, Weston
R. McLaren, GE
S. Messur, BBL
K.C. Mitkevicius, USACE
R. Nasman, Berkshire Gas
J. Porter, Mintz, Cohn, Ferris, Glovsky & Popeo, P.C.
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Public Information Repositories ECL I-P-IV(A) (1)
GE Internal Repositories
* Cover letter only

GENERAL ELECTRIC COMPANY – PITTSFIELD, MASSACHUSETTS
UPPER ½-MILE REACH REMOVAL ACTION

RESULTS OF CELL J1 DNAPL INVESTIGATION AND PROPOSAL TO ADDRESS PRESENCE OF DNAPL IN CELL J1

I. INTRODUCTION

On October 22, 2001, during the performance of remediation activities in Cell J1, representatives of the General Electric Company (GE) visually observed a small amount of dense non-aqueous phase-liquid (DNAPL) of unknown composition in sediment in the downstream portion of that cell. The observation was reported to the National Response Center (NRC), the U.S. Environmental Protection Agency (USEPA), and the Massachusetts Department of Environmental Protection (MDEP). A sample of that DNAPL was obtained on October 26, 2001 (J1-NAPL-L1) and analyzed for polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs). The results indicated the presence of polychlorinated biphenyls (PCBs) at 83,000 parts per million (ppm), chlorinated benzenes, including chlorobenzene at 1,200 ppm, and 1,2,4-trichlorobenzene at 41,000 ppm, and polycyclic aromatic hydrocarbons (PAHs), such as acenaphthene at 8,200 ppm, anthracene at 5,000 ppm, benzo(a)anthracene at 3,200 ppm, benzo(a)pyrene at 2,500 ppm, benzo(b)fluoranthene 1,700 ppm, indeno(1,2,3-cd)pyrene at 690 ppm, naphthalene at 550 ppm, phenanthrene at 22,000 ppm, and pyrene at 14,000 ppm (see Table 1 for a complete list of detected constituents). Based on the analytical results, the chemical composition of this downstream DNAPL is indicative of a PCB/coal-tar DNAPL mixture. Following receipt of analytical results, another sample of the DNAPL present in the downstream portion of Cell J1 (J1-BERK-L1) was split with Berkshire Gas on November 2, 2001. The results further confirm the general chemical composition of this DNAPL (see Table 1 for a complete list of detected constituents).

Following discovery of DNAPL in the downstream portion of Cell J1, sediment removal activities were continued in the upstream part of Cell J1 in accordance with the Upper ½-Mile Reach Removal Action Work Plan (Work Plan) with the intent of completing those activities and then attempting to excavate the DNAPL-impacted sediments in the downstream portion of the cell. Soil and sediment removal activities (to the limits identified in the Work Plan) in Cell J1 were completed during the last week in October.

On October 31, 2001, during continuing removal activities in Cell J1, GE representatives visually observed an additional area of DNAPL of unknown composition in sediment in the upstream portion of Cell J1. The observation was reported to the NRC, EPA, and MDEP. A sample of this DNAPL was obtained on November 1, 2001 (J1-NAPL-L2) and analyzed for PCBs, VOCs, and SVOCs. The results indicated the presence of PAHs, such as acenaphthene at 170 ppm, anthracene at 660 ppm, benzo(a)anthracene at 350 ppm, benzo(a)pyrene at 260 ppm, benzo(b)fluoranthene 200 ppm, phenanthrene at 2,100 ppm, and pyrene at 1,000 ppm (see Table 1 for a complete list of detected constituents). Neither PCBs nor VOCs were detected in this sample. Based on the analytical results, the chemical composition of this upstream DNAPL is indicative of a coal-tar DNAPL.

During sediment excavation activities in Cell J1, a sewer siphon pipeline was encountered at the bottom of the excavation near midcell. This siphon provides a reference point for the distinction between the upstream coal-tar DNAPL and the downstream PCB/coal-tar DNAPL mixture.

GE, with verbal approval from the EPA, initiated excavation activities to attempt to remove the DNAPL-impacted materials. On November 2, 2001 GE first implemented an investigation program, at the request of EPA, to further delineate the extent of DNAPL-impacted materials. This investigation program included the installation of six borings, excavation of test pits, and performance of shake tests on stained soils. These investigations as well as visual observations of the presence of DNAPL were used to guide the extent of excavation in the river bottom and at the toe of the bank. These excavation activities resulted in the excavation to an approximate depth of 4 to 5 feet in the bottom of the river within the majority of Cell J1 (i.e., approximately 2 to 3 feet deeper than the initial Work Plan limits). This excavation has led to the removal of approximately 700 cubic yards (cy) of material; however, an area of DNAPL-impacted soils was still observed in the north bank of the upstream portion of the cell and the vertical limits of DNAPL-impacted materials in the river bottom both upstream and downstream of the siphon pipeline were not reached.

At the request of EPA, in an effort to determine the depth to a grey fine sand layer, which appears to be acting as a confining layer within the river bottom, and in order to determine the depth of potential additional excavation, GE installed seven additional borings in the river bottom on November 15, 2001. Between November 17 and 20, 2001, GE installed two additional soil borings at the toe of the bank to determine the depth to till for use in designing a source control barrier wall for the coal-tar DNAPL present in the bank in the upstream portion of the cell. Details pertaining to the investigation program and results of investigative borings and test pits installed in Cell J1 are discussed in Section II. Sections III and IV present GE's proposal to address the DNAPL-impacted materials. Section V provides information pertaining to proposed future monitoring activities and Section VI presents the proposed schedule.

II. SUMMARY OF DNAPL INVESTIGATION AND RESULTS

On November 2, 2001, six soil borings were installed along the riverbed within Cell J1 (J1-SB-1 through J1-SB-6) to determine the potential presence of DNAPL within Cell J1 and the potential for additional excavation activities in this area. The boring locations and visual/olfactory observations are shown on Figure 1 and the boring descriptions are included in Attachment A. Although DNAPL was identified in two of the borings, the results were inconclusive with respect to determining the extent of DNAPL (based on visual observations during excavation activities). Following the installation of the six soil borings, shake tests were performed on 3 samples (S-1 through S-3, see Figure 1) of stained soils along the north bank at the upstream portion of the cell. The results of the shake tests indicated that NAPL may be present in sample S-1 (the downstream most location). Three test pits were excavated in the bank below the shake test sample locations (see Figure 1); however, DNAPL was not observed in any of the test pits. Based on the above information, it appears that the coal-tar DNAPL present in the upstream portion of Cell J1 may have migrated there from the north bank. Additionally, some DNAPL and DNAPL-impacted materials remain in the bank and river bottom. Based on these factors, a sheetpile barrier wall is proposed for the upstream portion of Cell J1 as further discussed in Section III. Additional excavation activities in the river bottom are also proposed for the upstream portion of Cell J1 as further discussed in Section IV.

On November 14, 2001, two additional test pits were installed in the bank at the downstream portion of Cell J1 to determine whether PCB and/or coal-tar DNAPL was migrating from the north bank into the river. The locations of the test pits are shown on Figure 1. Test pit observations indicated that DNAPL was not emanating from the bank in this area. Based on visual observations during excavation, in conjunction with the test pit observations, a sheetpile barrier wall is not proposed for the downstream portion of Cell J1; however, additional excavation activities are proposed and further discussed in Section IV.

III. PROPOSED SHEETPILE BARRIER WALL INSTALLATION

The primary component of the proposed supplemental containment measure is the installation of a physical containment barrier along and parallel to a portion of the Housatonic River riverbank. Specifically, GE proposes the installation of an approximately 140-foot long steel sheetpile wall parallel to and along the edge of the river, as shown on Figure 2.

The proposed containment barrier will be constructed of a steel sheetpile wall with sealable joints. This type of steel sheetpiling has been successfully installed at several previously identified NAPL locations along this ½-Mile Reach of River: GE's Building 68 Area; East Street Area 2 – South; and as part of activities to address DNAPL in Cells G1, G2 and G3. The sheetpile wall will be constructed of Waterloo brand, heavy-wall, sealable sheetpiling (WEZ95) manufactured by Canadian Metal Rolling Mills under license to the University of Waterloo. The sheeting will be driven into place with a vibratory or impact hammer. Structural calculations regarding the long-term stability of the sheetpile wall are provided in Attachment B. These calculations show that the sheetpile wall will be stable under long-term (restored) conditions.

The location and depth of the proposed containment barrier were conservatively selected, based on visual observations following excavation activities and boring information, to include those areas (both vertically and horizontally) where coal-tar DNAPL has been identified. Once this area was determined, several other technical and operational factors were considered in the detailed design activities. These factors include possible impacts to the existing hydrogeologic conditions in the area, possible effects of future river flooding on the migration/containment of DNAPL, laboratory analytical results, historic groundwater elevations, typical river elevations, and existing bank geometry. However, the actual alignment of the containment barrier may be adjusted somewhat during construction based on actual field conditions. These field adjustments are not anticipated to be significant.

Horizontal and Vertical Extent

The horizontal extent of the proposed containment barrier is shown on Figure 2. The wall will be located parallel to the river approximately 4 feet up the bank measured horizontally from the water edge (at elevation 971.5). This location has been selected based on a review of information obtained from the recent investigation activities summarized in Section II. Using this information, the location of the proposed containment barrier was established to include known areas of DNAPL that could potentially migrate toward the river.

A wing wall angled at 45° will extend up the bank approximately 30 feet at the upstream end of the proposed barrier wall. The wing wall at the downstream end will extend up the bank approximately 20 feet, parallel to the sewer siphon. The length of the proposed containment barrier along the riverbank will be approximately 90 feet. With the addition of the wing walls, the overall length of the proposed containment barrier will be approximately 140 feet.

Several considerations were taken into account in selecting the vertical extent of the proposed containment barrier, including the results from recent investigations; historic, current, and predicted groundwater hydraulics; and geotechnical considerations. In addition, between November 17 and 20, 2001, to determine top of till elevations within the upstream portion of Cell J1, two deep borings (J1-SB-7 and J1-SB-8) were installed at the toe of the bank (see Figure 1).

Two deep boring were determined to be adequate since an existing till boring (ES2C-15) was previously installed adjacent to the western edge of observed DNAPL. The surveyed soil boring locations are shown on Figures 1 and 2. The recovered soils were continuously logged and boring logs were developed (included in Attachment A to this document). Soils were characterized with regard to the potential presence of DNAPL based on visual descriptions and/or odors. A geologic cross-section of this area has been developed and is shown on Figure 3 (with the location of that cross-section shown on Figure 2). The borings indicated that till was present at an approximate elevation ranging from 951 to 956 feet above mean sea level (AMSL) (see Figure 3 and boring logs in Attachment A).

From this information, it is anticipated that the vertical extent of the containment barrier will extend at least to the upper surface of the till unit (i.e., approximately 951 to 956 feet). The sheetpile wall will extend approximately 5 feet into the till if it is physically possible for the sheetpiling installation equipment to advance the sheetpile to this elevation.

The proposed upper elevation of the containment barrier is 975 feet. This top of sheetpile elevation was selected based on the existing bank elevations in this area. The upper elevation of the wing walls will be sloped and range between approximately elevation 975 and elevation 980 based on site topography (i.e., a minimum of two feet below final grade). However, the lower elevation of the wing walls will remain approximately 5 feet into the till.

In addition to the presence of DNAPL, groundwater hydraulics were factored into the selection of the location and configuration (e.g., vertical extent) of the proposed containment barrier. The groundwater hydraulics associated with typical hydrogeologic conditions in this area were modeled by Blasland, Bouck & Lee, Inc. (BBL) using the publicly available and well-documented MODFLOW program. This modeling effort is described and the results presented in Attachment C. The results of the modeling effort indicate that the groundwater mounding caused by the installation of the sheetpile wall would be minor (ranging from approximately 0.5 foot within 20 feet of the wall to 0.01 foot approximately 150 feet upgradient of the wall). As a result, groundwater recovery behind the wall is not anticipated. In the event that groundwater recovery becomes necessary, the modeling indicates that a pumping rate of 10 gallons per minute (gpm) would reduce the groundwater mounding effects.

IV. PROPOSED ADDITIONAL EXCAVATION

Based on the excavation and investigation activities performed within Cell J1, additional excavation activities will be performed to further address the known or potential presence of DNAPL in the upstream and downstream portions of this cell. It is anticipated that the depth of excavation will be to the grey fine sand layer that is apparently acting as a confining layer. To determine the potential depth of additional excavation, at the request of EPA, GE installed seven borings in the river bottom (on the toe of the bank) of Cell J1 (J1-SB-9 through J1-SB-15). The boring locations and visual/olfactory descriptions are shown of Figure 1 and the boring descriptions are included in Attachment A. The visual descriptions indicate that the grey fine sand layer is present less than approximately one foot below the current bottom of the excavation (with the exception of J1-SB-12 which has not been excavated to the same depth as the remainder of the cell due to its proximity to the sewer siphon). The approximate horizontal extent of initial excavation is shown on Figure 2, with the approximate maximum depth (elevation of 963 feet) shown on Figure 4 (a cross-section whose location is shown on Figure 2). To achieve this additional removal depth, excavation sheetpiling has been installed on the upstream and downstream side of the sewer siphon, and an attempt will be made to drive the existing Cell J1 centerline sheetpile deeper (to a minimum top elevation of 975 with the lift holes subsequently plugged) to provide additional structural stability. On November 21, 2001 the Remediation Contractor initiated driving the centerline sheeting deeper, however, these activities were suspended due to the occurrence of "boils" and stability concerns. To attempt to drive the centerline sheeting deeper, the cell will be flooded to relieve hydraulic pressures. Once the centerline sheetpile has been driven deeper (if possible), the cell will again be dewatered (by pumping to the treatment system) to allow work activities to continue. If the centerline sheeting cannot be driven deeper, the Remediation Contractor will install a support system (e.g., utilize tie-backs, whalers, etc.) such that excavation activities may proceed to a maximum depth of 963 feet in elevation. Following excavation activities, the 12-foot long excavation sheetpiling installed on the upstream and downstream side of the sewer siphon will remain in-place. This sheetpiling will be cut off flush with the top of the sewer siphon and the sediment located in the sheetpile webbing (between the sheetpile and the sewer siphon) will be hand excavated approximately one foot. Following hand excavation, the voids will be sealed with grout. In addition, holes will be drilled at several locations along the top of the sewer siphon to allow for injection grouting below the sewer siphon to address boils that have been occurring along side of the sewer siphon. This sheetpiling will not restrict river flow. The excavations to be conducted in the downstream and upstream portions of Cell J1 are described further below.

Downstream Portion of Cell J1

Excavation will initially be performed to a maximum depth of 5 feet or to the grey fine sand layer, based on visual observations and the results of soil borings, in the downstream portion of Cell J1. If it appears that the DNAPL-impacted materials have been removed, then the area will be restored in accordance with the requirements of the Work Plan. If it appears that additional DNAPL-impacted materials remain, then additional excavations will be performed until the maximum excavation depth has been reached. It is anticipated that the maximum excavation depth in the interior portions of the Cell J1 DNAPL area will be an elevation of 963 feet based on structural considerations. However, if the excavation becomes unsafe due to "boils", the maximum excavation depth may be further limited. The Remediation Contractor will have the responsibility for the structural stability of the excavation and will evaluate the maximum possible depth to which excavation may be performed, based on conditions observed in the field. Since there does not appear to be a significant source of DNAPL in this portion of the cell, it is not anticipated that a collection system will be required. However, in the event the maximum excavation depth has been reached and DNAPL-impacted materials remain, a protective cap and DNAPL collection system similar to the one installed in the river at East Street Area 2 – South may also be installed here.

Upstream Portion of Cell J1

Following installation of the Waterloo barrier sheetpile, excavation will initially be performed to a maximum depth of 5 feet or to the grey fine sand layer, based on visual observations and the results of soil borings, in the upstream portion of Cell J1. If it appears that the DNAPL-impacted materials have been removed, then the area will be restored in accordance with the requirements of the Work Plan. If it appears that additional DNAPL-impacted materials remain, then additional excavations will be performed until the maximum excavation depth has been reached. It is anticipated that the maximum excavation depth in the interior portions of the Cell J1 DNAPL area will be an elevation of 963 feet based on structural considerations. As in the downstream portion of the cell, if the excavation becomes unsafe due to "boils", the maximum excavation depth may be further limited. The Remediation Contractor will have the responsibility for the structural stability of the excavation and will evaluate the maximum possible depth to which excavation may be performed, based on conditions observed in the field. In the event the maximum excavation depth has been reached and DNAPL-impacted materials remain, a protective cap and DNAPL collection system may also be installed (similar to the one installed in the river at East Street Area 2 – South).

Excavated materials that are observed to contain DNAPL will be separately managed and will be subject to off-site disposal. Excavated materials that are not observed to contain DNAPL will be placed in the appropriate On-Plant Consolidation Areas (OPCAs).

Following completion of excavation activities in Cell J1, the area will be restored in a similar manner to the restoration at Cell G1. Figure 4 provides a cross-section of the proposed restoration in the upstream portion of Cell J1. To avoid potential damage that may be caused by construction-related impacts, the area in front of the proposed sheetpile wall will be restored to a minimum elevation of 967 feet prior to grouting of the sheetpile joints. Following backfill to this level, the sheetpile joints will be grouted and restoration activities will be completed.

V. PROPOSED FUTURE MONITORING ACTIVITIES

Following the installation of the proposed containment barrier and restoration of Cell J1, GE proposes to install three monitoring wells on the landward side (i.e., north) of the proposed containment barrier, as shown on Figure 2. GE proposes to install two perimeter monitoring wells at the east and west ends of the proposed containment barrier, respectively, and one monitoring well between the ends of the containment barrier. The installation of the monitoring wells will be accomplished using a truck-mounted drill rig and hollow-stem auger (HSA) methods. A standard truck-mounted 4-inch HSA will be used to install the 2-inch diameter wells. A minimum distance of 10 feet will be maintained undisturbed between the containment barrier and the edge of the auger.

During well installation, construction details and actual field measurements will be recorded by a supervising geologist and all materials used (e.g., screen and riser footage, bags of bentonite, cement, and sand) will be tabulated in a field logbook. The monitoring well will be installed using 2-inch diameter PVC risers and slotted screens with stick-up surface completions. A monitoring well construction detail will be prepared for each well following installation. The wells will be advanced to the till surface and the screens will extend above that elevation approximately 10 feet. Following well installation, the wells will be locked and the area will be restored to its existing condition. After a period of at least 24 hours following well installation, the wells will be developed using alternating surging and pumping methods. Well installation and development activities will be performed in accordance with GE's approved *Field Sampling Plan/Quality Assurance Project Plan* (FSP/QAPP).

Following well development, GE will initially monitor the perimeter wells on a weekly basis to confirm that DNAPL is not present outside the limits of the containment barrier. In addition, GE will monitor the center well on a weekly basis for the presence of DNAPL and will assess whether additional investigative or response actions are appropriate. GE anticipates that installation of these wells will be initiated within two weeks after the installation of the proposed containment barrier wall and completion of restoration activities associated with Cell J1. Also, GE will submit an evaluation of the results of the first four weekly monitoring events and the potential need for additional investigative or response actions in this area within 6 weeks following initiation of weekly monitoring of the wells. In addition, monitoring results will be included in monthly status reports for the GE-Pittsfield/Housatonic River Site.

VI. SCHEDULE

The proposed activities outlined herein will be implemented following EPA's approval of this proposal. It is anticipated that, following such EPA approval, sheetpile wall installation and restoration activities within Cell J1 will be completed within a 6 – 8 week time frame assuming that no significant unanticipated obstacles are encountered. To the extent that EPA can provide verbal approval of the described length and vertical extent of the barrier wall, the lead time associated with procuring Waterloo sheetpiling may be reduced.

Tables

TABLE 1

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS

REMOVAL ACTION - UPPER 1/2-MILE REACH OF HOUSATONIC RIVER

SUMMARY OF CELL J1 DNAPL OIL SAMPLE DATA RESULTS

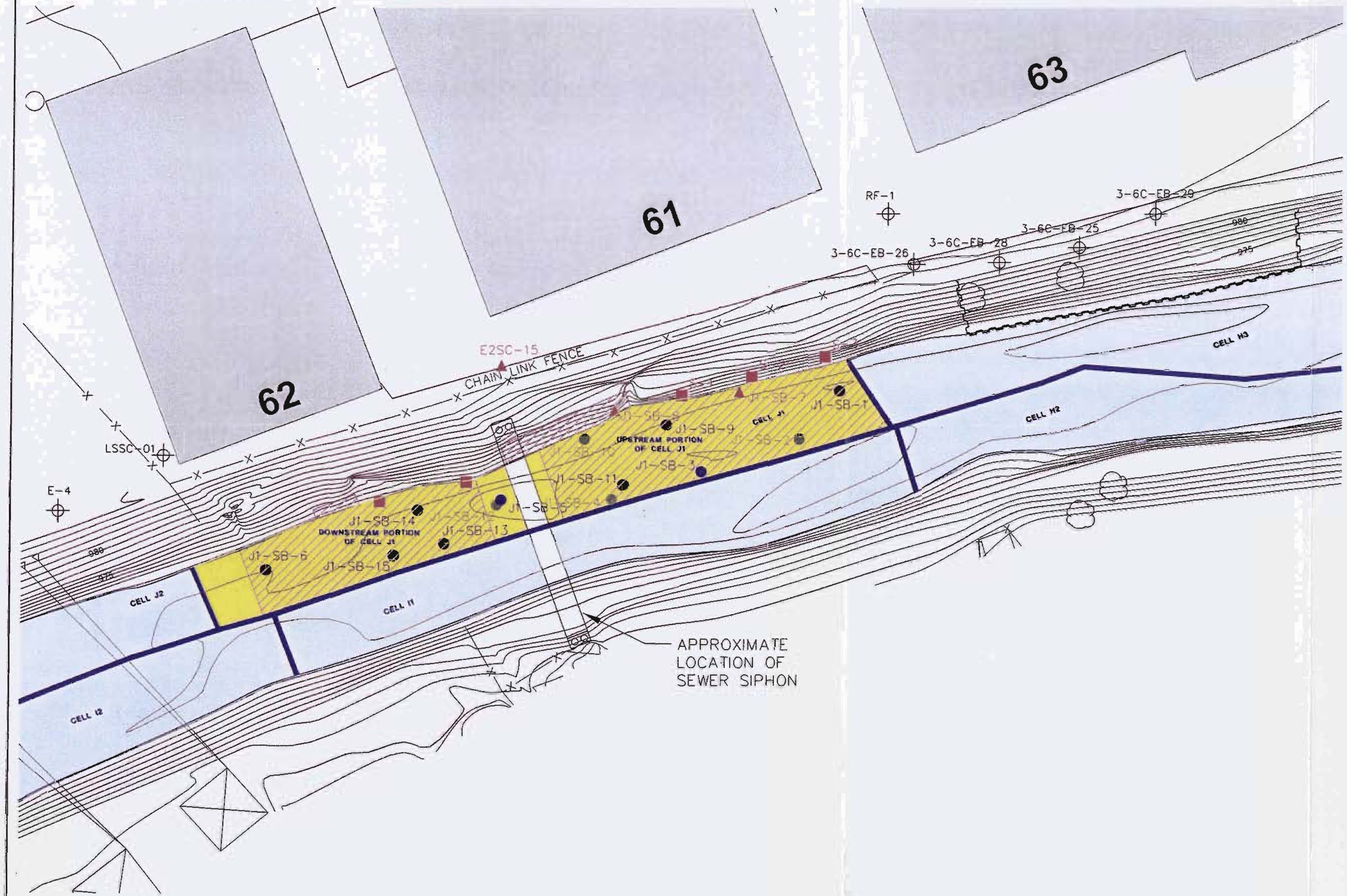
(Results are presented in parts per million, ppm)

	Downstream DNAPL		Upstream DNAPL
Sample ID:	**J1-NAPL-L1**	**J1-BERK-L1**	**J1-NAPL-L2**
Parameter Date Collected:	**10/26/01**	**11/02/01**	**11/01/01**
Volatile Organics			
Chlorobenzene	1200	710	ND
Ethylbenzene	ND	6.7	ND
m&p-Xylene	ND	6.1	ND
PCBs			
Aroclor-1260	83000	16000	ND
Total PCBs	83000	16000	ND
Semivolatile Organics			
1,2,4-Trichlorobenzene	41000	420	ND
1,2-Dichlorobenzene	520	190	ND
1,3-Dichlorobenzene	1300	1300	ND
1,4-Dichlorobenzene	21000	7900	ND
2-Methylnaphthalene	240	3600	ND
Acenaphthene	8200	14000	170
Acenaphthylene	760	1200	130
Anthracene	5000	7700	660
Benzo(a)anthracene	3200	4100	350
Benzo(a)pyrene	2500	2800	260
Benzo(b)fluoranthene	1700	2300	200
Benzo(g,h,i)perylene	910	1100	ND
Benzo(k)fluoranthene	430	730	ND
Butylbenzylphthalate	ND	170	ND
Chrysene	2200	3000	290
Dibenzo(a,h)anthracene	320	ND	ND
Dibenzofuran	540	690	ND
Fluoranthene	6200	7400	670
Fluorene	5400	8800	420
Indeno(1,2,3-cd)pyrene	690	830	ND
Naphthalene	550	3800	ND
N-Nitrosodiphenylamine	ND	ND	350
Phenanthrene	22000	29000	2100
Pyrene	14000	9800	1000

Notes:
1. Samples were collected by Blasland, Bouck & Lee, Inc. and were submitted to Northeast Analytical Services, Inc. for analysis of PCBs, volatiles and semivolatiles.
2. Only detected constituents are summarized.
3. J1-BERK-L1 was obtained as a split sample with Berkshire Gas.
4. ND - indicates constituent was not detected.

Figures

BLASLAND, BOUCK & LEE, INC. *engineers & scientists*



LEGEND:

- AREAS IN PROGRESS
- —980— GROUND SURFACE ELEVATION CONTOUR (FT.)
- EXISTING CONTAINMENT BARRIER LOCATION
- REMOVAL CELL
- SOIL BORING LOCATION
- MONITORING WELL
- TEST PIT LOCATION
- TILL BORING LOCATION
- SHEEN AND/OR STRONG ODOR
- SLIGHT ODOR AND/OR OILY LENS
- EXCAVATION BEYOND WORK PLAN LIMITS

NOTES:

1. MAPPING IS BEST AVAILABLE INFORMATION AS OF 12/10/98 BASED ON MAPPING PROVIDED BY LOCKWOOD MAPPING, INC. PREPARED FROM 1990 AERIAL PHOTOGRAPHY; DATA PROVIDED BY GENERAL ELECTRIC; AND BLASLAND AND BOUCK, P.C. CONSTRUCTION PLANS, RIVERBANK AND RIVER BED TOPOGRAPHIC INFORMATION PROVIDED BBL FROM OCTOBER 12-23, 1998 FIELD SURVEY.
2. COORDINATE GRID BASED ON 1927 STATE PLAN COORDINATES.
3. ELEVATION DATUM REFERENCED TO NGVD 1929.
4. CELL LOCATIONS AND DISTANCES ARE APPROXIMATE.

0 20' 40'
GRAPHIC SCALE

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS

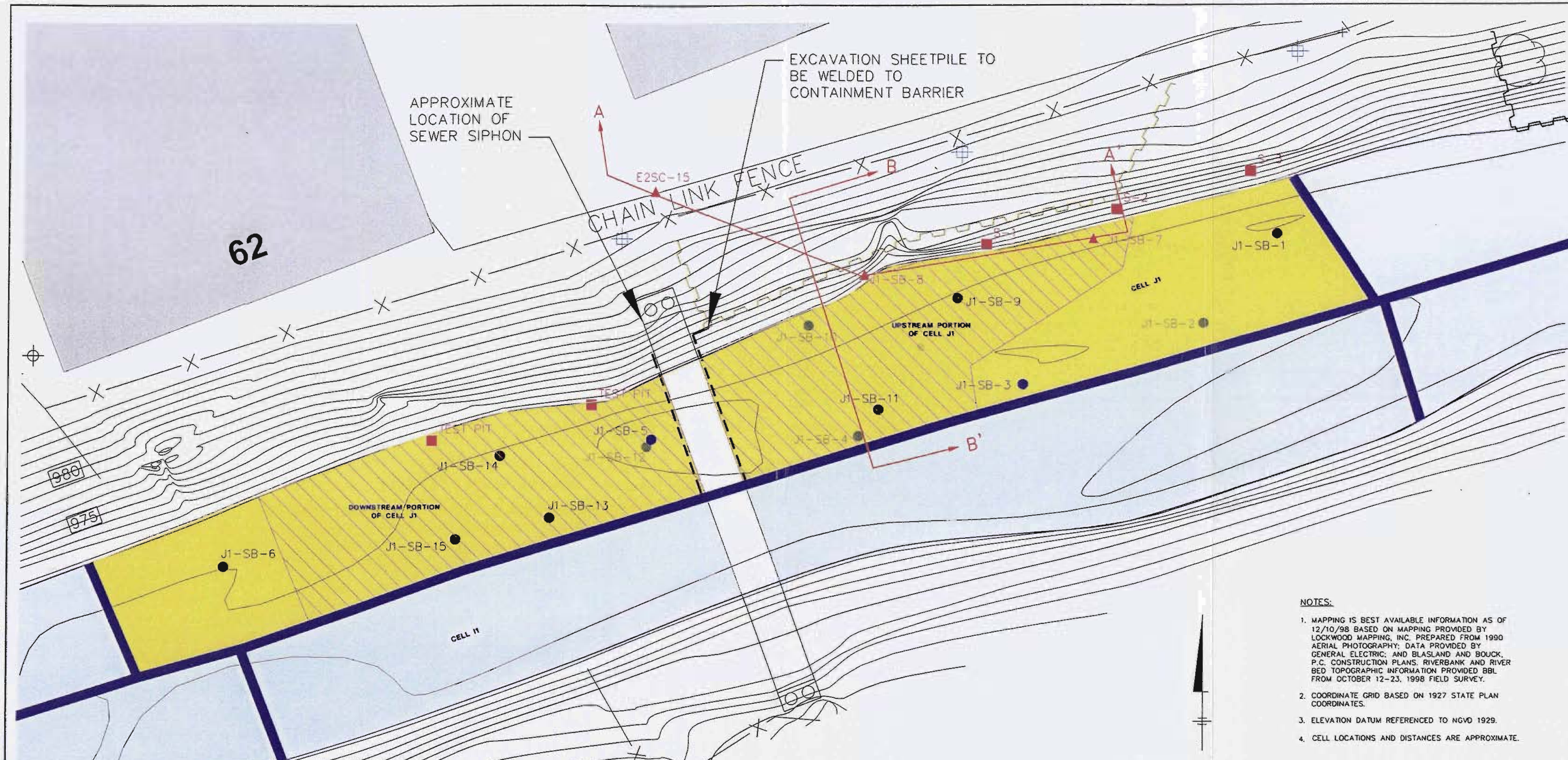
REMOVAL ACTION UPPER ½-MILE REACH OF HOUSATONIC RIVER

CELL J1
DNAPL INVESTIGATION AREA

BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
1

X: 20197X04.DWG
L: ON=*, OFF=REF
P: PAGESET/PLT-DL2B
11/28/01 SYR-54-PCL LAF LJP
20197074/20197B02.DWG



NOTES:

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2. COORDINATE GRID BASED ON 1927 STATE PLAN COORDINATES.
3. ELEVATION DATUM REFERENCED TO NGVD 1929.
4. CELL LOCATIONS AND DISTANCES ARE APPROXIMATE.

GRAPHIC SCALE: 0 10' 20'

LEGEND:

- AREAS IN PROGRESS
- —980— GROUND SURFACE ELEVATION CONTOUR (FT.)
- ADDITIONAL EXCAVATION SHEETPILE (TO REMAIN IN PLACE)
- PROPOSED CONTAINMENT BARRIER LOCATION
- EXISTING CONTAINMENT BARRIER LOCATION
- REMOVAL CELL
- A A' CROSS-SECTION LOCATON
- PROPOSED ADDITIONAL EXCAVATION
- SOIL BORING LOCATION
- MONITORING WELL
- TEST PIT LOCATION
- TILL BORING LOCATION
- SHEEN AND/OR STRONG ODOR
- SLIGHT ODOR AND/OR OILY LENS
- PROPOSED MONITORING WELL LOCATION

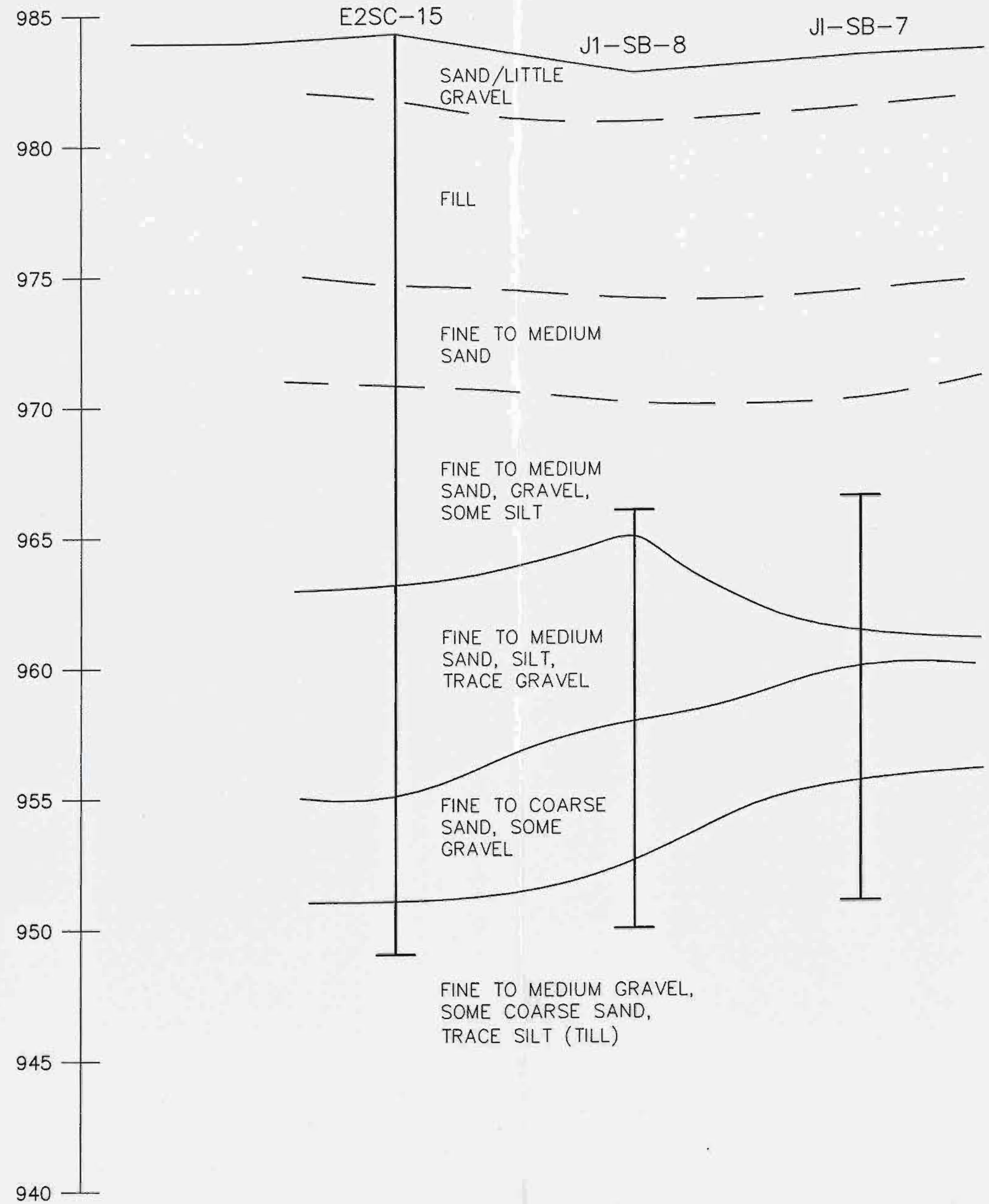
X: 20197X04.DWG
L: ON=*, OFF=REF
P: PAGESET/PLT-DL2B
11/28/01 SYR-54-POL LAF LJP
20197074/20197805.DWG

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
REMOVAL ACTION
UPPER ½-MILE REACH OF HOUSATONIC RIVER

CELL J1
DNAPL INVESTIGATION AREA - PROPOSED ACTIVITIES

BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE 2



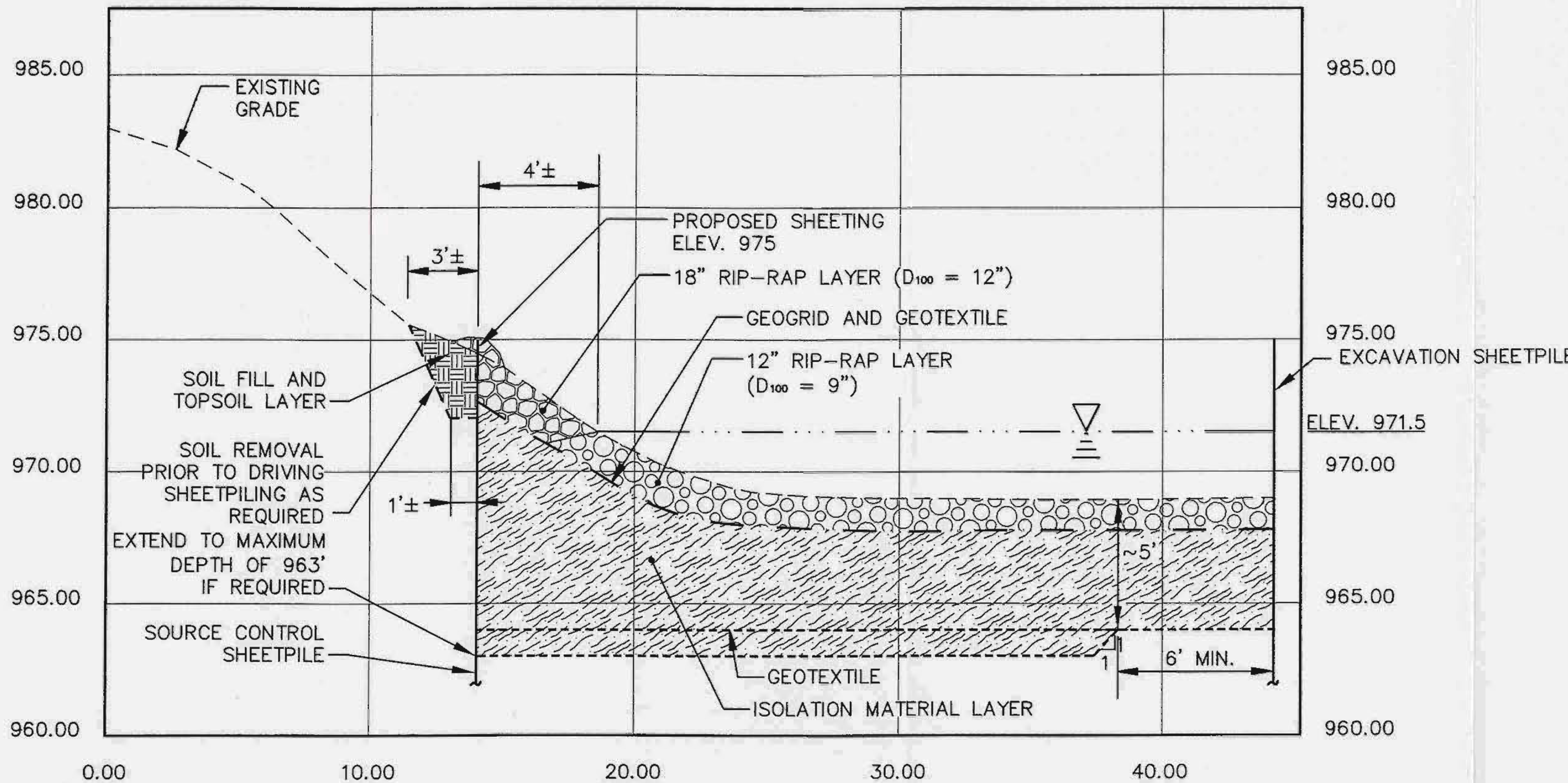
X: NONE
L: ON=*, OFF=REF
P: PAGESET/PLT-BL
11/26/01 SYR-54-LJP
20197074/20197V02.DWG

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
REMOVAL ACTION
UPPER 1/2-MILE REACH OF HOUSATONIC RIVER

GEOLOGIC CROSS-SECTION A-A'

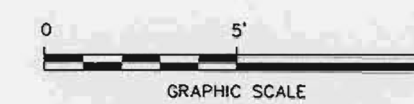
BBL
BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
3



SECTION B-B'

SCALE: HORIZ. 1"=5'
VERT. 1"=5'



GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
REMOVAL ACTION
UPPER 1/2-MILE REACH OF HOUSATONIC RIVER

RESTORATION CROSS-SECTION B-B'

BBL BLASLAND, BOUCK & LEE, INC. engineers & scientists

FIGURE
4

X: NONE
L: ON=*, OFF=REF
P: PAGESET/PLT-BL
11/21/01 SYR-54-RCB KMD LJP
20197074/20197V01.DWG

Attachments

Attachment A

BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

Soil Boring Descriptions and Logs

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
UPPER ½-MILE REACH REMOVAL ACTION

SOIL BORING DESCRIPTIONS – CELL J1

Boring ID: J1-SB-1

Date: 11/2/01
Elevation: Boring location was not surveyed
Sediment Penetrated: 4.0'
Sediment Recovered: 2.4'
Description:
0 – 0.6': grey-brown fine to coarse sand
0.6' – 1.9': brown fine sand
1.9' – 2.4': grey-brown fine to medium sand

Boring ID: J1-SB-2

Date: 11/2/01
Elevation: Boring location was not surveyed
Sediment Penetrated: 4.0'
Sediment Recovered: 2.4'
Description:
0 – 0.4': grey fine to coarse sand, strong odor
0.4' – 2.4': grey-brown fine sand, a few lens of medium sand

Boring ID: J1-SB-3

Date: 11/3/01
Elevation: Boring location was not surveyed
Sediment Penetrated: 4.0'
Sediment Recovered: 1.6'
Description:
0 – 0.4': brown fine to coarse sand
0.4' – 0.8': grey fine to medium sand, some odor
0.8' – 1.1': grey tight fine sand
1.1' – 1.6': brown fine to medium sand

Boring ID: J1-SB-4

Date: 11/3/01
Elevation: Boring location was not surveyed
Sediment Penetrated: 4.0'
Sediment Recovered: 2.5'
Description:
0 – 1.4': grey fine to coarse sand, odor, sheen visible
1.4' – 2.5': grey tight fine sand

Boring ID: J1-SB-5

Date: 11/3/01
Elevation: Boring location was not surveyed
Sediment Penetrated: 4.0'
Sediment Recovered: 1.5'
Description:
0 – 1.5': grey-brown fine to coarse sand, a small oily lens at 1.2'

Boring ID: J1-SB-6

Date: 11/3/01
Elevation: Boring location was not surveyed
Sediment Penetrated: 4.0'
Sediment Recovered: 2.2'
Description:
0 – 0.6': brown fine to coarse sand
0.6' – 2.2': grey fine sand, some lens of organic matter (wood)

Boring ID: J1-SB-9

Date: 11/15/01
Elevation: 965.60 feet
Sediment Penetrated: 4.0'
Sediment Recovered: 2.3'
Description:
0 – 0.5': grey fine sand, some gravel
0.5' – 2.3': grey fine and very fine sand (tight)

Boring ID: J1-SB-10

Date: 11/15/01
Elevation: 965.42 feet
Sediment Penetrated: 4.0'
Sediment Recovered: 1.0'
Description:
0 – 0.9': grey fine to coarse sand and gravel, very heavy oil sheen, very strong organic odor (coal-tar like)
0.9' – 1.0': grey tight fine sand, oil sheen, strong odor

Boring ID: J1-SB-11

Date: 11/15/01
Elevation: 965.33 feet
Sediment Penetrated: 4.0'
Sediment Recovered: 1.5'
Description:
0 – 0.7': grey fine to coarse sand, some gravel
0.7' – 1.2': grey tight fine sand
1.2' – 1.5': grey fine to coarse sand and gravel

Boring ID: J1-SB-12

Date: 11/15/01
Elevation: 966.62 feet
Sediment Penetrated: 6.0' (0 – 2.0' with shovel, 2.0' – 6.0' with geoprobe)
Sediment Recovered: 3.6'
Description:
0 – 2.0': grey fine to coarse sand and gravel (dug with shovel)
2.0' – 3.0': light brown fine sand, some coarse sand
3.0' – 3.3': grey-brown fine to medium sand, some gravel, oil sheen
3.3 – 3.6': grey fine sand, some medium to coarse sand, heavy oil sheen, strong odor

Boring ID: J1-SB-13

Date: 11/15/01
Elevation: 964.91 feet
Sediment Penetrated: 4.0'
Sediment Recovered: 2.3'
Description:
0 – 0.4': grey-brown fine to medium sand
0.4' – 2.3': grey tight fine and very fine sand

Boring ID: J1-SB-14

Date: 11/15/01
Elevation: 965.38 feet
Sediment Penetrated: 4.0'
Sediment Recovered: 2.2'
Description:
0 – 1.1': grey fine to medium sand with gravel
1.1' – 2.2': grey tight fine and very fine sand

Boring ID: J1-SB-15

Date: 11/15/01
Elevation: 964.94 feet
Sediment Penetrated: 4.0'
Sediment Recovered: 2.2'
Description:
0 – 1.0': grey-brown fine to coarse sand
1.0' – 2.2': grey tight fine and very fine sand

Date Start/Finish: 11/17/01 **Drilling Company:** BBL **Driller's Name:** Alex Marconi **Drilling Method:** Direct Push **Bit Size:** NA **Auger Size:** NA **Rig Type:** Jack Hammer **Sampling Method:** 4' sampler	**Northing:** NA **Easting:** NA **Casing Elevation:** NA **Borehole Depth:** 15' below grade **Surface Elevation:** 966.46' **Geologist:** Leanne Sanders	**Well/Boring ID:** HR-J1-SB-7 **Client:** General Electric Company **Location:** Housatonic River 1/2 Mile Cell J-1 Borings

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Blows / 6 Inches	N - Value	Geologic Column	Stratigraphic Description	Well/Boring Construction
0									Dark brown fine to medium SAND, some coarse Sand, little fine to medium subangular Gravel, poorly sorted, saturated.	Boring backfilled with Bentonite to grade.
	965	1	0-4	2.7	NA	NA	NA			
5									Medium brown very fine to fine SAND, little Iron-staining.	
	960	2	4-8	2.6	NA	NA	NA		Olive-brown fine to coarse SAND, little subrounded Gravel, poorly sorted, saturated.	
10		3	8-12	4.0	NA	NA	NA		Olive-brown SILT, trace coarse Sand and subrounded fine to medium Gravel, very poorly sorted. [TILL]	
	955								Olive-brown fine SAND and SILT, little coarse Sand and fine Gravel, saturated.	
		4	12-15	2.0	NA	NA	NA			
15										

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Remarks: NA = Not Available; bgs = below ground surface.

Project: 201.97.074 Template:J:/Rockware/Logplot2001/Logfiles/20197/SB_Well.ldf
Data File:HR-J1-SB-7.dat Date:11/20/01

Date Start/Finish: 11/20/01
Drilling Company: BBL
Driller's Name: JAB
Drilling Method: Direct Push
Bit Size: NA
Auger Size: NA
Rig Type: Jack Hammer
Sampling Method: 4' Macrocore

Northing: NA
Easting: NA
Casing Elevation: NA

Borehole Depth: 16' below grade
Surface Elevation: 966.05'

Geologist: Leanne Sanders

Well/Boring ID: HR-J1-SB-8

Client: General Electric Company

Location: Housatonic River 1/2 Mile
Cell J-1 Borings

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Blows / 6 Inches	N - Value	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	965	1	0-4	2.3	NA	NA	NA		Olive-brown fine to medium SAND, some coarse Sand, trace fine to medium subangular Gravel, poorly sorted, saturated.	Boring backfilled with Bentonite to grade.
									Olive-brown fine SAND and SILT interbedded, trace very dark brown layering @ 6.9' - 7.0' bgs (layered with Sands and Silts), no odor, appears to be organic in nature, saturated.	
5	960	2	4-8	4.0	NA	NA	NA			
									Olive-brown medium to coarse SAND, trace fine to medium subrounded Gravel, poorly sorted.	
									Olive-brown medium to coarse SAND, grading to coarse Sand and fine to medium subrounded Gravel, fairly well sorted, saturated.	
10	955	3	8-12	4.0	NA	NA	NA			
									Olive-brown fine to medium SAND, some coarse Sand, trace fine to medium subrounded Gravel, poorly sorted, saturated.	
15		4	12-16	3.85	NA	NA	NA		Olive-brown SILT, trace fine to medium angular to rounded Gravel, very poorly sorted. [TILL]	

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Remarks: NA = Not Available; bgs = below ground surface.

HSI GEOTRANS
A TETRA TECH COMPANY

BORING/WELL CONSTRUCTION LOG

PROJECT NUMBER P009-001
PROJECT NAME Source Control Upper Reach Housatonic River
LOCATION Pittsfield, Massachusetts
DRILLING METHOD HSA
SAMPLING METHOD SS
GROUND ELEVATION N/A
TOP OF CASING N/A
LOGGED BY MJJ
REMARKS

BORING/WELL NUMBER E2SC-15
DATE DRILLED 10/20/98
CASING TYPE/DIAMETER None
SCREEN TYPE/SLOT None
GRAVEL PACK TYPE None
GROUT TYPE/QUANTITY Portland/Volclay
DEPTH TO WATER
GROUND WATER ELEVATION

FID (ppm)	BLOW COUNTS	SAMPLE ID.	LITHOLOGIC DESCRIPTION	CONTACT DEPTH
0	3 4 6 2	SS02	Loose, Moderate olive Brown, SAND w/ little gravel, few fines(organics), dry, well graded, (SW).	3.0
	5 4 3 4	SS03	Loose, Moderate olive Brown to Dusk yellow Brown, SAND w/ little gravel, few fines, dry, coal slag fragments (SW), (Fill).	5.0
1.8	4 4	SS04	Same as above.	6.0
0	3 6 6 18	SS05	Medium dense, Dark yellowish Brown, fine SAND w/ trace fines and gravel, dry, graded, (SW), (Fill).	8.0
1.4	4 5 7 6	SS06	Similar to above except wood fragments.	10.0
0	3 4 8 9	SS07	Medium dense, Light olive Grey to Moderate olive Brown, fine SAND w/ few fines, trace organics, poorly graded, Iron staining (SP).	12.0
5	3 2 5 1	SS08	Loose, Light olive Grey, SAND w/ trace fines interbedded w/ fine - medium sand and trace organics, wet, graded, (SW).	14.0
0.2	4 6	SS09	Loose, Light olive Grey to Moderate olive Brown, sandy GRAVEL w/ trace organics, wet, well graded, sub-angular (GW-SW).	15.0
0.4	4 10	SS10	Same as above	16.0
0.2	4 8 10 13	SS11	Medium dense, Moderate olive Brown, sandy GRAVEL few fines, wet, well graded, sub-angular (GW-SW).	18.0
8.2	10 5 3 7	SS12	Top 0.6 Same as above. Bottom 0.5 loose, Light olive Grey, silty SAND, wet, poorly graded, (SP-SM).	20.0
0	4 4 4 6	SS13	Loose, Greyish Olive, silty fine SAND w/ trace clay, wet, poorly graded, laminated 1-3mm (SP-SM).	22.0
0	3 5 9 10	SS14	Top 0.6 Same as above. Bottom 0.7 Medium dense, Greyish Brown to Moderate olive Brown, medium SAND, wet, poorly graded, top of sand has grayish interval (SW)	24.0
0.4	4 6 9 11	SS15	Same as above (Bottom).	26.0
0	5 13 28 60	SS16	Top 0.9 Same as above. Bottom 0.2 Dense, Olive Grey, SAND and GRAVEL w/ trace fines, wet, well graded, sub-rounded (SW-GW).	28.0
0	6 12 26 45	SS17	Dense, Olive Grey to Moderate olive Brown, sandy GRAVEL w/ few fines, wet, well graded, sub-rounded (GW-SW).	30.0
N/A	10 28 33 34	SS18	No Recovery.	32.0
0	8 16 24	SS19	Dense, Light olive Brown, SAND w/ some silt, few gravel, wet, well graded, sub-angular, glacial outwash (SM).	34.0

Depth (ft. BGL) scale: 5, 10, 15, 20, 25, 30

WELL DIAGRAM: Portland / Volclay Grout

Continued Next Page

HSI GEOTRANS
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BORING/WELL CONSTRUCTION LOG

PROJECT NUMBER P009-001
BORING/WELL NUMBER E2SC-15
PROJECT NAME Source Control Upper Reach Housatonic River
DATE DRILLED 10/20/98

Continued from Previous Page

FID (ppm)	BLOW COUNTS	SAMPLE ID.	EXTENT	DEPTH (ft. BGL)	U.S.C.S.	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	CONTACT DEPTH	WELL DIAGRAM
0	17 17 33 66 71	SS20		35			Very dense, Light olive Brown, silty SAND w/ some gravel few clay, moist, well graded, sub-angular (SM), (Till).	36.0	

BORING_WELL GPJ HSI_MA.GDT 11/15/98

Attachment B

BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

Structural Calculations

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engineers & scientists

CALCULATION SHEET

PROJECT NO. 20197.074

CLIENT:	GE	SUBJECT:	Sheetpile Design Calculations	PREPARED BY: LKB	DATE: 11/15/01
				REVIEWED BY:	DATE:
PROJECT:	Cell J1, Upper 1/2-Mile Reach of Housatonic River				

TASK

Calculate the required embedment depth, maximum moment, and section modulus for a sheetpile wall supporting a 2 horizontal: 1 vertical (2H:1V) slope. The sheetpile wall has a top elevation of 975 feet, and the river is assumed to be at elevation 971.5 feet.

REFERENCES

1. NAVAFAC DM-7, March 1971.

2. Das, B. M. (1990). *Principles of Foundation Engineering*, 2nd Edition, PWS-Kent Publishing Company.

ASSUMPTIONS AND PARAMETERS

Soil friction angle, ϕ =	35	degree
Soil unit weight, γ =	125	pcf
Buoyant soil unit weight, γ' =	62.6	pcf
Unit weight of water =	62.4	pcf
Bank soil elevation =	975	feet
Groundwater elevation =	971.5	feet
of sediment elevation (riverside) =	969	feet

FIGURES

Figure 1 - Typical Net Pressure Diagram

ATTACHMENTS

Attachment 1 - Reference Material from References 1 and 2 listed above.

CALCULATIONS

References	Calculations		Units
	Global parameters:		
	Soil unit weight, γ	125	pcf
	Buoyant soil unit weight, γ'	62.6	pcf
	Calculate coefficient of passive pressure, Kp:		
Refer to Sheet 1, Attachment 1 (Ref. 1)	Wall friction angle, δ	14	degrees
	Soil internal friction angle, ϕ	35	degrees
	Slope angle on the riverside, β	0	degrees
Refer to Figure 6, Sheet 2, Attachment 1 (Ref. 1)	for β/ϕ	0.00	
	for δ/ϕ	-0.4	
	Reduction factor, R	0.603	
	Kp for δ/ϕ = -1	6.5	
	Therefore, Kp = R*(Kp for δ/ϕ = -1)	**3.92**	
	Calculate coefficient of active pressure, Ka:		
	Soil internal friction angle, ϕ	0.61	radians
	Slope angle for bank soil, β	0.46	radians
Refer to Sheet 1, Attachment 1 (Ref. 1)	Wall friction angle, δ	0.24	radians
Refer to Sheet 3, Attachment 1 (Ref. 1)	Slope of wall against vertical, θ	0	radians
	$ka = \cos^2\phi / \cos\delta \cdot [1 + ((\sin(\phi+\delta) \cdot \sin(\phi-\beta)/(\cos\delta \cdot \cos(-\beta)))^{0.5}]^2$	**0.37**	
Refer to Figure 1 and Sheets 4 through 11, Attachment 1 (Ref. 2)	**Active pressures and forces acting on wall:**		
	Exposed wall height, L1	6	feet
	p1= p2 = γ*L1*Ka	277.5	psf
	Location of zero net pressure, L3 = p2/(γ' *(Kp-Ka))	1.25	feet
	P = 0.5p1*L1 + 0.5p1*L3	1006	lb
	location, z1 = (0.5*(p1*L1*(L3 + L1/3) + 0.5*p1*L3*(2/3*L3))/P	2.83	feet

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CALCULATION SHEET

PROJECT NO. 20197.074

CLIENT: GE SUBJECT: Sheetpile Design Calculations PREPARED BY: LKB DATE: 11/15/01
REVIEWED BY: DATE:

PROJECT: Cell J1, Upper 1/2-Mile Reach of Housatonic River

p5 = γ*L1*Kp + γ' *L3*(Kp-Ka)	3218	psf
A1 = p5/(γ' *(Kp-Ka))	14.48	
A2 = 8*P/(γ' *(Kp - Ka))	36.21	
A3 = 6*P*(2*z1*γ' *(kp-Ka)+p5)/(γ')^2*(Kp-Ka)^2	547.04	
A4 = P*(6*z1*p5+4P)/((γ')^2*(Kp-Ka)^2)	1195.02	

L4^4 + A1*L4^3 - A2*L4^2 -A3*L4 - A4 = 0

By Trial and error:

L4	Equation for L4
7	569.05
6	-1357.14
6.8	101.87

Therefore, L4 **6.8** **feet**

Other Parameters		**Units**
p3 = L4*(Kp-Ka)*γ'	1511	psf
p4 = p5 + γ' *L4*(Kp-Ka)	4729	psf
L5 = (0.5P3L4-P)/(0.5(p3+p4))	1.32	feet

Embedment depth, D = L3+L4	8.05	feet
Sheetpile bottom elevation at FS =1	**960.95**	**feet**
Increase embedment depth by 40 percent for FS = 2.0	11.27	feet
Sheetpile bottom elevation at FS = 2.0	**957.73**	**feet**

Calculate maximum bending moment:

Location of maximum bending moment, z' = (2*P/((Kp-Ka)*γ')^0.5)	3.01	feet
Maximum bending moment, Mmax = P*(z1+z') - (0.5*γ' *(z')^2*(Kp-Ka))*1	4865	lb-ft/ft
	58380	lb-in/ft
Required Section Modulus, S = Mmax/fb	**2.34**	**in^3**

Where, fb = 25 ksi for allowable stress on σy = 36 ksi steel.

Conclusions

For a bank elevation of 975 feet, a river elevation of 971.5 feet, and a sediment elevation of 969 feet, the required toe elevation of the sheetpile wall is 961 feet for a FS=1 and 957.7 feet for a FS=2.0. Since the anticipated bottom elevation of 945 feet is lower than the required toe elevation, the design is adequate. Furthermore, since the required section modulus (2.34 in^3) is less than the modulus of WEZ95 (24.9 in^3/wall ft), the design is adequate.

Figure

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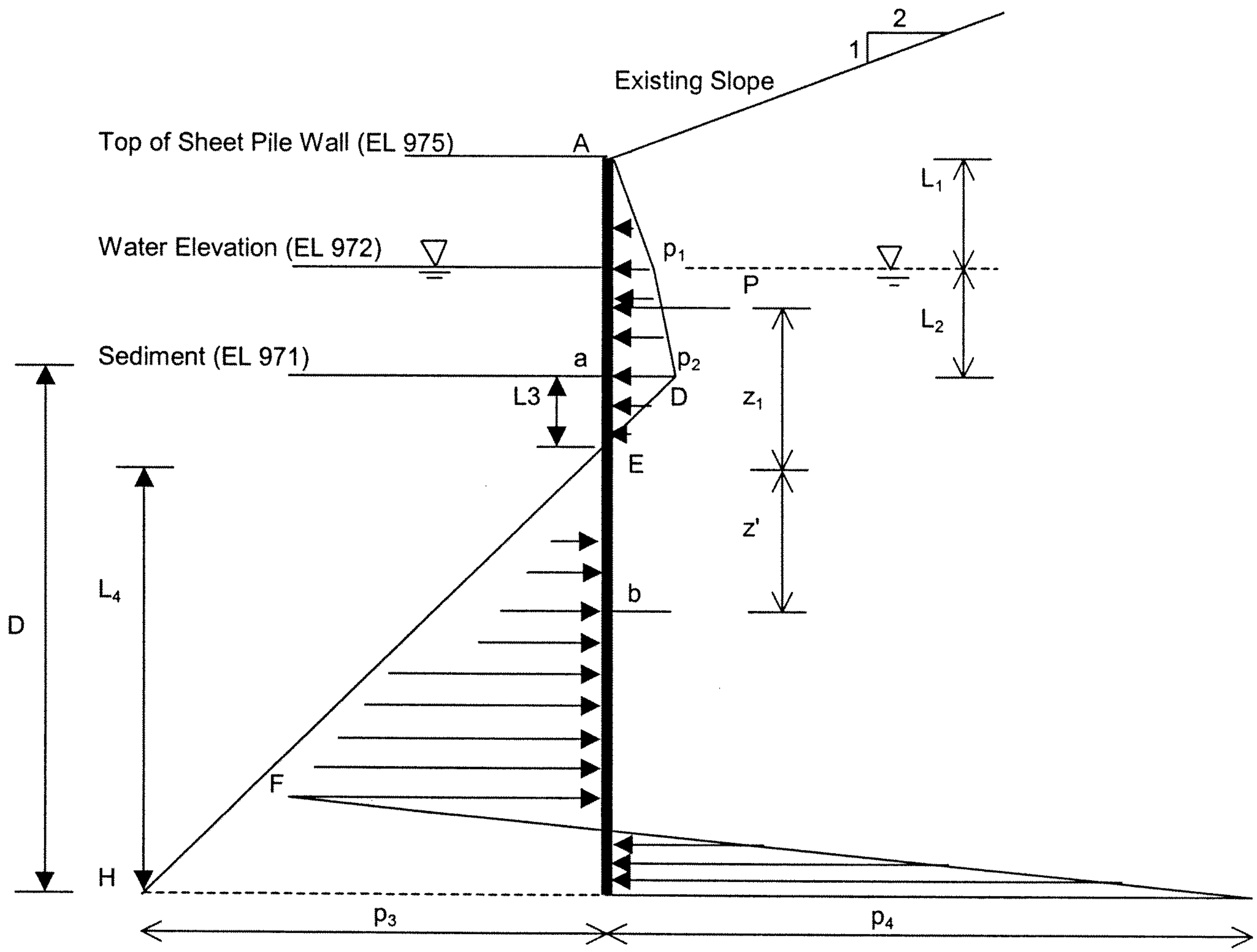


Figure 1 Typical Net Pressure Diagram for a Cantilever Sheetpile wall

NOT TO SCALE

Attachment 1

Reference Material

REF. 1

1/11

TABLE 1
Ultimate Friction Factors and Adhesion for Dissimilar Materials

Interface Materials	Friction factor, tan δ	Friction angle, δ degrees
Mass concrete on the following foundation materials:		
Clean sound rock..................................	0.70	35
Clean gravel, gravel-sand mixtures, coarse sand...	0.55 to 0.60	29 to 31
Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel....................	0.45 to 0.55	24 to 29
Clean fine sand, silty or clayey fine to medium sand..	0.35 to 0.45	19 to 24
Fine sandy silt, nonplastic silt..................	0.30 to 0.35	17 to 19
Very stiff and hard residual or preconsolidated clay..	0.40 to 0.50	22 to 26
Medium stiff and stiff clay and silty clay........	0.30 to 0.35	17 to 19
(Masonry on foundation materials has same friction factors.)		
Steel sheet piles against the following soils:		
Clean gravel, gravel-sand mixtures, well-graded rock fill with spalls..........................	0.40	22
Clean sand, silty sand-gravel mixture, single size hard rock fill................................	0.30	17
Silty sand, gravel or sand mixed with silt or clay	0.25	14
Fine sandy silt, nonplastic silt..................	0.20	11
Formed concrete or concrete sheet piling against the following soils:		
Clean gravel, gravel-sand mixture, well-graded rock fill with spalls..........................	0.40 to 0.50	22 to 26
Clean sand, silty sand-gravel mixture, single size hard rock fill................................	0.30 to 0.40	17 to 22
Silty sand, gravel or sand mixed with silt or clay	0.30	17
Fine sandy silt, nonplastic silt..................	0.25	14
Various structural materials:		
Masonry on masonry, igneous and metamorphic rocks:		
Dressed soft rock on dressed soft rock..........	0.70	35
Dressed hard rock on dressed soft rock..........	0.65	33
Dressed hard rock on dressed hard rock..........	0.55	29
Masonry on wood (cross grain).....................	0.50	26
Steel on steel at sheet pile interlocks...........	0.30	17

Interface Materials (Cohesion)	Adhesion C_a (psf)
Very soft cohesive soil (0 - 250 psf)	0 - 250
Soft cohesive soil (250 - 500 psf)	250 - 500
Medium stiff cohesive soil (500 - 1000 psf)	500 - 750
Stiff cohesive soil (1000 - 2000 psf)	750 - 950
Very stiff cohesive soil (2000 - 4000 psf)	950 - 1,300

REDUCTION FACTOR (R) OF Kp FOR VARIOUS RATIOS OF -δ/φ

φ \ δ/φ	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0.0
10	.978	.962	.946	.929	.912	.898	.881	.864
15	.961	.934	.907	.881	.854	.830	.803	.775
20	.939	.901	.862	.824	.787	.752	.716	.678
25	.912	.860	.808	.759	.711	.666	.620	.574
30	.878	.811	.746	.686	.627	.574	.520	.467
35	.836	.752	.674	.603	.536	.475	.417	.362
40	.783	.682	.592	.512	.439	.375	.316	.262
45	.718	.600	.500	.414	.339	.276	.221	.174

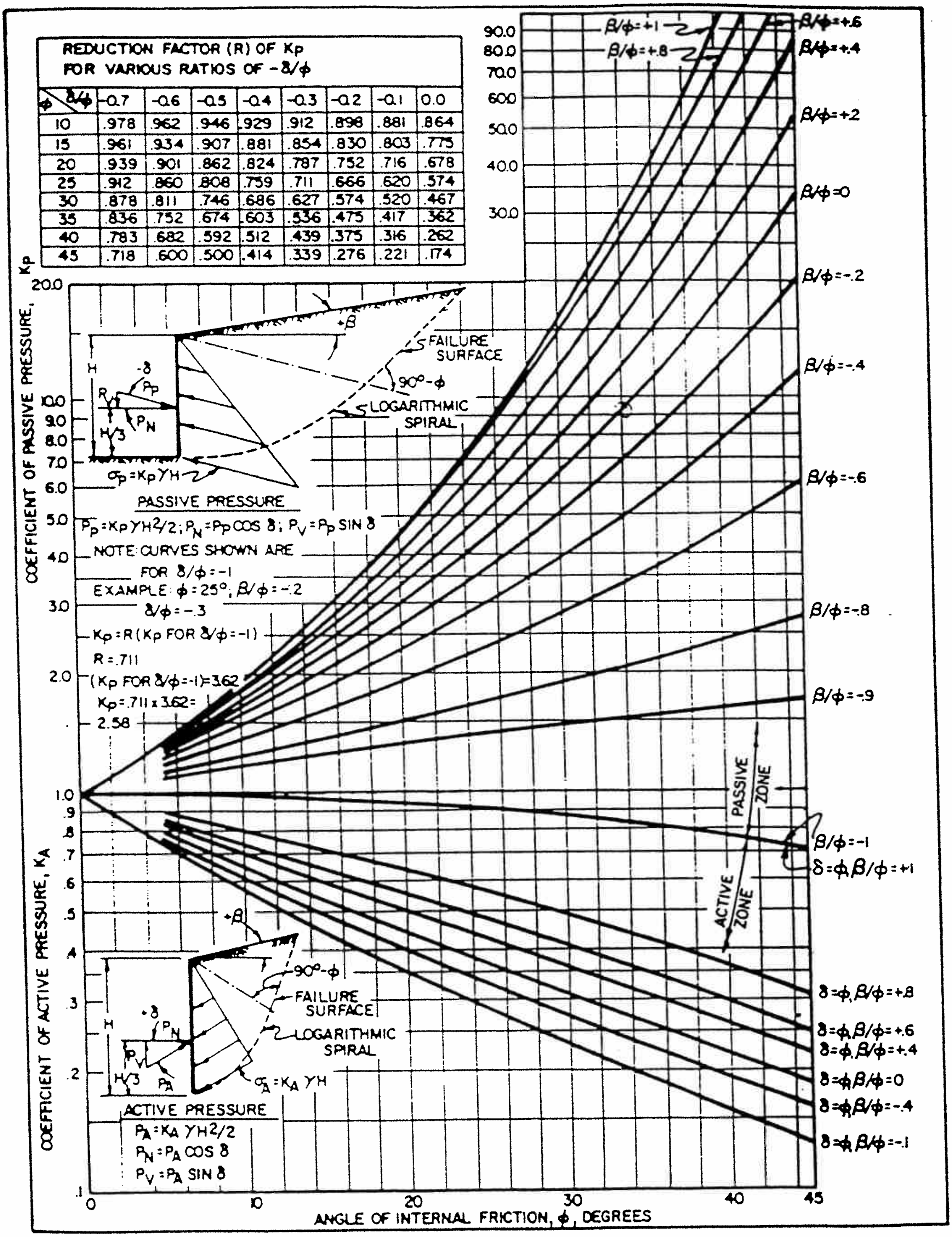


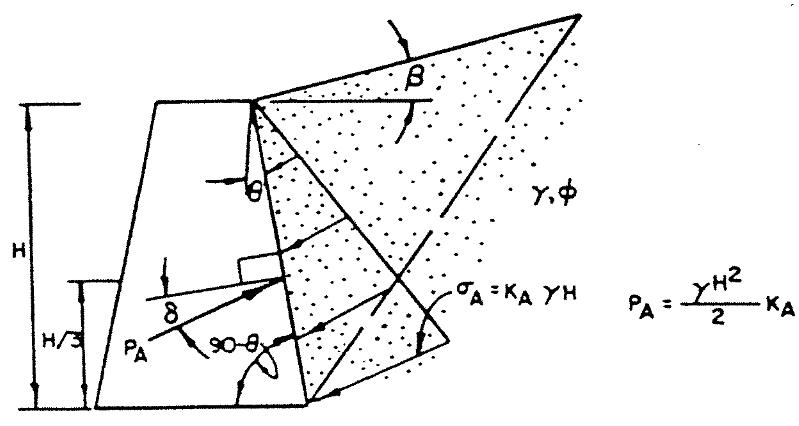
FIGURE 6

Active and Passive Coefficients with Wall Friction

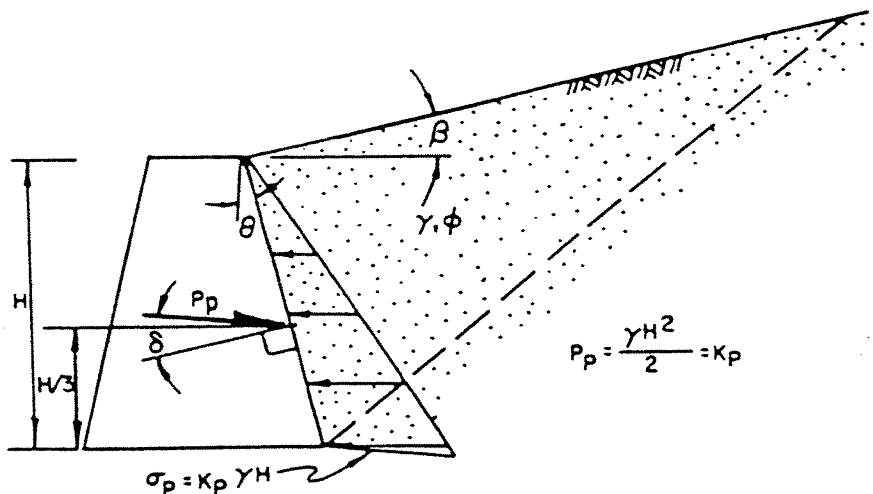
(Sloping Backfill)

REF. 1

3/11



$$K_A = \frac{\cos^2(\phi-\theta)}{\cos^2\theta \cos(\theta+\delta)\left[1+\sqrt{\frac{\sin(\phi+\delta)\sin(\phi-\beta)}{\cos(\theta+\delta)\cos(\theta-\beta)}}\right]^2}$$



$$K_p = \frac{\cos^2(\theta+\phi)}{\cos^2\theta \cos(\theta-\delta)\left[1-\sqrt{\frac{\sin(\phi+\delta)\sin(\phi+\beta)}{\cos(\theta-\delta)\cos(\theta-\beta)}}\right]^2}$$

K_p VALUES ARE SATISFACTORY FOR $\delta \leq \phi/3$ BUT ARE UNCONSERVATIVE FOR $\delta > \phi/3$ AND THEREFORE SHOULD NOT BE USED.

FIGURE 8
Coefficients K_A and K_p for Walls with Sloping Wall and Friction, and Sloping Backfill

REF. 2

4/11

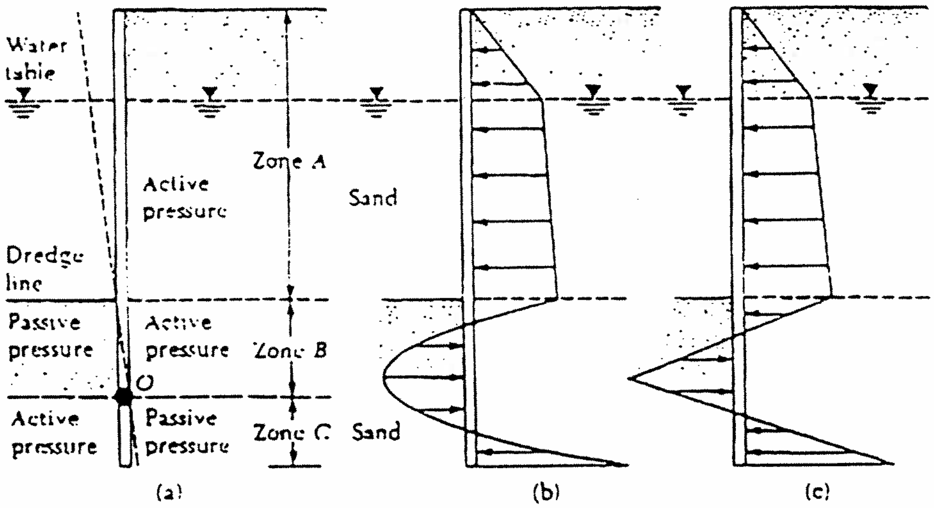


Figure 6.6 Cantilever sheet pile penetrating sand

The following sections (Sections 6.3 through 6.6) present the mathematical formulation of the analysis of cantilever sheet pile walls. Note that, in some waterfront structures, the water level may fluctuate as the result of tidal effects. Care should be taken in determining the water level that will affect the net pressure diagram.

6.3 Cantilever Sheet Piling Penetrating Sandy Soils

To develop the relationships for the proper depth of embedment of sheet piles driven into a granular soil, we refer to Figure 6.7a. The soil retained by the sheet piling above the dredge line is also sand. The water table is located at a depth of L_1 below the top of the wall. Let the angle of friction of the sand be ϕ. The intensity of the active pressure at a depth $z = L_1$ can be given as

$$p_1 = \gamma L_1 K_a \tag{6.1}$$

where K_a = Rankine active pressure coefficient = $\tan^2 (45 - \phi/2)$
γ = unit weight of soil above the water table

Similarly, the active pressure at a depth of $z = L_1 + L_2$ (that is, at the level of the dredge line) is equal to

$$p_2 = (\gamma L_1 + \gamma' L_2)K_a \tag{6.2}$$

where γ' = effective unit weight of soil = $\gamma_{sat} - \gamma_w$

Note that, at the level of the dredge line, the hydrostatic pressures from both sides of the wall are of the same magnitude and cancel each other.

REF. 2

5/11

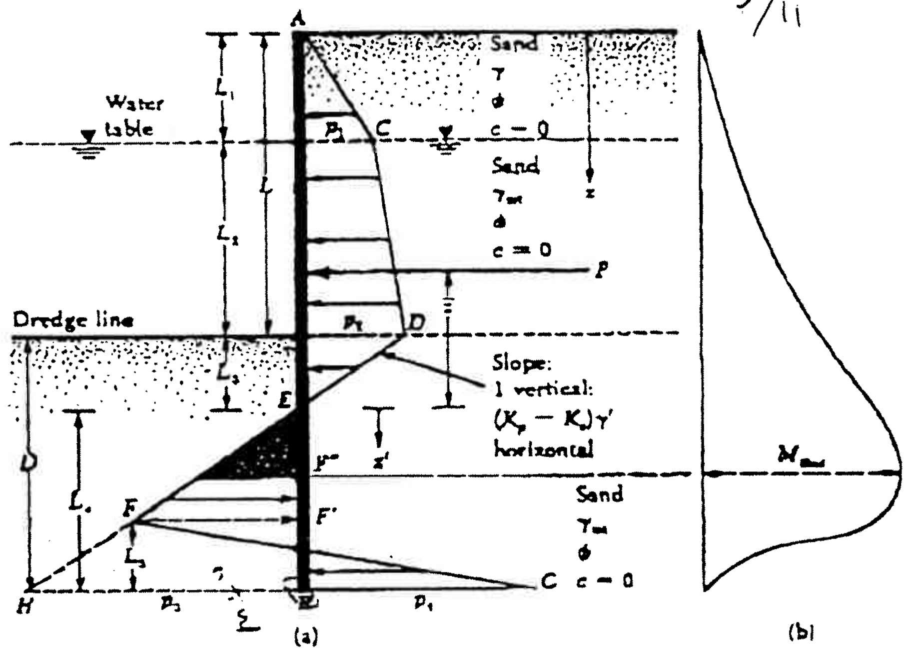


Figure 6.7 Cantilever sheet pile penetrating sand: (a) variation of net pressure diagram. (b) variation of moment

In order to determine the net lateral pressure below the dredge line up to the point of rotation O, as shown in Figure 6.6a, one has to consider the passive pressure acting from the left side (water side) toward the right side (land side) and also the active pressure acting from the right side toward the left side of the wall. For such cases, ignoring the hydrostatic pressure from both sides of the wall, the active pressure at a depth z can be given as

$$p_a = [\gamma L_1 + \gamma' L_2 + \gamma'(z - L_1 - L_2)]K_a \tag{6.3}$$

Also, the passive pressure at that depth z is equal to

$$p_p = \gamma'(z - L_1 - L_2)K_p \tag{6.4}$$

where K_p = Rankine passive pressure coefficient = $\tan^2(45 + \phi/2)$

Hence, combining Eqs. (6.3) and (6.4), the net lateral pressure can be obtained as

$$\begin{aligned} p = p_a - p_p &= (\gamma L_1 + \gamma' L_2)K_a - \gamma'(z - L_1 - L_2)(K_p - K_a) \\ &= p_2 - \gamma'(z - L)(K_p - K_a) \end{aligned} \tag{6.5}$$

where $L = L_1 + L_2$

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The net pressure, p, becomes equal to zero at a depth L_3 below the dredge line; or

$$p_2 - \gamma'(z - L)(K_p - K_a) = 0$$

or

$$(z - L) = L_3 = \frac{p_2}{\gamma'(K_p - K_a)} \qquad (6.6)$$

From the preceding equation, it is apparent that the slope of the net pressure distribution line DEF is 1 vertical to $(K_p - K_a)\gamma'$ horizontal. So, in the pressure diagram

$$\overline{HB} = p_3 = L_4(K_p - K_a)\gamma' \qquad (6.7)$$

At the bottom of the sheet pile, passive pressure (p_p) acts from the right toward the left side, and active pressure acts from the left toward the right side of the sheet pile. So, at $z = L + D$

$$p_p = (\gamma L_1 + \gamma' L_2 + \gamma' D)K_p \qquad (6.8)$$

At the same depth

$$p_a = \gamma' D K_a \qquad (6.9)$$

Hence, the net lateral pressure at the bottom of the sheet pile is equal to

$$\begin{aligned} p_p - p_a = p_4 &= (\gamma L_1 + \gamma' L_2)K_p + \gamma' D(K_p - K_a) \\ &= (\gamma L_1 + \gamma' L_2)K_p + \gamma' L_3(K_p - K_a) + \gamma' L_4(K_p - K_a) \\ &= p_5 + \gamma' L_4(K_p - K_a) \end{aligned} \qquad (6.10)$$

where $p_5 = (\gamma L_1 + \gamma' L_2)K_p + \gamma' L_3(K_p - K_a)$ (6.11)

$$D = L_3 + L_4 \qquad (6.12)$$

For the stability of the wall, the principles of statics can now be applied; or

$$\sum \text{horizontal forces per unit length of wall} = 0$$

and

$$\sum \text{moment of the forces per unit length of wall about point } B = 0$$

For summation of the horizontal forces,

area of the pressure diagram $ACDE$ − area of $EFHB$ + area of $FHBG = 0$

or

$$P - \tfrac{1}{2}p_3 L_4 + \tfrac{1}{2}L_5(p_3 + p_4) = 0 \qquad (6.13)$$

where P = area of the pressure diagram $ACDE$

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Summing the moment of all the forces about point B

$$P(L_4 + \bar{z}) - \left(\frac{1}{2} L_4 p_3\right)\left(\frac{L_4}{3}\right) + \frac{1}{2} L_5(p_3 + p_4)\left(\frac{L_5}{3}\right) = 0 \qquad (6.14)$$

From Eq. (6.13)

$$L_5 = \frac{p_3 L_4 - 2P}{p_3 + p_4} \qquad (6.15)$$

Combining Eqs. (6.7), (6.10), (6.14), and (6.15) and simplifying them further, one obtains the following fourth-degree equation in terms of L_4.

$$\boxed{L_4^4 + A_1 L_4^3 - A_2 L_4^2 - A_3 L_4 - A_4 = 0} \qquad (6.16)$$

where

$$A_1 = \frac{p_5}{\gamma'(K_p - K_a)} \qquad (6.17)$$

$$A_2 = \frac{8P}{\gamma'(K_p - K_a)} \qquad (6.18)$$

$$A_3 = \frac{6P[2\bar{z}\gamma'(K_p - K_a) + p_5]}{\gamma'^2(K_p - K_a)^2} \qquad (6.19)$$

$$A_4 = \frac{P(6\bar{z}p_5 + 4P)}{\gamma'^2(K_p - K_a)^2} \qquad (6.20)$$

Step-by-Step Procedure for Obtaining the Pressure Diagram

Based on the preceding theory, the step-by-step procedure for obtaining the pressure diagram for a cantilever sheet pile wall penetrating a granular soil is as follows:

1. Calculate K_a and K_p.
2. Calculate p_1 [Eq. (6.1)] and p_2 [Eq. (6.2)]. *Note:* L_1 and L_2 will be given.
3. Calculate L_3 [Eq. (6.6)].
4. Calculate P.
5. Calculate $\bar{z}$ (that is, the center of pressure for the area $ACDE$) by taking the moment about E.
6. Calculate p_5 [Eq. (6.11)].
7. Calculate A_1, A_2, A_3, and A_4 [Eqs. (6.17) to (6.20)].
8. Solve Eq. (6.16) by trial and error to determine L_4.
9. Calculate p_4 [Eq. (6.10)].

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10. Calculate p_5 [Eq. (6.7)].
11. Obtain L_5 from Eq. (6.15).
12. Now the pressure distribution diagram as shown in Figure 6.7a can easily be drawn.
13. Obtain the theoretical depth [Eq. (6.12)] of penetration as $L_3 + L_4$. The actual depth of penetration is increased by about 20–30%.

Note: Some designers prefer to use a factor of safety on the passive earth pressure coefficient at the beginning. In that case, in Step 1

$$K_{p(design)} = \frac{K_p}{FS}$$

where FS = factor of safety (usually between 1.5 to 2)

For this type of analysis, follow Steps 1 through 12 with the value of $K_a = \tan^2(45 - \phi/2)$ and $K_{p(design)}$ (instead of K_p). The actual depth of penetration can now be determined by adding L_3, obtained from Step 3, and L_4, obtained from Step 8.

Calculation of Maximum Bending Moment

The nature of variation of the moment diagram for a cantilever sheet pile wall is shown in Figure 6.7b. The maximum moment will occur between the points E and F'. To obtain the maximum moment (M_{max}) per unit length of the wall, one must determine the point of zero shear. Adopting a new axis z' (with origin at point E) for zero shear

$$P = \tfrac{1}{2}(z')^2(K_p - K_a)\gamma'$$

or

$$z' = \sqrt{\frac{2P}{(K_p - K_a)\gamma'}} \tag{6.21}$$

Once the point of zero shear force is determined (point F'' in Figure 6.7a), the magnitude of the maximum moment can be obtained as

$$\boxed{M_{max} = P(\bar{z} + z') - [\tfrac{1}{2}\gamma' z'^2(K_p - K_a)](\tfrac{1}{3})z'} \tag{6.22}$$

The sizing of the necessary profile of the sheet piling is then made according to the allowable flexural stress of the sheet pile material, or

$$\boxed{S = \frac{M_{max}}{\sigma_{all}}} \tag{6.23}$$

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where S = section modulus of the sheet pile required per unit length of the structure

σ_{all} = allowable flexural stress of the sheet pile

Example 6.1

Refer to Figure 6.7. For a cantilever sheet pile wall penetrating a granular soil, given: $L_1 = 2$ m, $L_2 = 3$ m. The granular soil has the following properties:

$$\phi = 32^\circ$$
$$c = 0$$
$$\gamma = 15.9 \text{ kN/m}^3$$
$$\gamma_{sat} = 19.33 \text{ kN/m}^3$$

Make the necessary calculations to determine the theoretical and actual depth of penetration. Also determine the miminum size of sheet pile (section modulus) necessary.

Solution

The step-by-step procedure given in Section 6.3 will be followed here.

Step 1

$$K_a = \tan^2\left(45 - \frac{\phi}{2}\right) = \tan^2\left(45 - \frac{32}{2}\right) = 0.307$$

$$K_p = \tan^2\left(45 + \frac{\phi}{2}\right) = 3.25$$

Step 2

$$p_1 = \gamma L_1 K_a = (15.9)(2)(0.307) = 9.763 \text{ kN/m}^2$$

$$p_2 = (\gamma L_1 + \gamma' L_2)K_a = [(15.9)(2) + (19.33 - 9.81)3]0.307$$
$$= 18.53 \text{ kN/m}^2$$

Step 3

$$L_3 = \frac{p_2}{\gamma'(K_p - K_a)} = \frac{18.53}{(19.33 - 9.81)(3.25 - 0.307)} = 0.66 \text{ m}$$

Step 4

$$P = \tfrac{1}{2}p_1L_1 + p_1L_2 + \tfrac{1}{2}(p_2 - p_1)L_2 + \tfrac{1}{2}p_2L_3$$
$$= \tfrac{1}{2}(9.763)(2) + (9.763)(3) + \tfrac{1}{2}(18.53 - 9.763)3 + \tfrac{1}{2}(18.53)(0.66)$$
$$= 9.763 + 29.289 + 13.151 + 6.115 = 58.32 \text{ kN/m}$$

Step 5. Taking the moment about E

$$\bar{z} = \frac{1}{58.32}\left[9.763\left(0.66 + 3 + \frac{2}{3}\right) + 29.289\left(0.66 + \frac{3}{2}\right) + 13.151\left(0.66 + \frac{3}{3}\right) + 6.115\left(0.66 \times \frac{2}{3}\right)\right] = 2.23 \text{ m}$$

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Step 6

$$\begin{aligned} p_5 &= (\gamma L_1 + \gamma' L_2)K_p + \gamma' L_3(K_p - K_a) \\ &= [(15.9)(2) + (19.33 - 9.81)3]3.25 + (19.33 - 9.81)(0.66)(3.25 - 0.307) \\ &= 196.17 + 18.49 = 214.66 \text{ kN/m}^2 \end{aligned}$$

Step 7

$$A_1 = \frac{p_5}{\gamma'(K_p - K_a)} = \frac{214.66}{(9.52)(2.943)} = 7.66$$

$$A_2 = \frac{8P}{\gamma'(K_p - K_a)} = \frac{(8)(58.32)}{(9.52)(2.943)} = 16.65$$

$$\begin{aligned} A_3 &= \frac{6P[2\bar{z}\gamma'(K_p - K_a) + p_5]}{\gamma'^2(K_p - K_a)^2} \\ &= \frac{(6)(58.32)[(2)(2.23)(9.52)(2.943) + 214.66]}{(9.52)^2(2.943)^2} = 151.93 \end{aligned}$$

$$\begin{aligned} A_4 &= \frac{P(6\bar{z}p_5 + 4P)}{\gamma'^2(K_p - K_a)^2} \\ &= \frac{58.32[(6)(2.23)(214.66) + (4)(58.32)]}{(9.52)^2(2.943)^2} = 230.72 \end{aligned}$$

Step 8. From Eq. (6.16)

$$L_4^4 + 7.66L_4^3 - 16.65L_4^2 - 151.39L_4 - 230.72 = 0$$

The following table shows the solution of the preceding equation by trial and error.

Assumed L_4 (m)	Left side of Eq. (6.16)
4	−356.44
5	+178.58
4.8	+36.96

So, $L_4 \approx 4.8$ m

Step 9

$$\begin{aligned} p_4 &= p_5 + \gamma' L_4(K_p - K_a) \\ &= 214.66 + (9.52)(4.8)(2.943) = 349.14 \text{ kN/m}^2 \end{aligned}$$

Step 10

$$p_3 = \gamma'(K_p - K_a)L_4 = (9.52)(2.943)(4.8) = 134.48 \text{ kN/m}^2$$

Step 11

$$L_5 = \frac{p_3 L_4 - 2P}{p_3 + p_4} = \frac{(134.48)(4.8) - 2(58.32)}{134.48 + 349.14} = 1.09 \text{ m}$$

Step 12. The net pressure distribution diagram can now be drawn, as shown in Figure 6.7a.

Step 13. The actual depth of penetration $= 1.3(L_3 + L_4) = 1.3(0.66 + 4.8) = 7.1$ m. The theoretical depth of penetration $= 0.66 + 4.8 = 5.46$ m.

REF. 2

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Size of Sheet Piling

Using Eq. (6.21)

$$z' = \sqrt{\frac{2P}{\gamma'(K_p - K_a)}} = \sqrt{\frac{(2)(58.32)}{9.52(2.943)}} = 2.04 \text{ m}$$

From Eq. (6.22)

$$M_{max} = P(\bar{z} + z') - \left[\frac{1}{2}\gamma' z'^2 (K_p - K_a)\right]\left(\frac{z'}{3}\right)$$

$$= (58.32)(2.23 + 2.04) - \frac{1}{2}(9.52)(2.04)^2(2.943)\left(\frac{2.04}{3}\right)$$

$$= 249.03 - 39.64 = 209.39 \text{ kN-m}$$

The required section modulus of the sheet pile

$$S = \frac{M_{max}}{\sigma_{all}}$$

With $\sigma_{all} = 172.5 \text{ MN/m}^2$

$$S = \frac{209.39 \text{ kN-m}}{172.5 \times 10^3 \text{ kN/m}^2} = 1.214 \times 10^{-3} \text{ m}^3\text{/m of wall}$$

6.4 Special Cases for Cantilever Wall (Penetrating a Sandy Soil)

Following are two special cases of the mathematical formulation shown in Section 6.3.

Case 1: Sheet Pile Wall with the Absence of Water Table

In the absence of the water table, the net pressure diagram on the cantilever sheet pile wall will be as shown in Figure 6.8, which is a modified version of Figure 6.7. For this figure

$$p_2 = \gamma L K_a \tag{6.24}$$

$$p_3 = L_4(K_p - K_a)\gamma \tag{6.25}$$

$$p_4 = p_5 + \gamma L_4(K_p - K_a) \tag{6.26}$$

$$p_5 = \gamma L K_p + \gamma L_3(K_p - K_a) \tag{6.27}$$

$$L_3 = \frac{p_2}{\gamma(K_p - K_a)} = \frac{LK_a}{(K_p - K_a)} \tag{6.28}$$

$$P = \tfrac{1}{2}p_2 L + \tfrac{1}{2}p_2 L_3 \tag{6.29}$$

$$\bar{z} = L_3 + \frac{L}{3} = \frac{LK_a}{K_p - K_a} + \frac{L}{3} = \frac{L(2K_a + K_p)}{3(K_p - K_a)} \tag{6.30}$$

Attachment C

BLASLAND, BOUCK & LEE, INC. *engineers & scientists*

Summary of Groundwater Modeling

GENERAL ELECTRIC COMPANY - PITTSFIELD, MASSACHUSETTS
UPPER ½-MILE REACH REMOVAL ACTION

SUMMARY OF GROUNDWATER MODELING - CELL J1

Introduction

Groundwater flow modeling was utilized to evaluate the potential for water table mounding associated with a proposed sheetpile containment wall at Cell J1 just south of Building 61. The groundwater model utilized for the Building 64W Area, Cell G2, and Cell G3 source control sheetpile containment assessments was expanded westward for this effort with some minor modifications, which are described below.

The publicly available and well-documented Visual MODFLOW™ program was used for the groundwater modeling effort (Waterloo Hydrogeologic, Inc., 1996). Visual MODFLOW™ is a proprietary pre- and post-processing program formulated to allow quick and efficient model setup and graphical presentation of model results for the MODFLOW, MODPATH, and MT3D groundwater programs. MODFLOW is a three-dimensional groundwater flow model developed by the USGS to simulate groundwater movement (McDonald, M. G. and A.W. Harbaugh, 1988). MODPATH is a three-dimensional advective particle tracking program designed for use with MODFLOW steady-state flow simulations. MODPATH was also developed by the USGS (Pollack, D. W., 1989). MT3D is a three-dimensional solute transport program developed by S. S. Papadopolus & Associates, Inc. (Zheng, C., 1992) for use with programs such as MODFLOW that accounts for advection, dispersion, and chemical reactions. For this model application, only MODFLOW and MODPATH were applied.

Model Setup

The area subject to modeling extends in a north-south direction from Silver Lake to the Housatonic River. In the east-west direction, the model extends from, and includes, the East Street Area 2 - South recharge pond westward to Lyman Street. Portions of the model grid (Figure 1) that extend beyond these model boundaries (i.e., south of the Housatonic River) are set as inactive and are not incorporated in the model calculations. The model grid is designed with 170 rows and 260 columns and 4 layers.

Horizontally, the grid spacing is a uniform 10 feet in the X and Y directions. Vertically (Z direction), each model layer is 8 feet thick (Figure 2). There is no differentiation among the different geologic deposits encountered above the till. Since the till has a substantially lower hydraulic conductivity than the overlying fill and alluvium, the top of till surface has been modeled as the impermeable base of the model. For much of the model domain, this impermeable surface is the base of Model Layer 4, which was set at an elevation of 955 feet. In the vicinity of the Cell J1, the base of the model is the bottom of Model Layer 4, which was set at an elevation of 955 feet. In the northern and east central portion of the model domain (where the top of till is observed at higher elevations), this impermeable till surface is the base of Model Layer 2, which was set at an elevation of 963 feet.

The input data required for the model include stratigraphic, groundwater elevations, and hydraulic properties for each layer; estimates regarding the amount of water entering and leaving the hydrogeologic system; and the description of the model boundary conditions. Except for the model layering, the input data remained identical to that used in the Building 64W source control model. Much of this input was duplicated from the East Street Area 2 - South model and the Lyman Street Area model, and supplemented with data from borings and monitoring wells within the modeled area.

Based on the East Street Area 2 - South model, and site geologic logs, the top of till is a sloping surface (from north to south), with till elevations range from 930.0 feet amsl along the Housatonic River to 970 feet amsl closer to East Street. A sloping till surface was not used in this model due to the lack of sensitivity to a sloping till surface that was demonstrated in the East Street Area 2 - South model. However, as indicated above, portions of Model Layers 3 and 4 were not activated (made impermeable) in those areas where the observed till elevation was greater than the elevation of the top of the applicable model layer.

The horizontal hydraulic conductivity for all the saturated overburden materials above the till was set to 2 x 10^{-2} cm/sec (56.7 feet/day) and the vertical hydraulic conductivity was set 10 times less. This approach and hydraulic conductivity values were the same as used in the East Street Area 2 - South model. The model boundary conditions include precipitation recharge, the Housatonic River, the groundwater recharge pond, the till confining layer, and regional groundwater flow lines.

Recharge due to precipitation was set to 10 inches per year based on the previous modeling efforts. The eastern and western model boundaries were impermeable or 'no flow' boundaries presumed to correspond with groundwater flow lines. The till also was modeled as a no flow boundary on the bottom and northern side wall of model. Constant heads were used to represent the Housatonic River with the river stage held constant at 971.6 feet amsl all along the southern edge of the model, which was the high stage value used in the Lyman Street model prepared by HSI GeoTrans (1999). Constant heads were also set along the northern model boundary in Layer 1 to allow upgradient inflow of groundwater. This line of constant heads was set north of East Street at values varying linearly from 985 to 995 feet amsl. The recharge pond was simulated with a higher permeability pond bottom. The elevation of the recharge pond was set to 983.0 feet amsl and the bottom of recharge pond (set as 3 feet thick) was assigned a conductance value of 50 $feet^2$/day. Silver Lake was added to the model, since the model now extends farther west. The elevation of Silver Lake was set at 976.5 feet and the bottom of the lake (set as 2.5 feet thick) was assigned a conductance value of 50 $feet^2$/day.

Additional boundary features incorporated into the model include the existing recovery wells and the proposed sheetpile wall. The wall was set at the location shown on the site map. The wells included in the model and the pumping rates used for each well are as follows:

Well ID	Pumping Rate
64S	25 gpm
RW-1(S)	20 gpm
RW-1(X), RW-2(X), 64X(W) combined	20 gpm

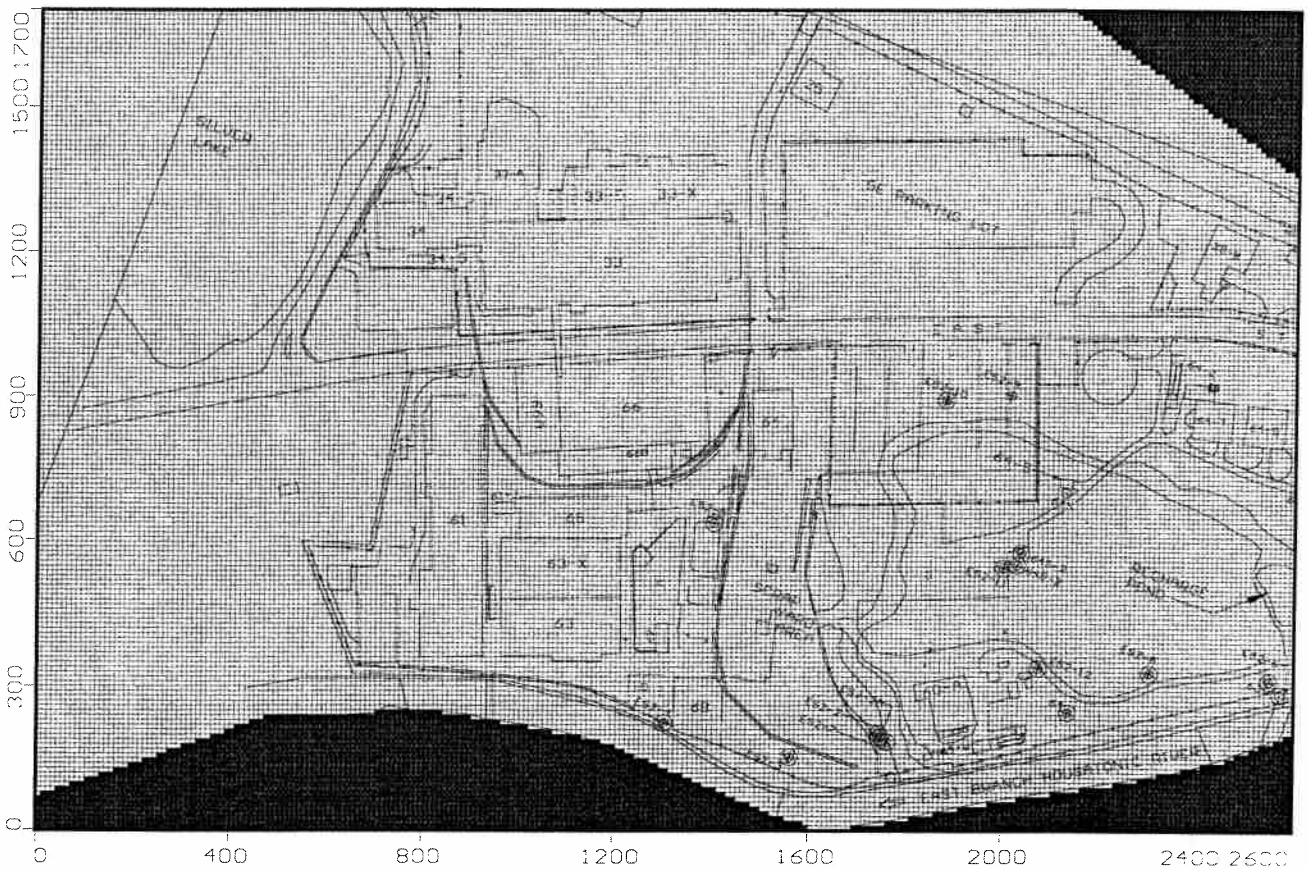
The actual pumping rates for RW-1(X), RW-2(X), 64X(W) were combined and then half that amount was input into the model (assuming symmetry) as a single well since these recovery wells are all along the model's eastern boundary. Standard vertical tubular well designs were used for all the pumping wells.

The proposed sheetpile wall was incorporated with the MODFLOW wall option. The sheetpile wall was placed across Model Layers 1 through 4, and wing walls were incorporated (Figure 3). The width of the sheetpile wall was 0.021 feet (0.25 inches) and the hydraulic conductivity was set at 1 x 10^{-9} cm/sec (0.00000284 feet/day).

Calibration of the model was performed during previous modeling efforts. Additional calibration was also performed for this application since this model was expanded westward. Basically, the conductance of Silver Lake was adjusted until groundwater elevations between Silver Lake and the Housatonic River reasonably matched observed groundwater elevations.

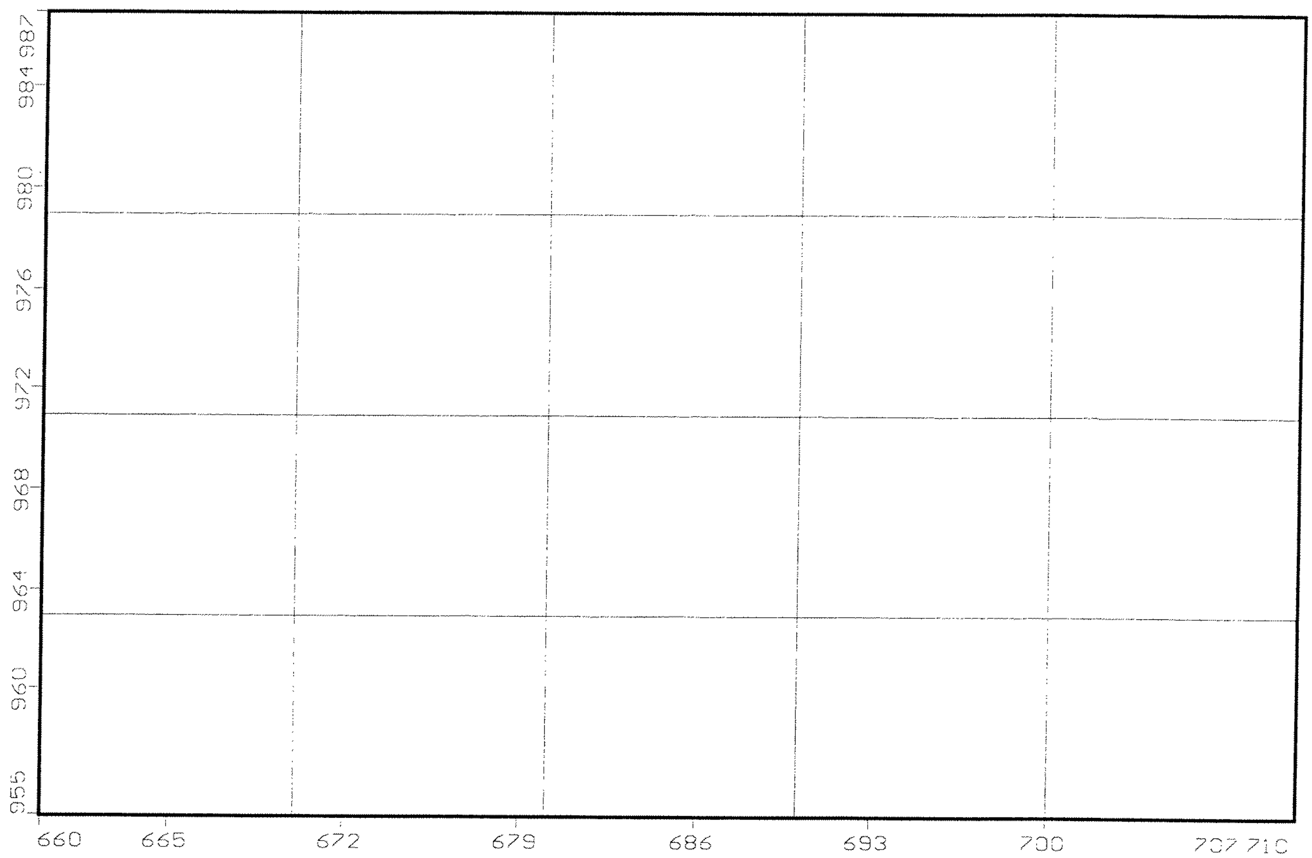
Analysis of the mounding potential following sheetpile emplacement indicates that the groundwater mounding north of the sheet pile wall would be minor. The model results show groundwater mounding by approximately 0.5 feet within 20 feet of the wall and 0.01 feet approximately 150 feet upgradient of the wall (Figure 4). As a result, groundwater recovery behind the wall does not appear to be necessary. If data collected during monitoring indicates otherwise, pumping groundwater immediately north of the wall at a rate of approximately 10 gpm could control mounding. The pre-sheetpile wall groundwater ("calibrated") contours elevations are shown on Figure 5. The post-sheetpile wall groundwater elevation contours are shown on Figure 6. The slight increase in the groundwater elevation (mounding) due to emplacement of the sheetpile wall is shown on Figure 4.

Figure 1



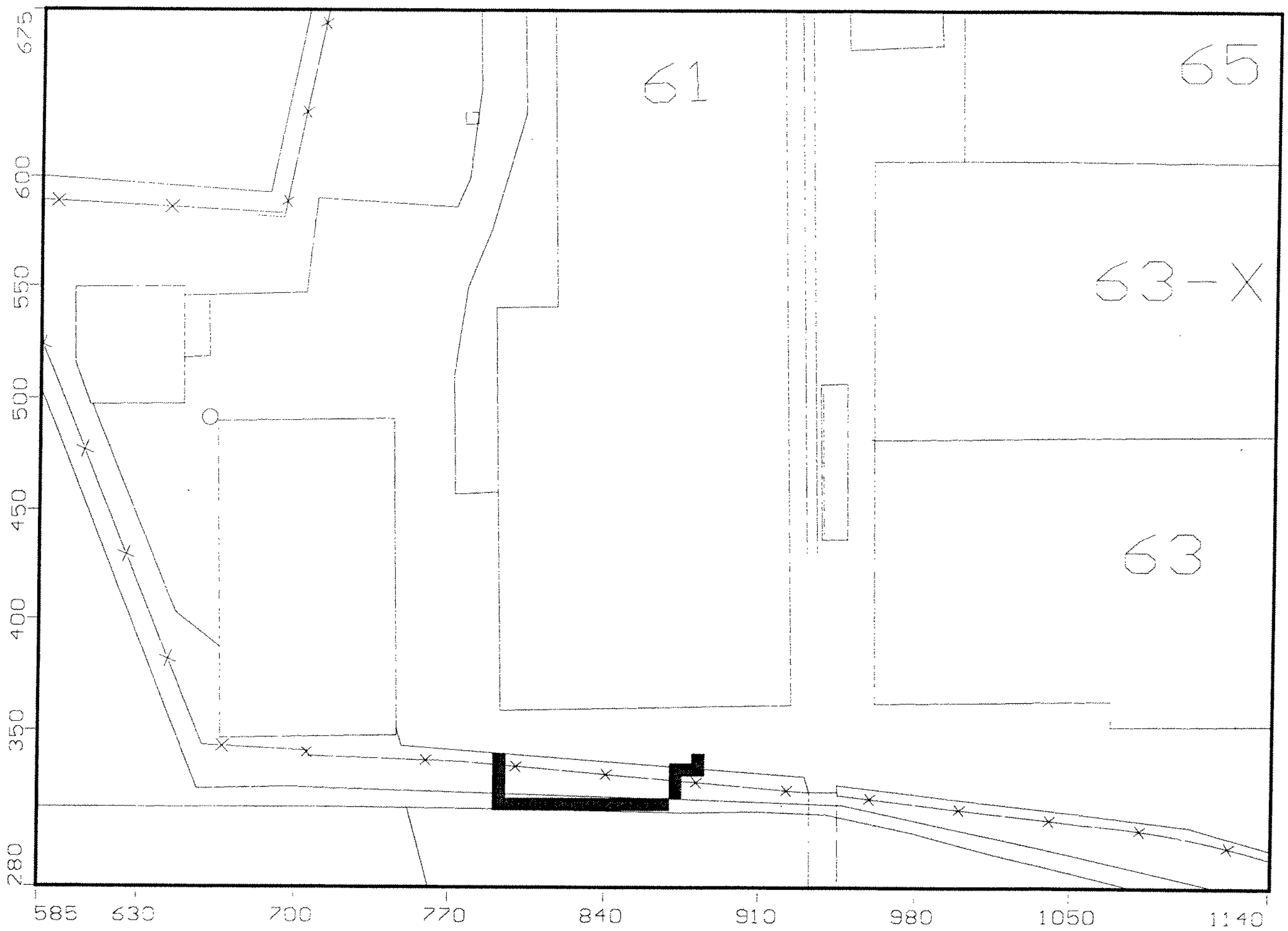
Blasland, Bouck & Lee, Inc. Project: 1/2-Mile – Cell J1 – Description: Finite-Difference Grid 22 Nov 01	Visual MODFLOW v.2.8.2, (C) 1995-1999 Waterloo Hydrogeologic, Inc. NC: 260 NR: 170 NL: 4 Current Layer: 1

Figure 2



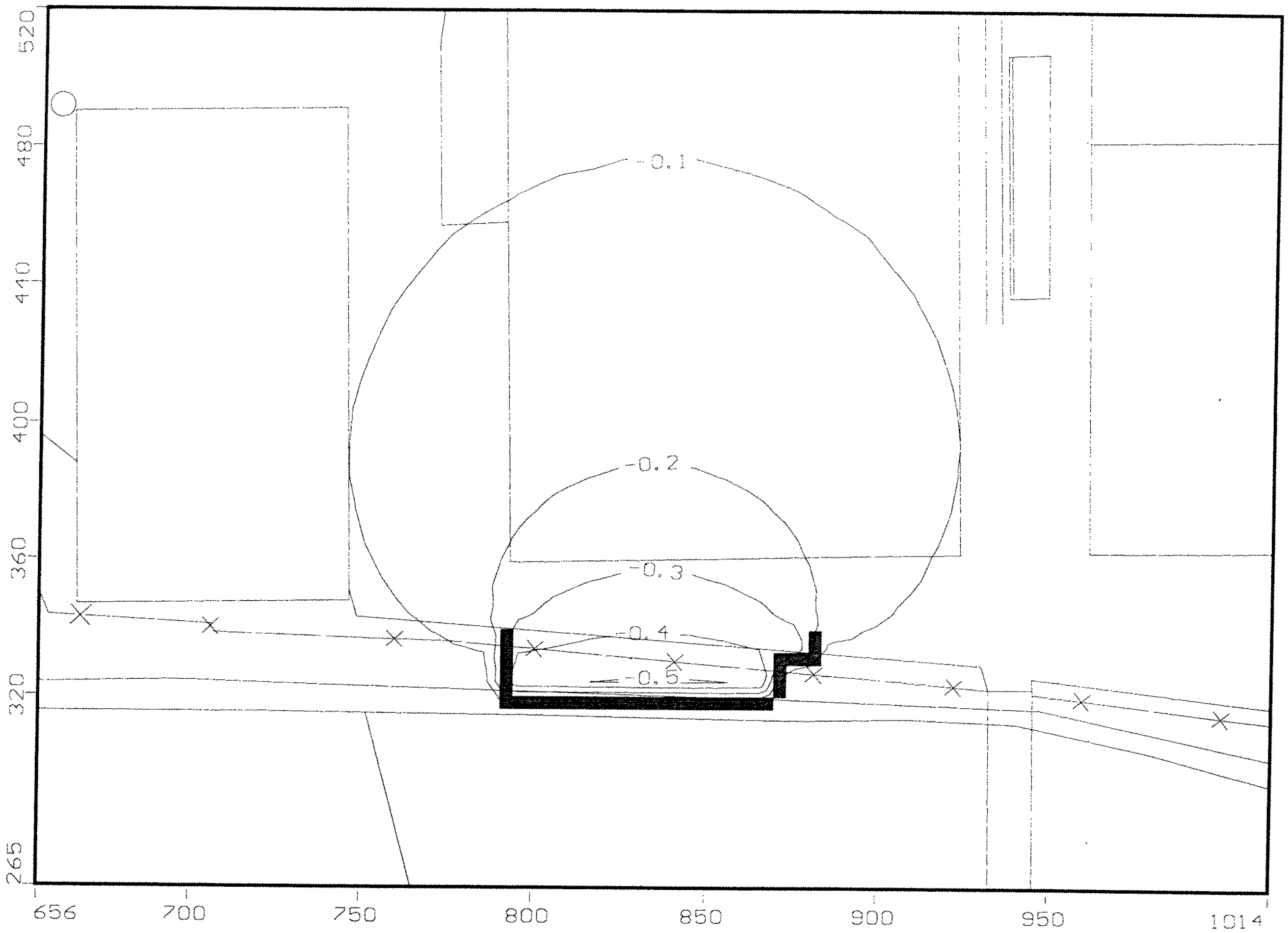
Blasland, Bouck & Lee, Inc. Project: 1/2-Mile – Cell J1 – Description: Model Layer Elevations 22 Nov 01	Visual MODFLOW v.2.8.2, (C) 1995–1999 Waterloo Hydrogeologic, Inc. NC: 260 NR: 170 NL: 4 Current Column: 85

Figure 3



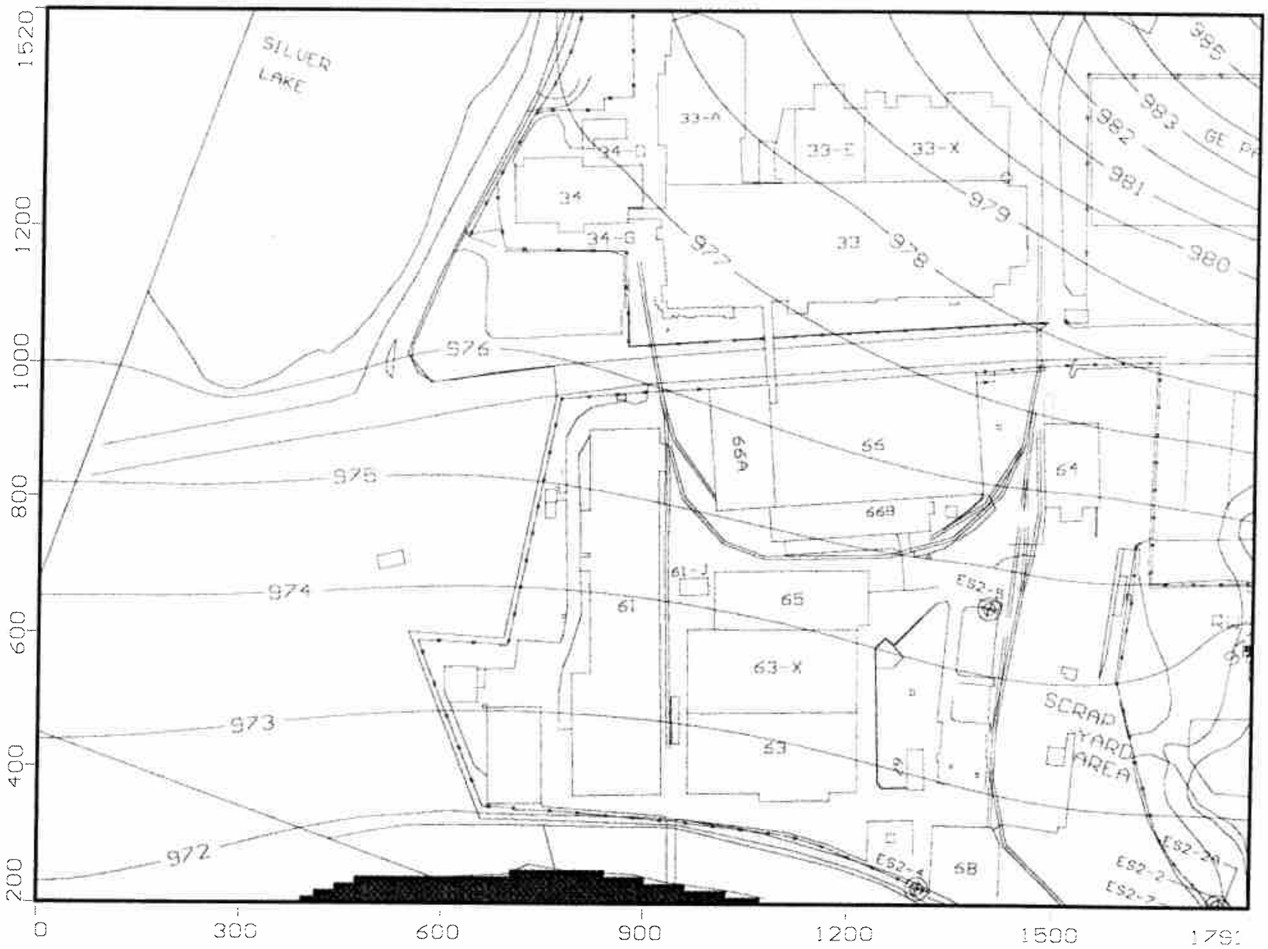
Blasland, Bouck & Lee, Inc. Project: 1/2-Mile - Cell J1 - Description: Simulated Sheetpile Wall 22 Nov 01	Visual MODFLOW v.2.8.2, (C) 1995-1999 Waterloo Hydrogeologic, Inc. NC: 260 NR: 170 NL: 4 Current Layer: 2

Figure 4



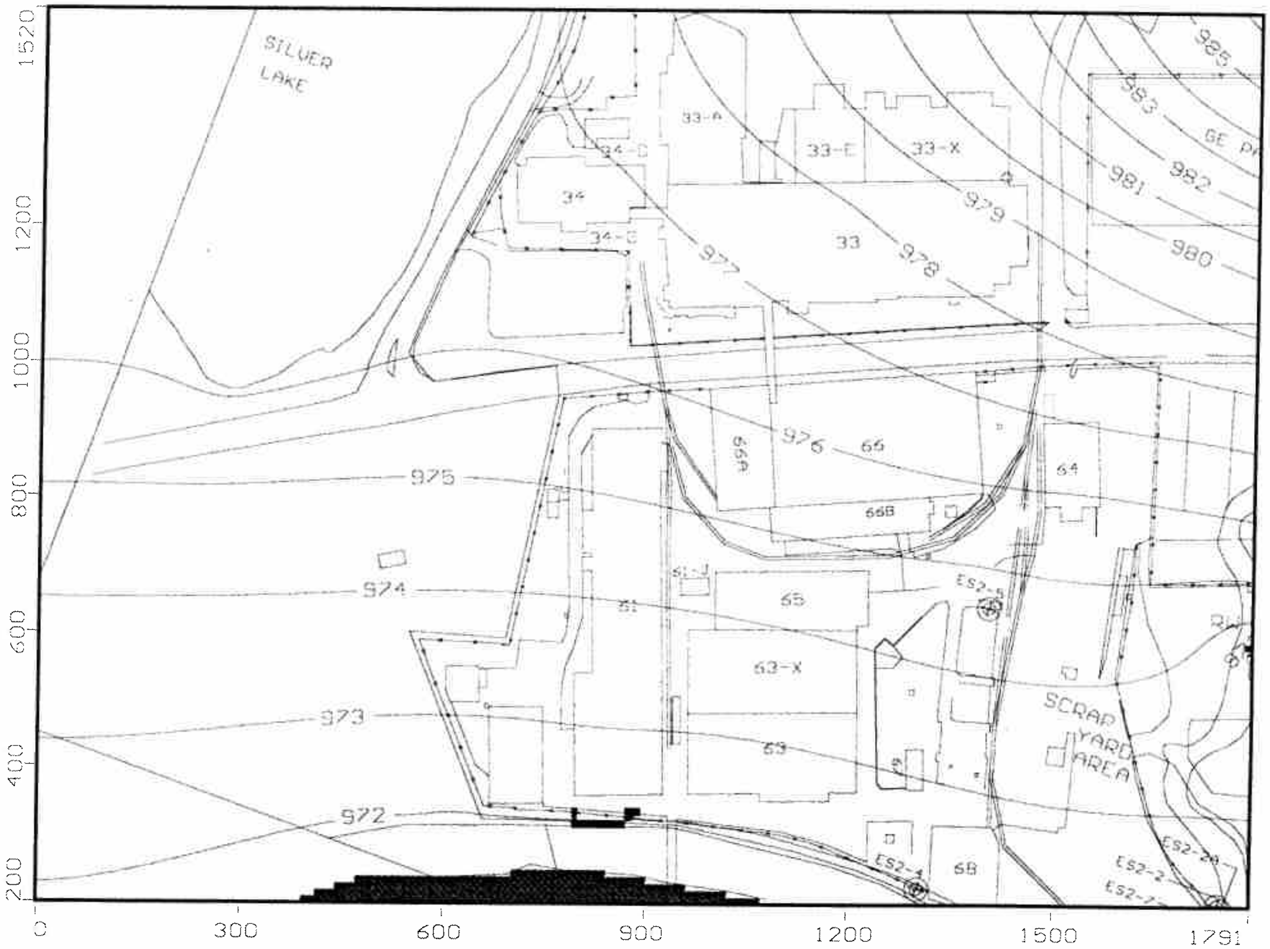
Blasland, Bouck & Lee, Inc. Project: 1/2-Mile – Cell J1 – Description: Simulated GW Mound 27 Nov 01	Visual MODFLOW v.2.8.2, (C) 1995–1999 Waterloo Hydrogeologic, Inc. NC: 260 NR: 170 NL: 4 Current Layer: 2

Figure 5



Blasland, Bouck & Lee, Inc. Project: 1/2–Mile – Cell J1 – Description: Pre–Sheet GW Elevations 22 Nov 01	Visual MODFLOW v.2.8.2, (C) 1995–1999 Waterloo Hydrogeologic, Inc. NC: 260 NR: 170 NL: 4 Current Layer: 2

Figure 6



Blasland, Bouck & Lee, Inc.
Project: 1/2-Mile – Cell J1 –
Description: Post-Sheet GW Elevations
27 Nov 01

Visual MODFLOW v.2.8.2, (C) 1995–1999
Waterloo Hydrogeologic, Inc.
NC: 260 NR: 170 NL: 4
Current Layer: 2