NEW YORK STATE
DEPARTMENT OF
ENVIRONMENTAL CONSERVATION

SUPERFUND STANDBY CONTRACT

SERVALL LAUNDRY SITE
Bay Shore, New York
WORK ASSIGNMENT NO DOO2472-12

PLUME DISCHARGE STUDY
SUBTASK 9.1 PHASE I ASSESSMENT REPORT

DECEMBER 1995

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ABB ENVIRONMENTAL SERVICES

September 7, 1995

Ms. Sally Dewes, P.E.
Bureau of Eastern Remedial Action
New York State Department of Environmental Conservation
50 Wolf Road
Albany, New York 12233-7010

Subject: ServAll Laundry Site
Work Assignment No. D002472-12
Response to Plume Discharge Study Comments

Dear Sally:

We have received your August 2, 1995 comment letter and provide the following responses:

1. Comment: Pages 3-7 and 3-8: This section only discusses particles 2 and 4 released for the vertical tracking in the area of PZ-94-23D. Is the portion of the Penataquit Creek between PZ-94-23 and PZ-94-19 gaining or losing?

   Response: The model suggests that, under the conditions of the calibration, the Penataquit is almost entirely a gaining stream, with only a few nodes (four) in the model at the confluence of the upper east and west branches being slightly losing. Also see Appendix G for a print-out of the model river package which lists node-by-node fluxes.

2. Comment: Page 3-9: The statement in the last paragraph of Section 3-5, "the VOCs are confined to the Upper Glacial Aquifer above the upper clay unit", is not consistent with the information on Figure 3-4, MW-16. The deep screen shows VOC contamination. Please verify.

   Response: The screen in MW-16 actually straddles the upper aquifer and the intermediate zone of glacial outwash sand. The report text suggests that, of the four possible explanations of the observed contaminant distribution, that the one where VOCs were confined to the upper aquifer seemed most likely. If MW-16 were entirely screened in the intermediate sand and gravel zone, then this statement would have to be re-considered. As it is, with the well screen open to the surficial aquifer, this possibility still seems most likely.

3. Comment: Page 3-10: Does ABB intend to say the preferred biodegradation pathway is aerobic or just that it is possible?

   Response: The text is in error, and should say "anaerobic", not "aerobic" on Page 3-10. Successive dechlorination of the PCE/TCE/DCE family is known to occur most rapidly under anaerobic conditions. The text is indicating that this is the preferred chemical transformation mechanism, and is possible (daughter products are present), but this presence may be related to more extreme conditions when product was originally introduced into the ground at the site. Further degradation of the ethenes may not be significant during the remainder of the transport pathway in groundwater. The text will be corrected.

4. Comment: On page 4-4 the southern boundary is termed "constant head" while on page 4-2 wedge is termed impermeable boundary. Please clarify.

   Response: Both conditions exist in the southern portion of the model. In the uppermost Layer 1, the influence of the ocean is represented by constant head nodes. In lower Layers 2 and 3, the estimated location and effect of the saline wedge has been represented as a no-flow boundary to simulate the non-mixing and the upward forcing of the fresh water flow. See also Figure 3-4, section A-A_0.

5. Comment: Page 4-5: The second paragraph on this page suggests that there is a downward gradient across the clay. This is not consistent with the data for MW-19 or MW-23. Please clarify.

   Response: The reference to downward gradients is primarily with regard to gradients observed in wells near the ServAll site, and, in general, to the more regional situation where significant head differentials are indicated across the Gardiners Clay from the upper to lower aquifers (Doriski, 1986). Upward gradients from the intermediate sandy zone to the upper surficial aquifer are not fully understood as yet, but, with regard to comment number 2, may be another factor in preventing deeper migration of the contaminants primarily located in the surficial aquifer.

6. Comment: Page 4-13: Please clarify what is meant by stating that particles released at the site *terminate* in Layer 5.

   Response: The term "terminated in Layer 5" is meant to indicate that the particles moved downward in the model, finally reaching the perimeter of the model in Layer 5. The text will be modified to clarify this.

7. Comment: On page 4-15 it is stated that the groundwater velocity has been estimated at 914 feet per year. This seems a little high. What has this estimate been based on?

   Response: As indicated in the text, the basis for this estimate of groundwater velocity was the model and the MODPATH particle tracking, assuming an effective porosity of 0.3. A check with Darcy's Law, using an overall gradient of 0.00308 ft/ft, a K of 255 ft/d, and the cited effective porosity, leads to an estimate of 955 ft/yr, a reasonable comparison. The K value is toward the high end of reported values, and the porosity could be somewhat higher. These factors could reduce the estimated groundwater velocity a bit. The values used were considered to be more conservative in predicting groundwater flow rates, and in the potential use of the model to evaluate groundwater extraction scenarios, if needed. In estimating contaminant transport, however, the estimated (computed) groundwater velocity and the estimated (observed) contaminant transport rates are reconciled by the calculation of a retardation factor. Thus the contaminant transport analysis presented is based on estimated contaminant plume migration rates (as observed over the years of monitoring plume migration), and depends to a lesser extent on the computed groundwater flow rates.

8. Comment: Page 5-10 refers to Table 5-1. Please clarify.

   Response: This table, missing from the report copies originally supplied to NYSDEC, was supplied to NYSDEC under a separate cover shortly after the original submission. The final report will, of course, include this table.

9. Comment: Page 5-16 refers to pond water. It should refer to pore water.

   Response: This typo will be corrected in the final report.

10. Comment: Figure 3-4: It is not clear that the interpretation of the stratigraphy at PZ-94-23 is consistent with the boring logs or published literature (USGS WRIR 82-4056), however the scale of the inconsistency is much smaller than the scale of the flow model and should not affect the results.

    Response: ABB-ES reviewed the cited published literature (USGS WRIR 82-4056). This reference shows well S23455 on Plate 3, Profile C-C', which is within the study area. This well is approximately 4000 feet east of the PZ-94-23 cluster and 2000 feet west of the PZ-94-17 cluster. Both the 17 and 23 clusters encountered the top of clay at about 50 to 60 feet below sea level, which agrees with that shown for S23455. Cluster 23, projected and superimposed on Profile C-C', plots in an area where the Gardiners Clay is shown as being absent; however, no borings between S66145 and S23455 are shown to support this interpretation. Piezometers PZ-94-4, PZ-94-3, and PZ-94-23D, projected and superimposed on profile B-B', show good agreement with the interpreted geology. While the Gardiners Clay is shown as a single unit by USGS, the logging of 27D showed a sand stringer within the clay unit at that location, which is consistent with the sequence noted in several of the deep borings. It is our belief that the cited literature, which uses widely spaced borings performed by various entities for various purposes does generally agree with the results presented in this document. As stated in the comment, these minor differences, which reflect an increased knowledge of the extent of the Gardiners Clay, "should not affect the results".

Please call me if you have any questions at (207) 828-3636.

Sincerely,

ABB ENVIRONMENTAL SERVICES

Mark Seelen

Mark A. Seelen
Project Manager

cc: R. Lewis B. Johnson File

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NYSDEC SUPERFUND STANDBY CONTRACT
WORK ASSIGNMENT NO. D002472-12

PLUME DISCHARGE STUDY
SUBTASK 9.1 PHASE I ASSESSMENT REPORT

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Submitted to:

New York State Department of Environmental Conservation
Albany, New York

Submitted by:

ABB Environmental Services
Portland, Maine

December 1995

Submitted by:
Mark Seelen
Mark A. Seelen
Project Manager
ABB Environmental Services

Approved by:
Mark Seelen FOR
Robert E. Handy, Jr., P.E.
Program Manager
ABB Environmental Services

PLUME DISCHARGE STUDY
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EXECUTIVE SUMMARY

This Phase I Assessment Report presents a description of the performance of field work and interpretations of data collected during Subtask 9.1 as outlined in the ServAll Task 9 Plume Discharge Study Work Plan (ABB-ES, 1994b). The overall purpose of the Subtask 9.1 Phase I Assessment has been to provide a more detailed evaluation of the potential ecological impacts of the contaminant plume associated with the ServAll Laundry Site (ServAll) at projected points of discharge to surface waters. This work was initiated after a preliminary screening analysis (ABB-ES, 1994a) predicted potential unacceptable impacts to ecological receptors under a reasonable worst-case scenario of potential discharge to the nearest freshwater (Penataquit Creek) or saltwater (Great South Bay) receptors.

The ServAll site, located in the unincorporated hamlet of Bay Shore in the town of Islip, Long Island, New York, was operated as a commercial laundry from 1969 to 1972, and as a commercial laundry and dry cleaner from 1972 through 1984. Wastewater containing the solvent tetrachloroethene (PCE) was discharged to cesspools on site, and contaminants subsequently migrated through the soils beneath the site and into groundwater. A substantial plume, with PCE and its degradation products, was formed in the upper glacial aquifer, migrating south toward Great South Bay at an approximate rate of 350 feet/year. The Gardiners Clay underlying the plume appears to retard migration to the lower Magothy Aquifer, with ultimate discharge of the plume to surface waters predicted near the shoreline. Prior to the completion of this Phase I Assessment, the probable point of discharge and concentrations of contaminants at receptor locations were unknown, and little detail regarding the aquifer geology and hydrogeology in the probable pathway of the plume was available.

A screening analysis of potential discharge contaminant concentrations was made (ABB-ES, 1994a) with a simple analytical transport equation to estimate potential worst-case impacts on surface water ecological receptors. The results of this analysis and associated preliminary ecological risk assessment indicated that potential adverse impacts could occur, and that a more detailed analysis was warranted. This initiated the 1994 Phase I field work, which consisted of installing piezometers and monitoring wells, logging of borehole geology, and gathering water level information from new and existing wells, piezometers and surface water locations, and obtaining water quality data in order to provide information to construct a more detailed flow model of the aquifer. This flow model has been developed to provide a more accurate estimate of plume discharge locations. These modeling results have also been coupled with further transport analyses to provide refined estimates of expected contaminant concentrations at these discharge locations. The ecological risk assessment has been repeated for those constituents of concern based on the preliminary screening evaluation.

The 1994 Phase I field work included the installation of 27 shallow piezometers, 13 deep piezometers, and two groundwater monitoring wells. These explorations provided significant information regarding groundwater flow (water level data) and geologic information (the stratigraphy of the aquifer and the underlying Gardiners Clay). A significant finding, which caused some modifications of the scope of the exploration and modeling phases of the program, was the discovery of two clay layers underlying the upper glacial aquifer, and sandwiching a zone of sand and gravel between them. This initially suggested a possible alternate pathway for a plume originating at the ServAll site although groundwater quality data taken in the new monitoring wells screened above and within this newly discovered zone suggest that the pathway into this zone is limited, or possibly non-existent, and that the contaminant plume appears to be migrating southward above the upper clay layer. The present interpretation of the encountered geology is that the clay-sand-clay sequence constitutes the Gardiners Clay in this area. This intervening sand zone carries freshwater, even in areas where a saline wedge has encroached landward from Great South Bay, as indicated by induction logging in wells drilled through this zone. This sequence of clay-sand-clay may or may not be consistently present from the site to the shoreline. It appears that only one clay layer is present at the site, i.e., the intervening sand layer may pinch out near the site. The remaining explorations indicated a relatively uniform upper glacial aquifer. Water level measurements were used to prepare an interpretive water table surface contour map, and to provide data and calibration targets for the groundwater model.

The groundwater model was constructed for evaluating likely plume pathways and discharge locations. The USGS groundwater flow model program MODFLOW was used to prepare the model, which covered about 11.5 square miles, from just north of the site south to the shoreline of Great South Bay. The model was calibrated to measured water levels and to interpreted flow directions and hydraulic gradients. The model output was compared with estimated seepage rates to streams and the bay, based on literature reported values. The model appeared to be well calibrated, but, due to the simplification necessary to represent the hydrogeologic system, may be somewhat conservative by overestimating potential impacts to the lower reaches of the Penataquit Creek, the identified probable discharge location of site-related volatile organic contaminants. Potential concentrations of major constituents in the plume (PCE, TCE, 1,2-DCE, and vinyl chloride) were estimated by an analytical model, AT123D, used in the preliminary screening analysis. Mass loadings to the creek were estimated using the flow rates from the MODFLOW model, pathlines indicated by particle tracking with MODPATH, and the concentrations estimated with AT123D. The groundwater concentrations, estimated concentrations in sediments in the stream, and surface water concentrations, as a function of discharge location, were compiled and used in the Ecological Risk Assessment (ERA).

The ERA evaluated the potential future risks that plume-related constituents may pose to resident and migratory fish, other aquatic life, and wildlife receptors following discharge of contaminated groundwater to surface water bodies. The ERA was conducted in accordance with state and federal guidance documents; toxicological information was derived from several sources, including the AQUIRE database. Where toxicological data were missing for some compounds, data for similar chemicals were used, e.g., data for 1,1-DCE were used as a surrogate for 1,2-DCE. Risk to receptors was estimated based on calculated pore water, sediment, and surface water maximum and average concentrations. The ERA concluded that it would be unlikely that aquatic organisms would experience adverse effects from exposure to any of the expected discharge concentrations of contaminants evaluated. The predicted pore water (in sediment) did, in some cases, slightly exceed some chronic and mean acute values for certain taxa; however, those organisms were pelagic species not expected to be exposed on a regular basis.

This Phase I Assessment Report concludes that a second round (Phase II) of groundwater and ecological risk assessment modeling does not appear to be necessary based on the findings of no probable significant adverse ecological impact.

1.0 INTRODUCTION

This Phase I Assessment Report presents an evaluation of the potential for the groundwater contaminant plume from the ServAll Laundry site (ServAll) to impact downgradient aquatic receptors. The Phase I Assessment was completed as the second component (Subtask 9.1) of the Plume Discharge Study (Subtask 9) performed by ABB Environmental Services (ABB-ES), formerly E.C. Jordan Co. (Jordan), under the New York State Superfund Contract Work Assignment No. D002472-12. The Plume Discharge Study is designed to meet the intent of the Record of Decision (New York State Department of Environmental Conservation [NYSDEC], 1992) for ServAll and provide the NYSDEC with predictive tools to evaluate the ecological risks associated with the ServAll plume when it begins discharging to surface water.

ServAll was occupied by a commercial laundry (ServAll Uniform Rental, Inc.) from 1969 through 1972, and a commercial dry cleaner/laundry from 1972 through 1984. Wastewater containing the solvent tetrachloroethene (PCE) was discharged to 10 cesspools located behind the building. Soil and groundwater at ServAll were contaminated with PCE and its breakdown products and a volatile organic compound (VOC) plume has formed migrating south towards Great South Bay. ServAll is classified as a Type 2 inactive hazardous waste site listed by identification (ID) No. 152-077 in the Registry of Inactive Hazardous Waste Disposal Sites in New York (NYSDEC, 1990). The ServAll groundwater discharge study area is located in the unincorporated hamlet of Bay Shore, which is located in the town of Islip, in the southwest corner of Suffolk County, near Great South Bay, Long Island, New York (Figure 1-1). This Phase I Assessment focuses on the Study Area shown in Figure 1-2, the anticipated future discharge area for the contaminated groundwater plume.

The ServAll Remedial Investigation/Feasibility Study (RI/FS) Report (Jordan, 1992) concluded that the contaminant plume associated with ServAll is migrating southward toward Great South Bay at an estimated rate of approximately 350 feet per year. Groundwater analytical results from wells and screened-auger sampling, collected as part of the RI/FS, showed the plume descending through the upper glacial (unconfined) aquifer and moving along the upper surface of the Gardiners Clay, an aquitard between the upper glacial aquifer and the underlying Magothy aquifer. The primary groundwater contaminants comprising the ServAll plume include VOCs

(PCE, trichloroethene [TCE]; 1,2-dichloroethene [DCE]; 1,1-DCE; 1,1-dichloroethane [DCA]; and vinyl chloride [VC]); and one semivolatile organic compound (SVOC), bis(2-ethylhexyl)phthalate (BEHP) (Jordan, 1992).

The vertical and horizontal movement of the plume is controlled principally by the Gardiners Clay, vertical hydraulic gradients in the vicinity of Penataquit Creek, and the presence of a saline wedge causing upward gradients near the shoreline of Great South Bay. This report presents the technical approach (Section 2) used to develop an understanding of the geology and hydrogeology in the Study Area (Section 3). Based on this understanding, a groundwater flow model was developed (Section 4) to evaluate the potential discharge area of the known plume. Section 5 presents an assessment of the risks that the plume-related contamination may pose to aquatic and wildlife receptors following discharge to surface water bodies.

The objectives of the Phase I Assessment were to:

- install piezometers to provide geological and hydrogeological information for the development and calibration of the Phase I numerical MODFLOW (the United States Geological Survey (USGS) modular three-dimensional finite difference groundwater) model, and to install groundwater monitoring wells to monitor and evaluate current plume status for analytical transport model refinement;

- construct a MODFLOW model to provide input to the Ecological Risk Assessment (ERA) and to evaluate and predict the groundwater-to-surface-water interaction in the study area;

- prepare a phased impact analysis predicting the path and behavior of the VOC plume as it migrates toward the coast, and evaluate its potential impact on aquatic organisms as it discharges;

- prepare an ERA based on a comparison of the toxicological benchmark values developed during the screening level assessment with the more precise and realistic exposure point concentrations and fluxes provided by the output of the Phase I numerical MODFLOW model and accompanying analytical transport modeling; and

- establish stream gauging stations to provide water levels in streams and Great South Bay for use in the numerical MODFLOW model.

2.0 PHASE I TECHNICAL APPROACH

Subtask 9.1 includes up to three phased levels of groundwater modeling and ERA. The conclusions of Subtask 9.1 may be used by NYSDEC and other state and local agencies to predict the plume migration pathway from its current location to its discharge point, and estimate the effects of dilution of the plume and volatilization of contaminants at the discharge location. The three phases of assessment are as follows: (1) a screening level analysis, conducted in 1994 (ABB-ES, 1994a), with an analytical transport model using conservative assumptions for estimating contaminant concentrations along the flow path; (2) since this screening level analysis indicated potential unacceptable ecological risk, a more detailed flow modeling (Phase I), coupled with analytical transport modeling and ecological risk assessment, conducted and described in this report; and (3) if this Phase I modeling shows a potential for unacceptable ecological risk, a refined detailed model (Phase II) and a probabilistic ecological risk characterization.

This report presents findings, conclusions, and recommendations from the Phase I Assessment. Data generated during the Subtask 9.1 field investigation activities are presented in Section 3. Information generated through performing Subtask 9.1 field investigation activities, as well as information from the RI/FS were used in the development of the groundwater and contaminant transport modeling. The groundwater modeling was performed using MODFLOW and estimates of contaminant concentrations in groundwater at the most likely points of discharge were provided using an analytical transport model (see Section 4). The results of the groundwater modeling and contaminant transport modeling were used to assess ecological risk in Section 5. Recommendations for the completion of Subtask 9.1 are presented in Section 6.

2.1 PHASE I FIELD ACTIVITIES

The Phase I field activities were designed to provide the data necessary to meet the hydrogeologic input requirements for construction of the Phase I MODFLOW model. Phase I field activities included installing piezometers and groundwater monitoring wells at 28 separate locations and the establishing five stream gauging stations. The locations extend from the present southern terminus of the existing contaminated groundwater plume to the shoreline of Great South Bay in Bay Shore (Figure 2-1), nearly four miles to the south. The piezometers are spaced approximately 2,200 feet apart over a 9,000-foot-wide (east to west) by 11,000-foot-long (north to south) grid. In addition, the field activities included installing a pair of monitoring wells (one deep and one intermediate depth) near the anticipated leading edge of the plume. These monitoring wells are discussed further in Subsection 2.1.1, and were installed to assess the present extent of the plume and provide additional sampling points for a long-range monitoring program, Subtask 9.2.

The scope of the field investigation activities, as presented in the Plume Discharge Study Work Plan (ABB-ES, 1994b), included:

- piezometer and monitoring well installing and developing
- groundwater sampling
- borehole geophysical logging
- exploration topographic surveying
- one round of synoptic water level measuring

Details on each of these tasks are presented in Subsections 2.1.1 through 2.1.5.

2.1.1 Piezometer and Monitoring Well Installation and Development

As part of the Phase I Assessment field investigation activities, 27 shallow piezometers, 13 deep piezometers, and two groundwater monitoring wells were installed between September 20, 1994 and October 10, 1994. This represents an expansion in the scope presented in the Plume Discharge Study Work Plan (ABB-ES, 1994b). The change in scope was developed by ABB-ES in conjunction with NYSDEC due to data gaps identified during the execution of the original scope of work. Drilling services were provided by Advanced Drilling Investigations of Buffalo, New York, with field oversight provided by ABB-ES.

The piezometers and wells were installed in the upper glacial aquifer above the Gardiners Clay, as well as between an upper and lower clay unit. The Gardiners Clay unit encountered in the study area generally appears to be a three-layered system, with an upper clay unit underlain by a gravelly sand unit on top of a deeper clay unit. This three-layered structure of the Gardiners Clay was unexpected from previous information and this interpretation is the result of data collected. Table 2-1 provides elevation information on installation and drilling of each piezometer and well. The rationale for the exploration types and locations is as follows:

- A total of 27 shallow piezometers (maximum 30 feet in depth) were installed at the locations shown in Figure 2-1. These piezometers were used to collect water table elevation data to evaluate horizontal hydraulic gradients for the Phase I modeling.

- Thirteen deep piezometers and two monitoring wells (ranging from 65 to 112 feet in depth) were installed at the locations shown in Figure 2-1. These piezometers and wells were installed to provide hydraulic head data above and below the upper clay layer (Subsection 3.3).

- Groundwater salinity in the deep piezometers was investigated using borehole induction logging at four separate locations (Subsection 2.1.3) to evaluate fresh water boundary conditions near the shoreline.

- The stratigraphic variation of the geology within the study area was investigated using borehole gamma logging in five selected deep boreholes and one monitoring well (MW-16) from the RI.

- Fourteen shallow/deep paired piezometers and wells were placed downgradient of the existing plume at locations shown in Figure 2-1. These were used to collect water level data to calculate vertical groundwater flow gradients. Gradient information, flow directions, and estimated travel times are presented in Subsection 3.4.

Split-spoon soil samples were collected from four separate boring locations to provide information on subsurface geological conditions. These locations (PZ-94-27D (D for deep), MW-94-23S (S for shallow) and D, PZ-94-17D, and PZ-94-21D) were selected to provide the widest spatial distribution. The depths logged extended to 107 feet below ground surface (bgs). Split-spoon soil samples were obtained at 5-foot intervals as the borings were advanced. The split-spoon soil samples collected in PZ-94-27D were used to supplement the borehole gamma logging and provide a field check prior to piezometer installation. During piezometer and well drilling, observations of auger down pressure provided valuable information on the depth of the clay strata and other changes in subsurface geology (Subsection 3.3).

Prior to piezometer installation at six separate locations, the selected boreholes were logged using a borehole gamma-logging technique, described in Subsection 2.1.3.1, to confirm the stratigraphy of the upper glacial aquifer, to verify the existence of the upper clay unit, and to supplement the split-spoon sample data. Three piezometers were logged using the borehole induction logging technique, described in Subsection 2.1.3.2, to identify the location of the freshwater/saltwater interface and to assess the water contained in the sandy zone between the upper and lower clay units.

The monitoring well and piezometer locations proposed in the Plume Discharge Study Work Plan (ABB-ES, 1994b) were based on interpretations of groundwater flow direction. Drilling permits were obtained through the Islip Town Hall by ABB-ES personnel. Drilling logs, piezometer and well installation diagrams, piezometer and well development records, and groundwater sampling records are provided in Appendices A, B, C, and D, respectively.

2.1.1.1 Piezometer Installation. Borings for the piezometers were drilled with 4.25-inch inside diameter (ID) hollow-stem augers. Reference soil samples were collected using a 1.5-inch-ID split-spoon soil sampler during advancement of PZ-94-27D and PZ-94-17D (see Appendix A). The primary goal of split-spoon soil sample collection in the deep borings was to confirm the existence and depth of the upper clay unit in the study area. Piezometer construction details are provided in Table 2-1 and Appendix B.

The 27 shallow piezometers were constructed of 0.75-inch-ID, Schedule 40, flush-joint polyvinyl chloride (PVC). All piezometer screens were 3-foot, Schedule 40, 0.010-inch, machine slotted PVC. The sand formation around the shallow piezometers was allowed to cave naturally around the well screens and risers. The cuttings and natural cave material were firmly tamped at ground surface prior to installation of the flush protective casing.

The 13 deep piezometers were constructed of 2-inch-ID, Schedule 40, flush-joint PVC with 3-foot, Schedule 40, 0.010-inch, machine-slotted PVC screens. The deep piezometers were constructed with 2-inch PVC to accommodate the borehole logging apparatus and allow for possible future use as groundwater monitoring wells. The piezometer screens were set above the upper clay unit in the upper glacial aquifer, except for PZ-94-19D which was screened between the upper and lower clay units. The sand formation around the 3-foot screened intervals and the lower most seven feet of the risers was allowed to cave naturally around the PVC. The remainder of the annulus was typically filled with bentonite slurry to the water table, with Portland cement/bentonite grout from the water table to 3 feet bgs (see installation diagrams in Appendix B). Excess soil cuttings were collected at the surface, screened using a portable photoionization detector, and transported to the ServAll site. The stockpiled cuttings will be spread on the ground surface when the soil vapor extraction system is installed as part of the source remediation. Surficial cuttings from two piezometers, PZ-94-19S and D and PZ-94-12S, appeared to be contaminated with fuel; NYSDEC personnel collected samples for analysis, and these soils were placed in a 55-gallon drum and staged at the ServAll site as directed by NYSDEC personnel. Each piezometer was protected by a flush-mounted protective casing cemented in place.

2.1.1.2 Monitoring Well Installation. The borings for the monitoring wells were drilled with 4.25-inch ID hollow-stem augers. Soil samples were collected at 5-foot intervals using a 2-foot-long, 1.5-inch-ID split-spoon sampler. Details on well construction are provided in Table 2-1 and Appendix B.

The well screens were set above the upper clay unit in MW-94-23S, and between the upper clay and the lower clay units in MW-94-23D. These wells were installed to monitor deep groundwater quality along the interpreted plume axis, and to obtain vertical hydraulic gradient data.

The monitoring wells were constructed with 2-inch-ID, Schedule 40, flush-jointed PVC with 0.010-inch machine-slotted well screens. The well screen in MW-94-23S is three feet long, and in MW-94-23D it is 5 feet long. The screened intervals are listed in Table 2-1. A sandpack of clean silica sand was placed around the well screens. Details on well construction are provided in Appendix B. A flush-mount steel protective casing with a locking expansion cap was placed over the top of the well and cemented into place.

2.1.1.3 Piezometer and Monitoring Well Development. The monitoring wells and the 2-inch-ID piezometers were developed by ABB-ES personnel with submersible pumps, employing a pump-and-surge method to establish good hydraulic connection with the formation. Development records are presented in Appendix C. Wells were developed in accordance with the ServAll Quality Assurance Project Plan (QAPjP) (ABB-ES, 1990). Development water from the monitoring wells and piezometers was discharged at the ground surface and allowed to infiltrate into surrounding soils. The shallow piezometers were pumped using two peristaltic pumps simultaneously, each of which pumped at a rate of approximately 0.2 gallons per minute for between 20 and 30 minutes each (4 to 5 gallons purged). Development was done to ensure that the screened intervals were not clogged, and that the piezometers and wells would provide valid groundwater level measurements. Re-development may be required prior to measuring future groundwater levels because no sand pack was used in the piezometer construction.

2.1.2 Groundwater Sampling

Groundwater sampling of the new monitoring wells was performed after each well was installed and developed. The wells were sampled two days after development was completed. The wells were otherwise sampled in accordance with procedures outlined in the ServAll QAPjP (ABB-ES, 1990). Analysis for VOCs was performed using U.S. Environmental Protection Agency (USEPA) SW-846 Method 8010. The analytical data from the new wells (MW-94-23S and MW-94-23D) were validated in accordance with the *National Functional Guidelines for Organic Data Review* (USEPA, 1991a) and *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (USEPA, 1989a), along with USEPA Region II and NYSDEC revisions. These data are presented in Subsection 3.5.

2.1.3 Borehole Geophysical Logging

Two borehole geophysical methods, gamma logging and induction (conductivity) logging, were performed in six and three selected deep piezometers, respectively, by NYSDEC personnel using a Geonics™ EM-39. The data was collected automatically using a data logger and recorded with depth in feet from ground surface. The tested piezometers were each logged twice for comparison and to provide assurances of data quality.

2.1.3.1 Borehole Gamma Logging. Borehole gamma logs, also called borehole gamma-ray logs or natural-gamma logs, were obtained at PZ-94-2D, PZ-94-3D, PZ-94-10D, MW-16, PZ-94-19D, and PZ-94-27D for interpretation of lithology and stratigraphy. A detector sensitive to small amounts of gamma radiation is lowered into the augers and a data logger records the depth and intensity of gamma radiation detected. The data is then plotted for interpretation. Clay particles in the Gardiners Clay contain radioactive potassium isotopes that produce a strong signal on the gamma logs which is interpreted to indicate the presence of clay.

The gamma logging was performed inside the augers prior to piezometer installation to assist in proper screen placement. Logging prior to piezometer installation also simplified data interpretation, which could have been complicated by the presence of bentonite grout around the riser. The logs were used in combination with field observations of drilling and split-spoon sampling to assist in identifying the location of the upper surfaces of the clay units and other fine-grained strata. Prior to piezometer installation in PZ-94-19D, the borehole was logged through the auger casing using a gamma log geophysical survey technique. The observations made during boring advancement (i.e., down pressure to advance augers) were used to support the interpretation of this first log. Additional gamma log data were collected from four other deep piezometer borings in place of split-spoon sampling. Split-spoon sampling was performed in PZ-94-27D, prior to gamma logging to provide further calibration. Both field drilling observations and the results of the gamma logs were used to interpret stratigraphy (see Subsection 3.3). The boring locations selected for gamma logging were chosen to characterize the overall local geology for input in the Phase I groundwater model.

Gamma logging was performed in MW-16, installed as part of the RI/FS, (see Jordan, 1992). This well was gamma logged to see if it penetrated the upper clay unit. See Subsection 3.4 for a discussion of the results.

2.1.3.2 Borehole Induction Logging. Borehole induction logging was used to measure the relative conductivity of the groundwater at PZ-94-2D, PZ-94-3D, and PZ-94-27D. The method measures the electrical conductivity of the soil and interstitial water in the formations around the casing from approximately 0.12 foot from the center of the casing to a radial distance of three feet. PVC casing does not interfere with the EM-39 induction probe signal.

The induction logging technique allowed for the measurement and evaluation of relative conductivity of the groundwater in the vicinity of the shoreline of Great South Bay. The data was used to evaluate the location of the saltwater/freshwater interface which is discussed in Subsection 3.3. The induction data interpretation has been incorporated into the assumptions to the Phase I groundwater model, presented in Section 4.

2.1.4 Exploration Location and Elevation Survey

The new piezometers, wells, and five stream gauges were field surveyed to the nearest 0.02 foot vertically and 0.1 foot horizontally. The survey was performed using the Global Positioning Satellite (GPS) system, with three stationary control points (to eliminate random drift imposed by the U.S. Government for National Security reasons). The data were collected and reduced by RU-SH GPS Consultants & Land Surveyors, P.C., under subcontract to YEC, Inc. and ABB-ES. The horizontal locations were tied to the New York State Plane Coordinate System. Vertical elevations were tied to Mean Sea Level (MSL) as established by the 1929 General Adjustment. The elevation controls were consistent with those used for the earlier RI/FS exploration survey. Locations have been electronically plotted on digitized USGS topographic quadrangle maps for use in this report. Results of the survey are presented in Table 2-2.

2.1.5 Synoptic Water Levels

On October 26, 1994, ABB-ES personnel obtained water levels from all new piezometers and wells, the five new stream gauges, and selected existing monitoring wells. The location of the stream gauges are indicated in Figure 2-1. To evaluate the degree of tidal influence, twelve piezometers (PZ-94-1, 2, 2D, 3, 3D, 4, 4D, 6, 7, 7D, 8, and 8D) south of Main Street in Bay Shore were measured twice in one day at separate times (see Subsection 3.4). All measurements were collected using an electronic water level indicator. Results from this round of water level measurements are presented in Table 2-3. Groundwater contour maps with water level elevations are discussed in Section 3.4.

2.2 PHASE I MODELING

A five-layer MODFLOW model was constructed to provide input to the Phase I ERA and investigate the groundwater-to-surface water interactions in the study area. The model incorporated all significant hydraulic boundary conditions identified. Sensitivity analyses were performed on the model to evaluate the potential for plume discharge to streams and saltwater creeks before reaching Great South Bay. Concentrations of contaminants at the exposure points were estimated with an analytical transport model in conjunction with particle tracking runs with the groundwater flow model.

The output of the model (i.e., the estimated concentrations and discharge flux rates) were input to the Phase I ERA presented in Section 5.

2.3 PHASE I ECOLOGICAL RISK ASSESSMENT

Phase I ecological risk assessment activities consisted of a predictive ERA based on a comparison of the toxicological benchmark values developed during the screening level assessment (ABB-ES, 1994a) with the more precise and realistic exposure point concentrations and fluxes provided by the output of the Phase I numerical MODFLOW model and accompanying analytical transport modeling.

The ERA was performed as part of the Phase I Assessment in accordance with available federal and state guidance documents (USEPA, 1989b; 1989c; 1991b; 1992a, and NYSDEC, 1989; 1991b). The purpose of the ERA was to define baseline biological effects associated with exposure to groundwater plume constituents at potentially impacted aquatic habitats. The ERA consists of the following five elements:

- development of a conceptual site model;
- biological characterization;
- ecological exposure assessment;
- ecological effects assessment; and
- ecological risk characterization.

3.0 PHASE I FIELD ACTIVITY RESULTS

This section presents a discussion of the geology and hydrogeology of the study area, groundwater analytical data, and fate and transport.

3.1 STUDY AREA

The study area extends from the ServAll site south to Great South Bay, a distance of about four miles, and extends laterally (east to west) almost two miles, as shown in Figure 1-2. The maximum ground surface elevation in the study area is 65 feet above MSL. The maximum depth of exploration undertaken in this Phase I Assessment was 103 feet below MSL.

The plume discharge study area is located in southwestern Suffolk County. This area is underlain by Wisconsinan-stage glacial drift deposits of stratified sand and gravel known as the upper glacial aquifer. The upper glacial aquifer overlies the Gardiners Clay within the study area, which directly overlies the Magothy Aquifer, as indicated in cross section in Figure 3-1 (Soren and Simmons, 1987). Near the study area, the limits of the Gardiners Clay has been mapped as indicated in Figure 3-2 (Soren and Simmons, 1987).

Groundwater flow within the study area is generally to the south, with discharge to creeks, canals, and Great South Bay. A saltwater wedge is present along the shoreline.

3.2 REGIONAL GEOLOGY

Two Late Wisconsinan-stage end moraines, each with extensive outwash plains, comprise most of the surface of Long Island (Flint, 1971). Most of southwestern Suffolk County, south of the Ronkonkoma terminal moraine, is characterized by glacial drift deposits of coarsely stratified sands and gravels. The sands and gravels are major components of the upper glacial aquifer. Outside of wetland and forest areas, the surface soil is very sandy with thin, poorly developed topsoil.

The Gardiners Clay unit, a northward-thinning wedge of silty marine clay (Figure 3-1), discontinuously underlies the upper glacial aquifer outwash deposits (Figure 3-2). The inferred limit of the Gardiners Clay shown in Figure 3-2, (based on Soren and Simmons, 1987), indicates a small portion of the western edge of the study area may not be underlain by Gardiners Clay. However, explorations performed as part of this Phase I Assessment encountered soils interpreted to be Gardiners Clay beneath the entire study area (see Subsection 3.3). The northern terminus of the Gardiners Clay was formed by Late Pleistocene erosion which cut back into the upper glacial aquifer.

The aquifers of Long Island are generally hydraulically interconnected. However, pumping tests conducted by the USGS in the Magothy Formation near ServAll indicated poor hydraulic connection between the Magothy Aquifer and the upper glacial aquifer where the Gardiners Clay is present (NUS, 1989). The vertical hydraulic conductivity in the Gardiners Clay has been estimated at 0.01 feet per day (ft/day) (Franke and Cohen, 1972).

3.3 STUDY AREA GEOLOGY

The study area surface topography dips uniformly from north to south. Elevations in the north, near ServAll are 65 feet above MSL, with a near uniform slope to the south. The shoreline peninsulas average less than 5 feet above MSL.

Geologic interpretations are based on split-spoon sampling, observations made during drilling, and borehole geophysical investigations performed by NYSDEC personnel. The soil samples collected using split spoons encountered four different soil types.

- The upper glacial aquifer, from ground surface to about 68 feet bgs in the south and 110 feet bgs under ServAll, consists of medium to fine sands with varying amounts of silt and coarse sand to fine gravel.

- The upper clay unit varies in thickness from four feet in the north to nearly 20 feet in the south and is interpreted to be part of the Gardiners Clay. The upper clay unit consists of gray to black laminated silt/clay which exhibited slight plasticity with layers of silty fine sand.

- The stratum underlying the upper clay unit is a gray to rust-stained and brown, stratified, dense, fine silty micaceous sand with gravelly sand and laminated silt/clay. This unit varies in thickness from nonexistent under ServAll to 15 feet thick near Great South Bay.

- The lower clay unit which begins at approximately 100 feet bgs contained the deepest soils encountered within the study area and is up to 20 feet thick, and consists of gray to black laminated silt/clay with layers of silty fine micaceous sand.

Table 3-1 shows the depths and elevations of the top and bottom of the upper clay unit and the top of the lower clay unit where encountered. Four interpretive geologic profiles, located and oriented as depicted in Figure 3-3, have been developed for this Phase I Assessment. The profiles are combined on one foldout map, Figure 3-4, contained in a pocket at the rear of this report. The upper glacial aquifer is present across the entire study area and ranges in thickness from 110 feet under the ServAll site to 68 feet at the southern end of the study area. The upper surface of the Gardiners Clay unit encountered beneath the upper glacial aquifer is generally flat in the northern half of the study area. In the southern half of the study area, the Gardiners Clay dips southward at 0.0025 feet per foot (ft/ft) (see Figures 3-4 and 3-5). The upper glacial aquifer in the northern half of the study area is interpreted to lie on top of the Gardiners Clay which was eroded, while the southern half is representative of the southerly dip of the other unconsolidated deposits forming Long Island (see Figure 3-1). ServAll appears to be situated at or very close to the northern terminus of the Gardiners Clay.

The stratum underlying the upper clay unit is a stratified fine silty micaceous sands, with gravelly sand layers and laminated silt/clay. This unit is assumed to be part of the Gardiners Clay, due to similarities with the soils above and below. During drilling of both PZ-94-19D and PZ-94-27S, artesian conditions were encountered in a coarser zone within this stratum, causing water to come up and out of the augers above ground surface (see Subsection 3.4).

A second distinct clay layer, the lower clay unit, was encountered in the deeper borings (see Figure 3-4). Contours of the upper surface of the lower clay unit have been mapped (see Figure 3-6). The surface of the lower clay unit dips to the south at about 0.004 ft/ft. A bend in the contours, indicating a drop-off to the west indicates thinning and supports the limit line of the Gardiners Clay shown in Figure 3-2.

Borehole gamma logging was performed in five selected piezometers and MW-16 (installed during the RI/FS), to provide more information on the location of clay within the study area. The result of this logging technique is a plot of counts/second versus depth bgs. A correlation between these plots and observations made during the drilling of PZ-94-19D is presented in Figure 3-7. The gamma log measures the presence of gamma radioactivity, which is typically interpreted to represent clay. However, observations made during drilling and split-spoon sampling indicated that hardness, or required down pressure on the augers during drilling, along with observations of rig vibrations (indicative of gravel and cobbles) provided more useful data, in some cases, than the borehole geophysics. The Gardiners Clay has significant silt content, which does not produce as strong a radioactive signature on the gamma logs as would a more pure clay. The silt, however, is expected to exhibit a low hydraulic conductivity similar to that of the clay. For these reasons, the interpreted stratigraphy shown in Figures 3-4 and 3-7 indicates the presence of glacial marine clay which does not always coincide with the results of the borehole gamma logging. This interpretation was made because the groundwater model presented in Section 4 is concerned with soils with differing hydraulic conductivity, not necessarily just clay content.

Borehole gamma-logging was performed in MW-16, installed during the RI. This was done to investigate the presence of the upper clay unit and the lower sandy unit. The gamma log, presented in Appendix F, produced for MW-16 does not appear to identify either unit.

3.4 STUDY AREA HYDROGEOLOGY

Information about the local hydrogeology was collected from the 40 piezometers and two monitoring wells installed as part of this Phase I Assessment, along with the 18 monitoring wells installed as part of the RI/FS. The data collected as part of the Phase I Assessment included stratigraphic information from gamma logs, split-spoon sampling, and field observations of drilling; borehole induction logging to evaluate the position of the saltwater-freshwater interface; synoptic water level measurements; and an assessment of tidal influences. In-situ hydraulic conductivity measurements were performed as part of the RI/FS only.

Depths to the groundwater table vary from about 20 feet above MSL near ServAll to nearly 1 foot above MSL in areas adjacent to bays and tidal backwaters. The creeks and canals locally influence the flow of shallow groundwater, as shown on Figure 3-8. Groundwater flow is generally to the south-southeast from ServAll toward Great South Bay, where it is intercepted by creeks and canals along the way. The average horizontal hydraulic gradient near the surface of the upper glacial aquifer, over the study area is about 0.003 ft/ft, and steepens near the shoreline to approximately 0.01 ft/ft.

Groundwater flow near the surface of the upper clay unit has been mapped based on observations in deep piezometers (Figure 3-9). The deep groundwater flow contours parallel the shoreline as expected, indicating little to no influence due to manmade stresses (i.e., pumping or re-injection) within the study area. The horizontal hydraulic gradient, near the surface of the upper clay unit, is relatively uniform at 0.003 ft/ft, except beneath the canals where it reduces to about 0.0015 ft/ft.

Water level measurements from paired piezometers/wells screened at different depths have been used to assess vertical hydraulic gradients. Table 3-2 presents a summary of vertical gradients in each paired piezometer/well. The vertical hydraulic gradients observed vary from a maximum of 0.0494 ft/ft (upward) between PZ-94-21D and PZ-94-21S to a minimum of -0.0107 ft/ft (downward) between MW-94-23S and PZ-94-23S. Upward hydraulic gradients were observed across the upper clay unit, between MW-94-23D (in between the upper and lower clay units) and MW-94-23S (near the top of the upper clay) at 0.0083 ft/ft and between PZ-94-19D (in between the upper and lower clay units) and PZ-94-19S (near ground surface). No hydraulic gradient information is available for PZ-94-27D, because there is no shallow piezometer paired with it. Artesian pressures were observed during drilling between the upper and lower clay units at PZ-94-19D and PZ-94-27D. These higher upward gradients across the upper clay unit were observed in the field during drilling as artesian pressures, causing water to flow to the ground surface from within the augers. The wide range of variations observed in vertical hydraulic gradients are similar to those observed in the wells installed as part of the RI/FS. No pattern of vertical gradients can be ascertained from the limited groundwater level data available. The gradients observed near the shoreline are believed to be influenced by tidal variations, and the presence of a saltwater wedge beneath the southern shoreline and the bays and channels.

Using the borehole induction logging technique, four piezometers, located near Great South Bay were logged. The logs indicated a zone of mixed fresh and salt water within the upper glacial aquifer that varied in thickness from 22 feet in PZ-94-2D to 5 feet in PZ-94-4D. This thick zone of mixing may be the result of logging the well too soon after installation (not allowing the water column to equilibrate), disturbance due to the logging instrument traveling up and down in the riser pipe, and, to a lesser degree, natural tidal fluctuations (about two feet in Great South Bay due to the buffering effects of Fire Island and the Causeways). Figure 3-10 presents an interpretation of the induction log from PZ-94-27D. As seen in Figure 3-10, two zones of freshwater were encountered: one in the upper 57 feet of the upper glacial aquifer; and the second within the sandy layer between the upper and lower clay units. The observance of this second zone of freshwater was made possible through the installation of a 40-foot sump in the piezometer. It is significant that it shows substantial groundwater flows in this sandy zone, based on the reduction in salt content which is interpreted from the decreased conductivity of the water. The middle of the zone of mixing has been interpreted to represent the freshwater-saltwater interface, as shown in Figure 3-4. There does not appear to be extensive saltwater intrusion into the upper glacial aquifer, as has been reported in the Magothy aquifer as the result of excessive pumping and inadequate recharge/reinjection in the past at other locations on Long Island.

The presence of saltwater in the water column in wells within approximately 800 feet of saltwater bodies is possible, based on the density of saltwater, and the observed static water table levels. Water levels observed in piezometers which encounter saltwater may be expected to be biased low approximately 2.5 percent of the thickness of saltwater encountered. This is not considered to be significant, and water levels were not modified, considering the majority of the potentially affected wells are also subject to tidal influences.

Multiple groundwater level readings were obtained on October 26, 1994 at selected deep and shallow piezometers (PZ-94-1, PZ-94-2, PZ-94-3, PZ-94-4, PZ-94-6, PZ-94-7, PZ-94-8, and PZ-94-27D) along with tidal readings taken at SW-E (located in a canal on Penataquit Point, see Figure 2-1). A summary of the observed water levels and their fluctuations versus horizontal distance to the nearest tidal water body is presented in Table 3-3. The effects of tidal variations appear to dissipate to near zero at about 400 feet from the shoreline, as presented in the graph on Table 3-3. The lack of a damped sinusoidal fluctuation (which would appear as some water levels going down as the tide is rising and vice-versa) is attributed to high hydraulic conductivities in the upper glacial aquifer and the small tidal fluctuations in Great South Bay.

Hydraulic conductivities of the upper glacial aquifer were tested using the slug test method and analyzed using the Bouwer and Rice method, and were reported in the RI/FS. Due to the high hydraulic conductivity of this material, available analytical methods are not suitable largely due to the inherent problems in testing such permeable materials (i.e., turbulent flow and oscillations in the water column during testing). Slug test data presented in the RI/FS indicated an underdamped harmonic variation in recorded hydraulic pressure (an indication of hydraulic head) within the wells with time. The data were previously reduced with limited success as reported in the RI/FS (Jordan, 1992). A recently obtained program, HARMONIC (Smith, 1994), which reduces underdamped slug test data, was used to reduce the data. Results from the analyses performed are provided in Appendix F. The new results varied from 2.6 to 185.8 feet per day (ft/day), with an average of 37 ft/day. However, the new analyses indicated relatively large potential errors in the fit, possibly due to actual conditions not satisfying assumptions made in the development of the analytical model utilized by the program. Since several of the test analyses produced hydraulic conductivities less than 10 ft/day, and inertial effects are not generally considered to occur in soils exhibiting a hydraulic conductivity above 28 ft/day, it is believed that the results of the analysis using the HARMONIC program are too low. Consequently, the hydraulic conductivity of the soils surrounding these wells is considered to be greater than those estimated using HARMONIC, which are generally lower than those reported in the RI/FS. The values used in the groundwater model are discussed further in Section 4.

The groundwater flow in the study area, especially within upper glacial aquifer, has been modeled and is discussed in detail in Section 4. One of the objectives of the groundwater modeling effort was to predict where contaminant discharge to surface water might occur. Through the use of particle tracking, a method which simulates the movement of particles released at a particular location in the model and their subsequent migration with time as they move through the model, groundwater flow and discharge to surface water can be evaluated. Particles were introduced to the model in the vicinity of MW-94-23S, and their migration in three-dimensions were analyzed. Four representative particles were selected, and their pathways through the aquifer to their discharge to surface water are presented in Figure 3-11. These traces represent the groundwater model's predicted paths for groundwater originally at different depths in the vicinity of MW-94-23S. These flow paths are comparable to flow lines on a flow net. Flow nets based on collected water level data were not generated due to horizontal-to-vertical exaggerations in scale and hydraulic conductivity and the low vertical hydraulic gradients observed. If flow nets were generated they would either have had equipotential lines spaced closer than available data can support (less than 0.01 feet) or to produce square flow blocks, the figure would have had to be too large to handle practically. The dip in the two deepest particle traces in the vicinity of PZ-94-19 is attributed to the presence of a losing surface stream in this area. These particle traces show that the contamination detected in MW-94-23S may be expected to discharge to Penataquit Creek between PZ-94-19 and PZ-94-14. The estimated time and location of plume discharge is discussed in Section 4.

3.5 GROUNDWATER ANALYTICAL RESULTS

Groundwater sampling and analysis events have been performed in 1991 and 1994 on monitoring wells installed by ABB-ES. Screened auger borings were installed and sampled between December 1990 and January 1991, and monitoring wells and monitoring wells installed in these borings were sampled in February and March of 1991 by Jordan (Jordan, 1992); and a second round of samples was collected by ABB-ES in June 1994 along with samples collected in October 1994 from two new wells (MW-94-23S and MW-94-23D). The groundwater sampling results are presented in Table 3-4. These data provide information on plume chemistry, revealing its areal and vertical extent.

During the RI/FS, screened auger sampling was conducted and groundwater samples were collected from 18 monitoring wells. Analyses were performed for site-related contaminants, primarily chlorinated aromatic VOCs (Jordan, 1992). The interpretive geologic profile A-A_0 in Figure 3-4 presents these results and shows contours for total VOCs for the 1991 data. This figure shows the contaminated groundwater plume sinking to the top of the upper clay unit and extending approximately 7,200 feet south from the site.

Groundwater samples were collected in June 1994 from monitoring wells (MW-1, MW-3A, MW-3B, MW-4, MW-6A, MW-6B with a duplicate, MW-7, MW-8, MW-11, MW-13, MW-15, and MW-16) installed as part of the RI/FS. Samples were analyzed in accordance with USEPA SW-846, Method 8240, by NYTEST Environmental, Inc. (NYTEST) of Port Washington, New York. Results were not subjected to a comprehensive data validation procedure. These data were reviewed and, where available, the undiluted values exceeding the calibration range were replaced with the diluted value to provide a more accurate quantitative result. These combined original and diluted analyses are reported in Table 3-4. The total VOC concentrations have been incorporated into profile A-A_0 of Figure 3-4, as data boxes to the left of the appropriate screened interval.

Groundwater samples were collected for analysis in October 1994 from MW-94-23S and MW-94-23D. Samples were again analyzed in accordance with USEPA SW-846, Method 8240, by NYTEST Environmental, Inc. Results were subjected to a comprehensive data validation procedure, as discussed in Subsection 2.1.2. These validated data are presented in Table 3-5.

The ServAll groundwater contaminant plume appears to have migrated to MW-94-23S, as of October 1994. As will be discussed in Section 4, this well is apparently located slightly west of the plume axis. The analytical results from groundwater samples collected from the RI/FS wells in June 1994, are shown in profile A-A_0 on Figure 3-4, and Table 3-4. The location of the southern leading edge of the contaminated groundwater plume, as of October 1994, is shown in profile A-A_0 on Figure 3-4. It should be noted, again, that the extent shown is along the profile line, and the actual leading edge of the plume may be further south of MW-94-23S. The results of the analysis performed on the groundwater sample collected from MW-94-23D (screened in between the upper and lower clay units) were non-detect for the analytes reported, indicating that either; (1) the plume is contained entirely in the upper glacial aquifer above the upper clay unit; (2) the plume is diluted in the coarser grained soils of the sandy zone between the upper and lower clay units and the analytical method used was not sensitive enough to detect any contaminants; (3) the plume has not yet reached the well; and/or (4) the plume in this layer is directed away from the well by the horizontal gradients in the sandy layer. The most likely scenario appears to be that the VOCs are confined to the upper glacial aquifer above the upper clay unit.

3.6 FATE AND TRANSPORT OF SITE-RELATED CONTAMINANTS IN GROUNDWATER

Seven organic chemical compounds have been identified in groundwater downgradient of the ServAll site as primary site-related contaminants. These include six chlorinated hydrocarbons and one phthalate. Four of the six chlorinated volatile hydrocarbons, PCE, TCE, 1,2-DCE, and VC, form a well-defined plume from the site, are present at relatively high concentrations in the aquifer, and also demonstrate the well-known degradation of PCE to its daughter products by successive dechlorination, a usually aerobic degradation process. Two other volatile chlorinated hydrocarbons (1,1-DCA and 1,1-DCE) are more sporadically encountered, are present at much lower concentrations than the other chlorinated VOCs, and do not form a well-defined plume. They may be associated with the site, or there may be other unknown sources. The other organic compound detected was BEHP, an SVOC commonly used as a plasticizer. Detections of BEHP were also sporadic, and may or may not be site-related as it is known to be a common artifact of sampling or analytical procedures.

The principal fate and transport mechanisms for these compounds in groundwater are advection, dilution by dispersion, sorption, and, under proper conditions, volatilization and biodegradation. Dissolved constituents are carried downgradient by the groundwater flow. For all of these compounds except BEHP, sorption potentials are low as suggested by the low organic carbon partition coefficient (K_{oc}) and octanol/water partition coefficient (K_{ow}) values (see Table 3-6 for the physicochemical properties of the eight compounds), and the probable low fraction organic carbon of the aquifer materials. For BEHP, retardation is significant due to the much higher K_{oc} value. The plume also becomes more dilute as it spreads out along its migration pathway. Due to the relatively homogeneous nature of the aquifer and the characteristics of sands, dispersivities defining the rate of spreading are expected to be low, but still significant in reducing original plume concentrations due to the long migration path (3 to 4 miles) before the plume is likely to discharge to surface water. Further significant biodegradation of the chlorinated hydrocarbons, which is more probable under anaerobic conditions, seems unlikely before discharge to surface water, although some degradation has apparently occurred in the past as indicated by the presence of the daughter products. BEHP, while degrading more slowly, is also appreciably retarded in its migration rate so that biodegradation is the probable ultimate fate of the BEHP before reaching a discharge point to surface water. If the plume rises to the water table surface (it presently is moving along the bottom of the upper glacial aquifer), then conditions might favor the loss of contaminants from groundwater via volatilization. VC, with its high vapor pressure is a candidate for this, and several of the other VOCs also have relatively high Henry's Law Constants (a measure of the relative tendency to partition to the air phase rather than remain in aqueous solution).

For the compounds likely reaching surface water discharge (essentially the chlorinated VOCs), the plume may pass through bottom sediments where benthic macroinvertebrates may be exposed. In this zone, if significant bottom sediments are present, further partitioning to sediments may occur. In the analysis that follows, fraction organic carbon concentrations of the bottom sediments have been assumed to be 0.01 (1 percent), while the bottom sediments have been assumed not to be of sufficient mass to alter the pore water concentrations significantly (this is a conservative approach for both the sediments and the water column). Table 3-6 also shows the bioconcentration factor (BCF) (albeit for fish) which indicates that the VOCs, due to their relatively low K_{oc} values with the possible exception of the PCE, have little tendency to bioaccumulate. The BCF for BEHP would be relatively high, but BEHP is not expected to reach surface water at detectable concentrations, but to be biodegraded in the aquifer. Therefore, BEHP is not evaluated further in the modeling and ERA.

The VOCs reaching surface water (projected to be entirely within Penataquit Creek) are anticipated to undergo rapid dilution and loss to the atmosphere by volatilization. Dilution is accomplished by expected rapid mixing in the relatively small stream with upstream flow from clean groundwater discharge and surface run-off. Dilution in the lower stream tidal reach will also be aided by estuarine mixing with salt water from the bay. This effect is not included in the analysis in Section 4 which is another conservative approach, as the mixing effect cannot be accurately determined without further physical measurements of the estuary. Volatilization will occur rapidly in the shallow stream; estimates of half-lives under quiescent conditions are on the order of a few hours for these compounds with relatively high Henry's Law Constants. Since the stream is shallow and turbulent in some stretches (e.g., tumbling through culverts) and well-aerated, volatilization is likely to be even more rapid. Photo-oxidation potentials for the chlorinated VOCs in surface water are low, and the travel time between the point of discharge in the Penataquit and arrival in the bay is relatively short, so photo-oxidation of compounds is not a significant fate mechanism. Also, none of the compounds is particularly amenable to hydrolysis.

4.0 PHASE I ASSESSMENT MODELING RESULTS

The Phase I modeling consisted of the expansion and refinement of the screening level modeling previously conducted (ABB-ES, 1994a). The Phase I Assessment applies numerical models to simulate groundwater/surface water interaction to more fully evaluate various ecologic risk scenarios for potential receptors between the ServAll Laundry Site and Great South Bay (Study Area). A groundwater flow model was specifically developed to provide reasonable estimates of groundwater discharge flow rates, and probable plume discharge locations. The flow modeling was supplemented with analytical transport modeling to provide estimates of maximum and average groundwater contaminant concentrations at the point of discharge. Finally, a weighted overall mass balance approach was used to estimate contaminant concentrations in the surface water at the time of the arrival of maximum concentrations in groundwater. The modeling evaluations support the assessment of possible ecological exposure risk and design of remedial actions, if necessary, to protect freshwater and/or marine ecological receptors. The groundwater flow model will also support the evaluation and design of a groundwater extraction system, should it be necessary to intercept the plume prior to discharge to surface waters.

Some representative model inputs and outputs, as well as some supporting calculations, have been included in Appendix G. Complete input/output electronic files for calibrated MODFLOW models, and for all particle tracking results can be provided as compressed files on diskettes, if requested.

4.1 CONCEPTUAL FLOW MODEL

A numerical groundwater flow model was constructed over the area shown in Figure 4-1 to incorporate flow boundaries and evaluate all possible discharge areas within the Study Area.

As previously discussed in Section 3, the hydrogeologic regime under consideration primarily includes the upper glacial aquifer which overlies the Gardiners Clay unit. In some portions of the Study Area, a thin, coarse outwash sand zone was observed directly below an upper clay unit. This coarse sand zone may provide a preferential route for groundwater flow from the upper aquifer, or at least influence flow in the upper glacial aquifer.

The study area surface topography dips uniformly from north to south. Elevations in the north, near ServAll are 65 feet above MSL, with a near uniform slope to the south. The shoreline peninsulas average less than 5 feet above MSL.

Subsurface exploration data indicate four different soil types present at the site as discussed in Subsection 3.4.

A conceptual groundwater flow model was developed for the study area based on the current understanding of hydrogeologic conditions, surface water information, and the objectives of the modeling study. The groundwater flow system in the Study Area is conceptualized as follows:

- A five-layer model system: three separate layers (Layers 1 through 3) within the upper glacial sand aquifer; one layer (Layer 4) which represents a siltier sand in the northern portion of the Study Area, and also a clay layer (the upper clay encountered) in the southern portions of the Study Area; and one layer (Layer 5) which incorporates a coarser sand zone located below the upper clay layer within the southern Study Area, and is inactive in the northern portion of the model as the sand zone is assumed not significant in this area (conservative assumption). Note that the five-layer model represents a departure from the three-layer model anticipated in the Work Plan, and was necessitated by the discovery of the upper and lower clay units during the field work. Figure 4-2 illustrates the conceptual schematic of the model grid layers for the Study Area.

- The various units are relatively flat-lying across the Study Area, with a slight dip towards the south.

- Portions of the groundwater located within the Study Area are interpreted to discharge to river systems, lake systems, the ocean, and/or the thin zone of coarser material identified beneath the upper clay unit during the 1994 field program. Discharge to the ocean is largely controlled by the presence of a saline wedge along the shoreline which is assumed to be an impermeable boundary for freshwater flow.

- The model area is recharged principally by infiltrating precipitation over the Study Area, and to a lesser degree by upgradient groundwater flow. Based on extensive areas of pavement in portions of the Study Area, and possible effects of drains (including infiltration to sewer or storm drain lines), net recharge rates may vary throughout the Study Area.

4.2 SELECTION OF MODEL CODE AND MODEL IMPLEMENTATION

Selection of an appropriate groundwater model numerical code is based on several considerations: the code must have the capability to simulate, as boundary or initial conditions, all significant hydrogeologic influences, be well accepted and documented, and be readily available for use by others (i.e., in the public domain). It is for these reasons that USEPA favors models by the USGS, and has issued guidance for modeling that encourages model selection based on the criteria listed above. Based on these considerations and the prior use of the USGS model code, MODFLOW has been selected as the model that would best evaluate site groundwater conditions and satisfy the above criteria. The positive aspects of this selection included the model's three-dimensionality, variety of boundary condition modules, ability to express variability in thickness of aquifer/aquitard units, spatial variation in aquifer parameters, and acceptance by the groundwater modeling community. MODFLOW is a finite difference numerical model that provides the essential features needed for the evaluation of the potential ecological risk exposures posed by the flow and discharge to surface water of contaminated groundwater.

The MODFLOW model code (McDonald and Harbaugh, 1988) is installed at ABB-ES as Geraghty and Miller's version for 386- and 486-based personal computers (Geraghty and Miller, 1990a). This version of the code also includes the Preconditioned Conjugate-Gradient 2 (PCG2) (Hill, 1990) solver package, which was used to overcome some of the non-linear numerical closure difficulties experienced in the early model runs. Initial model setup was expedited by use of the preprocessor, ModelCad®, also by Geraghty and Miller (1993).

In several simulations, ABB-ES also used the USGS particle tracking program, MODPATH (Pollack, 1989) to estimate plume pathways and probable discharge locations. This program is also available for 386- and 486-based PCs through Geraghty and Miller (1990b).

MODFLOW output head matrices and MODPATH particle tracks were contoured with Golden Software's SURFER® (Golden, 1990) programs during calibration and simulation runs.

4.3 MODEL BOUNDARIES AND DATA INPUTS

This subsection describes the groundwater flow model using the MODFLOW code to simulate hydrogeologic conditions in the model area. The ranges of parameter input values that were used, as well as the final calibration input values, are presented. Examples of specific model simulations and further modeling details are included in Appendix G. An overall review of the model development is included in Subsection 4.4.

4.3.1 Lateral Boundaries and Grid Size

Figure 4-1 shows the lateral boundaries and orientation of the model area. Figure 4-3 shows the model grid and details of the boundary conditions discussed in succeeding subsections. The model was set up with 100 rows and 80 columns and a uniform 200-foot nodal spacing. The entire model area encompasses approximately 7,300 acres, or about 11.5 square miles.

Not all of the model area is active in each layer. A primary factor in determining the active area of the model was to allow sufficient distance to boundaries such that stresses simulated near the center of the model (such as in evaluating groundwater extraction systems) would not produce excessive boundary effects at the perimeter of the model. The primary lateral boundaries of the model include: a no-flow boundary based on interpreted streamlines for flow on the west side; an inferred groundwater divide west of Orowoc Creek; a constant head boundary to the south representing the ocean/bay; and a constant head boundary arbitrarily selected about 1,000 feet north of the ServAll site (see Figure 4-3). To evaluate possible influences of Orowoc Creek on the ServAll plume pathway, and also not constrain the model space with regard to possible simulations of extraction systems, Orowoc Creek was included in the model domain, although a possible alternative boundary was an inferred divide between Penataquit and Orowoc Creeks. The model boundary along a portion of Orowoc Creek is within the model, and is considered to have minimal significant influence on the model in the area of primary interest, i.e., along the axis of the plume and the immediate area of Penataquit Creek.

The base of the model is assumed to be impermeable, i.e., the Gardiners Clay is an effective aquiclude which is a reasonable assumption based on the primarily horizontal nature of groundwater flow in the aquifer. Further, this assumption is necessary based on the limited geologic/hydrogeologic data for the lower aquifer in this particular area of Long Island, and at the scale (resolution) of the model. However, the extent and thickness of the Gardiners Clay is probably limited, as inferred both from USGS reports (e.g., Soren and Simmons, 1987) and the data gathered during the current study. The USGS-interpreted extent and thickness in this area shows a thinning out of the Gardiners Clay to the west and north from the southeast corner of the model area. The USGS-interpretation also shows the clay absent in the western portion of the model, but the recent field data suggests it may extend slightly further west than the USGS interpretation. Groundwater data in this area do not exhibit significant influences that might be expected if the clay were absent and the upper aquifer was subject to the lower heads in the underlying Magothy Aquifer.

Of interest and possible significance to the groundwater flow and plume pathway in the aquifer and model, was the identification of a zone of apparently coarse sand underlying a moderately thin upper layer of clay in the southern part of the model area (see Figure 3-4). This zone may represent a thin layer within the Gardiners Clay, or the upper clay may be a separate zone in the upper aquifer. Regardless of the classification of this stratum, it was important to include the potential effect in the model. Also, downward hydraulic gradients have been recorded in wells and piezometers installed just above the upper clay. This suggests, as does the plume's steep descent into the aquifer at the site, some seepage through the clay into the lower aquifer which is also at a lower piezometric head. The seepage rate through the clay is likely small compared to the horizontal flow in the upper aquifer.

In the model, Layers 1 through 3 represent the upper glacial aquifer across the model area. In the northern portion of the model, Layer 4 represents the siltier, lower hydraulic conductivity sand, while in the southern portion of the model, Layer 4 represents the upper clay unit encountered. Layer 5 represents the Gardiners Clay in the northern portion of the model and is made inactive, while in the southern portion of the model, Layer 5 represents the coarse sandy zone, perhaps a significant flow zone. While the interpreted geologic cross section (Figure 3-4) shows the possibility that the coarser sand zone may extend further north, there is presently no direct evidence to confirm this. It is more conservative to assume an impermeable bottom to the aquifer in the northern portion of the model with respect to potential discharge locations for the plume. The silty sand of Layer 4 overlaps the coarser zone by one row in the model, thus providing a hydraulic connection to the lower coarse sand zone. The extent and degree of this connection is not known, so the effects of this potential flowpath were explored by varying the transmissivity of Layer 5. Even if this zone is compared of high conductivity material, it may not be well-connected, and therefore may have a low effective transmissivity.

The presence of a saline wedge near the shoreline has importance as a boundary condition for the freshwater (groundwater) flow toward the ocean. This boundary and its representation in the model are discussed in more detail in Subsection 4.3.7.

4.3.2 River Package and Fluxes

The river package of MODFLOW is a module that simulates interaction of groundwater with a stream or river. The mathematical formulation of the river module is based on the head difference between the groundwater elevation and a specified stage or water level in the river, and a conductance term which includes the effects of the area of the river and the hydraulic conductivity and thickness of an actual or assumed layer of bottom sediments in the river. Figure 4-3 illustrates the streams included in the model through this module. Typically much of this information along the river is not well known, and a common approach taken in model calibration is to adjust river stages and conductance terms to match some estimate of flow in the river. This is the approach used in this modeling effort, as only a few elevation points are known along the streams. However, a study of base flow (groundwater discharge) to streams on Long Island was performed by USGS (Reynolds, 1982) based on data collected for water years 1960 to 1975. The average of these data for the Penataquit Creek (5.8 cubic feet per second [cfs]) has been used as an approximate target reference for groundwater discharge in the model. The USGS report cited annual estimated baseflow ranging from 3.67 to 7.58 cfs over these years, with a standard deviation of 0.84 cfs. Measurements at gauging stations on the Penataquit and Awixa Creeks are only made infrequently now (see Water Resources Data for New York, Water Year 1985 [USGS, 1987]). Similar flows for other streams included in the model are based on stream length and approximate drainage area. Note that these data are for the period of 1960 through 1975, and other factors, such as urban development (i.e., potential increase in paved areas resulting in reduced infiltration), may have affected baseflow to streams (the USGS study [Heisig and Prince, 1993] at East Meadow cited infiltration to storm sewers as an important factor in significant observed decreases in base flow to streams).

Also, the conditions calibrated to (primarily matches to water level data gathered in November 1994) may not represent average annual water level conditions. However, they should be reasonably representative, as water level changes throughout the model area are not great. The baseflow target values for the streams included in the model are: Penataquit, 5.8 cfs; Orowoc, 4.5 cfs; Awixa, 1.2 cfs; and Bull Ditch, 0.2 cfs. Model output within 20% of these values was considered acceptable, given the uncertainty and variability in the data. Stream gauge measurements on the Penataquit Creek made during the field program were used as a guide in establishing and modifying river input data files.

4.3.3 Diffuse Recharge

Diffuse recharge represents the net recharge of precipitation falling on the ground and infiltrating to the aquifer. As such, it represents the total precipitation minus runoff, evapotranspiration and whatever other influences may exist, e.g., recharge stormwater basins or subsurface drains that are not otherwise provided for the model. In the model, an initial uniform recharge of 20 inches per year was applied, and modified as indicated in the water balance and matches with observed heads. A recharge in the range of 18 to 20 inches corresponds to that used in previous analog modeling of the Long Island aquifer systems (Getzen, c. 1976), but that modeling was done with a much coarser grid spacing. Another USGS report (Peterson, 1987) also discusses recharge in the Study Area.

For final calibration, an areal distribution of recharge rates was defined based on the presumed presence of paved surface area over much of the south-central portion of the model area (central Bay Shore). Final recharge rates ranged from 16 to 22 inches per year, as shown on Figure 4-4.

4.3.4 Layer Boundary Conditions

Layer boundary conditions have been largely discussed in Subsection 4.3.1 with regard to the lateral boundaries for the model. In addition, while Layer 1 has been designated as water table, all other layers have been specified as confined/unconfined, allowing the maximum of the available geologic information to be built into the model, and to allow the possibility of layer partial dewatering (lowering of the heads below the specified top of layer), under conditions of aquifer stress (pumping). The top and bottom elevations of layers have been estimated based on exploration information and kriged over the model area. Where data away from the axis of the model were lacking, uniformity parallel to the coastline (along rows in the model) was assumed. Bottom elevations for Layers 1 and 2 were arbitrarily assigned, with Layers 1, 2, and 3 representing the relatively uniform upper sand aquifer. Layer thicknesses for Layers 1, 2, and 3 were made by dividing that aquifer into layers of approximately equal thickness (about 25 feet thick). Layer 4 was about 10 feet thick, and Layer 5, where active, was set to 18 feet thick. Elevation information for the top and bottom of the clays penetrated during the site investigations were incorporated into the determinations of top and bottom layer elevation files to MODFLOW. Some files were generated by kriging (contouring) the data in SURFER® and importing the resultant files.

Vertical anisotropy in hydraulic conductivity (K), as included in the calculation of the vertical conductance terms for the model, have been assigned as 5:1 for the permeable sands, and 10:1 for the silts and clays. These values are within the range reported in the literature for aquifer and aquitard materials on Long Island (Wexler, 1988).

4.3.5 Hydraulic Conductivity and Transmissivity

Hydraulic conductivity values assigned to the various layers were: 255 ft/day for Layers 1, 2, and 3, the upper sandy aquifer; 30 ft/day for the siltier sand in Layer 4, the northern portion of the model; 0.003 ft/day for the clay in Layer 4, the southern portion of the model; and 500 ft/day, 100 ft/day, and 10 ft/day to simulate high, medium, and low transmissivity in the coarse sand aquifer represented by Layer 5 (constant thickness) in the southern portion of the model. The equivalent transmissivity values for Layer 5 were 9,000, 1,800, and 180 ft^2/day, respectively. Model runs were made with these simulated conditions to see the effects on potentially drawing part of the plume into Layer 5, and in evaluating these effects on the estimated locations for plume discharge.

Two lakes, Lawrence Lake and Lake Orowoc, are probably the only surface ponds/lakes of sufficient size to influence groundwater flow within the model area. In the model, these lakes are presumed to be expressions of groundwater, i.e., flow-through surface water bodies. Rather than assign a constant head to them, they have been represented as high conductivity nodes (10,000 ft/day) so that they do not overly bias groundwater contours, and do not serve as infinite sources of water should water levels be drawn down in their vicinity, for example, by simulating pumping in their area.

Note that the values of K used for the modeling are consistent with those reported in the literature for the upper glacial aquifer, with values ranging from 187 to 400 ft/day (Wexler, 1988; Heisig and Prince, 1993).

4.3.6 Storage Coefficients and Porosity

Since the MODFLOW flow model is being run under steady-state conditions, no values for storage or porosity are needed. However, running MODPATH does require an effective porosity to calculate time of travel along the pathlines. For this, an effective porosity of 0.30 was used, which is consistent with literature sources and with effective porosity values used in other modeling and groundwater flow studies in this area of Long Island (Heisig and Prince, 1993).

4.3.7 Simulation of the Saline Wedge

The proximity of the site to the shoreline, and concerns for potential discharge to Great South Bay, prompted the inclusion of a model boundary condition representing a saline wedge intruding inward toward the land. The effect of this boundary is to cause the freshwater flow to ride up on the saline wedge with minimal mixing, and to eventually discharge to Great South Bay, probably near the shoreline (Getzen, c. 1976). In the model, the position and representation of the wedge has been based on theoretical calculations (Fetter, 1988), and confirmed during the field program as present at PZ-94-2D. The maximum theoretical distance landward that the saline wedge would extend was about 900 feet. This was apportioned step-wise with depth in the three layers that represent the upper glacial aquifer near the shore, with the presence of the wedge being simulated by no-flow cells. The approximate theoretical maximum extent of the saline wedge as input into the model is also shown on Figure 4-3. Freshwater discharge to the bay was estimated to occur right along the shoreline, within the first constant head node representing the ocean/bay in model Layer 1, i.e., within 200 feet of the shoreline.

4.4 MODEL DEVELOPMENT

Model development consisted of preparing input data packages in accordance with the conceptual model, and with initial parameter values based on the available data from field programs and from literature. Model output file results (groundwater heads and fluxes) were then compared with calibration targets. Input data files were prepared with the aid of the preprocessor, ModelCad^{386}® (Geraghty and Miller, 1993). Further changes to files were usually accomplished with one of several available text editors. Output head files for the flow model were read directly and/or post-processed for visualization with a Geraghty and Miller utility package, Modgrid®, and input into the SURFER® contouring program for output to monitor and/or printer. In addition to seeking a generally overall good fit (i.e., good agreement with interpreted flow direction and gradient), the fitting process also consisted of checking matches with point values (the measured water levels), and performing statistical analysis on the residuals of this comparison. This was accomplished through another Geraghty and Miller MODFLOW utility program, Calstats® (Geraghty and Miller, 1992). The other targets were the fluxes to streams. The model river package output was edited out of the main model output and processed by a program developed by ABB-ES to sum user-specified reaches of streams. This output was compared to the stream flux target values described in Subsection 4.3.2 to aid in adjusting river package input parameter values in order to improve the model fit. Once the input files were checked and debugged, calibration could begin.

4.5 MODEL CALIBRATION

Modeling was carried out under steady-state conditions, i.e., assumed to represent average conditions. The calibration targets (measured heads) were collected in November 1994, and constitute the only complete data set available over the model area. It is recognized that the water table conditions may be somewhat lower than annual average conditions, but the anticipated impact on the conclusions of plume discharge locations, or potential use of the model to assess pumping scenarios, is anticipated to be slight, as the water table variations over a normal year of recharge are relatively small.

Model calibration consisted mainly of varying the principal hydrogeologic parameters in the model, including horizontal hydraulic conductivity values, recharge distribution, river conductance and stage heights, and effective transmissivity in Layer 5. As mentioned above, the influence of the more highly conductive sand zone (Layer 5) is unknown, so three degrees of influence were set up and further evaluated in the particle tracking phase of the modeling. The Ks for Layer 5 were set at 500 ft/day, 100 ft/day, and 10 ft/day (effectively transmissivities of 9,000, 1,800, and 180 ft^2/day) as a basis for evaluating this influence on model heads and particle tracks (approximating the plume pathway). Attainment of river discharge to within 20% of the target values, and an average absolute head differences within 0.5 foot for Layer 1, and to about 1 foot for the lower layers, were considered acceptable criteria for calibration, in addition to general overall agreement with interpreted flow directions and gradients. Lower layers, particularly Layer 4 near the site show the influence of the elevation within the siltier material as well as a probable influence of lower heads in the aquifer underlying the Gardiners Clay, which has been interpreted as thin near the site. This effect could not be simulated in the present model.

The strongly implicit procedure solver was used in some initial model runs, but nonlinearity in the model did not allow the closure of the model to the specified 0.001 foot criterion, and the overall mass balance closure was not as good as desired, with some runs exceeding an internal mass balance error of greater than 1 percent. The solver was changed to the PCG2 solver for later runs (Hill, 1990). With the PCG2 solver, head differences were less than 0.001, and overall internal mass balances of less than 0.1 percent were routinely achieved. Time per run was approximately 15 minutes for 500 iterations.

Over 20 runs were made in providing the initial calibration for a high influence of Layer 5. The primary modifications in the input data to achieve acceptable calibration were in the distribution of recharge, variations in the northern constant head boundary value, and in modifications to stream conductances and stages (mainly in adjusting the slope of the streambed and stage). Modifications to input parameters are shown on Table 4-1 and Figure 4-4 (for recharge).

Fewer runs were needed to provide acceptable calibrations for the medium and low influence of Layer 5 cases. As the Layer 5 influence lessened (less flow into and out of Layer 5), the match with heads remained relatively good, with most of the extra water in the system discharging into streams. The difference here was also within acceptable variations in the baseflow to streams. The major difference in the functioning of the models was in the pathlines generated for groundwater originating in the vicinity of the site and at different depths there. This is discussed more in Subsection 4.6.

The river package balances and summary statistics for the point head matches are presented in Tables 4-2 and 4-3. In all three model versions, there was good agreement with interpreted flow direction and overall hydraulic gradient. Figure 4-5, a plot of the heads for a moderate influence of Layer 5, shows the contoured heads. The plots of output heads for the other two models are only minimally different.

The point-wise calibration is good for the overall model, and in particular for Layer 1, where there is quite a bit of information. The fit is not as good for the other individual layers, but there are very few target values available for each of these layers, and most of the calculated statistics may have little real significance. What the data in Layer 5 represent, is uncertain, as the character of this aquifer layer is not well-defined, and little emphasis has been placed in matching these data. Note also, that the inclusion of the saline wedge as a no-flow boundary did not allow the inclusion of Layer 2 and 3 data points in the target match where the wedge was present. To keep target values in this area of the model, it has been assumed that vertical gradients and head differences are small, and the value for the lower layer has been moved to Layer 1 at each of these locations in the target match file. This maintains the number of target matches, particularly important since head data are of low density, while only minimally affecting the assessment of the fit. Another source of variance in the fit could be due to fluctuations in the water table due to tidal changes. However, these are believed to be small due to the small tidal changes observed in Great South Bay (Bokuniewicz and Zeitlin, 1980).

A calculation was made to provide a comparison of the water available upgradient of the model boundary and the amount of water being provided by the assumption of a constant head along the model northern boundary. The calculated water recharged between the model boundary and the approximate location of the groundwater divide along Long Island (Doriski, 1986) was approximately 12 cfs. The amount of water provided by the constant head boundary along the model's northern perimeter was about 5 cfs. Since the recharge also supplies the underlying Magothy Aquifer, this comparison indicates a reasonable flux across the northern boundary of the model.

Further comparisons between modeled and measured values of groundwater flux were made when a report on groundwater discharge to Great South Bay

(Bokuniewicz and Zeitlin, 1980) was located after the modeling had been completed. An estimate of the total groundwater discharge along the coastline (of the model area) was computed based on the report data. The computed estimated discharge flow was from 5.5 to 8.0 cfs, while the model discharge to constant heads along the southern boundary of the model (in Layer 1) was 7.0 cfs. The comparison between the two is favorable, and further indicative of the overall validity of the model with respect to water flux. Bokuniewicz and Zeitlin also discuss their finding of a broader zone of discharge for groundwater to the Bay than theory would have predicted based on the probable saline-freshwater interface, but suggest that most of the discharge occurs within 100 meters of the shoreline.

4.6 PARTICLE TRACKING ANALYSIS OF GROUNDWATER DISCHARGE AREAS

Particle tracking was performed with MODPATH for the selected best-fit models showing appreciable, moderate, and relatively low influence of flow in Layer 5. Basic input files for MODPATH include the output head matrices from the calibrated models, and a subset of information provided in the MODFLOW input files. MODPATH also requires an effective porosity for each layer to allow particle tracking in time (at steady state); this was taken as 0.30 as discussed in Subsection 4.3.6. Particles were released and tracked for a number of scenarios for each of the models, including: particles released at the water table, and within Layers 1 through 4, at the site; particles released in the immediate vicinity of MW-94-23; particles released along a line in the vicinity of MW-94-23 to show probable ultimate receptor locations for particles in Layer 3 (just above the upper clay); and particles released representing a plume 1,200 feet wide in Layer 3 near MW-94-23. Particles were designated to be captured if they entered weak sinks (nodes in which the water removed is a fraction of the total flow through the cell). This is a conservative assumption relative to the potential impact on the streams, but probably accurate based on the match with observed fluxes to streams.

In all cases, particles released at the site terminated in Layer 5 (their final position at the model perimeter) or else in the lower reaches (below the gauging station) of Penataquit Creek. Particles released in the immediate vicinity of MW-94-23S (beyond the apparent influence of Layer 5) discharged entirely to the Penataquit Creek in all three versions.

Figure 4-6 shows the pathlines for particles released at the water table near the ServAll site. The pathlines stay very close to the model grid centerline (the projected plume axis), bending only slightly to the west. The pathlines suggest that MW-94-23 may be monitoring the western leading edge of the ServAll plume, hence concentrations detected here may not be as high as would be intercepted at the plume axis at this distance from the site. Figure 4-7 shows the ultimate fate of an east-west oriented line of particles introduced into Layer 3 (just above the upper clay). This figure shows the different discharge locations for groundwater flowing through this section of the model, and delineates the zone of influence of Penataquit Creek. The interpreted location of the plume is toward the eastern side of this interval, but well within it. Figure 4-8 shows the pathlines for particles released along a 1,200-foot plume width in Layer 3 near MW-94-23. As shown in Figure 4-8, the particle tracking analysis indicates probable plume discharge would occur between the conjunction of the two upper reaches of Penataquit Creek and Great South Bay.

Table 4-4 summarizes and compares the particle tracking runs for each of the three levels of influence assumed for Layer 5. The table shows the number of particles released and the number winding up at the various potential receptors. The output ENDPOINT files from MODPATH were used to identify the locations each particle would discharge to in the contaminant transport analysis discussed in Subsection 4.7.

The predicted pathlines of the particles released at the site suggested some influence from a lower level, i.e., that there may be some general downward seepage through the Gardiners Clay or the upper clay unit. This influence is not included in the northern portion of the model, but the defined presence (if not extent or character) of Layer 5 in the recent explorations provides a means in the model to achieve some of the effects observed in the aquifer system and at the site. These include primarily a plume descending steeply in the aquifer, and present above the clay along a path which includes the new well MW-94-23S. However, an assumed high level of influence of Layer 5 resulted in a nearly complete capture of the site-related plume in Layer 5, which is contrary to observed concentrations arriving in MW-94-23S. At the other extreme, with a relatively low level of influence from a lower layer, particles released at the water table at the site do not descend steeply into the modelled aquifer. They only appear in Layer 3 considerably south of MW-94-23S. This is, again, contrary to the contamination observed just above the clay extending from immediately south of the site all the way to MW-16, and with the indication of it just arriving at MW-94-23S. While part of this presence may be due to dense non-aqueous phase liquid (DNAPL) pooling on the clay beneath the site, there doesn't appear to be enough time for migration from the site to MW-16 through the lower K siltier sand (Layer 4). Part of the contamination found as far south as MW-16 appears to be due to migration through the higher K material. This may occur if the siltier zone becomes more permeable to the south of the site, or if contaminant presence is due to a rapidly descending plume in the higher K materials above the silty sand.

The observed conditions appear to favor some limited influence of a lower layer, and the best model to represent this among the three generated is the one including some moderate influence from Layer 5. Even so, there is not much difference in the probable discharge locations along Penataquit Creek, or in the probable exposure concentrations, for contaminants present near MW-94-23S (and in Layer 3) as will be discussed in Subsection 4.7. Using the most reasonable parameter values, the site plume is expected to discharge to Penataquit Creek along the area indicated on Figure 4-9.

4.7 TRANSPORT MODELING AND EXPOSURE CONCENTRATIONS IN STREAMS

Transport modeling was conducted for the purpose of estimating concentrations of contaminants in Penataquit Creek due to discharge of the ServAll plume at the locations and rates identified in the particle tracking runs. First, another AT123D (Yeh, 1981) run was made as in the preliminary modeling (ABB-ES, 1994a) to estimate the maximum and average concentrations of PCE in the plume as it approached the nearest probable discharge point. The maximum concentration, estimated at 6.3 milligrams per liter (mg/L), is only slightly less than that estimated for the nearest freshwater discharge point in the preliminary modeling. The printout of the output of the AT123D model run is included in Appendix G. Note that at the point where the plume enters the influence of Penataquit Creek, streamtubes begin to constrict, and further dilution through dispersion is probably not significant.

Assuming a Gaussian distribution across the width of the plume, a total width of about 1,200 feet, and using the estimated groundwater velocity of 912 feet/year (based on the travel time estimates in MODPATH), an estimated total mass discharge of 0.85 pounds per day of PCE was calculated (corresponding to the time the maximum concentration begins discharging to the creek). The plume cross section was conceptualized as having an approximate normally distributed mass.

Using 200 feet as one standard deviation from the mean (since six standard deviations would be about the total width of the plume), weights were assigned to the particles within one, two, and three standard deviations of the plume axis. Thus a fraction of the total mass, or an equivalent mass, could be assigned to each of the particles discharging to a given stretch of a stream. Concentrations in the stream were estimated by identifying which node or model block particles discharged to (from the MODPATH ENDPOINT file output), and dividing the cumulative mass (adding the mass contributed by each discharging particle) by the cumulative baseflow (obtained from the river package output) for each successive reach of the simulated stream.

Concentrations of the other major constituents in the plume (TCE, 1,2-DCE, and VC) were estimated based on the ratio of the estimated maximum constituent concentration to that of PCE (see Table 4-5). That is, the plume distributions and arrival time at the river were conservatively assumed to be the same as for PCE. The analysis is also conservative in that it does not consider the added dilution that occurs due to the added streamflow by runoff and estuarine flushing, and by the shallow, rapid streamflow that would promote rapid volatilization. Even under quiescent conditions, VOC volatilization half-lives in the stream would be on the order of only a few hours. Since the concentrations for 1,1-DCA and 1,1-DCE were two to three orders of magnitude lower than the major constituents they were not further refined in this part of the Phase I analysis. However, for the purpose of the ERA, pore water concentrations were used from the conservative screening analysis (ABB-ES, 1994a).

Calculations made based on the apparent retarded velocity of the plume indicate that the leading edge of the plume would begin to discharge in 5 to 10 years, while maximum concentrations (the plume centroid) would not arrive until about 15 to 20 years hence.

4.8 MODEL LIMITATIONS AND SENSITIVITY ANALYSIS

It is important to realize that the flow model constructed for this project does not purport to be a definitive model of the hydrogeologic regime over the model area. There are too many gaps in our detailed knowledge of the geology, hydrogeology, and the interaction of groundwater with surface water to allow a uniquely determined model to be constructed. However, the model captures the essential elements of what is known about the hydrogeologic response in the upper aquifer, is reasonably calibrated to available data, and is a close match to observed or measured fluxes and gradients. Where gaps in knowledge exist, assumptions in the model have been made that are generally conservative relative to the purposes of the model, i.e., estimating locations and flows of the contaminant plume to surface water, and possible use in aiding in downgradient groundwater extraction should decision criteria deem this necessary.

The principal areas in which the model could be refined include: a broader understanding of the influence of lower aquifers, and the competency of the Gardiners Clay as an aquitard over the entire model domain; detail regarding the physical characteristics of the principal streams over greater stretches of the streams; current measurements of stream baseflow; more detailed knowledge of the effects of anthropogenic influences (e.g., pavement, drains, recharge basins, or sewers) in the urbanized areas of the model; a greater knowledge of the model area geology (since much of the deeper information is confined to a narrow band along the plume pathway and projected pathway); a greater knowledge of the variability of flows and water elevations over the course of the year; and calibration to a set of conditions which truly represent average or, in the case of the baseflow estimates to Penataquit Creek, current flow conditions.

Sensitivity of the model to variation in the effects of parameters was noted during calibration runs. The model was most sensitive to changes in the stage elevations input for the streams, changes in the transmissivity attributed to Layer 5, and variations in recharge. The model was less sensitive to moderate changes in hydraulic conductivity for Layers 1 through 3 (varied between 200 and 300 ft/day), and in conductance values assigned to the river package input. In the latter case, initial conductance values were quite high, so that further increases in conductance yielded little extra stream baseflow (differences between the input stream stage values and the computed heads in the corresponding model block had become very small). The possible influence of the more highly conductive sand zone represented by Layer 5 in the model has been approached by setting up three versions of the model to represent relatively high, moderate, and low effects of this layer. The results of varying the influence of Layer 5 did have some impact on pathlines predicted for particles released at the site, but little impact on particles representing the present position of the leading edge of the plume in the vicinity of MW-94-23S.

5.0 PHASE I ECOLOGICAL ASSESSMENT

5.1 INTRODUCTION

The purpose of this Ecological Risk Assessment for the ServAll Plume Discharge Study is to provide a detailed evaluation of potential future risks that plume-related constituents may pose to resident and migratory fish, other aquatic life, and wildlife receptors following discharge of contaminated groundwater to surface water bodies. This ERA is predictive, rather than retrospective (Suter, 1993), because ecological impacts will not occur until such time as contaminated groundwater discharge commences. The results of this ERA, in conjunction with other information presented in this report, will be used to determine what further investigations, if any, are warranted at the study area. This study was conducted following an initial screening of potential ecological risks (ABB-ES, 1994a), and is based on a more precise estimate of likely plume discharge concentrations as well as a more comprehensive evaluation of the likely toxicological effects associated with these contaminants.

The ERA includes the following elements:

- Identification of Contaminants of Concern (Subsection 5.2)
- Biological Characterization (Subsection 5.3)
- Ecological Exposure Assessment (Subsection 5.4)
- Ecological Effects Assessment (Subsection 5.5)
- Ecological Risk Characterization (Subsection 5.6)
- Risk Uncertainties/Data Gaps (Subsection 5.7)
- Summary (Subsection 5.8)

The ERA has been conducted in accordance with the following state and federal guidance documents:

- "Framework for Ecological Risk Assessment" (USEPA, 1992a)

- "Risk Assessment Guidance for Superfund (RAGS): Volume 2 - Environmental Evaluation Manual" (USEPA, 1989b);

- "Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference" (USEPA, 1989c); and
- "Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites" (NYSDEC, 1991b)

In addition, recent supplemental risk assessment guidance such as USEPA "Eco Update Bulletins" (USEPA, 1991c,d; 1992b,c,d) have been considered in the development of this ERA.

5.2 IDENTIFICATION OF CONTAMINANTS OF CONCERN

In most retrospective ERAs, the chemical contaminants of concern (COCs) detected in environmental media at a site are typically screened, and only those contaminants likely to pose a risk to ecological receptors are carried through the assessment process. An important screening criterion is a comparison of site-related contaminant concentrations with naturally occurring or background concentrations. The primary reason for conducting this step is to make the assessment process more manageable and to focus on those constituents most likely to result in risk within the study area. This contaminant elimination step was not conducted in this ERA because of the anthropogenic nature and limited number of plume constituents evaluated. The COCs evaluated in this ERA consist of all contaminants detected in the ServAll groundwater plume that are expected to discharge into aquatic habitat. The following groundwater plume constituents were selected as COCs for this assessment: PCE, TCE, 1,2-DCE, VC, 1,1-DCE, and 1,1-DCA.

5.3 BIOLOGICAL CHARACTERIZATION

The purpose of the biological characterization is to identify ecological receptors that could potentially be exposed to groundwater plume constituents following discharge into aquatic habitats. This subsection includes general descriptions and mapping of vegetative cover-types in the vicinity of the predicted groundwater discharge area, and is based on scientific literature and other published accounts, site-specific reports and records, contact with regional authorities, and observations made during a December 1994 site walkover by ABB-ES biologists. Figure 5-1 presents habitat information for the general area of the ServAll groundwater plume and follows the classification system provided in Reschke (1990).

Regionally, less than 33% of the land surface is forested and receives approximately 45 inches of rain per year (Anderle and Carroll, 1988). The region falls within the Coastal Lowlands ecozone. The substrate in upland areas is generally sand characteristic of glacial outwash plains. Pitch pine and various oak species are the primary forest canopy cover types (Anderle and Carroll, 1988).

Groundwater contaminated with chemical constituents from ServAll is expected to discharge to Penataquit Creek in approximately ten years (Subsection 4.6). Great South Bay is located inside a barrier beach system on the southern side of Long Island, New York (Figure 2-1).

Much of Bay Shore is zoned for residential and commercial uses. Various urban classifications for Bay Shore (as provided in Reschke, 1990) include urban vacant lots, landfills, urban structures, paved roads, and mowed lawns/roadsides (with or without trees). The general category is referred to as "urban terrestrial/cultural" (Figure 5-1). Although much of Bay Shore is urbanized, several conservation areas and wildlife refuges exist within a three-mile radius: Seatuck National Wildlife Refuge, Islip Meadows County Nature Preserve, Heckscher State Park, the Nature Conservancy, the New York State Conservation Area, and the Suffolk County Gardiner Park (Figure 5-1). These areas, ranging in size from approximately 60 acres to over 2,100 acres, are indicative of the coastal ecosystem that existed prior to development.

5.3.1 Midreach Stream Habitat

The fresh-water portions of the Penataquit River (north of Main Street in Bay Shore), as well as other similar streams in the study area as indicated in Figure 5-1, may be classified as a midreach stream habitat type (Reschke, 1990). This community is characterized by alternating pools, riffles, and run sections, and may possibly have waterfalls and springs. Erosion typically occurs laterally, with deposition occurring along the stream bottom and in pools.

Penataquit Creek originates about one-eighth of a mile south of the Southern State Parkway (Figure 2-1). The culverted stream travels south underneath the South Shore Mall, the Sunrise Highway, and the Long Island Railroad, and through several heavily populated suburban neighborhoods and business districts. The stream width varies between 10 and 20 feet, and has a sand and fine gravel bottom substrate. Except for the occasional pool, stream depth in both upstream and downstream portions is approximately 2-4 inches. The stream banks are generally steep, with some overhanging vegetation in places. Penataquit Creek appears to be fairly oxygenated in the faster flowing areas. The overall condition of Penataquit Creek appears to be generally degraded as evidenced by the accumulation of trash and litter noticed throughout the stream reach. Many of the plant species observed in the riparian sections of the creek are also indicative of human disturbance. These species include: tree-of-heaven (*Ailanthus altissima*), catalpa (*Catalpa speciosa*), weeping willow (*Salix babylonica*), locusts, reedgrass (*Phragmites autralis*), and Japanese knotweed (*Polygonum cuspidatum*),

No survey of the aquatic species found in Penataquit Creek is available. Fishes typically found in midreach stream communities include creek chub (*Semotilus atromaculatus*), pumpkinseed (*Lepomis gibbosus*), and common shiner (*Notropis cornutus*). Some aquatic macrophytes commonly encountered in these communities include waterweed (*Elodea canadensis*) and sago pondweed (*Potamogeton pectinatus*) (Reschke, 1990). It is also likely that this habitat supports various aquatic invertebrate groups typical of small midreach streams on Long Island.

5.3.2 Tidal River Habitat

The portion of the Penataquit River extending from south of Main Street in Bay Shore to the bay may be classified, according to Reschke, 1990, as a tidal river with a vertical salinity gradient, subject to tidal fluctuations. The substrates support no emergent vegetation and are continuously flooded. Penataquit Creek becomes brackish within a mile of Great South Bay. The stream and two smaller branches are wide (approximately 20 to 40 feet) and are bordered by man-made berms and suburban neighborhoods, thus creating an artificial deepwater community (classified by Reschke, 1990 as an estuarine channel/artificial impoundment). The branches of the stream have slips for boats and, in some cases, are connected by canals. Near its mouth, Penataquit Creek is approximately 100 feet wide and flows approximately 0.5 miles before discharging into the Great South Bay in the vicinity of the Bay Shore Marina (Figure 5-1).

Fish species that may inhabit tidal rivers include year-round freshwater species and seasonal anadromous species, including: hogchoker (*Trinectes maculatus*), rainbow smelt (*Osmerus mordax*), striped bass (*Morone saxatilis*), spottail shiner (*Notropis hudsonius*), pumpkinseed, bay anchovy (*Anchoa mitchilli*), blueback herring (*Alosa aestivalis*), white perch (*Morone americana*), and alewife (*Alosa pseudoharengus*) (Reschke, 1990).

5.3.3 Marine Eelgrass Meadow Habitat

The protection provided by Fire Island maintains relatively calm waters inside Great South Bay that support highly productive marine eelgrass meadow communities. Eelgrass (*Zostera marina*), the dominant plant species, provides protective cover for fish eggs and larvae and allows for sediment stabilization. Other plant species that may occur include sea lettuce (*Ulva lactuca*) and various algal species. Some animals that may be found in the marine eelgrass meadow community include bay scallop (*Aequipectin irradians*), sticklebacks (*Apeltes quadracus* and *Gasterosteus aculeatus*), and mummichog (*Fundulus heteroclitus*) (Reschke, 1990).

Shellfishing from the waters in and around the Bay Shore Marina is prohibited, however, the bay has historically been a fertile shellfishing region on Long Island (Jones and Schubel, 1980). Due to the decreased productivity of the shellfishing industry in the greater New York and New Jersey area, a number of studies have been undertaken to monitor the contaminant uptake by shellfish (e.g., the mussel watch program [NOAA, 1989]), however, no specific data are available for the Great South Bay.

Great South Bay is connected via the Fire Island Inlet (through which tidal mixing occurs) to the Atlantic Ocean. The ecological community on the seaward side of Fire Island may be classified by Reschke (1990) as a marine deepwater community; an area of both quiet and rough open ocean beyond the limits of any rooted vascular plants.

5.3.4 Other Habitat Types

Examples of other habitat types are located throughout the general Bay Shore area (Figure 5-1). Although none of these communities are expected to be impacted by future discharge of the ServAll groundwater plume, they are qualitatively discussed below.

Transition zone/beach. Beaches characteristically have both a salt barren community (an area above the high tide line that may experience tidal flooding only during extremely high tides) and a transition zone (the area above the highest tide). Various plant species observed at the beaches and marsh areas of Great South Bay include: reedgrass, beardgrass, bayberry, seaside goldenrod (*Solidago sempervirens*), silverberry (*Elaeagnus* sp.), red cedar, and beach rose.

Many of these species, in addition to sumac (*Rhus typhina*), viburnum (*Viburnum* sp.), blueberries, bayberry, and groundsel tree (*Baccharis halimifolia*), were also observed in a broad-leaved deciduous forested wetland (Cowardin, et al., 1979) dominated by black gum and red maple at the Suffolk County Gardiner Park (Figure 5-1).

Marine intertidal sand/gravel beach. The intertidal sandy beach, as characterized by Reschke (1990), occurs between the high- and low-tide marks where the substrate is subject to wave action and temperature and salinity fluctuations, and is well drained at low tide. This community was not observed at any of the shore-front areas along Penataquit Creek, as all properties are bermed and impounded. Some organisms typically found in this community include benthic invertebrates (i.e., polychaetes and amphipods) and shorebirds (Reschke, 1990). Other organisms that may be found in the intertidal zone include soft shell clams (*Mya sp.*), oysters, periwinkles (*Littorina littorea*), blue mussels (*Mytilus edulis*), lady slippers (*Crepidula fornicata*), quohogs or hard shell clams (*Mercenaria mercenaria*), hermit crabs, and barnacles (*Balanus* sp.). Seaweed and shore plants that may be found in the intertidal areas along Great South Bay include surf grass, sea lettuce, rockweed (*Fucus* sp.), knotted wrack, green algae (*Codium fragile*), red algae (*Polysiphonia* sp.), and *Spartina.*

Low salt marsh. The low salt marsh (as described in Reschke, 1990) is a zone of sheltered coastal marsh that extends from mean high tide down to mean sea level, between the high salt marsh and the intertidal mudflats. A protected salt marsh area was observed at the Seatuck National Wildlife Refuge. In addition, areas of low salt marsh may exist at Heckscher State Park, Islip County Meadows Nature Preserve, and Gardner Park. Vegetation is dominated by cordgrass (*Spartina alterniflora*), however, other plants species may include reedgrass, knotted wrack, rockweed, sea lettuce, and green algae (*Enteromorpha* spp.) (Reschke, 1990).

5.3.5 Species and Habitats of Special Concern

The NYSDEC Significant Habitat Unit and New York Natural Heritage Program (NYNHP) maintain the New York Natural Heritage Database, a computerized database containing site-specific information on rare plant and animal species and natural communities in New York State. Although the files of the NYNHP are continually updated as rare species and communities are discovered, NYSDEC is unable to provide definitive information regarding the presence or absence of species, habitats, or natural communities (NYSDEC, 1995).

The United States Fish and Wildlife Service (USFWS) also maintains records regarding threatened, rare, and endangered species under the federal jurisdiction of the Endangered Species Act.

Both the Significant Habitat Program and the USFWS were contacted regarding the presence of rare and endangered plant and animal species at or in the vicinity of the Penataquit Creek where the ServAll groundwater plume will likely discharge. We are currently awaiting responses to these requests; any information obtained from these agencies will be included in a later draft of this report.

5.4 ECOLOGICAL EXPOSURE ASSESSMENT

The purpose of the ecological exposure assessment is to evaluate the potential for future ecological receptor exposure to ServAll groundwater plume constituents. This evaluation involves the identification of potential exposure routes to receptors and the evaluation of the magnitude of exposure to the identified ecological receptors. The development of estimated surface water and sediment discharge concentrations for the groundwater plume constituents is discussed in Subsection 4.7.

Exposure pathways describe the mechanism(s) by which ecological receptors are exposed to contaminated media, and consist of (1) a contaminant source; (2) environment transport mechanisms; (3) a point of receptor contact; and (4) the exposure route (e.g., ingestion of prey items that have bioconcentrated contaminants in their tissues, dermal absorption, inhalation, etc.). A general overview of the exposure pathways considered in the ServAll ERA is presented in Figure 5-2. Potentially exposed receptors include:

- Aquatic biota in Penataquit Creek

- Semi-aquatic biota that depend on the aquatic environment for a portion of their life history requirements

Exposure pathways and receptors evaluated in this ERA were chosen based on the characteristics of ecological receptors and habitats in the vicinity of the likely discharge of the ServAll groundwater plume, the physical and chemical properties of the COCs, and the environmental media that could potentially become contaminated as a result of groundwater discharge. Future exposure concentrations to aquatic receptors were quantified as the average and maximum predicted discharge concentrations in Penataquit Creek surface water and the pore water associated with creek sediments (Table 5-1). It is anticipated that only those aquatic organisms with life stages (e.g., egg, larvae, nymphs, adults) that are intimately associated with sediments would be exposed to the interstitial pore water concentrations of the plume constituents. Consequently, benthic and epibenthic taxa were differentiated from pelagic organisms (i.e., found primarily in the water column) in this ERA based on a system developed by DiToro (c. 1990).

5.4.1 Aquatic Biota

Aquatic organisms (including plants, invertebrates, fish, and amphibians) may be exposed to contaminants through dermal contact with, and ingestion of, contaminated surface water and sediments (Figure 5-2). For certain compounds, bioconcentration may also result in significant exposure for consumers of aquatic organisms. Bioconcentration is defined as "the process by which there is a net accumulation of a chemical directly from water into aquatic organisms resulting from simultaneous uptake (e.g., by gill and epithelial tissue) and elimination" (Rand and Petrocelli, 1985). Bioconcentration from contaminated surface water potentially results in aquatic food chain effects, and could result in exposure to both aquatic and semi-aquatic ecological receptors. Vascular aquatic plants may be exposed via root uptake from, and direct contact with, contaminated surface water and sediments (Figure 5-2).

The relative lack of ingestion toxicological data for predatory fish and invertebrates precluded an evaluation of the contaminated food chain pathway in this ERA. However, this exposure pathway is not considered to be a significant one for COCs evaluated in this ERA. In general, VOCs are characterized by low K_{ow} (Table 3-6), suggesting that this class of chemical compounds is unlikely to partition into biological tissues.

5.4.2 Semi-Aquatic Biota

Semi-aquatic receptors (including adult amphibians, reptiles, birds, and mammals) may be exposed to the groundwater plume constituents following discharge to surface water bodies via dermal contact with contaminated water and sediment, direct ingestion of these two media, and by consuming contaminated prey items (Figure 5-2). Bioconcentration from contaminated media may also result in semi-aquatic food chain exposures. Inhalation of VOCs from contaminated media also represents a potential exposure pathway.

Exposures to semi-aquatic receptors via dermal uptake and inhalation were not addressed in this ERA because little data exist necessary to quantify exposure concentrations for ecological receptors. Although dermal exposure may be an ecologically significant exposure route for amphibians and for young, hairless mammals in subterranean dens (e.g, juvenile muskrats), fur, feathers, and chitinous integument will generally minimize dermal absorption for the majority of ecological receptors. Inhalation exposures by ecological receptors are usually insignificant, except in emergency situations (e.g., following a chemical spill), and this pathway was also not evaluated in this ERA.

As discussed in Subsection 3.6, it is unlikely that the COCs evaluated in this ERA will likely bioconcentrate to any great degree. However, the K_{ow} for PCE is the highest of the evaluated COCs, the predicted discharge concentrations of this compound are expected to be the greatest in magnitude of the plume constituents, and the limited bioconcentration data suggest that this compound may bioconcentrate in fish tissues under certain laboratory conditions (see Subsection I.1 in Appendix I). Consequently, potential exposures to a semi-aquatic piscivore were evaluated for this compound to determine the significance of this pathway. The raccoon (*Procyon lotor*) was selected as a semi-aquatic receptor that may be exposed via this route and is expected to occur in the urbanized environment associated with the Penataquit Creek.

A conservative food chain model was developed to estimate semi-aquatic receptor exposures to PCE via the prey consumption pathway. A PCE ingestion dose to the raccoon was estimated based on ingestion of fish exposed to the maximum estimated concentration of PCE (27 micrograms per liter [μg/L]) in surface water (Table 5-1). The maximum fish BCF provided in the Ambient Water Quality Criteria (AWQC) document (USEPA, 1980a) was used to estimate the concentration of PCE in

Penataquit Creek fish tissue. A BCF for bluegill (*Lepomis macrochirus*) of 49 liters per kilogram was multiplied by the PCE concentration to yield a fish tissue concentration of 1.3 milligrams per kilogram (mg/kg) wet tissue. The raccoon ingestion rate was estimated from an allometric food ingestion rate equation in USEPA (1993), based on body weight. The estimated ingestion rate was then adjusted to a wet weight basis by applying a factor of 10, assuming that fish tissue consists of 90% water. This resulted in an estimated daily ingestion rate of 2.9 kg/day (wet weight) for the raccoon. The body weight of the raccoon was estimated to be 5.7 kg, which is an average of reported values from USEPA, 1993. A PCE dose (in mg/kg BW-day) for the raccoon was estimated by multiplying the fish tissue concentration by its ingestion rate, and dividing by body weight. This resulted in a body weight normalized dose estimate of 0.66 mg (PCE)/kg BW-day. Raccoons are omnivorous and ingest a variety of plants, invertebrates, amphibians, and small birds and mammals, as well as fish (DeGraaf and Rudis, 1987). It was conservatively assumed, however, that the raccoon's entire diet consisted of fish from the vicinity of the groundwater plume discharge zone in Penataquit Creek.

5.5 ECOLOGICAL EFFECTS ASSESSMENT

The purpose of the Ecological Effects Assessment is to describe the potential risks associated with the identified COCs in each potentially contaminated environmental medium, and to evaluate the relationship between the concentrations to which an organism is exposed and the potential for adverse effects due to acute and chronic exposures. The toxicological evaluation includes characterizing the inherent toxicity of the COCs and describing the relationship between exposure concentrations and adverse ecological effects. Information contained in the Ecological Effects Assessment, in conjunction with exposure information presented in Subsection 5.4, was used to evaluated the ecological risks to aquatic and semi-aquatic organisms in the ecological risk characterization (Subsection 5.6).

Appendix I contains a summary of the available aquatic toxicological information for each of the COCs. These toxicity profiles also present available information on the tendency of these compounds to bioconcentrate in biological tissues. Only data on effects to freshwater organisms are presented in Appendix I because the groundwater plume is not anticipated to discharge to the marine environment of Great South Bay (Subsection 4.6).

5.5.1 Effects to Aquatic Biota

Studies on the effects of contaminants on organisms in aquatic systems have been compiled and organized by USEPA and the Aquatic Information Retrieval (AQUIRE) database. Laboratory studies reporting acute (i.e., short-term) toxicity data typically involve exposing an invertebrate or fish species to high concentrations of a chemical for a relatively short time period (hours to a few days), after which the percentage of the population affected is recorded. From these data an EC_{50} (median effect concentration, which is defined as the concentration expected to produce an effect in 50 percent of the test population) or LC_{50} (median lethal concentration, defined as the concentration expected to be lethal to 50 percent of the test population) is derived.

Potential effects to aquatic receptors resulting from exposure to the groundwater plume constituents were evaluated by reviewing available information summarized in the USEPA AWQC documents and by obtaining a data download from the AQUIRE database for the COCs. Information provided in the AWQC documents was summarized in the screening level assessment (ABB-ES, 1994a). The toxicological data presented in the AWQC documents is now considered to be outdated, and the AQUIRE database was referred to as the main toxicological information source for this ERA.

Ambient Water Quality Criteria/Standards. USEPA developed and published AWQC for a variety of hazardous compounds based on available aquatic toxicological data. These criteria specify the contaminant concentration in ambient surface water that, if not exceeded, should protect most species of aquatic life and its uses. The chronic criterion represents the contaminant concentration that should not be exceeded by the four-day average chemical concentration more than once every three years (USEPA, 1983). In developing a chronic AWQC, USEPA estimates protective contaminant levels based on chronic toxicological data for animals, plants, and on residue levels in aquatic organisms. The acute criterion represents the concentration that should not be exceeded by the one-hour average concentration more than once every three years. The Quality Criteria for Water document summarized the available information presented in the individual AWQC documents (USEPA, 1986). USEPA considered the available toxicological data insufficient to develop AWQC for all the ServAll groundwater plume constituents. In fact, no toxicological data were provided for VC. For those chemicals lacking sufficient data necessary to derive AWQC, the 1986 summary document presents the lowest concentrations at which adverse effects had been observed in laboratory studies (referred to as lowest observed effect levels, or LOELs).

New York State water quality standards and guidance values have been established for numerous chemicals, including the targeted plume contaminants (NYSDEC, 1991a). Although the standards for these chemicals include consideration of effects such as protection of aquatic life and its uses, they are, for the most part, based on human health considerations and are not considered applicable for the evaluation of ecological risks. Comparison of maximum and average concentrations of VOCs in the ServAll plume modelling results (see Subsection 3.5) to New York State Class C surface water standards indicate that the TCE and PCE concentrations would potentially exceed the standards of 11 μg/L and 1 μg/L, respectively.

Aquatic Information Retrieval System (AQUIRE) Database. Freshwater toxicity data were obtained from USEPA's AQUIRE database for the following ServAll groundwater plume constituents: PCE; TCE; VC; and 1,1-DCE. Although 1,2-DCE is a groundwater plume constituent, data from USEPA's AQUIRE database on 1,2-DCE were not available and the toxicological data for 1,1-DCE were used to evaluate the potential toxicity associated with the discharge of both 1,1-DCE and 1,2-DCE into the aquatic environment. In a similar fashion, toxicological data for 1,2-DCA were used to evaluate the potential impacts associated with exposure to 1,1-DCA. Toxicological data that were assigned lower reliability categories in the AQUIRE database (i.e., reliability classes 3 and 4) were eliminated from the evaluation.

Acute and chronic studies reported in the AQUIRE database were segregated according to the exposure regimen, exposed life stage(s), and lifespan of the test organisms. Toxicological effects measured included lethality, growth, population decline, immobility, biological/physiological, photosynthetic, or reproductive effects and LC_{50} or EC_{50} endpoints. A summary of all data obtained are provided in Tables J-1 through J-5 (Appendix J).

For each distinct taxon, available acute EC_{50}s and LC_{50}s data were combined and the geometric mean effects concentration estimated as the species mean acute value. Relatively few studies of chronic duration are available for the COCs, however, chronic values were estimated in the same manner for those taxa where sufficient information was available. The species mean acute values provided in Tables J-6 through J-9 (Appendix J) for each compound are equal to the geometric mean of all acute data for that taxon. This approach is similar to that used by the USEPA in the AWQC documents to calculate mean acute values (USEPA, 1983). When chronic data were available, the same approach was used to calculate mean chronic values.

Only LC_{50}s effect concentration data have been reported in the USEPA criteria documents and the AQUIRE database for certain COCs. These concentrations are not considered appropriate as protective benchmark values for aquatic life, because 50 percent mortality is a significant effect with obvious population-level repercussions. For other chemicals, only acute LOELs were available. These concentrations also may not be appropriate as protective benchmark values because sublethal effects (e.g., decreased reproductive success or growth rates) could occur at concentrations well below acutely toxic or lethal concentrations. Therefore, toxicity values based on predicted chronic effects were also developed in this ERA. Extrapolative techniques were used to estimate chronic toxicity values for chemicals for which measured chronic toxicity values are not available. These techniques are most often presented in terms of a regression equation based on a database of acute and chronic toxicity data for a given chemical or chemical group. Suter et al. (1992) developed several equations to extrapolate from LC_{50} data to chronic values. Two equations are applicable to nonmetallic contaminants: one is based on toxicity data for an invertebrate group (daphnids) and the other is based on toxicity data for fish. These equations were used to extrapolate from acute to chronic toxicity values for those chemicals lacking measured chronic toxicity values. These equations are as follows (Suter, et. al., 1992):

$$\log (CV_{fish}) = 1.07 * \log(LC_{50}) - 1.51$$

and

$$\log (CV_{daphnid}) = 1.11 * \log(LC_{50}) - 1.3$$

where

CV = estimated chronic value (μg/L),
LC_{50} = geometric mean of multiple LC_{50} values for a chemical (μg/L),
and

These equations were applied to the estimated mean species acute values estimated from the AQUIRE database to estimate species-specific chronic values. The regression for fish was used to estimate chronic values for fish and other vertebrate species (e.g., amphibians); the daphnid regression was also utilized in estimating chronic values for other invertebrates and algal species.

For each compound, the LOELs (USEPA, 1986) and the species mean acute and chronic values were rank ordered, and each species was assigned a habitat suitability code according to the habitat classification system for life stages of organisms outlined in DiToro et al., (c. 1990). Habitat suitability was based on the degree of an organism's association with sediment (during any life stage), with codes 1 through 4 assigned to species with benthic and epibenthic life stages, and codes 5 through 8 representing water column, or pelagic, species (DiToro et al., c. 1990).

Figures 5-3 through 5-6 present the rank-ordered log-transformed species acute and chronic values and graphically depict the relative sensitivities of the various test taxa. Solid symbols represent mean acute values whereas dotted symbols represent mean chronic values. Squares represent pelagic organisms and circles represent benthic/epibenthic organisms (Figure 5-3 through 5-6).

Finally, the expected average and maximum discharge concentrations of surface water and pore water are plotted on each graph. Taxa, whose acute or chronic values lie to the left of these discharge concentrations, are considered to be sensitive to that particular contaminant and may exhibit either acute or chronic effects from exposure to expected discharge concentrations of that compound. Those taxa whose acute and chronic values lie to the right of the expected discharge concentrations are not expected to experience adverse effects from the exposure to these compounds.

The only acute study available for VC in the AQUIRE database download is a 10-day lethality study using the northern pike (*Esox lucius*). An acute effect concentration of 388,000 μg/L was reported in this study (AQUIRE, 1994). The calculated chronic value, based on the Suter et al., 1992 regression equation for fish, is equal to 29,500 μg/L.

As previously discussed, little toxicological data are available for 1,2-DCE, therefore, the potential aquatic effects associated with the discharge of this compound were estimated using the AQUIRE data for 1,1-DCE. A comparison of the 96-hour LC_{50} effect concentration data for the bluegill sunfish reported in USEPA (1980b) suggest that these two compounds are toxicologically similar, at least to fish. It was also assumed in this ERA that 1,2-DCA is a suitable surrogate for 1,1-DCA.

5.5.2 Effects to Semi-Aquatic Biota

Potential impacts to the raccoon associated with PCE food chain exposures were evaluated based on a comparison of the estimated total body dose (see Subsection 5.4.2) to a reference toxicity benchmark dose derived from a review of the toxicological literature. A reference toxicity value (RTV) of 100 mg/kg BW-day was chosen from a PCE ingestion toxicity study on mice. Subchronically (i.e., 6 weeks) exposed animals exhibited a statistically significant increase in hepatotoxicological effects compared to control mice in this study (Buben and O'Flaherty, 1985).

5.6 ECOLOGICAL RISK CHARACTERIZATION

The risk characterization presents an evaluation of the risks to aquatic and semi-aquatic receptors potentially exposed to plume constituents following groundwater discharge into the Penataquit Creek. The ecological risk is dependent upon the magnitude, duration, and frequency of exposure to these plume constituents, and on the characteristics of the potentially exposed populations. The results of the exposure information (Subsection 5.4), combined with the ecological effects data (Subsection 5.5) provides the basis for this characterization. It is important to reiterate that this is a predictive assessment based on modelled exposure concentrations.

5.6.1 Risks to Aquatic Biota

Potential risks to aquatic biota (e.g., fish, macroinvertebrates, algae) were evaluated by comparing the position of the toxicological effects with the estimated groundwater plume discharge concentrations (Figures 5-3 through 5-6). Although the predicted concentrations of plume constituents in pore water were much greater than in the overlying surface water, only certain aquatic taxa will be exposed to these higher concentrations. As indicated in Subsection 5.5.1 the toxicological data available for each COC were classified as to whether the test organisms have predominantly benthic, epibenthic, or pelagic life histories. It was assumed that only benthic/epibenthic organisms will be exposed to the pond water concentrations of the discharging plume.

Although 1,1-DCE is a COC in this ERA, the discharged concentrations are anticipated to be lower (i.e., near or below detection levels) than for 1,2-DCE. In addition, very limited toxicological data are available for 1,2-DCE (Subsection 5.5.1). Consequently, these two similar COCs were jointly evaluated in this ERA.

Tetrachloroethene. The plot of the log species mean acute and estimated chronic values for PCE are presented in Figure 5-3. Both average and maximum surface water discharge concentrations of PCE are lower than the mean acute and chronic values for all aquatic species. This suggests that aquatic organisms are unlikely to exhibit adverse effects resulting from exposure to the estimated surface water discharge concentrations of PCE.

The maximum pore water discharge concentration of PCE exceeds most of the chronic values (as well as a few mean acute values) for fish and invertebrates. However, all the exceeded values correspond to pelagic species which are unlikely to come in direct contact with pore water. The chronic value for the midge (6,611 μg/L), a benthic organism, is slightly higher than the estimated maximum pore water discharge concentration for PCE (6,300 μg/L). The estimated chronic value for the midge is based on the Suter et al., (1992) regression for waterfleas.

Trichloroethene. The plot of the log species mean acute and estimated chronic values for TCE are presented in Figure 5-4. Both average and maximum surface water discharge concentrations of TCE are lower than the mean acute or chronic values for all aquatic species. In addition, the average pore water discharge concentration of TCE is lower than all mean acute and chronic values. The maximum pore water concentration of TCE does exceed the estimated mean chronic value for the water flea (*Moina macrocopa*) and the bluegill. However, both species have little, if any, direct contact with sediments and are not expected to be exposed to TCE at maximum pore water concentrations. All amphibians, crustaceans, gastropods, and algae for which there are AQUIRE data are expected to be tolerant of estimated TCE discharge concentrations.

Dichloroethenes. The plot of the log species mean acute and estimated chronic values for 1,1-DCE are presented in Figure 5-5. The estimated combined discharge concentrations of 1,1-DCE and 1,2-DCE are also plotted in this figure.

Both average and maximum surface water and pore water discharge concentrations of the DCE compounds are lower than the mean acute or chronic values for 1,1-DCE for aquatic species, suggesting that risk to aquatic organisms from exposure to dichloroethenes is unlikely. It is important to note that available toxicological data are limited to pelagic species (including fish, insects, and algae).

Vinyl Chloride. Due to the limited toxicological data, no figure is presented for this COC. The limited toxicological effect data available for VC (presented in Subsection 5.5.1.2) are orders of magnitude higher than the estimated maximum discharge concentrations for surface water (9 μg/L) and pore water (2,100 μg/L). Consequently, the available information does not suggest that ecological impacts would result from exposure to VC at the predicted discharge concentrations.

1,1-Dichloroethane. The plot of the log species mean acute and estimated chronic values for 1,2-DCA, used as a surrogate for 1,1-DCA, are presented in Figure 5-6. The groundwater model predicts that the surface water and average pore water concentrations of 1,1-DCA would be below detection levels. The maximum pore water concentration is lower than the mean acute and chronic values for all pelagic and benthic species. This suggests that these organisms (including various species of amphibians, invertebrates, and fish) are not at risk from exposure to discharging concentrations of 1,1-DCA.

5.6.2 Risks to Semi-Aquatic Biota

The worst-case daily ingestion dose for the raccoon receptor (Subsection 5.4.2) was compared to the toxicological benchmark (Subsection 5.5.2) to derive an estimate of potential risk to piscivores associated with consumption of fish that might bioconcentrate PCE in their tissues. Risks are assumed to be possible if the dose that a receptor is exposed to exceeds the toxicological benchmark value, and the likelihood of adverse impacts occurring is related to the magnitude of the exceedance. Even under worst case assumptions (i.e., maximum estimated PCE surface water concentration, highest reported fish BCF, and the lowest available RTV for chronic exposures) the estimated dose of PCE that a raccoon is estimated to receive is over two orders of magnitude less than the benchmark toxicity value for long-term exposures (i.e., dose [0.67 mg/kg BW-day] ÷ RTV [100 mg/kg BW-day] = 6.7E-03). Consequently, it is unlikely that piscivores that forage in Penataquit Creek would be adversely impacted.

5.7 ECOLOGICAL RISK UNCERTAINTIES

Considerable uncertainty is associated with the risk assessment process. Numerous assumptions were made in conducting this risk assessment which add to the uncertainty associated with the results. When assumptions were made regarding toxicity and exposure, efforts were made to be realistic yet conservative. However, the additive effect of these conservative assumptions may have resulted in an overestimation of risk.

5.7.1 Uncertainties Associated with the Exposure Assessment

The exposure estimates considered in this ERA are based on a conservative groundwater model that will tend to overestimate potential discharge concentrations in Penataquit Creek. The Penataquit Creek in the vicinity of the estimated discharge zone of the ServAll groundwater plume is somewhat degraded due to the urbanized nature of the surrounding region. It is possible that the most sensitive components of the overall aquatic community are not present in this habitat as a result of habitat deterioration associated with urbanization. If this is the case, the generally more tolerant resident organisms may be less likely to be impacted when the groundwater plume begins to discharge.

5.7.2 Uncertainties Associated with the Effects Assessment

This ERA is based on available toxicological data, which for certain groundwater plume constituents, is very limited. Although extrapolation techniques were utilized to estimate potential adverse effect concentrations, there is considerable uncertainty associated with these methodologies. In particular, few chronic effects data are available in the AQUIRE database for any of the COCs evaluated. Moreover, the results of this ERA are limited to those taxa for which toxicity data are available. Toxicological data for plants and benthic organisms were generally not as available as for pelagic forms such as fish and cladocerans. It is assumed that the available toxicological data provide a good representation of species sensitivities to contaminant exposure. However, it is possible that species lacking toxicological effects data could be more sensitive than those for which data exist. If this were the case, then this ERA may have underestimated the potential adverse effects associated with groundwater discharge into the Penataquit Creek.

The use of regression equations to extrapolate between acute and chronic values results in additional risk uncertainty. These equations were derived from a large toxicological data set which included classes of compounds (e.g., pesticides) that are considered to be more toxic in general to aquatic organisms than VOCs (Suter et al., 1992). The chronic values estimated in this ERA may under- or over-estimate the actual chronic effects of VOCs depending upon whether the acute:chronic ratios for this class of compounds differ from those of other chemical classes included in database used to generate the regression equations.

This ERA also did not consider the potential effects of cumulative impacts associated with the simultaneous exposure to multiple groundwater plume constituents. This uncertainty is relatively unimportant however, because only PCE (and to a lesser extent TCE) is predicted to discharge at concentrations approximating the chronic effect concentrations for freshwater organisms.

Finally, the ecological significance of toxicity value exceedances by maximum predicted discharge concentrations remains a large source of risk uncertainty. The maximum COC concentrations in the discharging groundwater plume are anticipated to occur within fairly narrow spatial boundaries (Subsection 4.7) and the population-level effects of localized ecological impacts remain unclear.

5.8 SUMMARY

An Ecological Risk Assessment, following the NYSDEC "Fish and Wildlife Impact Analysis" (1991b) methodology, was conducted to evaluate the potential effects to aquatic and semi-aquatic receptors associated with exposure to ServAll plume constituents following groundwater discharge to Penataquit Creek. This analysis was based on a comparison of the average and maximum estimated future discharge concentrations (for both surface water and pore water) with mean acute values and estimated chronic values. In addition, potential risk associated with contaminated prey exposures by semi-aquatic piscivores was also evaluated using a simple food chain model.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The following subsections present conclusions based on field observations and interpretations.

6.1.1 Conclusions from Field Activities

- Four strata were encountered in the upper 100 feet of unconsolidated deposits. This stratigraphy consisted of the upper glacial aquifer underlain by the Gardiners Clay formation. The Gardiners Clay consisted of an apparently continuous aquitard termed the upper clay unit; underlain by a sandy, water bearing unit; underlain by a second apparently continuous aquitard, termed the lower clay unit.

- Upward hydraulic gradients, were observed across the upper clay unit. These upward gradients, combined with interpreted low permeabilities of the upper clay unit, enable the upper clay to serve as an effective barrier to downward migration of the ServAll groundwater plume into the Magothy aquifer.

- Groundwater originating at the ServAll site progressively sinks within the upper glacial aquifer, until it encounters the upper clay unit. After moving along the top of the upper clay for approximately 7,000 feet, flow begins to ascend toward Penataquit Creek, discharging between PZ-94-19 and PZ-94-14 (see Figure 3-11).

6.1.2 Conclusions from the Groundwater Modeling

- While it has limitations relative to details of the hydrogeologic system, the model captures the major features of the upper glacial aquifer, and provides more accurate and detailed estimates of exposure concentrations and probable plume discharge locations than were possible in the screening analysis. The model also provides a basis for a reasonable mathematical framework for the conceptual design of a plume containment system, which will take place in Subtask 9.4.

- Further refinement of the model for even more detailed analysis could include additional synoptic rounds of water levels with stream flows and stages. In addition, transient analysis coupled with a numerical transport model (such as MT3D) would allow more refined estimates of discharge concentrations with time.

- The potential discharge of the ServAll plume to Penataquit Creek is expected to be far enough in the future (a minimum of five years) to allow the collection of water level information and physical measurements on streams to permit further refinement of the model, if desired.

- The USGS might be amenable to the joint collection of further data given the opportunity to study the upper glacial aquifer in some detail. The possibility of their interest in this area could be explored with the potential for valuable shared data, should further refinement of the model be indicated.

- As the plume approaches the estimated area of discharge, further monitoring wells should be installed to verify model predictions regarding path and estimated concentrations. This information can be used to further support the model-based evaluations, and/or revise those estimates for further consideration. Recommendations regarding additional plume monitoring and other future re-evaluations of the plume's migration will be included in Subtask 9.2, the Long-term Plume Monitoring Program, and Subtask 9.3, the Development of the Decision Tree.

6.1.3 Conclusions from the Environmental Risk Assessment

- It is unlikely that aquatic organisms will experience adverse effects from exposure to any of the expected discharge concentrations of contaminants evaluated in this assessment. Although the predicted pore water concentrations of PCE and TCE do exceed some chronic (and in the case of PCE, mean acute values) for certain taxa, these particular organisms are pelagic species which are not anticipated to be exposed to pore water on a regular basis. A worst-case estimate of the dietary dose level that a mammalian piscivore (e.g., raccoon) might be exposed to is two orders of magnitude below doses associated with adverse effects to laboratory animals.

- The most significant risk uncertainties pertain to the estimated groundwater discharge concentrations and limitations in the toxicological database. Only few toxicological data were available for VC and 1,2-DCE. In addition, little chronic effects data or information for benthic or epibenthic taxa are available.

- The ecological environment of Penataquit Creek in the area and downstream of the modeled plume discharge location is currently degraded as the result of human activity (i.e., culverted reaches of the creek, boat traffic, other likely discharges of hazardous materials [primarily oils and fuels], and other manmade structures [e.g., dams]). It is likely that the most sensitive aquatic taxa are no longer present in the stream.

6.1.4 Overall Plume Discharge Study Conclusions

The following generalized conclusions are based on available data:

- The geology and hydrogeology of the study area encompassing the ServAll groundwater contaminant plume have been sufficiently characterized to provide information on the plume discharge location and contaminant concentrations.

- Adverse ecological impacts associated with the eventual discharge of the ServAll groundwater contaminant plume to Penataquit Creek are considered unlikely.

- The discharge of the groundwater contaminant plume in to saltwater estuaries and the Great South Bay is considered unlikely, based on available data.

- It is anticipated that the plume will discharge to reaches of Penataquit Creek beginning in the year 2000, at the earliest.

6.2 RECOMMENDATIONS

As a result of the evaluations and modeling performed as part of this Phase I Assessment, the following recommendations for further work associated with the Plume Discharge Study are as follows:

- The second phase of groundwater modeling and ecological risk assessment outlined in the Plume Discharge Study Work Plan (ABB-ES, 1994b) do not appear to be necessary.
- If it is determined by NYSDEC that additional studies are necessary, it is recommended that a second phase of ERA include a characterization of the actual ERA receptors likely to be exposed to plume constituents. This information would help define how significant the uncertainties are in the toxicological database and exposure assumptions. Depending on the results of the stream aquatic characterization, laboratory bioassays conducted using benthic invertebrates may be suggested. Benthic invertebrates are predicted to be exposed to the highest discharge concentrations and only limited toxicological data are available for this class of receptors. This will provide valuable information for the NYS Department of Inland Fisheries and Wildlife for assessing whether future intervention in plume migration is warranted.

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ABB-ES	ABB Environmental Services
AWQC	Ambient Water Quality Criteria
BCF	bioconcentration factor
BEHP	bis(2-ethylhexyl)phthalate
bgs	below ground surface
cfs	cubic feet per second
COC	contaminants of concern
DCA	dichloroethane
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
EC_{50}	effects concentration 50 percent
ERA	Ecological Risk Assessment
ft/day	feet per day
ft/ft	feet per foot
GPS	global positioning system
ID	inside diameter
K	hydraulic conductivity
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol/water partition coefficient
LC_{50}	lethal concentration 50 percent
LOEL	lowest observed effects level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MSL	Mean Sea Level
NYNHP	New York Natural Heritage Program
NYSDEC	New York State Department of Environmental Conservation

PCE	tetrachloroethene/perchloroethene
PCG2	Preconditioned Conjugate Gradient 2
PVC	polyvinyl chloride
QAPjP	Quality Assurance Project Plan
RI/FS	Remedial Investigation/Feasibility Study
RTV	reference toxicity values
SCDHS	Suffolk County Department of Health Services
SVOC	semivolatile organic compound
TCE	trichloroethene
μg/L	micrograms per liter
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VC	vinyl chloride
VOC	volatile organic compound

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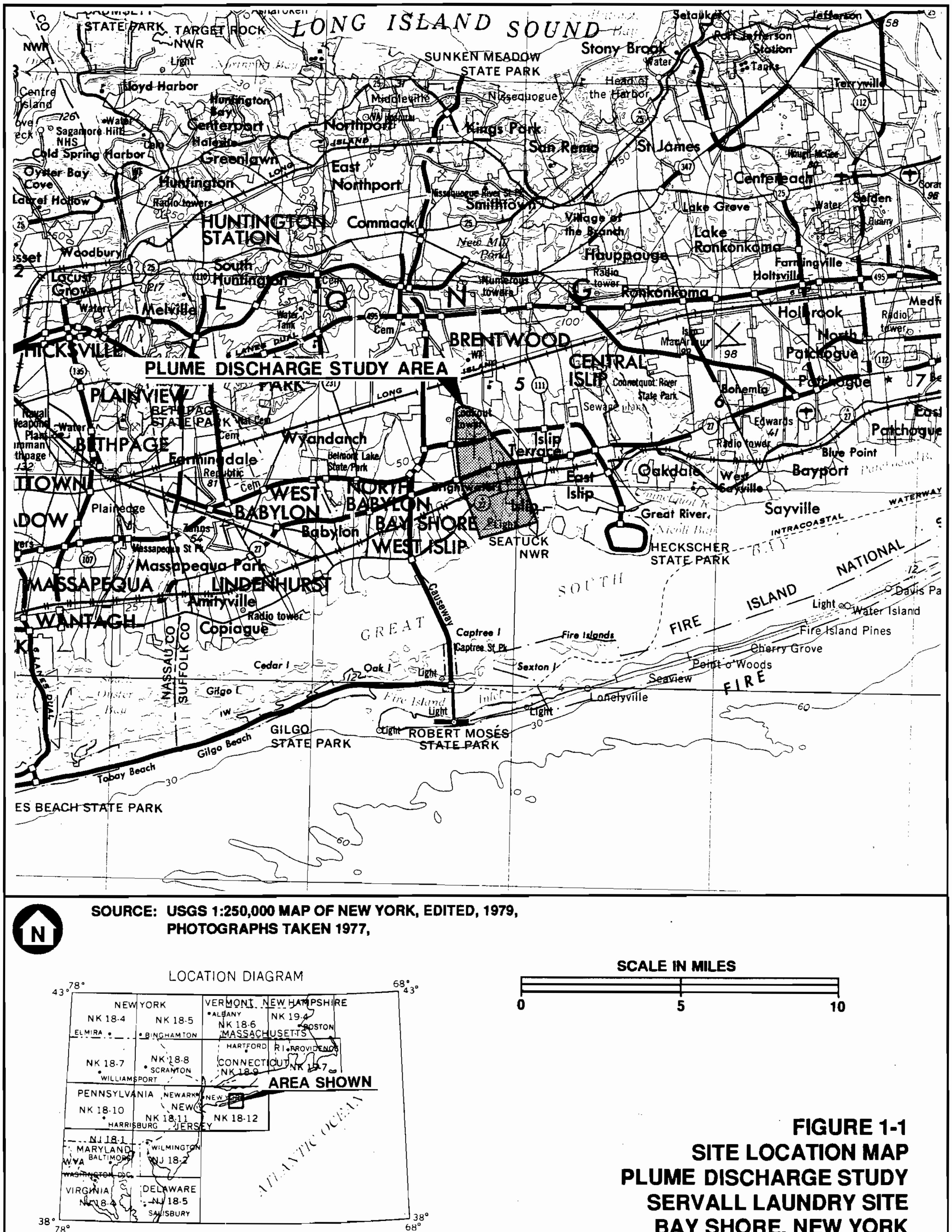


SOURCE: USGS 1:250,000 MAP OF NEW YORK, EDITED, 1979,
PHOTOGRAPHS TAKEN 1977,

FIGURE 1-1
SITE LOCATION MAP
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services

07135-90

QUADRANGLE LOCATION

SOURCE: USGS TOPOGRAPHIC QUADRANGLES 7.5-MINUTE SERIES, BAY SHORE EAST, NY, 1967, BAY SHORE WEST, NY, 1969, CENTRAL SLIP, NY, 1967, AND GREENLAWN, NY, 1967. ALL PHOTOREVISED 1969. REDUCED FOR THIS FIGURE.

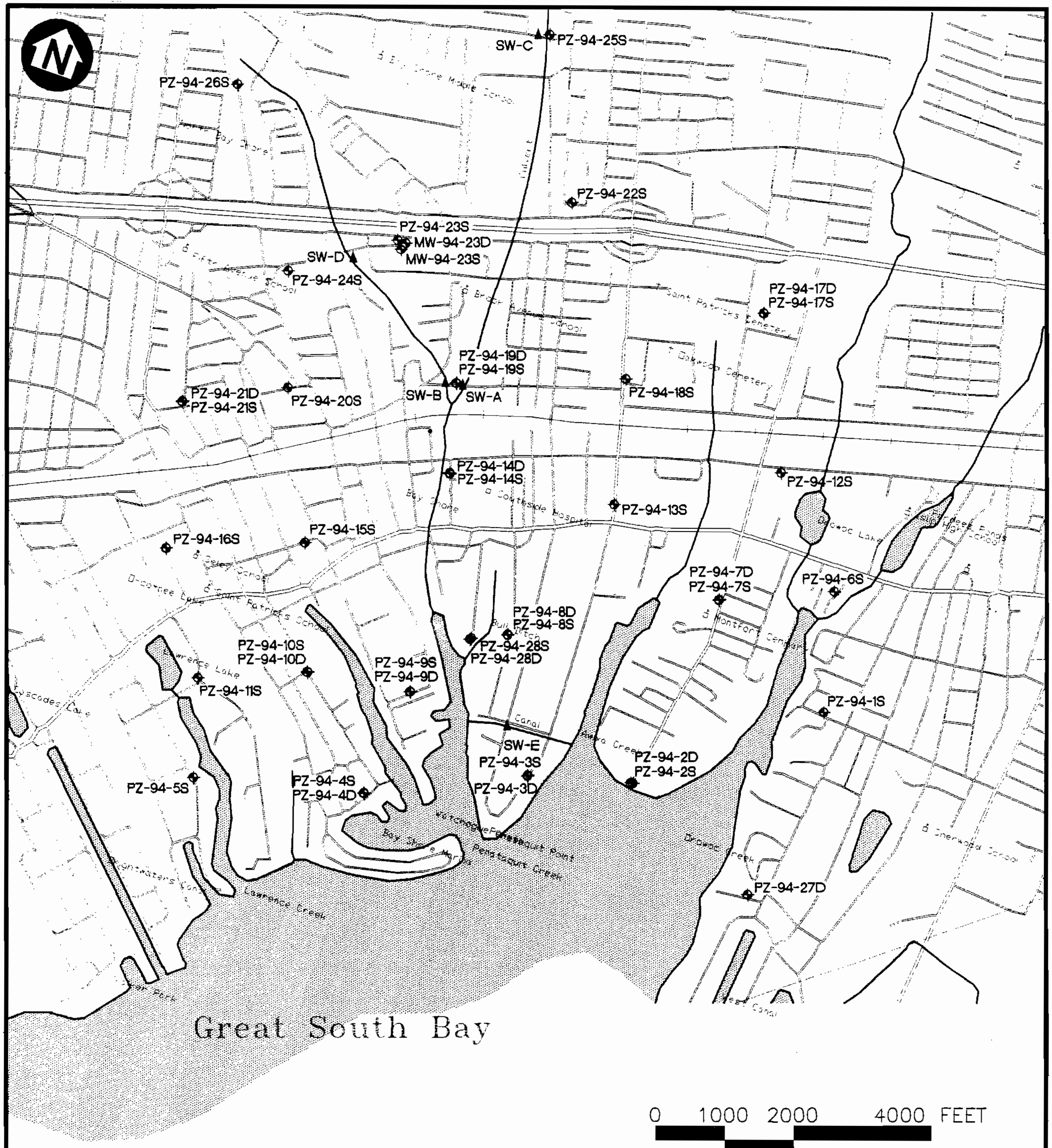
N

LEGEND

▨ LIMITS OF STUDY AREA

FIGURE 1-2
LIMITS OF STUDY AREA
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services



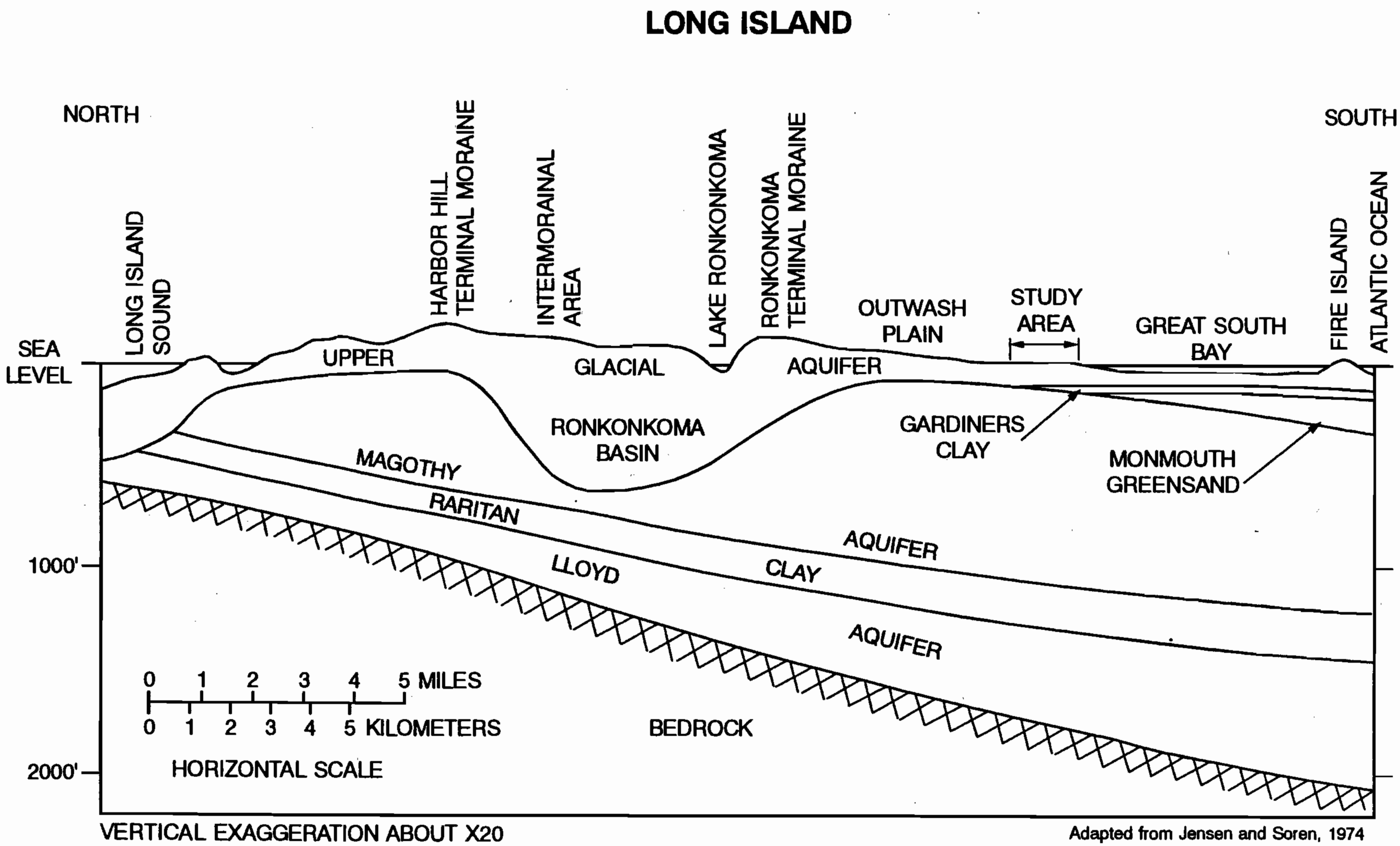
SCALE: 1" =2000'

LEGEND

PZ-94-10S ⊕ PZ-94-10D	PIEZOMETER LOCATION S – DENOTES SHALLOW D – DENOTES DEEP
MW-94-10D ⊕ MW-94-10S	MONITORING WELL LOCATION S – DENOTES SHALLOW D – DENOTES DEEP
SW-B ▲	STREAM GAUGE

FIGURE 2-1
EXPLORATION LOCATION MAP
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

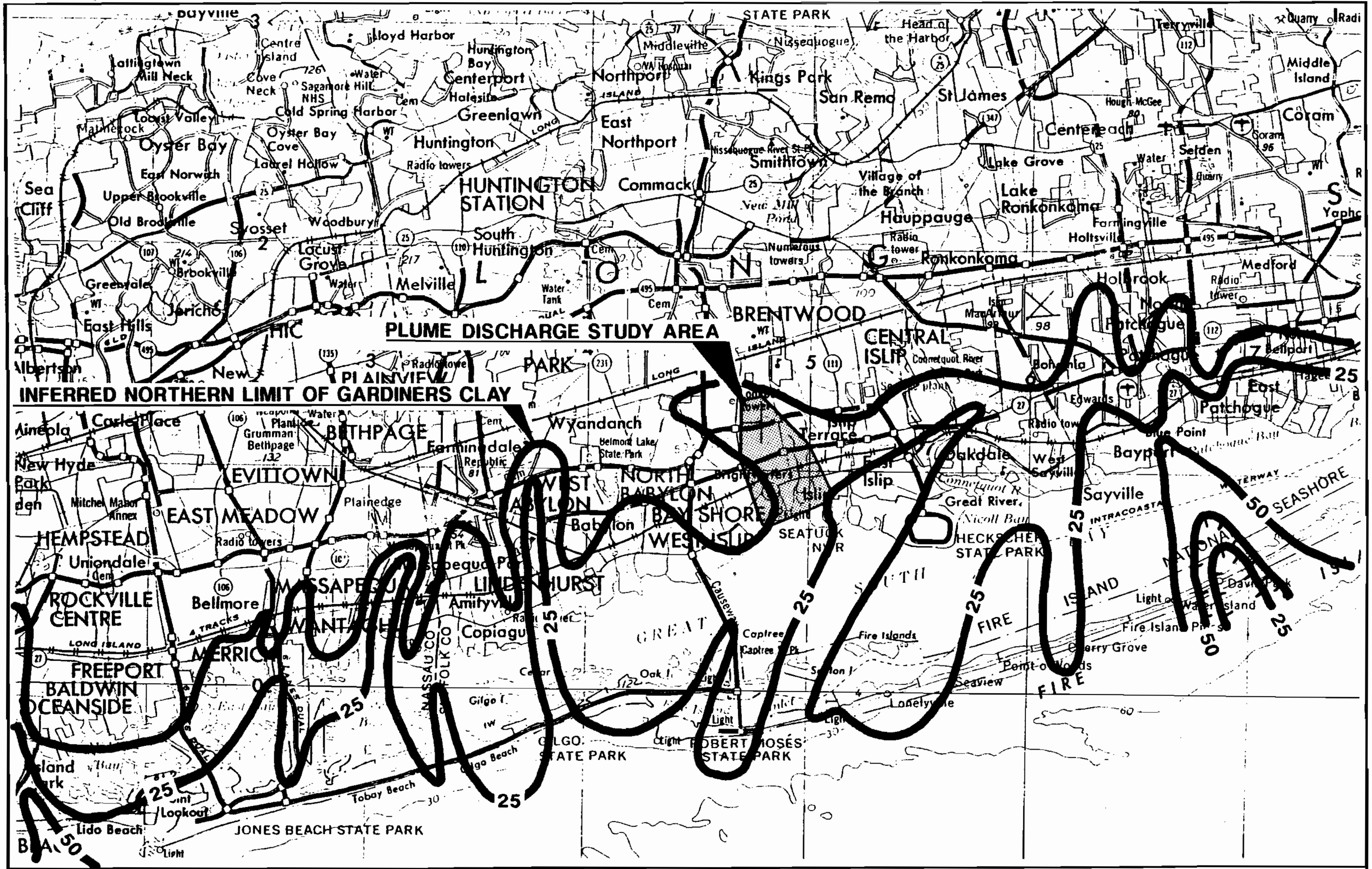
ABB Environmental Services



Adapted from Jensen and Soren, 1974
Sheet 1, Section B-B',
Source: Soren and Simmons, 1987.

PROFILE ORIENTED NORTH TO SOUTH AND IS LOCATED APPROXIMATELY 5 MILES TO THE EAST OF THE STUDY AREA.

FIGURE 3-1
REGIONAL STRATIGRAPHY
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK



SOURCE: U.S.G.S./N.Y.S.D.E.C. WATER-RESOURCES INVESTIGATION REPORT 86-4175;
SYOSSET N.Y.; 1987; JULIAN SOREN AND DALE L. SIMMONS;
SHEET 3 "THICKNESS AND EXTENT OF GARDINERS CLAY."

N

LEGEND

25 APPROXIMATE CONTOUR OF THICKNESS OF GARDINERS CLAY (FEET)

SCALE IN MILES

0 4 8

FIGURE 3-2

THICKNESS AND EXTENT OF GARDINERS CLAY

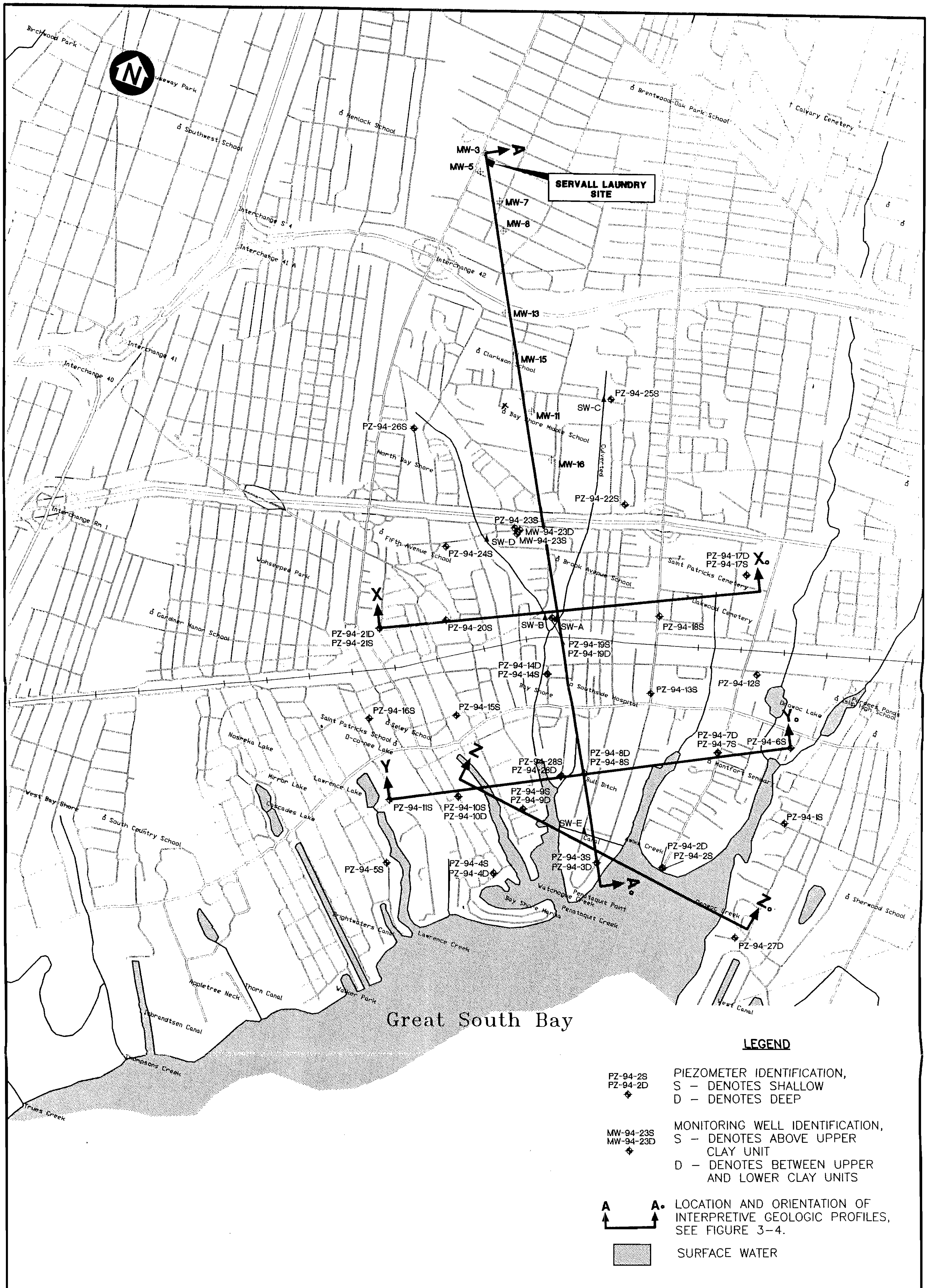
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE

BAY SHORE, NEW YORK

ABB Environmental Services

07135-90



LEGEND

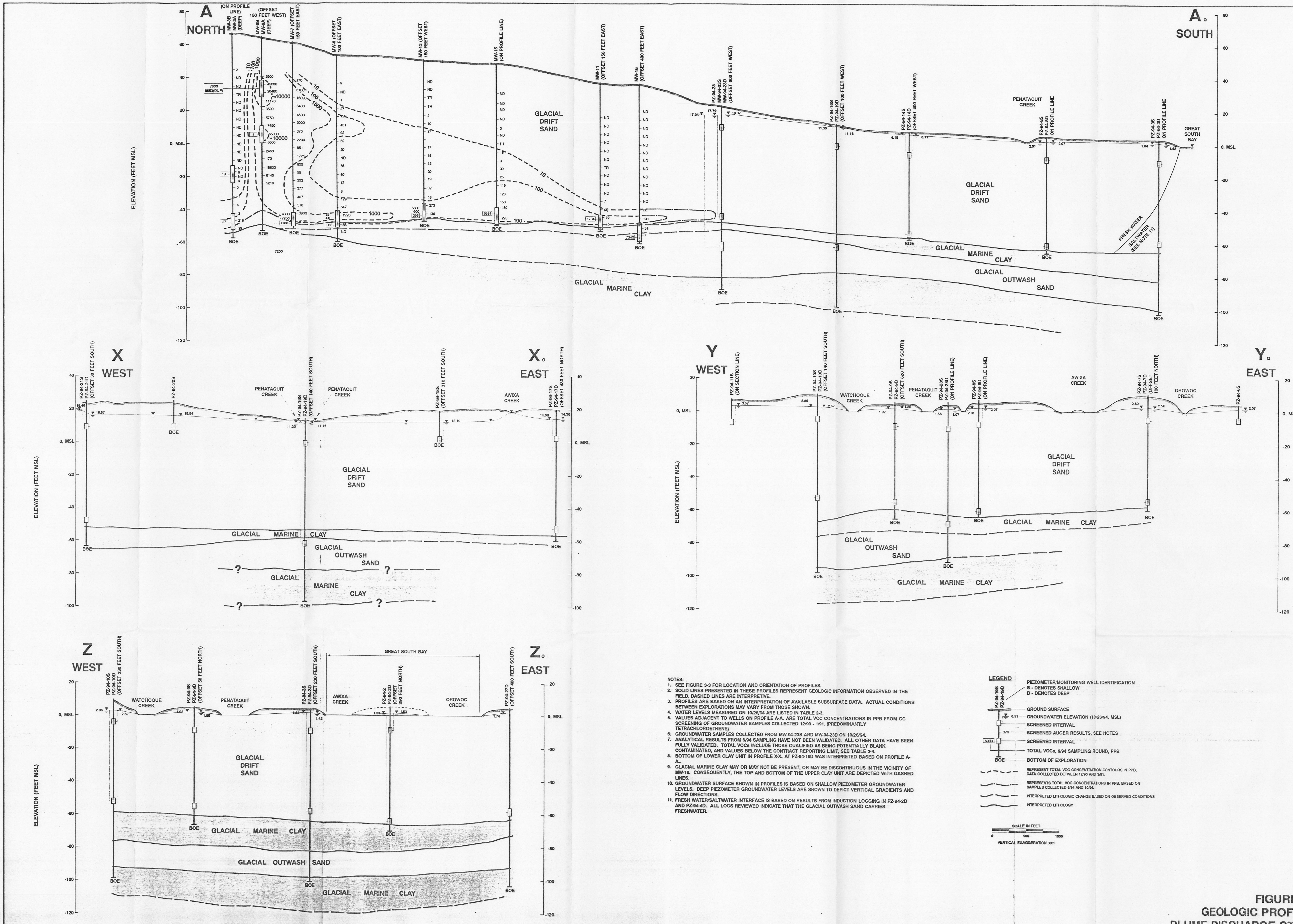
PZ-94-2S PZ-94-2D ⌖	PIEZOMETER IDENTIFICATION, S – DENOTES SHALLOW D – DENOTES DEEP
MW-94-23S MW-94-23D ⌖	MONITORING WELL IDENTIFICATION, S – DENOTES ABOVE UPPER CLAY UNIT D – DENOTES BETWEEN UPPER AND LOWER CLAY UNITS
A A°	LOCATION AND ORIENTATION OF INTERPRETIVE GEOLOGIC PROFILES, SEE FIGURE 3–4.
▨	SURFACE WATER

0 1000 2000 4000 FEET

SCALE: 1"=2000'

FIGURE 3-3
LOCATION AND ORIENTATION OF
INTERPRETIVE GEOLOGIC PROFILES
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services



NOTES:

1. SEE FIGURE 3-3 FOR LOCATION AND ORIENTATION OF PROFILES.
2. SOLID LINES PRESENTED IN THESE PROFILES REPRESENT GEOLOGIC INFORMATION OBSERVED IN THE FIELD, DASHED LINES ARE INTERPRETIVE.
3. PROFILES ARE BASED ON AN INTERPRETATION OF AVAILABLE SUBSURFACE DATA. ACTUAL CONDITIONS BETWEEN EXPLORATIONS MAY VARY FROM THOSE SHOWN.
4. WATER LEVELS MEASURED ON 10/26/94 ARE LISTED IN TABLE 2-3.
5. VALUES ADJACENT TO WELLS ON PROFILE A-A. ARE TOTAL VOC CONCENTRATIONS IN PPB FROM GC SCREENING OF GROUNDWATER SAMPLES COLLECTED 12/90 - 1/91. (PREDOMINANTLY TETRACHLOROETHENE)
6. GROUNDWATER SAMPLES COLLECTED FROM MW-94-23S AND MW-94-23D ON 10/26/94.
7. ANALYTICAL RESULTS FROM 6/94 SAMPLING HAVE NOT BEEN VALIDATED. ALL OTHER DATA HAVE BEEN FULLY VALIDATED. TOTAL VOCs INCLUDE THOSE QUALIFIED AS BEING POTENTIALLY BLANK CONTAMINATED, AND VALUES BELOW THE CONTRACT REPORTING LIMIT, SEE TABLE 3-4.
8. BOTTOM OF LOWER CLAY UNIT IN PROFILE X-X. AT PZ-94-19D WAS INTERPRETED BASED ON PROFILE A-A..
9. GLACIAL MARINE CLAY MAY OR MAY NOT BE PRESENT, OR MAY BE DISCONTINUOUS IN THE VICINITY OF MW-16. CONSEQUENTLY, THE TOP AND BOTTOM OF THE UPPER CLAY UNIT ARE DEPICTED WITH DASHED LINES.
10. GROUNDWATER SURFACE SHOWN IN PROFILES IS BASED ON SHALLOW PIEZOMETER GROUNDWATER LEVELS. DEEP PIEZOMETER GROUNDWATER LEVELS ARE SHOWN TO DEPICT VERTICAL GRADIENTS AND FLOW DIRECTIONS.
11. FRESH WATER/SALTWATER INTERFACE IS BASED ON RESULTS FROM INDUCTION LOGGING IN PZ-94-2D AND PZ-94-4D. ALL LOGS REVIEWED INDICATE THAT THE GLACIAL OUTWASH SAND CARRIES FRESHWATER.

FIGURE 3-4
GEOLOGIC PROFILES
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK
ABB Environmental Services

W9412024D

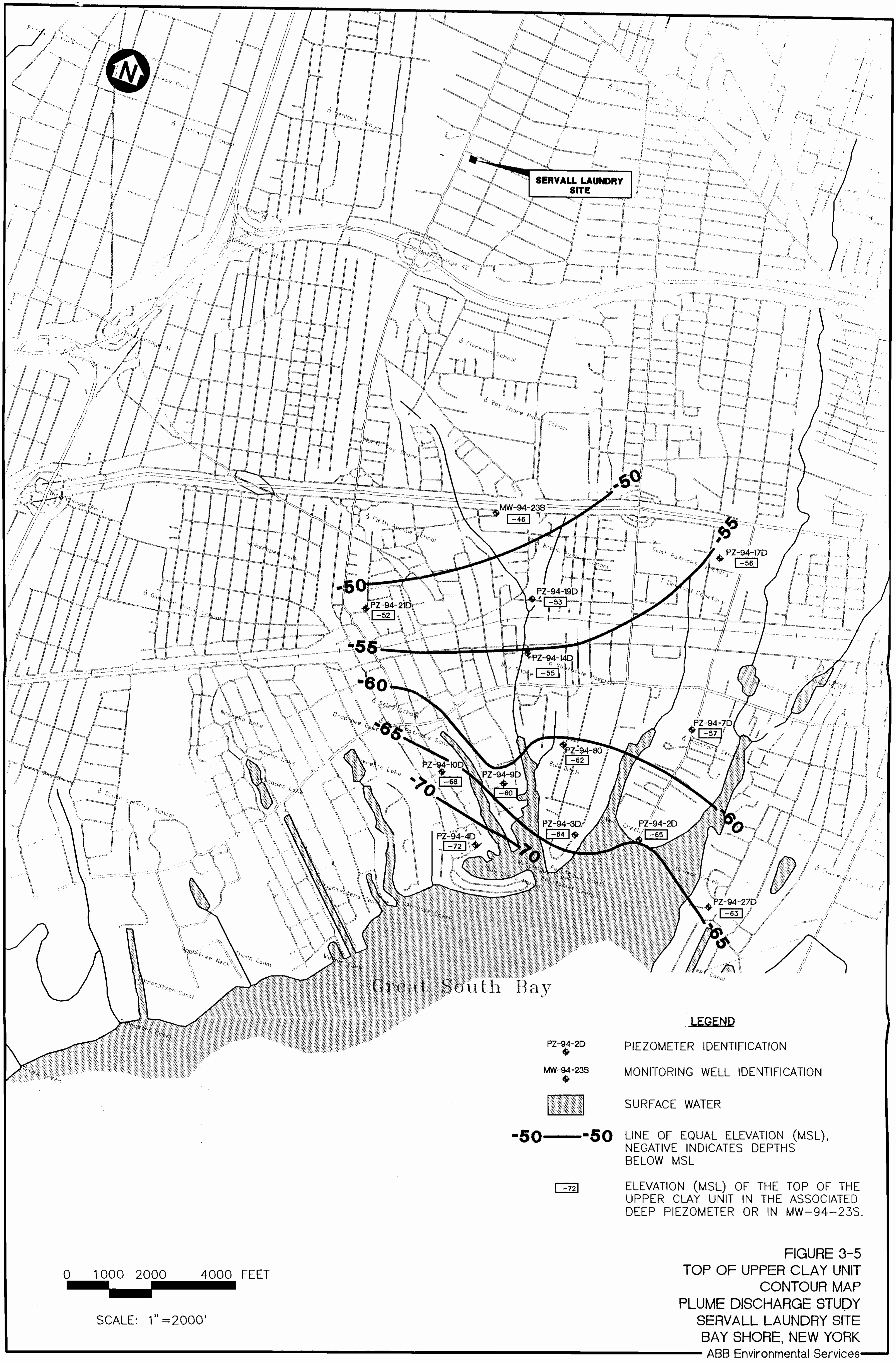
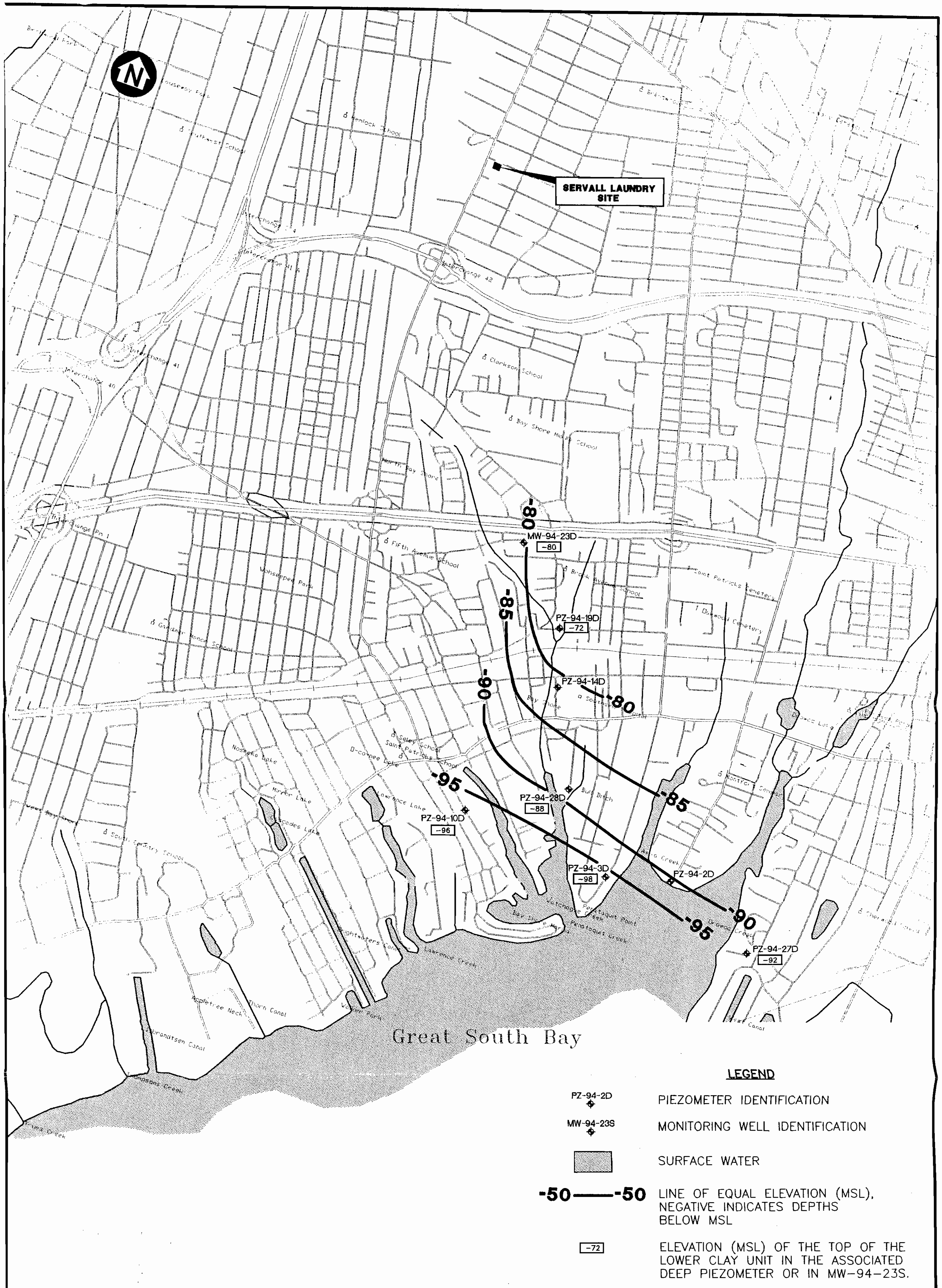


FIGURE 3-5
TOP OF UPPER CLAY UNIT
CONTOUR MAP
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services

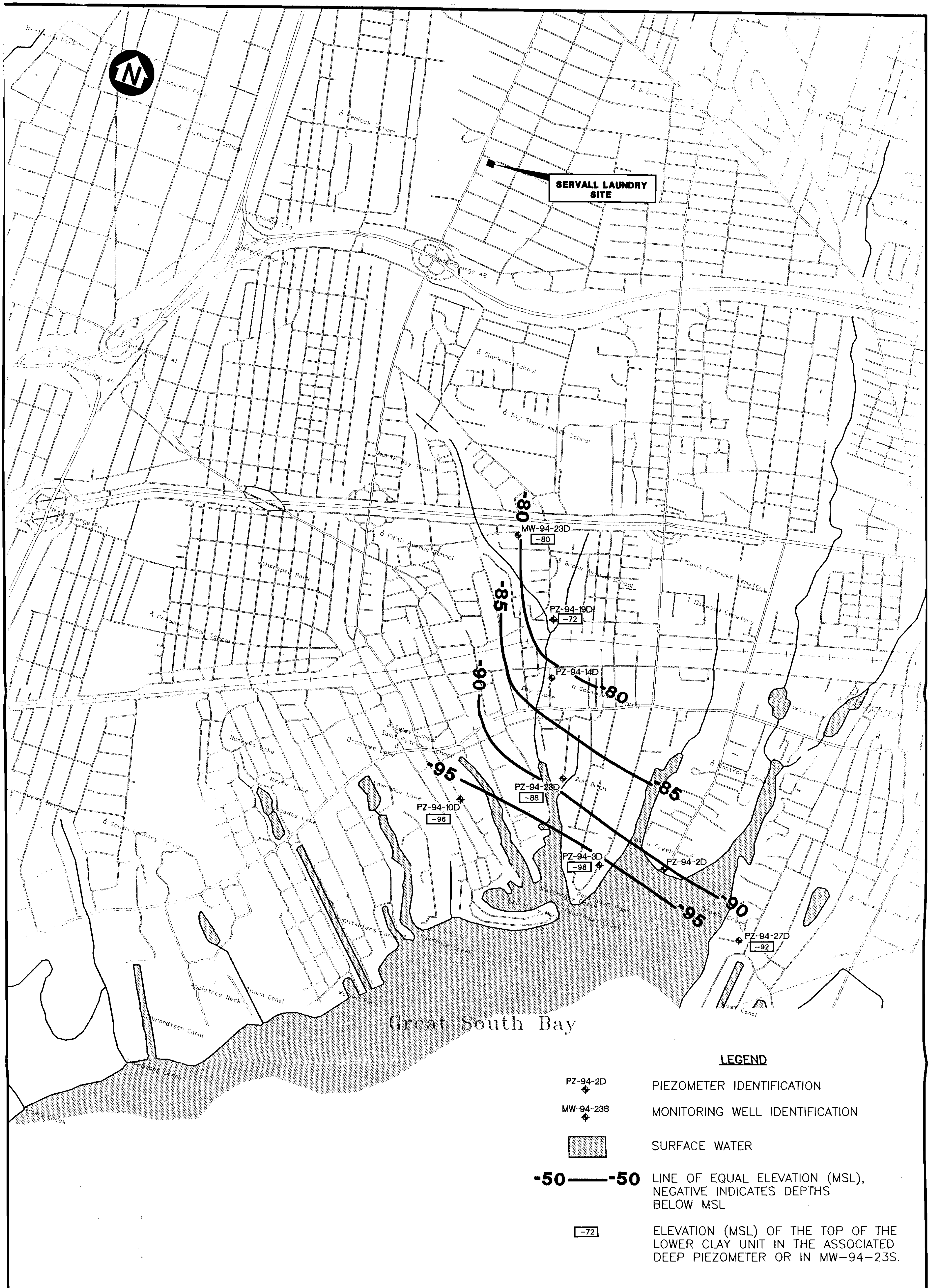


0 1000 2000 4000 FEET

SCALE: 1"=2000'

FIGURE 3-6
TOP OF LOWER CLAY UNIT
CONTOUR MAP
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services

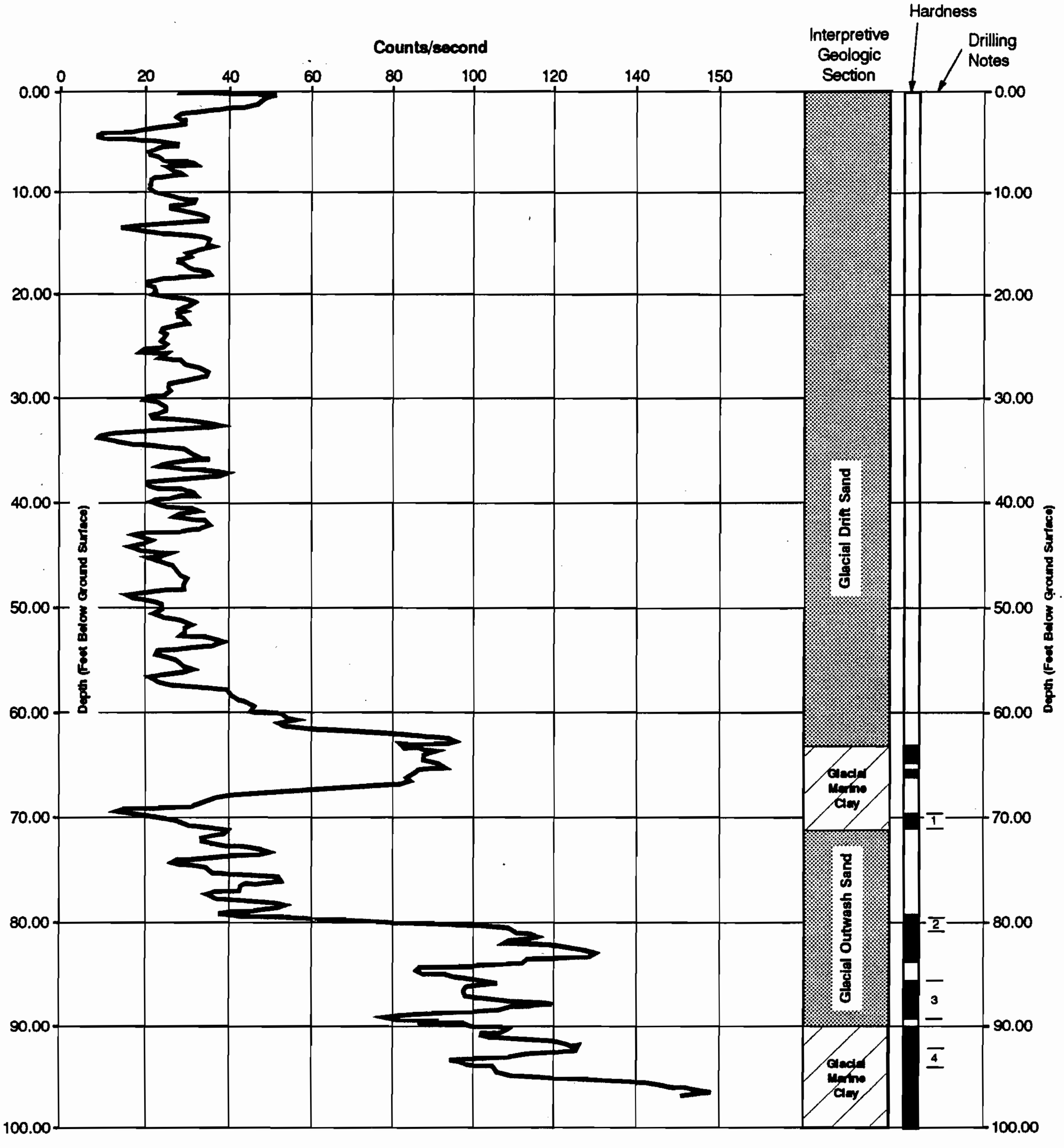


0 1000 2000 4000 FEET

SCALE: 1"=2000'

FIGURE 3-6
TOP OF LOWER CLAY UNIT
CONTOUR MAP
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services



KEY:

HARDNESS COLUMN:

■ INDICATES INCREASED DOWN PRESSURE REQUIRED DURING DRILLING.

DRILLING NOTES:

1 = 69.5 - 71.0 VERY HARD
2 = 79.0 - 81.0 APPEARED GRAVELLY
3 = 85.0 - 89.0 HARD WITH SOFT LAYERS
4 = 92.0 - 93.0 VERY HARD

FIGURE 3-7
INTERPRETATION OF BOREHOLE GAMMA LOG
FROM PZ-94-19D
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services

W9501004D(b)

TABLE OF WATER LEVEL DATA

LOCATION NAME	WATER LEVEL (FT. MSL)	LOCATION NAME	WATER LEVEL (FT. MSL)
PZ-94-1S	2.62	PZ-94-17S	14.30
PZ-94-2S	1.53	PZ-94-18S	12.10
PZ-94-3S	1.42	PZ-94-19S	11.16
PZ-94-4S	1.41	PZ-94-20S	15.54
PZ-94-5S	2.32	PZ-94-21S	16.57
PZ-94-6S	2.07	PZ-94-22S	19.48
PZ-94-7S	2.56	PZ-94-23S	18.37
PZ-94-8S	2.07	PZ-94-24S	19.87
PZ-94-9S	1.85	PZ-94-25S	26.53
PZ-94-10S	2.62	PZ-94-26S	26.33
PZ-94-11S	3.57	PZ-94-28S	1.07
PZ-94-12S	6.62	SW-A	11.35
PZ-94-13S	6.43	SW-B	11.31
PZ-94-14S	6.11	SW-C	25.62
PZ-94-15S	8.19	SW-D	16.74
PZ-94-16S	11.16	SW-E	0.81

LEGEND

SW-D ▲	STREAM GAUGE
PZ-94-2S ◆	PIEZOMETER IDENTIFICATION
MW-94-23S ◆	MONITORING WELL IDENTIFICATION
▨	SURFACE WATER
18——18	LINE OF EQUAL PIEZOMETRIC HEAD ELEVATION (MSL) NEAR THE TOP OF THE UPPER GLACIAL AQUIFER, GROUNDWATER SURFACE CONTOURS
2.01	ELEVATION (MSL) OF WATER IN THE ASSOCIATED MONITORING LOCATION VALUES OBTAINED ON 10/26/94.

0 1000 2000 4000 FEET

SCALE: 1"=2000'

FIGURE 3-8
PIEZOMETRIC SURFACE NEAR THE TOP
OF THE UPPER GLACIAL AQUIFER
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services

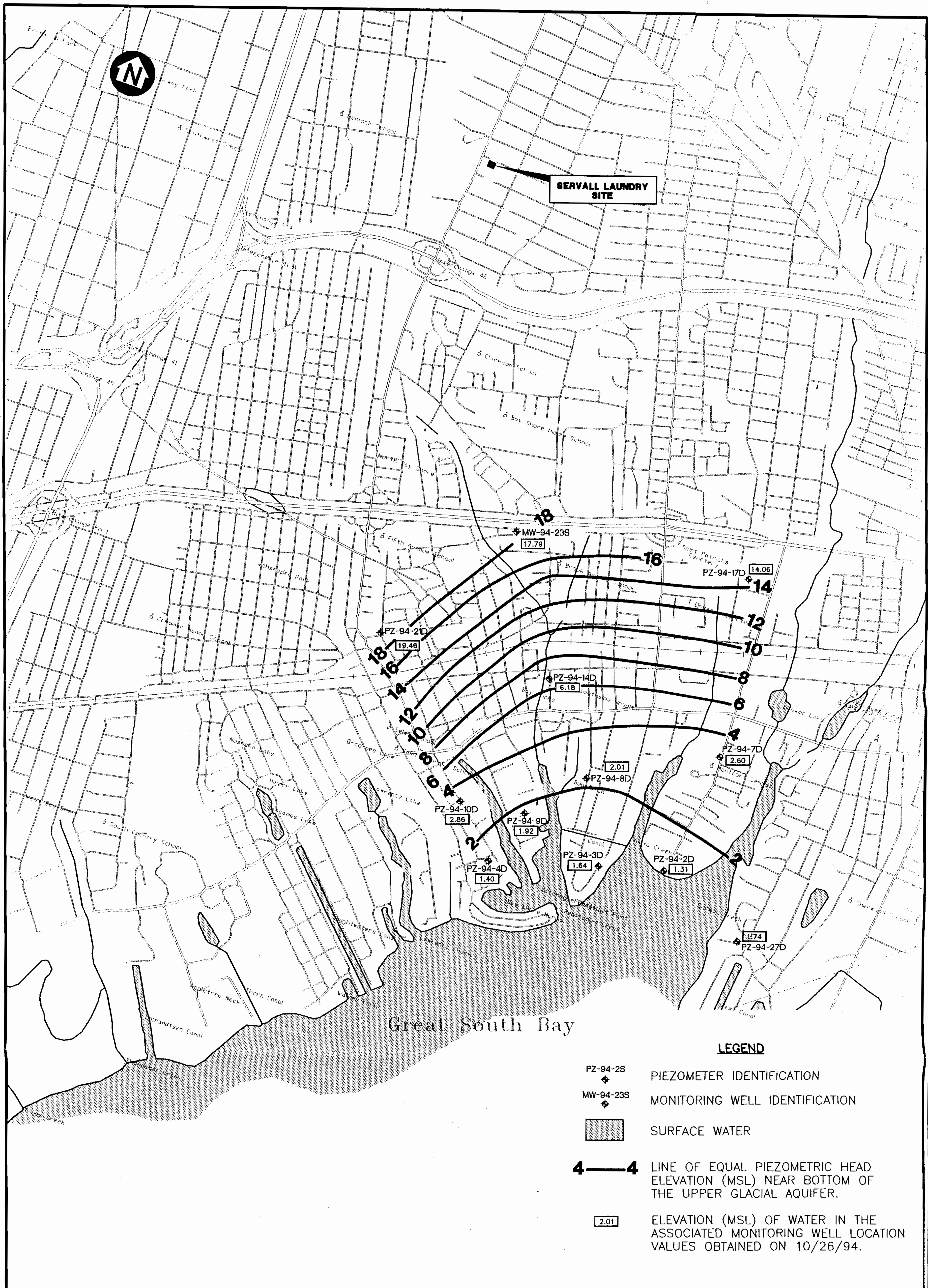
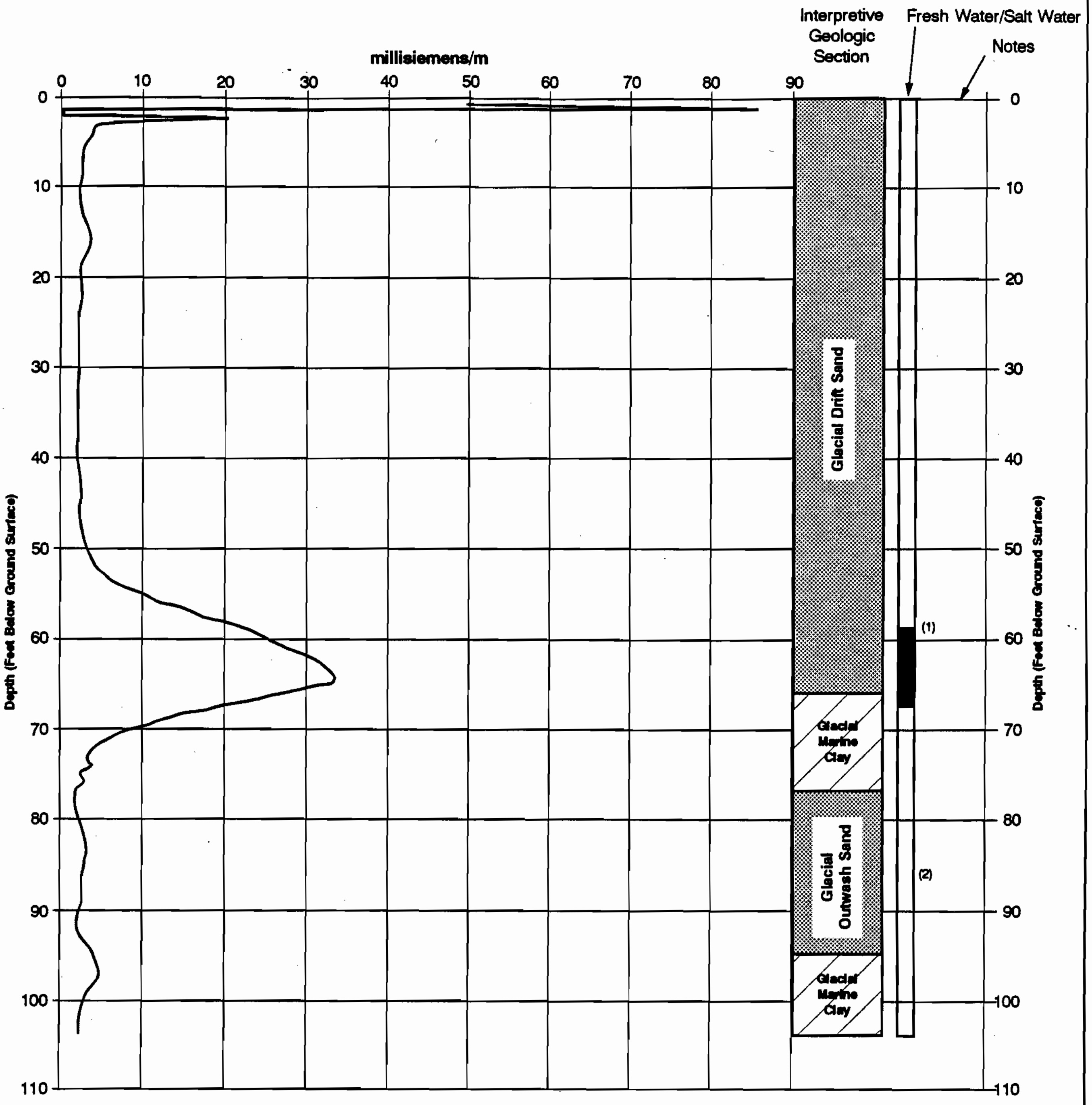


FIGURE 3-9
PIEZOMETRIC SURFACE NEAR THE BOTTOM
OF THE UPPER GLACIAL AQUIFER
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services



KEY:

FRESH WATER/SALT WATER COLUMN:

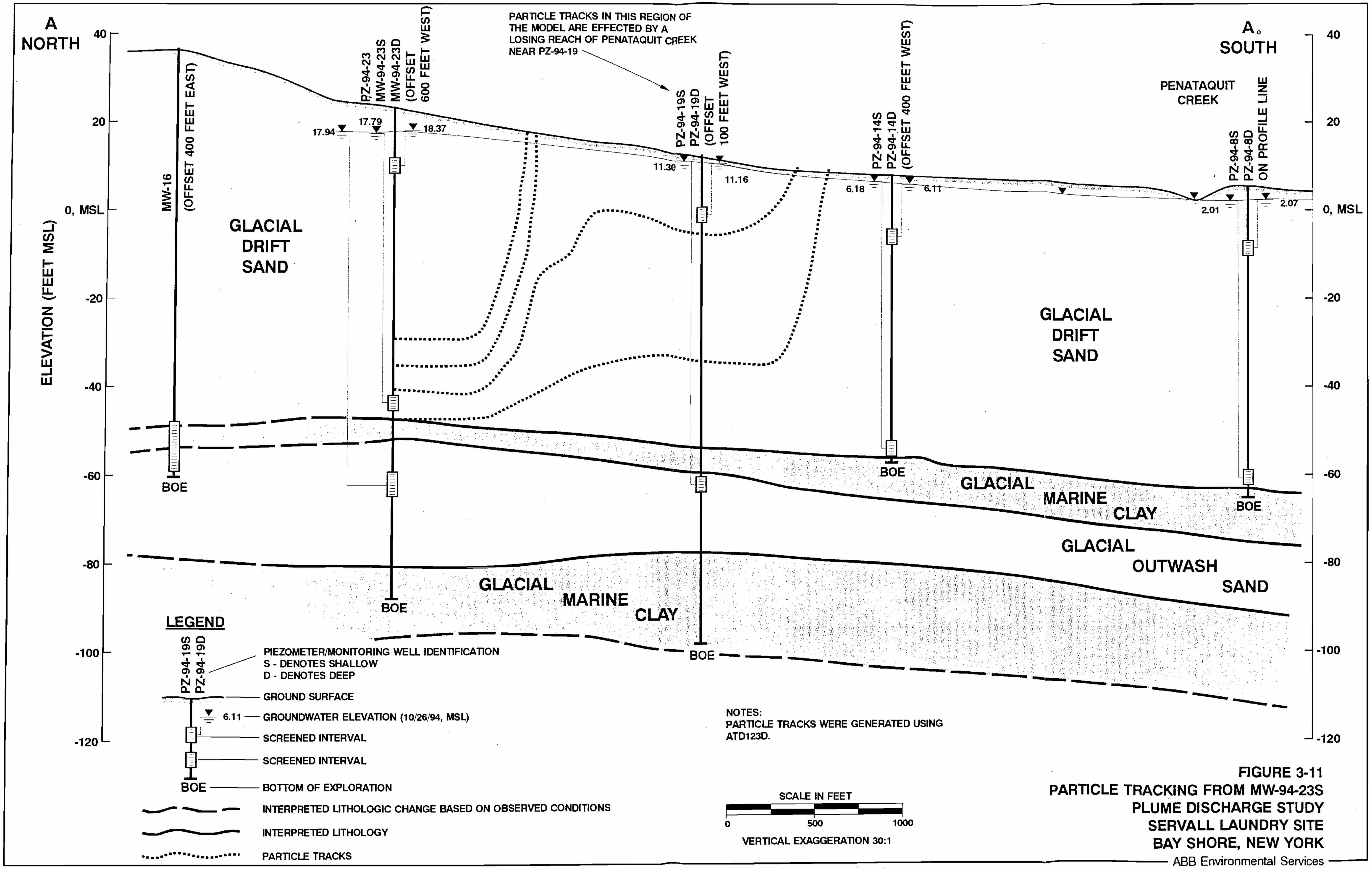
■ INDICATES INTERPRETED SALTWATER ZONE.

NOTES:

1: INTEREPRETED TOP AND BOTTOM OF SALT WATER/FRESH WATER INTERFACE TAKEN AS MIDDLE OF ZONE OF MIXING.

2: FRESH WATER ZONE IN BETWEEN THE UPPER AND LOWER CLAY UNIT.

FIGURE 3-10
INTERPRETATION OF INDUCTION LOG
FROM PZ-94-27D
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

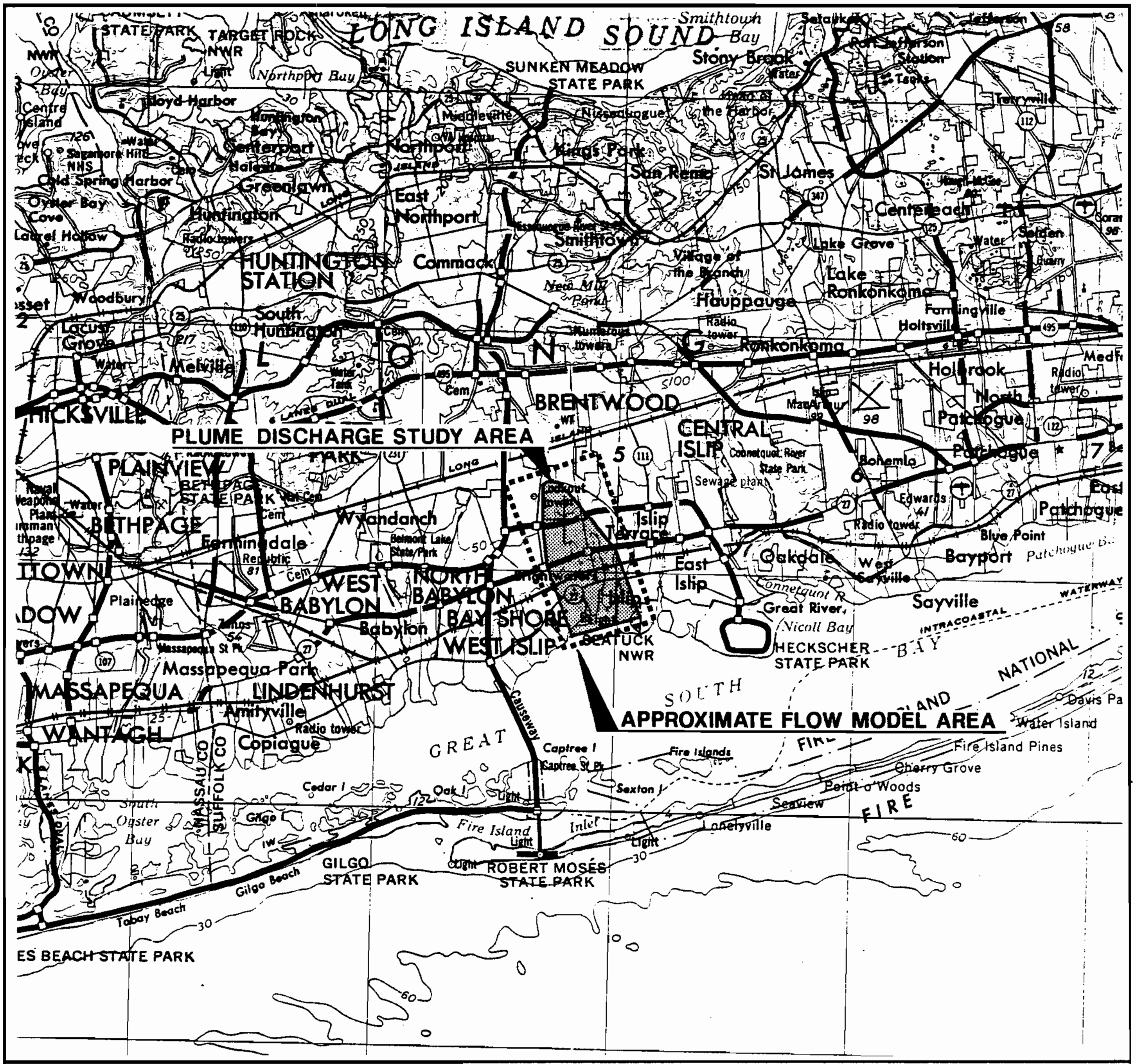


NOTES:
PARTICLE TRACKS WERE GENERATED USING ATD123D.

FIGURE 3-11
PARTICLE TRACKING FROM MW-94-23S
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services

W9412024D(B)



N

SOURCE: USGS 1:250,000 MAP OF NEW YORK, EDITED, 1979, PHOTOGRAPHS TAKEN 1977,

SCALE IN MILES

0 5 10

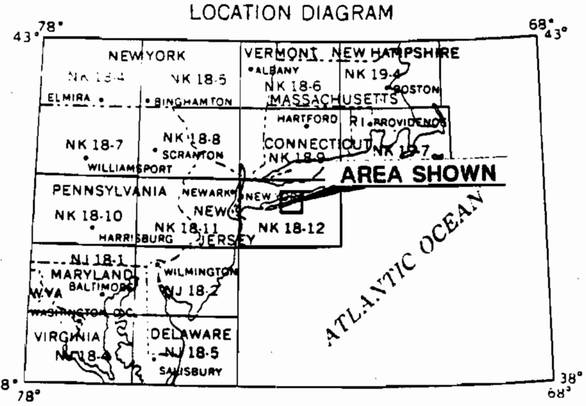


FIGURE 4-1
MODFLOW MODEL GRID LOCATION MAP
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

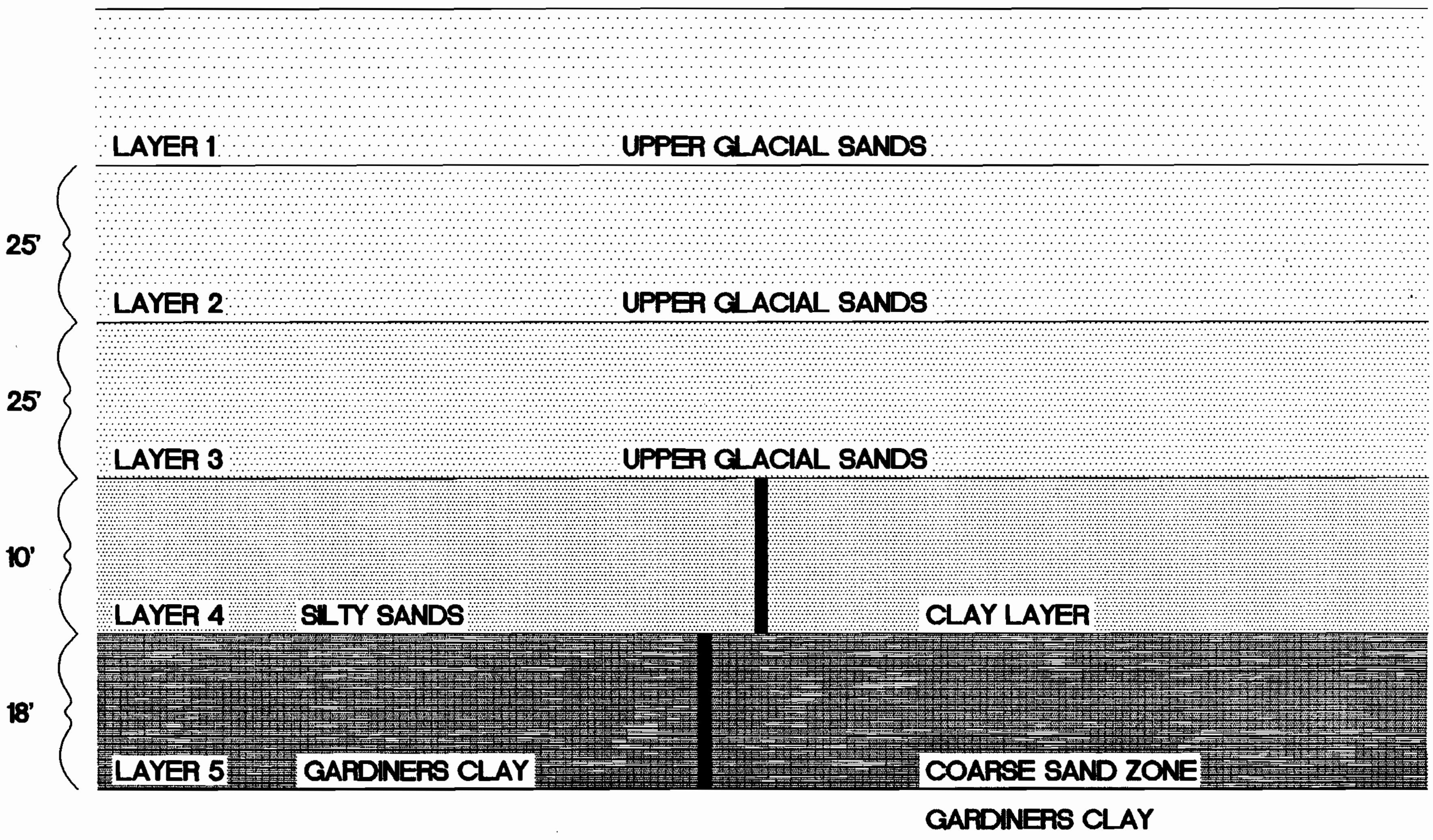
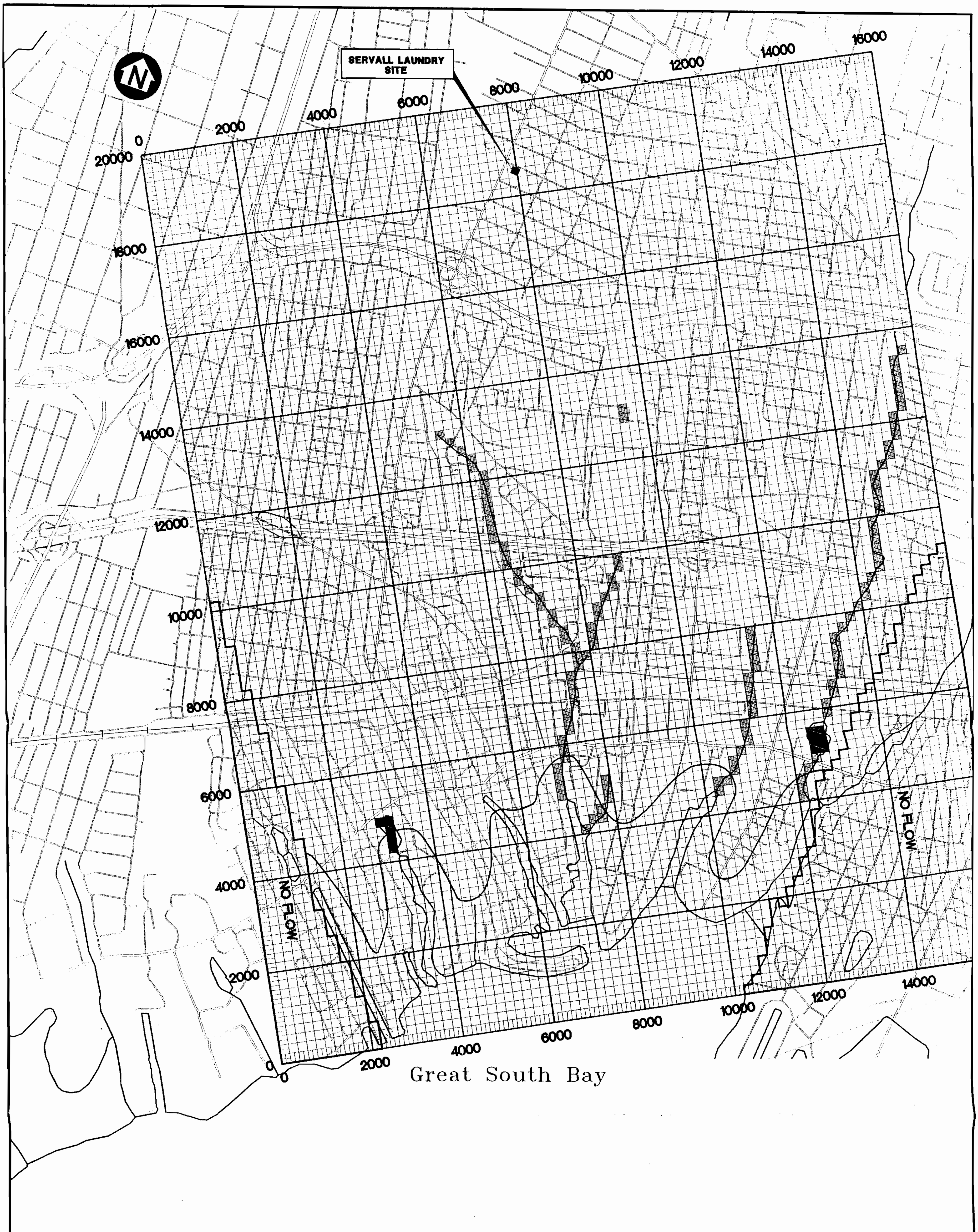


FIGURE 4-2
CONCEPTUAL SCHEMATIC OF MODEL GRID LAYERS
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services

T:\7135-20\FIG-3G

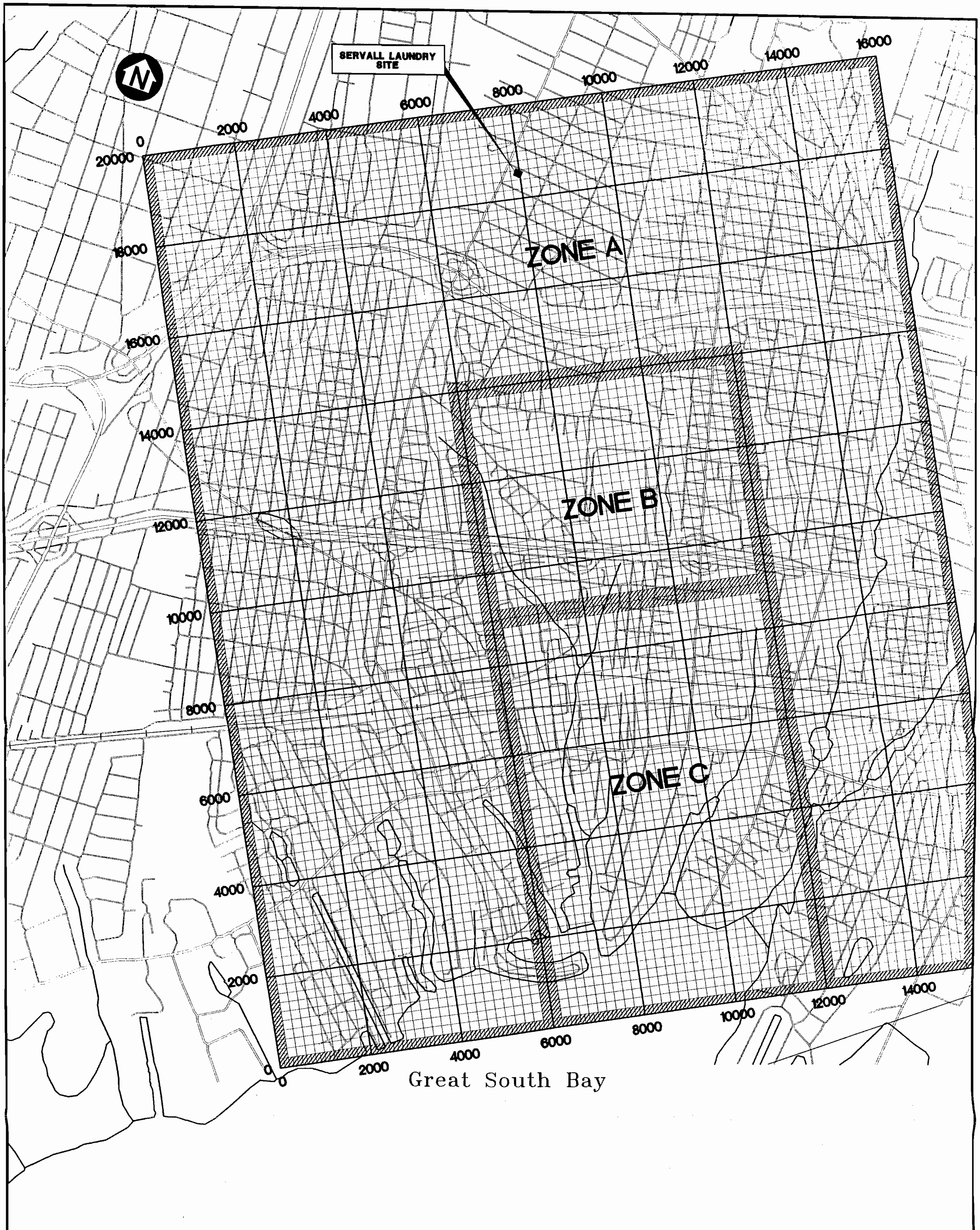


LEGEND

- ☐ CONSTANT HEADS
- ▨ RIVER PACKAGE
- ☐ NO-FLOW
- ■ HIGH K ZONE FOR LAKES
- ～ APPROXIMATE MAXIMUM ASSUMED LIMITS OF SALINE WEDGE INTRUSION LAYER 2 AND 3

FIGURE 4-3
MODEL GRID AND BOUNDARY CONDITIONS
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services



NOTES:

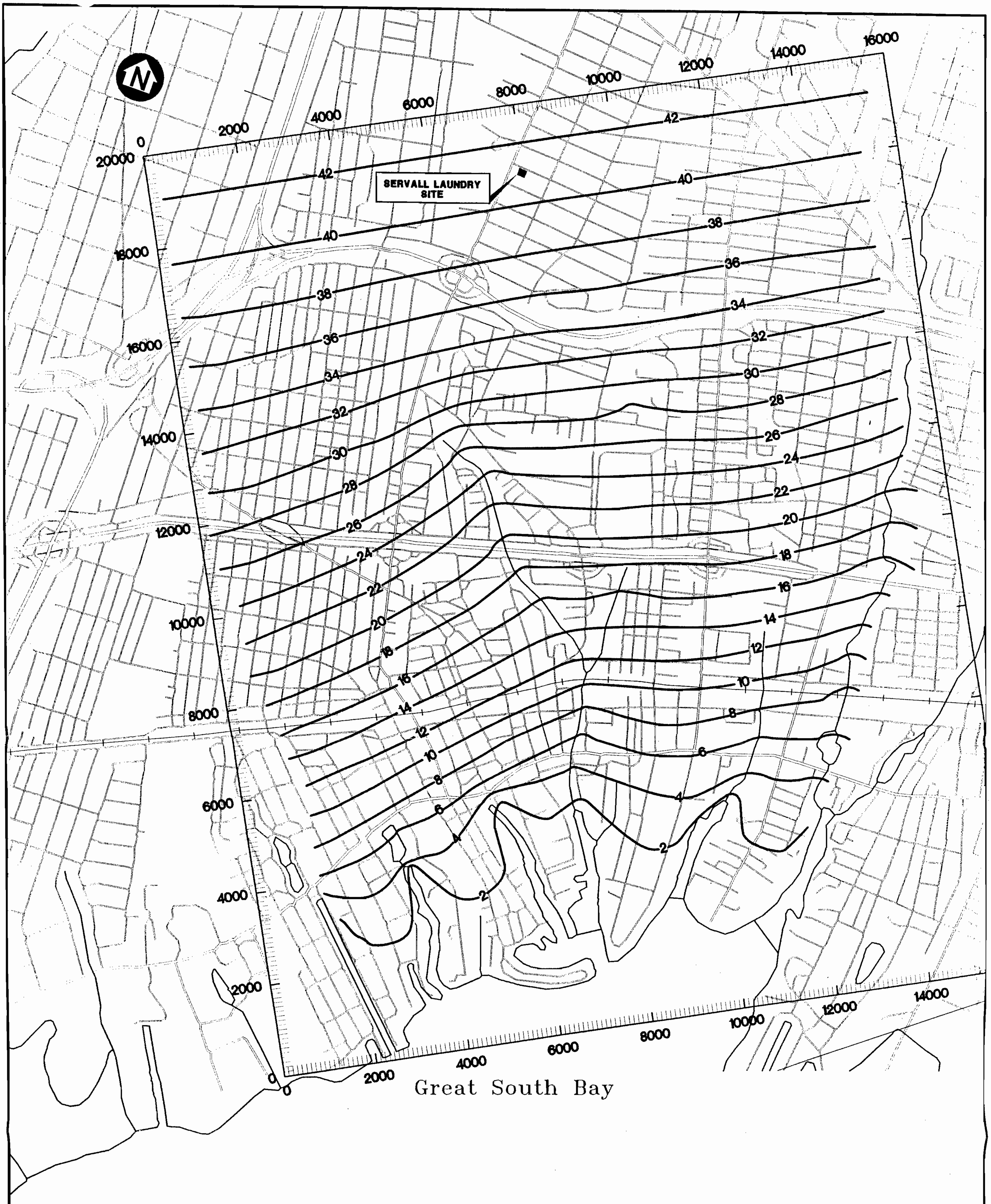
1. ZONE A = 22 INCHES/YEAR INFILTRATION
   ZONE B = 20 INCHES/YEAR INFILTRATION
   ZONE C = 16 INCHES/YEAR INFILTRATION
2. SEE SECTION 4.3.3 FOR A DETAILED DESCRIPTION OF DIFFUSE RECHARGE IN THE MODFLOW MODEL.

0 1000 2000 4000 FEET

SCALE: 1"=2000'

FIGURE 4-4
DIFFUSE RECHARGE INPUT
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services



NOTES:

1. GROUNDWATER LEVEL CONTOURS SHOWN ARE IN FEET ABOVE MEAN SEA LEVEL.

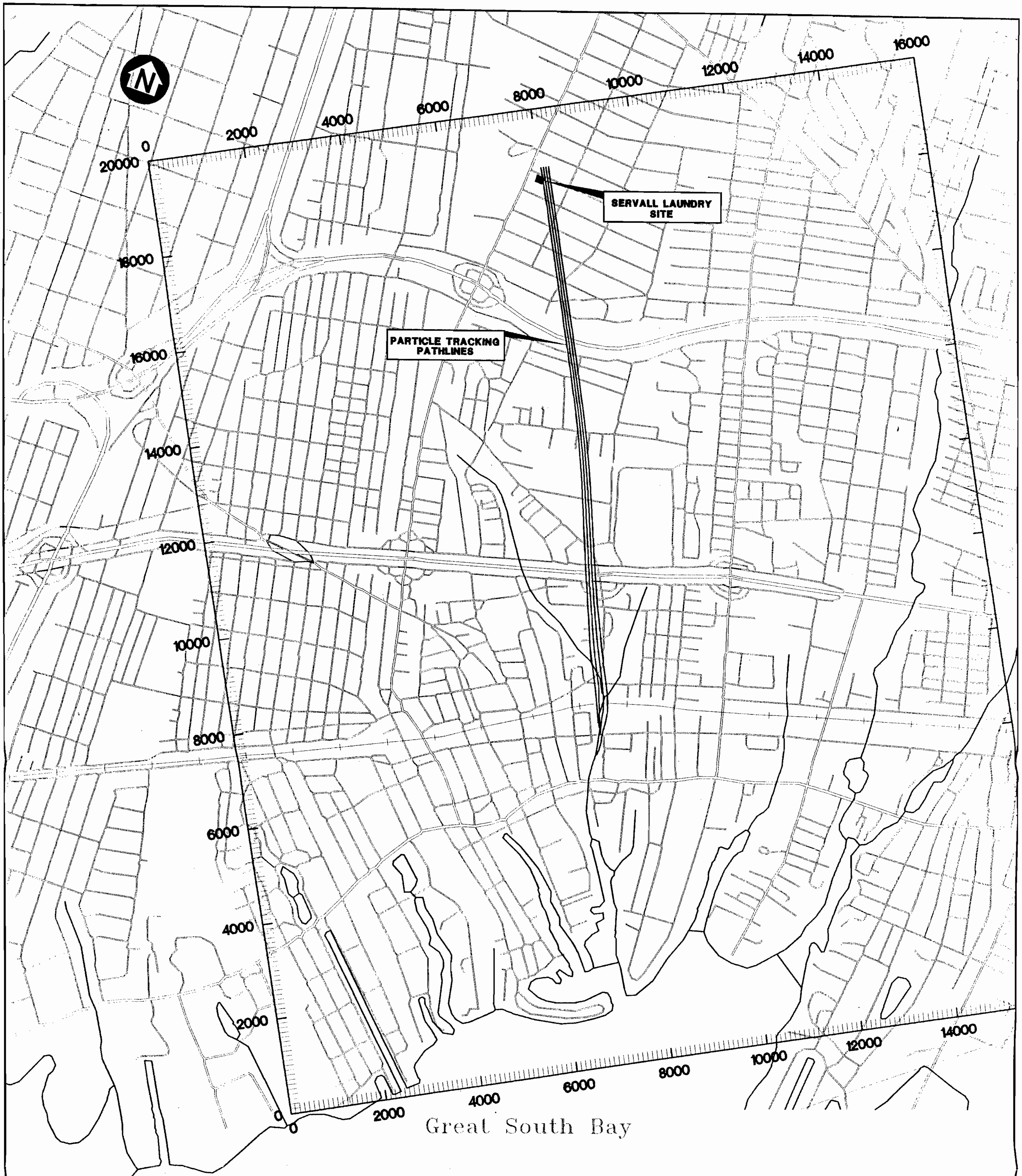
2. ALL CONTOURS BASED ON MODFLOW OUTPUT. MODEL SETUP AND SIMULATIONS DISCUSSED IN SECTION 4.0 OF TEXT.

0 1000 2000 4000 FEET

SCALE: 1"=2000'

FIGURE 4-5
FINAL CALIBRATION MODEL CONTOURS
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services



NOTES:

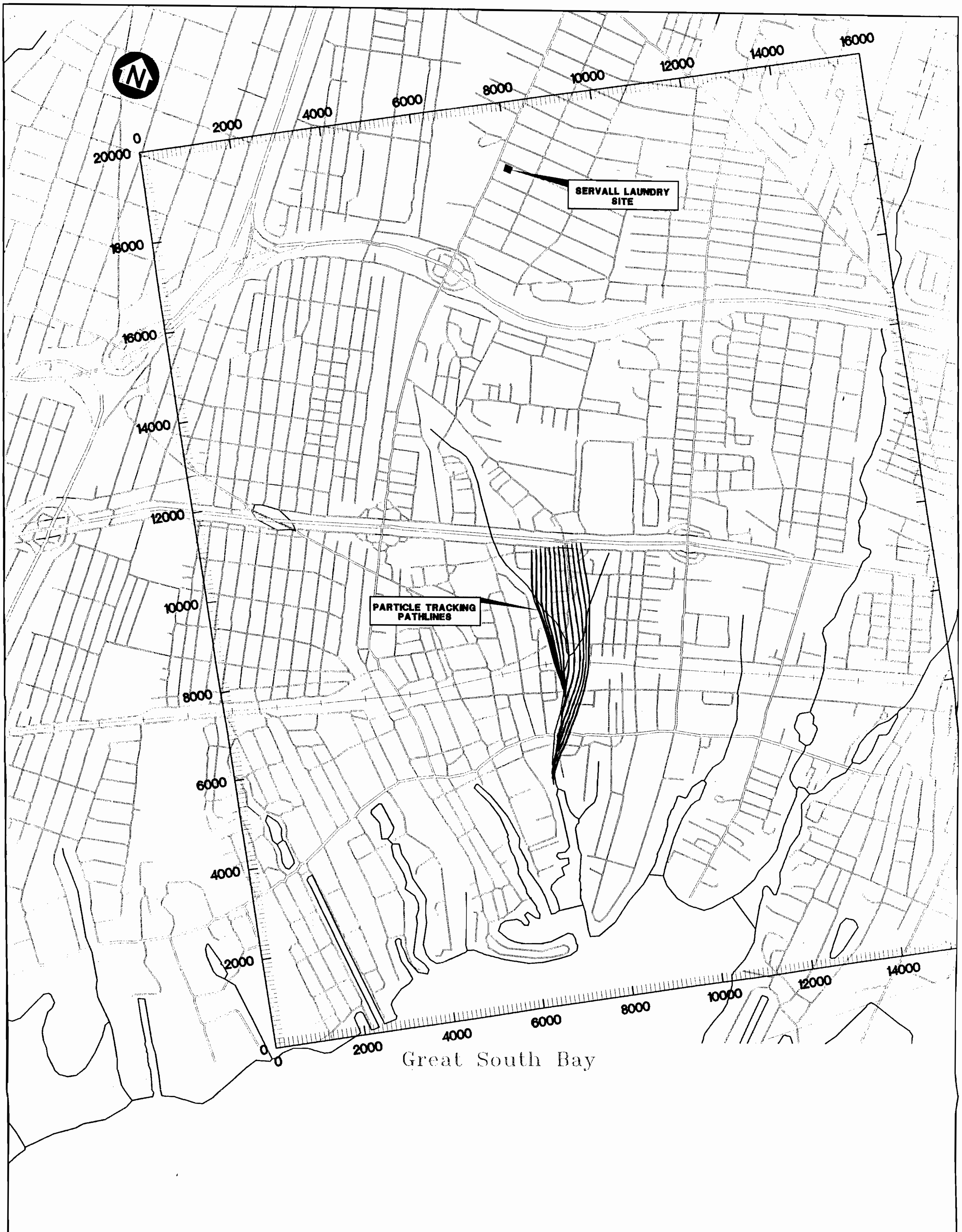
1. PARTICLE TRACKING BASED ON MODFLOW AND MODPATH OUTPUT DISCUSSED IN SECTION 4.0.

0 1000 2000 4000 FEET

SCALE: 1"=2000'

FIGURE 4-6
PARTICLE TRACKING ANALYSIS:
PARTICLES RELEASED AT WATER TABLE SURFACE
IN VICINITY OF SERVALL
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services



NOTES:

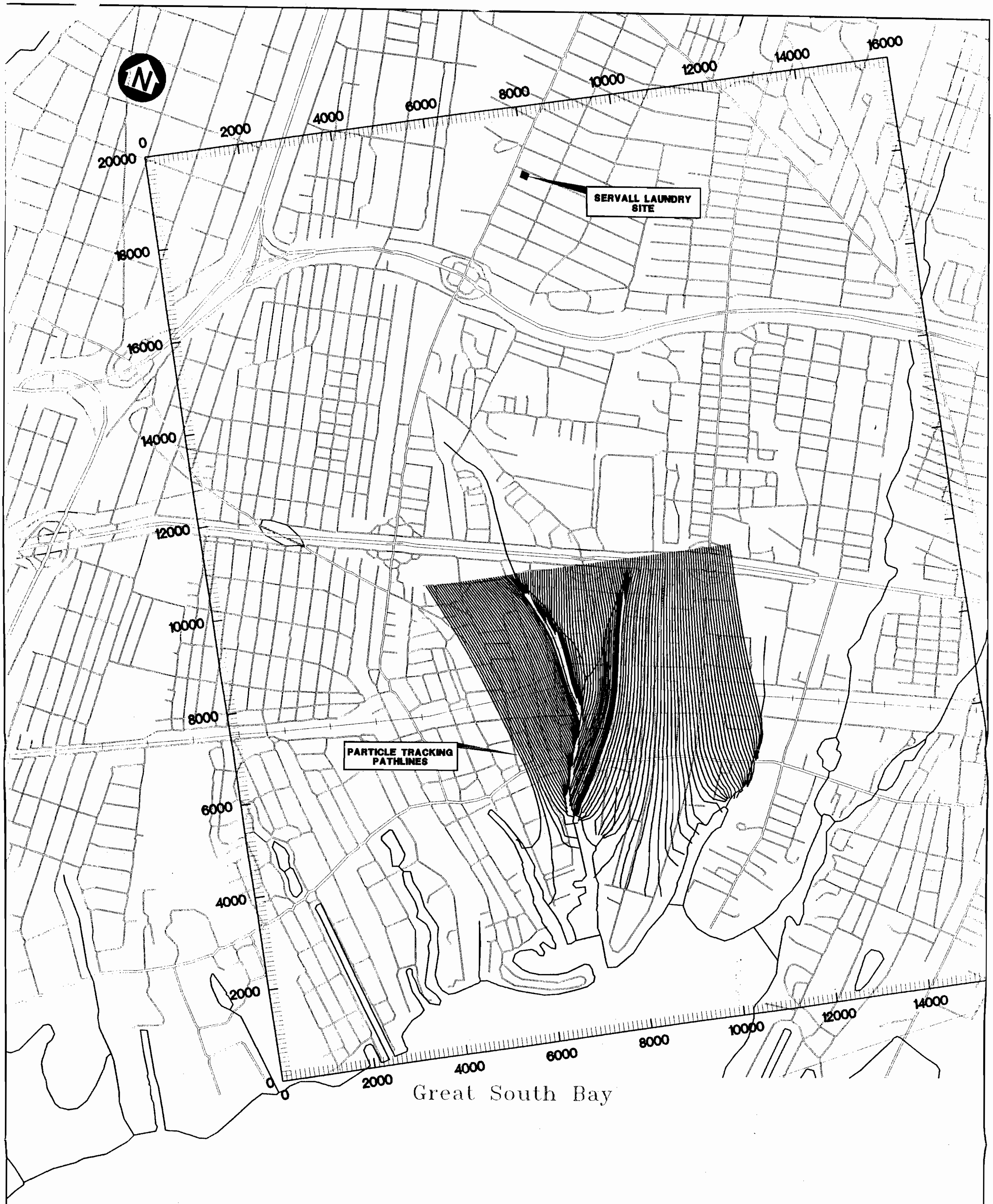
1. PARTICLE TRACKING BASED ON MODFLOW AND MODPATH OUTPUT DISCUSSED IN SECTION 4.0.

0 1000 2000 4000 FEET

SCALE: 1"=2000'

FIGURE 4-7
PARTICLE TRACKING ANALYSIS;
PARTICLES RELEASED INTO LAYER 3
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services



NOTES:

1. PARTICLE TRACKING BASED ON MODFLOW AND MODPATH OUTPUT DISCUSSED IN SECTION 4.0.

0 1000 2000 4000 FEET

SCALE: 1"=2000'

FIGURE 4-8
PARTICLE TRACKING ANALYSIS:
PARTICLES RELEASED ALONG A 1,200 FOOT
PLUME WIDTH IN LAYER 3
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

ABB Environmental Services

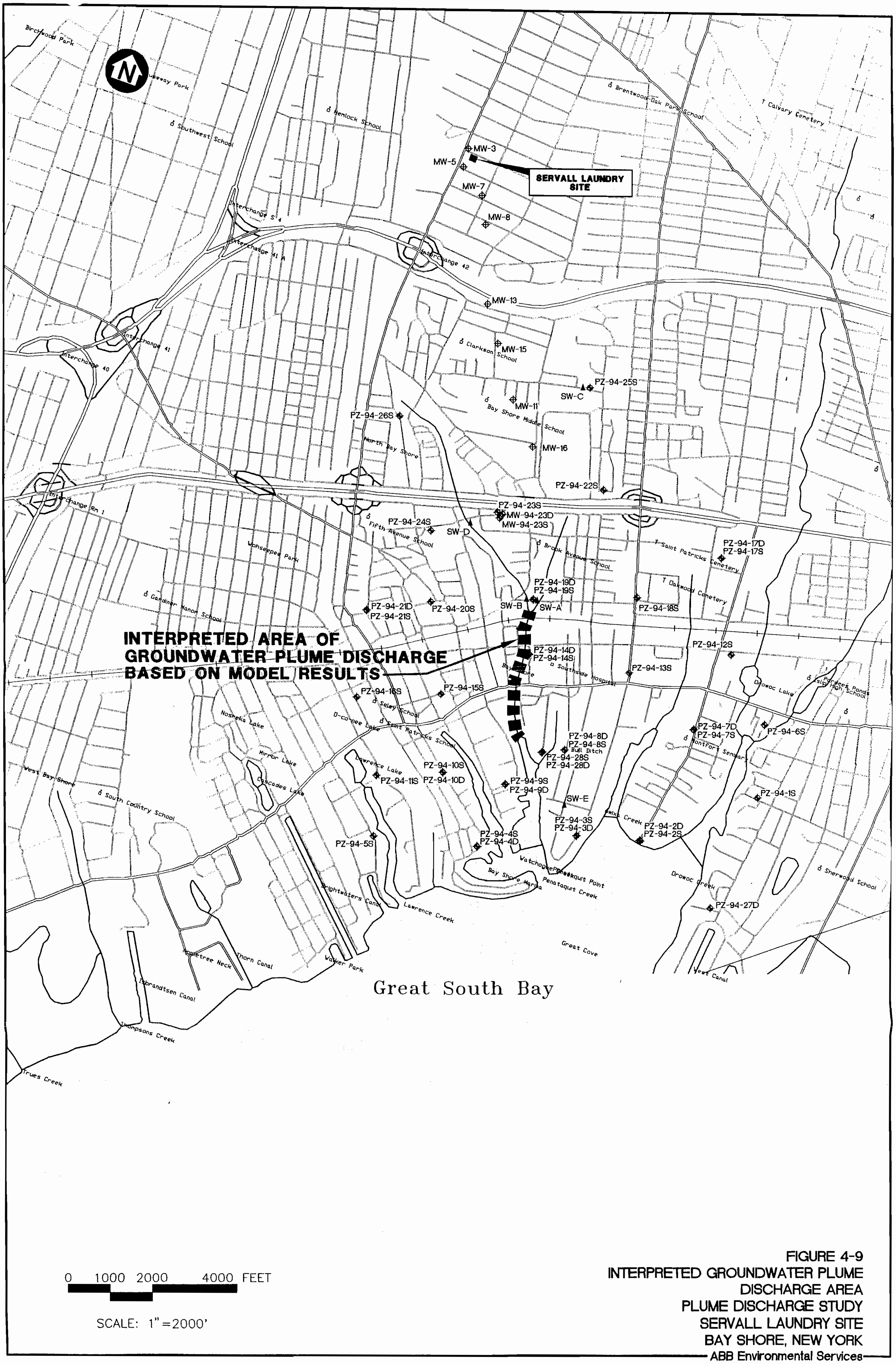


FIGURE 4-9
INTERPRETED GROUNDWATER PLUME
DISCHARGE AREA
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK
ABB Environmental Services

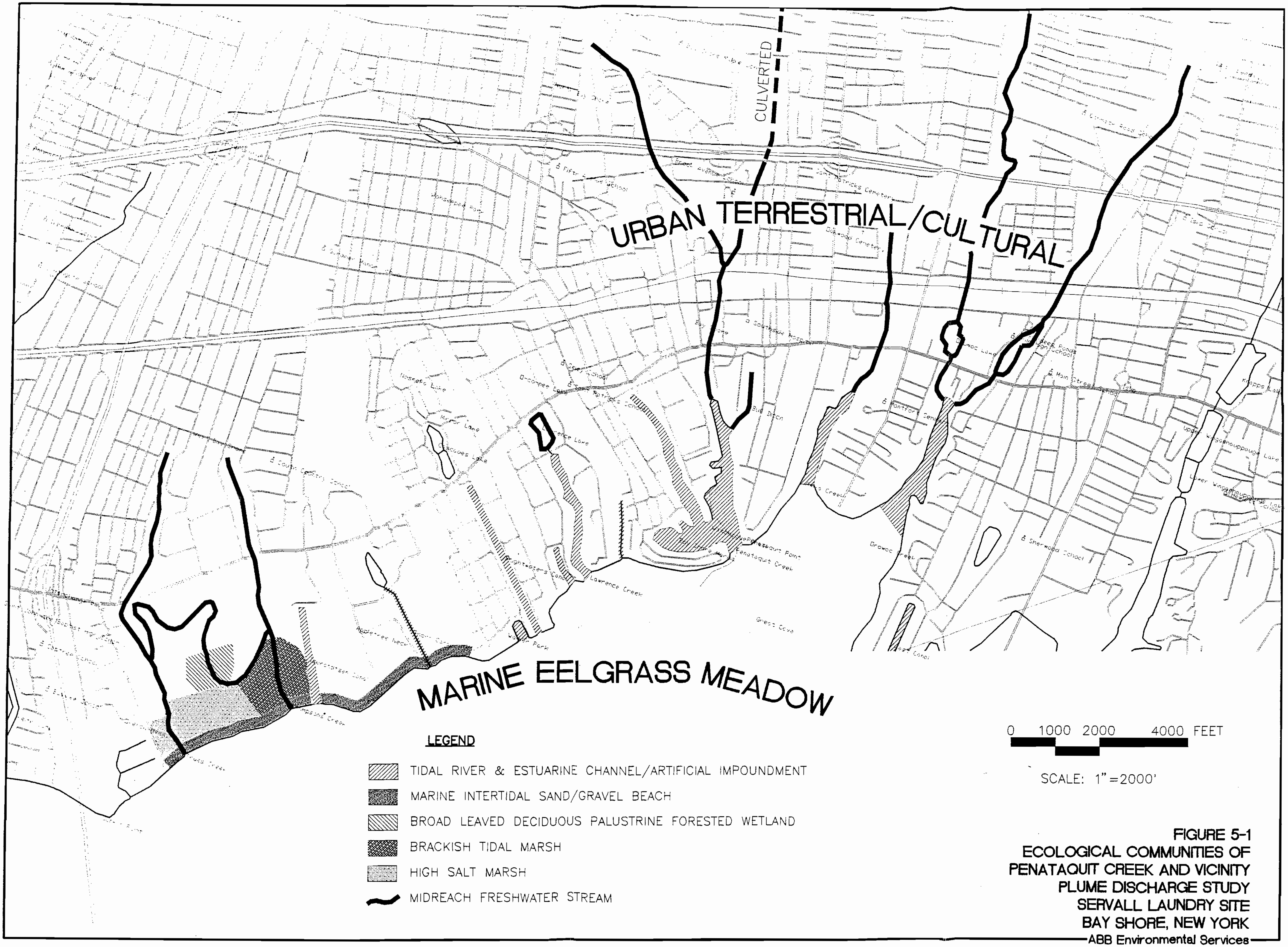
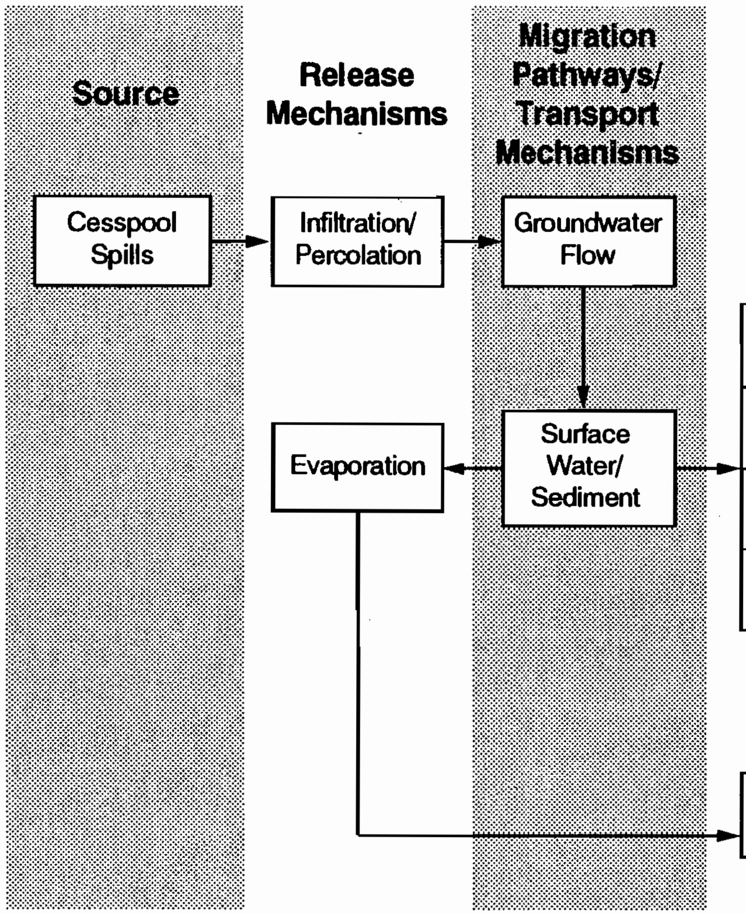


FIGURE 5-1
ECOLOGICAL COMMUNITIES OF
PENATAQUIT CREEK AND VICINITY
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK
ABB Environmental Services



Receptors

Surface Water/Sediment	Wildlife	Aquatic Fauna	Aquatic Plants
Ingestion	1	2	3
Direct Contact	1	●	●
Root Uptake	3	3	2
Ingestion of Food	●	3	3

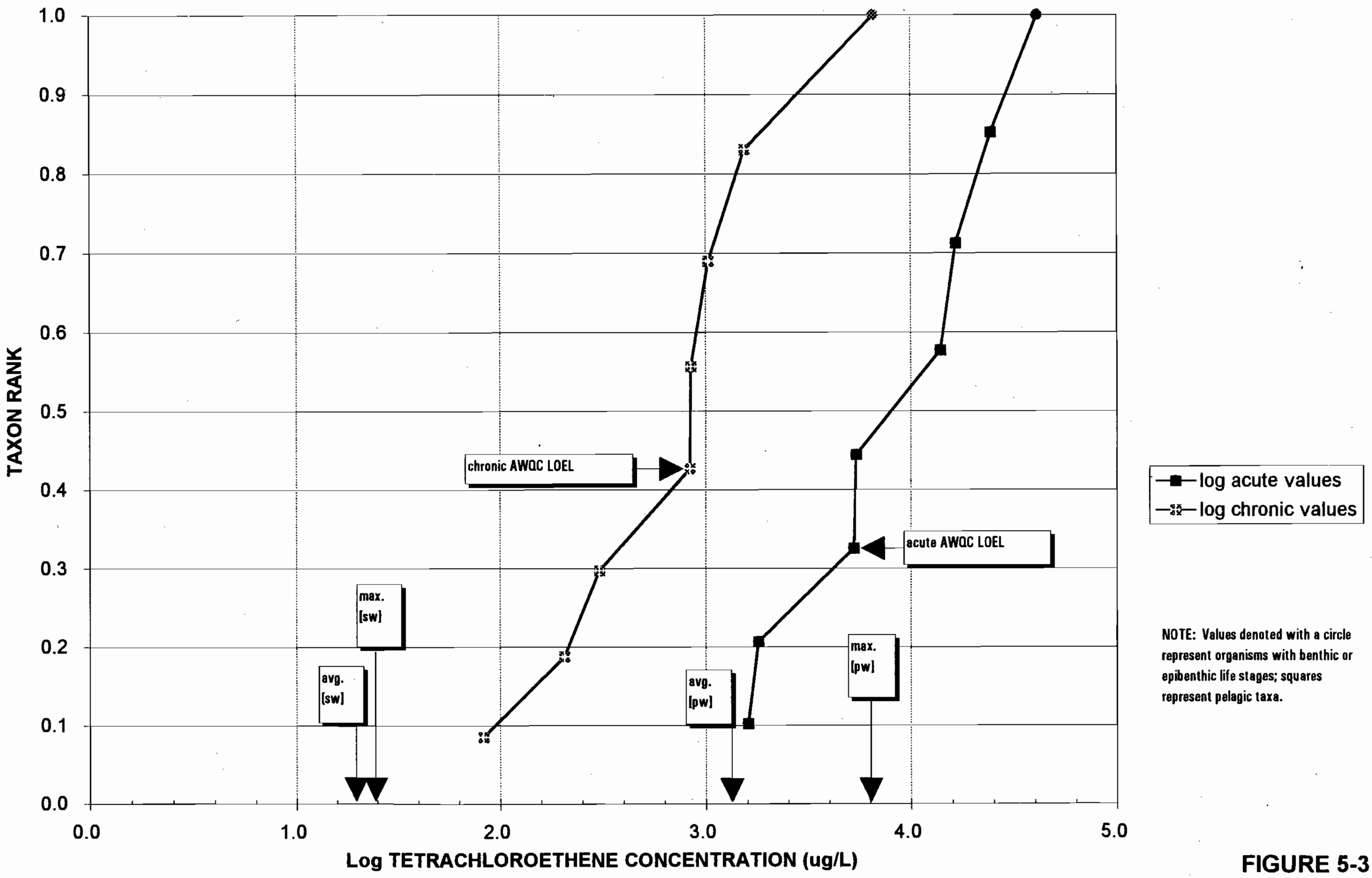
Air	Wildlife	Aquatic Fauna	Aquatic Plants
Inhalation	1	3	3

● = Pathway evaluated.
1 = Exposures possible but not expected to be significant via this exposure route.
2 = Exposures possible but cannot be evaluated due to a lack of relevant effects data.
2 = Not Applicable

FIGURE 5-2
ECOLOGICAL SITE CONCEPTUAL MODEL
FLOW DIAGRAM
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

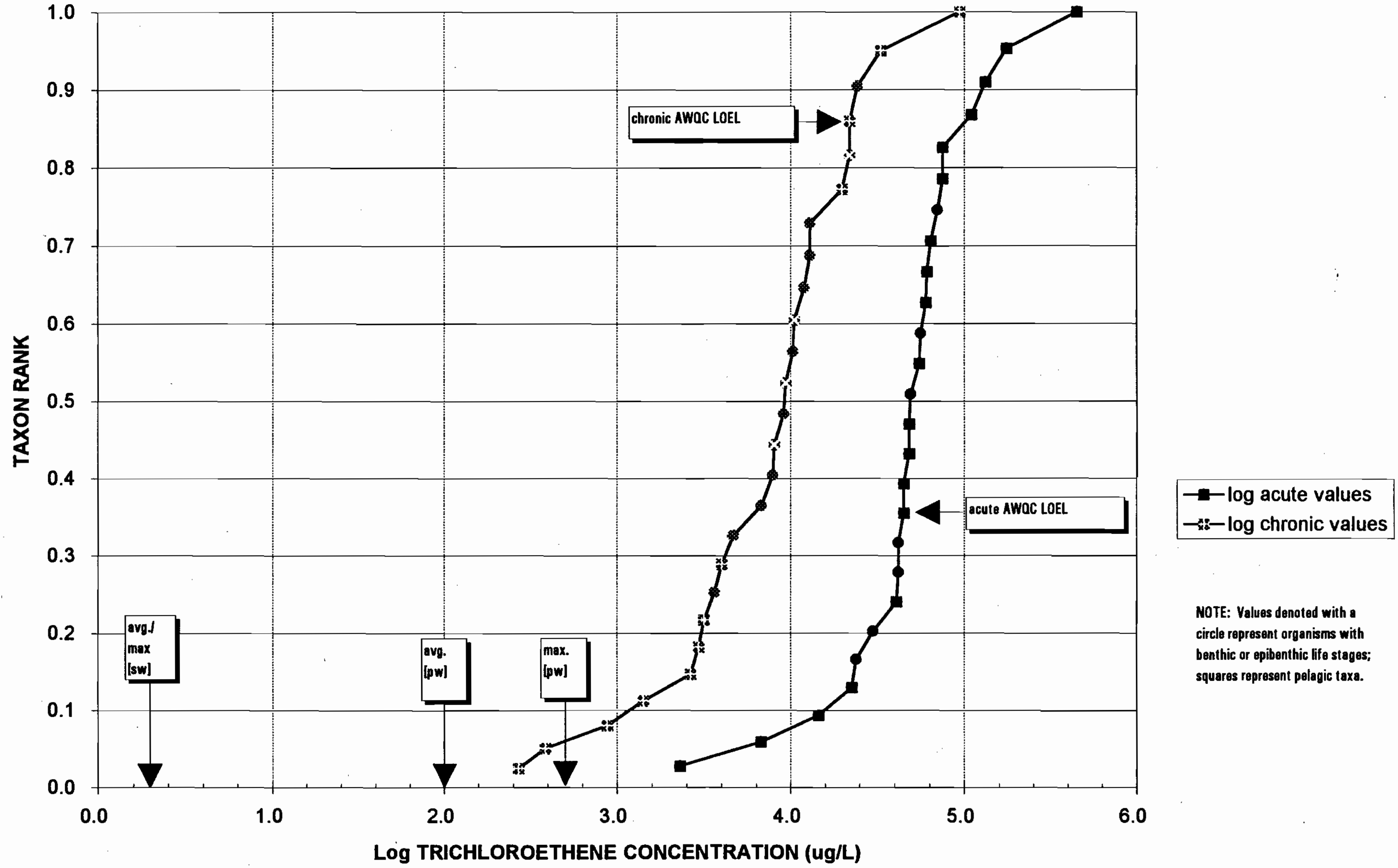
ABB Environmental Services

W9501006D



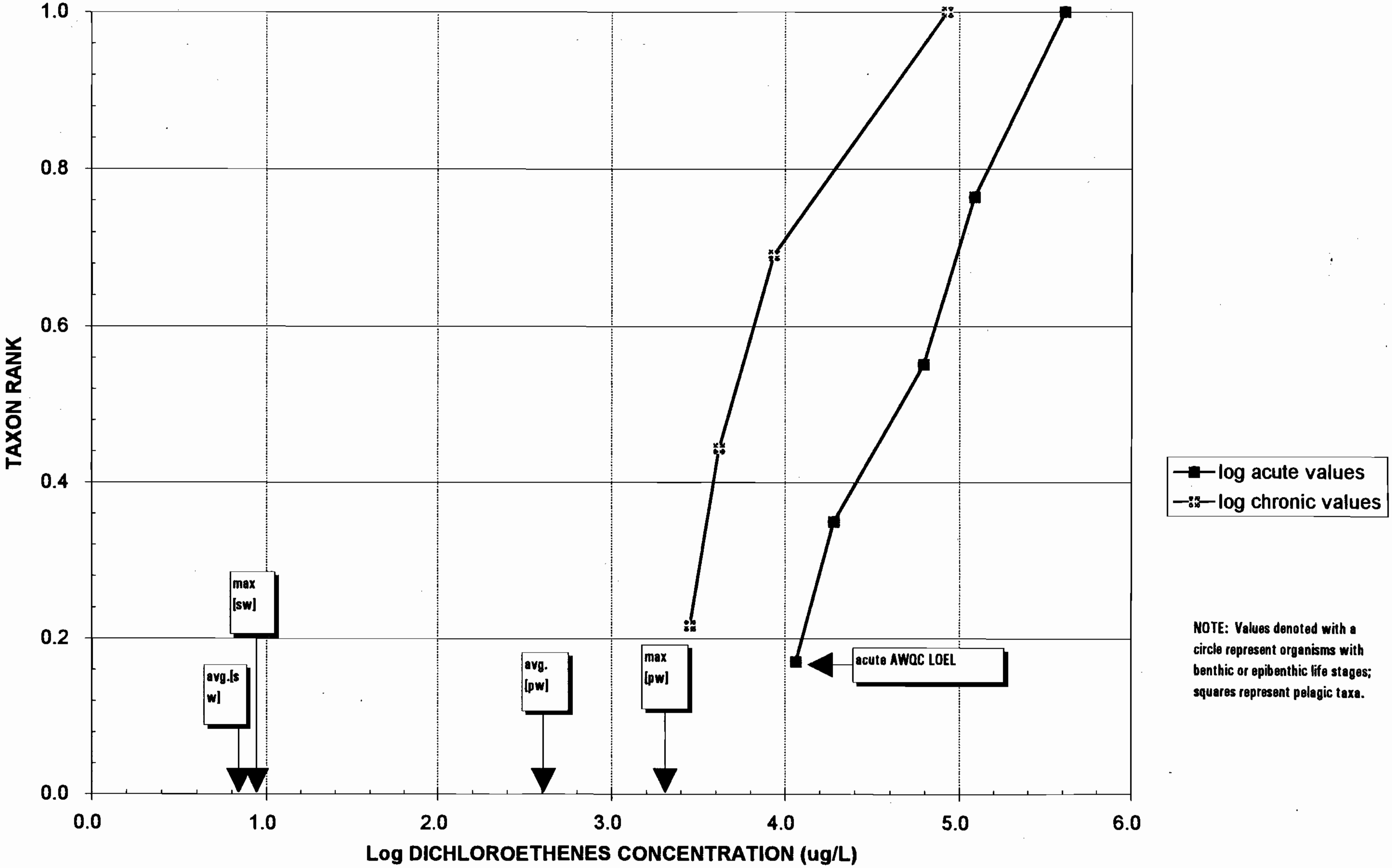
NOTE: Values denoted with a circle represent organisms with benthic or epibenthic life stages; squares represent pelagic taxa.

FIGURE 5-3
SPECIES ACUTE AND ESTIMATED CHRONIC VALUES:
TETRACHLOROETHENE
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK



NOTE: Values denoted with a circle represent organisms with benthic or epibenthic life stages; squares represent pelagic taxa.

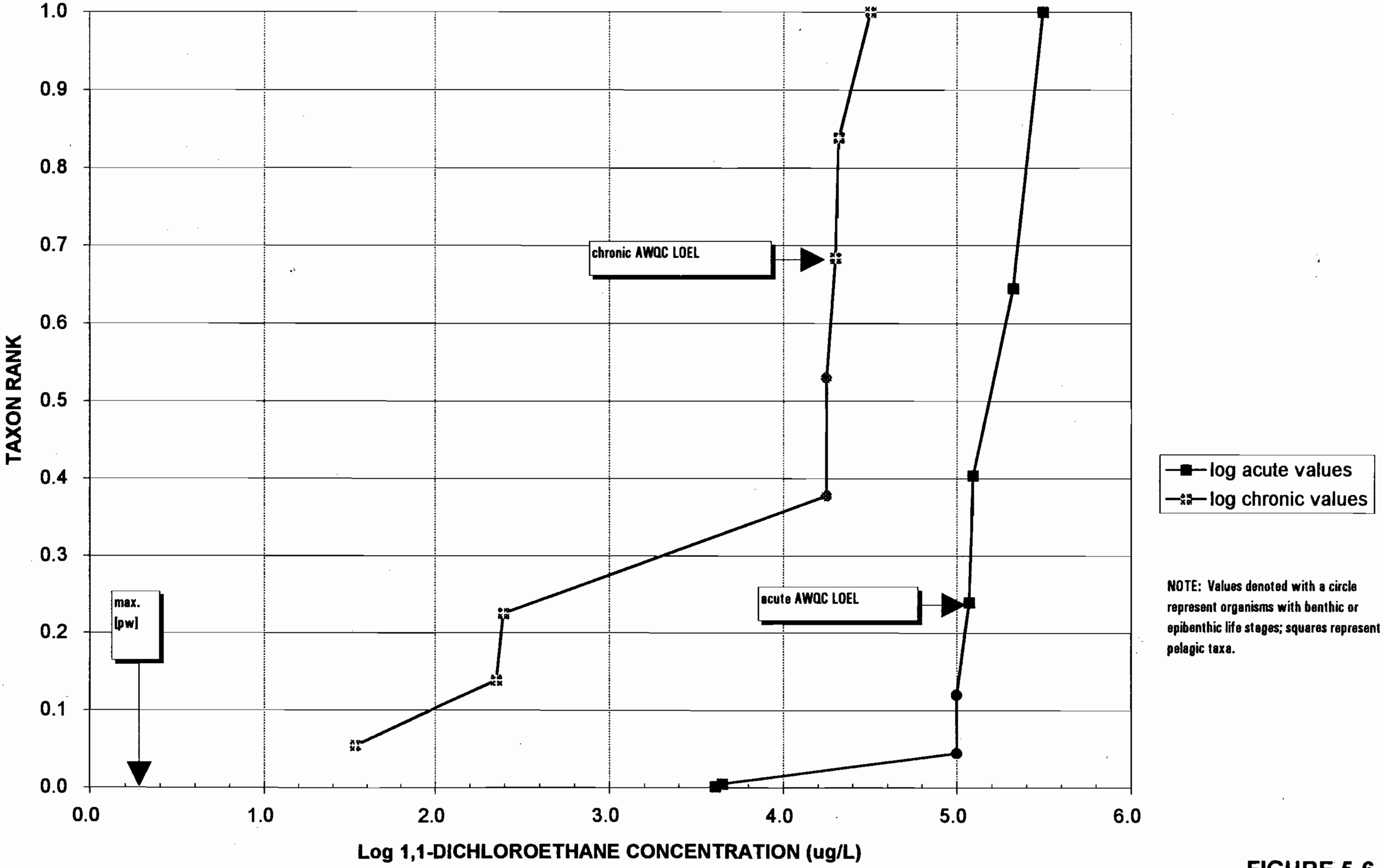
FIGURE 5-4
SPECIES ACUTE AND ESTIMATED CHRONIC VALUES:
TRICHLOROETHENE
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK



NOTE: Values denoted with a circle represent organisms with benthic or epibenthic life stages; squares represent pelagic taxa.

FIGURE 5-5
SPECIES ACUTE AND ESTIMATED CHRONIC VALUES: DICHLOROETHENES
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

.XLS



NOTE: Values denoted with a circle represent organisms with benthic or epibenthic life stages; squares represent pelagic taxa.

FIGURE 5-6
SPECIES ACUTE AND ESTIMATED CHRONIC VALUES:
1,1-DICHLOROETHANE
PLUME DISCHARGE STUDY
SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

E12DCA.XLS

TABLE 2-1
EXPLORATION SUMMARY TABLE
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

LOCATION ID	Elevation Ground Surf. (ft MSL)	Bottom of Exploration		Bottom of Screen		Top of Screen	
		Depth (ft bgs)	Elevation (ft MSL)	Depth (ft bgs)	Elevation (ft MSL)	Depth (ft bgs)	Elevation (ft MSL)
PZ-94-1S	6.54	15	-8	15	-8	12	-5
PZ-94-2S	3.64	15	-11	15	-11	12	-8
PZ-94-2D	5.13	75	-70	70	-65	67	-62
PZ-94-3S	3.95	15	-11	15	-11	12	-8
PZ-94-3DS	4.12	105	-101	64	-60	61	-57
PZ-94-4S	3.69	15	-11	15	-11	12	-8
PZ-94-4DS	3.70	78.5	-75	75	-71	72	-68
PZ-94-5S	7.04	15	-8	15	-8	12	-5
PZ-94-6S	4.75	10	-5	10	-5	7	-2
PZ-94-7S	10.32	15	-5	15	-5	12	-2
PZ-94-7D	10.23	70	-60	65	-55	62	-52
PZ-94-8S	5.91	15	-9	15	-9	12	-6
PZ-94-8D	6.05	70	-64	67	-61	64	-58
PZ-94-9S	4.82	15	-10	15	-10	12	-7
PZ-94-9D	4.79	70	-65	61	-56	58	-53
PZ-94-10S	9.63	15	-5	15	-5	12	-2
PZ-94-10D	9.44	108	-99	63	-54	60	-51
PZ-94-11S	6.88	15	-8	15	-8	12	-5
PZ-94-12S	9.31	19	-10	19	-10	16	-7
PZ-94-13S	13.83	15	-1	15	-1	12	2
PZ-94-14S	8.68	15	-6	15	-6	12	-3
PZ-94-14D	8.74	65	-56	63	-54	60	-51
PZ-94-15S	13.44	15	-2	15	-2	12	1
PZ-94-16S	17.61	15	3	15	3	12	6
PZ-94-17S	20.34	19	1	19	1	16	4
PZ-94-17D	20.41	80	-60	73	-53	70	-50
PZ-94-18S	19.39	19	0	19	0	16	3
PZ-94-19S	13.28	15	-2	15	-2	12	1
PZ-94-19D	13.25	110	-97	76	-63	73	-60
PZ-94-20S	24.03	15	9	15	9	12	12
PZ-94-21S	24.01	15	9	15	9	12	12
PZ-94-21D	23.91	87	-63	73	-49	70	-46
PZ-94-22S	29.18	15	14	15	14	12	17
PZ-94-23S	25.22	15	10	15	10	12	13
MW-94-23S	24.78	77	-52	69	-44	66	-41
MW-94-23D	24.60	112	-87	88	-63	83	-58
PZ-94-24S	31.66	15	17	15	17	12	20
PZ-94-25S	30.98	15	16	15	16	12	19
PZ-94-26S	44.49	30	14	30	14	27	17
PZ-94-27D	4.36	107	-103	65	-61	60	-56
PZ-94-28S	4.04	15	-11	15	-11	12	-8
PZ-94-28D	4.01	95	-91	73	-69	70	-66

NOTES:

MSL = Mean Sea Level
bgs = below ground surface
ft = feet

TABLE 2–2
SUMMARY OF GPS SURVEY DATA
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Location ID	Elevation Ground Surface	Elevation Top Casing	Northing	Easting
PZ–94–1S	6.54	6.36	182575.328	2216028.652
PZ–94–2S	3.64	3.36	180706.554	2213719.200
PZ–94–2D	5.13	4.67	180707.902	2213748.777
PZ–94–3S	3.95	3.79	180325.114	2212275.280
PZ–94–3D	4.12	3.67	180316.351	2212274.219
PZ–94–4S	3.69	3.61	179320.609	2210122.392
PZ–94–4D	3.70	3.40	179313.122	2210119.838
PZ–94–5S	7.04	6.82	178736.267	2207734.535
PZ–94–6S	4.75	4.51	184270.415	2215606.222
PZ–94–7S	10.32	10.14	183607.034	2214065.284
PZ–94–7D	10.23	9.95	183618.191	2214064.200
PZ–94–8S	5.91	5.68	182148.756	2211341.984
PZ–94–8D	6.05	5.85	182154.028	2211341.457
PZ–94–9S	4.82	4.65	180922.280	2210277.613
PZ–94–9D	4.79	4.60	180918.480	2210273.196
PZ–94–10S	9.63	9.48	180712.437	2208783.970
PZ–94–10D	9.44	9.23	180705.226	2208791.792
PZ–94–11S	6.88	6.75	180122.542	2207326.966
PZ–94–12S	9.31	8.91	185647.870	2214322.172
PZ–94–13S	13.83	13.66	184422.020	2212189.987
PZ–94–14S	8.68	8.36	184073.831	2209797.338
PZ–94–14D	8.74	8.49	184088.253	2209794.318
PZ–94–15S	13.44	13.04	182454.000	2208153.256
PZ–94–16S	17.61	17.46	181733.516	2206293.451
PZ–94–17S	20.34	20.14	187739.911	2213334.520
PZ–94–17D	20.41	20.22	187741.815	2213340.538
PZ–94–18S	19.39	19.16	186192.724	2211760.600
PZ–94–19S	13.28	13.16	185344.777	2209458.327
PZ–94–19D	13.25	12.95	185347.561	2209465.455
PZ–94–20S	24.03	23.89	184495.682	2207196.119
PZ–94–21S	24.01	23.71	183810.669	2205827.533
PZ–94–21D	23.91	21.61	183819.125	2205825.000
PZ–94–22S	29.18	28.92	188358.474	2210192.810
PZ–94–23S	25.22	25.06	187113.749	2208284.943
MW–94–23S	24.78	24.38	187099.544	2208295.492
MW–94–23D	24.60	24.45	187101.724	2208276.170
PZ–94–24S	31.66	31.53	186137.388	2206398.048
PZ–94–25S	30.98	30.76	190549.238	2209098.038
PZ–94–26S	44.49	44.19	188415.867	2205083.335
PZ–94–27D	4.36	4.18	179725.936	2215843.095
PZ–94–28S	4.04	3.76	181937.087	2210860.902
PZ–94–28D	4.01	3.82	181914.912	2210844.952
SW–A	––	11.35	185366.650	2209552.799

TABLE 2-2
SUMMARY OF GPS SURVEY DATA
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Location ID	Elevation Ground Surface	Elevation Top Casing	Northing	Easting
SW-B	--	12.71	185320.135	2209302.565
SW-C	--	27.67	190513.070	2208932.164
SW-D	--	22.26	186727.465	2207351.523
SW-E	--	5.66	180922.753	2211751.466

Stream gauges SW-A,B,C,D, and E, the elevations given in the Top of Casing column are the elevations of the measuring point: SW-A,B, and C are measured from the top of the corrugated metal pipe; SW-D is measured from the center of the top of the down stream head wall; and SW-E is measured from the top of the bridge deck on eastern side, center.

Data presented in this table are based on results presented in the GPS Report for ServAll Laundry Site-Bay Shore, Long Island; Prepared for YEC, Inc. & ABB Environmental Services; By RU-SH GPS Consultants & Land Surveyors, P.C.; October 19, 1994.

Elevations are based on Mean Sea Level. Benchmarks are presented in the GPS Report.

Northing and easting coordinates are based on: Lambert NAD 27; Spheroid: Clark 1866; Zone: 88.

GPS = global positioning system

TABLE 2-3
SUMMARY OF GROUNDWATER ELEVATIONS
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Location ID	Elevation Ground Surface (ft MSL)	Elevation Top Casing (ft MSL)	Water Elevation (ft MSL)
PZ-94-1	6.54	6.36	2.62
PZ-94-2	3.64	3.36	1.53
PZ-94-2D	5.13	4.67	1.31
PZ-94-3	3.95	3.79	1.42
PZ-94-3D	4.12	3.67	1.64
PZ-94-4	3.69	3.61	1.41
PZ-94-4D	3.70	3.40	1.40
PZ-94-6	4.75	4.51	2.07
PZ-94-7	10.32	10.14	2.56
PZ-94-7D	10.23	9.95	2.60
PZ-94-8	5.91	5.68	2.07
PZ-94-8D	6.05	5.85	2.01
PZ-94-9	4.82	4.65	1.85
PZ-94-9D	4.79	4.60	1.92
PZ-94-10	9.63	9.48	2.62
PZ-94-10D	9.44	9.23	2.86
PZ-94-11	6.88	6.75	3.57
PZ-94-12	9.31	8.91	6.62
PZ-94-13	13.83	13.66	6.43
PZ-94-14	8.68	8.36	6.11
PZ-94-14D	8.74	8.49	6.18
PZ-94-15	13.44	13.04	8.19
PZ-94-16	17.61	17.46	11.16
PZ-94-17	20.34	20.14	14.30
PZ-94-17D	20.41	20.22	14.06
PZ-94-18	19.39	19.16	12.10
PZ-94-19	13.28	13.16	11.16
PZ-94-19D	13.25	12.95	11.30
PZ-94-20	24.03	23.89	15.54
PZ-94-21	24.01	23.71	16.57
PZ-94-21D	23.91	21.61	19.46
PZ-94-22	29.18	28.92	19.48
PZ-94-23	25.22	25.06	18.37
MW-94-23	24.78	24.38	17.79
MW-94-23	24.60	24.45	17.94
PZ-94-24	31.66	31.53	19.87
PZ-94-25	30.98	30.76	26.53
PZ-94-26	44.49	44.19	26.33
PZ-94-27D	4.36	4.18	1.74
PZ-94-28	4.04	3.76	1.07
PZ-94-28D	4.01	3.82	1.56

Location ID	Elevation Ground Surface (ft MSL)	Elevation Top Casing (ft MSL)	Water Elevation (ft MSL)
SW-A	--	11.35	11.35
SW-B	--	12.71	11.31
SW-C	--	27.67	25.62
SW-D	--	22.26	16.74
SW-E	--	5.66	0.81

Notes

Water level data presented in this table are based on reading taken on 10/26/94.

Data were collected to assess the effects of tidal fluctuations, see Section 3.4 and Table 3-3.

See notes on Table 2-2 for location of measuring points for SW-A,B,C,D, and E.

MSL = Mean Sea Level

TABLE 3-1
SUMMARY OF PIEZOMETERS / WELL LITHOLOGY
PLUME DISCHARGE STUDY

SERVALL LAUNDRY
BAY SHORE, NEW YORK

Location ID	Elevation Ground Surface	Elevation Top Casing	Top of Clay (Upper Unit)		Bottom of Clay (Upper Unit)		Top of Clay (Deeper Unit)	
			Depth (ft bgs)	Elevation (ft MSL)	Depth (ft bgs)	Elevation (ft MSL)	Depth (ft bgs)	Elevation (ft MSL)
PZ-94-1S	6.54	6.36	–	–	–	–	–	–
PZ-94-2S	3.64	3.36	–	–	–	–	–	–
PZ-94-2D	5.13	4.67	70	-65	–	–	–	–
PZ-94-3S	3.95	3.79	–	–	–	–	–	–
PZ-94-3D	4.12	3.67	68	-64	86	-82	102	-98
PZ-94-4S	3.69	3.61	–	–	–	–	–	–
PZ-94-4D	3.70	3.40	76	-72	–	–	–	–
PZ-94-5S	7.04	6.82	–	–	–	–	–	–
PZ-94-6S	4.75	4.51	–	–	–	–	–	–
PZ-94-7S	10.32	10.14	–	–	–	–	–	–
PZ-94-7D	10.23	9.95	67	-57	–	–	–	–
PZ-94-8S	5.91	5.68	–	–	–	–	–	–
PZ-94-8D	6.05	5.85	69	-62	–	–	–	–
PZ-94-9S	4.82	4.65	–	–	–	–	–	–
PZ-94-9D	4.79	4.60	65	-60	–	–	–	–
PZ-94-10S	9.63	9.48		–	–	–	–	–
PZ-94-10D	9.44	9.23	77	-68	86	-77	105	-96
PZ-94-11S	6.88	6.75	–	–	–	–	–	–
PZ-94-12S	9.31	8.91	–	–	–	–	–	–
PZ-94-13S	13.83	13.66	–	–	–	–	–	–
PZ-94-14S	8.68	8.36	–	–	–	–	–	–
PZ-94-14D	8.74	8.49	64	-55	–	–	–	–
PZ-94-15S	13.44	13.04	–	–	–	–	–	–
PZ-94-16S	17.61	17.46	–	–	–	–	–	–
PZ-94-17S	20.34	20.14	–	–	–	–	–	–
PZ-94-17D	20.41	20.22	76	-56	–	–	–	–
PZ-94-18S	19.39	19.16	–	–	–	–	–	–
PZ-94-19S	13.28	13.16	–	–	–	–	–	–
PZ-94-19D	13.25	12.95	66	-53	71	-58	85	-72
PZ-94-20S	24.03	23.89	–	–	–	–	–	–
PZ-94-21S	24.01	23.71	–	–	–	–	–	–
PZ-94-21D	23.91	23.61	76	-52	86	-62	–	–
PZ-94-22S	29.18	28.92	–	–	–	–	–	–
PZ-94-23S	25.22	25.06	–	–	–	–	–	–
MW-94-23S	24.78	24.38	71	-46	75	-50	–	–
MW-94-23D	24.60	24.45	71		75	-50	105	-80
PZ-94-24S	31.66	31.53	–	–	–	–	–	–
PZ-94-25S	30.98	30.76	–	–	–	–	–	–
PZ-94-26S	44.49	44.19	–	–	–	–	–	–
PZ-94-27D	4.36	4.18	67	-63	77	-73	96	-92
PZ-94-28S	4.04	3.76	–	–	–	–	–	–
PZ-94-28D	4.01	3.82	76	-72	83	-79	92	-88

Depths to changes in lithology are based on field observations on drilling, split-spoon sampling and borehole gamma logs.

TABLE 3-2
SUMMARY OF VERTICAL HYDRAULIC GRADIENTS
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Location ID	Location of Center of Screen (ft MSL)	Distance Between Screens (ft)	Difference in Water Levels (ft)	Vertical Hydraulic Gradient (ft/ft)	Notes
PZ-94-2	-9.86				
PZ-94-2D	-63.37	53.51	-0.22	-0.0041	A
PZ-94-3	-9.55				
PZ-94-3D	-58.38	48.83	0.22	0.0045	A
PZ-94-4	-9.81				
PZ-94-4D	-69.80	59.99	-0.01	-0.0002	A
PZ-94-7	-3.18				
PZ-94-7D	-53.27	50.09	0.04	0.0008	A
PZ-94-8	-7.59				
PZ-94-8D	-59.45	51.86	-0.06	-0.0012	A
PZ-94-9	-8.68				
PZ-94-9D	-54.71	46.03	0.07	0.0015	A
PZ-94-10	-3.87				
PZ-94-10D	-52.06	48.19	0.24	0.0050	A
PZ-94-14	-4.82				
PZ-94-14D	-52.76	47.94	0.07	0.0015	A
PZ-94-17	2.84				
PZ-94-17D	-51.09	53.93	-0.24	-0.0045	A
PZ-94-19	-0.22				
PZ-94-19D	-61.25	61.03	0.14	0.0023	B
PZ-94-21	10.51				
PZ-94-21D	-47.59	58.10	2.89	0.0497	A
PZ-94-23	11.72				
MW-94-23S	-42.72	54.44	-0.58	-0.0107	A
MW-94-23D	-60.90	18.18	0.15	0.0083	B
PZ-94-28	-9.46				
PZ-94-28D	-67.49	58.03	0.49	0.0084	C

NOTES:

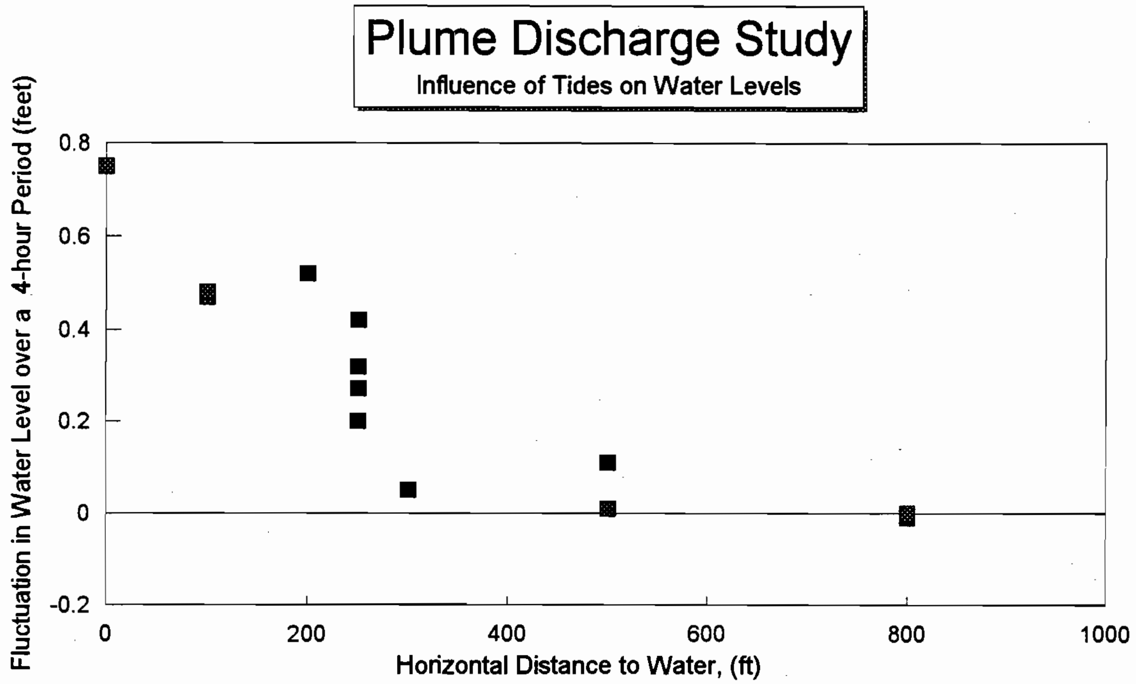
Negative values represent downward gradient flows.

A: Within the upper glacial aquifer.
B: Across the upper clay to the top of the upper glacial aquifer.
C: From within the upper clay to the top of the upper glacial aquifer.

TABLE 3-3
INFLUENCE OF TIDAL FLUCTUATIONS ON GROUNDWATER LEVELS
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Location ID	Water Level (ft MSL)	Hours Later	Water Level (ft MSL)	Change in Water Level (ft)	Horizontal Distance To Nearest Water (ft)
PZ-94-1	2.62	04:13	2.63	0.01	500
PZ-94-2	1.53	04:15	2.00	0.47	100
PZ-94-2D	1.31	04:16	1.79	0.48	100
PZ-94-3	1.42	04:15	1.84	0.42	250
PZ-94-3D	1.64	04:15	1.84	0.20	250
PZ-94-4	1.41	04:30	1.68	0.27	250
PZ-94-4D	1.40	04:26	1.72	0.32	250
PZ-94-6	2.07	04:15	2.59	0.52	200
PZ-94-7	2.56	04:17	2.55	-0.01	800
PZ-94-7D	2.60	04:18	2.60	0.00	800
PZ-94-8	2.07	04:22	2.12	0.05	300
PZ-94-8D	2.01	04:19	2.06	0.05	300
PZ-94-27D	1.74	04:13	1.85	0.11	500
SW-E	0.81	04:19	1.56	0.75	0



Water levels obtained on October 26, 1994.

Values in horizontal distance to nearest water column represent the distance to tidal water bodies.

TABLE 3–4
ANALYTICAL DATA RESULTS
MONITORING WELLS INSTALLED DURING THE RI/FS PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Sample Number	MWXX1	MWX3A	MWX3B	MWXX4	MWX6A	MWX6B	MWX6B (Dup)
Dilution of Sample	5	1	1	1	1	125	1
Analyte							
Vinyl Chloride							
Chloroethane							
Methylene Chloride	11 B		0.42 J			40 J	0.98 J
Acetone							
1,1–Dichloroethene	22	2	1	0.84 J			
1,1–Dichloroethane	2 J	5			0.43 J		
cis 1,2–Dichloroethene	10	2	2	2	0.63 J	160	140 E
trans 1,2–Dichloroethene							
Chloroform							
1,1,1–Trichloroethane	200 E	11	12	8	2		
Trichloroethene	3 J	7	4	3	0.66 J	300	230 E
1,1,2–Trichloroethane							
Benzene							0.32 J
Tetrachloroethene		0.34 J				8400 E	1300 E
Toluene							1
Chlorobenzene							
Xylene (total)							1
Total VOCs	248	27.34	19.42	13.84	3.72	8900	1673.3

TABLE 3-4
ANALYTICAL DATA RESULTS
MONITORING WELLS INSTALLED DURING THE RI/FS PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Sample Number Dilution of Sample Analyte	MWXX7 25	MWXX8 5	MWXX8 25	MWX11 100	MWX13 25	MWX15 1	MWX16 1
Vinyl Chloride				470		46 E	280 E
Chloroethane						4	
Methylene Chloride	44 JB	2 J		JB	8 JB	2	3
Acetone						4 J	
1,1–Dichloroethene						0.3 J	3
1,1–Dichloroethane							1
cis 1,2–Dichloroethene		10		830	24 J	320 E	670 E
trans 1,2–Dichloroethene						3	26 E
Chloroform						0.77 J	0.8 J
1,1,1–Trichloroethane	12 J					0.63 J	2
Trichloroethene	32	10	13 JD	74 J	94	110 E	600 E
1,1,2–Trichloroethane							1
Benzene							
Tetrachloroethene	1400 E	190 E	240 D	800	230	1400 E	1700 E
Toluene						0.45 J	0.47 J
Chlorobenzene							0.57 J
Xylenes (total)							2
Total VOCs	1488	212	253	2174	356	1891.15	3289.84

Data presented in this table has not been validated.
Results for all analytical runs are presented to allow for a better interpretation of the results.
All results are in µg/L

LIST OF QUALIFIERS USED:

B: Indicates analyte was detected in both the sample and the associated laboratory method blank.
J: Indicates an estimated concentration below the contract required quantitation limit (CRQL) but greater than 0, or when estimating a concentration for TICs.
E: Indicates that the analyte concentration exceeded the calibration range of the instrument and that a re–analysis of a diluted sample is required
D: Sample concentration was obtained by dilution to bring the result within calibration range.

TABLE 3-5
ANALYTICAL DATA RESULTS
MONITORING WELLS INSTALLED DURING THE PHASE I ASSESSMENT
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Sample Number	Method Reporting Limit	MW23S	MW23D
Dilution of Sample		25	1
Analyte			
1,1,1-Trichloroethane	1	1.7	ND
Tetrachloroethene	1	7.8	ND

All values in micrograms per liter.

Data presented in this table have been validated in accordance with the USEPA "National Functional Guidelines for Organics Data Review", (June 1991a) with USEPA Region II and NYSDEC revisions

Data validation indicates that no qualifiers need to be applied to this data.

Table 3-6
Physico-Chemical Properties of ServAll Site-Related Compounds
Plume Discharge Study

ServAll Laundry Site
Bay Shore, New York

Compound	MW	Vap. Pres. mm Hg	H atm-m3/mol	Solubility mg/l	K_{ow}	K_{oc} m/g	Halflife yrs	BCF l/kg	Photo-ox Halflife
PCE	166	17.8	0.0259	150	398	364	1	31	NA
TCE	131	30	0.0091	1100	240	126	1	10.6	NA
1,2-DCE	97	324	0.00656	6300	302	59	0.5	1.6	NA
VC	63	2660	0.0819	2670	24	57	0.5	1.17	low
1,1-DCA	99	182	0.000431	5600	61.7	30	0.4	NA	NA
1,1-DCE	97	600	0.0034	2250	69.2	65	0.5	1.6	NA
Toluene	92	28.1	0.00637	535	537	300	0.06	10.7	54 days
BEHP	391	2.0E-07	3.6E-07	0.285	9500	5900	0.06	NA	584 days

Notes:

1. Values from SPHEM (USEPA, 1986) or Basics of Pump-and-Treat (USEPA, 1980).
2. Values for biodegradation and photo-oxidation from Howard (1991) and represent high end of range given for half lives.

TABLE 4-1
VALUE FOR PRINCIPAL CALIBRATION PARAMETERS
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

PARAMETER/LAYER	INITIAL	RANGE	FINAL
Hydraulic Conductivity			
Layer 1	255 ft/d	200-300	255
Layer 2	255	200-300	255
Layer 3	255	200-300	255
Layer 4	30/0.003	-	30/0.003(1)
Layer 5	750	10-750	500/100/10(2)
Recharge (3)			
Zone A	20"/yr	12-22	22
Zone B	20	12-22	20
Zone C	20	12-22	16
River Conductance and Stages (4)	1000 ft^2/d	1000-10000	6000-10000
Northern Boundary Constant Head	40.0 ft	40.0-43.0	43.0

Notes:

(1) Higher value for silty sand, lower for clay.
(2) Corresponds to 3 versions of the final model with high, medium, and low influence of Layer 5, respectively. Model with Layer 5 K of 100 ft/d selected as best.
(3) See Figure 4-4 for definition of zone areas.
(4) See Appendix G for input river package values for river individual node conductances and stage elevations.
ft/d = feet per day

TABLE 4-2
MODEL BASEFLOW COMPARISON
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

STREAM	TARGET	MODEL VERSION K5=500	MODEL VERSION K5=100	MODEL VERSION K5=10
Penataquit	5.8 cfs	4.80 cfs	5.86 cfs	5.96 cfs
Bull Ditch	0.2	0.15	0.18	0.16
Awixa	1.2	1.10	1.27	1.19
Orowoc	4.5	4.20	4.57	4.61

Note:

cfs = cubic feet per second

TABLE 4-3
STATISTICS OF MODEL FITTING
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

RUN/STATISTIC	ALL	LAYER 1	LAYER 2	LAYER 3	LAYER 4	LAYER 5
Number of Targets	41	25	2	8	4	2
Version K=500						
Residual Mean	-0.14	0.37	-1.56	-0.45	-0.66	-2.85
Residual Standard Development	1.22	0.82	0.06	0.88	1.01	1.87
Absolute Mean Residual	0.94	0.77	1.56	0.84	1.00	2.85
Residual Standard Development/Range	0.03	0.03	0.09	0.05	0.06	0.59
Version K=100						
Residual Mean	-0.35	0.11	-1.64	-0.66	-1.02	-3.23
Residual Standard Development	1.16	0.71	0.07	0.99	0.94	1.66
Absolute Mean Residual	0.84	0.54	1.64	0.98	1.08	3.23
Residual Standard Development/Range	0.03	0.03	0.12	0.06	0.06	0.46
Version K=10						
Residual Mean	-0.34	0.11	-1.67	-0.67	-1.11	-1.74
Residual Standard Development	1.02	0.75	0.08	1.03	0.92	0.74
Absolute Mean Residual	0.84	0.60	1.67	0.99	1.13	1.74
Residual Standard Development/Range	0.02	0.03	0.12	0.06	0.06	0.13

TABLE 4-4
MODEL PARTICLE TRACKING RESULTS
LOCATIONS AND NUMBERS OF PARTICLES TO PENATAQUIT
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

		NUMBER OF PARTICLES DISCHARGING								
RIVER NODE LOCATION		**RUN K=500**			**RUN K=100**			**RUN K=10**		
ROW	**COLUMN**	**TYPE 1**	**TYPE 2**	**TYPE 3**	**TYPE 1**	**TYPE 2**	**TYPE 3**	**TYPE 1**	**TYPE 2**	**TYPE 3**
63	38	0	0	0	1	0	0	1	0	0
64	38	0	0	0	2	3	0	2	3	0
65	38	2	4	2	3	3	4	3	1	3
66	38	4	4	4	1	2	6	1	4	5
67	37	2	0	0	0	0	0	0	0	1
68	37	0	0	4	0	0	1	0	0	1
69	37	0	0	4	0	0	3	0	0	4
70	36	0	0	0	0	0	0	0	0	0
71	36	0	0	0	0	0	2	0	0	0
72	36	0	0	2	0	2	0	0	1	2
73	35	0	0	0	0	0	0	0	0	0
74	35	0	2	0	2	4	0	0	1	0
75	35	0	4	0	2	2	0	6	4	0
76	35	8	2	0	4	0	0	2	2	0

Notes:

1. The particles are introduced representing a 1,200-foot wide plume near its current interpreted southerly extent (in the model, row 50).

2. Type 3 particles originate within one standard deviation (200 feet) of the plume axis; Type 2 particles between 1 and 2 standard deviations; and Type 1 particles between 2 and 3 standard deviations. These types are weighted differently in estimating mass discharged to the stream.

TABLE 4–5
DISCHARGE CONCENTRATION ESTIMATE
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Assumed/Modelled Conditions:	
Plume Width (ft):	1200
Groundwater vel. (ft/yr):	912
Effective porosity:	0.3
Plume thickness(ft):	12
River flow upstream(cfs):	4.108

River location		Particles added			Mass added		Flow(cfs)		PCE	TCE	DCE	VC
Row	Col	Type 1	Type 2	Type 3	Fract	Sum	Inc	Sum	ppb	ppb	ppb	ppb
63	38	1	0	0	0.003125	0.003125	0.061	4.169	0.11799419	0.00936461	0.03933139	0.01311046
64	38	2	3	0	0.060625	0.06375	0.124	4.293	2.33755492	0.18552023	0.77918497	0.25972832
65	38	3	3	4	0.22875	0.2925	0.145	4.438	10.3748325	0.82339940	3.45827751	1.15275917
66	38	1	2	6	0.286875	0.579375	0.139	4.577	19.9260567	1.58143307	6.64201890	2.21400630
67	37	0	0	0	0	0.579375	0.132	4.709	19.3675008	1.53710324	6.45583362	2.15194454
68	37	0	0	1	0.04125	0.620625	0.125	4.834	20.2099455	1.60396393	6.73664851	2.24554950
69	37	0	0	3	0.12375	0.744375	0.126	4.96	23.6239560	1.87491714	7.87465201	2.62488400
70	36	0	0	0	0	0.744375	0.125	5.085	23.0432294	1.82882773	7.68107649	2.56035883
71	36	0	0	2	0.0825	0.826875	0.121	5.206	25.0021997	1.98430156	8.33406659	2.77802219
72	36	0	2	0	0.03625	0.863125	0.125	5.331	25.4863437	2.02272569	8.49544792	2.83181597
73	35	0	0	0	0	0.863125	0.125	5.456	24.9024374	1.97638392	8.30081247	2.76693749
74	35	2	4	0	0.07875	0.941875	0.125	5.581	26.5658533	2.10840105	8.85528444	2.95176148
75	35	2	2	0	0.0425	0.984375	0.132	5.713	27.1230718	2.15262475	9.04102395	3.01367465
76	35	4	0	0	0.0125	0.996875	0.146	5.859	26.7830313	2.12563741	8.92767712	2.97589237

Sediments:						
	Pore water (ppm)				Sed. conc. (ppm)	
Comp.	Max	Ave	Koc	foc	Max	Ave
PCE	6.3	1.26	364	0.01	22.932	4.5864
TCE	0.5	0.1	126	0.01	0.63	0.126
DCE	2.1	0.42	54	0.01	1.134	0.2268
VC	0.7	0.14	57	0.01	0.399	0.0798

TABLE 5-1
ESTIMATED SURFACE WATER AND PORE WATER CONCENTRATIONS IN PENATAQUIT CREEK

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

SURFACE WATER CONCENTRATION ($\mu g/L$) [a]	PCE	TCE	11DCE	12DCE	VC	11DCA
Average	20	2	[b]	7	2	[b]
Maximum	27	2	--	9	3	--
PORE WATER CONCENTRATION ($\mu g/L$) [a]	**PCE**	**TCE**	**11DCE**	**12DCE**	**VC**	**12DCA**
Average	1,260	100	--	420	140	--
Maximum	6,300	500	--	2,100	700	--
PORE WATER CONCENTRATION ($\mu g/L$) [c]	**PCE**	**TCE**	**11DCE**	**12DCE**	**VC**	**12DCA**
Average	1,200 - 1,600	100 - 140	ND	400 - 520	130 - 180	ND
Maximum	6,000 - 8,000	500 - 700	2 - 3	2,000 - 2,600	650 - 900	1 - 2

<u>NOTES:</u>

PCE = Tetrachloroethene
TCE = Trichloroethene
11DCE = 1,1-Dichloroethene
12DCE = 1,2-Dichloroethene
VC = Vinyl chloride
11DCA = 1,1-Dichloroethane
-- = Not evaluated
ND = Not Detected

[a] Predicted surface water and pore water concentrations based on MODFLOW model results for individual stream cells. Modeling accounted for the effects of dilution, but not volatilization.
[b] Surface water concentrations estimated to be <1 $\mu g/L$.
[c] Predicted pore water concentrations based on AT123D model. This data was utilized in the Task 9.1 preliminary screening assessment (ABB-ES, 1994).

APPENDIX A

GEOLOGIC BORING LOGS

Test Boring Log

Project **SERVALL LAUNDRY**
Boring/Well No. P2-94-21D
Project No. **7135-90**

Client **NYSDEC**
Site **G.W.D.S.**
Sheet No. 1 of 1

Logged By **Brian Johnson**
Ground Elevation
Start Date 10/9/94
Finish Date 10/9/94

Drilling Contractor **A.D.I.**
Driller's Name **Brian Lambert**
Rig Type **MOBIL B-57**

Drilling Method **4.25" HSA**
Protection Level **D**
P.I.D. (eV) **10.2**
Casing Size NA
Auger Size **4.25" ID**

Soil Drilled 87 ft
Rock Drilled **NA**
Total Depth 87 ft
Depth to Groundwater/Date
Piez ☐ Well ■ Boring ☐

Depth(Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm) PI Meter Field Scan	Monitoring (ppm) PI Meter Head Space		Lab Tests
						Augered 0'-70', no samples collected						
70	S-1 1.3/2.0	☒	33/20/18/25			70'-70.5': Yellowish Brown to Tan; Fine SAND; little silt; then 70.5-71': White-Tan; Fine Gravelly coarse SAND; little silt; then 71-72': Yellowish Brown; Silty Fine SAND.						
72												
74												
76	S-2 1.9/2.0	☒				75'-75.5': Yellow Brown; Fine to Medium SAND; trace to little silt; then sharp contact 75.5-77; Dark Gray to Black; laminated silt/clay; layered with layers of gray silt; micacteous.						
78												
80	S-3 ~~80~~ 1.7/2.0	☒				80-82': Black; SILT/CLAY; laminated; micacteous						
82												
84												
86	S-4 1.7/2.0	☒				85-87: Black; SILT/CLAY; laminated; micacteous; grading to more silt with depth; Bottom: Gray; Fine silty SAND; micacteous.						
88												
90						Bottom of Exploration at 87 feet b.g.s.						
92												

Test Boring Log

Project **SERVALL LAUNDRY**
Boring/Well No. MW-94-235
Project No. 7135-90

Client **NYSDEC**
Site **G.W.D.S.**
Sheet No. 1 of 4

Logged By **Brian Johnson**
Ground Elevation 24.60 msl
Start Date 9/22/94
Finish Date 9/23/94

Drilling Contractor **A.D.I.**
Driller's Name **Brian Lambert**
Rig Type **MOBIL B-57**

Drilling Method **4.25" HSA**
Protection Level **D**
P.I.D. (eV) **10.2**
Casing Size NA
Auger Size **4.25" ID**

Soil Drilled 80'
Rock Drilled **NA**
Total Depth 80'
Depth to Groundwater/Date 10/26/94 ▽@ 17.79 Ft MSL
Piez ☐ Well ■ Boring ☐

Depth(Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm) PI Meter Field Scan	PI Meter Head Space		Lab Tests
						Augered 0'-5'						
2												
4												
6	S-1 1.0/2.0	☒	5/3/5/3	8		5'-7': Light Brown; Medium-Fine SAND; trace-little coarse sand; trace silt and fine gravel; dry.			14			
8												
10	S-2 1.5/2.0	☒	2/4/5/4	9		10'-12': Light Brown; Medium-Coarse SAND; little-some fine sand; trace fine gravel and silt; saturated at bottom; Layared Coarse/fine.			0			
12												
14												
16	S-3 0/2	☒	1/2/2/3	4		Blowin; simmilar to above.		①	0			
18												
20	S-4 1.3/2.0	☒	3/4/6/6	10		20'-22': Light Brown; Fine-medium SAND; with layored coarse sand; little medium sand; trace fine sand and silt; Saturated.			0			
22												
24												

① Mixed bentonite slurry for inside augers after 3 feet of blowin Prior to collecting S-3 @ 15 feet.

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Test Boring Log

Project SERVALL LAUNDRY
Boring/Well No. MW-94-235
Project No. 7135-90

Client NYSDEC
Site G.W.D.S.
Sheet No. 2 of 4

Logged By Brian Johnson
Ground Elevation 24.60
Start Date 9/22/94
Finish Date 9/23/94

Drilling Contractor A.D.I.
Driller's Name Brian Lambert
Rig Type MOBIL B-57

Drilling Method 4.25" HSA
Protection Level D
P.I.D. (eV) 10.2
Casing Size NA
Auger Size 4.25" ID

Soil Drilled 80'
Rock Drilled NA
Total Depth 80'
Depth to Groundwater/Date
Piez ☐ Well ■ Boring ☐

Depth(Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm) PI Meter Field Scan	Monitoring (ppm) PI Meter Head Space	Monitoring (ppm)	Lab Tests
26 28	S-5 1.2/2.0	☒	3/5/6/7	11		25'-27': Light Brown; Fine and coarse SAND; little medium sand; trace silt and fine gravel; saturated.			0			
30 32 34	S-6 0.9/2.0	☒	7/11/11/12	22		30'-32': Light Brown; Medium-Fine SAND; some coarse sand; trace silt; some banding of darker fine sand; sat.			NR			
36 38	S-7 0.9/2.0	☒	5/7/10/11	17		35'-37': Light Brown; Fine-medium SAND; trace silt, coarse sand and fine gravel; saturated.			0			
40 42 44	S-8 1.2/2.0	☒	3/6/8/9	14		40'-42': Light Brown; Medium-coarse SAND; some-little fine sand; trace silt; sat.			0			
46 48 50	S-9 1.5/2.0	☒	7/11/14/18	25		45'-47': Light Brown; Medium-Fine SAND; little coarse sand; trace silt and fine gravel; saturated.			0			

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Test Boring Log

Project SERVALL LAUNDRY		Boring/Well No. MW-94-235	Project No. 7135-90
Client NYSDEC	Site G.W.D.S.	Sheet No. 3 of 4	
Logged By Brian Johnson	Ground Elevation 24.60	Start Date 9/22/94	Finish Date 9/23/94
Drilling Contractor A.D.I.	Driller's Name Brian Lambert	Rig Type MOBIL B-57	
Drilling Method 4.25" HSA	Protection Level D	P.I.D. (eV) 10.2	Casing Size NA	Auger Size 4.25" ID
Soil Drilled 80'	Rock Drilled NA	Total Depth 80'	Depth to Groundwater/Date Piez ☐ Well ■ Boring ☐

Depth(Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm) PI Meter Field Scan	PI Meter Head Space		Lab Tests
	S-10 1.7/2.0	☒	9/18/18/21	36		50'-52': Light Brown; Fine SAND; little medium sand; trace silt; sat; dense.			0			
52												
54												
56	S-11 0.9/2.0	☒	see Note ②	—		B.J. 55'-57': Light Brown & Rust; Fine SAND; little medium sand; trace silt, sat.		②	0			
58												
60	S-12 1.2/2.0	☒	9/16/23/26	39		60'-62': Brown & Rust; Banding; Fine SAND; trace-little medium sand; trace silt; Sat.			0			
62												
64												
66	S-13 1.3/2.0	☒	6/8/13/18	21		65'-67': Light Brown; more frequent about 1" banding of Rust staining; Fine SAND; trace medium sand, and silt; sat.			0			
68												
70	S-14 1.3/2.0	☒	12/14/19/26	33		70'-71': Light Brown; Medium-Course SAND; little fine sand, and fine gravel; trace silt; Sat.			25			
72	S-15 0/2.0	☒	12/15/32/29	47		71'-72': Gray and Rust; SILT; stiff, mottled; Blockey; dry-damp; PID=18ppm at interface.		③ ④				
74												
76												

② 1.2' Blowin in augeres, actual sample 55'-56'. Blow counts invalid. Overdriven to 57'

③ No recovery in S-15 from 72'-74'

④ Auger Refusal at 72', so a split spoon was attempted 72'-74'.

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Test Boring Log

Project SERVALL LAUNDRY
Boring/Well No. MW-94-235
Project No. 7135-90

Client NYSDEC
Site G.W.D.S.
Sheet No. 4 of 4

Logged By Brian Johnson
Ground Elevation 24.60
Start Date 9/22/94
Finish Date 9/23/94

Drilling Contractor A.D.I.
Driller's Name Brian Lambert
Rig Type MOBIL B-57

Drilling Method 4.25" HSA
Protection Level D
P.I.D. (eV) 10.2
Casing Size NA
Auger Size 4.25" ID

Soil Drilled 80'
Rock Drilled NA
Total Depth 80
Depth to Groundwater/Date
Piez ☐ Well ■ Boring ☐

Depth(Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm) PI Meter Field Scan	Monitoring (ppm) PI Meter Head Space		Lab Tests
	5-16	☒	16/19/27/28	46		75'-77': Gray with Black Streaks; Silty Fine SAND			Rain			
76												
78						Augered to 80 feet and Set monitoring well screen 69.5'-66.5' Bentonite slurry 59.5'-3.5'						
80						Bottom of Exploration at 80 Feet						

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Test Boring Log

Project SERVALL LAUNDRY		Boring/Well No. P2-94-23D		Project No. 7135-90
Client NYSDEC	Site G.W.D.S.		Sheet No. 1 of 2	
Logged By Brian Johnson	Ground Elevation	Start Date 10/10/94		Finish Date 10/10/94
Drilling Contractor A.D.I.	Driller's Name Brian Lambert		Rig Type MOBIL B-57	
Drilling Method 4.25" HSA	Protection Level D	P.I.D. (eV) 10.2	Casing Size	Auger Size 4.25" ID
Soil Drilled 112 ft	Rock Drilled NA	Total Depth 112 ft	Depth to Groundwater/Date	Piez ☐ Well ■ Boring ☐

Depth(Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm) PI Meter Field Scan	PI Meter Head Space		Lab Tests
						Augered to 80 feet See Boring Log for mw-94-23S for geology 0'-80'. clay: 71'-75'						
80	S-1 0.8/2.0	☒	20/18/25/27	43		80-82: Light Gray; Fine Silty SAND; Saturated.			0			
82												
84												
	S-2 1.4/2.0	☒	9/18/29/43	47		85'-87': Light Gray; Fine to Medium SAND; little to some silt; saturated.			0			
86												
88												
90	S-3 1.4/2.0	☒	16/24/32/40	56		90'-92': Light Gray: Fine to Medium SAND; some silt; saturated.			0			
92												
94												
96	S-4 0.8/2.0	☒	17/19/30/38	49		95'-97': Same as above.			0			
98												
100	S-5 0.7/2.0	☒	7/8/10/11	18		100'-101': Same as above. 101'-102': Yellow Brown and Dark Gray and Light Gray; Silt/clay; in thin laminations; micaceous; layered with silt/fine sand.			0			
102												

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Test Boring Log

Project SERVALL LAUNDRY
Boring/Well No. PZ-94-23D
Project No. 7135-90

Client NYSDEC
Site G.W.D.S.
Sheet No. 2 of 2

Logged By Brian Johnson
Ground Elevation
Start Date 10/10/94
Finish Date 10/10/94

Drilling Contractor A.D.I.
Driller's Name Brian Lambert
Rig Type MOBIL B-57

Drilling Method 4.25" HSA
Protection Level D
P.I.D. (eV) 10.2
Casing Size
Auger Size 4.25" ID

Soil Drilled 112 ft
Rock Drilled NA
Total Depth 112 ft
Depth to Groundwater/Date
Piez ☐ Well ☑ Boring ☐

Depth(Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm) PI Meter Field Scan	Monitoring (ppm) PI Meter Head Space	Monitoring (ppm)	Lab Tests
104												
106	S-6 1.9/2.0	☒	14/18/23/ 42	41		105'-107': Light Gray; Fine to medium SAND; little-some Silt; siltier with depth; laminated silt/clay layered with Yellow Brown Fine silty sand in bottom.			0			
108												
110	S-7 2.0/2.0	☒	12/15/10/ 27	25		110-112': Yellowish Brown; Fine to medium SAND.			0			
112						Bottom of Exploration at 112. feet b.g.s. Installed well 10/11/94, See ~~append~~ as well installation diagram.						

Test Boring Log

Project SERVALL LAUNDRY
Boring/Well No. P2-94-27D
Project No. 7135-90

Client NYSDEC
Site G.W.D.S.
Sheet No. 1 **of** 5

Logged By Doug Beal
Ground Elevation
Start Date 10/4/94
Finish Date 10/5/94

Drilling Contractor A.D.I.
Driller's Name Brian Lambert
Rig Type MOBIL B-57

Drilling Method 4.25" HSA
Protection Level D
P.I.D. (eV) 10.2
Casing Size NA
Auger Size 4.25" ID

Soil Drilled 107 Ft
Rock Drilled NA
Total Depth 107 Ft
Depth to Groundwater/Date
Piez ■ Well ☐ Boring ☐

Depth (Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm) PI Meter Field Scan	Monitoring (ppm) PI Meter Head Space		Lab Tests
2 4						Augered 0'-5'						
6 8	S-1 1.7/2.0	☒	2/2/2/4	4		5'-7': Brown; Fine SAND; little-some silt; trace medium sand and coarse sand and fine gravel; some organics; saturated			0			
10 12	S-2 1.3/2.0	☒	9/21/24/21	45		10'-12': Light Brown to Tan; Fine-Medium SAND little coarse sand; trace fine gravel and silt; sat.			0			
14 16 18	S-3 0.3/2.0	☒	5/8/7/9	15		15'-17': Brown; Coarse SAND; some fine gravel; trace medium sand; sat.		①	0			
20 22 24	S-4 1.1/2.0	☒	5/5/9/8	14		20'-22': Light Brown; Fine to Medium SAND; trace to little silt; trace coarse sand; sat.			0			

① mixed bentonite slurry for inside augers to keep out heaving sand.

Test Boring Log

Project SERVALL LAUNDRY
Boring/Well No. P2-94-27D
Project No. 7135-90

Client NYSDEC
Site G.W.D.S.
Sheet No. 2 of 5

Logged By Doug Beal
Ground Elevation
Start Date 10/4/94
Finish Date 10/5/94

Drilling Contractor A.D.I.
Driller's Name Brian Lambert
Rig Type MOBIL B-57

Drilling Method 4.25" HSA
Protection Level D
P.I.D. (eV) 10.2
Casing Size N/A
Auger Size 4.25" ID

Soil Drilled 101 Ft
Rock Drilled 1 NA
Total Depth 107 Ft
Depth to Groundwater/Date
Piez ■ Well ☐ Boring ☐

Depth(Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm) PI Meter Field Scan	Monitoring (ppm) PI Meter Head Space		Lab Tests
26	S-5 0.8/2.0	☒	5/5/9/8	14		25'-27': Light Brown; Fine to medium SAND; trace to little silt; trace coarse sand; sat			0			
28												
30	S-6 1.1/2.0	☒	5/8/9/11	17		30'-32': Light Brown; Fine to medium SAND; little silt; sat.			0			
32												
34												
36	S-7 1.1/2.0	☒	5/10/12/ 10	22		35'-37': Light Brown: Fine to medium SAND; little Silt; Sat.			0			
38												
40	S-8 1.1/2.0	☒	4/7/6/9	13		40'-42': Light Brown; Fine to Medium SAND; little Silt; sat.			0			
42												
44												
46	S-9 1.2/2.0	☒	7/9/15/ 20	24		45'-47': Light Brown; Fine to Medium SAND; little silt; Sat.			0			
48												

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Test Boring Log

Project SERVALL LAUNDRY
Boring/Well No. PZ-94-27D
Project No. 7135-90
Client NYSDEC
Site G.W.D.S.
Sheet No. 3 of 5
Logged By Doug Beal
Ground Elevation
Start Date 10/4/94
Finish Date 10/5/94
Drilling Contractor A.D.I.
Driller's Name Brian Lambert
Rig Type MOBIL B-57
Drilling Method 4.25" HSA
Protection Level D
P.I.D. (eV) 10.2
Casing Size NA
Auger Size 4.25" ID
Soil Drilled 107 ft
Rock Drilled NA
Total Depth 107 ft
Depth to Groundwater/Date
Piez ■ Well ☐ Boring ☐

Depth(Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm)			Lab Tests
									PI Meter Field Scan	PI Meter Head Space		
50	S-10 1.0/2.0	☒	11/18/18/21	36		50'-52': Light Brown; Fine SAND; little-some silt; sat.			0			
52												
54												
56	S-11 2.0/2.0	☒	13/14/19/77	33		55'-57': Light Brown; Fine SAND; little-some silt; sat.			0			
58												
60	S-12 1.4/2.0	☒	—	—		60'-62': Light Brown; Fine SAND; little silt; sat		②	0			
62												
64												
66	S-13 1.6/2.0	☒	20/12/17/32	29		65-67: Tan to Light Brown; Fine-Medium SAND; little-some silt; trace coarse sand; sat.			0			
68					CLAY							
70	S-14 1.5/2.0	☒	7/11/11/21	22		70'-72': Dark Green-Gray SILT/CLAY; slightly plastic.			0			
72												
74												

② Dropped rods and spoon in hole accidently, spoon went in 18" 25 blows last 6".

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Test Boring Log

Project SERVALL LAUNDRY	Boring/Well No. P2-94-27D	Project No. 7135-90
Client NYSDEC	Site G.W.D.S.	Sheet No. 4 of 5
Logged By Doug Beal	Ground Elevation	Start Date 10/4/94
Finish Date 10/5/94		
Drilling Contractor A.D.I.	Driller's Name Brian Lambert	Rig Type MOBIL B-57
Drilling Method 4.25" HSA	Protection Level D	P.I.D. (eV) 10.2
Casing Size NA	Auger Size 4.25" ID	
Soil Drilled 107 Ft	Rock Drilled NA	Total Depth 107 Ft
Depth to Groundwater/Date	Piez ■ Well ☐ Boring ☐	

Depth (Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm) PI Meter Field Scan	PI Meter Head Space		Lab Tests
76	S-15 1.4/2.0	☒	25/38/ 98/100 0.25	>100	CLAY	75'-77': Dark Green-Gray; SILT/CLAY; slightly plastic.						
78												
80	S-16 0.3/2.0	☒	18/100 0.3	REF		80'-82': White-Gray; Medium-Coarse Sand; some fine gravel.						
82												
84												
86	S-17 ~~0.9~~ 2.0/2.0 0.5	☒	13/19/24/ 38	43		85'-85.4': same as above 85.4'-87': Medium-Dark Gray; Clayey SILT; micaceous		③				
88												
90	S-18 1.8/2.0	☒	12/17/30/ 18	47		90'-91.5': same as above. 91.5'-92': Medium-Dark Gray; Fine sand; some silt.						
92												
94												
96	S-19 2.0/2.0	☒	7/12/20/ 28	32		95-96.5: same as above. 96.5-97: Black to Dark; SILT/CLAY; micaceous.						
98												

③ Water flowing out of top of augers.

Test Boring Log

Project SERVALL LAUNDRY
Boring/Well No. P2-94-27D
Project No. 7135-90

Client NYSDEC
Site G.W.D.S.
Sheet No. 5 **of** 5

Logged By Doug Beal
Ground Elevation
Start Date 10/4/94
Finish Date 10/5/94

Drilling Contractor A.D.I.
Driller's Name Brian Lambert
Rig Type MOBIL B-57

Drilling Method 4.25" HSA
Protection Level D
P.I.D. (eV) 10.2
Casing Size NA
Auger Size 4.25" ID

Soil Drilled 107 Ft
Rock Drilled NA
Total Depth 107 Ft
Depth to Groundwater/Date
Piez ■ Well ☐ Boring ☐

Depth(Feet)	Sample No. & Penetration/ Recovery (Feet)	Sample Type	SPT Blows/6" or Core Rec./Rqd. %	SPT-N (Blows/Ft.)	Graphic Log	Sample Description	USCS Group Symbol	Notes on Drilling	Monitoring (ppm)			Lab Tests
									PI Meter Field Scan	PI Meter Head Space		
100	S-20 2.0/2.0	☒	21/33/37/ 38	70		100'-102': Medium Gray-Black; SILT/CLAY; thin layers of clay and silt 2" beds.						
102												
104												
106	S-21 2.0/2.0	☒	12/18/18/ 23	36		105'-107': Black to Medium Gray; Fine-medium SAND; little silt.	sm-sp					
107												
						Bottom of Exploration at 107 feet.						

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APPENDIX B

PIEZOMETER AND WELL INSTALLATION DIAGRAMS

PIEZOMETER

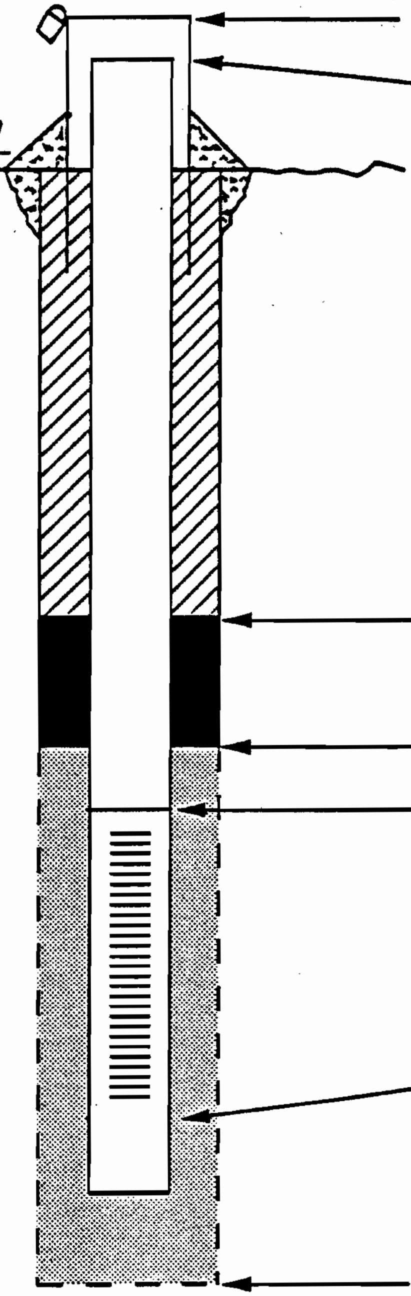
OVERBURDEN CONSTRUCTION DIAGRAM

Project **SERVALL LAUNDRY** Study Area **G.W.D.S.** Driller **A.D.I.**

Project No. **7135-90** Boring No. PZ-94-1 Drilling Method **4.25 in HSA**

Date Installed 9/24/94 Development Method

Field Geologist **Brian Johnson**



Ground Elevation 6.54

Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 6.36

Type of Surface Seal: Cement

Type of Surface Casing: Flushmount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"

Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None

Depth of Top of Seal:

Type of Seal:

Elevation of Top of Sand: None

Depth of Top of Sand:

Elevation of Top of Screen: -5.46

Depth of Top of Screen: 12

Type of Screen: PVC / Cut

Slot Size x Length: 0.010 / 3'

ID of Screen: 3/4'

Type of Sandpack: Native

Elevation of Bottom of Screen: -8.54

Depth of Bottom of Screen: 15

Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -8.54

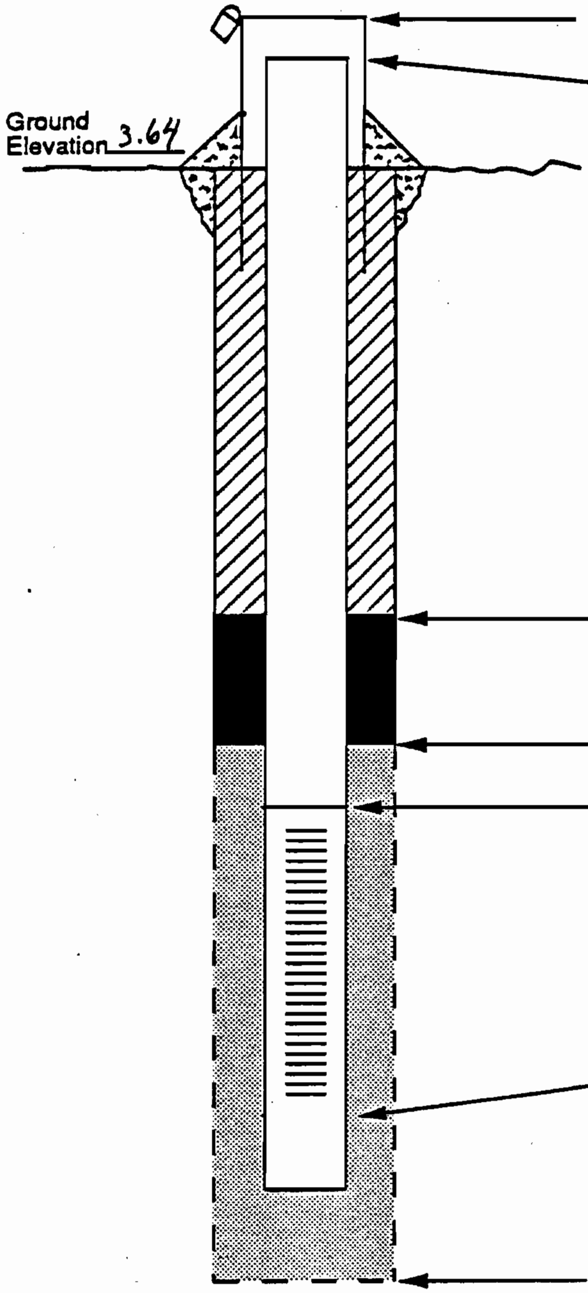
Depth of Bottom of Borehole: 15

ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-2
Drilling Method 4.25 in HSA
Date Installed 9/20/94
Development Method
Field Geologist Brian Johnson



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 3.36
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: -8.36
Depth of Top of Screen: 12

Type of Screen: PVC/cut
Slot Size x Length: 0.010"/3'
ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: -11.36
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole:
Depth of Bottom of Borehole: 15

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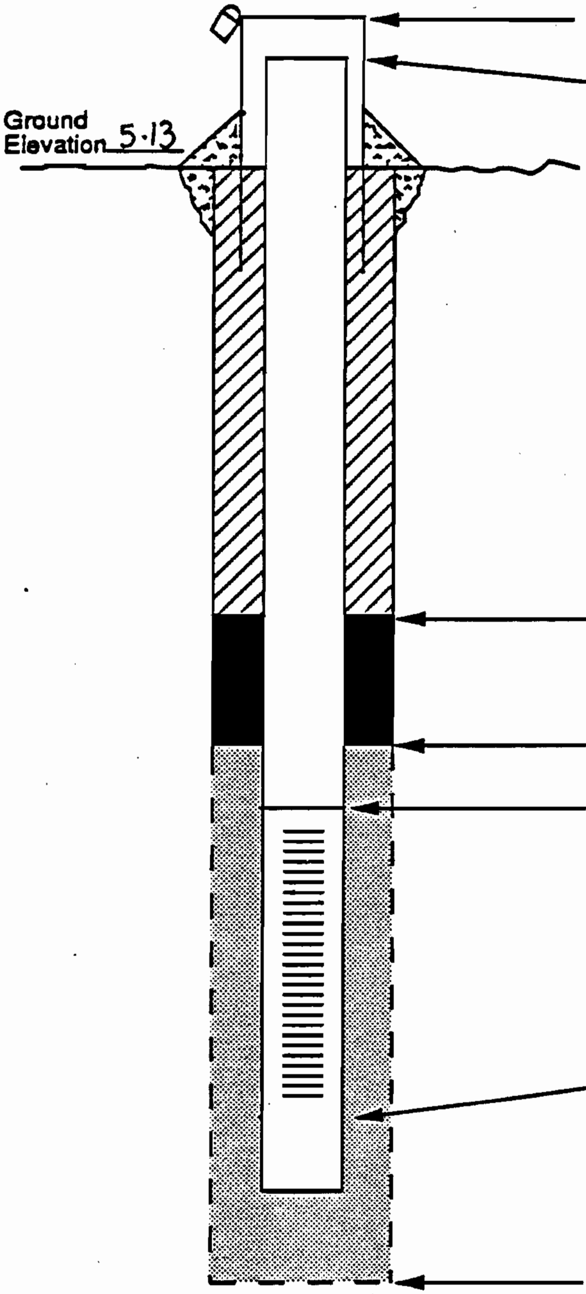
9404014D(z) L 16

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-2D
Drilling Method 4.25 in HSA
Date Installed 9/23/94
Development Method
Field Geologist Brian Johnson



Ground Elevation 5.13

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 4.67
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8'

Diameter of Borehole: 8¼"

Riser Pipe ID: 2"
Type of Riser Pipe: PVC

Type of Backfill: Bentonite Slurry

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: ~~-53.37~~
Depth of Top of Screen: ~~58.5~~ 67 BJ

Type of Screen: PVC /Cut
Slot Size x Length: 0.010 /12'
ID of Screen: 2"

Type of Sandpack: Native

Elevation of Bottom of Screen: -64.87 BJ ~~-63.37~~
Depth of Bottom of Screen: ~~68.5~~ 70 BJ
Depth of Sediment Sump with Plug: ~~68.5~~ 70

Elevation of Bottom of Borehole: 9 BJ -6~~3~~.87
Depth of Bottom of Borehole: ~~69~~ 75 BJ

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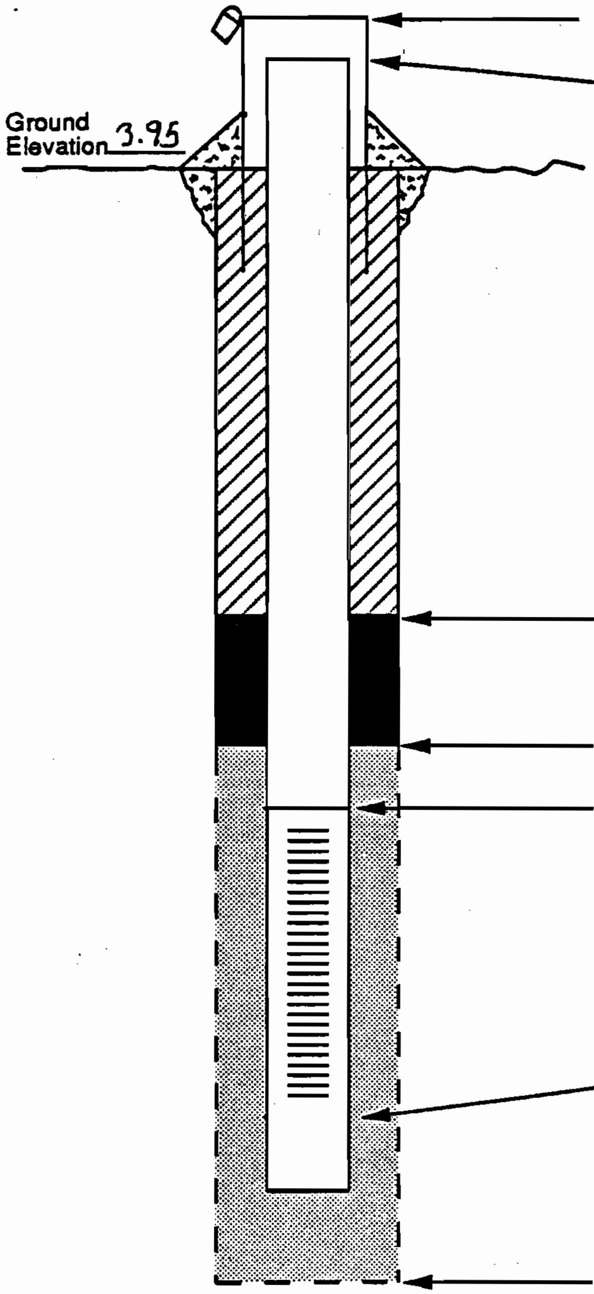
9404014D(z) L 16

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project **SERVALL LAUNDRY**
Study Area **G.W.D.S.**
Driller **A.D.I.**
Project No. **7135-90**
Boring No. PZ-94-3
Drilling Method **4.25 in HSA**
Date Installed 10/7/94
Development Method
Field Geologist **DOUG BEAL**



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 3.79
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: -8.05
Depth of Top of Screen: 12

Type of Screen: PVC/Cut
Slot Size x Length: 0.010"/3'
ID of Screen: 3/4"

Type of Sandpack: Native

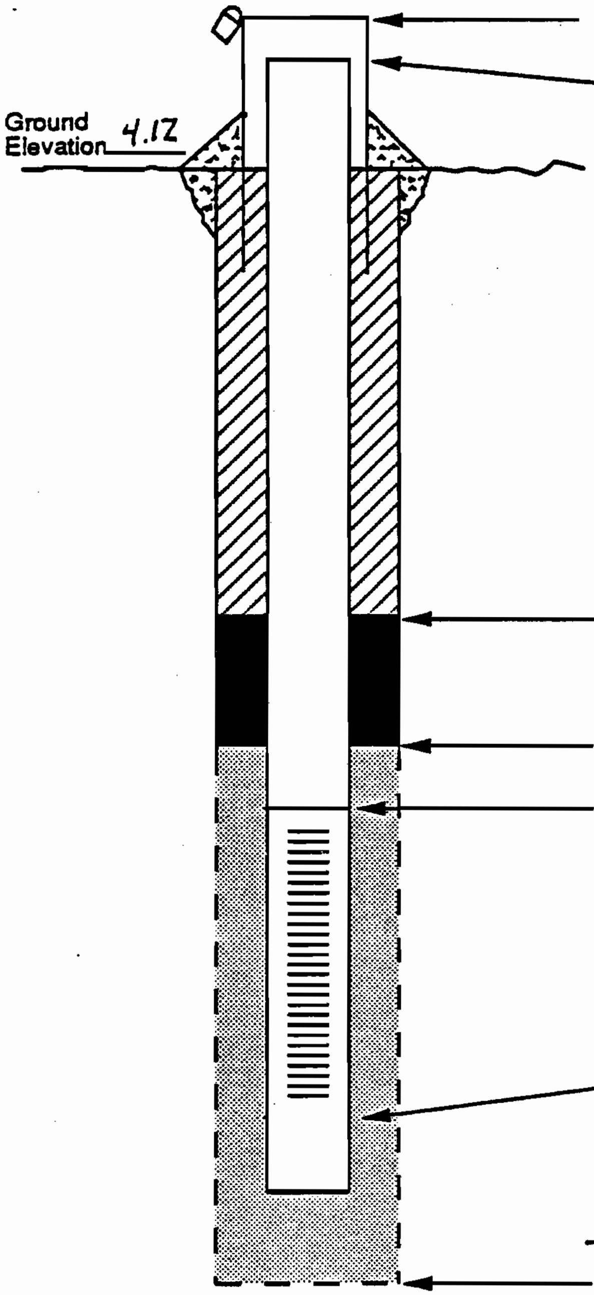
Elevation of Bottom of Screen: -11.05
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -11.05
Depth of Bottom of Borehole: 15

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.
Project No. 7135-90 Boring No. PZ-94-3D Drilling Method 4.25 in HSA
Date Installed 10/7/94 Development Method
Field Geologist DOUG BEAL



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 3.67
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 2"
Type of Riser Pipe: PVC

Type of Backfill: Bentonite Slurry

Elevation of Top of Seal:
Depth of Top of Seal:
Type of Seal: Bentonite Slurry

Elevation of Top of Sand: -53.88
Depth of Top of Sand: 58
Elevation of Top of Screen: -56.88
Depth of Top of Screen: 61

Type of Screen: PVC/cut
Slot Size x Length: 0.010" /13'
ID of Screen: 2"

Type of Sandpack: Native

Elevation of Bottom of Screen: -59.88
Depth of Bottom of Screen: 64
Depth of Sediment Sump with Plug: 64

~~Na~~ 85

Elevation of Bottom of Borehole: -100.88
Depth of Bottom of Borehole: 105

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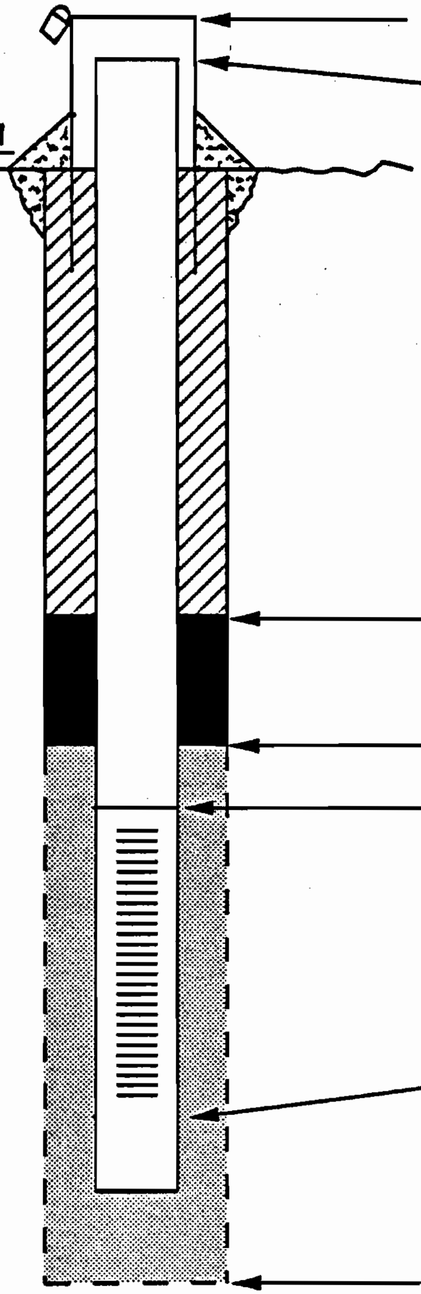
PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-4
Drilling Method 4.25 in HSA
Date Installed 10/4/94
Development Method
Field Geologist DOUG BEAL



Ground Elevation 3.69

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 3.61
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: -8.31
Depth of Top of Screen: 12

Type of Screen: PVC/Cut
Slot Size x Length: 0.010" 13'
ID of Screen: 3/4"

Type of Sandpack: Native

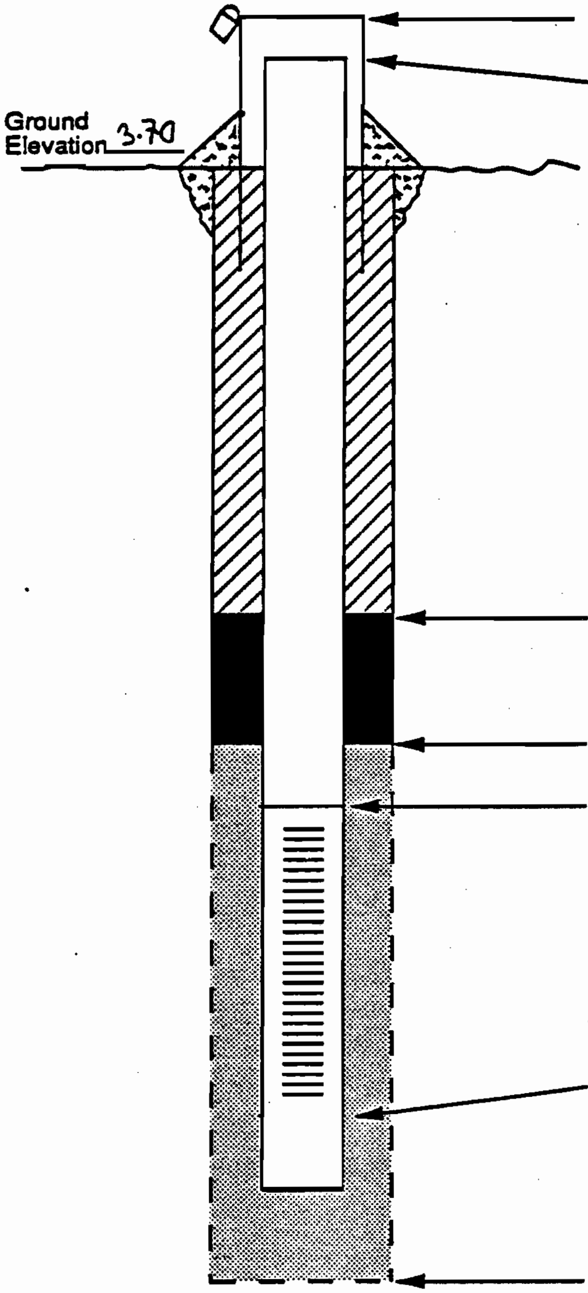
Elevation of Bottom of Screen: -11.31
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -11.31
Depth of Bottom of Borehole: 15

PIEZOMETER

OVERBURDEN **CONSTRUCTION DIAGRAM**

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-4D
Drilling Method 4.25 in HSA
Date Installed 9/28/94
Development Method
Field Geologist Brian Johnson



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 3.40
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: ~~3/4"~~ 2"BS
Type of Riser Pipe: PVC

Type of Backfill: Bentonite slurry upto 6' and chips upto 4'

Elevation of Top of Seal:
Depth of Top of Seal: 6 & 4
Type of Seal: Bentonite slurry & Bentonite chips

Elevation of Top of Sand: -62.3
Depth of Top of Sand: 66
Elevation of Top of Screen: -68.3
Depth of Top of Screen: 72

Type of Screen: PVC/cvt
Slot Size x Length: 0.010"/13'
ID of Screen: ~~3/4"~~ 2"BS

Type of Sandpack: Native

Elevation of Bottom of Screen: -71.3
Depth of Bottom of Screen: 75
Depth of Sediment Sump with Plug: 75

Elevation of Bottom of Borehole: -74.8
Depth of Bottom of Borehole: 78.5

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PIEZOMETER

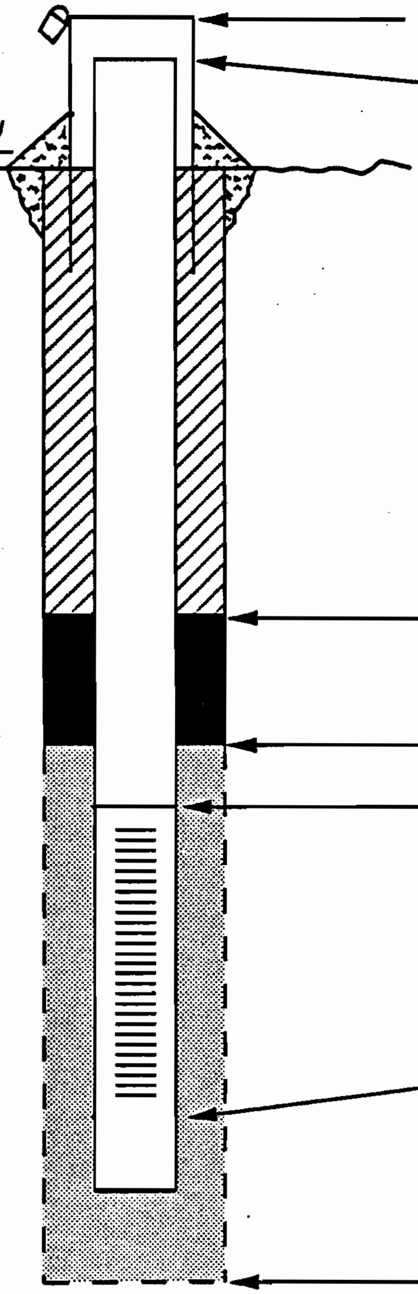
OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.

Project No. 7135-90 Boring No. PZ-94-5 Drilling Method 4.25 in HSA

Date Installed 10/4/94 Development Method ______

Field Geologist DOUG BEAL



Ground Elevation 7.04

Elevation of Top of Surface Casing: ______

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 6.82

Type of Surface Seal: Cement

Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"

Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None

Depth of Top of Seal: ______

Type of Seal: ______

Elevation of Top of Sand: None

Depth of Top of Sand: ______

Elevation of Top of Screen: -4.96

Depth of Top of Screen: 12

Type of Screen: PVC / cut

Slot Size x Length: 0.010" / 3'

ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: -7.96

Depth of Bottom of Screen: 15

Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -7.96

Depth of Bottom of Borehole: 15

PIEZOMETER

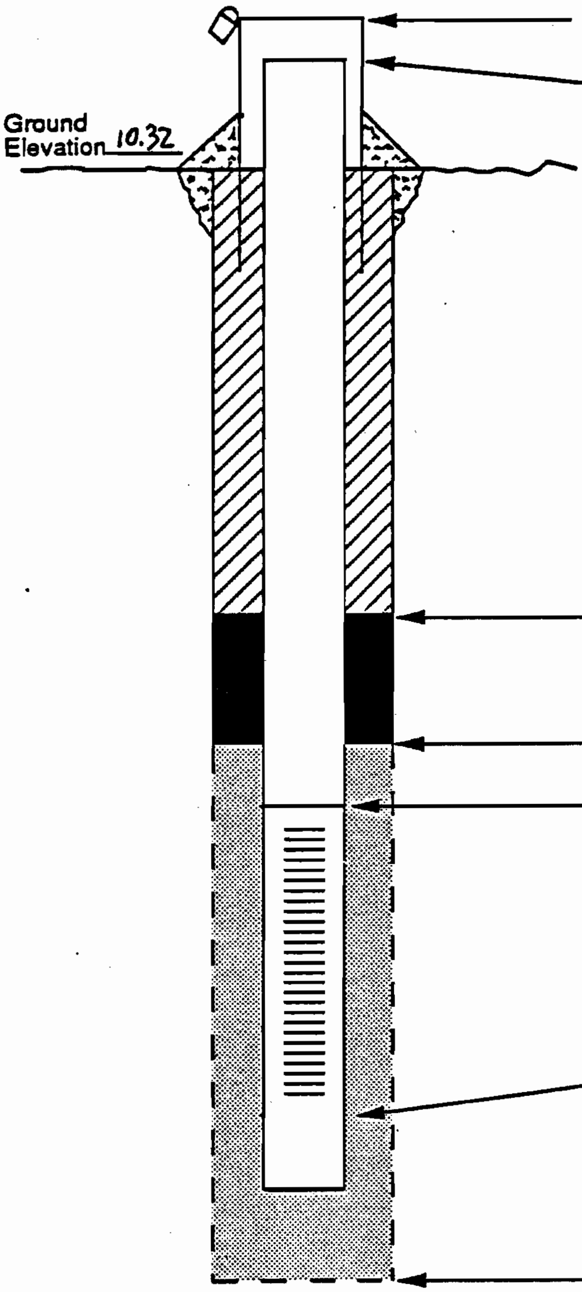
OVERBURDEN CONSTRUCTION DIAGRAM

Project **SERVALL LAUNDRY** Study Area **G.W.D.S.** Driller **A.D.I.**

Project No. **7135-90** Boring No. P2-94-7 Drilling Method **4.25 in HSA**

Date Installed 9/24/94 Development Method

Field Geologist **Brian Johnson**



Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 10.14

Type of Surface Seal: Cement

Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"

Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None

Depth of Top of Seal:

Type of Seal:

Elevation of Top of Sand: None

Depth of Top of Sand:

Elevation of Top of Screen: -1.68

Depth of Top of Screen: 12

Type of Screen: PVC/cut

Slot Size x Length: 0.010'/3'

ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: -4.68

Depth of Bottom of Screen: 15

Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -4.68

Depth of Bottom of Borehole: 15

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

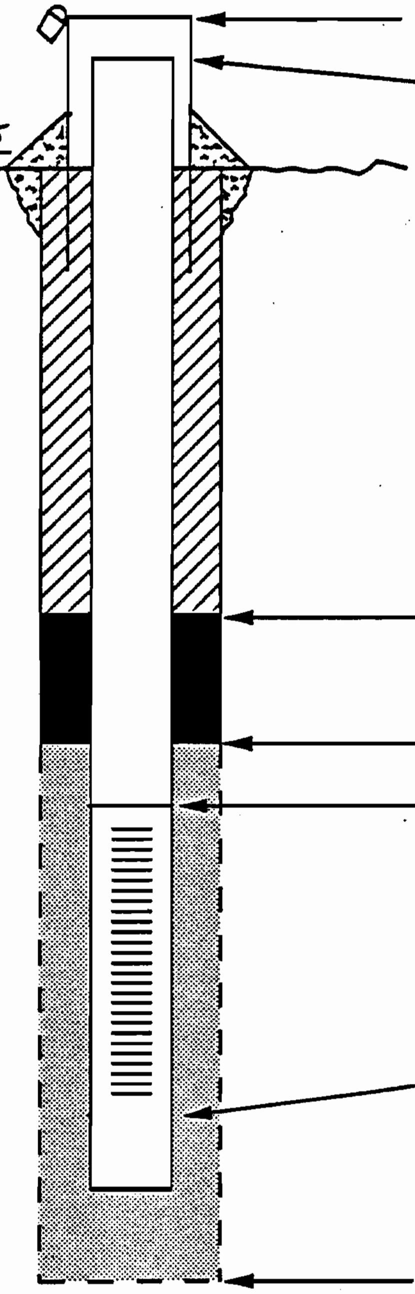
Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.

Project No. 7135-90 Boring No. PZ-94-6 Drilling Method 4.25 in HSA

Date Installed 9/21/94 Development Method

Field Geologist Brian Johnson

Ground Elevation 4.75



Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 4.51

Type of Surface Seal: Cement

Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"

Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None

Depth of Top of Seal:

Type of Seal:

Elevation of Top of Sand: None

Depth of Top of Sand:

Elevation of Top of Screen: -7.25

Depth of Top of Screen: 12

Type of Screen: PVC/Cut

Slot Size x Length: 0.010" / 3'

ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: -10.25

Depth of Bottom of Screen: 15

Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -10.25

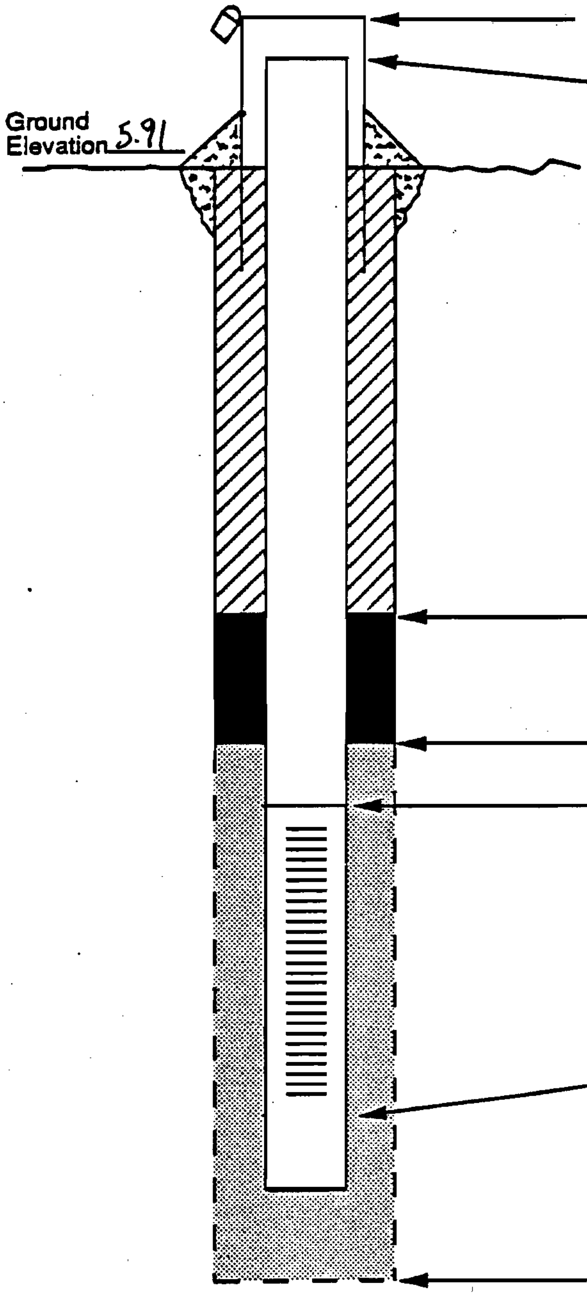
Depth of Bottom of Borehole: 15

ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN **CONSTRUCTION DIAGRAM**

Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.
Project No. 7135-90 Boring No. PZ-94-8 Drilling Method 4.25 in HSA
Date Installed 9/24/94 Development Method
Field Geologist Brian Johnson



Ground Elevation 5.91

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 5.68
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: -6.09
Depth of Top of Screen: 12

Type of Screen: PVC/cut
Slot Size x Length: 0.010"/3'
ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: -9.09
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -9.09
Depth of Bottom of Borehole: 15

PIEZOMETER

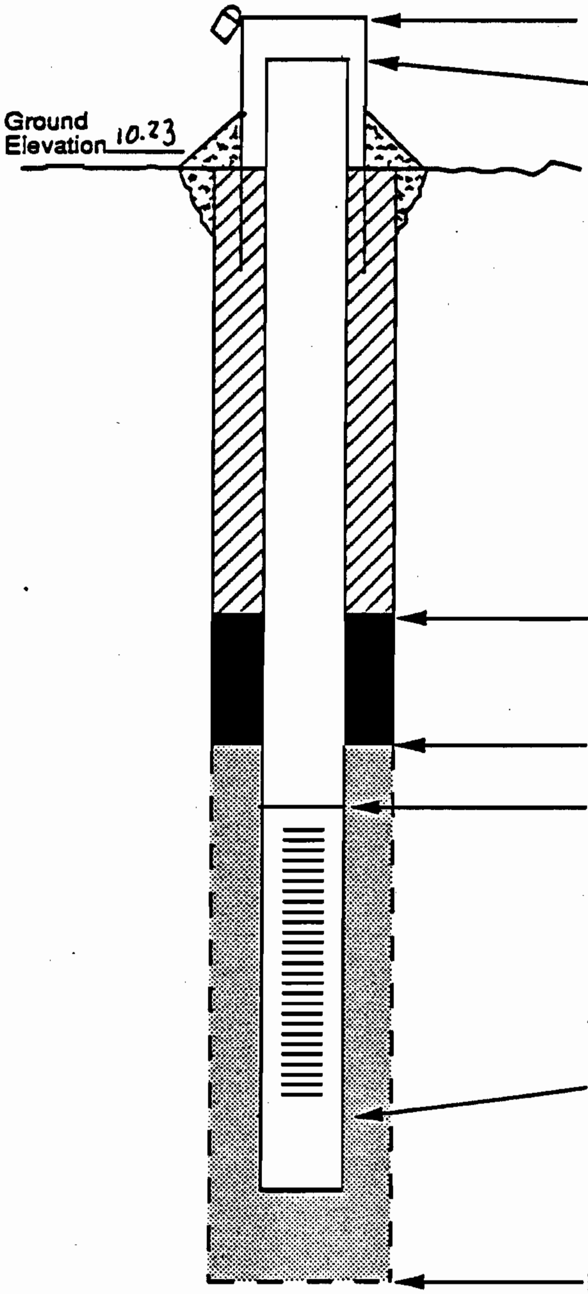
OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.

Project No. 7135-90 Boring No. PZ-94-7D Drilling Method 4.25 in HSA

Date Installed 9/28/94 Development Method

Field Geologist Brian Johnson



Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 9.95

Type of Surface Seal: Cement

Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: ~~3/4"~~ 2"BS

Type of Riser Pipe: PVC

Type of Backfill: Bentonite slurry upto 6' and chips upto 4'

Elevation of Top of Seal:

Depth of Top of Seal: 6' & 4'

Type of Seal: Bentonite Slurry & Bentonite chips

Elevation of Top of Sand: -43.77

Depth of Top of Sand: 54

Elevation of Top of Screen: -51.77

Depth of Top of Screen: 62

Type of Screen: PVC / cut

Slot Size x Length: 0.010"/3'

ID of Screen: ~~3/4"~~ 2"BS

Type of Sandpack: Native

Elevation of Bottom of Screen: -54.77

Depth of Bottom of Screen: 65

Depth of Sediment Sump with Plug: 65

Elevation of Bottom of Borehole: -59.77

Depth of Bottom of Borehole: 70

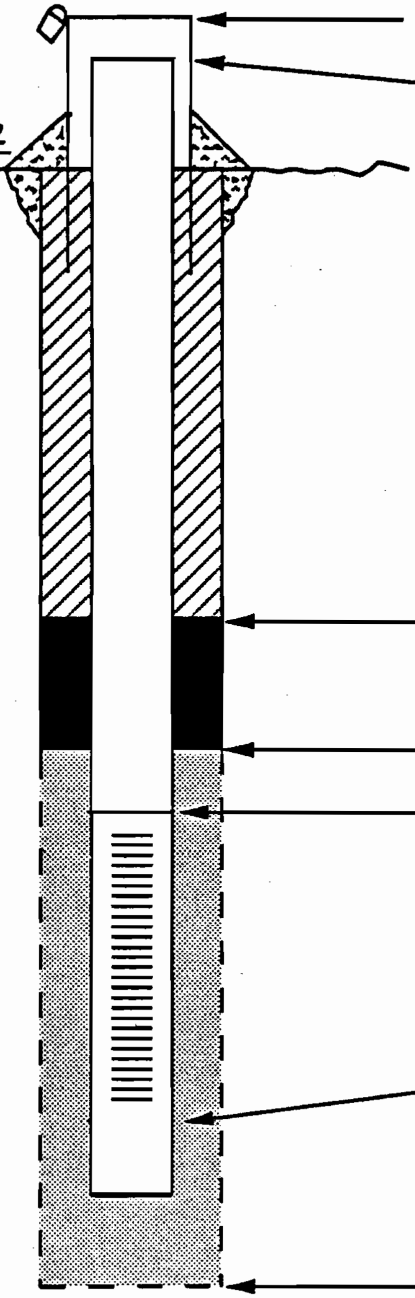
ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN **CONSTRUCTION DIAGRAM**

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-9
Drilling Method 4.25 in HSA
Date Installed 10/7/94
Development Method
Field Geologist DOUG BEAL

Ground Elevation 4.82



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 4.65
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: -7.18
Depth of Top of Screen: 12

Type of Screen: PVC/Cut
Slot Size x Length: 0.010" /13'
ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: -10.18
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -10.18
Depth of Bottom of Borehole: 15

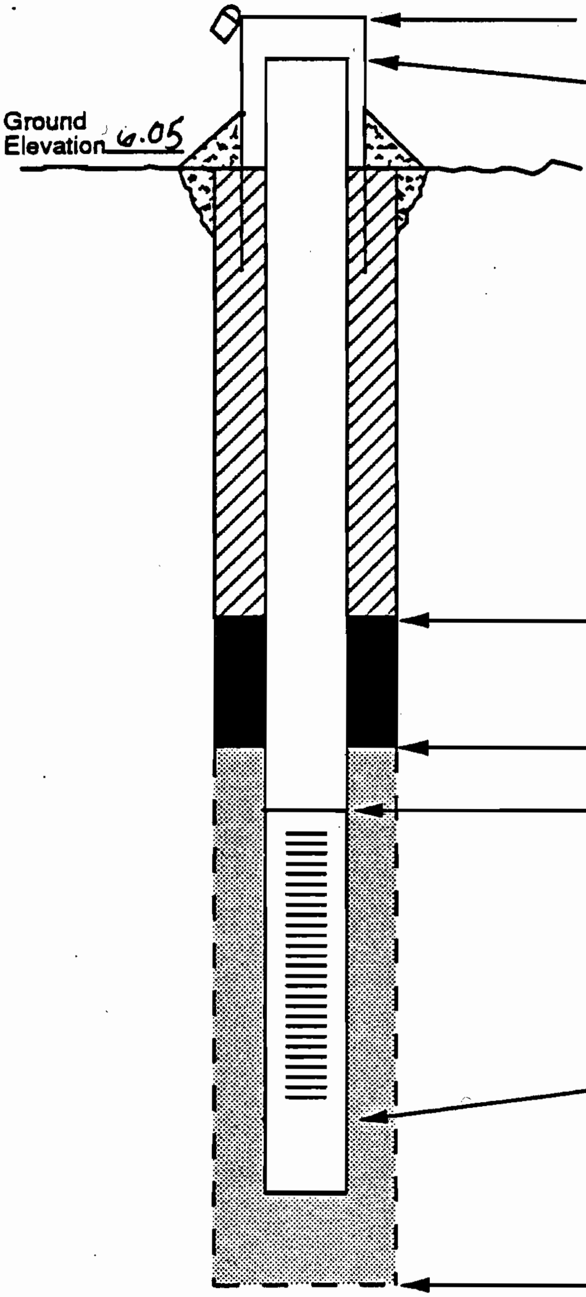
ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-8D
Drilling Method 4.25 in HSA
Date Installed 10/6/94
Development Method
Field Geologist DOUG BEAL

Ground Elevation 6.05



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 5.85
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 2"
Type of Riser Pipe: PVC

Type of Backfill: Bentonite Slurry

Elevation of Top of Seal:
Depth of Top of Seal: 0
Type of Seal: Bentonite Slurry

Elevation of Top of Sand: -43.95
Depth of Top of Sand: 50
Elevation of Top of Screen: -57.95
Depth of Top of Screen: 64

Type of Screen: PVC /cut
Slot Size x Length: 0.010"/3'
ID of Screen: 2"

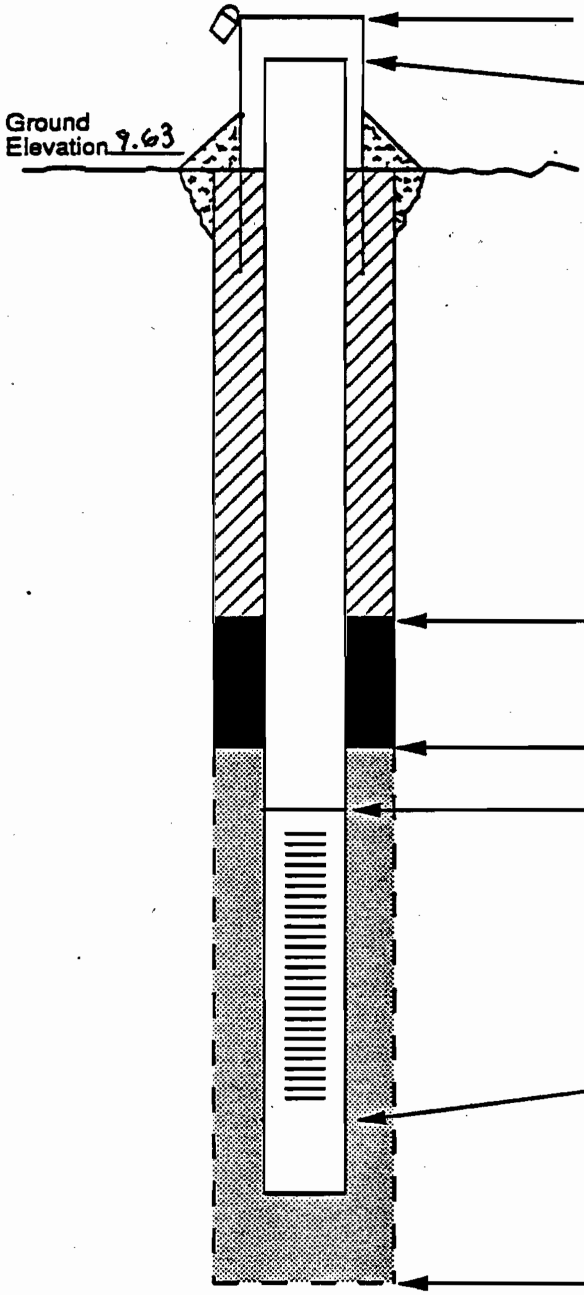
Type of Sandpack: Native

Elevation of Bottom of Screen: -60.95
Depth of Bottom of Screen: 67
Depth of Sediment Sump with Plug: 67

Elevation of Bottom of Borehole: -60.95
Depth of Bottom of Borehole: 67

PIEZOMETER
OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.
Project No. 7135-90 Boring No. PZ-94-10 Drilling Method 4.25 in HSA
Date Installed 9/26/94 Development Method
Field Geologist Brian Johnson



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 9.48
Type of Surface Seal: cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: -2.37
Depth of Top of Screen: 12

Type of Screen: PVC/cut
Slot Size x Length: 0.010"/3'
ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: -5.37
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

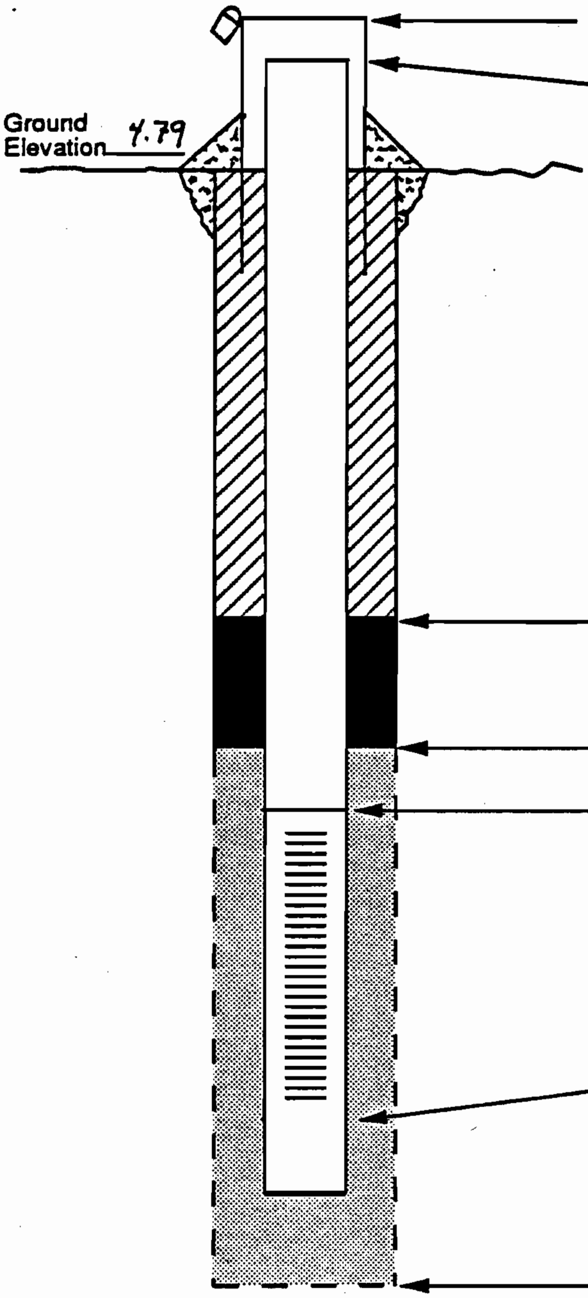
Elevation of Bottom of Borehole: -5.37
Depth of Bottom of Borehole: 15

ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project **SERVALL LAUNDRY** Study Area G.W.D.S. Driller A.D.I.
Project No. 7135-90 Boring No. P2-94-9D Drilling Method 4.25 in HSA
Date Installed 10/8/94 Development Method
Field Geologist DOUG BEAL



Ground Elevation 4.79

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 4.60
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 2"
Type of Riser Pipe: PVC

Type of Backfill: Bentonite Slurry

Elevation of Top of Seal:
Depth of Top of Seal:
Type of Seal: Bentonite Slurry

Elevation of Top of Sand: -45.21
Depth of Top of Sand: 50
Elevation of Top of Screen: -53.21
Depth of Top of Screen: 58

Type of Screen: PVC/cut
Slot Size x Length: 0.010"/3'
ID of Screen: 2"

Type of Sandpack: Native

Elevation of Bottom of Screen: -56.21
Depth of Bottom of Screen: 61
Depth of Sediment Sump with Plug: 61

Native 70-61
Elevation of Bottom of Borehole: -65.21
Depth of Bottom of Borehole: 70

ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY

Study Area G.W.D.S.

Driller A.D.I.

Project No. 7135-90

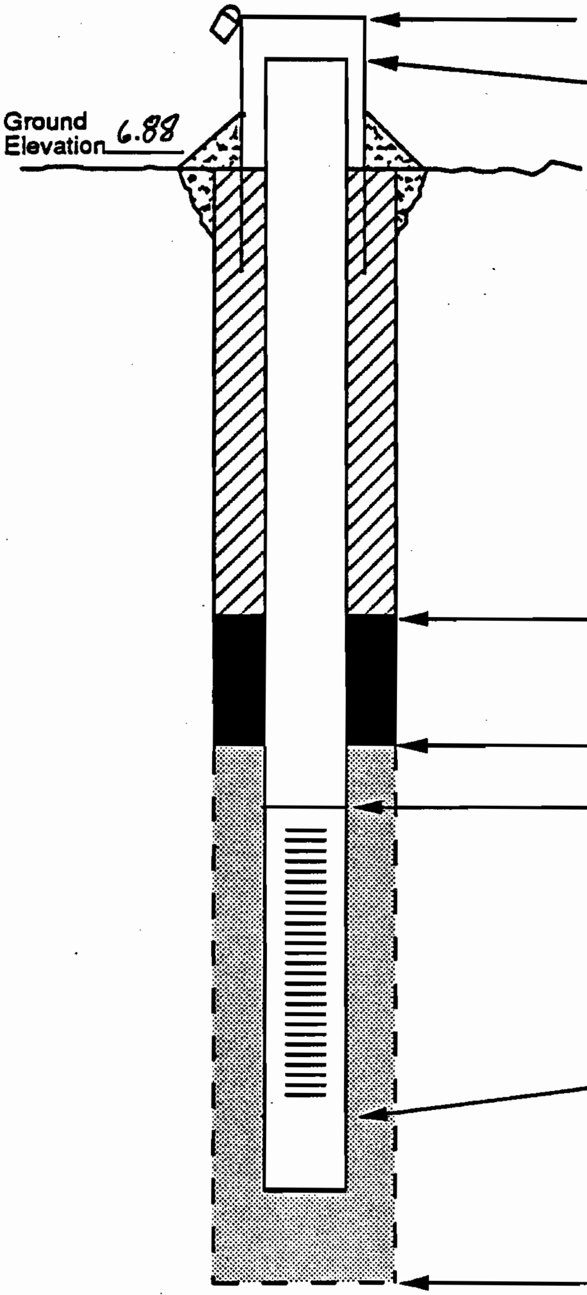
Boring No. P2-94-11

Drilling Method 4.25 in HSA

Date Installed 10/4/94

Development Method

Field Geologist DOUG BEAL



Ground Elevation 6.88

Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 6.75

Type of Surface Seal: Cement

Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"

Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None

Depth of Top of Seal:

Type of Seal:

Elevation of Top of Sand: None

Depth of Top of Sand:

Elevation of Top of Screen: -5.12

Depth of Top of Screen: 12

Type of Screen: PVC /cut

Slot Size x Length: 0.010" /13'

ID of Screen: 3/4"

Type of Sandpack:

Elevation of Bottom of Screen: -8.12

Depth of Bottom of Screen: 15

Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -8.12

Depth of Bottom of Borehole: 15

PIEZOMETER
OVERBURDEN CONSTRUCTION DIAGRAM

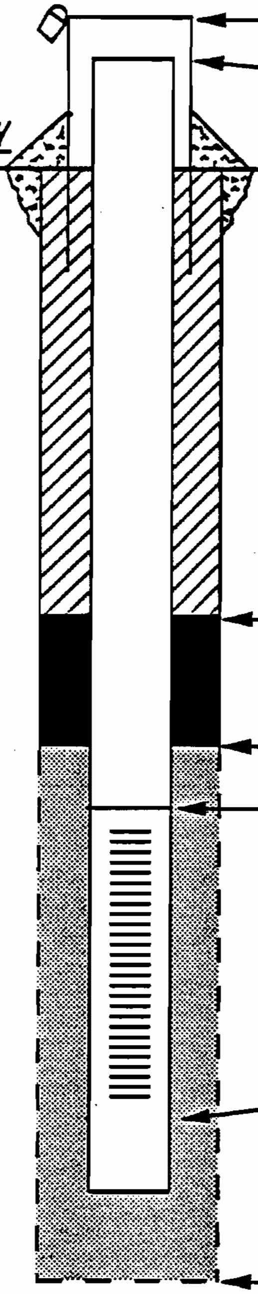
Project **SERVALL LAUNDRY** Study Area **G.W.D.S.** Driller **A.D.I.**

Project No. **7135-90** Boring No. PZ-94-10D Drilling Method **4.25 in HSA**

Date Installed 9/27/94 Development Method

Field Geologist **Brian Johnson**

Ground Elevation 9.44



Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 9.23

Type of Surface Seal: Cement

Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 3/4" 2" BJ

Type of Riser Pipe: PVC

Type of Backfill: Bentonite slurry

Elevation of Top of Seal: 6.44

Depth of Top of Seal: 3

Type of Seal: Bentonite slurry

Elevation of Top of Sand: -40.56

Depth of Top of Sand: 50-60 Native

Elevation of Top of Screen: -50.56

Depth of Top of Screen: 60

Type of Screen: PVC/cut

Slot Size x Length: 0.010"/3'

ID of Screen: 3/4" 2" BJ

Type of Sandpack: Morie #1 sand to 61'

Elevation of Bottom of Screen: -53.56

Depth of Bottom of Screen: 63

Depth of Sediment Sump with Plug: 63

Bentonite chips / Native 84-66.5

Native cave 108-84

Elevation of Bottom of Borehole: -98.56

Depth of Bottom of Borehole: 108

ABB Environmental Services, Inc.

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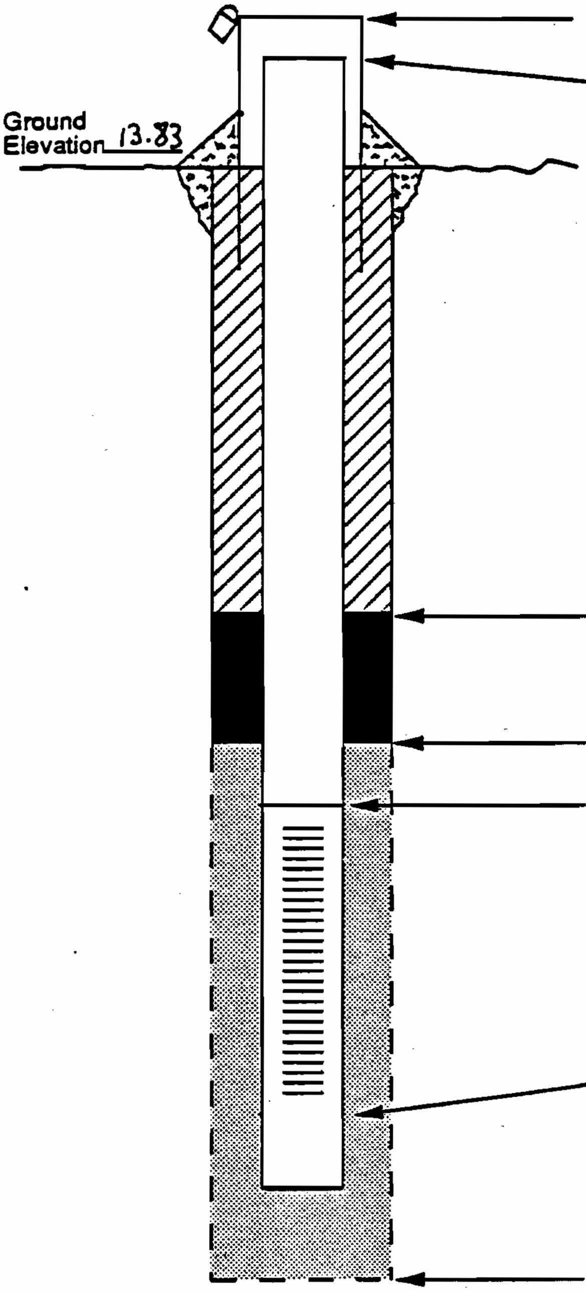
PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.
Project No. 7135-90 Boring No. PZ-94-13 Drilling Method 4.25 in HSA
Date Installed 9/24/94 Development Method
Field Geologist Brian Johnson



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 13.66
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: 1.83
Depth of Top of Screen: 12

Type of Screen: PVC/cut
Slot Size x Length: 0.010"/3'
ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: -1.17
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -1.17
Depth of Bottom of Borehole: 15

ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY

Study Area G.W.D.S.

Driller A.D.I.

Project No. 7135-90

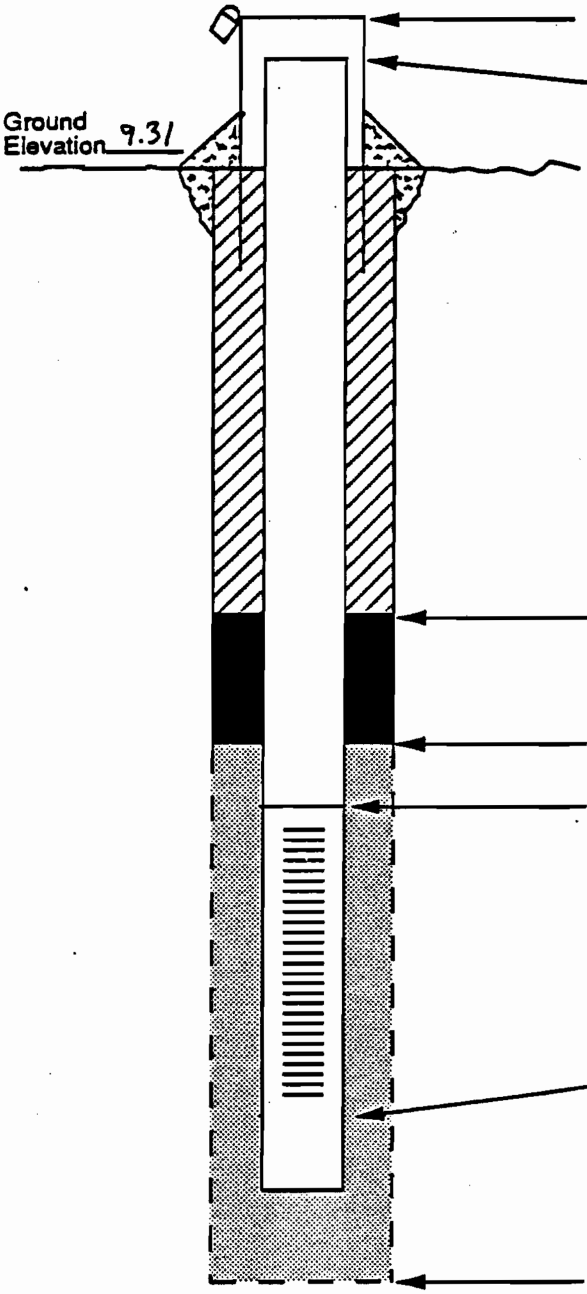
Boring No. PZ-94-12

Drilling Method 4.25 in HSA

Date Installed 9/20/94

Development Method

Field Geologist Brian Johnson



Ground Elevation 9.31

Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 8.91

Type of Surface Seal: Cement

Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"

Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None

Depth of Top of Seal:

Type of Seal:

Elevation of Top of Sand: None

Depth of Top of Sand:

Elevation of Top of Screen: -6.69

Depth of Top of Screen: 16

Type of Screen: PVC/Cut

Slot Size x Length: 0.010" /3'

ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: -9.69

Depth of Bottom of Screen: 19

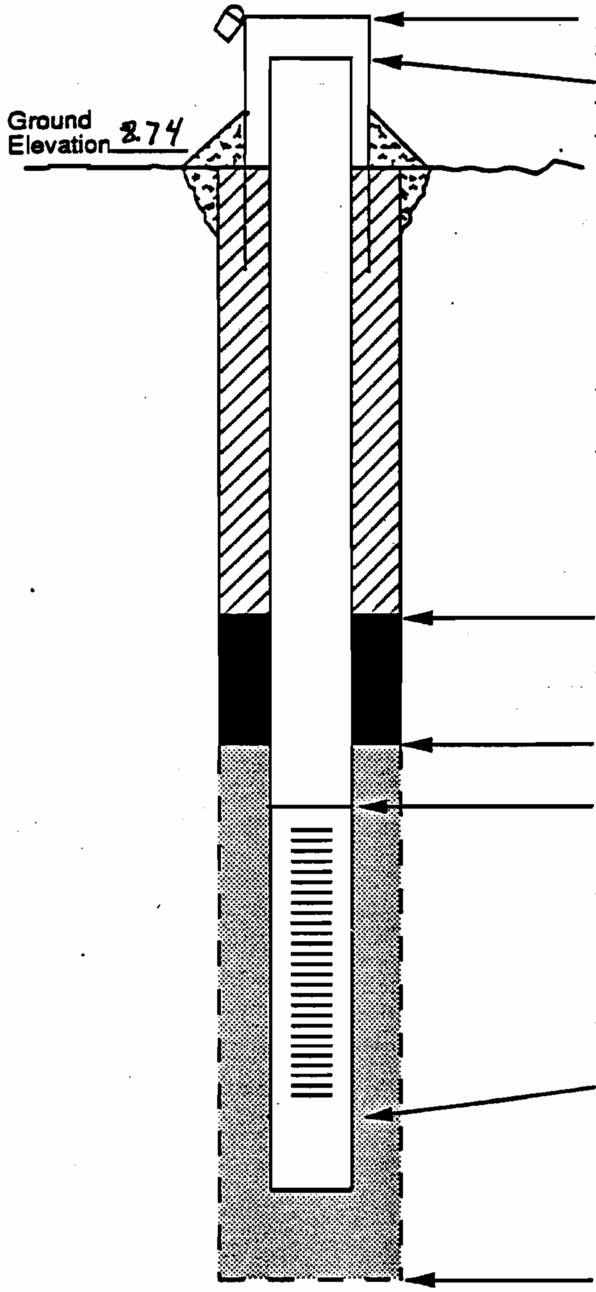
Depth of Sediment Sump with Plug: 19

Elevation of Bottom of Borehole: -9.69

Depth of Bottom of Borehole: 19

OVERBURDEN PIEZOMETER CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-14D
Drilling Method 4.25 in HSA
Date Installed 9/25/94
Development Method
Field Geologist Brian Johnson



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 8.49
Type of Surface Seal: cement
Type of Surface Casing: flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 2"
Type of Riser Pipe: PVC

Type of Backfill: Bentonite slurry
no surface, 1st settle,
then set road box

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: -44.26
Depth of Top of Sand: 53
Elevation of Top of Screen: -51.26
Depth of Top of Screen: 60

Type of Screen: PVC/cut
Slot Size x Length: 0.010"/3'
ID of Screen: 2"

Type of Sandpack: Native

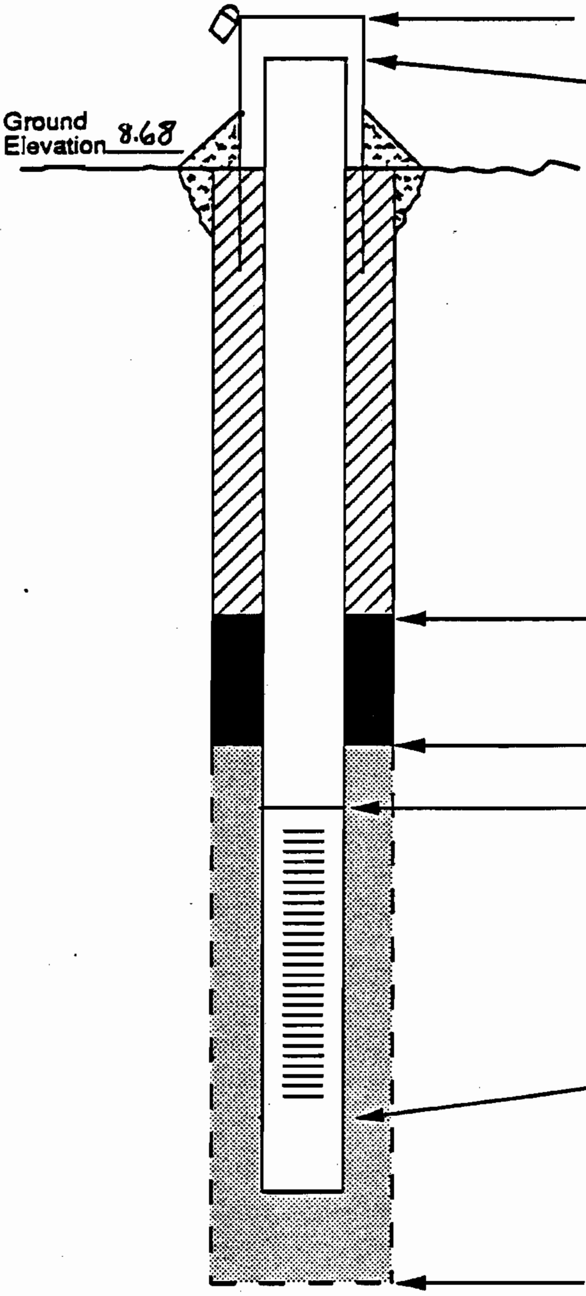
Elevation of Bottom of Screen: -54.26
Depth of Bottom of Screen: 63
Depth of Sediment Sump with Plug: 63

Elevation of Bottom of Borehole: -56.26
Depth of Bottom of Borehole: 65

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-14
Drilling Method 4.25 in HSA
Date Installed 9/20/94
Development Method
Field Geologist Brian Johnson



Ground Elevation 8.68

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 8.36
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: -3.32
Depth of Top of Screen: 12

Type of Screen: PVC/cut
Slot Size x Length: 0.010"/3'
ID of Screen: 3/4"

Type of Sandpack: Native

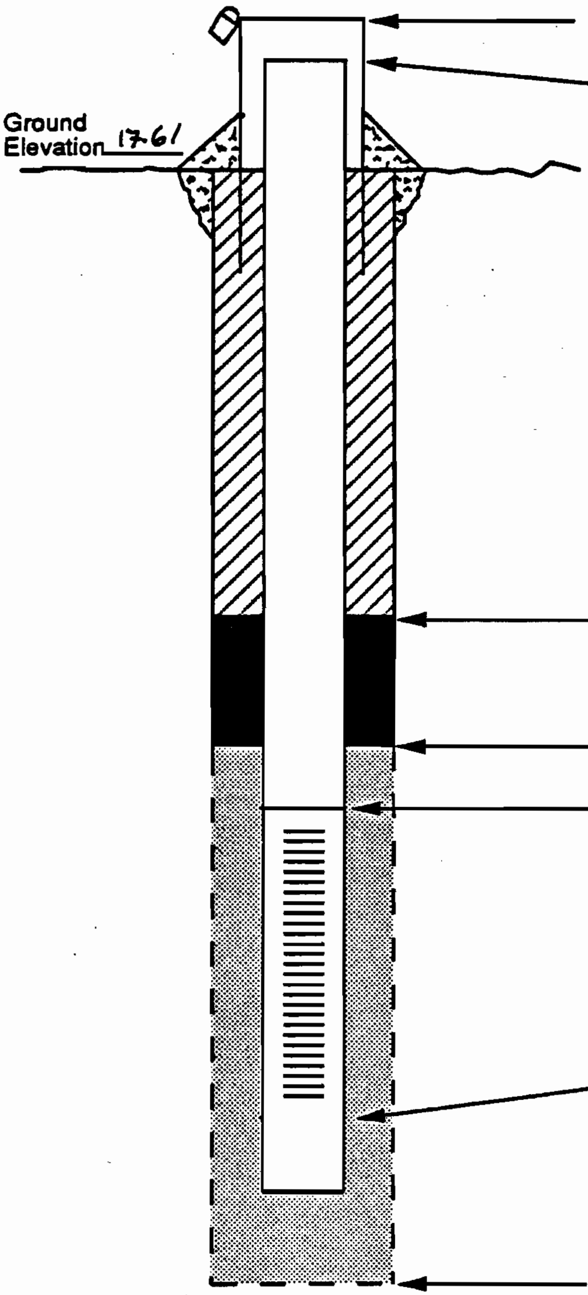
Elevation of Bottom of Screen: -6.32
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: -6.32
Depth of Bottom of Borehole: 15

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-16
Drilling Method 4.25 in HSA
Date Installed 10/4/94
Development Method
Field Geologist DOUG BEAL



Ground Elevation 17.61

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 17.46
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: 5.61
Depth of Top of Screen: 12

Type of Screen: PVC/cut
Slot Size x Length: 0.010" / 13'
ID of Screen: 3/4"

Type of Sandpack: Native

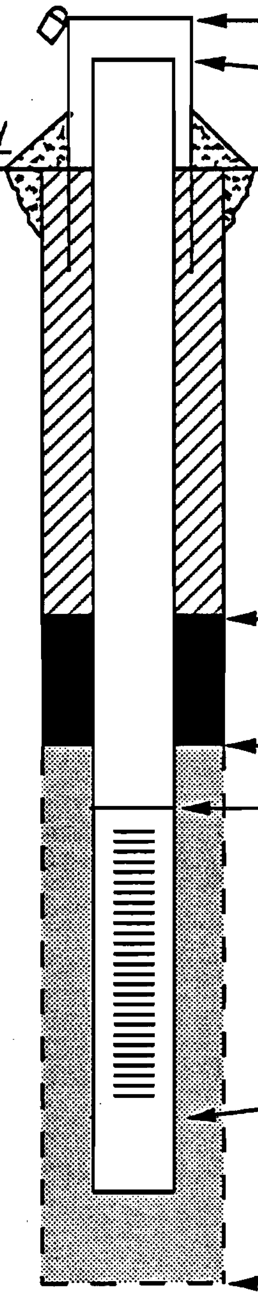
Elevation of Bottom of Screen: 2.61
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: 2.61
Depth of Bottom of Borehole: 15

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-15
Drilling Method 4.25 in HSA
Date Installed 10/8/94
Development Method
Field Geologist DOUG BEAL



Ground Elevation 13.44

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 13.04
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: 1.44
Depth of Top of Screen: 12

Type of Screen: PVC/ cut
Slot Size x Length: 0.010" /3'
ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: -1.56
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

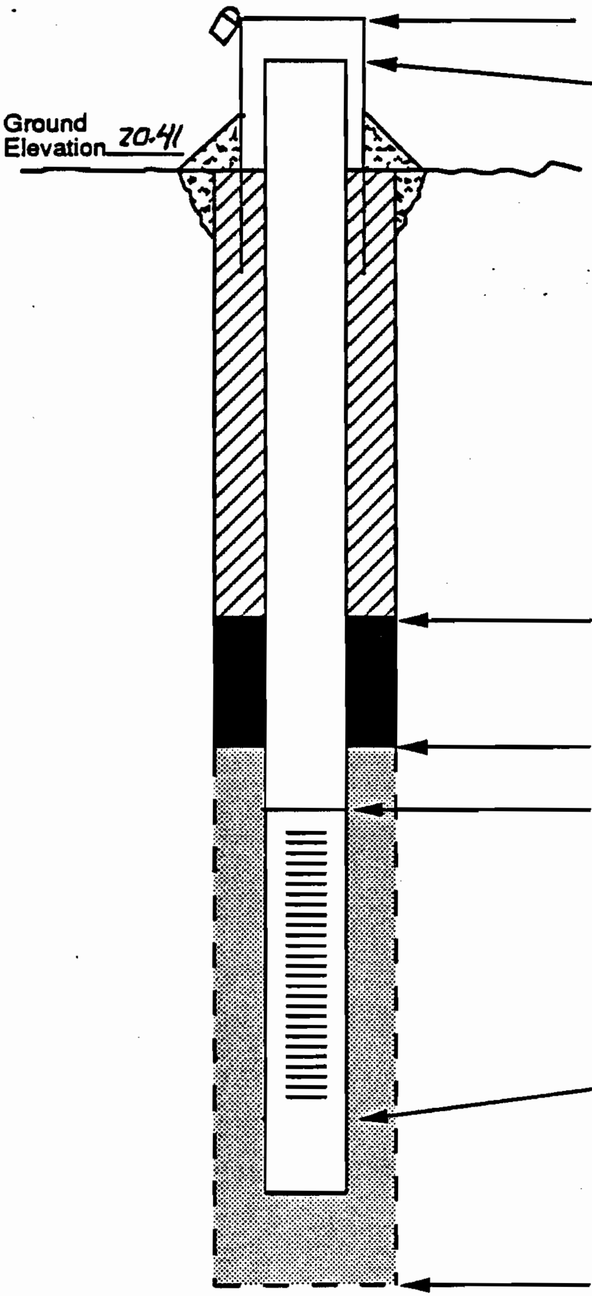
Elevation of Bottom of Borehole: -1.56
Depth of Bottom of Borehole: 15

ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project **SERVALL LAUNDRY** Study Area G.W.D.S. Driller A.D.I.
Project No. 7135-90 Boring No. PZ-94-17D Drilling Method 4.25 in HSA
Date Installed 10/8/94 Development Method
Field Geologist DOUG BEAL



Ground Elevation 20.41

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 20.22
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 2"
Type of Riser Pipe: PVC

Type of Backfill: Bentonite Slurry

Elevation of Top of Seal:
Depth of Top of Seal:
Type of Seal: Bentonite Slurry

Elevation of Top of Sand: -42.59
Depth of Top of Sand: 63
Elevation of Top of Screen: -49.59
Depth of Top of Screen: 70

Type of Screen: PVC/Cut
Slot Size x Length: 0.010" / 3'
ID of Screen: 2"

Type of Sandpack: Native

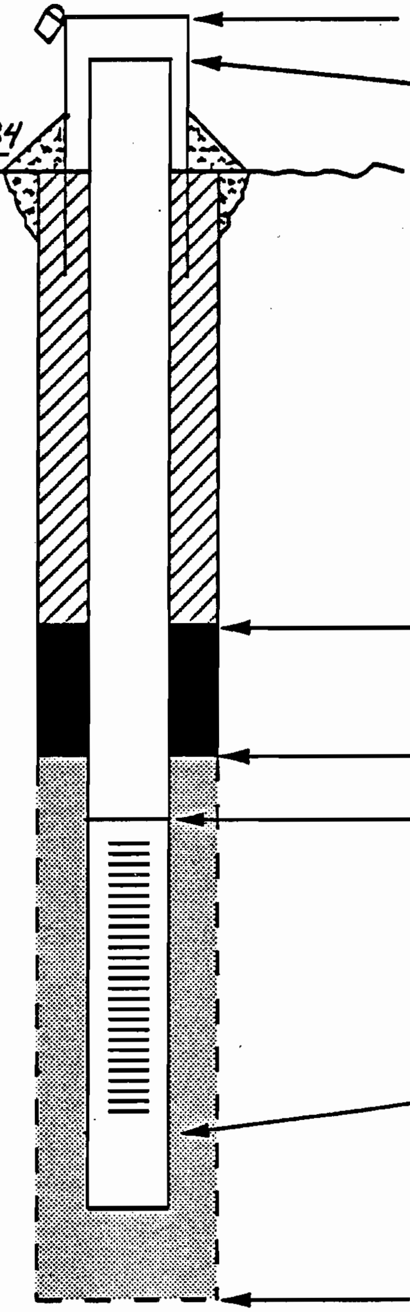
Elevation of Bottom of Screen: -52.59
Depth of Bottom of Screen: 73
Depth of Sediment Sump with Plug: 73

Elevation of Bottom of Borehole: -54.59
Depth of Bottom of Borehole: 75

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-17
Drilling Method 4.25 in HSA
Date Installed 9/20/94
Development Method
Field Geologist Brian Johnson



Ground Elevation 20.34

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 20.14
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: 4.34
Depth of Top of Screen: 16

Type of Screen: PVC/cvt
Slot Size x Length: 0.010"/3'
ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: 1.34
Depth of Bottom of Screen: 19
Depth of Sediment Sump with Plug: 19

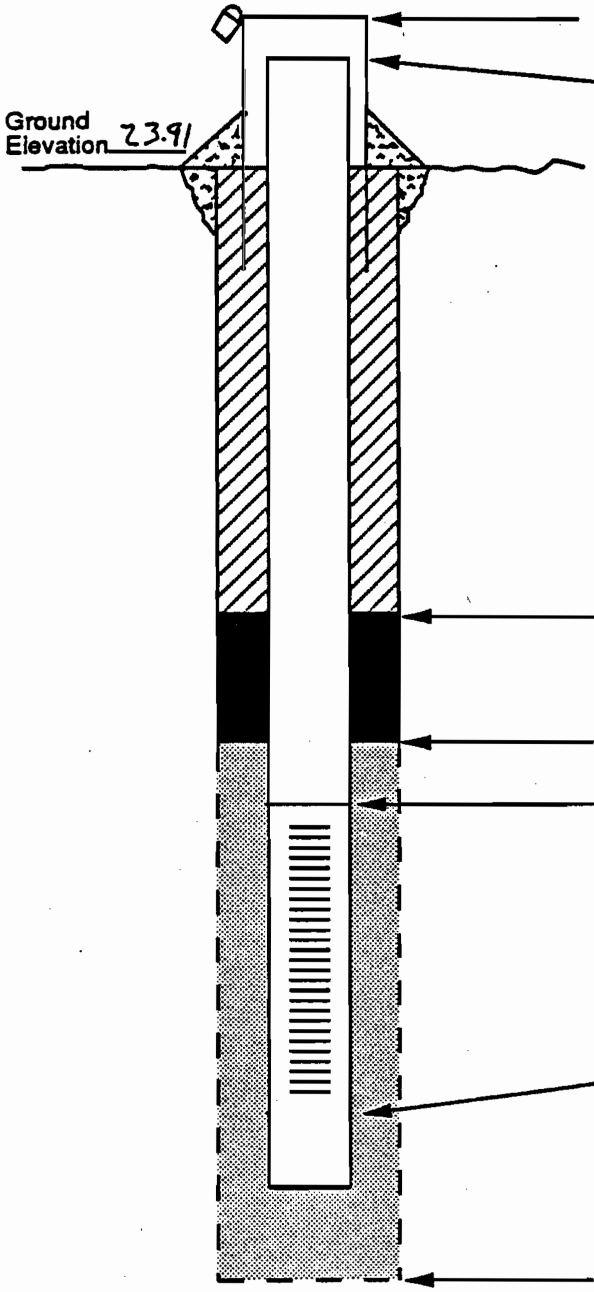
Elevation of Bottom of Borehole: 1.34
Depth of Bottom of Borehole: 19

ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-21D
Drilling Method 4.25 in HSA
Date Installed 10/9/94
Development Method
Field Geologist DOUG BEAL



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 23.61
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼'

Riser Pipe ID: 2"
Type of Riser Pipe: PVC

Type of Backfill: Bentonite Slurry

Elevation of Top of Seal:
Depth of Top of Seal:
Type of Seal: Bentonite Slurry

Elevation of Top of Sand: -39.09
Depth of Top of Sand: 63
Elevation of Top of Screen: -46.09
Depth of Top of Screen: 70

Type of Screen: PVC/cut
Slot Size x Length: 0.010"/3'
ID of Screen: 2"

Type of Sandpack: Native

Elevation of Bottom of Screen: -49.09
Depth of Bottom of Screen: 73
Depth of Sediment Sump with Plug: 73

Bentonite Chips 87'-75'

Elevation of Bottom of Borehole: -63.09
Depth of Bottom of Borehole: 87

ABB Environmental Services, Inc.

PIEZOMETER

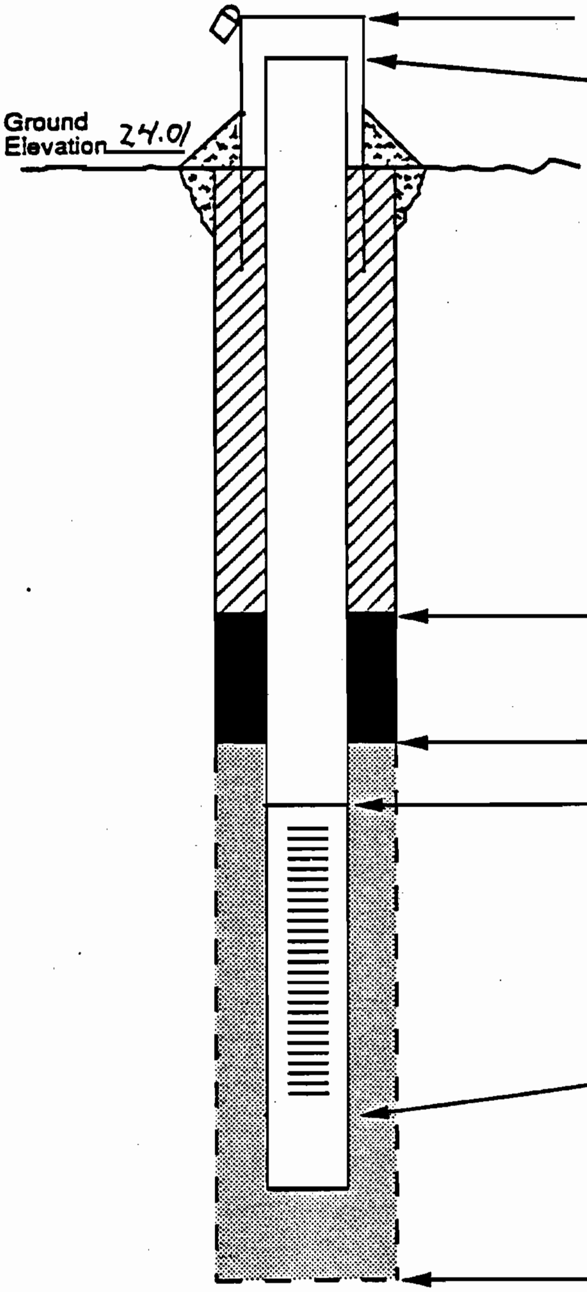
OVERBURDEN **CONSTRUCTION DIAGRAM**

Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.

Project No. 7135-90 Boring No. PZ-94-21 Drilling Method 4.25 in HSA

Date Installed 9/21/94 Development Method

Field Geologist Brian Johnson



Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 23.71

Type of Surface Seal: Cement

Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"

Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None

Depth of Top of Seal:

Type of Seal:

Elevation of Top of Sand: None

Depth of Top of Sand:

Elevation of Top of Screen: 12.01

Depth of Top of Screen: 12

Type of Screen: PVC/cut

Slot Size x Length: 0.010"/3'

ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: 9.01

Depth of Bottom of Screen: 15

Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: 9.01

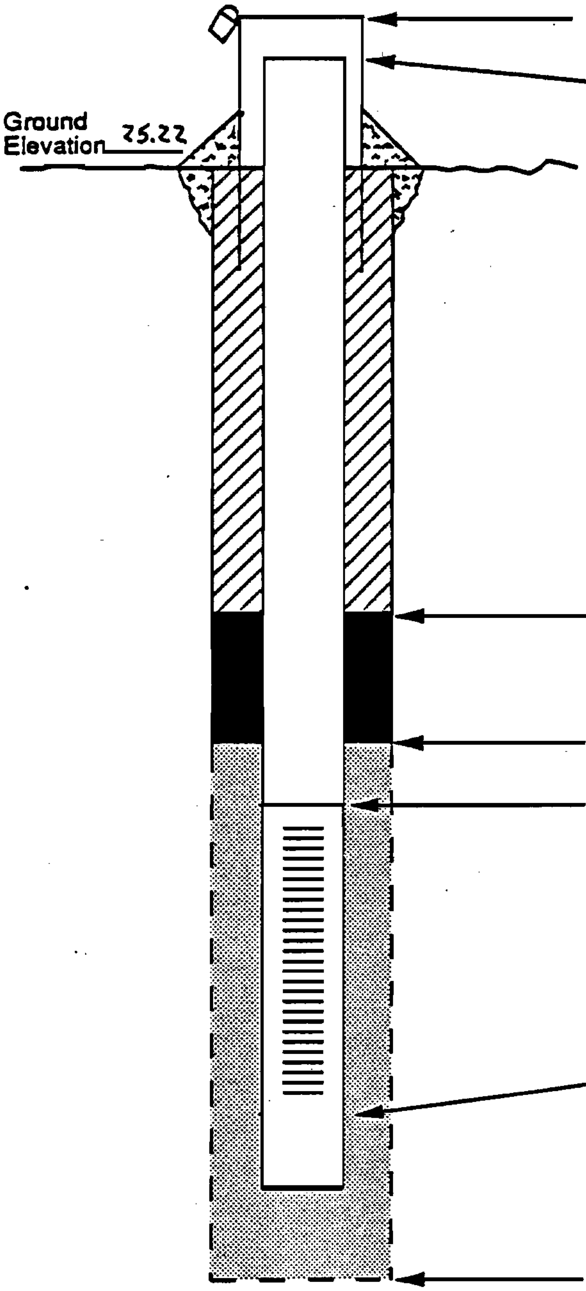
Depth of Bottom of Borehole: 15

ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-23
Drilling Method 4.25 in HSA
Date Installed 4/24/94
Development Method
Field Geologist Brian Johnson



Ground Elevation 25.22

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 25.06
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: 13.22
Depth of Top of Screen: 12

Type of Screen: PVC/cut
Slot Size x Length: 0.010" /3'
ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: 10.22
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: 10.22
Depth of Bottom of Borehole: 15

ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

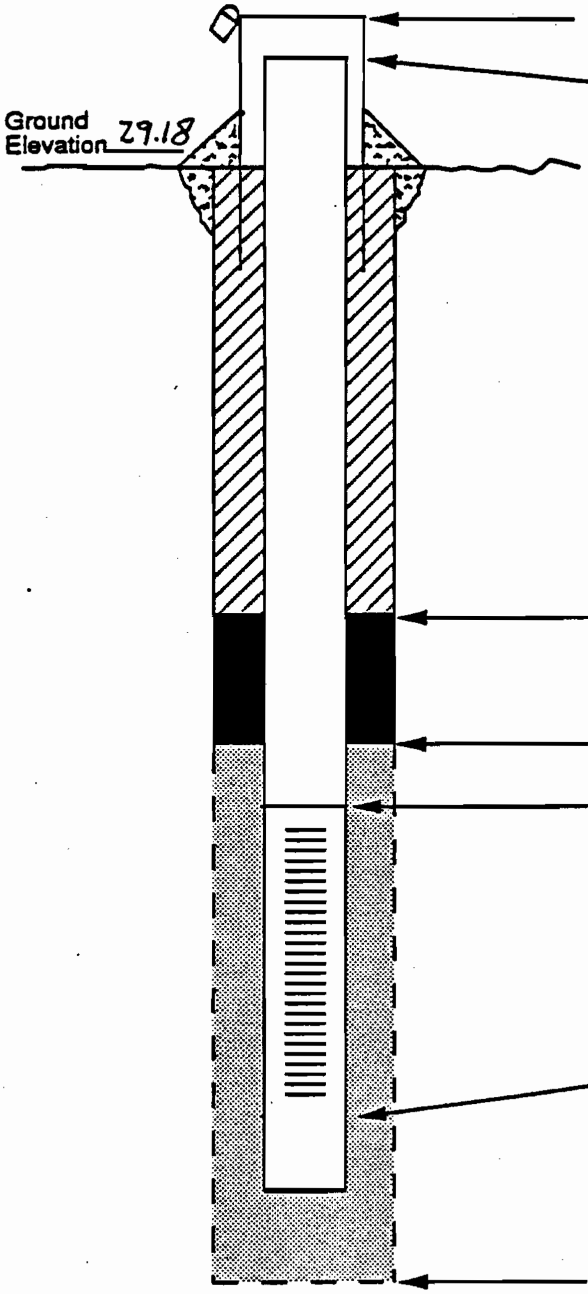
Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.

Project No. 7135-90 Boring No. PZ-94-22 Drilling Method 4.25 in HSA

Date Installed 9/24/94 Development Method

Field Geologist Brian Johnson

Ground Elevation 29.18



Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 28.92

Type of Surface Seal: Cement

Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 3/4"

Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None

Depth of Top of Seal:

Type of Seal:

Elevation of Top of Sand: None

Depth of Top of Sand:

Elevation of Top of Screen: 17.19

Depth of Top of Screen: 12

Type of Screen: PVC/Cut

Slot Size x Length: 0.010"/3'

ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: 14.19

Depth of Bottom of Screen: 15

Depth of Sediment Sump with Plug: 15

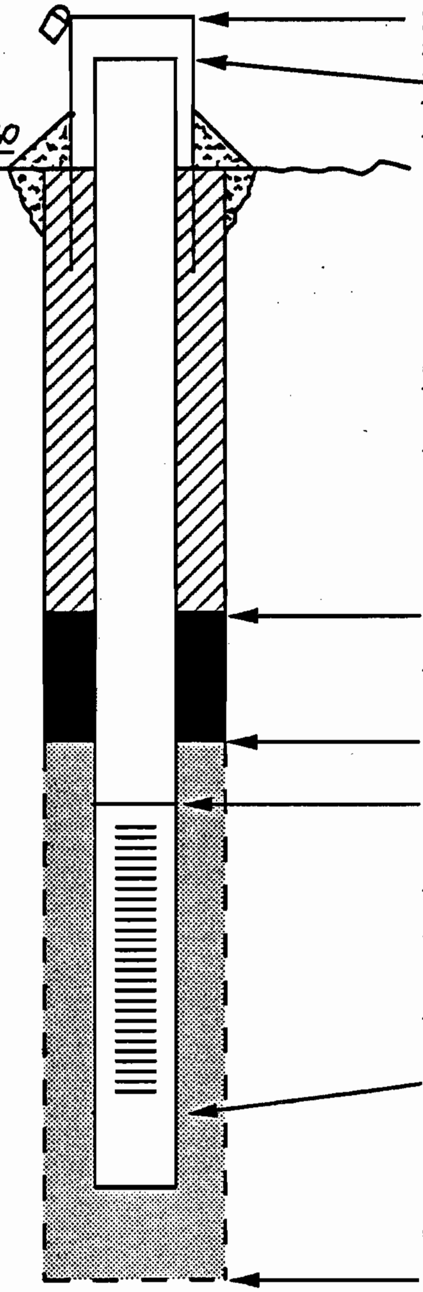
Elevation of Bottom of Borehole: 14.19

Depth of Bottom of Borehole: 15

OVERBURDEN MONITORING WELL CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. mw-94-23D
Drilling Method 4.25 in HSA
Date Installed 10/10/94
Development Method
Field Geologist DOUG BEAL

Ground Elevation 24.60



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 24.45
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 2"
Type of Riser Pipe: PVC

Type of Backfill: Bentonite Slurry

Elevation of Top of Seal:
Depth of Top of Seal:
Type of Seal: Bentonite Slurry

Elevation of Top of Sand: -53.4
Depth of Top of Sand: 78
Elevation of Top of Screen: -58.4
Depth of Top of Screen: 83

Type of Screen: PVC/cut
Slot Size x Length: 0.010"/5'
ID of Screen: 2"

Type of Sandpack: Morie #1

Elevation of Bottom of Screen: -63.4
Depth of Bottom of Screen: 88
Depth of Sediment Sump with Plug: 88

Bentonite Slurry 112-90 (Grout)
Elevation of Bottom of Borehole: -87.4
Depth of Bottom of Borehole: 112

ABB Environmental Services, Inc.

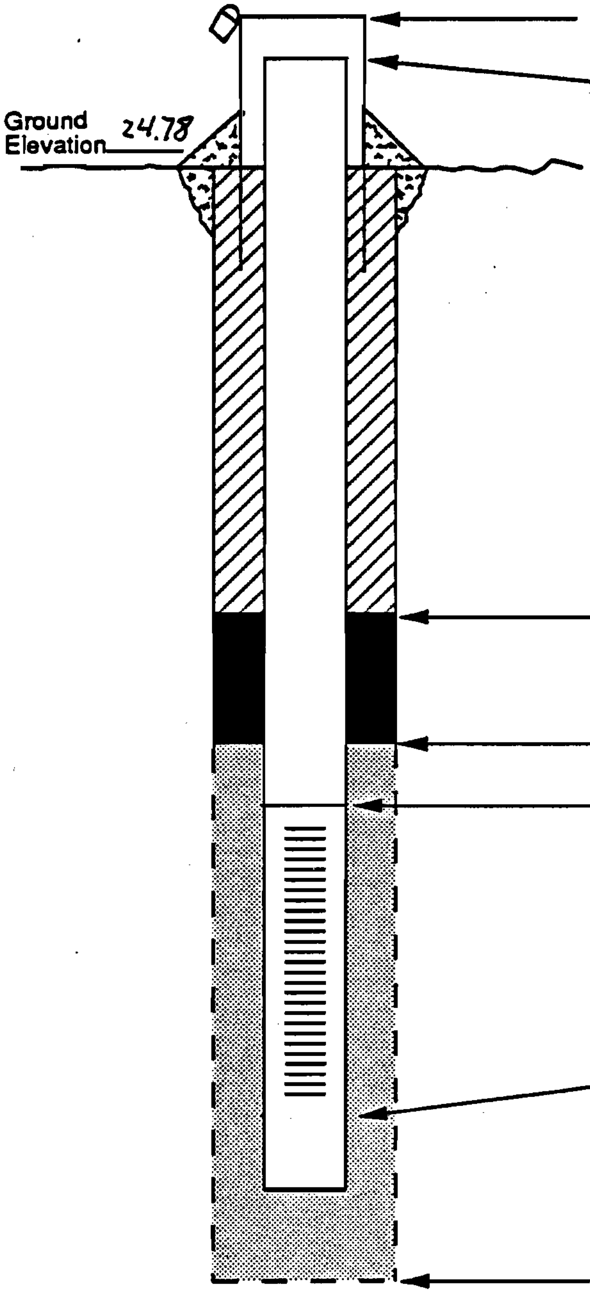
OVERBURDEN MONITORING WELL CONSTRUCTION DIAGRAM

Project **SERVALL LAUNDRY** Study Area **G.W.D.S.** Driller **A.D.I.**

Project No. **7135-90** Boring No. MW-94-235 Drilling Method **4.25 in HSA**

Date Installed 9/22/94 Development Method

Field Geologist **Brian Johnson**



Ground Elevation 24.78

Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 24.38

Type of Surface Seal: Cement

Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 2"

Type of Riser Pipe: PVC

Type of Backfill: Bentonite Slurry w/cement to 2' BGS.

Elevation of Top of Seal: 16.28

Depth of Top of Seal: 8.5

Type of Seal: Bentonite Slurry

Elevation of Top of Sand: -34.72

Depth of Top of Sand: 59.5

Elevation of Top of Screen: -41.72

Depth of Top of Screen: 66.5

Type of Screen: PVC/Cut

Slot Size x Length: 0.010"/3'

ID of Screen: 2"

Type of Sandpack: Morie #1

Elevation of Bottom of Screen: -44.72

Depth of Bottom of Screen: 69.5

Depth of Sediment Sump with Plug: 69.5

Elevation of Bottom of Borehole: -55.22

Depth of Bottom of Borehole: 80

PIEZOMETER

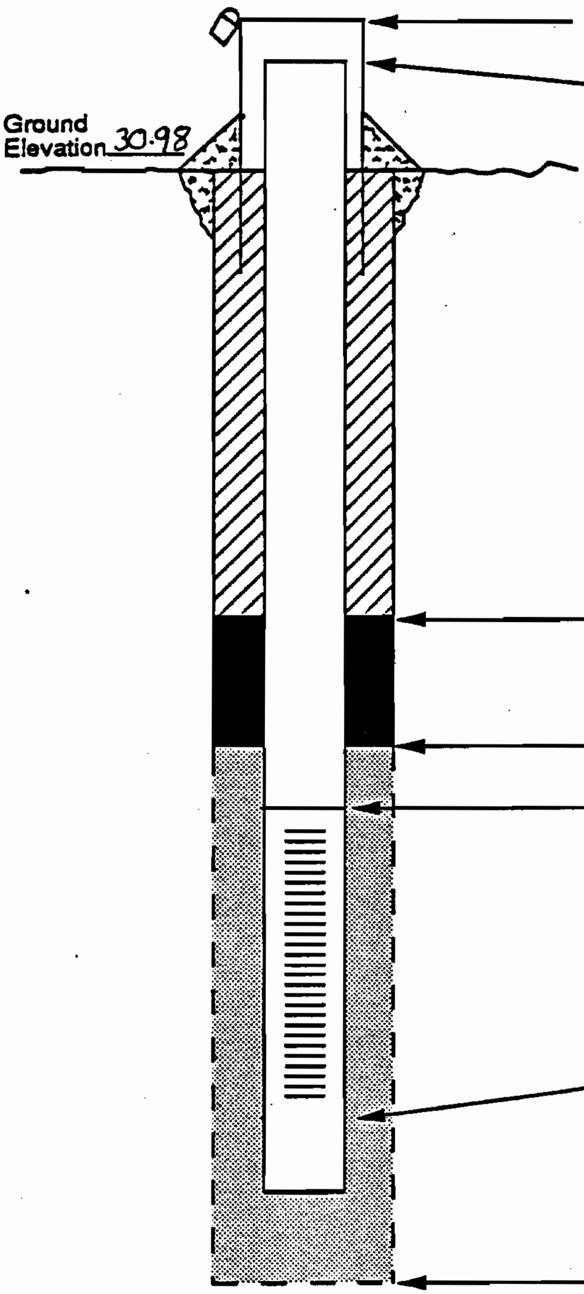
OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY **Study Area** G.W.D.S. **Driller** A.D.I.

Project No. 7135-90 **Boring No.** PZ-94-25 **Drilling Method** 4.25 in HSA

Date Installed 9/24/94 **Development Method**

Field Geologist Brian Johnson



Ground Elevation 30.98

Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 30.76
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: 18.98
Depth of Top of Screen: 12

Type of Screen: PVC/cut slots
Slot Size x Length: 0.010"/~~4~~3"
ID of Screen: 3/4"

Type of Sandpack: Native

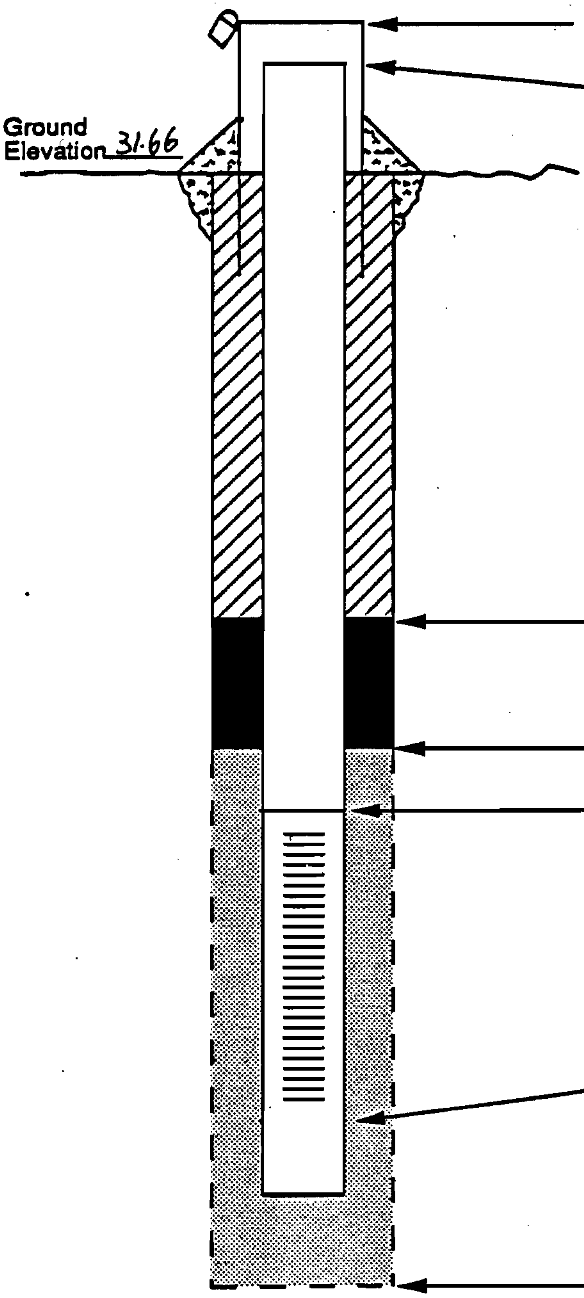
Elevation of Bottom of Screen: 15.98
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: 15.98
Depth of Bottom of Borehole: 15

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-24
Drilling Method 4.25 in HSA
Date Installed 9/24/94
Development Method
Field Geologist Brian Johnson



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 31.53
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: ¾"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: 19.66
Depth of Top of Screen: 12

Type of Screen: PVC/Cut
Slot Size x Length: 0.010"/3'
ID of Screen: ¾"

Type of Sandpack: Native

Elevation of Bottom of Screen: 16.66
Depth of Bottom of Screen: 15
Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: 16.66
Depth of Bottom of Borehole: 15

PIEZOMETER

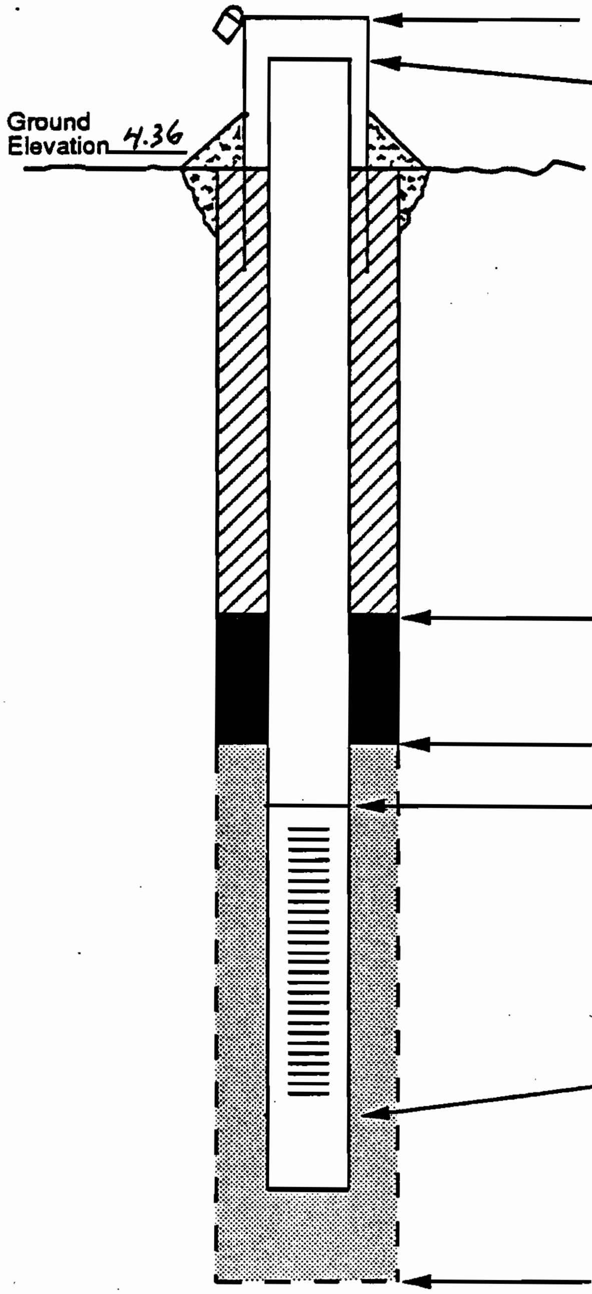
OVERBURDEN **CONSTRUCTION DIAGRAM**

Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.

Project No. 7135-90 Boring No. PZ-94-27D Drilling Method 4.25 in HSA

Date Installed 10/6/94 Development Method

Field Geologist DOUG BEAL



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 4.18
Type of Surface Seal: Cement
Type of Surface Casing: Flush mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 2"
Type of Riser Pipe: PVC

Type of Backfill: Bentonite Slurry

Elevation of Top of Seal:
Depth of Top of Seal: Surface
Type of Seal: Bentonite Slurry

Elevation of Top of Sand: -45.64
Depth of Top of Sand: 50'
Elevation of Top of Screen: -55.64
Depth of Top of Screen: 60'

Type of Screen: PVC /cut
Slot Size x Length: 0.010" 15'
ID of Screen: 2"

Type of Sandpack: Native / Morie #1

Elevation of Bottom of Screen: -60.64
Depth of Bottom of Screen: 65
Depth of Sediment Sump with Plug: 105
Bentonite pellets 77'-67'
Bentonite slurry 107'-77'
Elevation of Bottom of Borehole: -102.64
Depth of Bottom of Borehole: 107

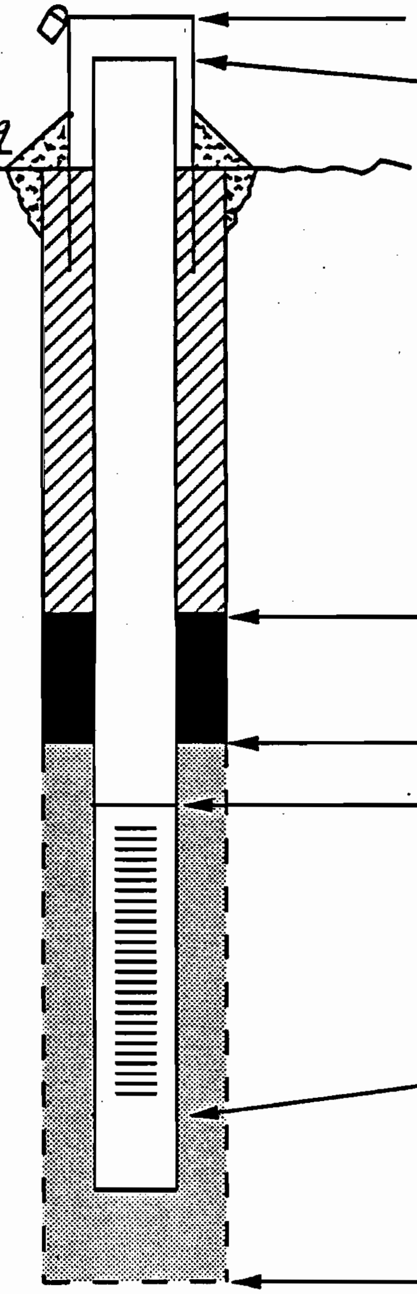
Long sump installed to allow for induction logging of hole to look for saltwater / fresh water

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project **SERVALL LAUNDRY**
Study Area **G.W.D.S.**
Driller **A.D.I.**
Project No. **7135-90**
Boring No. P2-94-26
Drilling Method **4.25 in HSA**
Date Installed 9/21/94
Development Method
Field Geologist **DOUG BEAL**

Ground Elevation 44.49



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 44.19
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"
Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None
Depth of Top of Seal:
Type of Seal:

Elevation of Top of Sand: None
Depth of Top of Sand:
Elevation of Top of Screen: 17.49
Depth of Top of Screen: 27

Type of Screen: PVC/Cut
Slot Size x Length: 0.010" 13'
ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: 14.49
Depth of Bottom of Screen: 30
Depth of Sediment Sump with Plug: 30

Elevation of Bottom of Borehole: 14.49
Depth of Bottom of Borehole: 30

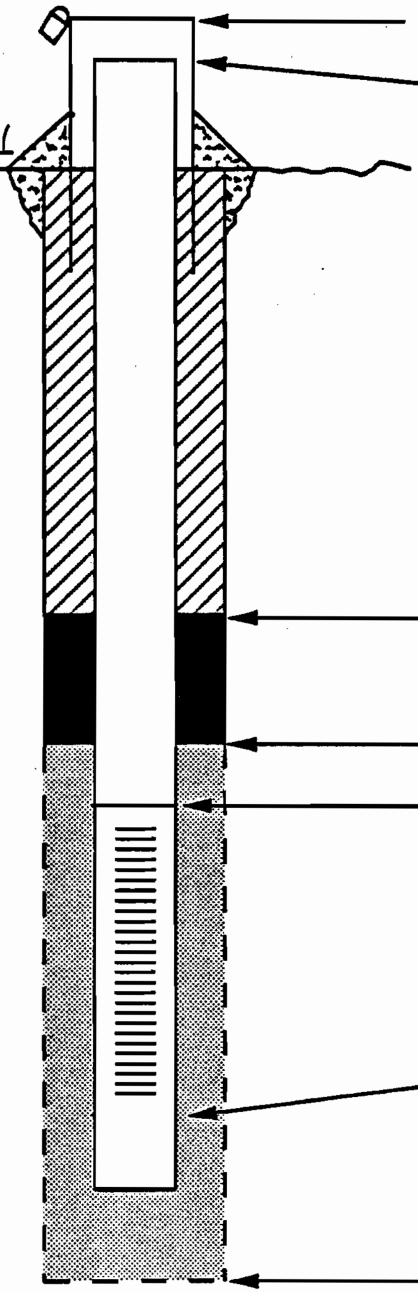
ABB Environmental Services, Inc.

PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

Project SERVALL LAUNDRY
Study Area G.W.D.S.
Driller A.D.I.
Project No. 7135-90
Boring No. PZ-94-28D
Drilling Method 4.25 in HSA
Date Installed 10/9/94
Development Method
Field Geologist DOUG BEAL

Ground Elevation 4.01



Elevation of Top of Surface Casing:
Stick-up of Casing Above Ground Surface: 0
Elevation of Top of Riser Pipe: 3.82
Type of Surface Seal: Cement
Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8¼"

Riser Pipe ID: 2"
Type of Riser Pipe: PVC

Type of Backfill: Bentonite Slurry

Elevation of Top of Seal:
Depth of Top of Seal:
Type of Seal: Bentonite slurry

Elevation of Top of Sand: -58.99
Depth of Top of Sand: 63
Elevation of Top of Screen: 65.99
Depth of Top of Screen: 70

Type of Screen: PVC / cut
Slot Size x Length: 0.010" / 13'
ID of Screen: 2"

Type of Sandpack: Native

Elevation of Bottom of Screen: -68.99
Depth of Bottom of Screen: 73
Depth of Sediment Sump with Plug: 73

Elevation of Bottom of Borehole: -90.99
Depth of Bottom of Borehole: 95

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PIEZOMETER

OVERBURDEN CONSTRUCTION DIAGRAM

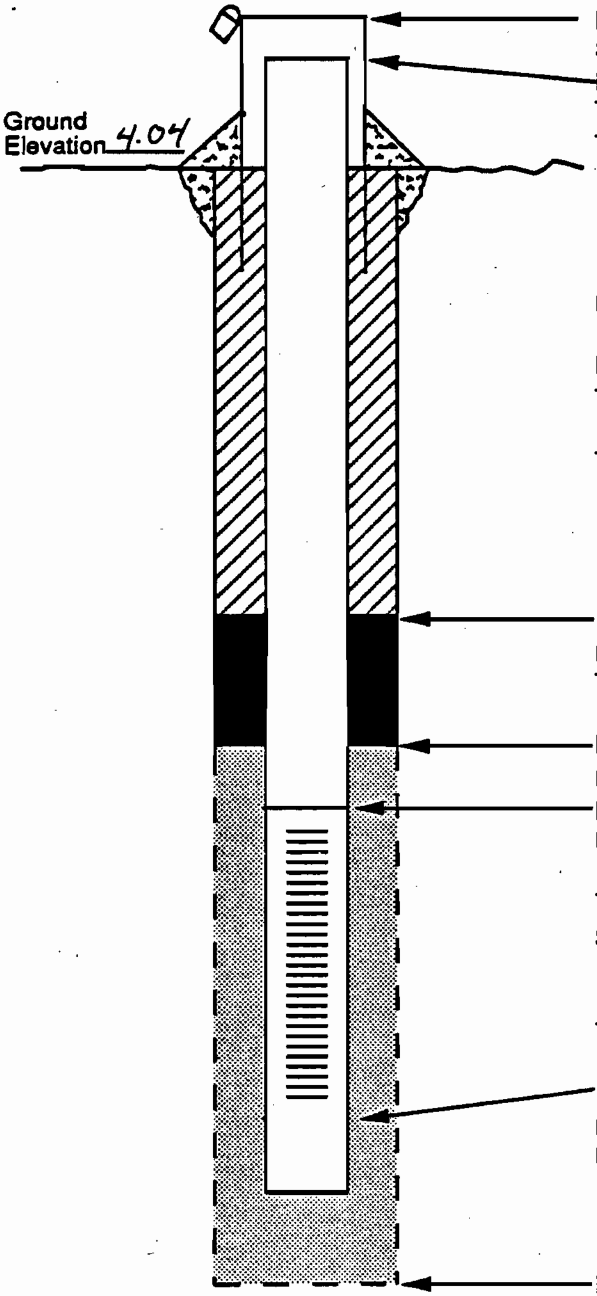
Project SERVALL LAUNDRY Study Area G.W.D.S. Driller A.D.I.

Project No. 7135-90 Boring No. PZ-94-28 Drilling Method 4.25 In HSA

Date Installed 10/8/94 Development Method

Field Geologist DOUG BEAL

Ground Elevation 4.04



Elevation of Top of Surface Casing:

Stick-up of Casing Above Ground Surface: 0

Elevation of Top of Riser Pipe: 3.76

Type of Surface Seal: Cement

Type of Surface Casing: Flush Mount

ID of Surface Casing: 8"

Diameter of Borehole: 8 1/4"

Riser Pipe ID: 3/4"

Type of Riser Pipe: PVC

Type of Backfill: Native

Elevation of Top of Seal: None

Depth of Top of Seal:

Type of Seal:

Elevation of Top of Sand: None

Depth of Top of Sand:

Elevation of Top of Screen: 7.96

Depth of Top of Screen: 12'

Type of Screen: PVC / Cut

Slot Size x Length: 0.010" / 13'

ID of Screen: 3/4"

Type of Sandpack: Native

Elevation of Bottom of Screen: 4.96

Depth of Bottom of Screen: 15

Depth of Sediment Sump with Plug: 15

Elevation of Bottom of Borehole: 4.96

Depth of Bottom of Borehole: 15

APPENDIX C

PIEZOMETER AND WELL DEVELOPMENT RECORDS

WELL DEVELOPMENT RECORD

Project: SERVALL LAUNDRY

Well Installation Date: ~~10/05~~ 9/22/94

Project No. 7135-90

Client: NYSDEC

Well Development Date: 10/24/94

Logged by: DB

Checked by: BBS

Well/Site I.D.: MW-94-23 S

Weather: Sunny, Clear 65°F

Start Date: 10/24/94

Finish Date: 10/24/94

Initial Water Level (ft): 6.48

Start Time: 1150

Finish Time: 1520

Water Level during Initial Pumping/Purging (ft): — Pumped till ~25' BTOC

Water Level at Termination of Pumping/Purging (ft): —

Number of Well Volumes	TIME	TEMP.	pH	Conductivity	Approximate Pumping Rate (gal/min)	Turbidity (NTU's)
0	1150	15.0	8.31	244		794
11	1207	15.8	8.55	211		810
15	1300	16.2	6.91	212		774
20	1318	16.7	7.63	250		504
25	1322	15.3	7.06	226		507
30	1335	14.5	6.40	181		936
35	1340	14.5	6.13	175		986
40	1350	14.5	6.19	164		894
45	1355	14.5	6.15	153		923
50	1400	14.5	5.94	147		911
55	1405	14.0	5.87	140		771
60	1410	13.8	5.95	137		609

NOTES:

65	1415	13.8	6.08	127		502
70	1420	13.9	6.14	130		356
75	1425	13.9	6.09	128		320
80	1430	13.5	5.80	127		246
85	1435	13.5	5.79	125		260
90	1440	13.6	5.83	124		220
95	1445	13.6	5.85	115		205
100	1450	13.5	5.87	122		167
105	1500	13.4	5.82	121		160
110	1505	13.5	5.83	120		147
115	1510	13.5	5.70	119		129
120	1515	13.4	5.67	118		117
125	1520	13.4	5.69	118		115

Well Developer's Signature for Doug Beal, transferred Original

WELL DEVELOPMENT RECORD

Project: SERVALL LAUNDRY

Well Installation Date: 10/10/94

Project No. 7135-90

Client: NYSDEC

Well Development Date: 10/24/94

Logged by: DB

Checked by: BBJ

Well/Site I.D.: MW-94-23D

Weather: Sunny & Clear 65°F

Start Date: 10/24/94

Finish Date: 10/24/94

Initial Water Level (ft): 7.39' BTOPVC

Start Time: 1005

Finish Time:

Water Level during Initial Pumping/Purging (ft): —

Water Level at Termination of Pumping/Purging (ft): —

Number of Well pJ ~~Volumes~~ gal	TIME	TEMP.	pH	Conductivity	Approximate Pumping Rate (gal/min)	Turbidity (NTU's)
0	1007	17.7	9.32	662		>1000 *
5	1025	14.6	8.78	666		>1000 *
13	1100	15.0	8.78	698		252 *
20	1140	14.6	8.05	543		232 *
25	1210	15.2	7.56	390		308 *
30	1220	15.6	6.85	273		743 *
35	1240	14.7	5.70	194		1050
40	1525	15.2	5.87	195		1182
45	1530	14.4	6.52	151		1036
50	1540	14.4	6.41	176		913
55	1600	14.2	6.36	121		1110
60	1610	14.4	6.07	105		1114

~~NOTES:~~

65	1625	13.5	5.74	124		1022
70	1635	13.5	5.49	128		912
75	1655	13.3	5.44	115		714
80	1705	12.8	5.35	108		535
85	1715	13.3	5.33	112		461
90	1720	12.6	5.23	110		346
95	1730	12.5	5.25	101		283
100	1750	12.6		102		240

PID ≈0.00ppm

~87.70' To bottom of well ≈80.31' H_2O ≈13.65 gal/vol
total volumes pumped 7.3

Well Developer's Signature for Doug Beal, transferred Original

* Turbidity readings not consistant; tried different method of cleaning measurement tube. Calibration checked many times

ABB Environmental Services, Inc.

9404014D(z) L6

APPENDIX D

GROUNDWATER SAMPLING RECORDS

GROUNDWATER SAMPLE FIELD DATA RECORD

Project: SERVALL LAUNDRY
Project Number: 7135-90
Sample Location ID: MW23-S
Site: G.W.D.S.
Date: 10-26-94
Time: Start: 845 End: 918
Signature of Sampler: D B

Water Level/Well Data

Well Depth 69.01 Ft. X Measured ___ Historical

___ Top of Well
___ Top of Protective Casing
X Top PVC

Well Riser Stick-up ≈0.5 Ft. (from ground)

Protective ___ Ft. Casing/Well Difference

Protective ___ Ft. Casing

Depth to Water 6.59 Ft.

Well Material: X PVC ___ SS ___

Well Locked?: X Yes ___ No

Well Dia. X 2 inch ___ 4 inch ___ 6 inch ___

Water Level Equip. Used: X Elect. Cond. Probe ___ Float Activated ___ Press. Transducer ___

Height of Water Column 62.42 Ft. X [X .16 Gal/Ft. (2 in.) / ___ .65 Gal/Ft. (4 in.) / ___ 1.5 Gal/Ft. (6 in.) / ___ Gal/Ft. (__ in.)] = 10.6 Gal/Vol. / 32 Total Gal Purged

Well Integrity:	Yes	No
Prot. Casing Secure	✓	
Concrete Collar Intact	✓	
Other		

Equipment Documentation

Purging/Sampling Equipment Used:

(✓ If Used For)

Purging	Sampling		Equipment ID
		Peristaltic Pump	
		Submersible Pump	
	✓	Bailer	
		PVC/Silicon Tubing	
		Teflon/Silicon Tubing	
		Airlift	
		Hand Pump	
		In-line Filter	
		Press/Vac Filter	
✓		whole pump/tubing	

Decontamination Fluids Used:

(✓ All That Apply at Location)
___ Methanol (100%)
___ 25% Methanol/75% ASTM Type II water
___ Deionized Water
___ Liquinox Solution
___ Hexane
___ HNO_3/D.I. Water Solution
___ Potable Water
___ None
✓ lab cleaned or disposable

Field Analysis Data

PID: Ambient Air 0.0 ppm Well Mouth 0.0 ppm

Purge Data Collected ___ In-line ___ In Container

Sample Observations: __ Turbid __ Clear __ Cloudy __ Colored __ Odor

Purge Data	@ 11 Gal.	@ 22 Gal.	@ 33 Gal.	@ ___ Gal.	@ ___ Gal.
Temperature, Deg. C	11.7	11.6	11.6		
pH, units	5.75	5.87	5.85		
Specific Conductivity (μmhos/cm)	.102 × 2K	.120 × 2K	.112 × 2K		
Turbidity (NTUS)	197	104	74		
Oxidation - Reduction, +/- mv	-	-	-		
Dissolved Oxygen, ppm	-	-	-		

Sample Collection Requirements

(✓ If Required at this Location)

Analytical Parameter	✓ If Sample Collected	Preservation Method	Volume Required	Sample Bottle /Lot Nos.
✓ VOCs	✓	4°C	2x40 ml	
SVOCs		4°C	2x1 liter AG	
Metals		HNO_3,4°C	1x1 liter P	
Cyanide		NaOH,4°C	1x500mLP	
Nitrate/Sulfate		H_2SO_4,4°C	1x1 liter P	
Nitrate/Phosphate		H_2SO_4,4°C	1x1 liter P	
Pest/PCB		4°C	3x1 liter AG	
TPH		H_2SO_4,4°C	2x1 liter AG	
TOC		H_2SO_4,4°C	1x1 liter P	

Notes: Vials preserved from laboratory

GROUNDWATER SAMPLE FIELD DATA RECORD

Project: SERVALL LAUNDRY
Project Number: 7135-90
Sample Location ID: MW23-D
Site: G.W.D.S.
Date: 10-26-94
Time: Start: 705 End: 839
Signature of Sampler: J B

Water Level/Well Data

Well Depth 87.44 Ft.
X Measured
__ Historical

__ Top of Well
__ Top of Protective Casing
X top PVC

Well Riser Stick-up ~0.5 Ft. (from ground)

Protective ____ Ft. Casing/Well Difference

Protective ____ Ft. Casing

Depth to Water 6.51 Ft.

Well Material:
X PVC
__ SS
____

Well Locked?:
X Yes
__ No

Well Dia.
X 2 inch
__ 4 inch
__ 6 inch
__ ____

Water Level Equip. Used:
X Elect. Cond. Probe
__ Float Activated
__ Press. Transducer
__ ____

Height of Water Column 80.43 Ft. X
X .16 Gal/Ft. (2 in.)
__ .65 Gal/Ft. (4 in.)
__ 1.5 Gal/Ft. (6 in.)
__ __ Gal/Ft. (__ in.)
= 12.94 Gal/Vol.
40 Total Gal Purged

Well Integrity:	Yes	No
Prot. Casing Secure	X	
Concrete Collar Intact	X	
Other ____		

Equipment Documentation

Purging/Sampling Equipment Used:

(✓ If Used For)

Purging	Sampling		Equipment ID
		Peristaltic Pump	
		Submersible Pump	
	X	Bailer	
		PVC/Silicon Tubing	
		Teflon/Silicon Tubing	
		Airlift	
		Hand Pump	
		In-line Filter	
		Press/Vac Filter	
X		Whale Pump/tubing	

Decontamination Fluids Used:

(✓ All That Apply at Location)
__ Methanol (100%)
__ 25% Methanol/75% ASTM Type II water
__ Deionized Water
__ Liquinox Solution
__ Hexane
__ HNO_3/D.I. Water Solution
__ Potable Water
__ None
X lab deconed/disposable
__ ____

Field Analysis Data

PID: Ambient Air 0.0 ppm Well Mouth 0.0 ppm

Purge Data Collected __ In-line
X In Container

Sample Observations:
X Turbid __ Clear X Cloudy
__ Colored __ Odor

Purge Data	@ 13 Gal.	@ 26 Gal.	@ 40 Gal.	@ ____ Gal.	@ ____ Gal.
Temperature, Deg. C	11.8	11.7	11.7		
pH, units	6.25	5.92	5.92		
Specific Conductivity (µmhos/cm)	.117 x 2K	.115 x 2K	.112 x 2K		
Turbidity (NTUS)	570	627	544		
Oxidation - Reduction, +/- mv	-	-	-		
Dissolved Oxygen, ppm	-	-			

Sample Collection Requirements
(✓ If Required at this Location)

Analytical Parameter	✓ If Sample Collected	Preservation Method	Volume Required	Sample Bottle ILot Nos.
X VOCs	✓	4°C	2x40 ml	
__ SVOCs		4°C	2x1 liter AG	
__ Metals		HNO_3,4°C	1x1 liter P	
__ Cyanide		NaOH,4°C	1x500mLP	
__ Nitrate/Sulfate		H_2SO_4,4°C	1x1 liter P	
__ Nitrate/Phosphate		H_2SO_4,4°C	1x1 liter P	
__ Pest/PCB		4°C	3x1 liter AG	
__ TPH		H_2SO_4,4°C	2x1 liter AG	
__ TOC		H_2SO_4,4°C	1x1 liter P	

Notes: vials pre-preserved from laboratory

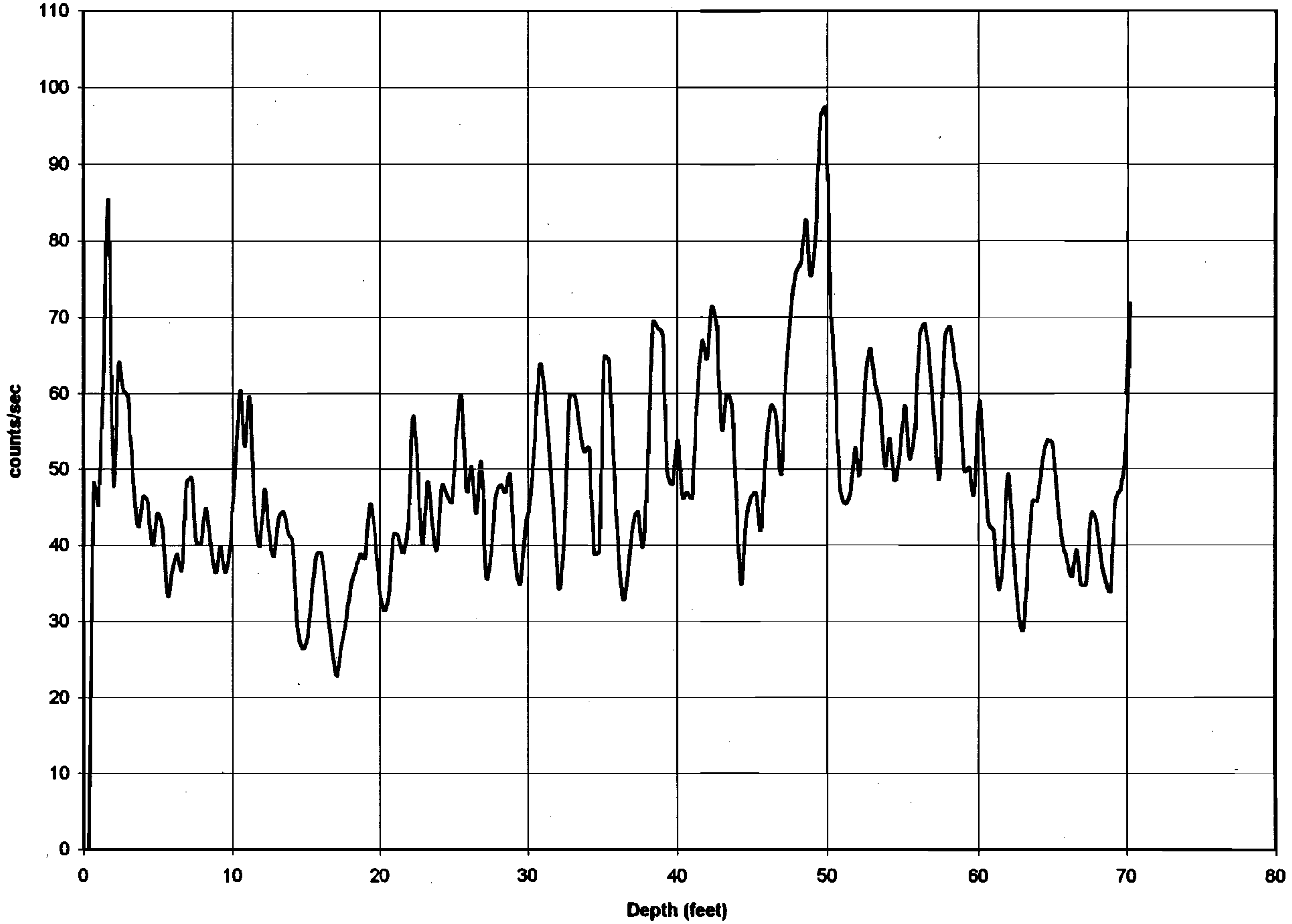
ABB Environmental Services

9404014D L22

APPENDIX E

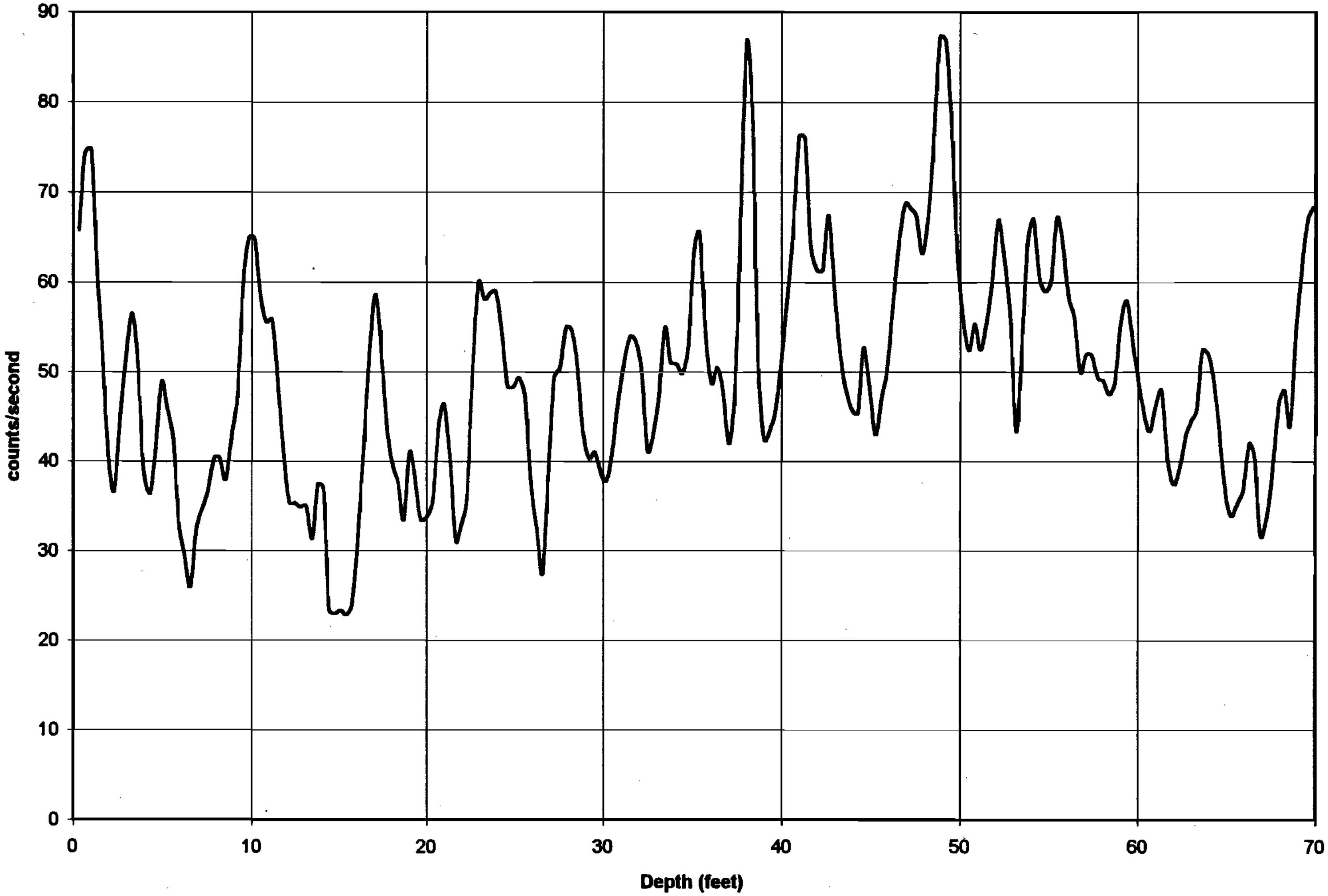
GAMMA LOGS AND INDUCTION LOGS

ServAll PZ94-2D Gamma Log (down) 9/26/94



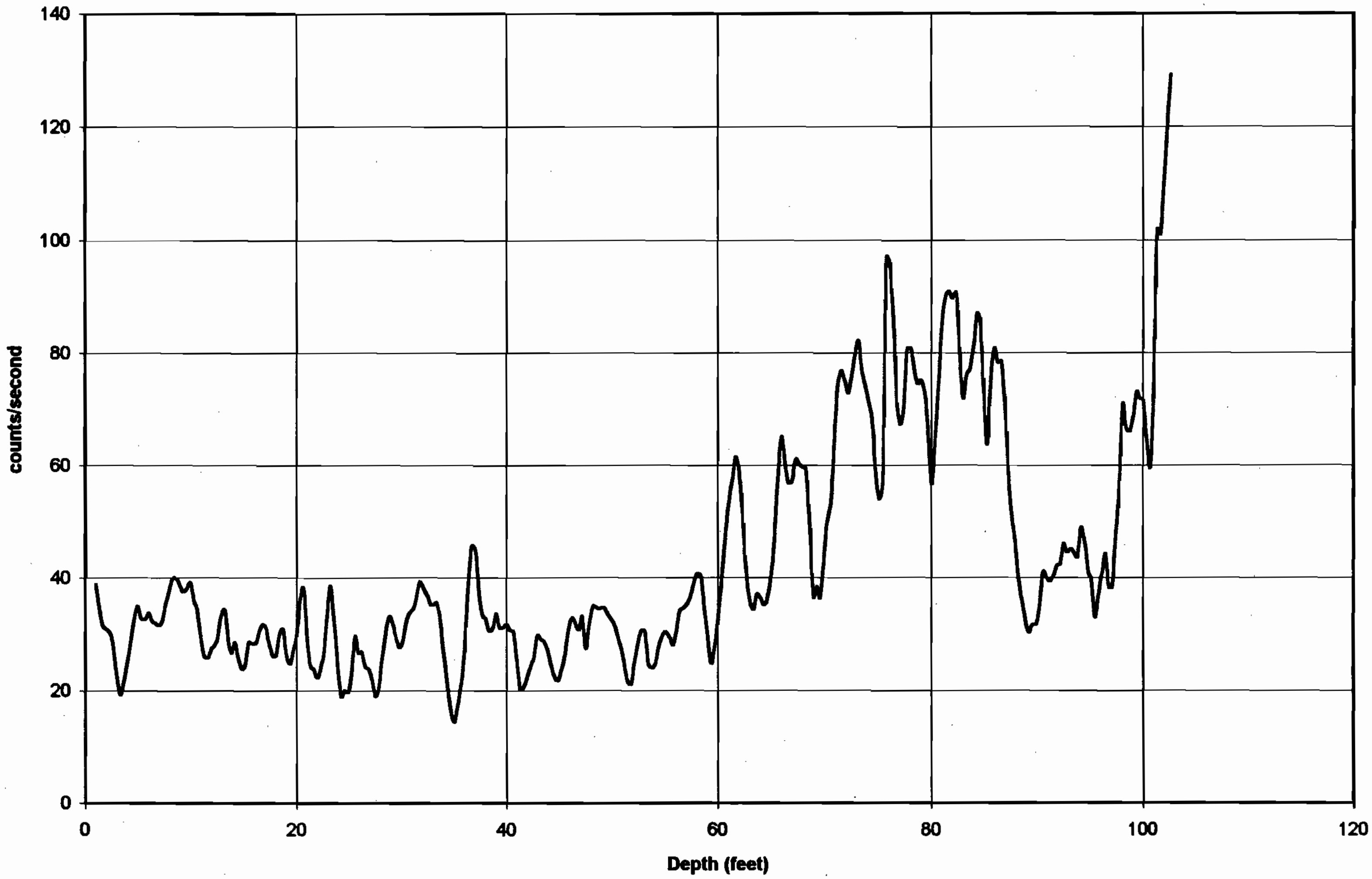
2D_GD Chart 1

ServAll PZ94-2D Gamma Log (up) 9/26/94



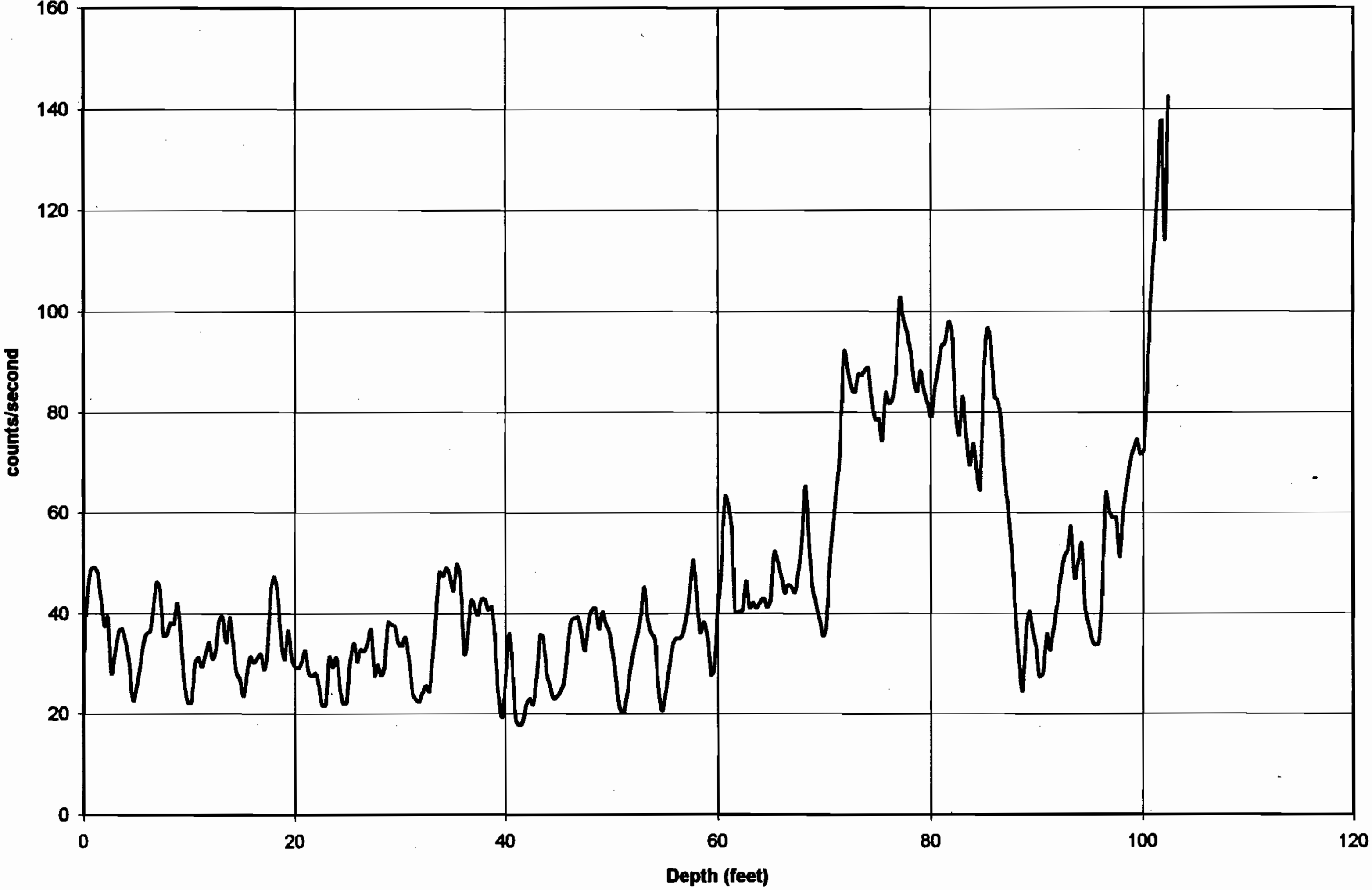
2D_GD Chart 2

ServAll PZ94-3D Gamma Log (up) 10/7/94



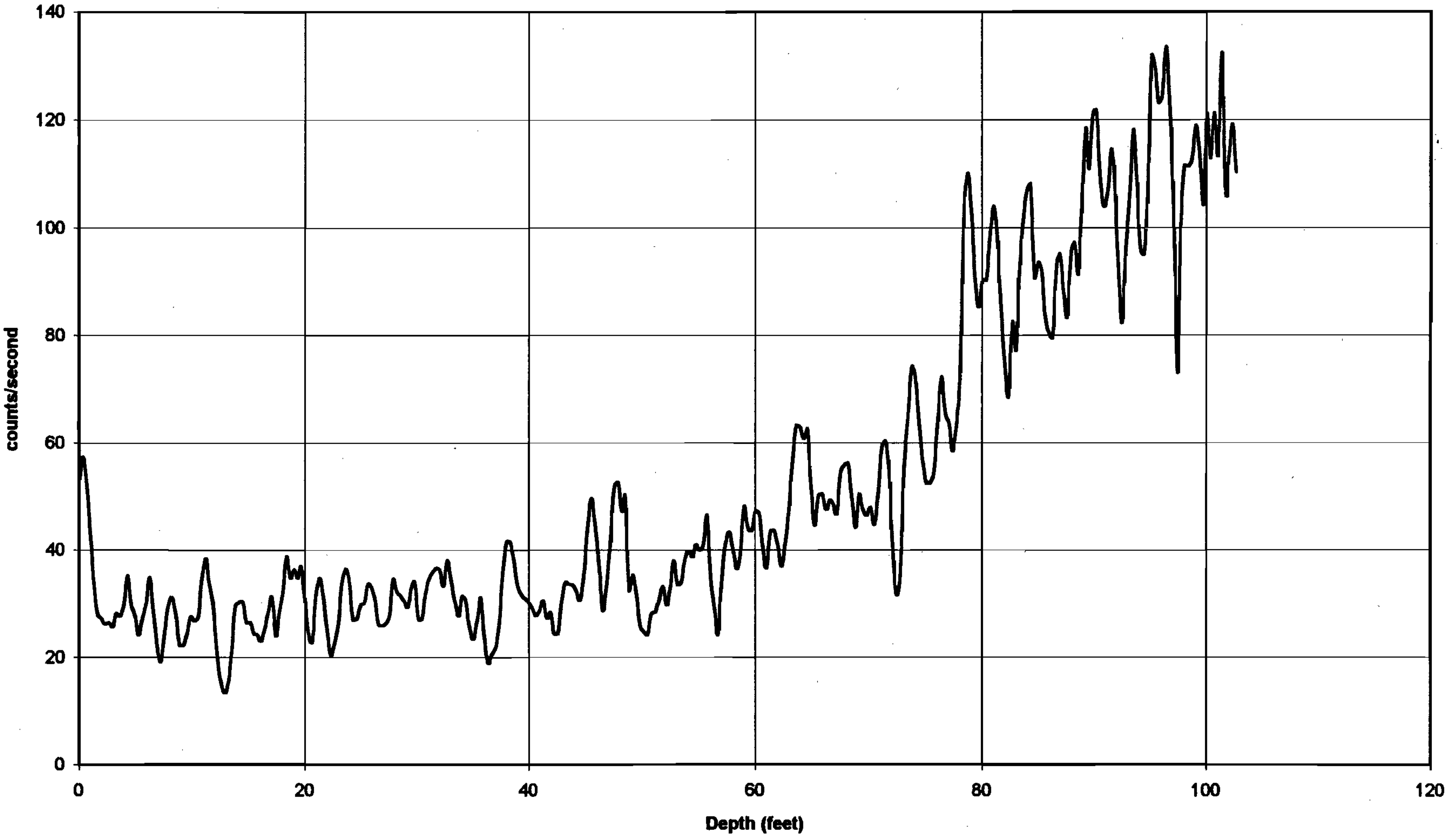
3D-GU Chart 1

ServAll PZ94-3D Gamma Log (down) 10/7/94

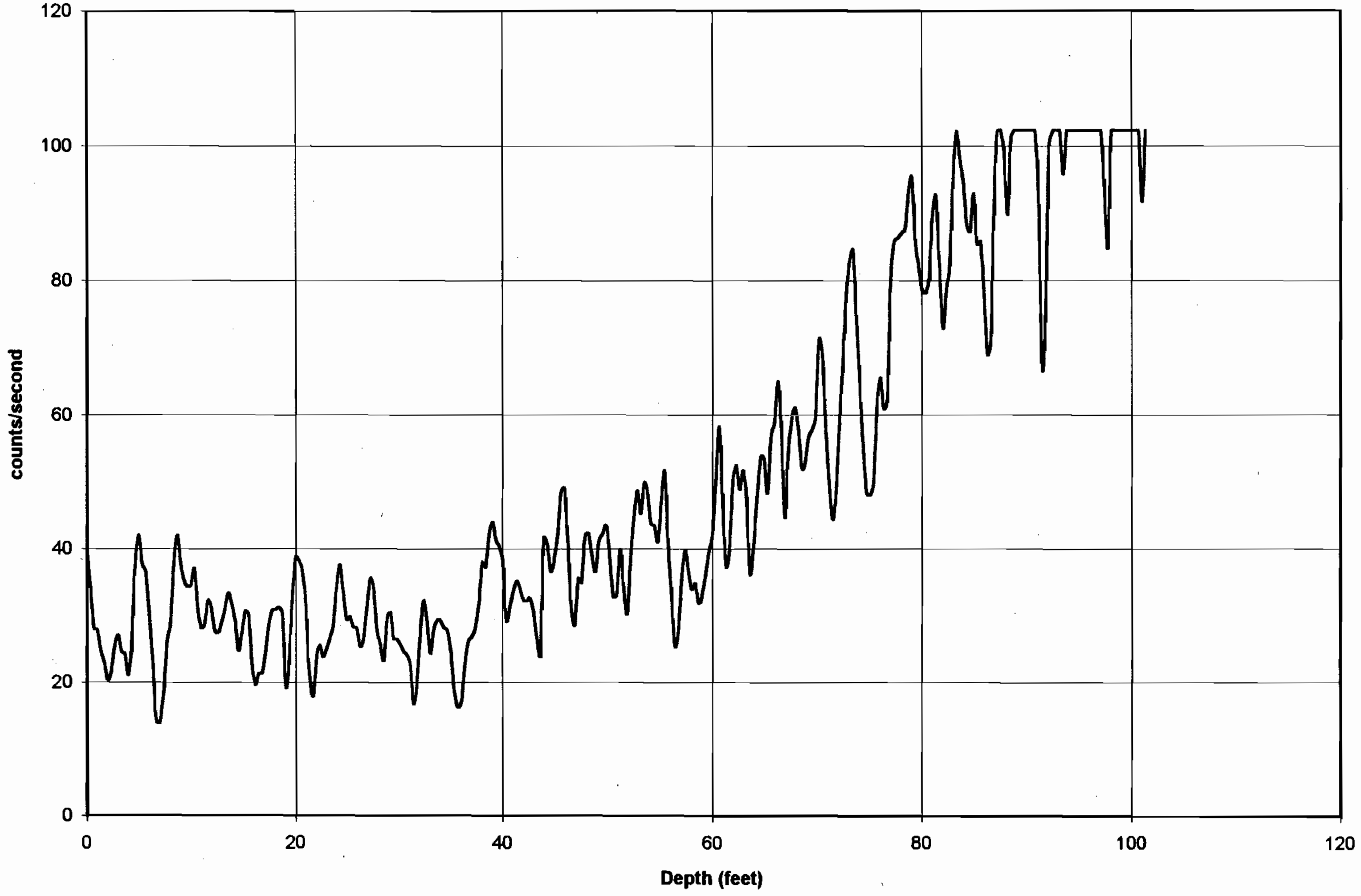


3D-GD Chart 1

ServAll PZ94-10D Gamma Log (up, run 1) 9/27/94

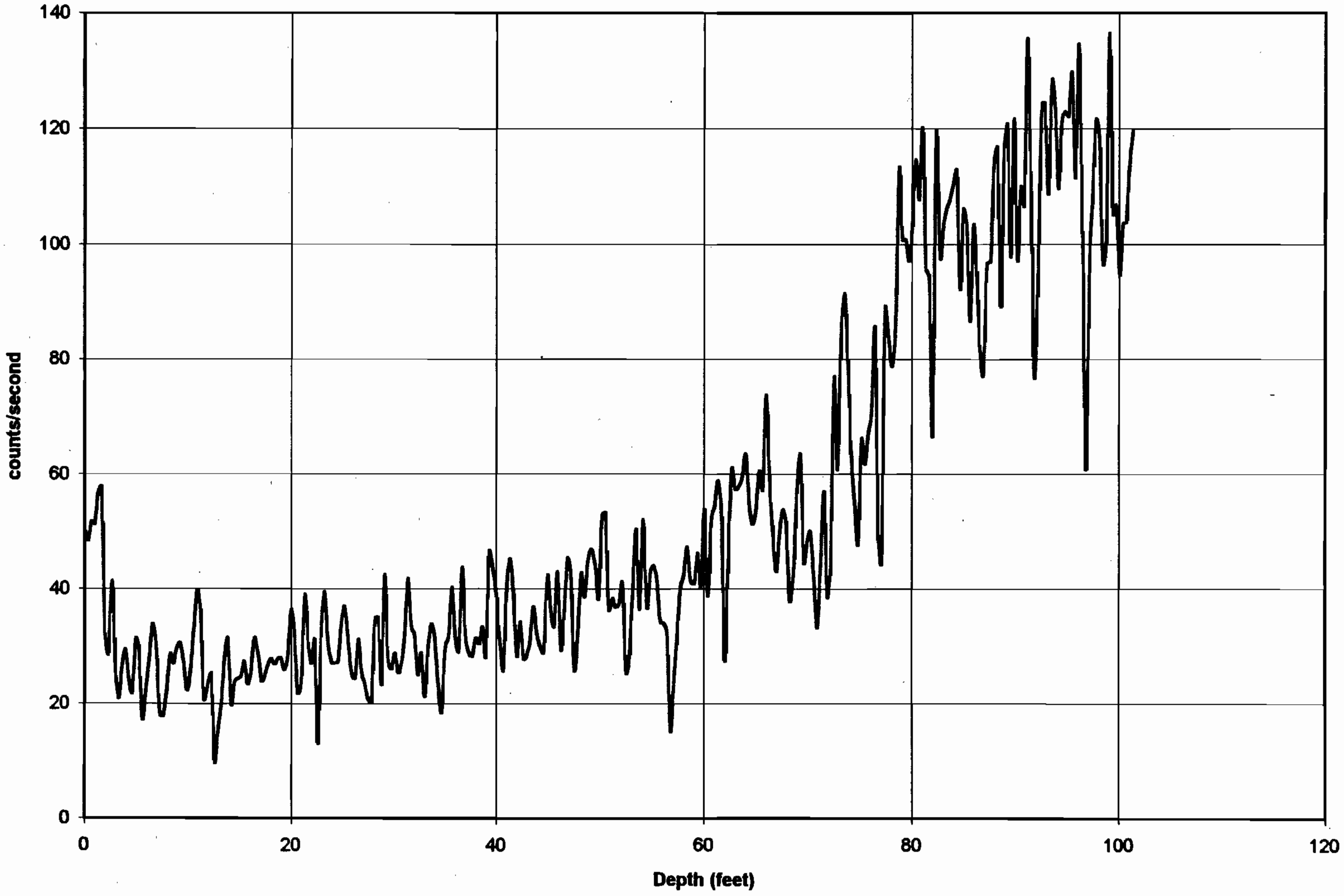


ServAll PZ94-10D Gamma Log (up, run 2) 9/27/94



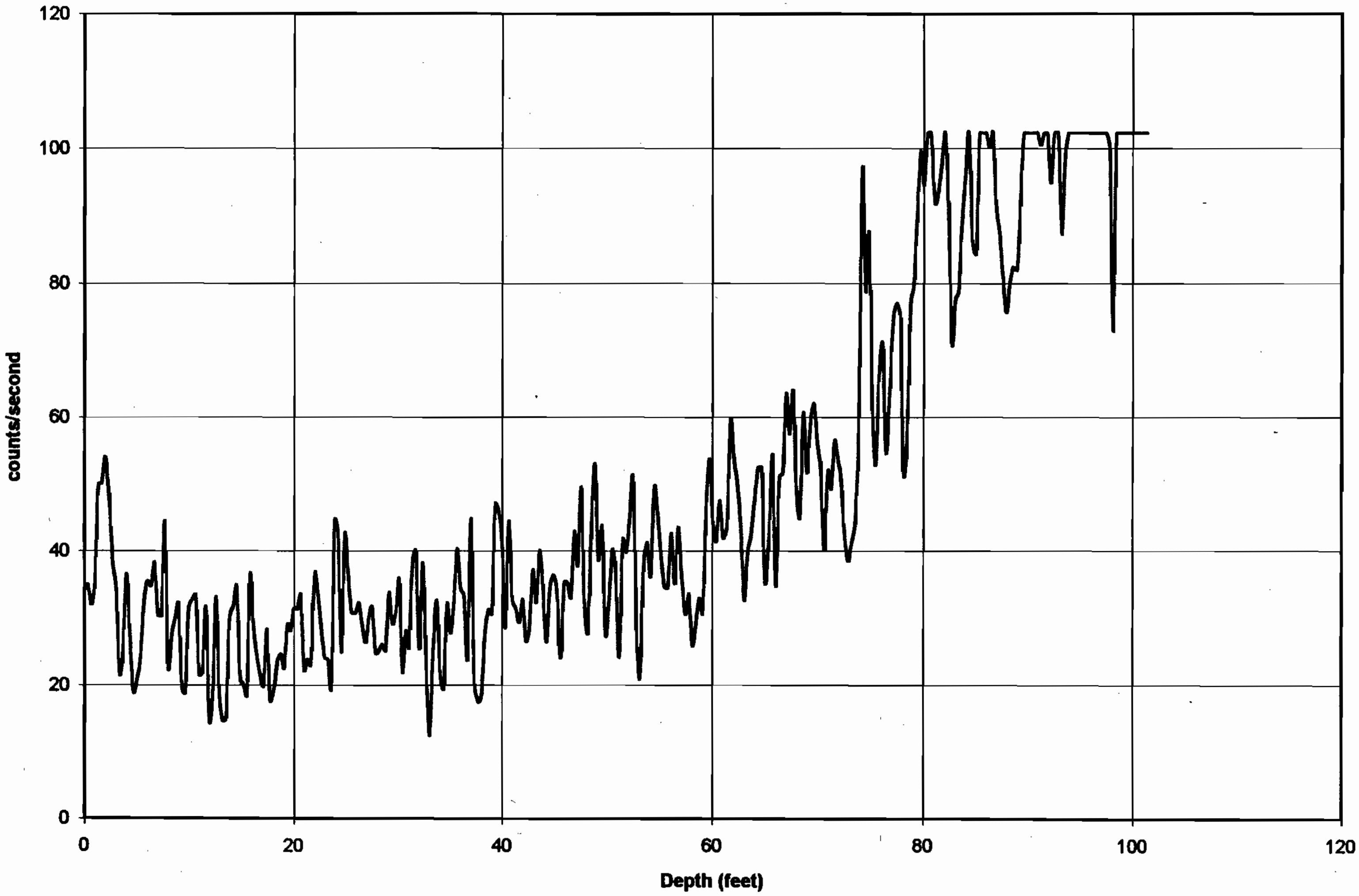
10D_GU2 Chart 1

ServAll PZ94-10D Gamma Log (down) 9/27/94



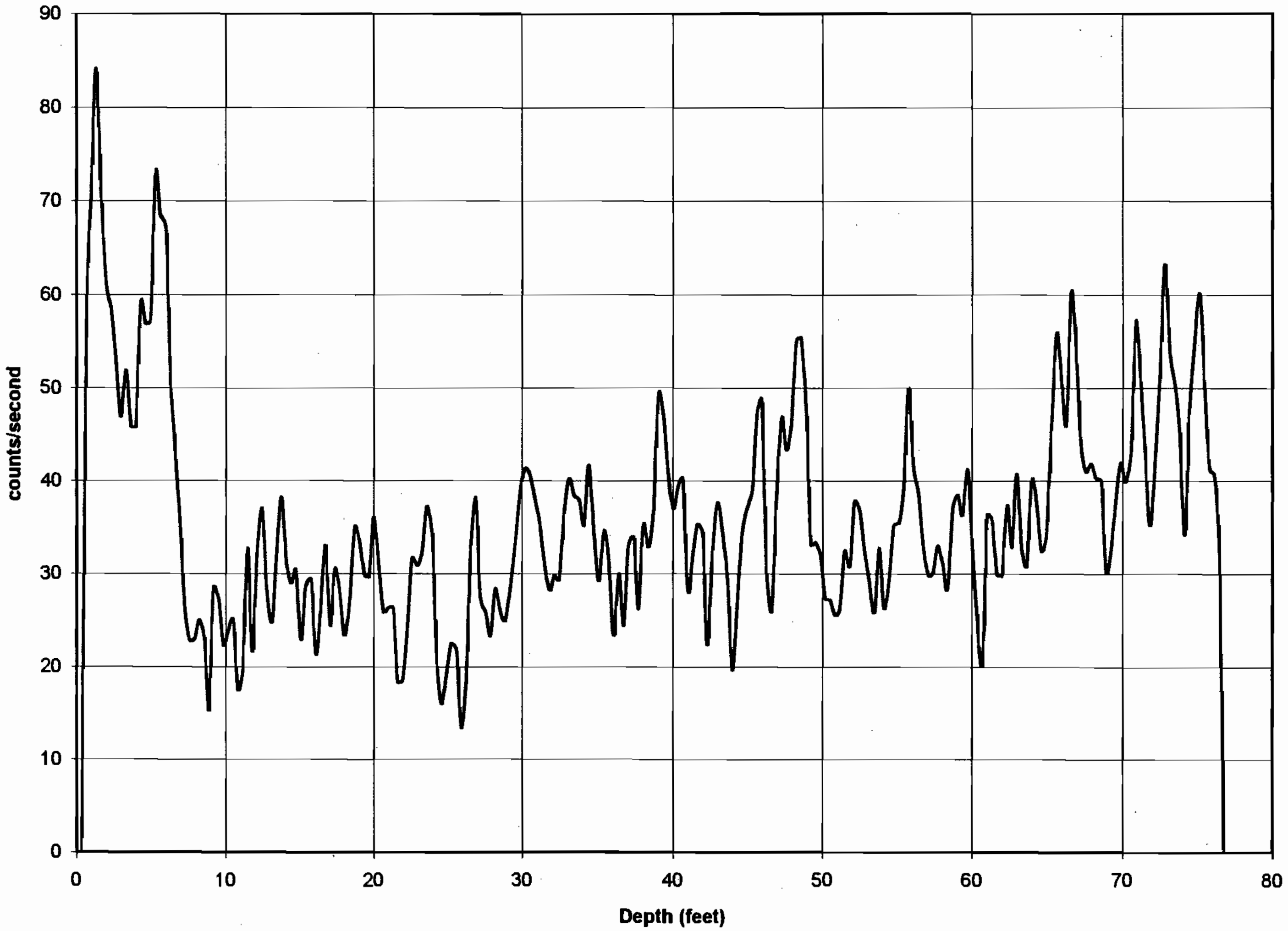
10D_GD Chart 1

ServAll PZ94-10D Gamma Log (down) 9/27/94

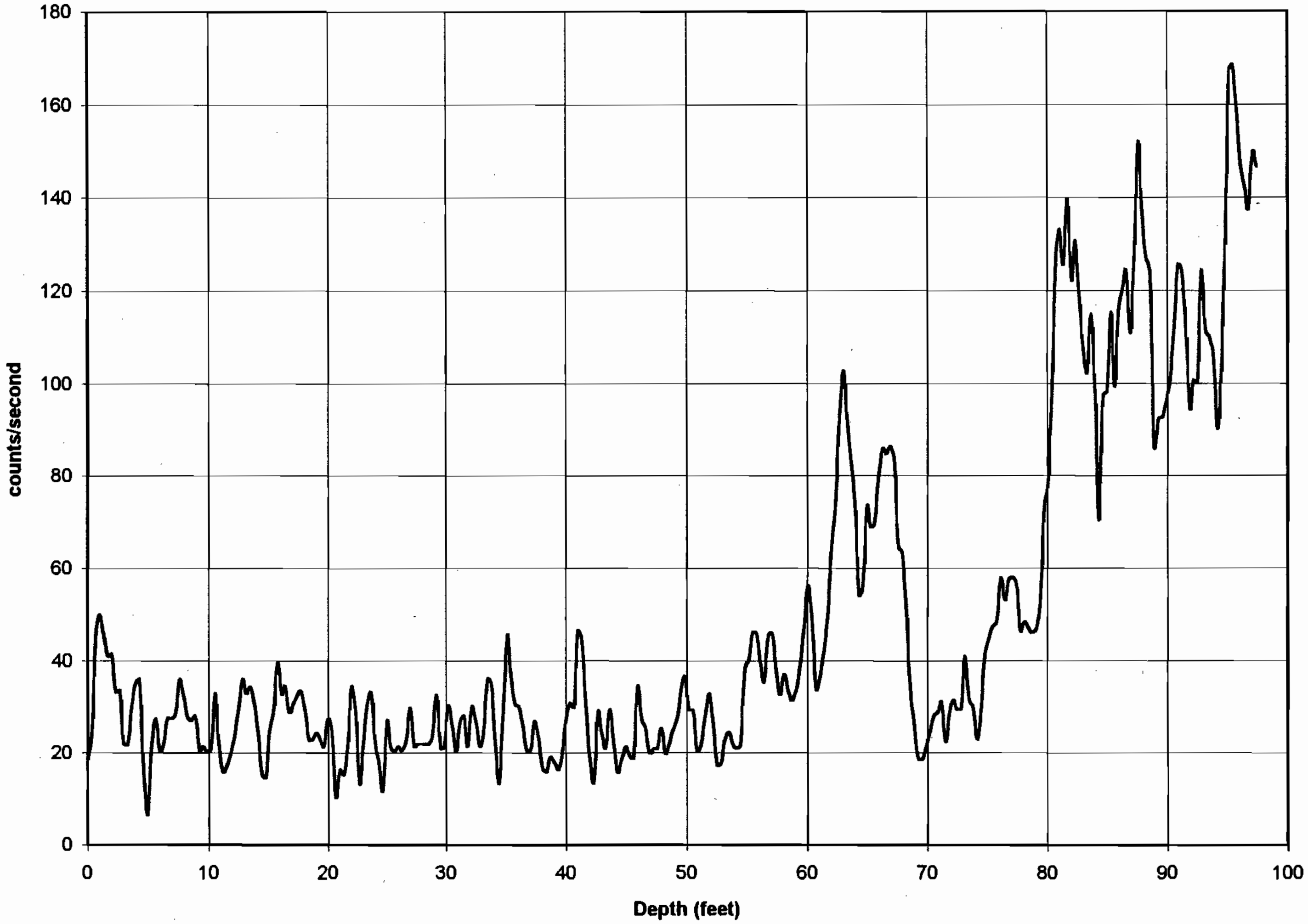


10D_GD2 Chart 1

ServAll MW-16 Gamma Log (down) 9/27/94

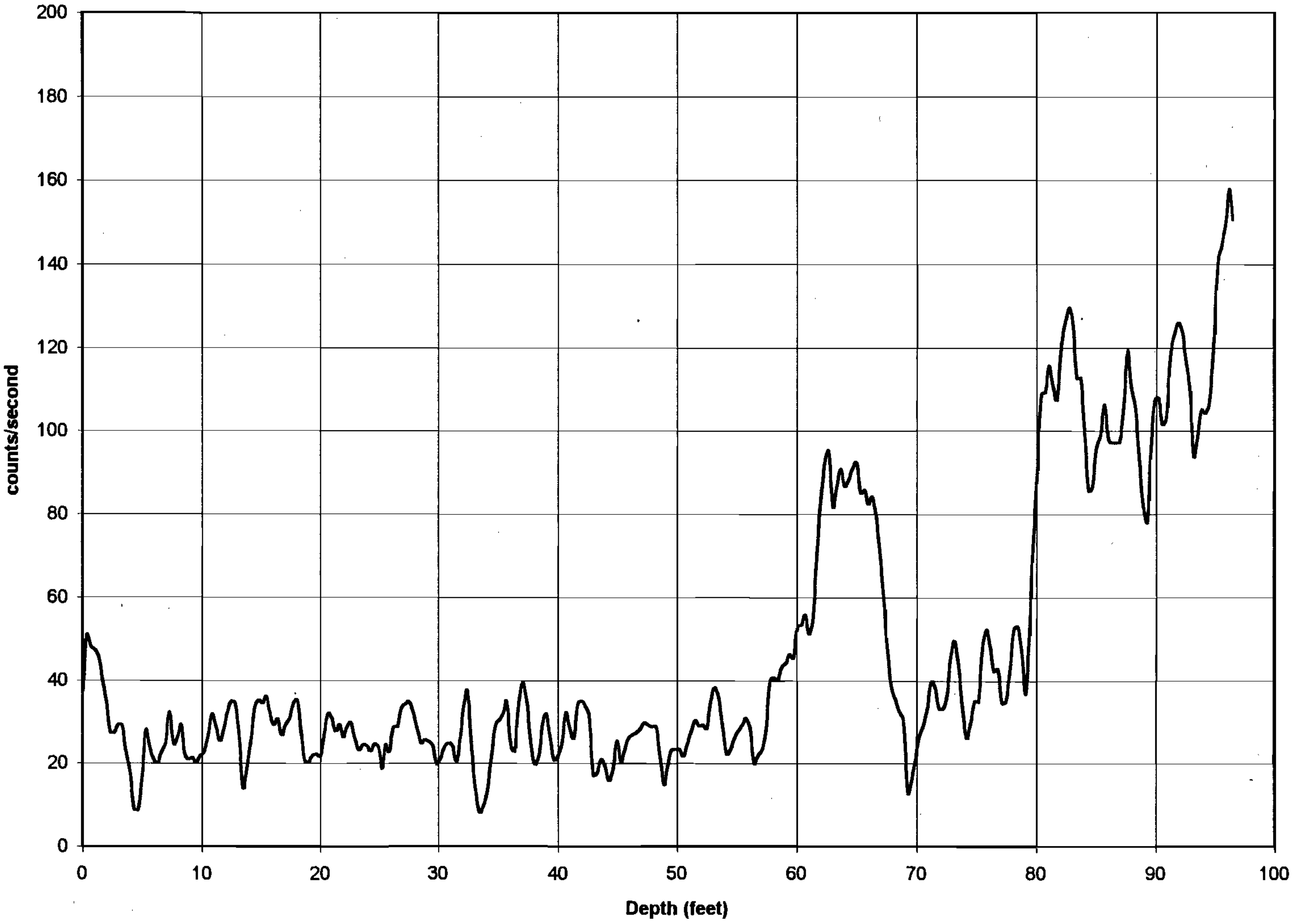


ServAll PZ94-19D Gamma Log (down, run 1) 9/26/94



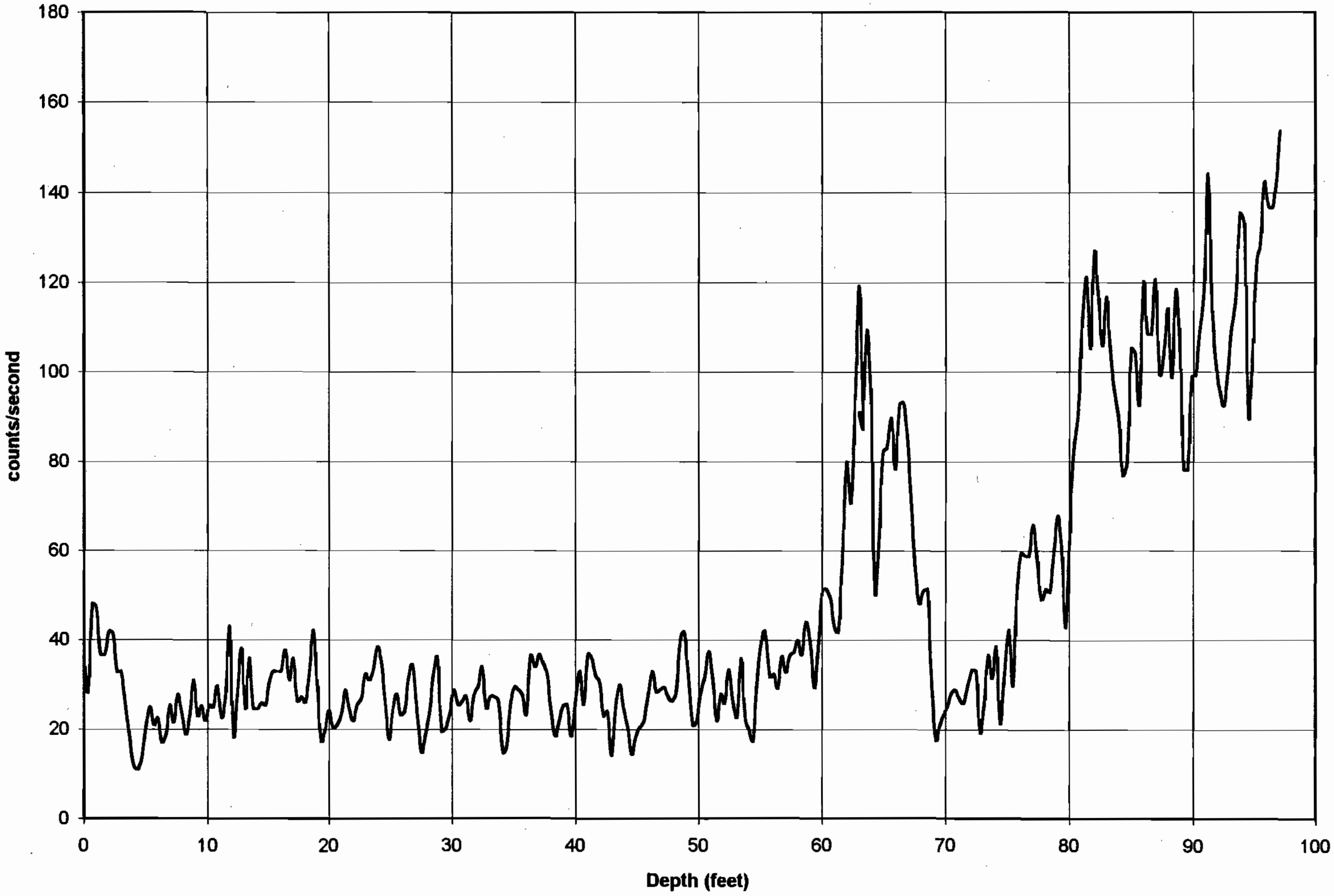
19D_GD Chart 1

ServAll PZ94-19D Gamma Log (up) 9/26/94

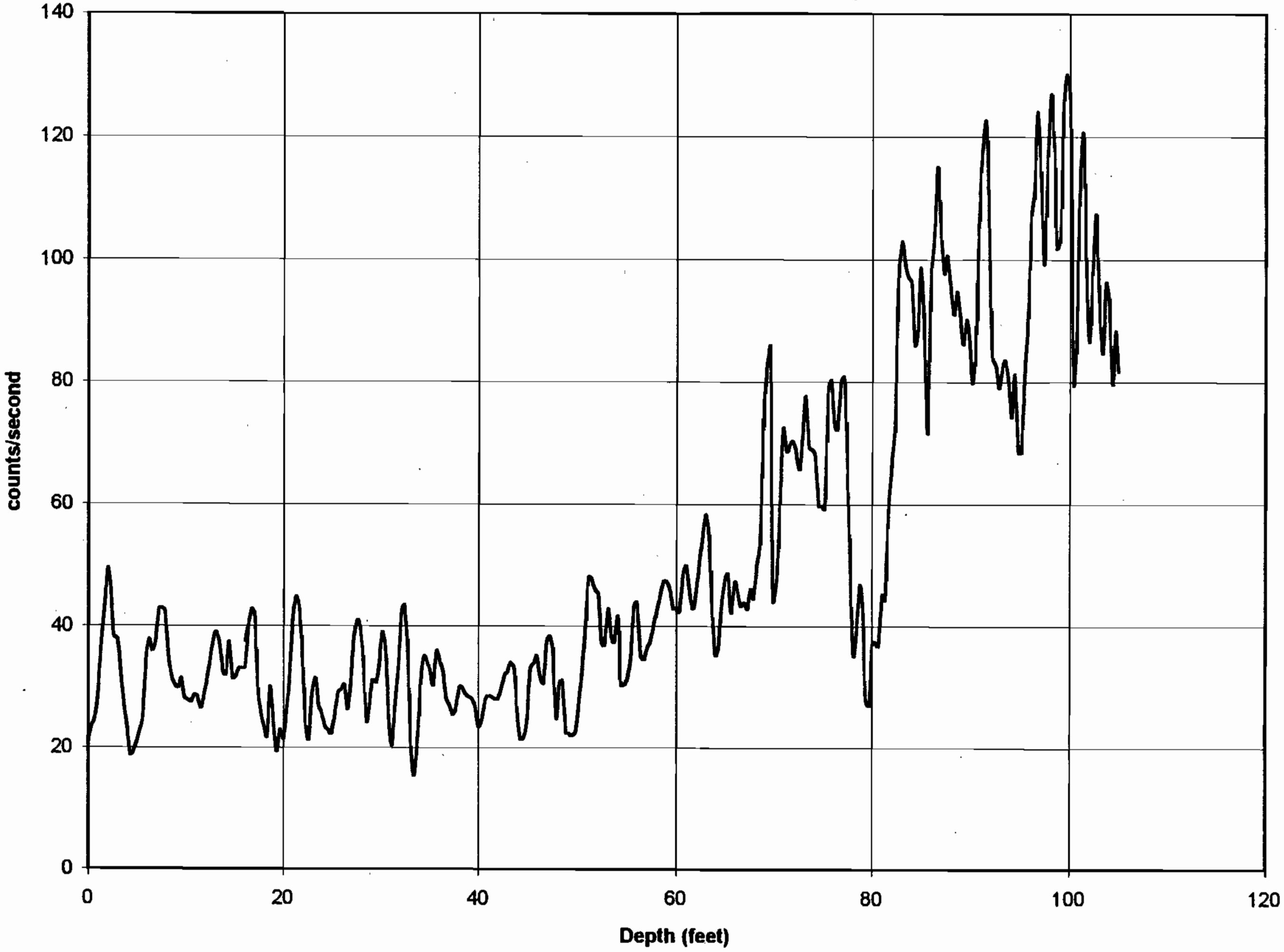


19D_GU Chart 1

ServAll PZ94-19D Gamma Log (down, run 2) 9/26/94

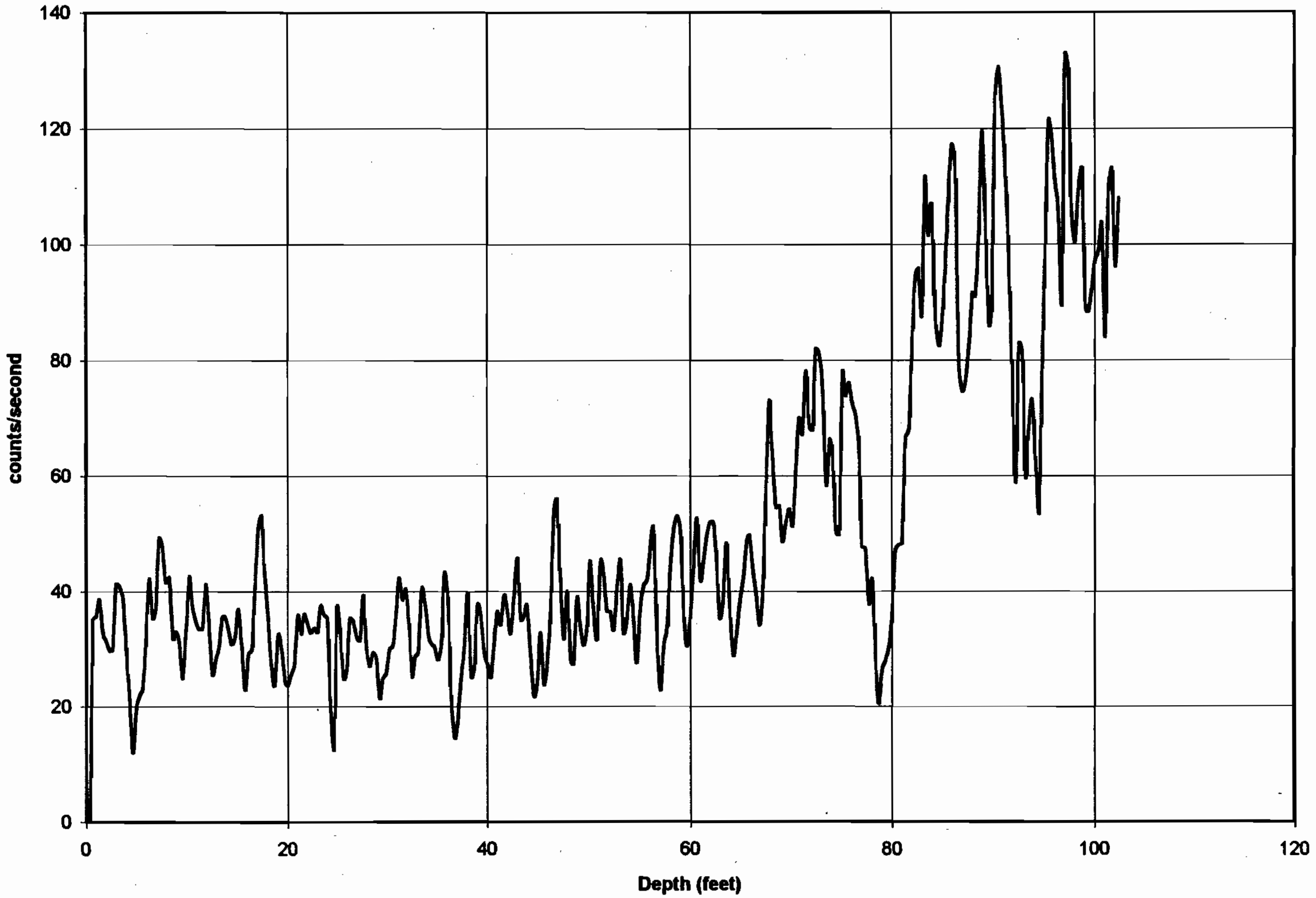


19D_GD2 Chart 1


ServAll PZ94-27D Gamma Log (up) 10/5/94

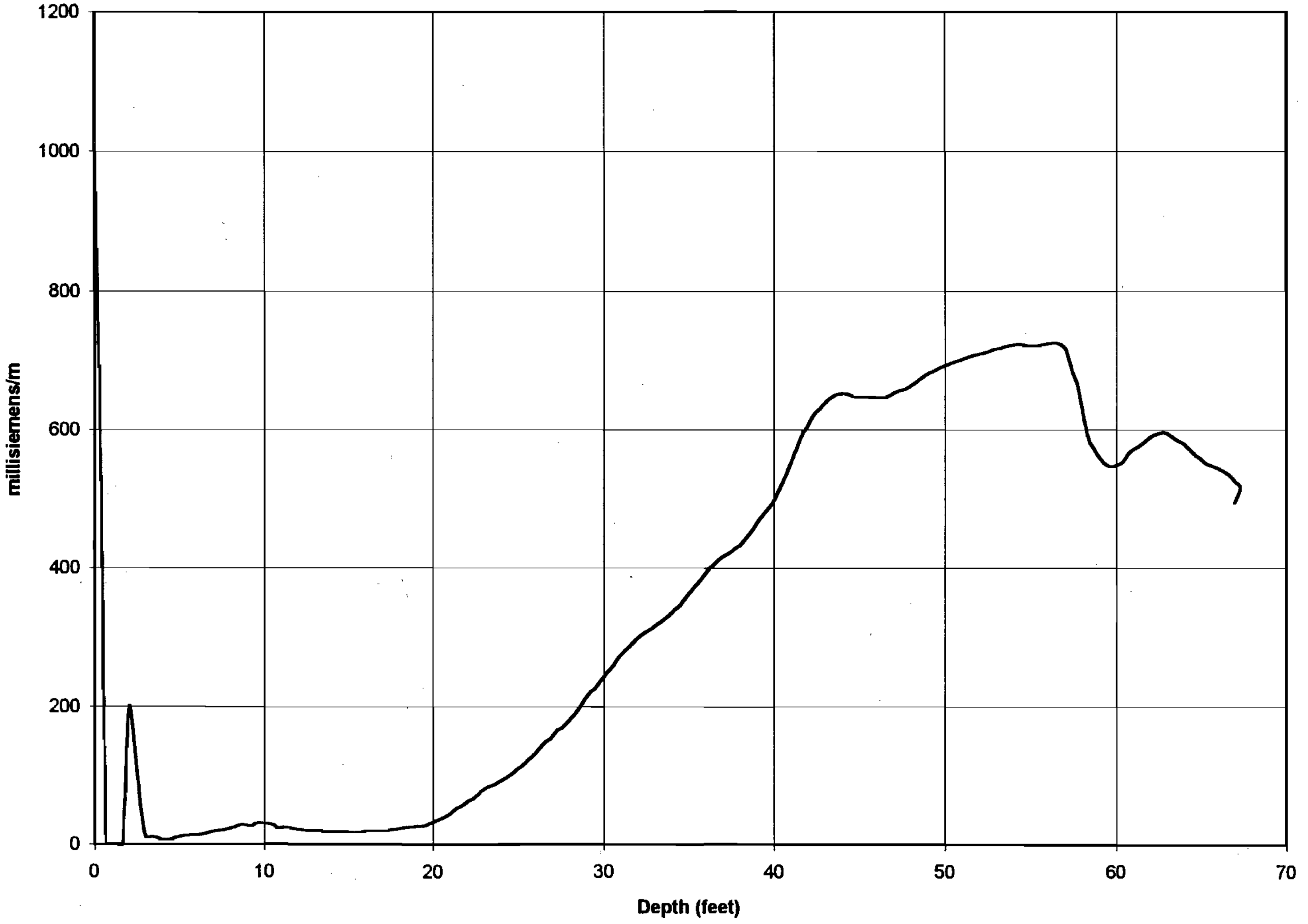
27D_GU Chart 1

ServAll PZ94-27D Gamma Log (down) 10/5/94



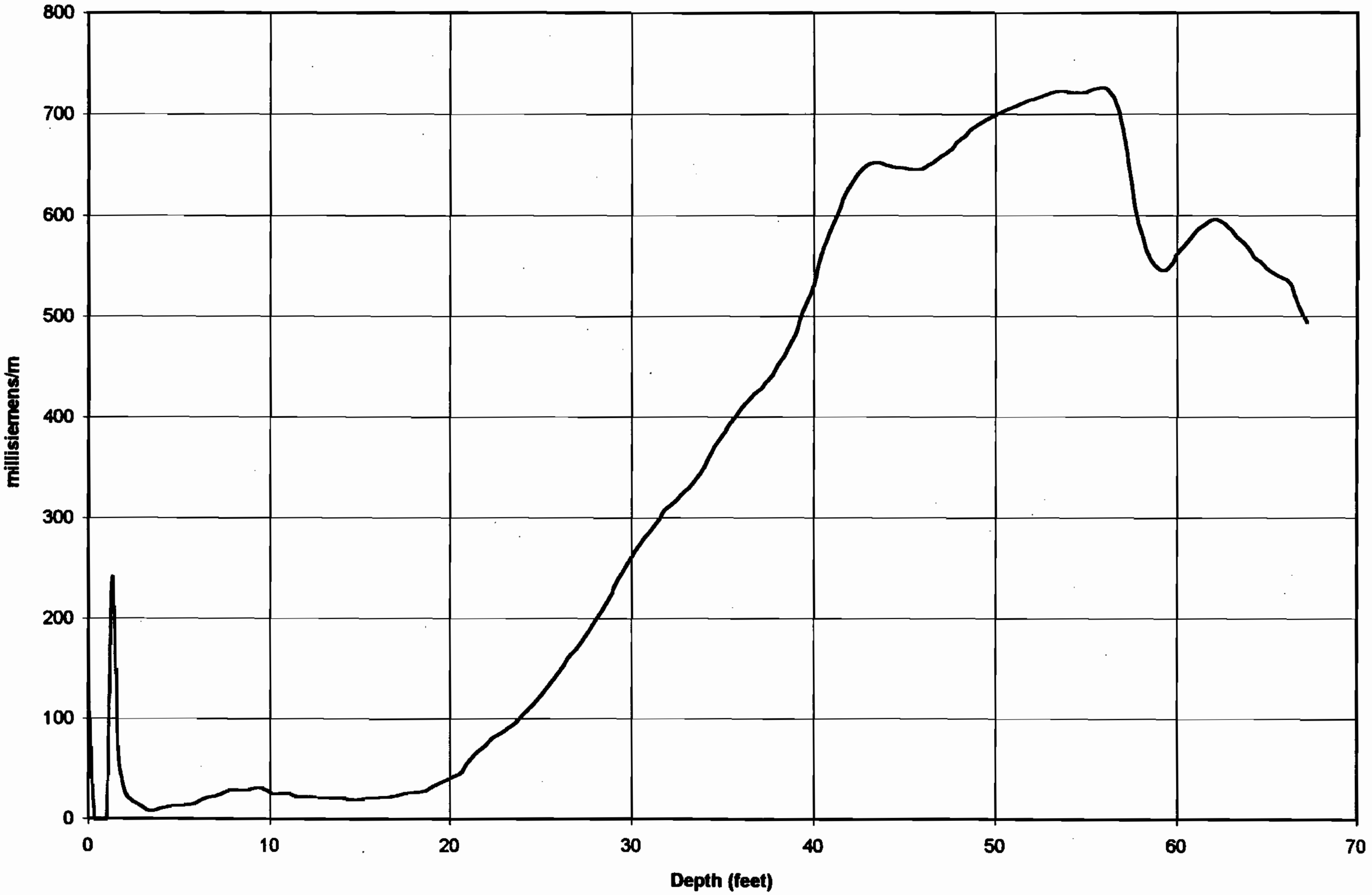
27D_GD Chart 1

ServAll PZ94-2D Induction Log (down) 9/26/94



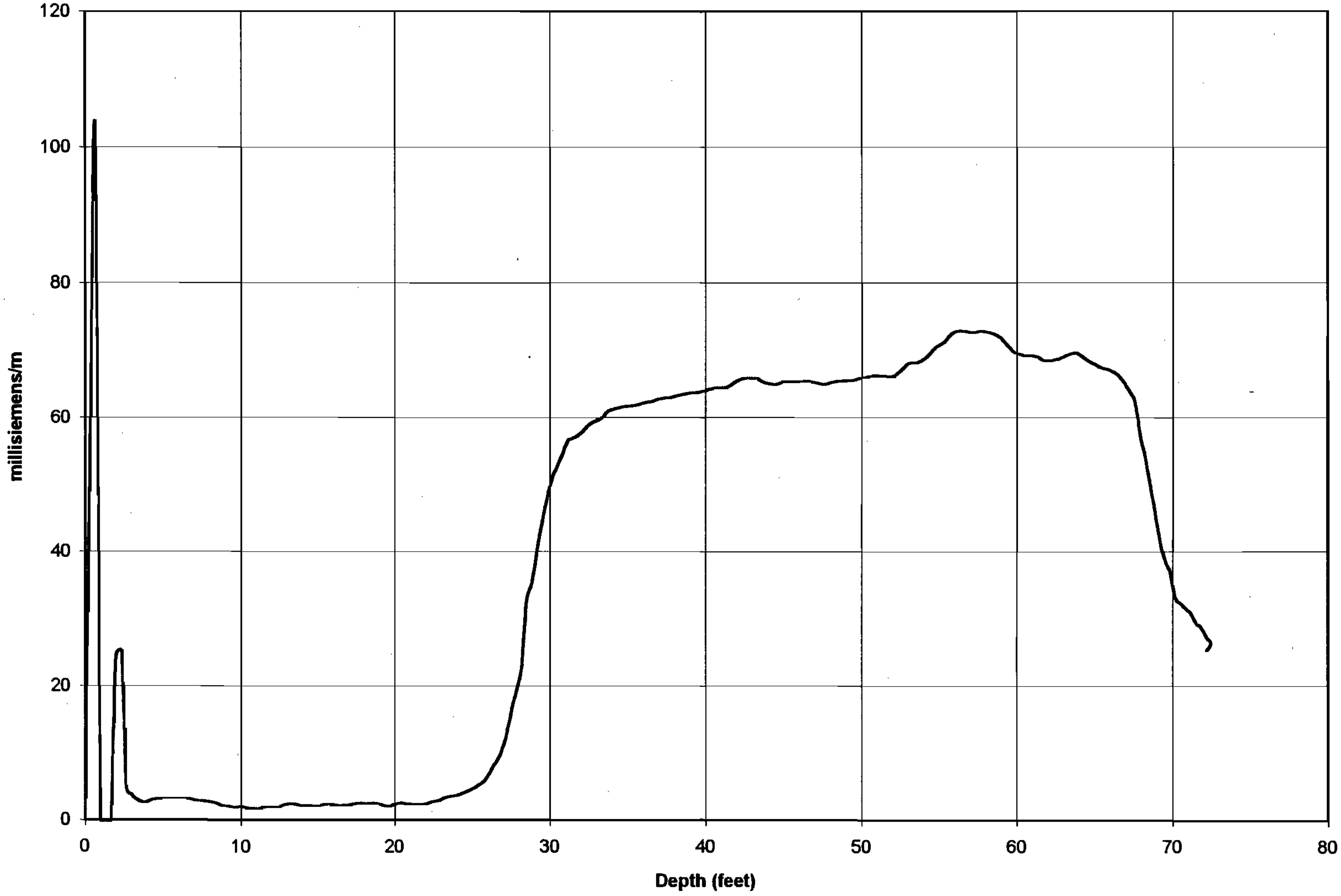
2D_CD Chart 1

ServAll PZ94-2D Induction Log (up) 9/26/94



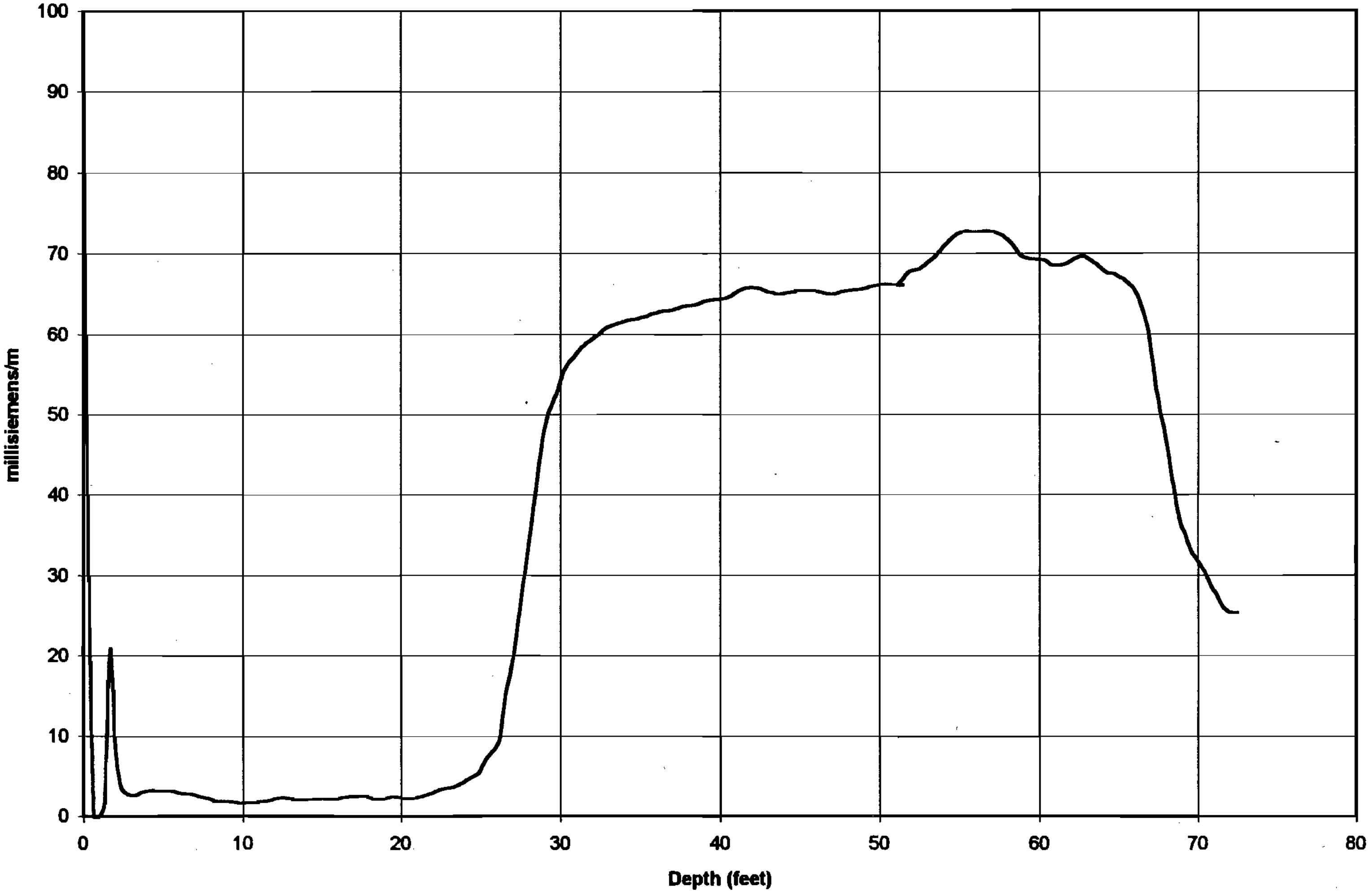
2D_CU Chart 2

ServAll PZ94-4D Induction Log (down) 10/6/94



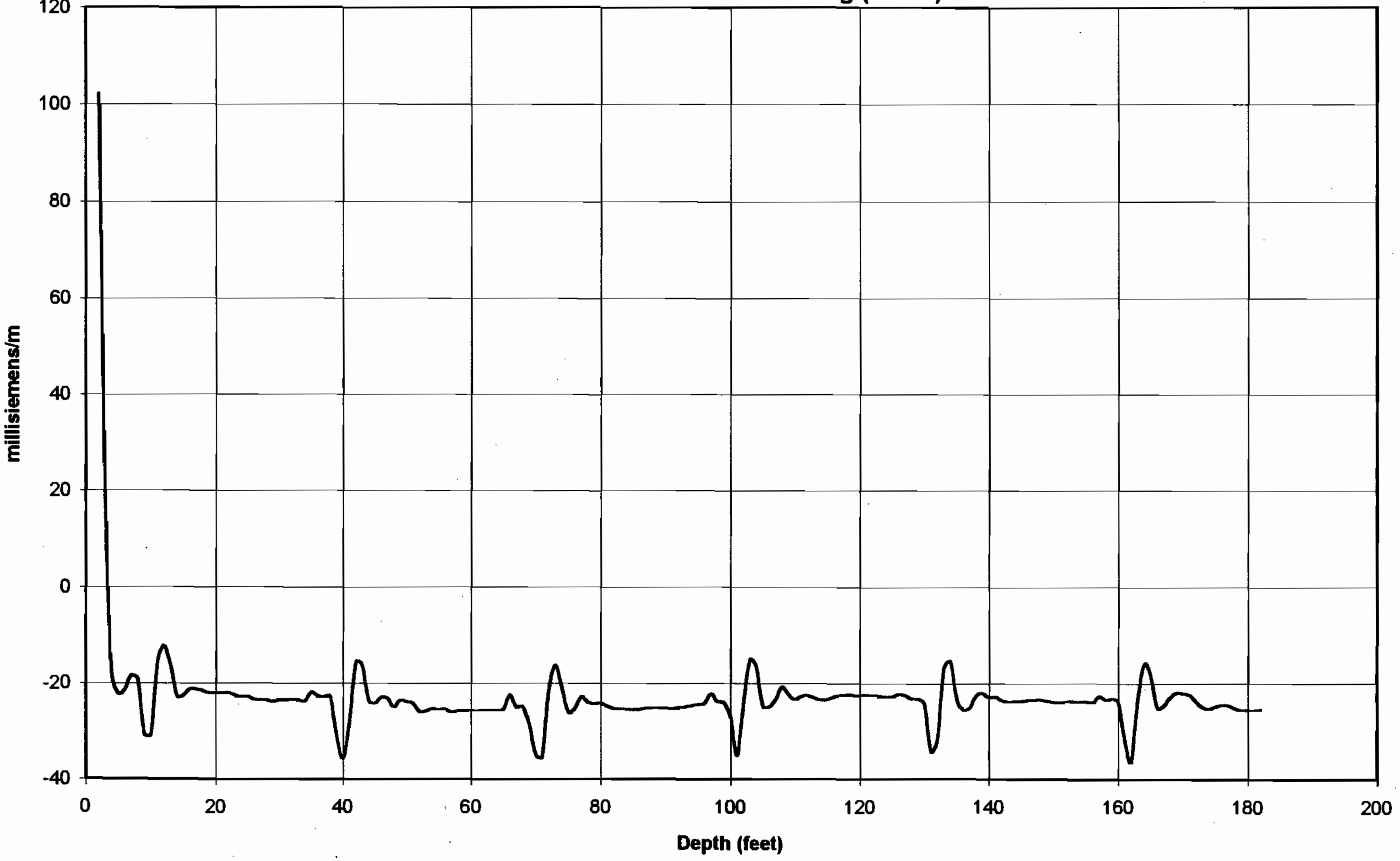
4D_CD Chart 1

ServAll PZ94-4D Induction Log (up) 10/6/94



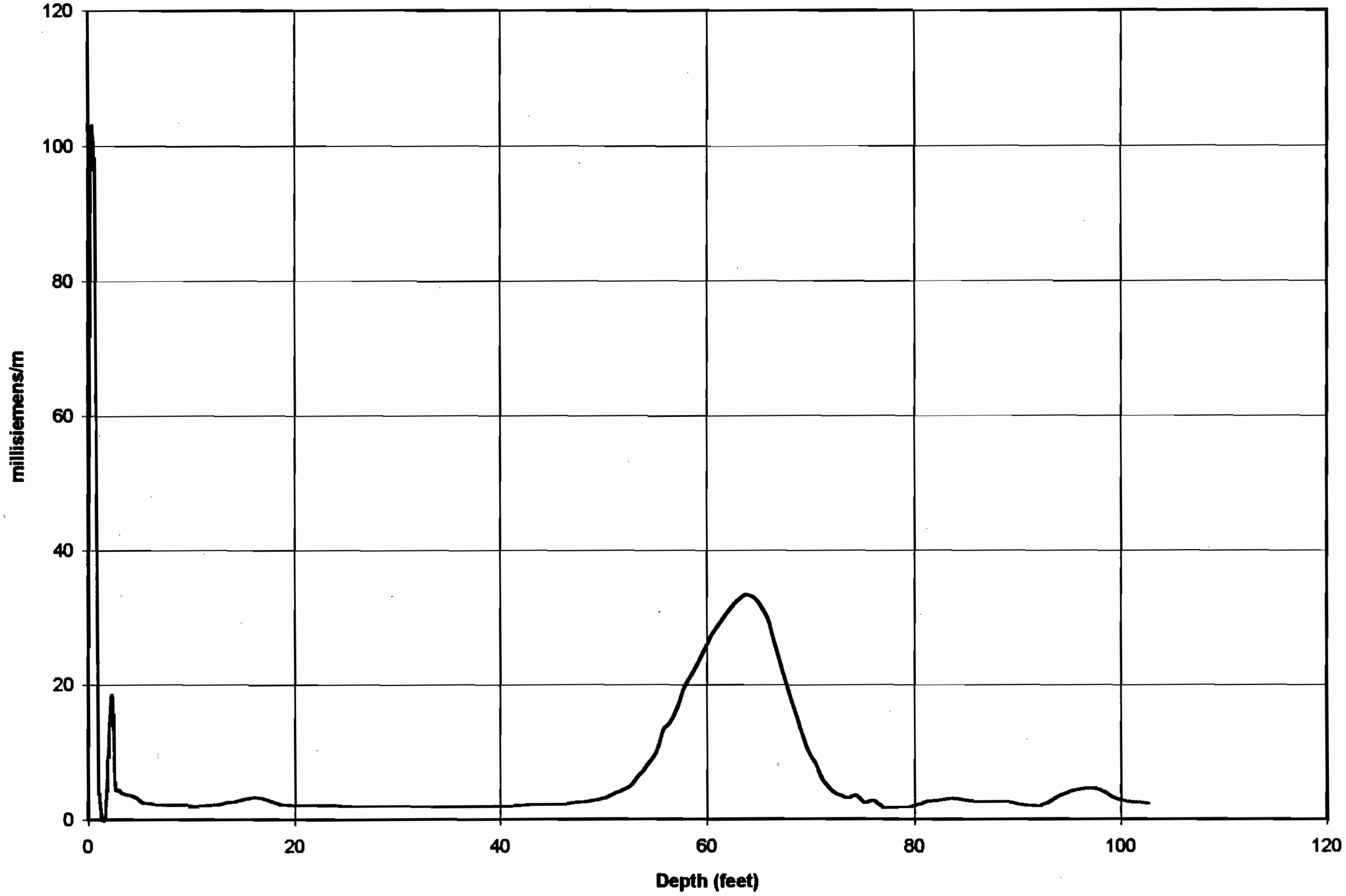
4D_CU Chart 1

ServAll MW16 Induction Log (down) 9/27/94

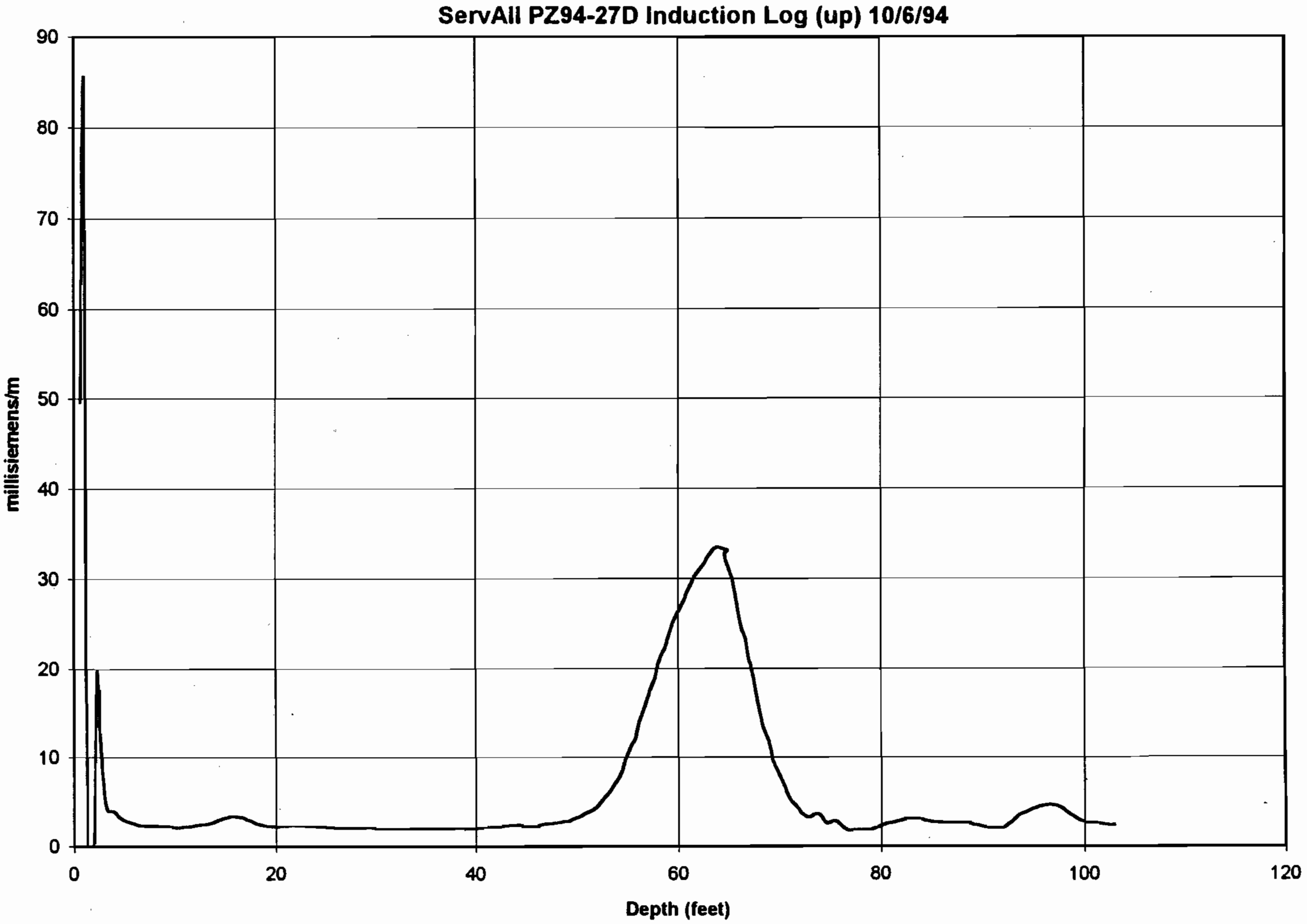


MW16_CD Chart 1

ServAll PZ94-27D Induction Log (down)10/6/94



27_CD Chart 1



27D_CU Chart 1

APPENDIX F

HARMONIC SLUG TEST RESULTS

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HARMONIC SLUG TEST ANALYSIS                                    07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                              SERVALL
                          MW-1 RH RUN 1
                        ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  55.8        ft
       Length of well screen:  10.0        ft
        Well casing diameter:   0.330      ft
       Drilled hole diameter:   0.420      ft
         Storage coefficient:   3.00E-01
            Gravity constant:   3.22E+01   ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

              Time per cycle:   3.67       sec
           Angular frequency:   1.71E+00   1/sec
            Damping constant:   5.36E-01   1/sec
            Effective length:  10.0        ft
               d Coefficient:   2.99E-01
               a Coefficient:   0.00E+00
               b Coefficient:   8.13E-02
           Error of fit (RMS):   7.7        %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   3.09E-02   sft/sec
     Hydraulic conductivity :   3.09E-03   ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDD

 No.  Time     WaterLvl    No.  Time     WaterLvl    No.  Time     WaterLvl
     (sec)     (ft)            (sec)     (ft)            (sec)     (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1  -0.0000    0.510      2   0.4020    0.300      3   1.4040    0.230
  4   2.4000    0.150      5   3.4020    0.080      6   4.4040    0.060
  7   5.4000    0.010      8   6.4020   -0.000      9   7.4040   -0.000
 10   8.4000    0.020     11   9.4020   -0.000     12  11.4000   -0.010
 13  12.4020    0.010     14  13.4040   -0.000     15  14.4000   -0.000
 16  15.4020   -0.000     17  16.4040   -0.000     18  17.4000   -0.010
 19  18.4020   -0.000     20  23.4060   -0.000     21  28.4040   -0.000
 22  33.4020   -0.000     23  38.4060   -0.000     24  43.4040   -0.000
 25  48.4020   -0.000     26  53.4060   -0.000     27  58.4040   -0.000
 28  63.4020   -0.010     29  68.4060   -0.000     30  73.4040   -0.000
 31  78.4020   -0.000     32  83.4000   -0.000     33  88.4040    0.010
 34  93.4020   -0.000     35  98.4060   -0.000     36 103.4040   -0.000
 37 108.4020   -0.000     38 113.4060   -0.000     39 118.4040   -0.000
```

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HARMONIC SLUG TEST ANALYSIS                                     07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                              SERVALL
                            MW-3B RH RUN 1
                           ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  58.2        ft
       Length of well screen:  10.0        ft
        Well casing diameter:   0.160      ft
        Drilled hole diameter:  0.210      ft
          Storage coefficient:  3.00E-01
             Gravity constant:  3.22E+01   ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

               Time per cycle:  8.72       sec
            Angular frequency:  7.20E-01   1/sec
             Damping constant:  2.77E-01   1/sec
             Effective length: 54.1        ft
                d Coefficient:  3.58E-01
                a Coefficient:  0.00E+00
                b Coefficient:  1.07E-02
           Error of fit (RMS): 41.7        %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   1.89E-03  sft/sec
     Hydraulic conductivity :   1.89E-04  ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDDD

 No.   Time     WaterLvl    No.   Time     WaterLvl    No.   Time     WaterLvl
      (sec)      (ft)            (sec)      (ft)            (sec)      (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1   -0.0000    3.730      2    0.3960    1.490      3    1.0020    0.810
  4    1.2000    0.640      5    1.3980    0.480      6    1.6020    0.340
  7    1.8000    0.150      8    2.8020   -0.470      9    4.8000   -0.600
 10    5.8020   -0.280     11    6.7980    0.030     12    7.8000    0.250
 13    8.8020    0.300     14    9.7980    0.220     15   10.8000    0.070
 16   11.8020   -0.040     17   12.7980   -0.100     18   13.8000   -0.100
 19   14.8020   -0.060     20   15.7980    0.000     21   16.8000    0.030
 22   17.8020    0.050     23   18.7980    0.040     24   19.8000    0.020
 25   24.8040   -0.010     26   29.8020    0.000     27   34.8000    0.000
 28   39.8040    0.000     29   44.8020    0.000     30   49.8000    0.000
 31   54.8040    0.000     32   59.8020    0.000     33   64.8000    0.000
 34   69.8040    0.000     35   74.8020    0.000     36   79.8000    0.000
 37   84.7980    0.000     38   89.8020    0.000     39   94.8000    0.000
 40   99.8040    0.000     41  104.8020    0.000     42  109.8000    0.000
 43  114.8040    0.000     44  119.8020   -0.010     45  109.8000    0.000
```

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HARMONIC SLUG TEST ANALYSIS                                       07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                              SERVALL
                           MW-3B FH RUN 1
                          ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  58.2        ft
       Length of well screen:  10.0        ft
        Well casing diameter:   0.160      ft
       Drilled hole diameter:   0.210      ft
         Storage coefficient:   3.00E-01
            Gravity constant:   3.22E+01   ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

              Time per cycle:   9.41       sec
           Angular frequency:   6.68E-01   1/sec
            Damping constant:   1.89E-01   1/sec
            Effective length:  66.9        ft
               d Coefficient:   2.72E-01
               a Coefficient:   0.00E+00
               b Coefficient:   1.29E-02
          Error of fit (RMS):  23.0        %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   1.69E-03   sft/sec
     Hydraulic conductivity :   1.69E-04   ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDD

 No.  Time     WaterLvl    No.   Time     WaterLvl    No.   Time     WaterLvl
     (sec)      (ft)           (sec)       (ft)           (sec)       (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1    0.0000    2.120      2    0.2040    2.100      3    0.4020    1.380
  4    0.6000    1.470      5    0.8040    0.580      6    1.0020    0.850
  7    2.0040   -0.090      8    3.0000   -0.430      9    5.0040   -0.340
 10    6.0000   -0.110     11    7.0020    0.070     12    8.0040    0.170
 13    9.0000    0.190     14   10.0020    0.130     15   11.0040    0.040
 16   12.0000   -0.050     17   13.0020   -0.070     18   14.0040   -0.060
 19   15.0000   -0.050     20   16.0020   -0.010     21   17.0040    0.020
 22   18.0000    0.030     23   19.0020    0.020     24   24.0060   -0.010
 25   29.0040    0.000     26   34.0020    0.000     27   39.0059    0.000
 28   44.0040    0.000     29   49.0021    0.000     30   54.0060    0.000
 31   59.0041    0.000     32   64.0019    0.000     33   69.0061    0.000
 34   74.0039    0.000     35   79.0020    0.010     36   84.0001    0.000
 37   89.0040    0.000     38   94.0021    0.000     39   99.0061    0.000
 40  104.0040    0.000     41  109.0020    0.000     42  114.0060    0.010
 43  119.0040    0.000
```

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HARMONIC SLUG TEST ANALYSIS                                    07-09-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                              SERVALL
                            MW-4 RH RUN 1
                          ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:   50.0         ft
       Length of well screen:   10.0         ft
        Well casing diameter:    0.160       ft
         Drilled hole diameter:  0.210       ft
          Storage coefficient:   3.00E-01
             Gravity constant:   3.22E+01    ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

               Time per cycle:   8.70        sec
          Angular frequency:     7.22E-01    1/sec
            Damping constant:    2.33E-01    1/sec
            Effective length:   56.0         ft
               d Coefficient:    3.07E-01
               a Coefficient:    0.00E+00
               b Coefficient:    1.23E-02
          Error of fit (RMS):   32.1         %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity  :   6.03E-04    sft/sec
     Hydraulic conductivity  :   6.03E-05    ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDD

 No.   Time     WaterLvl    No.   Time     WaterLvl    No.   Time     WaterLvl
      (sec)      (ft)            (sec)      (ft)            (sec)      (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1   0.0040    3.450       2   0.2080    3.090       3   0.4060    2.550
  4   0.8080    1.350       5   1.0060    0.990       6   1.2100    0.760
  7   1.4080    0.550       8   2.4100   -0.160       9   3.4060   -0.600
 10   5.4100   -0.360      11   6.4060   -0.030      12   7.4080    0.210
 13   8.4100    0.300      14   9.4060    0.240      15  10.4080    0.090
 16  11.4100   -0.020      17  12.4060   -0.090      18  13.4080   -0.090
 19  14.4100   -0.050      20  15.4060    0.010      21  16.4080    0.040
 22  17.4100    0.060      23  18.4060    0.050      24  19.4080    0.020
 25  24.4120    0.010      26  29.4100    0.010      27  34.4080    0.010
 28  39.4120    0.010      29  44.4100    0.000      30  49.4080    0.010
 31  54.4120    0.000      32  59.4100    0.000      33  64.4080    0.000
 34  69.4120    0.000      35  74.4100    0.000      36  79.4080    0.000
 37  84.4060    0.000      38  89.4100    0.000      39  94.4080    0.000
 40  99.4120    0.000      41 104.4100    0.010      42 109.4080    0.000
 43 114.4120    0.000      44 119.4100    0.000      45   0.0000    0.000
```

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HARMONIC SLUG TEST ANALYSIS                                       07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                                  SERVALL
                                MW-4 RH RUN 1
                              ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  54.6        ft
       Length of well screen:  10.0        ft
        Well casing diameter:   0.160      ft
       Drilled hole diameter:   0.210      ft
         Storage coefficient:   3.00E-01
            Gravity constant:   3.22E+01   ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

              Time per cycle:   8.70       sec
           Angular frequency:   7.22E-01   1/sec
            Damping constant:   2.79E-01   1/sec
            Effective length:  53.7        ft
               d Coefficient:   3.61E-01
               a Coefficient:   0.00E+00
               b Coefficient:   1.06E-02
          Error of fit (RMS):  28.2        %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   4.65E-04   sft/sec
     Hydraulic conductivity :   4.65E-05   ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDD

 No.   Time    WaterLvl    No.   Time    WaterLvl    No.   Time    WaterLvl
      (sec)     (ft)            (sec)     (ft)            (sec)     (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1   -0.0000   3.450      2    0.2040   3.090      3    0.4020   2.550
  4    0.8040   1.350      5    1.0020   0.990      6    1.2060   0.760
  7    1.4040   0.550      8    2.4060  -0.160      9    3.4020  -0.600
 10    5.4060  -0.360     11    6.4020  -0.030     12    7.4040   0.210
 13    8.4060   0.300     14    9.4020   0.240     15   10.4040   0.090
 16   11.4060  -0.020     17   12.4020  -0.090     18   13.4040  -0.090
 19   14.4060  -0.050     20   15.4020   0.010     21   16.4040   0.040
 22   17.4060   0.060     23   18.4020   0.050     24   19.4040   0.020
 25   24.4080   0.010     26   29.4060   0.010     27   34.4040   0.010
 28   39.4080   0.010     29   44.4060  -0.000     30   49.4040   0.010
 31   54.4080  -0.000     32   59.4060  -0.000     33   64.4040  -0.000
 34   69.4080  -0.000     35   74.4060  -0.000     36   79.4040  -0.000
 37   84.4020  -0.000     38   89.4060  -0.000     39   94.4040  -0.000
 40   99.4080  -0.000     41  104.4060   0.010     42  109.4040  -0.000
 43  114.4080  -0.000     44  119.4060  -0.000     45    0.0000   0.000
```

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HARMONIC SLUG TEST ANALYSIS                                       07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                              SERVALL
                            MW-4 FH RUN 1
                          ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  54.6        ft
       Length of well screen:  10.0        ft
        Well casing diameter:   0.160      ft
       Drilled hole diameter:   0.210      ft
         Storage coefficient:   3.00E-01
            Gravity constant:   3.22E+01   ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

              Time per cycle:   9.27       sec
           Angular frequency:   6.78E-01   1/sec
            Damping constant:   2.14E-01   1/sec
            Effective length:  63.7        ft
               d Coefficient:   3.02E-01
               a Coefficient:   0.00E+00
               b Coefficient:   1.19E-02
          Error of fit (RMS):  19.2        %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   2.97E-04   sft/sec
     Hydraulic conductivity :   2.97E-05   ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDDD

 No.  Time     WaterLvl    No.   Time     WaterLvl    No.   Time     WaterLvl
     (sec)      (ft)            (sec)      (ft)            (sec)      (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1  -0.0000    2.130       2    0.4020    1.750       3    0.6000    1.520
  4   1.0020    0.340       5    2.0040   -0.110       6    3.0000   -0.500
  7   5.0040   -0.410       8    6.0000   -0.010       9    7.0020    0.160
 10   8.0040    0.260      11    9.0000    0.220      12   10.0020    0.100
 13  11.0040   -0.010      14   12.0000   -0.090      15   13.0020   -0.110
 16  14.0040   -0.080      17   15.0000   -0.020      18   16.0020    0.010
 19  17.0040    0.040      20   18.0000    0.030      21   19.0020    0.010
 22  24.0060    0.000      23   29.0040    0.000      24   34.0020    0.000
 25  39.0060    0.000      26   44.0040    0.000      27   49.0020    0.000
 28  54.0060    0.000      29   59.0040    0.000      30   64.0020    0.000
 31  69.0060    0.000      32   74.0040    0.000      33   79.0020    0.000
 34  84.0000    0.000      35   89.0040    0.000      36   94.0020    0.000
 37  99.0060    0.000      38  104.0040    0.000      39  109.0020    0.000
 40 114.0060    0.000      41  119.0040    0.000      42  114.0060    0.010
```

```
HARMONIC SLUG TEST ANALYSIS                                  07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                              SERVALL
                            MW-5 RH RUN 1
                          ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  54.0        ft
       Length of well screen:  10.0        ft
        Well casing diameter:   0.160      ft
       Drilled hole diameter:   0.210      ft
         Storage coefficient:   3.00E-01
            Gravity constant:   3.22E+01   ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

              Time per cycle:   8.68       sec
           Angular frequency:   7.24E-01   1/sec
            Damping constant:   1.99E-01   1/sec
            Effective length:  57.2        ft
               d Coefficient:   2.65E-01
               a Coefficient:   0.00E+00
               b Coefficient:   1.41E-02
          Error of fit (RMS):  16.4        %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   1.99E-04   sft/sec
     Hydraulic conductivity :   1.99E-05   ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDDD

 No.  Time     WaterLvl    No.  Time     WaterLvl    No.  Time     WaterLvl
     (sec)      (ft)           (sec)      (ft)           (sec)      (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1  -0.0000    1.601       2   0.1980    1.480       3   0.3960    1.020
  4   0.6000    0.910       5   0.7980    0.770       6   1.0020    0.550
  7   1.2000    0.420       8   1.3980    0.260       9   1.6020    0.080
 10   1.8000   -0.010      11   2.8020   -0.450      12   4.8000   -0.400
 13   5.8020   -0.120      14   6.7980    0.130      15   7.8000    0.230
 16   8.8020    0.210      17   9.7980    0.110      18  10.8000    0.000
 19  11.8020   -0.060      20  12.7980   -0.080      21  13.8000   -0.050
 22  14.8020    0.000      23  15.7980    0.030      24  16.8000    0.040
 25  17.8020    0.040      26  18.7980    0.020      27  19.8000    0.000
 28  24.8040    0.000      29  29.8020    0.000      30  34.8000    0.000
 31  39.8040    0.000      32  44.8020    0.000      33  49.8000    0.000
 34  54.8040    0.000      35  59.8020    0.000      36  64.8000    0.000
 37  69.8040    0.000      38  74.8020    0.000      39  79.8000    0.000
 40  84.7980    0.000      41  89.8020    0.000      42  94.8000    0.000
 43  99.8040    0.000      44 104.8020    0.000      45 109.8000    0.000
 46 114.8040    0.000      47 119.8020    0.000      48   0.0000    0.000
```

```
HARMONIC SLUG TEST ANALYSIS                                    07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                              SERVALL
                            MW-5 FH RUN 1
                          ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:   54.0        ft
       Length of well screen:   10.0        ft
        Well casing diameter:    0.160      ft
       Drilled hole diameter:    0.210      ft
         Storage coefficient:    3.00E-01
            Gravity constant:    3.22E+01   ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

              Time per cycle:    8.25       sec
           Angular frequency:    7.61E-01   1/sec
            Damping constant:    3.79E-01   1/sec
            Effective length:   44.5        ft
               d Coefficient:    4.46E-01
               a Coefficient:    0.00E+00
               b Coefficient:    9.32E-03
          Error of fit (RMS):   67.1        %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :    4.44E-04   sft/sec
     Hydraulic conductivity :    4.44E-05   ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDDDDD

 No.   Time     WaterLvl    No.   Time     WaterLvl    No.   Time     WaterLvl
      (sec)      (ft)            (sec)      (ft)            (sec)      (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1   -0.0000    3.890      2    0.2040    1.550      3    0.6060    0.340
  4    0.8040   -0.050      5    1.4040   -0.150      6    3.4020   -0.380
  7    4.4040   -0.170      8    5.4060    0.170      9    7.4040    0.170
 10    8.4060    0.100     11    9.4020    0.020     12   10.4040   -0.040
 13   11.4060   -0.070     14   12.4020   -0.060     15   13.4040   -0.030
 16   14.4060   -0.010     17   15.4020    0.010     18   16.4040    0.020
 19   17.4060    0.010     20   18.4020    0.000     21   19.4040   -0.010
 22   24.4080    0.000     23   29.4060   -0.010     24   34.4040    0.000
 25   39.4080    0.000     26   44.4060    0.000     27   49.4040    0.000
 28   54.4080    0.000     29   59.4060    0.000     30   64.4040    0.000
 31   69.4080    0.000     32   74.4060    0.000     33   79.4040    0.000
 34   84.4020    0.000     35   89.4060    0.000     36   94.4040    0.000
 37   99.4080    0.000     38  104.4060    0.000     39  109.4040    0.000
 40  114.4080    0.000     41  119.4060    0.000     42  149.0040   -0.000
```

```
HARMONIC SLUG TEST ANALYSIS                                  07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                            SERVALL
                         MW-5   FH RUN 2
                        ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  54.0       ft
       Length of well screen:  10.0       ft
        Well casing diameter:   0.160     ft
        Drilled hole diameter:  0.210     ft
          Storage coefficient:  3.00E-01
             Gravity constant:  3.22E+01  ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

               Time per cycle:  9.05      sec
            Angular frequency:  6.94E-01  1/sec
             Damping constant:  2.05E-01  1/sec
             Effective length: 61.5       ft
                d Coefficient:  2.83E-01
                a Coefficient:  0.00E+00
                b Coefficient:  1.28E-02
           Error of fit (RMS): 15.4       %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   1.45E-03  sft/sec
     Hydraulic conductivity :   1.45E-04  ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDD

 No.   Time    WaterLvl    No.   Time    WaterLvl    No.   Time    WaterLvl
       (sec)     (ft)           (sec)      (ft)           (sec)      (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1   -0.0000    2.110      2    0.1980    1.920      3    0.6000    1.630
  4    1.2000    0.590      5    1.6020    0.170      6    2.6040   -0.270
  7    3.6000   -0.320      8    5.6040   -0.180      9    6.6000    0.010
 10    7.6020    0.130     11    8.6040    0.160     12    9.6000    0.110
 13   10.6020    0.040     14   11.6040   -0.020     15   12.6000   -0.050
 16   13.6020   -0.050     17   14.6040   -0.030     18   15.6000   -0.000
 19   16.6020    0.010     20   17.6040    0.030     21   18.6000    0.020
 22   19.6020    0.010     23   24.6060   -0.000     24   29.6040   -0.000
 25   34.6020   -0.000     26   39.6060   -0.000     27   44.6040   -0.000
 28   49.6020   -0.000     29   54.6060   -0.000     30   59.6040   -0.000
 31   64.6020   -0.000     32   69.6060    0.010     33   74.6040    0.010
 34   79.6020    0.010     35   84.6000    0.010     36   89.6040   -0.000
 37   94.6020   -0.000     38   99.6060   -0.000     39  104.6040   -0.000
 40  109.6020   -0.000     41  114.6060   -0.000     42  119.6040   -0.000
```

```
HARMONIC SLUG TEST ANALYSIS                                   07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                              SERVALL
                            MW-6A FH RUN1
                          ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  33.1        ft
       Length of well screen:  10.0        ft
        Well casing diameter:   0.160      ft
        Drilled hole diameter:  0.210      ft
          Storage coefficient:  3.00E-01
             Gravity constant:  3.22E+01   ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

               Time per cycle:  7.38       sec
            Angular frequency:  8.51E-01   1/sec
             Damping constant:  2.97E-01   1/sec
             Effective length: 39.6        ft
                d Coefficient:  3.30E-01
                a Coefficient:  0.00E+00
                b Coefficient:  1.32E-02
           Error of fit (RMS): 12.8        %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   2.90E-03   sft/sec
     Hydraulic conductivity :   2.90E-04   ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDD

 No.   Time     WaterLvl    No.   Time     WaterLvl    No.   Time     WaterLvl
      (sec)      (ft)            (sec)      (ft)            (sec)      (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1   0.0000    1.850       2   0.1980    1.420       3   0.6000    0.950
  4   1.6020   -0.140       5   3.6000   -0.250       6   4.6020   -0.080
  7   5.5980    0.050       8   6.6000    0.090       9   7.6020    0.070
 10   8.5980    0.020      11   9.6000    0.000      12  10.6020   -0.010
 13  11.5980   -0.010      14  12.6000    0.000      15  13.6020    0.010
 16  14.5980    0.010      17  15.6000    0.010      18  16.6020    0.000
 19  17.5980    0.000      20  18.6000    0.000      21  23.6040    0.000
 22  28.6020    0.000      23  33.6000    0.000      24  38.6040    0.000
 25  43.6020    0.000      26  48.6000    0.010      27  53.6040    0.010
 28  58.6020    0.010      29  63.6000    0.010      30  68.6040    0.010
 31  73.6020    0.010      32  78.6000    0.010      33  83.5980    0.010
 34  88.6020    0.010      35  93.6000    0.010      36  98.6040    0.010
 37 103.6020    0.000      38 108.6000    0.010      39 113.6040    0.000
 40 118.6020    0.000
```

```
HARMONIC SLUG TEST ANALYSIS                                          07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                                  SERVALL
                               MW-6A RH RUN 1
                              ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  33.1        ft
       Length of well screen:  10.0        ft
        Well casing diameter:   0.160      ft
       Drilled hole diameter:   0.210      ft
         Storage coefficient:   3.00E-01
            Gravity constant:   3.22E+01   ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

              Time per cycle:   7.32       sec
           Angular frequency:   8.59E-01   1/sec
            Damping constant:   3.70E-01   1/sec
            Effective length:  36.8        ft
               d Coefficient:   3.96E-01
               a Coefficient:   0.00E+00
               b Coefficient:   1.14E-02
          Error of fit (RMS):   9.6        %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   1.13E-03   sft/sec
     Hydraulic conductivity :   1.13E-04   ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDD

 No.  Time    WaterLvl    No.  Time    WaterLvl    No.  Time    WaterLvl
      (sec)    (ft)            (sec)    (ft)            (sec)    (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1  -0.0000   2.560       2   0.4020   1.700       3   0.6060   1.420
  4   1.2060   0.730       5   1.4040   0.490       6   2.4060  -0.230
  7   4.4040  -0.300       8   5.4060  -0.050       9   6.4020   0.100
 10   7.4040   0.110      11   8.4060   0.060      12   9.4020   0.000
 13  10.4040  -0.020      14  11.4060  -0.020      15  12.4020   0.000
 16  13.4040   0.010      17  14.4060   0.010      18  15.4020   0.010
 19  16.4040   0.000      20  17.4060   0.000      21  18.4020   0.000
 22  19.4040   0.000      23  24.4080   0.000      24  29.4060   0.000
 25  34.4040   0.000      26  39.4080   0.000      27  44.4060   0.000
 28  49.4040   0.000      29  54.4080   0.000      30  59.4060   0.000
 31  64.4040   0.000      32  69.4080   0.000      33  74.4060   0.000
 34  79.4040   0.000      35  84.4020   0.000      36  89.4060   0.000
 37  94.4040   0.000      38  99.4080   0.000      39 104.4060   0.000
 40 109.4040   0.000      41 114.4080   0.000      42 119.4060   0.000
```

```
HARMONIC SLUG TEST ANALYSIS                                07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                         SERVALL
                      MW-12 FH RUN 1
                     ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  65.4         ft
       Length of well screen:  10.0         ft
        Well casing diameter:   0.160       ft
       Drilled hole diameter:   0.210       ft
         Storage coefficient:   3.00E-01
            Gravity constant:   3.22E+01    ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

              Time per cycle:   9.83        sec
           Angular frequency:   6.39E-01    1/sec
            Damping constant:   1.92E-01    1/sec
            Effective length:  63.7         ft
               d Coefficient:   3.02E-01
               a Coefficient:   0.00E+00
               b Coefficient:   1.19E-02
          Error of fit (RMS):  19.2         %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   2.97E-04    sft/sec
     Hydraulic conductivity :   2.97E-05    ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDD

 No.  Time     WaterLvl    No.  Time     WaterLvl    No.  Time     WaterLvl
     (sec)      (ft)           (sec)      (ft)           (sec)      (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1   0.0000    2.220       2   0.2040    1.590       3   0.6060    1.140
  4   0.8040    0.890       5   1.2060    0.450       6   1.4040    0.310
  7   2.4060   -0.100       8   3.4020   -0.330       9   5.4060   -0.290
 10   6.4020   -0.040      11   7.4040    0.010      12   8.4060    0.070
 13   9.4020    0.150      14  10.4040    0.110      15  11.4060    0.040
 16  12.4020   -0.010      17  13.4040   -0.050      18  14.4060   -0.050
 19  15.4020   -0.030      20  16.4040   -0.010      21  17.4060    0.010
 22  18.4020    0.020      23  19.4040    0.020      24  24.4080   -0.010
 25  29.4060    0.000      26  34.4040    0.000      27  39.4080    0.000
 28  44.4060    0.000      29  49.4040    0.000      30  54.4080    0.000
 31  59.4060    0.000      32  64.4040    0.000      33  69.4080    0.000
 34  74.4060    0.000      35  79.4040    0.000      36  84.4020    0.000
 37  89.4060    0.010      38  94.4040    0.000      39  99.4080    0.000
 40 104.4060    0.000      41 109.4040    0.000      42 114.4080    0.000
 43 119.4060    0.000
```

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HARMONIC SLUG TEST ANALYSIS                                07-10-1994
MMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMMM

                         SERVALL
                      MW-13 RH RUN 1
                     ABB Environmental

Input Data
DDDDDDDDDD

 Depth of water above screen:  73.8        ft
       Length of well screen:  10.0        ft
        Well casing diameter:   0.160      ft
       Drilled hole diameter:   0.210      ft
         Storage coefficient:   3.00E-01
            Gravity constant:   3.22E+01   ft/sec/sec

Analytic Results
DDDDDDDDDDDDDDDD

              Time per cycle:   8.45       sec
           Angular frequency:   7.43E-01   1/sec
            Damping constant:   1.21E+00   1/sec
            Effective length:  16.0        ft
               d Coefficient:   8.52E-01
               a Coefficient:   0.00E+00
               b Coefficient:   7.46E-03
          Error of fit (RMS):  16.0        %

Estimated Aquifer Characteristics
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD

     Aquifer transmissivity :   1.35E-03   sft/sec
     Hydraulic conductivity :   1.35E-04   ft/sec


 Time vs Drawdown Data
DDDDDDDDDDDDDDDDDDD

 No.   Time     WaterLvl    No.   Time     WaterLvl    No.   Time     WaterLvl
       (sec)     (ft)             (sec)     (ft)             (sec)     (ft)
DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
  1   -0.0000    4.430      2    0.2040    4.180      3    0.8040    1.630
  4    1.0020    1.360      5    2.0040    0.140      6    3.0000   -0.300
  7    5.0040   -0.360      8    6.0000   -0.230      9    7.0020   -0.090
 10    8.0040   -0.000     11    9.0000    0.050     12   10.0020    0.070
 13   11.0040    0.060     14   12.0000    0.030     15   13.0020    0.030
 16   14.0040    0.010     17   15.0000   -0.000     18   16.0020    0.010
 19   17.0040    0.010     20   18.0000    0.010     21   19.0020    0.020
 22   24.0060    0.010     23   29.0040    0.010     24   34.0020    0.010
 25   39.0060    0.010     26   44.0040   -0.000     27   49.0020   -0.000
 28   54.0060   -0.000     29   59.0040   -0.000     30   64.0020   -0.000
 31   69.0060   -0.000     32   74.0040   -0.000     33   79.0020   -0.000
 34   84.0000   -0.000     35   89.0040   -0.000     36   94.0020   -0.000
 37   99.0060   -0.000     38  104.0040   -0.000     39  109.0020   -0.000
 40  114.0060   -0.000     41  119.0040   -0.000     42  149.0040   -0.000
```

APPENDIX G

SAMPLE MODEL CALCULATIONS, RESULTS, AND OUTPUTS

APPENDIX G
SAMPLE MODEL CALCULATIONS, INPUTS, AND OUTPUTS
SERVALL LAUNDRY SITE

TABLE OF CONTENTS

APPENDIX G-1

SAMPLE MODFLOW RIVER PACKAGE DATA OUTPUT

SAMPLE MODFLOW RIVER PACKAGE DATA OUTPUT

```
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL   1  RATE  2315.599
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL   2  RATE  2312.337
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL   3  RATE  2312.817
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL   4  RATE  2313.728
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL   5  RATE  2315.001
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL   6  RATE  2316.582
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL   7  RATE  2318.319
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL   8  RATE  2321.003
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL   9  RATE  2321.549
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  10  RATE  2325.346
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  11  RATE  2326.386
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  12  RATE  2330.484
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  13  RATE  2331.961
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  14  RATE  2334.528
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  15  RATE  2340.220
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  16  RATE  2340.191
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  17  RATE  2345.549
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  18  RATE  2351.129
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  19  RATE  2356.874
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  20  RATE  2362.678
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  21  RATE  2368.448
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  22  RATE  2367.789
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  23  RATE  2373.287
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  24  RATE  2378.548
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  25  RATE  2383.505
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  26  RATE  2388.116
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  27  RATE  2392.353
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  28  RATE  2396.080
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  29  RATE  2402.079
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  30  RATE  2404.964
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  31  RATE  2410.806
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  32  RATE  2416.467
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  33  RATE  2421.884
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  34  RATE  2424.029
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  35  RATE  2429.195
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  36  RATE  2434.366
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  37  RATE  2436.558
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  38  RATE  2444.395
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  39  RATE  2446.433
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  40  RATE  2447.723
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  41  RATE  2443.141
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  42  RATE  2444.019
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  43  RATE  2438.861
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  44  RATE  2433.963
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  45  RATE  2429.485
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  46  RATE  2428.309
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  47  RATE  2424.841
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  48  RATE  2421.909
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  49  RATE  2419.331
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  50  RATE  2423.473
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  51  RATE  2424.441
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0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  53  RATE  2431.834
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  54  RATE  2434.325
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  55  RATE  2439.772
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  56  RATE  2445.302
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  57  RATE  2450.844
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0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  59  RATE  2465.542
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  60  RATE  2471.460
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  61  RATE  2480.747
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  1  COL  62  RATE  2487.112
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0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 65  RATE  2511.969
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 66  RATE  2517.892
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 67  RATE  2530.223
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 68  RATE  2538.434
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 69  RATE  2550.218
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 70  RATE  2561.491
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0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 76  RATE  2607.461
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 77  RATE  2611.071
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 78  RATE  2613.828
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 79  RATE  2619.570
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW   1  COL 80  RATE  2620.673
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  75  COL 27  RATE -69826.91
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  76  COL 27  RATE -41499.07
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  77  COL 28  RATE -32074.47
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  77  COL 36  RATE -33260.57
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  78  COL 29  RATE -25163.75
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0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  79  COL 51  RATE -7118.470
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  80  COL 17  RATE -51471.59
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  80  COL 30  RATE -4133.336
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  80  COL 36  RATE -2525.194
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0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  80  COL 50  RATE -2466.431
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0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  81  COL 30  RATE -2871.813
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  81  COL 36  RATE -2413.616
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0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  82  COL 30  RATE -2770.229
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  82  COL 36  RATE -1889.243
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0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  83  COL 18  RATE -10849.67
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0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  83  COL 36  RATE -1142.847
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  83  COL 47  RATE -2891.918
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0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  84  COL 36  RATE 0.0000000
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  84  COL 37  RATE -810.5906
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  84  COL 38  RATE -3042.163
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  84  COL 46  RATE -4095.347
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  84  COL 60  RATE -3245.864
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  84  COL 61  RATE 0.0000000
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  85  COL  8  RATE -9794.645
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  85  COL 18  RATE -7086.139
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  85  COL 30  RATE -3605.538
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  85  COL 36  RATE -236.7994
0 CONSTANT HEAD   PERIOD  1  STEP  1  LAYER  1  ROW  85  COL 39  RATE -3429.671
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0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  85   COL  60   RATE   -1091.657
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  85   COL  61   RATE   0.0000000
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0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  86   COL  19   RATE   -6589.025
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  86   COL  31   RATE   -1733.071
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  86   COL  35   RATE   -418.4243
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  86   COL  36   RATE   -137.8496
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  86   COL  41   RATE   -2976.395
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  86   COL  42   RATE   -4454.094
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  86   COL  45   RATE   -1605.566
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  86   COL  46   RATE   -1536.526
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  86   COL  59   RATE   -2631.150
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  86   COL  60   RATE   0.0000000
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0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  87   COL  19   RATE   -5066.743
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  87   COL  31   RATE   -1544.263
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  87   COL  34   RATE   -491.3948
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0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  87   COL  43   RATE   -914.0046
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  87   COL  44   RATE   -664.1466
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  87   COL  45   RATE   -504.1320
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  87   COL  59   RATE   -827.0630
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  88   COL   9   RATE   -5694.027
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  88   COL  18   RATE   -5136.648
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  88   COL  31   RATE   -1828.232
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  88   COL  34   RATE   -129.5227
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0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  89   COL  18   RATE   -3230.863
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  89   COL  32   RATE   -577.1517
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0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  89   COL  44   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  89   COL  45   RATE   -460.6566
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  89   COL  56   RATE   -2103.227
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  89   COL  57   RATE   -767.2038
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0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  90   COL  43   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  90   COL  44   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  90   COL  45   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  90   COL  46   RATE   -1069.072
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  90   COL  55   RATE   -1607.020
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 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  91  COL  32  RATE  0.0000000
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 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  39  RATE  -225.5460
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  40  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  41  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  42  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  43  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  44  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  45  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  46  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  47  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  48  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  49  RATE  -413.9093
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  50  RATE  -527.2147
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  51  RATE  -431.3210
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  52  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  53  RATE  0.0000000
 0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  93  COL  54  RATE  0.0000000
```

```
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  19   RATE   -467.4820
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  20   RATE   -662.2236
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  21   RATE   -800.5784
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  22   RATE   -698.5593
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  23   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  24   RATE   -769.0251
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  25   RATE   -1274.978
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  35   RATE   -117.4277
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  36   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  37   RATE   -85.38013
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  38   RATE   -93.79654
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  39   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  40   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  41   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  42   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  43   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  44   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  45   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  46   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  47   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  48   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  49   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  50   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  51   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  52   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  53   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  94   COL  54   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  11   RATE   -1351.206
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  17   RATE   -311.4575
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  18   RATE   -75.23682
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  19   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  20   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  21   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  22   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  23   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  24   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  25   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  26   RATE   -351.6120
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  27   RATE   -356.1947
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  28   RATE   -486.6454
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  35   RATE   -90.44665
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  36   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  37   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  38   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  39   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  40   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  41   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  42   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  43   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  44   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  45   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  46   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  47   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  48   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  49   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  50   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  51   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  52   RATE   0.0000000
0   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  95   COL  53   RATE   0.0000000
                                                     ROW  95   COL  54   RATE   0.0000000
```

```
                                             0.0000E+00  0.1217E+04  0.7675E+04  0.1010E+05  0.1667E+00  39  50  3  1
1  38  66  1  0.7480E+04  0.6853E+04 -0.3700E+01  0.0000E+00  0.1217E+04  0.7725E+04  0.1010E+05  0.1667E+00  39  50  3  1
1  37  68  1  0.7394E+04  0.6585E+04 -0.5800E+01  0.0000E+00  0.1344E+04  0.7775E+04  0.1010E+05  0.1667E+00  39  50  3
1  38  65  1  0.7482E+04  0.7074E+04 -0.2700E+01  0.0000E+00  0.1136E+04  0.7625E+04  0.1010E+05  0.5000E+00  39  50  3  1
1  38  65  1  0.7492E+04  0.7074E+04 -0.2700E+01  0.0000E+00  0.1137E+04  0.7675E+04  0.1010E+05  0.5000E+00  39  50  3  1
1  38  65  1  0.7501E+04  0.7065E+04 -0.2700E+01  0.0000E+00  0.1136E+04  0.7725E+04  0.1010E+05  0.5000E+00  39  50  3  1
1  38  66  1  0.7502E+04  0.6972E+04 -0.3700E+01  0.0000E+00  0.1175E+04  0.7775E+04  0.1010E+05  0.5000E+00  39  50  3  1
1  38  65  1  0.7483E+04  0.7190E+04 -0.2700E+01  0.0000E+00  0.1099E+04  0.7625E+04  0.1010E+05  0.8333E+00  39  50  3  1
1  38  65  1  0.7497E+04  0.7189E+04 -0.2700E+01  0.0000E+00  0.1100E+04  0.7675E+04  0.1010E+05  0.8333E+00  39  50  3  1
1  38  65  1  0.7510E+04  0.7179E+04 -0.2700E+01  0.0000E+00  0.1099E+04  0.7725E+04  0.1010E+05  0.8333E+00  39  50  3  1
1  38  65  1  0.7514E+04  0.7078E+04 -0.2700E+01  0.0000E+00  0.1138E+04  0.7775E+04  0.1010E+05  0.8333E+00  39  50  3  1
1  37  68  1  0.7354E+04  0.6446E+04 -0.5800E+01  0.0000E+00  0.1401E+04  0.7825E+04  0.1010E+05  0.1667E+00  40  50  3  1
1  37  69  1  0.7317E+04  0.6270E+04 -0.6700E+01  0.0000E+00  0.1481E+04  0.7875E+04  0.1010E+05  0.1667E+00  40  50  3  1
1  36  71  1  0.7178E+04  0.5909E+04 -0.8600E+01  0.0000E+00  0.1659E+04  0.7925E+04  0.1010E+05  0.1667E+00  40  50  3  1
1  36  72  1  0.7122E+04  0.5697E+04 -0.9700E+01  0.0000E+00  0.1759E+04  0.7975E+04  0.1010E+05  0.1667E+00  40  50  3  1
1  38  66  1  0.7496E+04  0.6863E+04 -0.3700E+01  0.0000E+00  0.1227E+04  0.7825E+04  0.1010E+05  0.5000E+00  40  50  3  1
1  37  68  1  0.7378E+04  0.6509E+04 -0.5800E+01  0.0000E+00  0.1385E+04  0.7875E+04  0.1010E+05  0.5000E+00  40  50  3  1
1  37  69  1  0.7343E+04  0.6334E+04 -0.6700E+01  0.0000E+00  0.1459E+04  0.7925E+04  0.1010E+05  0.5000E+00  40  50  3  1
1  36  71  1  0.7194E+04  0.5933E+04 -0.8600E+01  0.0000E+00  0.1663E+04  0.7975E+04  0.1010E+05  0.5000E+00  40  50  3  1
1  38  66  1  0.7513E+04  0.6960E+04 -0.3700E+01  0.0000E+00  0.1187E+04  0.7825E+04  0.1010E+05  0.8333E+00  40  50  3  1
1  38  66  1  0.7507E+04  0.6832E+04 -0.3700E+01  0.0000E+00  0.1244E+04  0.7875E+04  0.1010E+05  0.8333E+00  40  50  3  1
1  37  68  1  0.7380E+04  0.6469E+04 -0.5800E+01  0.0000E+00  0.1407E+04  0.7925E+04  0.1010E+05  0.8333E+00  40  50  3  1
1  37  69  1  0.7338E+04  0.6265E+04 -0.6700E+01  0.0000E+00  0.1502E+04  0.7975E+04  0.1010E+05  0.8333E+00  40  50  3  1
1  35  74  1  0.6970E+04  0.5308E+04 -0.1180E+02  0.0000E+00  0.1955E+04  0.8025E+04  0.1010E+05  0.1667E+00  41  50  3  1
1  35  75  1  0.6937E+04  0.5131E+04 -0.1270E+02  0.0000E+00  0.2034E+04  0.8075E+04  0.1010E+05  0.1667E+00  41  50  3  1
1  35  75  1  0.6926E+04  0.5036E+04 -0.1270E+02  0.0000E+00  0.2092E+04  0.8125E+04  0.1010E+05  0.1667E+00  41  50  3  1
1  35  76  1  0.6929E+04  0.4930E+04 -0.1360E+02  0.0000E+00  0.2156E+04  0.8175E+04  0.1010E+05  0.1667E+00  41  50  3  1
1  36  72  1  0.7131E+04  0.5697E+04 -0.9700E+01  0.0000E+00  0.1763E+04  0.8025E+04  0.1010E+05  0.5000E+00  41  50  3  1
1  35  74  1  0.6995E+04  0.5349E+04 -0.1180E+02  0.0000E+00  0.1944E+04  0.8075E+04  0.1010E+05  0.5000E+00  41  50  3  1
1  35  74  1  0.6964E+04  0.5233E+04 -0.1180E+02  0.0000E+00  0.2003E+04  0.8125E+04  0.1010E+05  0.5000E+00  41  50  3  1
1  35  75  1  0.6940E+04  0.5059E+04 -0.1270E+02  0.0000E+00  0.2087E+04  0.8175E+04  0.1010E+05  0.5000E+00  41  50  3  1
1  36  71  1  0.7168E+04  0.5822E+04 -0.8600E+01  0.0000E+00  0.1710E+04  0.8025E+04  0.1010E+05  0.8333E+00  41  50  3  1
1  36  72  1  0.7140E+04  0.5674E+04 -0.9700E+01  0.0000E+00  0.1777E+04  0.8075E+04  0.1010E+05  0.8333E+00  41  50  3  1
1  36  72  1  0.7138E+04  0.5601E+04 -0.9700E+01  0.0000E+00  0.1826E+04  0.8125E+04  0.1010E+05  0.8333E+00  41  50  3  1
1  35  75  1  0.6962E+04  0.5169E+04 -0.1270E+02  0.0000E+00  0.2039E+04  0.8175E+04  0.1010E+05  0.8333E+00  41  50  3  1
1  35  76  1  0.6938E+04  0.4905E+04 -0.1360E+02  0.0000E+00  0.2173E+04  0.8225E+04  0.1010E+05  0.1667E+00  42  50  3  1
1  35  76  1  0.6943E+04  0.4858E+04 -0.1360E+02  0.0000E+00  0.2210E+04  0.8275E+04  0.1010E+05  0.1667E+00  42  50  3  1
1  35  76  1  0.6951E+04  0.4828E+04 -0.1360E+02  0.0000E+00  0.2237E+04  0.8325E+04  0.1010E+05  0.1667E+00  42  50  3  1
1  35  76  1  0.6963E+04  0.4811E+04 -0.1360E+02  0.0000E+00  0.2254E+04  0.8375E+04  0.1010E+05  0.1667E+00  42  50  3  1
1  35  75  1  0.6950E+04  0.5024E+04 -0.1270E+02  0.0000E+00  0.2108E+04  0.8225E+04  0.1010E+05  0.5000E+00  42  50  3  1
1  35  76  1  0.6956E+04  0.4942E+04 -0.1360E+02  0.0000E+00  0.2155E+04  0.8275E+04  0.1010E+05  0.5000E+00  42  50  3  1
1  35  76  1  0.6970E+04  0.4892E+04 -0.1360E+02  0.0000E+00  0.2183E+04  0.8325E+04  0.1010E+05  0.5000E+00  42  50  3  1
1  35  76  1  0.6985E+04  0.4803E+04 -0.1360E+02  0.0000E+00  0.2207E+04  0.8375E+04  0.1010E+05  0.5000E+00  42  50  3  1
1  35  75  1  0.6976E+04  0.5141E+04 -0.1270E+02  0.0000E+00  0.2056E+04  0.8225E+04  0.1010E+05  0.8333E+00  42  50  3  1
1  35  75  1  0.6964E+04  0.5038E+04 -0.1270E+02  0.0000E+00  0.2107E+04  0.8275E+04  0.1010E+05  0.8333E+00  42  50  3  1
1  35  76  1  0.6975E+04  0.4952E+04 -0.1360E+02  0.0000E+00  0.2148E+04  0.8325E+04  0.1010E+05  0.8333E+00  42  50  3  1
1  35  76  1  0.6992E+04  0.4831E+04 -0.1360E+02  0.0000E+00  0.2185E+04  0.8375E+04  0.1010E+05  0.8333E+00  42  50  3  1
1  36  77  1  0.7023E+04  0.4747E+04 -0.1510E+02  0.0000E+00  0.2266E+04  0.8425E+04  0.1010E+05  0.1667E+00  43  50  3  1
1  36  77  1  0.7047E+04  0.4710E+04 -0.1510E+02  0.0000E+00  0.2285E+04  0.8475E+04  0.1010E+05  0.1667E+00  43  50  3  1
1  36  77  1  0.7059E+04  0.4708E+04 -0.1510E+02  0.0000E+00  0.2296E+04  0.8525E+04  0.1010E+05  0.1667E+00  43  50  3  1
1  36  77  1  0.7066E+04  0.4696E+04 -0.1510E+02  0.0000E+00  0.2327E+04  0.8575E+04  0.1010E+05  0.1667E+00  43  50  3  1
1  36  77  1  0.7036E+04  0.4761E+04 -0.1510E+02  0.0000E+00  0.2214E+04  0.8425E+04  0.1010E+05  0.5000E+00  43  50  3  1
1  36  77  1  0.7057E+04  0.4748E+04 -0.1510E+02  0.0000E+00  0.2230E+04  0.8475E+04  0.1010E+05  0.5000E+00  43  50  3  1
1  36  77  1  0.7080E+04  0.4745E+04 -0.1510E+02  0.0000E+00  0.2240E+04  0.8525E+04  0.1010E+05  0.5000E+00  43  50  3  1
1  36  77  1  0.7092E+04  0.4729E+04 -0.1510E+02  0.0000E+00  0.2266E+04  0.8575E+04  0.1010E+05  0.5000E+00  43  50  3  1
1  36  77  1  0.7022E+04  0.4791E+04 -0.1510E+02  0.0000E+00  0.2201E+04  0.8425E+04  0.1010E+05  0.8333E+00  43  50  3  1
1  36  77  1  0.7057E+04  0.4774E+04 -0.1510E+02  0.0000E+00  0.2214E+04  0.8475E+04  0.1010E+05  0.8333E+00  43  50  3  1
1  36  77  1  0.7088E+04  0.4769E+04 -0.1510E+02  0.0000E+00  0.2222E+04  0.8525E+04  0.1010E+05  0.8333E+00  43  50  3  1
1  36  77  1  0.7111E+04  0.4752E+04 -0.1510E+02  0.0000E+00  0.2241E+04  0.8575E+04  0.1010E+05  0.8333E+00  43  50  3  1
1  36  77  1  0.7079E+04  0.4697E+04 -0.1510E+02  0.0000E+00  0.2333E+04  0.8625E+04  0.1010E+05  0.1667E+00  44  50  3  1
1  36  77  1  0.7077E+04  0.4678E+04 -0.1510E+02  0.0000E+00  0.2368E+04  0.8675E+04  0.1010E+05  0.1667E+00  44  50  3  1
1  36  77  1  0.7073E+04  0.4649E+04 -0.1510E+02  0.0000E+00  0.2410E+04  0.8725E+04  0.1010E+05  0.1667E+00  44  50  3  1
1  36  77  1  0.7089E+04  0.4634E+04 -0.1510E+02  0.0000E+00  0.2416E+04  0.8775E+04  0.1010E+05  0.1667E+00  44  50  3  1
1  36  77  1  0.7120E+04  0.4745E+04 -0.1510E+02  0.0000E+00  0.2264E+04  0.8625E+04  0.1010E+05  0.5000E+00  44  50  3  1
1  36  77  1  0.7113E+04  0.4712E+04 -0.1510E+02  0.0000E+00  0.2294E+04  0.8675E+04  0.1010E+05  0.5000E+00  44  50  3  1
1  36  77  1  0.7101E+04  0.4682E+04 -0.1510E+02  0.0000E+00  0.2326E+04  0.8725E+04  0.1010E+05  0.5000E+00  44  50  3  1
1  36  77  1  0.7099E+04  0.4672E+04 -0.1510E+02  0.0000E+00  0.2347E+04  0.8775E+04  0.1010E+05  0.5000E+00  44
```

```
1  36  77   1  0.7101E+04  0.4682E+04 -0.1510E+02  0.0000E+00  0.2326E+04  0.8725E+04  0.1010E+05  0.5000E+00  44  50   3   1
1  36  77   1  0.7099E+04  0.4672E+04 -0.1510E+02  0.0000E+00  0.2347E+04  0.8775E+04  0.1010E+05  0.5000E+00  44  50   3   1
1  36  77   1  0.7149E+04  0.4792E+04 -0.1510E+02  0.0000E+00  0.2256E+04  0.8625E+04  0.1010E+05  0.8333E+00  44  50   3   1
1  36  77   1  0.7154E+04  0.4777E+04 -0.1510E+02  0.0000E+00  0.2274E+04  0.8675E+04  0.1010E+05  0.8333E+00  44  50   3   1
1  36  77   1  0.7161E+04  0.4768E+04 -0.1510E+02  0.0000E+00  0.2293E+04  0.8725E+04  0.1010E+05  0.8333E+00  44  50   3   1
1  36  77   1  0.7166E+04  0.4761E+04 -0.1510E+02  0.0000E+00  0.2310E+04  0.8775E+04  0.1010E+05  0.8333E+00  44  50   3   1
1  36  77   1  0.7111E+04  0.4674E+04 -0.1510E+02  0.0000E+00  0.2376E+04  0.8825E+04  0.1010E+05  0.1667E+00  45  50   3   1
1  36  77   1  0.7119E+04  0.4673E+04 -0.1510E+02  0.0000E+00  0.2395E+04  0.8875E+04  0.1010E+05  0.1667E+00  45  50   3   1
1  36  77   1  0.7127E+04  0.4671E+04 -0.1510E+02  0.0000E+00  0.2410E+04  0.8925E+04  0.1010E+05  0.1667E+00  45  50   3   1
1  36  77   1  0.7135E+04  0.4668E+04 -0.1510E+02  0.0000E+00  0.2426E+04  0.8975E+04  0.1010E+05  0.1667E+00  45  50   3   1
1  44  54   1  0.8751E+04  0.9293E+04  0.1000E+00  0.0000E+00  0.3287E+03  0.8825E+04  0.1010E+05  0.5000E+00  45  50   3   1
1  44  54   1  0.8747E+04  0.9204E+04  0.1000E+00  0.0000E+00  0.3762E+03  0.8875E+04  0.1010E+05  0.5000E+00  45  50   3   1
1  36  77   1  0.7177E+04  0.4745E+04 -0.1510E+02  0.0000E+00  0.2354E+04  0.8925E+04  0.1010E+05  0.5000E+00  45  50   3   1
1  36  77   1  0.7170E+04  0.4727E+04 -0.1510E+02  0.0000E+00  0.2370E+04  0.8975E+04  0.1010E+05  0.5000E+00  45  50   3   1
1  45  52   1  0.8822E+04  0.9632E+04 -0.2000E+00  0.0000E+00  0.1805E+03  0.8825E+04  0.1010E+05  0.8333E+00  45  50   3   1
1  45  52   1  0.8846E+04  0.9632E+04 -0.2000E+00  0.0000E+00  0.1805E+03  0.8875E+04  0.1010E+05  0.8333E+00  45  50   3   1
1  45  52   1  0.8871E+04  0.9632E+04 -0.2000E+00  0.0000E+00  0.1805E+03  0.8925E+04  0.1010E+05  0.8333E+00  45  50   3   1
1  45  52   1  0.8896E+04  0.9632E+04 -0.2000E+00  0.0000E+00  0.1805E+03  0.8975E+04  0.1010E+05  0.8333E+00  45  50   3   1
1  36  77   1  0.7143E+04  0.4664E+04 -0.1510E+02  0.0000E+00  0.2445E+04  0.9025E+04  0.1010E+05  0.1667E+00  46  50   3   1
1  36  77   1  0.7142E+04  0.4647E+04 -0.1510E+02  0.0000E+00  0.2489E+04  0.9075E+04  0.1010E+05  0.1667E+00  46  50   3   1
1  36  77   1  0.7135E+04  0.4622E+04 -0.1510E+02  0.0000E+00  0.2564E+04  0.9125E+04  0.1010E+05  0.1667E+00  46  50   3   1
1  38  79   1  0.7402E+04  0.4272E+04 -0.1800E+02  0.0000E+00  0.2837E+04  0.9175E+04  0.1010E+05  0.1667E+00  46  50   3   1
1  36  77   1  0.7168E+04  0.4711E+04 -0.1510E+02  0.0000E+00  0.2394E+04  0.9025E+04  0.1010E+05  0.5000E+00  46  50   3   1
1  36  77   1  0.7171E+04  0.4679E+04 -0.1510E+02  0.0000E+00  0.2443E+04  0.9075E+04  0.1010E+05  0.5000E+00  46  50   3   1
1  36  77   1  0.7159E+04  0.4637E+04 -0.1510E+02  0.0000E+00  0.2516E+04  0.9125E+04  0.1010E+05  0.5000E+00  46  50   3   1
1  38  79   1  0.7403E+04  0.4316E+04 -0.1800E+02  0.0000E+00  0.2762E+04  0.9175E+04  0.1010E+05  0.5000E+00  46  50   3   1
1  44  54   1  0.8799E+04  0.9212E+04  0.1000E+00  0.0000E+00  0.3795E+03  0.9025E+04  0.1010E+05  0.8333E+00  46  50   3   1
1  36  77   1  0.7192E+04  0.4705E+04 -0.1510E+02  0.0000E+00  0.2417E+04  0.9075E+04  0.1010E+05  0.8333E+00  46  50   3   1
1  36  77   1  0.7176E+04  0.4646E+04 -0.1510E+02  0.0000E+00  0.2497E+04  0.9125E+04  0.1010E+05  0.8333E+00  46  50   3   1
1  38  79   1  0.7403E+04  0.4349E+04 -0.1800E+02  0.0000E+00  0.2719E+04  0.9175E+04  0.1010E+05  0.8333E+00  46  50   3   1
```

TR48

```
1  36 100    5  0.7081E+04  0.2000E+03 -0.9884E+02  0.3665E-01  0.4913E+05  0.8025E+04  0.1863E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7117E+04  0.2000E+03 -0.9886E+02  0.3551E-01  0.4911E+05  0.8075E+04  0.1863E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7154E+04  0.2000E+03 -0.9885E+02  0.3609E-01  0.4906E+05  0.8125E+04  0.1863E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7190E+04  0.2000E+03 -0.9883E+02  0.3724E-01  0.4902E+05  0.8175E+04  0.1863E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7081E+04  0.2000E+03 -0.9885E+02  0.3631E-01  0.4947E+05  0.8025E+04  0.1868E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7117E+04  0.2000E+03 -0.9887E+02  0.3518E-01  0.4944E+05  0.8075E+04  0.1868E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7154E+04  0.2000E+03 -0.9886E+02  0.3576E-01  0.4940E+05  0.8125E+04  0.1868E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7190E+04  0.2000E+03 -0.9884E+02  0.3691E-01  0.4936E+05  0.8175E+04  0.1868E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7081E+04  0.2000E+03 -0.9885E+02  0.3597E-01  0.4981E+05  0.8025E+04  0.1873E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7117E+04  0.2000E+03 -0.9887E+02  0.3486E-01  0.4978E+05  0.8075E+04  0.1873E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7154E+04  0.2000E+03 -0.9886E+02  0.3543E-01  0.4974E+05  0.8125E+04  0.1873E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7190E+04  0.2000E+03 -0.9884E+02  0.3658E-01  0.4970E+05  0.8175E+04  0.1873E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7081E+04  0.2000E+03 -0.9886E+02  0.3563E-01  0.5015E+05  0.8025E+04  0.1878E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7117E+04  0.2000E+03 -0.9888E+02  0.3453E-01  0.5012E+05  0.8075E+04  0.1878E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7154E+04  0.2000E+03 -0.9887E+02  0.3510E-01  0.5008E+05  0.8125E+04  0.1878E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7190E+04  0.2000E+03 -0.9885E+02  0.3626E-01  0.5004E+05  0.8175E+04  0.1878E+05  0.2500E+00  41   7   4   1
1  36 100    5  0.7115E+04  0.2000E+03 -0.9746E+02  0.1131E+00  0.4870E+05  0.8025E+04  0.1863E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7150E+04  0.2000E+03 -0.9753E+02  0.1096E+00  0.4869E+05  0.8075E+04  0.1863E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7186E+04  0.2000E+03 -0.9745E+02  0.1139E+00  0.4864E+05  0.8125E+04  0.1863E+05  0.7500E+00  41   7   4   1
1  37 100    5  0.7220E+04  0.2000E+03 -0.9724E+02  0.1145E+00  0.4862E+05  0.8175E+04  0.1863E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7115E+04  0.2000E+03 -0.9748E+02  0.1121E+00  0.4904E+05  0.8025E+04  0.1868E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7150E+04  0.2000E+03 -0.9755E+02  0.1086E+00  0.4902E+05  0.8075E+04  0.1868E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7186E+04  0.2000E+03 -0.9747E+02  0.1128E+00  0.4897E+05  0.8125E+04  0.1868E+05  0.7500E+00  41   7   4   1
1  37 100    5  0.7220E+04  0.2000E+03 -0.9726E+02  0.1135E+00  0.4896E+05  0.8175E+04  0.1868E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7115E+04  0.2000E+03 -0.9750E+02  0.1110E+00  0.4937E+05  0.8025E+04  0.1873E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7150E+04  0.2000E+03 -0.9756E+02  0.1076E+00  0.4936E+05  0.8075E+04  0.1873E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7186E+04  0.2000E+03 -0.9749E+02  0.1118E+00  0.4931E+05  0.8125E+04  0.1873E+05  0.7500E+00  41   7   4   1
1  37 100    5  0.7220E+04  0.2000E+03 -0.9727E+02  0.1125E+00  0.4929E+05  0.8175E+04  0.1873E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7115E+04  0.2000E+03 -0.9752E+02  0.1100E+00  0.4972E+05  0.8025E+04  0.1878E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7150E+04  0.2000E+03 -0.9758E+02  0.1066E+00  0.4970E+05  0.8075E+04  0.1878E+05  0.7500E+00  41   7   4   1
1  36 100    5  0.7186E+04  0.2000E+03 -0.9751E+02  0.1107E+00  0.4965E+05  0.8125E+04  0.1878E+05  0.7500E+00  41   7   4   1
1  37 100    5  0.7220E+04  0.2000E+03 -0.9729E+02  0.1115E+00  0.4964E+05  0.8175E+04  0.1878E+05  0.7500E+00  41   7   4   1
```

```
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  18  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  19  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  20  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  21  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  22  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  23  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  24  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  25  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  26  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  27  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  28  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  29  RATE  -183.1707
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  30  RATE  -220.3731
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  31  RATE  -188.4487
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  32  RATE  -163.6777
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  33  RATE  -136.1096
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  34  RATE  -90.64682
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  35  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  36  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  37  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  38  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  39  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  40  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  41  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  42  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  43  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  44  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  45  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  46  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  47  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  48  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  49  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  50  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  51  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  52  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  53  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  96  COL  54  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  11  RATE  -233.5874
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  14  RATE  -831.4741
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  15  RATE  -342.4655
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  16  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  17  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  18  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  19  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  20  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  21  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  22  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  23  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  24  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  25  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  26  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  27  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  28  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  29  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  30  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  31  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  32  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  33  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  34  RATE  0.0000000
   CONSTANT       PERIOD  1  STEP     LAYER     ROW  97  COL  35  RATE  0.0000000
```

```
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  44  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  45  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  46  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  47  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  48  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  49  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  50  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  51  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  52  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  97  COL  53  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  12  RATE  -383.3456
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  14  RATE  -148.8544
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  15  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  16  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  17  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  18  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  19  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  20  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  21  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  22  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  23  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  24  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  25  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  26  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  27  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  28  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  29  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  30  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  31  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  32  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  33  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  34  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  35  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  36  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  37  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  38  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  39  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  40  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  41  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  42  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  43  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  44  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  45  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  46  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  47  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  48  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  49  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  50  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  51  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  52  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  98  COL  53  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  99  COL  12  RATE  -86.54417
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  99  COL  14  RATE  -87.73368
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  99  COL  15  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  99  COL  16  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  99  COL  17  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  99  COL  18  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  99  COL  19  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  99  COL  20  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  99  COL  21  RATE  0.0000000
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  1  ROW  99  COL  22  RATE  0.0000000
```

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0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  28   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  29   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  30   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  31   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  32   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  33   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  34   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  35   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  36   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  37   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  38   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  39   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  40   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  41   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  42   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  43   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  44   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  45   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  46   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  47   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  48   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  49   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  50   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  51   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW  99   COL  52   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  12   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  13   RATE  -87.02386
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  14   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  15   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  16   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  17   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  18   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  19   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  20   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  21   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  22   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  23   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  24   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  25   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  26   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  27   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  28   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  29   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  30   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  31   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  32   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  33   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  34   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  35   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  36   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  37   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  38   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  39   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  40   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  41   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  42   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  43   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  44   RATE   0.0000000
0  CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  1   ROW 100   COL  45   RATE   0.0000000
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O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL   2   RATE   1530.606
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL   3   RATE   1530.931
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL   4   RATE   1531.534
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL   5   RATE   1532.377
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL   6   RATE   1533.435
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL   7   RATE   1534.689
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL   8   RATE   1536.464
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL   9   RATE   1538.745
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  10   RATE   1541.253
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  11  RATE   1543.994
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  12   RATE   1546.822
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  13   RATE   1549.964
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  14   RATE   1553.612
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  15   RATE   1557.384
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  16   RATE   1561.393
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  17   RATE   1565.064
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  18   RATE   1568.795
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  19   RATE   1572.624
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  20   RATE   1576.492
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  21   RATE   1580.337
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  22   RATE   1584.106
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  23   RATE   1587.780
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  24   RATE   1591.295
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  25   RATE   1594.607
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  26   RATE   1597.688
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  27   RATE   1600.519
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  28   RATE   1603.017
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  29   RATE   1605.022
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  30   RATE   1606.955
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  31   RATE   1608.705
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  32   RATE   1610.348
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  33   RATE   1611.805
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  34   RATE   1613.223
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  35   RATE   1614.531
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  36   RATE   1615.803
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  37   RATE   1617.150
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  38   RATE   1618.167
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  39   RATE   1619.414
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  40   RATE   1620.366
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  41  RATE   1621.506
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  42   RATE   1622.203
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  43   RATE   1623.082
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  44   RATE   1624.140
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  45   RATE   1625.484
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  46   RATE   1626.997
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  47   RATE   1629.030
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  48   RATE   1631.430
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  49   RATE   1634.080
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  50   RATE   1636.889
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  51  RATE   1639.871
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  52   RATE   1643.375
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  53   RATE   1646.939
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  54   RATE   1650.717
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  55   RATE   1654.399
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  56   RATE   1658.138
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  57   RATE   1661.891
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  58   RATE   1665.703
O   CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW  1   COL  59   RATE   1669.609
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0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  66   RATE   1697.995
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  67   RATE   1701.738
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  68   RATE   1705.108
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  69   RATE   1708.458
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  70   RATE   1711.555
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  71   RATE   1714.951
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  72   RATE   1718.228
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  73   RATE   1721.756
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  74   RATE   1725.226
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  75   RATE   1728.108
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  76   RATE   1730.420
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  77   RATE   1732.700
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  78   RATE   1734.508
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  79   RATE   1735.893
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  2   ROW   1   COL  80   RATE   1736.610
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL   1   RATE   1606.264
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL   2   RATE   1606.290
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL   3   RATE   1606.635
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL   4   RATE   1607.267
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL   5   RATE   1608.151
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL   6   RATE   1609.269
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL   7   RATE   1610.634
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL   8   RATE   1612.494
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL   9   RATE   1614.838
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  10   RATE   1617.461
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  11   RATE   1620.337
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  12   RATE   1623.354
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  13   RATE   1626.693
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  14   RATE   1630.472
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  15   RATE   1634.413
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  16   RATE   1638.561
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  17   RATE   1642.452
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  18   RATE   1646.369
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  19   RATE   1650.378
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  20   RATE   1654.427
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  21   RATE   1658.453
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  22   RATE   1662.404
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  23   RATE   1666.250
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  24   RATE   1669.930
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  25   RATE   1673.398
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  26   RATE   1676.624
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  27   RATE   1679.588
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  28   RATE   1682.209
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  29   RATE   1684.365
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  30   RATE   1686.395
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  31   RATE   1688.230
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  32   RATE   1689.944
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  33   RATE   1691.471
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  34   RATE   1692.950
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  35   RATE   1694.315
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  36   RATE   1695.640
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  37   RATE   1696.999
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  38   RATE   1698.104
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  39   RATE   1699.364
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  40   RATE   1700.405
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  41   RATE   1701.553
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  42   RATE   1702.339
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  43   RATE   1703.272
0    CONSTANT HEAD   PERIOD  1   STEP  1   LAYER  3   ROW   1   COL  44   RATE   1704.393
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0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  54  RATE   1732.258
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  55  RATE   1736.107
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  56  RATE   1740.016
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  57  RATE   1743.944
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  58  RATE   1747.934
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  59  RATE   1752.020
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  60  RATE   1756.198
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  61  RATE   1760.386
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  62  RATE   1764.720
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  63  RATE   1768.861
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  64  RATE   1773.074
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  65  RATE   1777.490
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  66  RATE   1781.653
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  67  RATE   1785.572
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  68  RATE   1789.153
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  69  RATE   1792.666
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  70  RATE   1795.962
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  71  RATE   1799.464
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  72  RATE   1802.884
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  73  RATE   1806.507
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  74  RATE   1810.063
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  75  RATE   1813.074
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  76  RATE   1815.543
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  77  RATE   1817.876
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  78  RATE   1819.751
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  79  RATE   1821.146
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  3  ROW   1  COL  80  RATE   1821.885
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  12  RATE  -5514.057
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  13  RATE  -5338.678
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  14  RATE  -5130.049
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  15  RATE  -4943.389
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  16  RATE  -4789.408
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  17  RATE  -4664.924
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  18  RATE  -4564.207
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  19  RATE  -4482.161
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  20  RATE  -4414.873
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  21  RATE  -4359.462
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  22  RATE  -4313.827
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  23  RATE  -4276.428
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  24  RATE  -4246.130
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  25  RATE  -4222.093
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  26  RATE  -4203.697
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  27  RATE  -4190.490
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  28  RATE  -4182.153
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  29  RATE  -4178.477
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  30  RATE  -4179.347
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  31  RATE  -4184.734
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  32  RATE  -4194.694
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  33  RATE  -4209.364
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  34  RATE  -4228.967
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  35  RATE  -4253.824
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  36  RATE  -4284.369
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  37  RATE  -4321.173
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  38  RATE  -4364.978
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  39  RATE  -4416.746
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  40  RATE  -4477.742
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  41  RATE  -4549.650
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  42  RATE  -4634.766
0  CONSTANT HEAD  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  43  RATE  -4736.312
                  PERIOD  1  STEP  1  LAYER  5  ROW 100  COL  44  RATE  -4858.990
```

Run 3V
K=500

2.3 cfs

```
                                                                                1.847
                                          ROW 100    COL   51    RATE    -9170.922
        LEAKAGE   PERIOD  1   STEP  1   REACH   1   LAYER  1   ROW  62   COL  39   RATE    3051.205
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH   2   LAYER  1   ROW  61   COL  39   RATE    1332.073
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH   3   LAYER  1   ROW  60   COL  39   RATE     270.4620
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH   4   LAYER  1   ROW  59   COL  38   RATE    -385.8471
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH   5   LAYER  1   ROW  58   COL  38   RATE    -965.0231
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH   6   LAYER  1   ROW  57   COL  37   RATE   -1238.193
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH   7   LAYER  1   ROW  56   COL  37   RATE   -5564.680
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH   8   LAYER  1   ROW  55   COL  36   RATE   -5809.078
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH   9   LAYER  1   ROW  54   COL  36   RATE   -6051.388
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  10   LAYER  1   ROW  53   COL  35   RATE   -6623.859
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  11   LAYER  1   ROW  52   COL  34   RATE   -6981.439
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  12   LAYER  1   ROW  51   COL  34   RATE   -6949.139
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  13   LAYER  1   ROW  50   COL  33   RATE   -7460.365
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  14   LAYER  1   ROW  49   COL  33   RATE   -7218.266
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  15   LAYER  1   ROW  48   COL  33   RATE   -7397.804    2.5
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  16   LAYER  1   ROW  47   COL  32   RATE   -8030.090
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  17   LAYER  1   ROW  46   COL  32   RATE   -7873.116
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  18   LAYER  1   ROW  45   COL  32   RATE   -8118.629
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  19   LAYER  1   ROW  44   COL  32   RATE   -8521.957
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  20   LAYER  1   ROW  43   COL  32   RATE   -9012.909
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  21   LAYER  1   ROW  42   COL  32   RATE   -9597.874
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  22   LAYER  1   ROW  41   COL  32   RATE  -10353.47
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  23   LAYER  1   ROW  40   COL  32   RATE  -11581.65
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  24   LAYER  1   ROW  39   COL  31   RATE  -12750.87
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  25   LAYER  1   ROW  38   COL  31   RATE  -14073.35
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  26   LAYER  1   ROW  37   COL  30   RATE  -16252.06
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  27   LAYER  1   ROW  36   COL  29   RATE  -18736.00
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  28   LAYER  1   ROW  35   COL  28   RATE  -22296.60
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  29   LAYER  1   ROW  61   COL  40   RATE    1035.290
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  30   LAYER  1   ROW  60   COL  41   RATE    -194.5400
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  31   LAYER  1   ROW  59   COL  41   RATE    -838.8329
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  32   LAYER  1   ROW  58   COL  41   RATE   -1398.954
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  33   LAYER  1   ROW  57   COL  42   RATE   -2150.001    0.1
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  34   LAYER  1   ROW  56   COL  42   RATE   -2628.431
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  35   LAYER  1   ROW  55   COL  43   RATE   -3474.903
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  36   LAYER  1   ROW  54   COL  44   RATE   -4201.079
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  37   LAYER  1   ROW  53   COL  44   RATE   -4678.450
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  38   LAYER  1   ROW  52   COL  45   RATE   -5732.937
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  39   LAYER  1   ROW  51   COL  45   RATE   -6574.402
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  40   LAYER  1   ROW  36   COL  48   RATE  -13623.24
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  41   LAYER  1   ROW  35   COL  48   RATE  -14757.90
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  42   LAYER  1   ROW  76   COL  35   RATE  -12214.30
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  43   LAYER  1   ROW  75   COL  35   RATE  -10932.66
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  44   LAYER  1   ROW  74   COL  35   RATE  -10272.45
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  45   LAYER  1   ROW  73   COL  35   RATE  -10193.41
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  46   LAYER  1   ROW  72   COL  36   RATE  -10173.85
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  47   LAYER  1   ROW  71   COL  36   RATE   -9728.503
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  48   LAYER  1   ROW  70   COL  36   RATE   -9980.808
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  49   LAYER  1   ROW  69   COL  37   RATE  -10135.36
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  50   LAYER  1   ROW  68   COL  37   RATE   -9966.350
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  51   LAYER  1   ROW  67   COL  37   RATE  -10539.12    0.5
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  52   LAYER  1   ROW  66   COL  38   RATE  -11119.03
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  53   LAYER  1   ROW  65   COL  38   RATE  -11640.46
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  54   LAYER  1   ROW  64   COL  38   RATE   -9796.200    0.14
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  55   LAYER  1   ROW  63   COL  38   RATE   -4369.679
0   RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  56   LAYER  1   ROW  80   COL  37   RATE   -3705.07
0     VER L    GE     IOD       STE
```

$DF = \frac{3.36 + 0.5}{0.5} = 7.7$
shallow @ site

$DF = \frac{0.385 + 3.36}{0.385} = 9.7$
deep @ MW-15

```
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  66   LAYER  1   ROW  76   COL  54   RATE  -10836.84
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  67   LAYER  1   ROW  75   COL  54   RATE  -9066.286
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  68   LAYER  1   ROW  74   COL  55   RATE  -8088.486
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  69   LAYER  1   ROW  73   COL  56   RATE  -6976.046
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  70   LAYER  1   ROW  72   COL  56   RATE  -5556.173
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  71   LAYER  1   ROW  71   COL  56   RATE  -4674.354
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  72   LAYER  1   ROW  70   COL  57   RATE  -4053.207
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  73   LAYER  1   ROW  69   COL  57   RATE  -3102.875
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  74   LAYER  1   ROW  68   COL  57   RATE  -2374.263
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  75   LAYER  1   ROW  67   COL  57   RATE  -1730.900
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  76   LAYER  1   ROW  66   COL  57   RATE  -1132.059
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  77   LAYER  1   ROW  65   COL  58   RATE  -453.3005
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  78   LAYER  1   ROW  64   COL  58   RATE  -514.2880
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  79   LAYER  1   ROW  63   COL  58   RATE  -561.2946
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  80   LAYER  1   ROW  62   COL  58   RATE  -605.3448
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  81   LAYER  1   ROW  61   COL  58   RATE  -671.8445
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  82   LAYER  1   ROW  80   COL  61   RATE  -6468.381
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  83   LAYER  1   ROW  79   COL  61   RATE  -10490.68
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  84   LAYER  1   ROW  78   COL  61   RATE  -9418.626
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  85   LAYER  1   ROW  77   COL  62   RATE  -9422.275
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  86   LAYER  1   ROW  76   COL  63   RATE  -10171.80
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  87   LAYER  1   ROW  71   COL  65   RATE  -14731.52
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  88   LAYER  1   ROW  70   COL  65   RATE  -13271.45
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  89   LAYER  1   ROW  69   COL  66   RATE  -12610.13
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  90   LAYER  1   ROW  68   COL  66   RATE  -12276.67
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  91   LAYER  1   ROW  67   COL  67   RATE  -12182.60
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  92   LAYER  1   ROW  66   COL  67   RATE  -11263.39
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  93   LAYER  1   ROW  65   COL  67   RATE  -10696.94
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  94   LAYER  1   ROW  64   COL  67   RATE  -10326.07
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  95   LAYER  1   ROW  63   COL  67   RATE  -10246.92
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  96   LAYER  1   ROW  62   COL  68   RATE  -10479.13
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  97   LAYER  1   ROW  61   COL  69   RATE  -10553.16
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  98   LAYER  1   ROW  60   COL  70   RATE  -10522.13
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH  99   LAYER  1   ROW  59   COL  71   RATE  -10356.19
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 100   LAYER  1   ROW  58   COL  71   RATE  -9663.356
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 101   LAYER  1   ROW  57   COL  72   RATE  -9778.816
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 102   LAYER  1   ROW  56   COL  73   RATE  -9700.619
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 103   LAYER  1   ROW  55   COL  73   RATE  -8835.646
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 104   LAYER  1   ROW  53   COL  73   RATE  -10500.64
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 105   LAYER  1   ROW  52   COL  73   RATE  -9479.106
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 106   LAYER  1   ROW  51   COL  73   RATE  -8867.260
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 107   LAYER  1   ROW  50   COL  74   RATE  -8415.802
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 108   LAYER  1   ROW  49   COL  74   RATE  -7616.775
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 109   LAYER  1   ROW  48   COL  74   RATE  -7060.959
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 110   LAYER  1   ROW  47   COL  74   RATE  -6657.120
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 111   LAYER  1   ROW  46   COL  74   RATE  -6487.885
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 112   LAYER  1   ROW  45   COL  75   RATE  -6259.037
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 113   LAYER  1   ROW  44   COL  76   RATE  -5857.464
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 114   LAYER  1   ROW  43   COL  76   RATE  -5623.741
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 115   LAYER  1   ROW  42   COL  77   RATE  -5270.050
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 116   LAYER  1   ROW  41   COL  77   RATE  -5020.569
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 117   LAYER  1   ROW  40   COL  77   RATE  -4969.860
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 118   LAYER  1   ROW  39   COL  78   RATE  -4634.743
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 119   LAYER  1   ROW  38   COL  78   RATE  -4470.703
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 120   LAYER  1   ROW  37   COL  78   RATE  -4419.239
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 121   LAYER  1   ROW  36   COL  78   RATE  -4427.994
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 122   LAYER  1   ROW  35   COL  78   RATE  -4501.099
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH 123   LAYER  1   ROW  34   COL  78   RATE  -4700.638
0    RIVER LEAKAGE   PERIOD  1   STEP  1   REACH
```

APPENDIX G-2

SUMMARY OF RIVER FLUXES ALONG IDENTIFIED STREAM REACHES

SUMMARY OF RIVER FLUXES ALONG IDENTIFIED STREAM REACHES

```
RIVER SEGMENT      RIVER LOSS       RIVER GAIN        TOTAL (CF/D)
      1              3212.767    -286754.687    -283541.906
      2               465.689     -84126.680     -83660.992
      3                 0.000    -108030.711    -108030.711
      4                 0.000     -39350.809     -39350.809
      5              2792.454     -16613.443     -13820.989
      6                 0.000     -70725.742     -70725.742
      7                 0.000     -32371.182     -32371.182
      8                 0.000    -398082.375    -398082.375



RIVER NODES THAT FAILED ARE:


NO RIVER NODES FAILED




RIVER SEGMENT      RIVER LOSS       RIVER GAIN        TOTAL (CFS)
      1                0.0372        -3.3189         -3.2817
      2                0.0054        -0.9737         -0.9683
      3                0.0000        -1.2504         -1.2504
      4                0.0000        -0.4554         -0.4554
      5                0.0323        -0.1923         -0.1600
      6                0.0000        -0.8186         -0.8186
      7                0.0000        -0.3747         -0.3747
      8                0.0000        -4.6074         -4.6074



RIVER SEGMENT      RIVER LOSS       RIVER GAIN        TOTAL (GPM)
      1                16.689      -1489.531       -1472.843
      2                 2.419       -436.991        -434.572
      3                 0.000       -561.160        -561.160
      4                 0.000       -204.406        -204.406
      5                14.505        -86.298         -71.792
      6                 0.000       -367.381        -367.381
      7                 0.000       -168.150        -168.150
      8                 0.000      -2067.817       -2067.817
```

APPENDIX G-3

ESTIMATED BASEFLOW OF STREAMS

PROJECT	COMP. BY	JOB NO.
ServAll – Estimated Baseflow of Streams	RAL	
	CHK. BY GnH	DATE 1/5/95

1 of 1

Baseflow for Penataquit has been computed (estimated) by USGS with an average of 5.8 cfs.

Estimate baseflows to other streams in model by comparison of drainage areas

Stream	Approximate area	Baseflow
Penataquit	$(4000)(10000) = 40(10^6)\,ft^2$	5.8 cfs
Bull Ditch	$(800)(2000) = 1.6(10^6)$	0.2
Awixa	$(1400)(6000) = 8.4(10^6)$	1.2
Orowoc	$(3100)(10000) = 31(10^6)$	4.5

Note: Only section of Orowoc within the model grid is considered.

Baseflows for other streams are estimated by

$$\text{Baseflow for Penataquit}\left(\frac{\text{Area for other stream}}{\text{Area for Penataquit}}\right)$$

APPENDIX G-4

INFLUENCE OF SALINE WEDGE

PROJECT ServAll – Influence of Saline Wedge

COMP. BY RAL

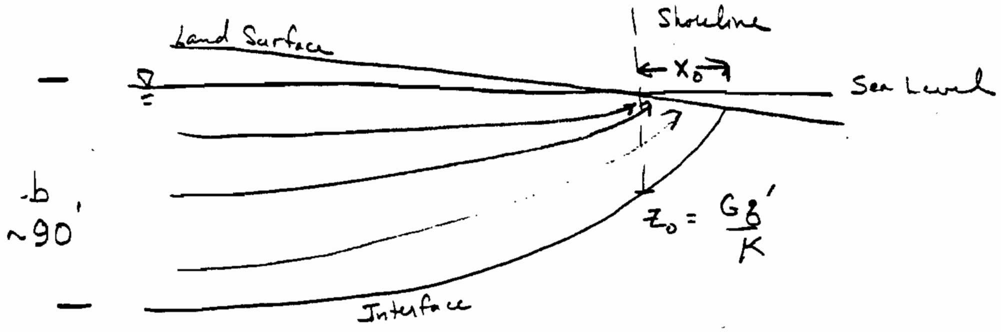
CHK. BY

JOB NO. 7135-91

DATE 1/5/95

1 of 2

From Fetter (1988) Applied Hydrogeology, 2nd ed



$$X_0 = -\frac{Gq'}{2K}$$

$$z = \frac{Gq'}{K} + \sqrt{\frac{2Gq'x}{K}} \quad ; \quad h = \sqrt{\frac{2q'x}{GK}}$$

where

$$G = \frac{\rho_w}{\rho_s - \rho_w} \approx \frac{1.0}{1.025-1.0} = 40$$

q' = aquifer discharge per unit width [=] $(L^3/T)/L$

K = aquifer hydraulic conductivity

h = height of water table (above sea level)

z = depth to interface (below sea level)

with $K \approx 255$ ft/d and $h \approx iX = 0.0024X$ and

$$q' = Kib \approx (255)(0.0024)(90') = 55.1 \text{ ft}^3/d/\text{ft}$$

$$z = \frac{(40)(55.1)}{255} + \sqrt{\frac{2(40)(55.1)}{255}}\, x$$

$$z = 8.64 + 4.16 X^{1/2}$$

PROJECT	COMP. BY	JOB NO.
ServAll - Influence of Saline Water	RAL	
	CHK. BY GH	DATE 1/5/95

2 of 2

X	Z
100	50.2
300	80.7
500	101.7
700	118.7
900	133.4

or interface would extend ~400' inland

By an alternate estimate

$$z(x,y) = \frac{\rho_w}{\rho_s - \rho_w} h(x,y) = G h$$

and, since $h = ix$,

$$z = GiX = 40(.0024)X = 0.096X$$

so if $z \simeq 90'$

$$X = \frac{90}{0.096} = 937.5$$ or interface would extend ~900' inland.

Use this latter estimate, which Fetter cites as being close to observed conditions on Long Island (p. 152).

In this case,

X	Z
100	9.6
300	28.8
500	48.0
700	67.2
900	86.4

or interface would extend about 900 feet inland.

Use the first equation to estimate X_0

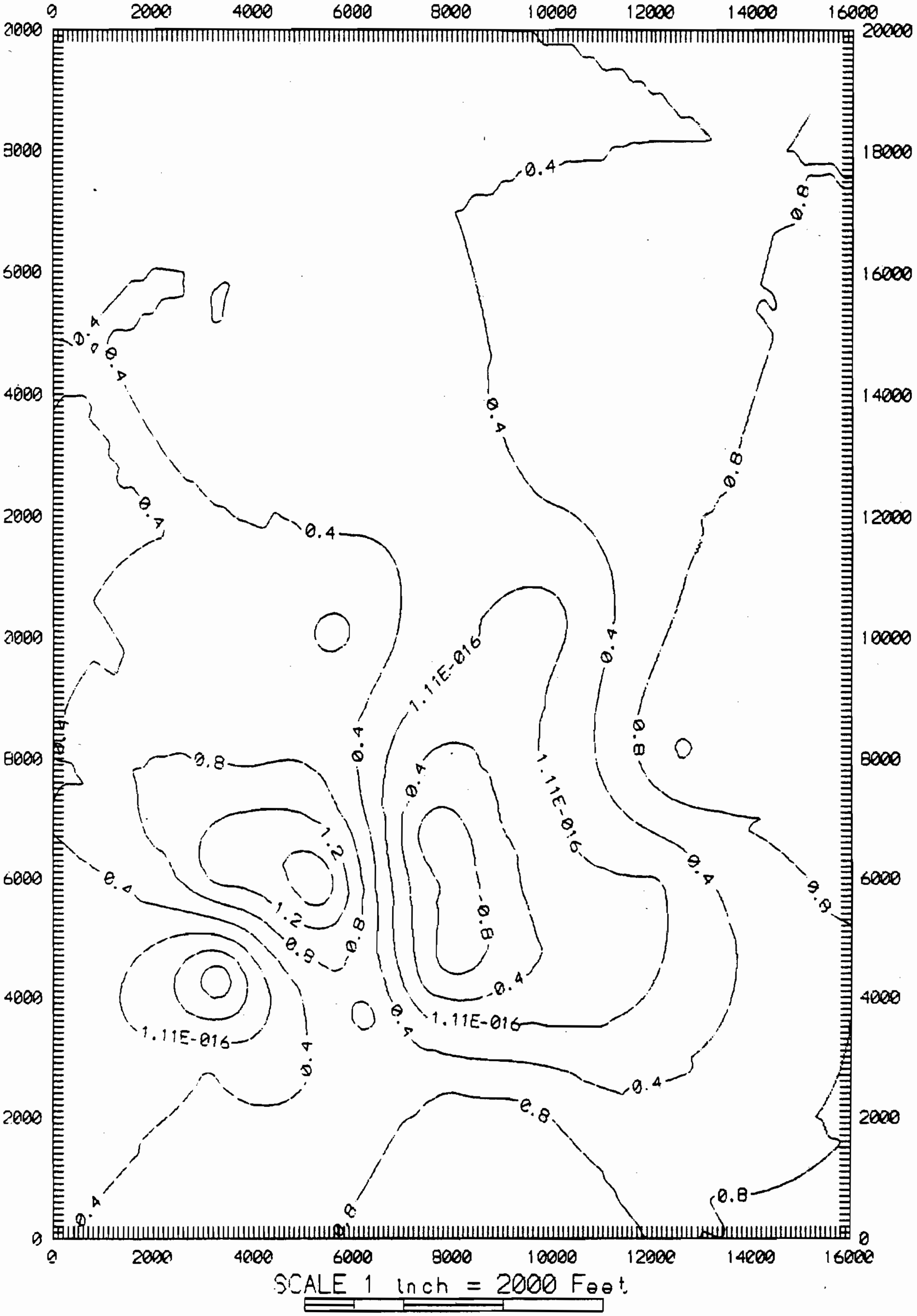
$$X_0 = \frac{Gq'}{2K} = \frac{40(55.1)}{2(255.)} = 4.3 \text{ ft}$$

[See Bokuniewicz & Zeitlin for discussion of why fresh water seepage occurs at greater distances into the Bay.]

APPENDIX G-5

RESIDUAL HEADS CONTOUR MAP-RUN 4-FINAL CALIBRATION RUN

RESIDUAL HEADS CONTOUR MAP - RUN 4 - FINAL CALIBRATION RUN



APPENDIX G-6

SAMPLE PARTICLE TRACKING ENDPOINT FILE DATA OUTPUT

SAMPLE PARTICLE TRACKING ENDPOINT FILE DATA OUTPUT

```
1  37  68  1  0.7323E+04  0.6550E+04 -0.5800E+01  0.0000E+00  0.1441E+04  0.6625E+04  0.1010E+05  0.1667E+00  34  50  3  1
1  37  68  1  0.7327E+04  0.6558E+04 -0.5800E+01  0.0000E+00  0.1438E+04  0.6675E+04  0.1010E+05  0.1667E+00  34  50  3  1
1  37  68  1  0.7334E+04  0.6579E+04 -0.5800E+01  0.0000E+00  0.1428E+04  0.6725E+04  0.1010E+05  0.1667E+00  34  50  3  1
1  37  67  1  0.7341E+04  0.6613E+04 -0.4900E+01  0.0000E+00  0.1412E+04  0.6775E+04  0.1010E+05  0.1667E+00  34  50  3  1
1  35  53  1  0.6800E+04  0.9422E+04  0.1531E+01  0.7861E-01  0.3465E+03  0.6625E+04  0.1010E+05  0.5000E+00  34  50  3  1
1  35  53  1  0.6800E+04  0.9456E+04  0.1318E+01  0.6500E-01  0.3272E+03  0.6675E+04  0.1010E+05  0.5000E+00  34  50  3  1
1  35  53  1  0.6800E+04  0.9488E+04  0.1098E+01  0.5093E-01  0.3080E+03  0.6725E+04  0.1010E+05  0.5000E+00  34  50  3  1
1  35  53  1  0.6800E+04  0.9519E+04  0.8694E+00  0.3635E-01  0.2888E+03  0.6775E+04  0.1010E+05  0.5000E+00  34  50  3  1
1  34  52  1  0.6680E+04  0.9734E+04  0.3000E+00  0.0000E+00  0.1618E+03  0.6625E+04  0.1010E+05  0.8333E+00  34  50  3  1
1  34  52  1  0.6704E+04  0.9734E+04  0.3000E+00  0.0000E+00  0.1618E+03  0.6675E+04  0.1010E+05  0.8333E+00  34  50  3  1
1  34  52  1  0.6727E+04  0.9734E+04  0.3000E+00  0.0000E+00  0.1618E+03  0.6725E+04  0.1010E+05  0.8333E+00  34  50  3  1
1  34  52  1  0.6750E+04  0.9734E+04  0.3000E+00  0.0000E+00  0.1618E+03  0.6775E+04  0.1010E+05  0.8333E+00  34  50  3  1
1  37  68  1  0.7343E+04  0.6595E+04 -0.5800E+01  0.0000E+00  0.1413E+04  0.6825E+04  0.1010E+05  0.1667E+00  35  50  3  1
1  37  68  1  0.7320E+04  0.6407E+04 -0.5800E+01  0.0000E+00  0.1452E+04  0.6875E+04  0.1010E+05  0.1667E+00  35  50  3  1
1  37  68  1  0.7327E+04  0.6425E+04 -0.5800E+01  0.0000E+00  0.1445E+04  0.6925E+04  0.1010E+05  0.1667E+00  35  50  3  1
1  37  68  1  0.7341E+04  0.6494E+04 -0.5800E+01  0.0000E+00  0.1421E+04  0.6975E+04  0.1010E+05  0.1667E+00  35  50  3  1
1  35  53  1  0.6821E+04  0.9460E+04  0.3000E+00  0.0000E+00  0.3085E+03  0.6825E+04  0.1010E+05  0.5000E+00  35  50  3  1
1  37  67  1  0.7365E+04  0.6651E+04 -0.4900E+01  0.0000E+00  0.1360E+04  0.6875E+04  0.1010E+05  0.5000E+00  35  50  3  1
1  37  67  1  0.7399E+04  0.6743E+04 -0.4900E+01  0.0000E+00  0.1354E+04  0.6925E+04  0.1010E+05  0.5000E+00  35  50  3  1
1  38  66  1  0.7415E+04  0.6901E+04 -0.3700E+01  0.0000E+00  0.1291E+04  0.6975E+04  0.1010E+05  0.5000E+00  35  50  3  1
1  34  52  1  0.6775E+04  0.9671E+04  0.3000E+00  0.0000E+00  0.1954E+03  0.6825E+04  0.1010E+05  0.8333E+00  35  50  3  1
1  37  67  1  0.7399E+04  0.6777E+04 -0.4900E+01  0.0000E+00  0.1332E+04  0.6875E+04  0.1010E+05  0.8333E+00  35  50  3  1
1  36  55  1  0.7021E+04  0.9000E+04  0.5000E+00  0.0000E+00  0.5057E+03  0.6925E+04  0.1010E+05  0.8333E+00  35  50  3  1
1  36  55  1  0.7020E+04  0.9077E+04  0.5000E+00  0.0000E+00  0.4654E+03  0.6975E+04  0.1010E+05  0.8333E+00  35  50  3  1
1  37  67  1  0.7369E+04  0.6605E+04 -0.4900E+01  0.0000E+00  0.1389E+04  0.7025E+04  0.1010E+05  0.1667E+00  36  50  3  1
1  37  67  1  0.7381E+04  0.6648E+04 -0.4900E+01  0.0000E+00  0.1364E+04  0.7075E+04  0.1010E+05  0.1667E+00  36  50  3  1
1  37  67  1  0.7387E+04  0.6659E+04 -0.4900E+01  0.0000E+00  0.1354E+04  0.7125E+04  0.1010E+05  0.1667E+00  36  50  3  1
1  37  67  1  0.7400E+04  0.6708E+04 -0.4523E+01  0.3209E-01  0.1342E+04  0.7175E+04  0.1010E+05  0.1667E+00  36  50  3  1
1  38  66  1  0.7408E+04  0.6994E+04 -0.3700E+01  0.0000E+00  0.1254E+04  0.7025E+04  0.1010E+05  0.5000E+00  36  50  3  1
1  38  65  1  0.7410E+04  0.7020E+04 -0.2700E+01  0.0000E+00  0.1225E+04  0.7075E+04  0.1010E+05  0.5000E+00  36  50  3  1
1  38  65  1  0.7421E+04  0.7019E+04 -0.2700E+01  0.0000E+00  0.1213E+04  0.7125E+04  0.1010E+05  0.5000E+00  36  50  3  1
1  38  65  1  0.7422E+04  0.7057E+04 -0.2700E+01  0.0000E+00  0.1201E+04  0.7175E+04  0.1010E+05  0.5000E+00  36  50  3  1
1  36  55  1  0.7020E+04  0.9154E+04  0.5000E+00  0.0000E+00  0.4245E+03  0.7025E+04  0.1010E+05  0.8333E+00  36  50  3  1
1  36  55  1  0.7046E+04  0.9138E+04  0.5000E+00  0.0000E+00  0.4090E+03  0.7075E+04  0.1010E+05  0.8333E+00  36  50  3  1
1  36  55  1  0.7083E+04  0.9068E+04  0.5000E+00  0.0000E+00  0.4294E+03  0.7125E+04  0.1010E+05  0.8333E+00  36  50  3  1
1  36  55  1  0.7106E+04  0.9068E+04  0.5000E+00  0.0000E+00  0.4294E+03  0.7175E+04  0.1010E+05  0.8333E+00  36  50  3  1
1  38  66  1  0.7444E+04  0.6831E+04 -0.3700E+01  0.0000E+00  0.1285E+04  0.7225E+04  0.1010E+05  0.1667E+00  37  50  3  1
1  38  66  1  0.7445E+04  0.6874E+04 -0.3700E+01  0.0000E+00  0.1268E+04  0.7275E+04  0.1010E+05  0.1667E+00  37  50  3  1
1  38  66  1  0.7450E+04  0.6857E+04 -0.3700E+01  0.0000E+00  0.1270E+04  0.7325E+04  0.1010E+05  0.1667E+00  37  50  3  1
1  38  66  1  0.7455E+04  0.6854E+04 -0.3700E+01  0.0000E+00  0.1248E+04  0.7375E+04  0.1010E+05  0.1667E+00  37  50  3  1
1  38  65  1  0.7420E+04  0.7102E+04 -0.2700E+01  0.0000E+00  0.1188E+04  0.7225E+04  0.1010E+05  0.5000E+00  37  50  3  1
1  38  65  1  0.7417E+04  0.7147E+04 -0.2700E+01  0.0000E+00  0.1175E+04  0.7275E+04  0.1010E+05  0.5000E+00  37  50  3  1
1  38  65  1  0.7434E+04  0.7107E+04 -0.2700E+01  0.0000E+00  0.1178E+04  0.7325E+04  0.1010E+05  0.5000E+00  37  50  3  1
1  38  65  1  0.7445E+04  0.7069E+04 -0.2700E+01  0.0000E+00  0.1166E+04  0.7375E+04  0.1010E+05  0.5000E+00  37  50  3  1
1  36  55  1  0.7129E+04  0.9068E+04  0.5000E+00  0.0000E+00  0.4296E+03  0.7225E+04  0.1010E+05  0.8333E+00  37  50  3  1
1  36  55  1  0.7153E+04  0.9057E+04  0.5000E+00  0.0000E+00  0.4360E+03  0.7275E+04  0.1010E+05  0.8333E+00  37  50  3  1
1  37  57  1  0.7239E+04  0.8644E+04  0.8000E+00  0.0000E+00  0.6387E+03  0.7325E+04  0.1010E+05  0.8333E+00  37  50  3  1
1  38  64  1  0.7424E+04  0.7215E+04 -0.1700E+01  0.0000E+00  0.1123E+04  0.7375E+04  0.1010E+05  0.8333E+00  37  50  3  1
1  38  66  1  0.7459E+04  0.6902E+04 -0.3700E+01  0.0000E+00  0.1226E+04  0.7425E+04  0.1010E+05  0.1667E+00  38  50  3  1
1  38  66  1  0.7463E+04  0.6945E+04 -0.3700E+01  0.0000E+00  0.1207E+04  0.7475E+04  0.1010E+05  0.1667E+00  38  50  3  1
1  38  66  1  0.7468E+04  0.6960E+04 -0.3700E+01  0.0000E+00  0.1195E+04  0.7525E+04  0.1010E+05  0.1667E+00  38  50  3  1
1  38  66  1  0.7468E+04  0.6861E+04 -0.3700E+01  0.0000E+00  0.1218E+04  0.7575E+04  0.1010E+05  0.1667E+00  38  50  3  1
1  38  65  1  0.7447E+04  0.7126E+04 -0.2700E+01  0.0000E+00  0.1146E+04  0.7425E+04  0.1010E+05  0.5000E+00  38  50  3  1
1  38  65  1  0.7450E+04  0.7177E+04 -0.2700E+01  0.0000E+00  0.1127E+04  0.7475E+04  0.1010E+05  0.5000E+00  38  50  3  1
1  38  65  1  0.7456E+04  0.7195E+04 -0.2700E+01  0.0000E+00  0.1116E+04  0.7525E+04  0.1010E+05  0.5000E+00  38  50  3  1
1  38  65  1  0.7473E+04  0.7074E+04 -0.2700E+01  0.0000E+00  0.1137E+04  0.7575E+04  0.1010E+05  0.5000E+00  38  50  3  1
1  38  64  1  0.7425E+04  0.7279E+04 -0.1700E+01  0.0000E+00  0.1103E+04  0.7425E+04  0.1010E+05  0.8333E+00  38  50  3  1
1  38  64  1  0.7427E+04  0.7331E+04 -0.1700E+01  0.0000E+00  0.1085E+04  0.7475E+04  0.1010E+05  0.8333E+00  38  50  3  1
1  38  64  1  0.7437E+04  0.7349E+04 -0.1700E+01  0.0000E+00  0.1074E+04  0.7525E+04  0.1010E+05  0.8333E+00  38  50  3  1
1  38  65  1  0.7468E+04  0.7190E+04 -0.2700E+01  0.0000E+00  0.1100E+04  0.7575E+04  0.1010E+05  0.8333E+00  38  50  3  1
1  38  66  1  0.7472E+04  0.6861E+04 -0.3700E+01  0.0000E+00  0.1217E+04  0.7625E+04  0.1010E+05  0.1667E+00  39  50  3  1
```

APPENDIX G-7

AT123D SIMULATION RUN DATA OUTPUT

ATT23D SIMULATION RUN DATA OUTPUT

```
Run at 42 yrs, x = 3810m

     NO. OF POINTS IN X-DIRECTION ......................   14
     NO. OF POINTS IN Y-DIRECTION ......................    7
     NO. OF POINTS IN Z-DIRECTION ......................    3
     NO. OF ROOTS & NO. OF SERIES TERMS ................  400
     NO. OF BEGINNING TIME STEPS .......................   43
     NO. OF ENDING TIME STEP ...........................   43
     NO. OF TIME INTERVALS FOR PRINTED OUT SOLUTION ....    1
     INSTANTANEOUS SOURCE CONTROL = 0 FOR INSTANT SOURCE    0
     SOURCE CONDITION CONTROL = 0 FOR STEADY SOURCE ....    0
     INTERMITTENT OUTPUT CONTROL = 0 NO SUCH OUTPUT ....    2
     CASE CONTROL =1 THERMAL, = 2 FOR CHEMICAL, = 3 RAD

     AQUIFER DEPTH, = 0.0 FOR INFINITE DEEP (METERS) ... 27.000000
     AQUIFER WIDTH, = 0.0 FOR INFINITE WIDE (METERS) ...**********
     BEGIN POINT OF X-SOURCE LOCATION (METERS) .........-15.250000
     END POINT OF X-SOURCE LOCATION (METERS) ........... 15.250000
     BEGIN POINT OF Y-SOURCE LOCATION (METERS) .........-15.250000
     END POINT OF Y-SOURCE LOCATION (METERS) ........... 15.250000
     BEGIN POINT OF Z-SOURCE LOCATION (METERS) .........  0.000000
     END POINT OF Z-SOURCE LOCATION (METERS) ...........  2.000000


     POROSITY ..........................................  0.300000
     HYDRAULIC CONDUCTIVITY (METER/HOUR) ...............  1.550000
     HYDRAULIC GRADIENT ................................  0.002770
     LONGITUDINAL DISPERSIVITY (METER) ................. 21.299999
     LATERAL DISPERSIVITY (METER) ......................  0.300000
     VERTICAL DISPERSIVITY (METER) .....................  0.001000
     DISTRIBUTION COEFFICIENT, KD (M**3/KG) ............  0.000067
     HEAT EXCHANGE COEFFICIENT (KCAL/HR-M**2-DEGREE C) .  0.000000


     MOLECULAR DIFFUSION MULTIPLY BY TORTUOSITY(M**2/HR)  0.0000E+00
     DECAY CONSTANT (PER HOUR) .........................  0.0000E+00
     BULK DENSITY OF THE SOIL (KG/M**3) ................  0.1800E+04
     DENSITY OF WATER (KG/M**3) ........................  0.1000E+04
     ACCURACY TOLERANCE FOR REACHING STEADY STATE ......  0.1000E-01
     TIME INTERVAL SIZE FOR THE DESIRED SOLUTION (HR) ..  0.8760E+04
     DISCHARGE TIME (HR) ...............................  0.1000E+01
     WASTE RELEASE RATE (KCAL/HR), (KG/HR), OR (CI/HR) .  0.1200E+04

     2438.     2591.     2743.     2896.     3048.     3200.     3353.
     3658.     3810.     3962.     4114.     4267.     4430.
        0.        30.       61.       91.      122.      152.      183.
        0.         3.        6.


0
     RETARDATION FACTOR ................................  0.1400E+01
     RETARDED DARCY VELOCITY (M/HR) ....................  0.1022E-01
     RETARDED LONGITUDINAL DISPERSION COEF. (M**2/HR) ..  0.2177E+00
     RETARDED LATERAL DISPERSION COEFFICIENT (M**2/HR) .  0.3066E-02
     RETARDED VERTICAL DISPERSION COEFFICIENT (M**2/HR)   0.1022E-04

OSTEADY STATE SOLUTION HAS NOT BEEN REACHED BEFORE FINAL SIMULATING TIM
```

```
1
   DISTRIBUTION OF CHEMICALS IN PPM AT  15330.00 DAYS
0                       Z =        0.00
                                                     X
   Y        2438.       2591.       2743.       2896.      3048.       3200.       3353.       3505.       3658.       3810.

    0.       0.027       0.088       0.248       0.610       1.288       2.355       3.739       5.120       6.075       6.230
   30.       0.022       0.072       0.203       0.500       1.055       1.930       3.064       4.196       4.978       5.105
   61.       0.012       0.040       0.112       0.275       0.581       1.062       1.685       2.308       2.738       2.808
   91.       0.004       0.015       0.041       0.101       0.214       0.392       0.622       0.852       1.011       1.037
  122.       0.001       0.004       0.010       0.025       0.053       0.097       0.154       0.211       0.250       0.257
  152.       0.000       0.001       0.002       0.004       0.009       0.016       0.026       0.035       0.042       0.043
  183.       0.000       0.000       0.000       0.000       0.001       0.002       0.003       0.004       0.005       0.005
0                                                CONTINUE
                                                     X
   Y        3962.       4114.       4267.       4430.

    0.       5.531       4.252       2.820       1.551
   30.       4.532       3.484       2.311       1.271
   61.       2.493       1.917       1.271       0.699
   91.       0.921       0.708       0.469       0.258
  122.       0.228       0.175       0.116       0.064
  152.       0.038       0.029       0.019       0.011
  183.       0.004       0.003       0.002       0.001
0                       Z =        3.10
                                                     X
   Y        2438.       2591.       2743.       2896.      3048.       3200.       3353.       3505.       3658.       3810.

    0.       0.016       0.052       0.145       0.357       0.754       1.379       2.189       2.997       3.556       3.647
   30.       0.013       0.042       0.119       0.292       0.618       1.130       1.793       2.456       2.914       2.988
   61.       0.007       0.023       0.066       0.161       0.340       0.622       0.987       1.351       1.603       1.644
   91.       0.003       0.009       0.024       0.059       0.125       0.229       0.364       0.499       0.592       0.607
  122.       0.001       0.002       0.006       0.015       0.031       0.057       0.090       0.124       0.147       0.150
  152.       0.000       0.000       0.001       0.002       0.005       0.009       0.015       0.021       0.024       0.025
  183.       0.000       0.000       0.000       0.000       0.001       0.001       0.002       0.002       0.003       0.003
0                                                CONTINUE
                                                     X
   Y        3962.       4114.       4267.       4430.

    0.       3.238       2.489       1.651       0.908
   30.       2.653       2.039       1.353       0.744
   61.       1.460       1.122       0.744       0.409
   91.       0.539       0.414       0.275       0.151
  122.       0.133       0.103       0.068       0.037
  152.       0.022       0.017       0.011       0.006
  183.       0.002       0.002       0.001       0.001
0                       Z =        6.10
                                                     X
   Y        2438.       2591.       2743.       2896.      3048.       3200.       3353.       3505.       3658.       3810.

    0.       0.003       0.011       0.031       0.075       0.159       0.291       0.461       0.632       0.749       0.768
   30.       0.003       0.009       0.025       0.062       0.130       0.238       0.378       0.518       0.614       0.630
   61.       0.001       0.005       0.014       0.034       0.072       0.131       0.208       0.285       0.338       0.346
   91.       0.001       0.002       0.005       0.013       0.026       0.048       0.077       0.105       0.125       0.128
  122.       0.000       0.000       0.001       0.003       0.007       0.012       0.019       0.026       0.031       0.032
  152.       0.000       0.000       0.000       0.001       0.001       0.002       0.003       0.004       0.005       0.005
  183.       0.000       0.000       0.000       0.000       0.000       0.000       0.000       0.000       0.001       0.001
0                                                CONTINUE
                                                     X
   Y        3962.       4114.       4267.       4430.



    0.       0.682       0.524       0.348       0.191
   30.       0.559       0.430       0.285       0.157
   61.       0.308       0.236       0.157       0.086
   91.       0.114       0.087       0.058       0.032
  122.       0.028       0.022       0.014       0.008
  152.       0.005       0.004       0.002       0.001
  18         0.001       0.000       0.000       0.000
```

APPENDIX G-8

TRANSPORT CALCULATIONS

PROJECT
ServAll – Transport Calculations

COMP. BY RAL

CHK. BY GH

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Estimate total mass in cross-section of plume:

Ave. concentration assuming Gaussian distribution across ellipsoid ≈ Cmax/5.

Max conc. @ approximate beginning location of discharge to Pawtoguit = 6.3 mg/l PCE based on AT123D Run.

Plume is approx. 1200 ft wide, but only ~12 ft thick. Porosity = 0.3, and groundwater velocity (from tracking runs) ≈ 912 ft/yr.

$$Q = (912\ ft/yr)(1200 ft)(12 ft)(0.3)$$
$$= 3{,}939{,}840\ ft^3/yr \Rightarrow 0.12\ cfs$$

Total mass @ 6.3 ppm (max)

$$M = \left[\left(\frac{6.3\ \#}{\cancel{10^6}\ \#}\right)/5\right](3.94\cancel{(10^6)}\ ft^3/yr)\left(62.4\ \frac{\#}{ft^3}\right) = 310\ \#/yr$$

$$= 0.85\ \#/d$$

[Note this is the maximum discharge rate.]

For particle tracking, particles were entered in a 2×2×4 array in 6 grid blocks [row 50, cols 37-42] for a total of 96 particles. Of these, only the two bottom particle layers were considered to represent contaminated groundwater, or 48 particles carried the total mass of PCE.

The plume is assumed (as in AT123D) to have a Gaussian (normal) distribution of mass across the plume. The entire width is 1200 feet, which is presumed to represent 6 standard deviations about the plume axis.

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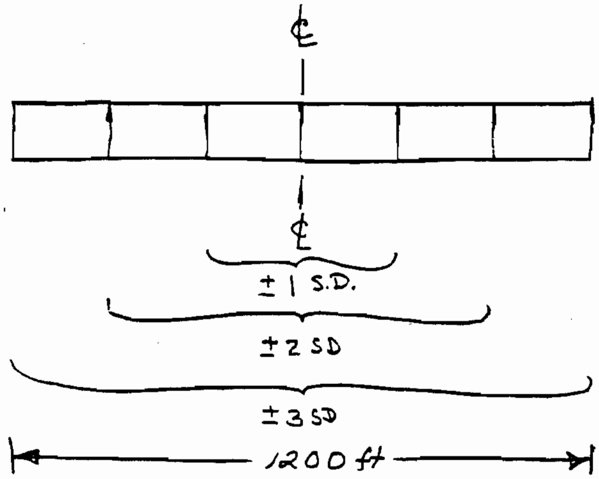

For a normal distribution, approximately 66% of the mass is within 1 standard deviation, 29% between 1 and 2 standard deviations, and about 5% between 2 and 3.

Note that while the plume geometry may be considered as concentric ellipsoids, the distribution (laterally) still is as the normal distribution.

In the calculations that follow, particles representing mass within 1 S.D of the axis are termed Type 3 particles, those between 1 and 2 SDs as Type 2 particles, and those between 2 and 3 SDs as Type 1 particles.

Then there are 16 of each type of particle, and we can weight them as to the mass each carries.

16 Type 3	= 66% of mass	1056
16 Type 2	= 29	464
16 Type 1	= 5	80
		1600

An alternate approach could have been to assign 200 particles (since 5% is odd), as follows, to the blocks, with equal mass (0.85#/200) for each

5	29	66	66	29	5

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We chose the first method because of the fewer particles to track.

At each reach of the Ponataquit that particles discharge to, the incremental mass is computed as:

$$\left[\frac{66(\overset{\#}{\text{Type 3}})+29(\overset{\#}{\text{Type 2}})+5(\overset{\#}{\text{Type 3}})}{1600}\right](0.85\ \#/d)$$

Concentration in the stream is computed as

$$\frac{\text{Cumulative mass}}{\text{Cumulative baseflow}}$$

for each successive stream reach.

Worksheets for each of the three model versions (dependent on the K selected in layer 5) have been prepared and included in the appendix. and the best fit model in the text. Table 4-5 also summarizes the numbers of particles for all three model versions. The variation between models is slight.

For other compounds, contaminants were assumed to move at approximately the same rate (i.e., retardation is approximately the same for all compounds). Given the present location and distribution of contaminants in the VOC plume, this appears to be true although greater retardation of the PCE relative to the other species would be expected. Retardation of VOCs in the aquifer appears to be less than 2 for the contaminant migration. Distributions were assumed to be similar.

The release rates for other compounds, and incremental masses to the Ponataquit (via particle tracking), are simply proportional to the ratio of the maximum concentrations to that for PCE. The estimated concentrations based on previous and recent AT123D runs were:

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	@ 1524 m	@ 4180 m	
	Max	Max	Mean
PCE	18.0 mg/L	6.3 mg/L	1.26 mg/L
TCE	1.5	0.5	0.1
DCE	6.0	2.1	0.42
VC	2.0	0.7	0.14

Toluene would be totally degraded as indicated in the screening analysis.

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APPENDIX G-9

DISCHARGE CONCENTRATION TABLES

TABLE G-1 (APPENDIX G)
DISCHARGE CONCENTRATION SENSITIVITY (K5 = 500)
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Assumed/Modelled Conditions:	
Plume Width (ft):	1200
Groundwater vel. (ft/yr):	912
Effective porosity:	0.3
Plume thickness(ft):	12
River flow upstream(cfs):	3.2

River location		Particles added			Mass added		Flow(cfs)		PCE	TCE	DCE	VC
Row	Col	Type 1	Type 2	Type 3	Fract	Sum	Inc	Sum	ppb	ppb	ppb	ppb
63	38	0	0	0	0	0	0.05	3.25	0	0	0	0
64	38	0	0	0	0	0	0.113	3.363	0	0	0	0
65	38	2	4	2	0.16125	0.16125	0.135	3.498	7.25642049	0.57590638	2.41880683	0.80626894
66	38	4	4	4	0.25	0.41125	0.129	3.627	17.8484652	1.41654486	5.94948842	1.98316280
67	37	2	0	0	0.00625	0.4175	0.122	3.749	17.5300664	1.39127511	5.84335548	1.94778516
68	37	0	0	4	0.165	0.5825	0.115	3.864	23.7301965	1.88334893	7.91006551	2.63668850
69	37	0	0	4	0.165	0.7475	0.117	3.981	29.5570810	2.34580008	9.85236035	3.28412011
70	36	0	0	0	0	0.7475	0.116	4.097	28.7202196	2.27938250	9.57340653	3.19113551
71	36	0	0	0	0	0.7475	0.112	4.209	27.9559847	2.21872894	9.31866157	3.10622052
72	36	0	0	2	0.0825	0.83	0.118	4.327	30.1949086	2.39642132	10.0649695	3.35498985
73	35	0	0	0	0	0.83	0.118	4.445	29.3933340	2.33280428	9.79777801	3.26592600
74	35	0	2	0	0.03625	0.86625	0.119	4.564	29.8772165	2.37120766	9.95907219	3.31969073
75	35	0	4	0	0.0725	0.93875	0.126	4.69	31.5079124	2.50062797	10.5026374	3.50087916
76	35	8	2	0	0.06125	1	0.141	4.831	32.5840816	2.58603822	10.8613605	3.62045352

Sediments:						
	Pore water (ppm)				Sed. conc. (ppm)	
Comp.	Max	Ave	Koc	foc	Max	Ave
PCE	6.3	1.26	364	0.01	22.932	4.5864
TCE	0.5	0.1	126	0.01	0.63	0.126
DCE	2.1	0.42	54	0.01	1.134	0.2268
VC	0.7	0.14	57	0.01	0.399	0.0798

APPENDIX H

AGENCY RESPONSES TO REQUESTS FOR INFORMATION OF SPECIES AND HABITATS OF SPECIAL CONCERN

Agency responses to be included when they are received.

APPENDIX I

ECOLOGICAL TOXICITY PROFILES

I.1 TETRACHLOROETHENE

Tetrachloroethene (PCE) exposure by aquatic receptors has been associated with acute toxic effects to fish, invertebrates and plants (USEPA, 1980a; AQUIRE, 1994). In human and animal studies, PCE has been shown to enter the blood through respiration and absorption through skin (USEPA, 1980a). Once in the body, it tends to distribute to body fat due to its lipophilicity. PCE metabolizes into trichloro-compounds and ultimately trichloroacetic acid, which may be less reactive than the reactive metabolic intermediates of similar VOCs such as vinyl chloride, 1,1-DCE, and TCE. In animals, PCE is primarily excreted through respiration, and the metabolic product is primarily eliminated via the urine. Toxic effects in laboratory animals have included central nervous system depression (USEPA, 1980a). These chemical effects at the cellular level may also occur in aquatic species.

Short-term (acute) duration exposure toxicity studies data are presented in USEPA, 1980a for three fish species and two invertebrates. LC_{50}s ranged from 5,280 μg/L for the rainbow trout (*Salmo gairdneri*) to 30,840 μg/L for the midge (*Tanytarsus disimilis*), with water flea (*Daphnia magna*), fathead minnow (*Pimephales promelas*), and bluegill (*Lepomis macrochirus*) LC_{50}s occurring within the range. Data obtained from AQUIRE are presented in Table J-1 and Figure 5-3. Table J-1 presents over 50 studies of acute duration on seven different aquatic taxa, including fish, water fleas and midges. These data show results similar to USEPA's, with LC_{50}s values reported for the midge and bluegill at the high end of the range. LC_{50} values reported for the water flea (*Moina macrocopa*), rainbow trout (*Oncorhynchus mykiss*) and medaka fish (*Oryzias latipes*) are among the lowest (Figure 5-3). Midge larva dwell in the benthic substrate and appear to fairly tolerant of PCE exposure, while pelagic species such as fish and water fleas appear to be more sensitive.

Studies of PCE exposure to algae (*Selenastrum capricornutum*) have demonstrated effects at concentrations an order of magnitude greater (816,000 μg/L) than those from the animal studies (USEPA, 1980a). Algae studies included measurements of effects on chlorophyll *a* production and cell growth.

Long-term exposure studies (chronic) of PCE on the embryo-larval stages of fathead minnow have indicated effects at concentrations (840 μg/L) lower than those of the acute studies (USEPA, 1980a). Chronic exposure studies on the water flea compiled by AQUIRE have shown similar results, with effects on growth and reproduction occurring at an average concentration of 854 μg/L (Table J-1). An acute:chronic ratio of 16 was calculated based on the fathead minnow study (USEPA, 1980a), and one of 16 was calculated based on the water flea study (Table J-1). An acute:chronic ratio of 6 was calculated from the USEPA report, based on the acute and chronic LOELs (for bluegill and rainbow trout, respectively).

Due to their high vapor pressure and rate of volatilization, VOCs typically do not remain in solution in water long enough to be available for bioaccumulation in aquatic systems. VOCs such as dichloroethanes evaporate from water in a matter of hours (Howard, 1990) to two days (USEPA, 1980b). However, in laboratory tests at high concentrations, PCE has been shown to become concentrated in biological tissues in aquatic organisms at levels greater than other VOCs, based on bioconcentration studies on fish (USEPA, 1980a, Howard, 1990). This is most likely a result of the lipophilicity of PCE relative to other VOCs such as trichloroethylene (TCE). Bioconcentration of PCE in fish tissue was determined to be 49 for the bluegill (USEPA, 1980a; AQUIRE, 1994) and 39 for the fathead minnow (Howard, 1990). A BCF of 226 was estimated based on the $\log K_{ow}$ (Howard, 1990). Bioconcentration potential has been shown to increase with increasing molecular chlorinization.

I.2 TRICHLOROETHENE

TCE exposure in aquatic environments has been associated with acute toxic effects to fish, invertebrates and plants (USEPA, 1980c; AQUIRE, 1994). As is the case with PCE, toxic effects reported in laboratory animals involve primarily central nervous system depression (USEPA, 1980c). These chemical effects at the cellular level in laboratory mammals may be similar for aquatic fauna, as well.

Short-term (acute) exposure toxicity studies data are presented in USEPA, 1980c for two fish species and two invertebrates. LC_{50}s ranged from 40,700 μg/L for the fathead minnow to 64,000 μg/L for the water flea with the bluegill and water flea (*D. pulex*) LC_{50}s occurring at 44,700 μg/L and 45,000 μg/L, respectively. Data obtained from AQUIRE are presented in Table J-2 and Figure 5-4. Table J-2 presents over 50 studies of acute duration on 25 different aquatic taxa, including amphibians, fish, insects, crustaceans, mollusks, flatworms, annelids, cnidarians and algae. These data are comparable to data presented in USEPA, 1980c, with several LC_{50}s greater than 100,000 μg/L. A benthic tubificid worm is reported to have the greatest LC_{50} (132,000 μg/L) (Figure 5-4). Species with the lowest LC_{50}s and presumably the most sensitive to TCE exposure include rainbow trout, the bluegill, and the water flea, *Moina macrocopa*, (with the lowest LC_{50} [2,300 μg/L]).

Studies of TCE exposure to algae (*Selenastrum capricornutum*) have demonstrated effects on uptake of carbon in photosynthesis at 8,000 μg/L (USEPA, 1980c). The AQUIRE data for algal species indicated effects concentrations higher than those reported for aquatic animal species. Population effects occurred to the algae *Selenastrum capricornutum* and *Scenedesmus abundans* at 175,000 μg/L and 450,000 μg/L, respectively (AQUIRE, 1994; Table J-2).

Chronic exposure studies of TCE are generally unavailable, and an acute:chronic ratio was not identified.

TCE has been shown to become concentrated in biological tissues in aquatic organisms at levels 2 to 25 times greater than the concentration in water, based on bioconcentration studies on fish (USEPA, 1980c; Howard, 1990). This is most likely a result of the lipophilicity of TCE. Bioconcentration of TCE in fish tissue was determined to be 17 for the bluegill (USEPA, 1980c) and 39 for the rainbow trout (Howard, 1990). AQUIRE reports BCFs ranging from 2 for algae to 17 for bluegill. The half-life of TCE is less than one day. This fact, coupled with the bioconcentration data, suggests that residue problems will not occur at exposure concentrations that are not directly toxic to aquatic life (USEPA, 1980c).

I.3 DICHLOROETHENES

Exposure to dichloroethenes (DCEs) in aquatic environments has been associated with acute toxic effects in fish, invertebrates and plants (USEPA, 1980b; AQUIRE, 1994). The DCEs, similarly to related chloroethenes, are likely readily absorbed by all routes of exposure, including respiration, dermal exposure, and ingestion, as demonstrated in studies on humans and other mammals (USEPA, 1980b). Once in the body, the lipophilic DCEs have been shown to deposit in the kidney, liver, and brain. DCEs metabolize in several ways, the essential feature being the formation of epoxide intermediates which are reactive and may form covalent bonds with tissue macromolecules. The relationship of metabolism of DCEs to toxicity is unclear. However, hepatotoxicity associated with DCE increases with decreasing concentrations of hepatic glutathione. DCEs, like other chlorinated ethenes, possess anesthetic properties and affect the central nervous system. Other effects shown in studies include damage to the liver and kidney, and teratogenicity. The chemical effects of DCEs at the cellular level in laboratory animals may also be similar in aquatic organisms.

Studies of short-term exposure (acute) toxicity studies data are presented in USEPA, 1980b for two fish species and an invertebrate. In this group of studies, the fish species appeared to be slightly more tolerant of DCEs than the invertebrate *Daphnia magna*. LC_{50}s ranged from 135,000 μg/L for 1,2-DCE for the bluegill to 30,300 μg/L for 1,1-DCE for the water flea (*Daphnia magna*), with the fathead minnow LC_{50} for 1,1-DCE at 108,000 μg/L. Data obtained from AQUIRE include only studies for 1,1-DCE, and are presented in Table J-4 and Figure 5-5. Table J-4 presents 27 studies of acute duration on four different aquatic taxa, including fish, water fleas and algae. These data show results similar to USEPA's (Figure 5-5). The species with the lowest LC_{50}s and presumably the most sensitive to DCE in both USEPA and AQUIRE is *Daphnia magna* (19,037 μg/L in AQUIRE).

Studies of 1,1-DCE exposure to the alga *Selenastrum capricornutum*, have resulted in LC_{50}s greater than those from the animal studies of both USEPA and AQUIRE data compilations. Algae EC_{50}s are 410,000 μg/L in the AQUIRE compilation (Table J-4) and 798,000 μg/L in the USEPA report. Effects were measured on growth and development (AQUIRE, 1994; Table J-3) and chlorophyll *a* production (USEPA, 1980b). Effects concentrations of 1,2-DCE exposures to algae would likely be similar to those of 1,1-DCE.

Long-term exposure studies for DCE are few, but a fathead minnow study in USEPA, 1980b with 1,1-DCE reports an EC_{50} of greater than 2,800 in an embryo-larval study. An acute:chronic ratio of 39 was calculated, based on the species mean acute value.

VOCs such as dichloroethanes (DCAs) evaporate from water in a matter of hours (Howard, 1990) to 2 days (USEPA, 1980b). However, in laboratory tests at high concentrations, DCE has been shown to become concentrated in biological tissues in aquatic organisms at levels of approximately 15 times greater than the concentration in water, based on the logK_{ow} and a recommended regression equation (Howard, 1990). This is most likely a result of the lipophilicity of DCE.

I.4 VINYL CHLORIDE

Data on acute toxic effects to aquatic life from vinyl chloride were not available in USEPA AWQC reports. Data on vinyl chloride from the AQUIRE database were from studies of low reliability and/or not applicable to acute toxicity measurements (Table J-3). In the Phase I Report (ABB-ES, 1994a) an aquatic life toxicity benchmark was estimated for vinyl chloride based on a QSAR equation from USEPA (1988), that calculates an approximate LC_{50} based on the chemical's K_{ow}. Using this method, vinyl chloride was estimated be slightly more toxic to aquatic life than 1,1-DCA and TCE, and less toxic than 1,1-DCE, 1,2-DCE, PCE and toluene.

I.5 DICHLOROETHANES

Exposure to chlorinated ethanes in aquatic environments has been associated with acute toxic effects to fish, invertebrates and plants (USEPA, 1980d; AQUIRE, 1994). In human and laboratory studies on other mammals, DCA has been shown to enter the blood through respiration, systemic absorption by ingestion, and to a slight degree, absorption through skin (USEPA, 1980d). Once in the body, it tends to distribute to body fat due to its lipophilicity, especially to the liver, brain, kidney, and blood. DCA metabolizes into thiodiacetic acid and chloroethanol. Toxic effects in laboratory tests have primarily included central nervous system depression, gastrointestinal upset, and damage to the liver, kidneys, and lungs. (USEPA, 1980d). Some of these same effects may also be expressed in aquatic organisms.

Short-term (acute) duration exposure toxicity studies data on 1,2-DCA are presented in USEPA, 1980d for two fish species and two invertebrates. Both groups contain species with varying LC_{50}s. LC_{50}s ranged from 113,000 μg/L for the mysid shrimp (*Mysidopsis bahia*) to 489,000 μg/L for the bluegill. Data obtained from AQUIRE are presented in Table J-5 and Figure 5-6. Table J-5 presents over 30 studies of acute duration on seven different aquatic taxa, including frogs, salamanders, fish, water fleas and stoneflies. These data are comparable to the USEPA results, with the water flea (*Daphnia magna*) average LC_{50} at the high end of the range, and those of the salamander (*Ambystoma gracile*) and leopard frog (*Rana pipiens*) among the lowest (Figure 5-6). Studies for 1,1-DCA were not available, but effects at concentrations similar to those of 1,2-DCA would be expected for 1,1-DCA.

Studies of 1,2-DCA and 1,1-DCA exposure to algae were not available. However, studies on other chlorinated ethanes resulted in EC_{50}s similar to those of the animal studies (USEPA, 1980d). Algae studies (on *Selenastrum capricornutum*) included measurements of effects on chlorophyll *a* production and cell propagation.

A long-term (chronic) duration exposure study of 1,2-DCA on the fathead minnow embryo-larval life stages was presented, showing an LC_{50} of 20,000 μg/L. Chronic studies on 1,2-DCA have been compiled by AQUIRE for fish and *Daphnia magna*, with effects on growth, development and reproduction ranging from 34 μg/L (rainbow trout (*Oncorhynchus mykiss*)) to 72,000 μg/L (*Daphnia magna*) (Table J-5). An acute:chronic ratio of 5.9 was calculated based on the USEPA fathead minnow study (1980d), and ratios ranging from 2.5 (fathead minnow) to 6,208 (rainbow trout) were calculated based on the AQUIRE data (Table J-5). No chronic studies of 1,1-DCA exposures were available, but effects at concentrations similar to those of 1,2-DCA would be expected for 1,1-DCA.

1,2-DCA has been shown to become concentrated in biological tissues in aquatic organisms, based on fish studies (USEPA, 1980d; Howard, 1990). This is most likely a result of the lipophilicity of chlorinated ethanes. Bioconcentration of 1,2-DCA in fish tissue was determined to be 2 (USEPA, 1980d) and 0.3 (Howard, 1990) for the bluegill (*Lepomis macrochirus*). A BCF of 8 was estimated based on $\log K_{ow}$ (Howard, 1990). AQUIRE reports a BCF of 2 based on a bluegill study.

APPENDIX J

AQUIRE DATA SUMMARIES

TABLE J-1
ACUTE TOXICOLOGICAL DATA FOR TETRACHLOROETHENE FROM AQUIRE
UNITS = μg/L
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Scientific Name	Life Stage	Exposure Regimen	Test Conditions	Effect	Effect Category	Endpoint	Effect Concentration	Author	Year Published
Daphnia magna	FIRST INSTAR, <= 24 H	48 H	FW; LAB	IMM	lethal, behavior	EC_{50}	7490 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Daphnia magna	<24 H	24 H	FW; LAB	MOR	lethal	LC_{50}	18000 (F)	LeBlanc,G.A.	80
Daphnia magna	<24 H	48 H	FW; LAB	MOR	lethal		10000 (F)	LeBlanc,G.A.	80
Daphnia magna	FIRST INSTAR, <= 24 H	48 H	FW; LAB	MOR	lethal	LC_{50}	9090 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Daphnia magna	FIRST INSTAR, < 24 H	48 H	FW; LAB	IMM	lethal, behavior	EC_{50}	8500 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, <= 24 H	48 H	FW; LAB	MOR	lethal	LC_{50}	18100 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Daphnia magna	FIRST INSTAR, < 24 H	48 H	FW; LAB	MOR	lethal	LC_{50}	18000 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, <= 24 H	48 H	FW; LAB	IMM	lethal, behavior	EC_{50}	8500 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Daphnia magna	FIRST INSTAR, < 24 H	48 H	FW; LAB	MOR	lethal	LC_{50}	9100 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	<24 H	48 H	FW; LAB	MOR	lethal	LC_{50}	18000 (F)	LeBlanc,G.A.	80
Daphnia magna	NR	24 H	FW; LAB			EC_{50}	147000 (F)	Bringmann,G.; Kuhn,R.	82
Daphnia magna	FIRST INSTAR, < 24 H	48 H	FW; LAB	IMM	lethal, behavior	EC_{50}	7500 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Lepomis macrochirus	JUVENILE, 0.32-1.2 G	24 H	FW; LAB	MOR	lethal	LC_{50}	46000 (F)	Buccafusco,R.J.; Ells,S.J.; LeBlanc,G.A.	81
Lepomis macrochirus	JUVENILE, 0.32-1.2 G	96 H	FW; LAB	MOR	lethal	LC_{50}	13000 (F)	Buccafusco,R.J.; Ells,S.J.; LeBlanc,G.A.	81
Moina macrocopa	5 D	3 H	FW; LAB	MOR	lethal	LC_{50}	1800 (F)	Yoshioka,Y.; Ose,Y.; Sato,T.	86
Oncorhynchus mykiss	6.1 CM, 3.2 G, FINGERLING	48 H	FW; LAB	MOR	lethal	LC_{50}	4990 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Oncorhynchus mykiss	3.20 G	96 H	FW; LAB	MOR	lethal	LC_{50}	4990 (F)	Shubat,P.J.; Poirier,S.H.; Knuth,M.L.; Brooke,L.T.	82
Oncorhynchus mykiss	7.3 CM, 5.86 G, FINGERLING	24 H	FW; LAB	MOR	lethal	LC_{50}	6310 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Oncorhynchus mykiss	7.3 CM, 5.86 G, FINGERLING	96 H	FW; LAB	MOR	lethal	LC_{50}	5840 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Oncorhynchus mykiss	6.1 CM, 3.2 G, FINGERLING	72 H	FW; LAB	MOR	lethal	LC_{50}	4990 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Oncorhynchus mykiss	6.1 CM, 3.2 G, FINGERLING	96 H	FW; LAB	MOR	lethal	LC_{50}	4990 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Oncorhynchus mykiss	7.3 CM, 5.86 G, FINGERLING	72 H	FW; LAB	MOR	lethal	LC_{50}	5810 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Oncorhynchus mykiss	7.3 CM, 5.86 G, FINGERLING	48 H	FW; LAB	MOR	lethal	LC_{50}	5950 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Oncorhynchus mykiss	6.1 CM, 3.2 G, FINGERLING	24 H	FW; LAB	MOR	lethal	LC_{50}	4990 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Oryzias latipes	3 CM, 0.3 G	48 H	FW; LAB	MOR	lethal	LC_{50}	1600 (F)	Yoshioka,Y.; Ose,Y.; Sato,T.	86
Pimephales promelas	1.04 G, 49.0 MM	96 H	FW; LAB	MOR	lethal	LC_{50}	21400 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	30-35 D	72 H	FW; LAB	MOR	lethal	LC_{50}	14900 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	1.04 G, 49.0 MM	72 H	FW; LAB	MOR	lethal	LC_{50}	18900 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	1.04 G, 49.0 MM	96 H	FW; LAB	MOR	lethal	LC_{50}	18400 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	1.04 G, 49.0 MM	96 H	FW; LAB	IMM	lethal, behavior	EC_{50}	14400 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	31 D, 20.3 MM, 0.120 G	96 H	FW; LAB	MOR	lethal	LC_{50}	20300 (F)	Geiger,D.L.; Northcott,C.E.; Call,D.J.; Brooke,L.T.	85
Pimephales promelas	30 D	96 H	FW; LAB	MOR	lethal	LC_{50}	13400 (F)	Geiger,D.L.; Northcott,C.E.; Call,D.J.; Brooke,L.T.	85
Pimephales promelas	1.04 G, 49.0 MM	48 H	FW; LAB	MOR	lethal	LC_{50}	19600 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	0.12 G	96 H	FW; LAB	MOR	lethal	LC_{50}	13500 (F)	Veith,G.D.; Call,D.J.; Brooke,L.T.	83
Pimephales promelas	30-35 D	48 H	FW; LAB	MOR	lethal	LC_{50}	15900 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	30-35 D	96 H	FW; LAB	MOR	lethal	LC_{50}	13400 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	1.04 G, 49.0 MM	72 H	FW; LAB	IMM	lethal, behavior	EC_{50}	14400 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	1.04 G, 49.0 MM	24 H	FW; LAB	IMM	lethal, behavior	EC_{50}	14400 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	1.04 G, 49.0 MM	48 H	FW; LAB	IMM	lethal, behavior	EC_{50}	14400 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	30-35 D	24 H	FW; LAB	MOR	lethal	LC_{50}	17900 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	1.04 G, 49.0 MM	24 H	FW; LAB	MOR	lethal	LC_{50}	23500 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Tanytarsus dissimilis	3RD OR 4TH INSTAR, 2.0-3.5 MM	24 H	FW; LAB	MOR	lethal	LC_{50}	54600 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Tanytarsus dissimilis	3RD OR 4TH INSTAR, 2.0-3.5 MM	48 H	FW; LAB	MOR	lethal	LC_{50}	30800 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
CHRONIC DATA									
Daphnia magna	< 24 H	28 D	FW; LAB	GRO	growth, development		1110 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Daphnia magna	FIRST INSTAR, < 24 H	28 D	FW; LAB	GRO	growth, development		1100 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83

TABLE J–1
ACUTE TOXICOLOGICAL DATA FOR TETRACHLOROETHENE FROM AQUIRE
UNITS = $\mu g/L$
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Scientific Name	Life Stage	Exposure Regimen	Test Conditions	Effect	Effect Category	Endpoint	Effect Concentration	Author	Year Published
CHRONIC DATA (cont.)									
Daphnia magna	FIRST INSTAR, < 24 H	28 D	FW; LAB	GRO	growth, development		510 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, < 24 H	28 D	FW; LAB	REP	reproduction		510 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, < 24 H	28 D	FW; LAB	REP	reproduction		1100 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	< 24 H	28 D	FW; LAB	REP	reproduction		1110 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
OTHER DATA									
Daphnia magna	NR	24 H	FW; LAB			EC_{100}	250000 (F)	Bringmann,G.; Kuhn,R.	82
Daphnia magna	NR	24 H	FW; LAB			EC_0	65000 (F)	Bringmann,G.; Kuhn,R.	82
BIOCONCENTRATION									
Lepomis macrochirus	0.37–0.95 G, 25–35 MM	to 21 D	FW; LAB	RSD	bioconcentration	BCF	3.43 (F)	Barrows,M.E.; Petrocelli,S.R.; Macek,K.J.; Carroll,J.J.	80
RELIABILITY CLASS 3,4 DATA									
Carassius auratus	NR	1 to 180 D	FW; LAB				100 (F)	Loekle,D.	87
Carassius auratus	NR	>=90 D	FW; LAB				100 (F)	Loekle,D.	87
Spirogyra sp	NR	7 WK	FW; FIELD				25000 (F)	Lay,J.P.; Schauerte,W.; Klein,W.; Korte,F.	84
Stichococcus bacillaris	NR	7 WK	FW; FIELD				25000 (F)	Lay,J.P.; Schauerte,W.; Klein,W.; Korte,F.	84
Chilomonas paramecium	NR	7 WK	FW; LAB				25000 (F)	Lay,J.P.; Schauerte,W.; Klein,W.; Korte,F.	84
Nitzschia acicularis	NR	7 WK	FW; LAB				25000 (F)	Lay,J.P.; Schauerte,W.; Klein,W.; Korte,F.	84
Cyprinus carpio	NR	94 H	FW; LAB				119 to 282 (F)	Loeb,H.A.; Kelly,W.H.	63
Daphnia magna	NR	to 48 H	FW; FIELD				250000 (F)	Lay,J.P.; Schauerte,W.; Klein,W.; Korte,F.	84
Actinophrys sp	NR	7 WK	FW; LAB				25000 (F)	Lay,J.P.; Schauerte,W.; Klein,W.; Korte,F.	84
Anacystis flosaquae	NR	7 WK	FW; FIELD				25000 (F)	Lay,J.P.; Schauerte,W.; Klein,W.; Korte,F.	84
Daphnia magna	NR	7 to 96 H	FW; FIELD				25000 (F)	Lay,J.P.; Schauerte,W.; Klein,W.; Korte,F.	84

# TABLE J–2
# ACUTE TOXICOLOGICAL DATA FOR TRICHLOROETHENE FROM AQUIRE
UNITS = μg/L
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Scientific Name	Life Stage	Exposure Regimen	Test Conditions	Effect	Effect Category	Endpoint	Effect Concentration	Author	Year Published
Aedes aegypti	3RD INSTAR	48 H	FW; LAB	MOR	lethal	LC_{50}	48000 (F)	Slooff,W.; Canton,J.H.; Hermens,J.L.M.	83
Ambystoma mexicanum	3–4 WK	48 H	FW; LAB	MOR	lethal	LC_{50}	48000 (F)	Slooff,W.; Baerselman,R.	80
Asellus aquaticus	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	30000 (F)	Slooff,W.	83
Brachydanio rerio	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	60000 (F)	Slooff,W.	79
Chironomus thummi	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	64000 (F)	Slooff,W.	83
Cloeon dipterum	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	42000 (F)	Slooff,W.	83
Corixa punctata	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	110000 (F)	Slooff,W.	83
Culex pipiens	3RD INSTAR	48 H	FW; LAB	MOR	lethal	LC_{50}	55000 (F)	Slooff,W.; Canton,J.H.; Hermens,J.L.M.	83
Daphnia magna	NR	24 H	FW; FIELD	MOR	lethal	leth	110000 (F) (*)	Lay,J.P.; Schauerte,W.; Klein,W.	84
Daphnia magna	24 H	24 H	FW; LAB	MOR	lethal	LC_{50}	> 1000000 (F)	Bringmann,G.; Kuhn,R.	77
Daphnia magna	<=24 H	48 H	FW; LAB	MOR	lethal		2200 (F)	LeBlanc,G.A.	80
Daphnia magna	<=24 H	24 H	FW; LAB	MOR	lethal	LC_{50}	22000 (F)	LeBlanc,G.A.	80
Daphnia magna	NR	24 H	FW; LAB			EC_{50}	1313000 (F)	Bringmann,G.; Kuhn,R.	82
Daphnia magna	<=24 H	48 H	FW; LAB	MOR	lethal	LC_{50}	18000 (F)	LeBlanc,G.A.	80
Daphnia magna	NR	3 D	FW; FIELD	ABD	population, community		25000 (F) (*)	Lay,J.P.; Schauerte,W.; Klein,W.	84
Dugesia lugubris	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	42000 (F)	Slooff,W.	83
Erpobdella octoculata	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	75000 (F)	Slooff,W.	83
Gammarus pulex	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	24000 (F)	Slooff,W.	83
Hydra oligactis	BUDLESS	48 H	FW; LAB	MOR	lethal	LC_{50}	75000 (F)	Slooff,W.; Canton,J.H.; Hermens,J.L.M.	83
Hydra oligactis	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	75000 (F)	Slooff,W.	83
Ischnura elegans	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	49000 (F)	Slooff,W.	83
Lepomis macrochirus	JUVENILE, 0.32–1.2 G	24 H	FW; LAB	MOR	lethal	LC_{50}	>68000 to <100000 (F)	Buccafusco,R.J.; Ells,S.J.; LeBlanc,G.A.	81
Lepomis macrochirus	JUVENILE, 0.32–1.2 G	96 H	FW; LAB	MOR	lethal	LC_{50}	45000 (F)	Buccafusco,R.J.; Ells,S.J.; LeBlanc,G.A.	81
Lepomis macrochirus	JUVENILE 75 D, 2.2 CM	1 H	FW; LAB	RES	physiological, biological		100 (F)	Diamond,J.M.; Parson,M.J.; Gruber,D.	90
Lymnaea stagnalis	3–4 WK	48 H	FW; LAB	MOR	lethal	LC_{50}	56000 (F)	Slooff,W.; Canton,J.H.; Hermens,J.L.M.	83
Lymnaea stagnalis	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	56000 (F)	Slooff,W.	83
Moina macrocopa	5 D	3 H	FW; LAB	MOR	lethal	LC_{50}	2300 (F)	Yoshioka,Y.; Ose,Y.; Sato,T.	86
Nemoura cinerea	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	70000 (F)	Slooff,W.	83
Oncorhynchus mykiss	NR	24 H	FW; LAB	RES	physiological, biological		5000 (F)	Slooff,W.	79
Oncorhynchus mykiss	5–8 WK	48 H	FW; LAB	MOR	lethal	LC_{50}	42000 (F)	Slooff,W.; Canton,J.H.; Hermens,J.L.M.	83
Oryzias latipes	3 CM, 0.3 G	48 H	FW; LAB	MOR	lethal	LC_{50}	1900 (F)	Yoshioka,Y.; Ose,Y.; Sato,T.	86
Oryzias latipes	4–5 WK	48 H	FW; LAB	MOR	lethal	LC_{50}	270000 (F)	Slooff,W.; Canton,J.H.; Hermens,J.L.M.	83
Pimephales promelas	1.04 G, 49.0 MM	96 H	FW; LAB	MOR	lethal	LC_{50}	40700 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	30–35 D	72 H	FW; LAB	MOR	lethal	LC_{50}	55400 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	3–4 WK	48 H	FW; LAB	MOR	lethal	LC_{50}	47000 (F)	Slooff,W.; Canton,J.H.; Hermens,J.L.M.	83
Pimephales promelas	1.04 G, 49.0 MM	48 H	FW; LAB	MOR	lethal	LC_{50}	53300 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	30–35 D	48 H	FW; LAB	MOR	lethal	LC_{50}	57900 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	1.04 G, 49.0 MM	72 H	FW; LAB	MOR	lethal	LC_{50}	39000 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	1.04 G, 49.0 MM	24 H	FW; LAB	MOR	lethal	LC_{50}	52400 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	1.04 G, 49.0 MM	48 H	FW; LAB	IMM	lethal, behavior	EC_{50}	22700 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	1.04 G, 49.0 MM	24 H	FW; LAB	IMM	lethal, behavior	EC_{50}	23000 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	1.04 G; 49.0 MM	96 H	FW; LAB	MOR	lethal	LC_{50}	66800 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	31 D	96 H	FW; LAB	MOR	lethal	LC_{50}	44100 (F)	Geiger,D.L.; Northcott,C.E.; Call,D.J.; Brooke,L.T.	85
Pimephales promelas	30–35 D	24 H	FW; LAB	MOR	lethal	LC_{50}	58800 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	1.04 G, 49.0 MM	96 H	FW; LAB	IMM	lethal, behavior	EC_{50}	21900 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	1.04 G, 49.0 MM	72 H	FW; LAB	IMM	lethal, behavior	EC_{50}	22200 (F)	Alexander,H.C.; McCarty,W.M.; Bartlett,E.A.	78
Pimephales promelas	30–35 D	96 H	FW; LAB	MOR	lethal	LC_{50}	45000 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	0.12 G	96 H	FW; LAB	MOR	lethal	LC_{50}	44100 (F)	Veith,G.D.; Call,D.J.; Brooke,L.T.	83
Scenedesmus abundans	10E4 CELLS/ML	96 H	FW; LAB	GRO	growth, development	EC_{50}	450000 (F)	Geyer,H.; Scheunert,I.; Korte,F.	85
Selenastrum capricornutum	LOG PHASE	96 H	FW; LAB	PGR	population, community		175000 (F)	Slooff,W.; Canton,J.H.; Hermens,J.L.M.	83
Tubificidae	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	132000 (F)	Slooff,W.	83
Xenopus laevis	3–4 WK	48 H	FW; LAB	MOR	lethal	LC_{50}	45000 (F)	Slooff,W.; Baerselman,R.	80

TABLE J–2
ACUTE TOXICOLOGICAL DATA FOR TRICHLOROETHENE FROM AQUIRE
UNITS = µg/L
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Name	Life Stage	Exposure Regimen	Test Conditions	Effect	Effect Category	Endpoint	Effect Concentration	Author	Year Published
Other Data									
Daphnia magna	4–6 D	48 H	FW; LAB	IMM	lethal, behavior	EC_{50}	59 MM/M3 (F)	Abernethy,S.; Bobra,A.M.; Shiu,W.Y.; Wells,P.G.; Mackay,D.	86
Daphnia magna	NR	24 H	FW; LAB			EC100	1.5 (F)	Bringmann,G.; Kuhn,R.	82
Daphnia magna	NR	24 H	FW; LAB			EC0	1.13 (F)	Bringmann,G.; Kuhn,R.	82
Bioconcentration Data									
Lepomis macrochirus	0.37–0.95 G, 25–35 MM	to 14 D	FW; LAB	RSD	bioconcentration	BCF	8.23 (F)	Barrows,M.E.; Petrocelli,S.R.; Macek,K.J.; Carroll,J.J.	80
Reliability Class 3,4 Data									
Oryzias latipes	NR	24 H	FW; LAB	MOR	lethal	LC_{50}	440000 (F)	Tsuji,S.; Tonogai,Y.; Ito,Y.; Kanoh,S.	86
Carassius auratus	NR	>=60 D	FW; LAB	HIS	physiological, biological		100 (F)	Loekle,D.	87
Oryzias latipes	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	440000 (F)	Tsuji,S.; Tonogai,Y.; Ito,Y.; Kanoh,S.	86
Carassius auratus	NR	1 to 180 D	FW; LAB	GRO	growth,development		100 (F)	Loekle,D.	87
Oryzias latipes	NR	48 H	FW; LAB	MOR	lethal	LC_{50}	730000 (F)	Tsuji,S.; Tonogai,Y.; Ito,Y.; Kanoh,S.	86
Oryzias latipes	NR	24 H	FW; LAB	MOR	lethal	LC_{50}	730000 (F)	Tsuji,S.; Tonogai,Y.; Ito,Y.; Kanoh,S.	86
Daphnia magna	< 1 D	48 H	FW; LAB	MOR	lethal	LC_{50}	43000 (F)	Canton,J.H.; Adema,D.M.M.	78
Scenedesmus quadricauda	STATIONARY PHASE	5 D	FW; LAB	RSD	bioconcentration	BCF	5 to 1000 (F)	Smets,B.F.; Rittmann,B.E.	90
Chlorella vulgaris	STATIONARY PHASE	5 D	FW; LAB	RSD	bioconcentration	BCF	5 to 1000 (F)	Smets,B.F.; Rittmann,B.E.	90
Daphnia magna	< 1 D	48 H	FW; LAB	MOR	lethal	LC_{50}	100000 (F)	Canton,J.H.; Adema,D.M.M.	78
Daphnia cucullata	11 D	48 H	FW; LAB	MOR	lethal	LC_{50}	56000 (F)	Canton,J.H.; Adema,D.M.M.	78
Daphnia pulex	< 1 D	48 H	FW; LAB	MOR	lethal	LC_{50}	51000 (F)	Canton,J.H.; Adema,D.M.M.	78
Daphnia magna	< 1 D	48 H	FW; LAB	MOR	lethal	LC_{50}	56000 (F)	Canton,J.H.; Adema,D.M.M.	78
Daphnia cucullata	11 D	48 H	FW; LAB	MOR	lethal	LC_{50}	58000 (F)	Canton,J.H.; Adema,D.M.M.	78
Daphnia magna	< 1 D	48 H	FW; LAB	MOR	lethal	LC_{50}	55000 (F)	Canton,J.H.; Adema,D.M.M.	78
Selenastrum capricornutum	STATIONARY PHASE	5 D	FW; LAB	RSD	bioconcentration	BCF	5 to 1000 (F)	Smets,B.F.; Rittmann,B.E.	90
Daphnia magna	< 1 D	48 H	FW; LAB	MOR	lethal	LC_{50}	41000 (F)	Canton,J.H.; Adema,D.M.M.	78
Daphnia magna	< 1 D	48 H	FW; LAB	MOR	lethal	LC_{50}	94000 (F)	Canton,J.H.; Adema,D.M.M.	78
Daphnia pulex	< 1 D	48 H	FW; LAB	MOR	lethal	LC_{50}	39000 (F)	Canton,J.H.; Adema,D.M.M.	78

# TABLE J–3
# ACUTE TOXICOLOGICAL DATA FOR VINYL CHLORIDE FROM AQUIRE
UNITS = μg/L
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Scientific Name	Life Stage	Exposure Regimen	Test Conditions	Effect	Effect Category	Endpoint	Effect Concentration	Author	Year Published
Esox lucius	15–48 CM	10 D	FW; LAB	MOR	LETHAL	lethality	388000 (F) (*)	Brown,E.R.; Sinclair,T.; Keith,L.; Beamer,P.; Hazdra,J.J.; Nair,V.; Callaghan,O.	77
BIOCONCENTRATION DATA									
Gambusia affinis	NR	72 D	FW; LAB	RSD	BIOCONCENTRATION	NR	41.74 (F) (*)	Lu,P.Y.; Metcalf,R.L.; Plummer,N.; Mandel,D.	77
Oedogonium cardiacum	NR	72 D	FW; LAB	RSD	BIOCONCENTRATION	NR	41.74 (F) (*)	Lu,P.Y.; Metcalf,R.L.; Plummer,N.; Mandel,D.	77
Physa sp.	NR	72 D	FW; LAB	RSD	BIOCONCENTRATION	NR	41.74 (F) (*)	Lu,P.Y.; Metcalf,R.L.; Plummer,N.; Mandel,D.	77
Culex pipiens quinquefasciata	LARVAE	72 D	FW; LAB	RSD	BIOCONCENTRATION	NR	41.74 (F) (*)	Lu,P.Y.; Metcalf,R.L.; Plummer,N.; Mandel,D.	77
Daphnia magna	NR	72 D	FW; LAB	RSD	BIOCONCENTRATION	NR	41.74 (F) (*)	Lu,P.Y.; Metcalf,R.L.; Plummer,N.; Mandel,D.	77

TABLE J–4
ACUTE TOXICOLOGICAL DATA FOR 1,1–DICHLOROETHENE FROM AQUIRE [a]
UNITS = $\mu g/L$
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Scientific Name	Life Stage	Exposure Regimen	Test Condition	Effect	Effect Category	Endpoint	Effect Concentration	Author	Year Published
Daphnia magna	FIRST INSTAR	24 H	FW; LAB	MOR	lethal	LC_{50}	11600 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Daphnia magna	<24 H	24 H	FW; LAB	MOR	lethal	LC_{50}	98000 (F)	LeBlanc,G.A.	80
Daphnia magna	<24 H	48 H	FW; LAB	MOR	lethal		<2400 (F)	LeBlanc,G.A.	80
Daphnia magna	<24 H	48 H	FW; LAB	MOR	lethal	LC_{50}	79000 (F)	LeBlanc,G.A.	80
Daphnia magna	FIRST INSTAR	48 H	FW; LAB	MOR	lethal	LC_{50}	11600 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Lepomis macrochirus	33–75 MM	98 H	FW; LAB	MOR	lethal	LC_{50}	220000 (F)	Dawson,G.W.; Jennings,A.L.; Drozdowski,D.; Rider,E.	77
Lepomis macrochirus	JUVENILE, 0.32–1.2 G	98 H	FW; LAB	MOR	lethal	LC_{50}	140000 (F)	Buccafusco,R.J.; Ells,S.J.; LeBlanc,G.A.	81
Lepomis macrochirus	JUVENILE, 0.32–1.2 G	96 H	FW; LAB	MOR	lethal	LC_{50}	74000 (F)	Buccafusco,R.J.; Ells,S.J.; LeBlanc,G.A.	81
Lepomis macrochirus	JUVENILE, 0.32–1.2 G	24 H	FW; LAB	MOR	lethal	LC_{50}	74000 (F)	Buccafusco,R.J.; Ells,S.J.; LeBlanc,G.A.	81
Lepomis macrochirus	JUVENILE, 0.32–1.2 G	24 H	FW; LAB	MOR	lethal	LC_{50}	165000 (F)	Buccafusco,R.J.; Ells,S.J.; LeBlanc,G.A.	81
Pimephales promelas	0.8 G, 35 MM, ADULT	9 D	FW; LAB	MOR	lethal	LC_{50}	29000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	ADULT, 0.8 G, 35 MM	48 H	FW; LAB	MOR	lethal	LC_{50}	169000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	ADULT, 0.8 G, 35 MM	5 D	FW; LAB	MOR	lethal	LC_{50}	97000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	0.8 G, 35 MM, ADULT	8 D	FW; LAB	MOR	lethal	LC_{50}	29000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	ADULT, 0.8 G, 35 MM	6 D	FW; LAB	MOR	lethal	LC_{50}	74000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	0.8 G, 35 MM, ADULT	96 H	FW; LAB	MOR	lethal	LC_{50}	108000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	ADULT, 0.8 G, 35 MM	7 D *	FW; LAB	MOR	lethal	LC_{50}	29000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	ADULT, 0.8 G, 35 MM	24 H	FW; LAB	MOR	lethal	LC_{50}	175000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	ADULT, 0.8 G, 35 MM	96 H	FW; LAB	MOR	lethal	LC_{50}	169000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	0.8 G, 35 MM, ADULT	13 D	FW; LAB	MOR	lethal	LC_{50}	29000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	ADULT, 0.8 G, 35 MM	24 H	FW; LAB	MOR	lethal	LC_{50}	116000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	0.8 G, 35 MM, ADULT	10 D	FW; LAB	MOR	lethal	LC_{50}	29000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	0.8 G, 35 MM, ADULT	12 D	FW; LAB	MOR	lethal	LC_{50}	29000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	ADULT, 0.8 G, 35 MM	48 H	FW; LAB	MOR	lethal	LC_{50}	108000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Pimephales promelas	0.8 G, 35 MM, ADULT	11 D	FW; LAB	MOR	lethal	LC_{50}	29000 (F)	Dill,D.C.; McCarty,W.M.; Alexander,H.C.; Bartlett,E.A.	80
Scenedesmus abundans	10E4 CELLS/ML	96 H	FW; LAB	GRO	growth, development	EC_{50}	410000 (F)	Geyer,H.; Scheunert,I.; Korte,F.	85

NOTES:

[a] Due to the lack of toxicity data for 1,2–Dichloroethylene, the AQUIRE data for 1,1–Dichloroethylene are being used to predict effects from exposure to 1,2–Dichloroethylene

TABLE J–5
ACUTE TOXICOLOGICAL DATA FOR 1,2–DICHLOROETHANE FROM AQUIRE
UNITS = $\mu g/L$
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Scientific Name	Life Stage	Exposure Regimen	Test Conditions	Effect	Effect Concentration	Author	Year Published
Ambystoma gracile	EMBRYO	5.5 D	FW; LAB	LC_{50}	6530 (F)	Black,J.A.; Birge,W.J.; McDonnell,W.E.; Westerman,A.G.; Ramey,B.A.; Bruser,D.M.	82
Ambystoma gracile	EMBRYO	9.5 D	FW; LAB	LC_{50}	2540 (F)	Black,J.A.; Birge,W.J.; McDonnell,W.E.; Westerman,A.G.; Ramey,B.A.; Bruser,D.M.	82
Daphnia magna	6–24 H	48 H	FW; LAB	EC_{50}	324000 (F)	Kuhn,R.; Pattard,M.; Pernak,K.; Winter,A.	89
Daphnia magna	NR	24 H	FW; LAB	EC_{50}	540000 (F)	Bringmann,G.; Kuhn,R.	82
Daphnia magna	FIRST INSTAR, <= 24 H	48 H	FW; LAB	LC_{50}	315000 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Daphnia magna	<24 H	48 H	FW; LAB	LETHAL	<68000 (F)	LeBlanc,G.A.	80
Daphnia magna	24 H	24 H	FW; LAB	LC_{50}	1350000 (F)	Bringmann,G.; Kuhn,R.	77
Daphnia magna	NR	24 H	FW; LAB	EC_{0}	385000 (F)	Bringmann,G.; Kuhn,R.	82
Daphnia magna	YOUNG, <= 24 H	48 H	FW; LAB	LC_{50}	1430000 (F)	Qureshi,A.A.; Flood,K.W.; Thompson,S.R.; Janhurst,S.M.; Inniss,C.S.; Rokosh,D.A.	82
Daphnia magna	<24 H	48 H	FW; LAB	LC_{50}	220000 (F)	LeBlanc,G.A.	80
Daphnia magna	6–24 H	24 H	FW; LAB	EC_{50}	383000 (F)	Kuhn,R.; Pattard,M.; Pernak,K.; Winter,A.	89
Daphnia magna	FIRST INSTAR, < 24 H	48 H	FW; LAB	LC_{50}	270000 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, <= 24 H	48 H	FW; LAB	EC_{50}	155000 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Daphnia magna	FIRST INSTAR, < 24 H	48 H	FW; LAB	LC_{50}	320000 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, < 24 H	48 H	FW; LAB	EC_{50}	160000 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, <= 24 H	48 H	FW; LAB	LC_{50}	268000 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Daphnia magna	<24 H	24 H	FW; LAB	LC_{50}	250000 (F)	LeBlanc,G.A.	80
Daphnia magna	NR	24 H	FW; LAB	EC_{100}	682000 (F)	Bringmann,G.; Kuhn,R.	82
Daphnia magna	FIRST INSTAR, < 24 H	48 H	FW; LAB	EC_{50}	180000 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, <= 24 H	48 H	FW; LAB	EC_{50}	183000 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Gammarus fasciatus	MATURE	96 H	FW; LAB	LC_{50}	> 100000 (F)	Johnson,W.W.; Finley,M.T.	80
Oncorhynchus mykiss	1.8 G	96 H	FW; LAB	LC_{50}	225000 (F)	Johnson,W.W.; Finley,M.T.	80
Oncorhynchus mykiss	YOUNG OF YR, 0.5–3.0 G	24 H	FW; LAB	LC_{50}	198000 (F)	Qureshi,A.A.; Flood,K.W.; Thompson,S.R.; Janhurst,S.M.; Inniss,C.S.; Rokosh,D.A.	82
Pimephales promelas	30–35 D	96 H	FW; LAB	LC_{50}	116000 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	31 D	96 H	FW; LAB	LC_{50}	136000 (F)	Geiger,D.L.; Northcott,C.E.; Call,D.J.; Brooke,L.T.	85
Pimephales promelas	30–35 D	24 H	FW; LAB	LC_{50}	141000 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	30–35 D	48 H	FW; LAB	LC_{50}	118000 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pimephales promelas	0.12 G	96 H	FW; LAB	LC_{50}	118000 (F)	Veith,G.D.; Call,D.J.; Brooke,L.T.	83
Pimephales promelas	30–35 D	72 H	FW; LAB	LC_{50}	116000 (F)	Walbridge,C.T.; Fiandt,J.T.; Phipps,G.L.; Holcombe,G.W.	83
Pteronarcys californica	2ND YR CLASS	96 H	FW; LAB	LC_{50}	> 100000 (F)	Johnson,W.W.; Finley,M.T.	80
Rana pipiens	EMBRYO	5 D	FW; LAB	LC_{50}	4520 (F)	Black,J.A.; Birge,W.J.; McDonnell,W.E.; Westerman,A.G.; Ramey,B.A.; Bruser,D.M.	82
Rana pipiens	EMBRYO	9 D	FW; LAB	LC_{50}	4400 (F)	Black,J.A.; Birge,W.J.; McDonnell,W.E.; Westerman,A.G.; Ramey,B.A.; Bruser,D.M.	82

TABLE J–5
ACUTE TOXICOLOGICAL DATA FOR 1,2–DICHLOROETHANE FROM AQUIRE
UNITS = μg/L
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

Scientific Name	Life Stage	Exposure Regimen	Test Conditions	Effect	Effect Concentration	Author	Year Published
CHRONIC DATA							
Daphnia magna	< 24 H	28 D	FW; LAB	REPRODUCTION	20700 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Daphnia magna	FIRST INSTAR, < 24 H	28 D	FW; LAB	GROWTH; DEVELOPMENT	42000 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, < 24 H	28 D	FW; LAB	GROWTH; DEVELOPMENT	72000 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, < 24 H	28 D	FW; LAB	REPRODUCTION	11000 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	FIRST INSTAR, < 24 H	28 D	FW; LAB	REPRODUCTION	21000 (F)	Richter,J.E.; Peterson,S.F.; Kleiner,C.F.	83
Daphnia magna	< 24 H	28 D	FW; LAB	GROWTH; DEVELOPMENT	71700 (F)	Call,D.J.; Brooke,L.T.; Ahmad,N.; Richter,J.E.	83
Oncorhynchus mykiss	EMBRYO	28 D	FW; LAB	LC_{50}	34 (F)	Black,J.A.; Birge,W.J.; McDonnell,W.E.; Westerman,A.G.; Ramey,B.A.; Bruser,D.M.	82
Oncorhynchus mykiss	EMBRYO	23 D	FW; LAB	LC_{50}	34 (F)	Black,J.A.; Birge,W.J.; McDonnell,W.E.; Westerman,A.G.; Ramey,B.A.; Bruser,D.M.	82
Pimephales promelas	EGG, < 8 H	28 D *	FW; LAB	GROWTH; DEVELOPMENT	29000 (F)	Benoit,D.A.; Puglisi,F.A.; Olson,D.L.	82
Pimephales promelas	EGG, < 8 H	28 D *	FW; LAB	LETHAL	59000 (F) (*)	Benoit,D.A.; Puglisi,F.A.; Olson,D.L.	82
Pimephales promelas	EGG, < 8 H	28 D *	FW; LAB	GROWTH; DEVELOPMENT	59000 (F)	Benoit,D.A.; Puglisi,F.A.; Olson,D.L.	82
Pimephales promelas	EGG, < 8 H	28 D *	FW; LAB	REPRODUCTION	59000 (F) (*)	Benoit,D.A.; Puglisi,F.A.; Olson,D.L.	82
BIOCONCENTRATION DATA							
Lepomis macrochirus	0.37–0.95 G, 25–35 MM	to 14 D	FW; LAB	BCF	95.6 (F)	Barrows,M.E.; Petrocelli,S.R.; Macek,K.J.; Carroll,J.J.	80

TABLE J–6
CALCULATION OF SPECIES ACUTE AND CHRONIC MEAN VALUES FOR TETRACHLOROETHENE
PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

SPECIES ACUTE VALUES

TAXA	SPECIES MEAN ACUTE VALUES [a]	LOG SPECIES MEAN ACUTE VALUES	RANK
Oryzias latipes	1600	3.20	0.10
Moina macrocopa	1800	3.26	0.21
Acute AWQC LOEL	5280 b	3.72	0.33
Oncorhynchus mykiss	5406	3.73	0.44
Daphnia magna	13902	4.14	0.58
Pimephales promelas	16519	4.22	0.71
Lepomis macrochirus	24454	4.39	0.85
Tanytarsus dissimilis	41008	4.61	1.00

SPECIES CHRONIC VALUES

TAXA	SPECIES MEAN CHRONIC VALUES	LOG SPECIES MEAN CHRONIC VALUES	RANK
Oryzias latipes	83 c	1.92	0.08
Moina macrocopa	206 d	2.31	0.19
Oncorhynchus mykiss	305 c	2.48	0.30
Chronic LOEL	840 b	2.92	0.43
Daphnia magna	854 e	2.93	0.56
Pimephales promelas	1032 e	3.01	0.69
Lepomis macrochirus	1533 c	3.19	0.83
Tanytarsus dissimilis	6611 d	3.82	1.00

				AQUIRE/AWQC DATA		
TAXA	CLASS	ORDER/ FAMILY	HABITAT CLASSIFICATION [f]	SPECIES ACUTE VALUE	SPECIES CHRONIC VALUE	ACUTE/ CHRONIC RATIO
Oryzias latipes	OSTEICHTHYES	Cyprinodontidae	5 pelagic	1600		
Moina macrocopa	CRUSTACEA	Cladocera	8 pelagic	1800		
AWQC LOEL				5280	840	6.3
Oncorhynchus mykiss	OSTEICHTHYES	Salmonidae	8 pelagic	5406		
Daphnia magna	CRUSTACEA	Cladocera	8 pelagic	13902	854	16.3
Pimephales promelas	OSTEICHTHYES	Cyprinidae	5 pelagic	16519	1032	13.5
Lepomis macrochirus	OSTEICHTHYES	Centrarchidae	5 pelagic	24454	1533	16
Tanytarsus dissimilis	INSECTA	Diptera	2 benthic	41008		

NOTES:

a. Derived from 12/94 download of acute data from AQUIRE database; see Table J–1. All values in μg/L.

b. Based on the acute and chronic LOELs listed in USEPA, 1991.

c. Estimated from the species mean acute value using the following equation (fish for nonmetallic contaminants) provided in Suter et al., 1992:
log CV = 1.07 log LC50 – 1.51; 95 % prediction interval [PI] = 1.5.

d. Estimated from the species mean acute value using the following equation (daphnids for nonmetallic contaminants) provided in Suter et al., 1992:
log CV = 1.11 log LC50 – 1.30; 95 % prediction interval [PI] = 1.35.

e. Derived from 12/94 download of chronic data from AQUIRE database; see Table J–1. All values in μg/L.

f. Habitat classification based on approach presented in DiToro et al., c. 1990.

TABLE J-7
CALCULATION OF SPECIES ACUTE AND CHRONIC MEAN VALUES FOR TRICHLOROETHENE PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

SPECIES ACUTE VALUES			LOG	
TAXA	SPECIES MEAN ACUTE VALUE [a]	RANK	SPECIES MEAN ACUTE VALUE	RANK
Moina macrocopa	2300	0.00	3.36	0.03
Lepomis macrochirus	6739	0.00	3.83	0.06
Oncorhynchus mykiss	14491	0.01	4.16	0.09
Oryzias latipes	22650	0.03	4.36	0.13
Gammarus pulex	24000	0.04	4.38	0.17
Asellus aquaticus	30000	0.05	4.48	0.20
Pimephales promelas	40772	0.08	4.61	0.24
Dugesia lugubris	42000	0.10	4.62	0.28
Cloeon dipterum	42000	0.12	4.62	0.32
Xenopus laevis	45000	0.15	4.65	0.36
Acute AWQC LOEL	45000 b	0.17	4.65	0.39
Aedes aegypti	48000	0.20	4.68	0.43
Ambystoma mexicanum	48000	0.22	4.68	0.47
Ischnura elegans	49000	0.25	4.69	0.51
Culex pipiens	55000	0.28	4.74	0.55
Lymnaea stagnalis	56000	0.31	4.75	0.59
Brachydanio rerio	60000	0.34	4.78	0.63
Daphnia magna	61008	0.38	4.79	0.67
Chironomus thummi	64000	0.41	4.81	0.71
Nemoura cinerea	70000	0.45	4.85	0.75
Erpobdella octoculata	75000	0.49	4.88	0.79
Hydra oligactis	75000	0.53	4.88	0.83
Corixa punctata	110000	0.59	5.04	0.87
Tubificidae	132000	0.66	5.12	0.91
Selenastrum capricornutum	175000	0.76	5.24	0.95
Scenedesmus abundans	450000	1.00	5.65	1.00
SPECIES CHRONIC VALUES			LOG	
TAXA	SPECIES MEAN CHRONIC VALUE	RANK	SPECIES MEAN CHRONIC VALUE	RANK
Moina macrocopa	270 c	0.00	2.43	0.02
Lepomis macrochirus	386 d	0.00	2.59	0.05
Oncorhynchus mykiss	876 d	0.00	2.94	0.08
Oryzias latipes	1412 d	0.01	3.15	0.11
Pimephales promelas	2649 d	0.02	3.42	0.15
Xenopus laevis	2944 d	0.03	3.47	0.18
Ambystoma mexicanum	3154 d	0.04	3.50	0.22
Gammarus pulex	3648 c	0.05	3.56	0.25
Brachydanio rerio	4005 d	0.06	3.60	0.29
Asellus aquaticus	4673 c	0.07	3.67	0.33
Dugesia lugubris	6789 c	0.09	3.83	0.37
Cloeon dipterum	6789 c	0.12	3.83	0.41
Aedes aegypti	7874 c	0.14	3.90	0.45
Ischnura elegans	8056 c	0.17	3.91	0.48
Culex pipiens	9158 c	0.19	3.96	0.53
Lymnaea stagnalis	9343 c	0.22	3.97	0.57
Daphnia magna	10275 c	0.25	4.01	0.61
Chironomus thummi	10836 c	0.29	4.03	0.65
Nemoura cinerea	11969 c	0.32	4.08	0.69
Erpobdella octoculata	12922 c	0.36	4.11	0.73

TABLE J-7
CALCULATION OF SPECIES ACUTE AND CHRONIC MEAN VALUES FOR TRICHLOROETHENE PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

SPECIES CHRONIC VALUES			LOG	
TAXA	SPECIES MEAN CHRONIC VALUE	RANK	SPECIES MEAN CHRONIC VALUE	RANK
Hydra oligactis	12922 c	0.40	4.11	0.77
Corixa punctata	19767 c	0.46	4.30	0.82
Chronic AWQC LOEL	21900 b	0.53	4.34	0.86
Tubificidae	24201 c	0.61	4.38	0.90
Selenastrum capricornutum	33096 c	0.71	4.52	0.95
Scenedesmus abundans	94420 c	1.00	4.98	1.00

TAXA	CLASS	ORDER/ FAMILY	HABITAT CLASSIFICATION [e]	
Moina macrocopa	CRUSTACEA	Cladocera	8	pelagic
Lepomis macrochirus	OSTEICHTHYES	Centrarchidae	5	pelagic
Oncorhynchus mykiss	OSTEICHTHYES	Salmonidae	8	pelagic
Dugesia lugubris	PLATYHELMINTHES	Turbellaria	3	epibenthic
Oryzias latipes	OSTEICHTHYES	Cyprinodontidae	5	pelagic
Gammarus pulex	CRUSTACEA	Amphipoda	3	epibenthic
Asellus aquaticus	CRUSTACEA	Isopoda	3	epibenthic
Pimephales promelas	OSTEICHTHYES	Cyprinidae	5	pelagic
Cloeon dipterum	INSECTA	Ephemeroptera	4	epibenthic
Acute AWQC LOEL				
Xenopus laevis	AMPHIBIA	Pipidae	6	pelagic
Aedes aegypti	INSECTA	Diptera	8	pelagic
Ambystoma mexicanum	AMPHIBIA	Ambystomatidae	6	pelagic
Ischnura elegans	INSECTA	Odonata	4	epibenthic
Culex pipiens	INSECTA	Diptera	8	pelagic
Lymnaea stagnalis	MOLLUSCA	Gastropoda	3	epibenthic
Brachydanio rerio	OSTEICHTHYES	Cyprinidae	6	pelagic
Daphnia magna	CRUSTACEA	Cladocera	8	pelagic
Chironomus thummi	INSECTA	Diptera	2	benthic
Nemoura cinerea	INSECTA	Plecoptera	4	epibenthic
Erpobdella octoculata	ANNELIDA	Hirudinea	1	benthic
Hydra oligactis	CNIDARIA		8	pelagic
Corixa punctata	INSECTA	Hemiptera	8	pelagic
Tubificidae	ANNELIDA	Oligochaeta	1	benthic
Selenastrum capricornutum	ALGAE	Chlorophyta	8	pelagic
Scenedesmus abundans	ALGAE	Chlorophyta	8	pelagic

NOTES:

a. Derived from 12/94 download of acute data from AQUIRE database; see Table J-2. All values in μg/L.

b. Based on acute and chronic LOELs listed in USEPA, 1991.

c. Estimated from the species mean acute value using the following equation (daphnids for nonmetallic contaminants) provided in Suter et al., 1992:

log CV = 1.11 log LC50 – 1.30; 95 % prediction interval [PI] = 1.35.

d. Estimated from the species mean acute value using the following equation (fish for nonmetallic contaminants) provided in Suter et al., 1992:

log CV = 1.07 log LC50 – 1.51; 95 % prediction interval [PI] = 1.5.

e. Habitat classification based on approach presented in DiToro et al., c. 1990.

TABLE J-8
CALCULATION OF SPECIES ACUTE AND CHRONIC MEAN VALUES FOR 1,1-DICHLOROETHENE PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

SPECIES ACUTE VALUES

		LOG	
TAXA	**SPECIES MEAN ACUTE VALUE [a]**	**SPECIES MEAN ACUTE VALUE**	**RANK**
Acute AWQC LOEL	11600 b	4.06	0.17
Daphnia magna	19037	4.28	0.35
Pimephales promelas	62353	4.79	0.55
Lepomis macrochirus	122716	5.09	0.76
Scenedesmus abundans	410000	5.61	1.00

SPECIES CHRONIC VALUES

		LOG	
TAXA	**SPECIES MEAN CHRONIC VALUE**	**SPECIES MEAN CHRONIC VALUE**	**RANK**
Chronic AWQC LOEL	NA b	NA	NA
Daphnia magna	2821 c	3.45	0.22
Pimephales promelas	4174 d	3.62	0.44
Lepomis macrochirus	8612 d	3.94	0.69
Scenedesmus abundans	85151 c	4.93	1.00

TAXA	**CLASS**	**ORDER/ FAMILY**	**HABITAT CLASSIFICATION [e]**
AWQC LOEL			
Daphnia magna	CRUSTACEA	Cladocera	8 pelagic
Pimephales promelas	OSTEICHTHYES	Cyprinidae	5 pelagic
Lepomis macrochirus	OSTEICHTHYES	Centrarchidae	5 pelagic
Scenedesmus abundans	ALGAE	Chlorophyta	8 pelagic

NOTES:

a. Derived from 12/94 download of acute data from AQUIRE database; see Table J-4. All values in μg/L.

b. Based on acute and chronic LOELs listed in USEPA, 1991.

c. Estimated from the species mean acute value using the following equation (daphnids for nonmetallic contaminants) provided in Suter et al., 1992:

$$\log CV = 1.11 \log LC50 - 1.30;\ 95\ \%\ \text{prediction interval [PI]} = 1.35.$$

d. Estimated from the species mean acute value using the following equation (fish for nonmetallic contaminants) provided in Suter et al., 1992:

$$\log CV = 1.07 \log LC50 - 1.51;\ 95\ \%\ \text{prediction interval [PI]} = 1.5.$$

e. Habitat classification based on approach presented in DiToro et al., c. 1990.

TABLE J–9
CALCULATION OF SPECIES ACUTE AND CHRONIC MEAN VALUES FOR 1,2–DICHLOROETHANE PLUME DISCHARGE STUDY

SERVALL LAUNDRY SITE
BAY SHORE, NEW YORK

SPECIES ACUTE VALUES

SPECIES TAXA	SPECIES MEAN ACUTE VALUES [a]	LOG SPECIES MEAN ACUTE VALUES	RANK
Ambystoma gracile	4073	3.61	0.09
Rana pipiens	4460	3.65	0.19
Gammarus fasciatus	100000	5.00	0.32
Pteronarcys californica	100000	5.00	0.45
Acute LOEL	118000 b	5.07	0.58
Pimephales promelas	123758	5.09	0.72
Oncorhynchus mykiss	211069	5.32	0.86
Daphnia magna	311373	5.49	1.00

SPECIES CHRONIC VALUES

TAXA	SPECIES MEAN CHRONIC VALUE	LOG SPECIES MEAN CHRONIC VALU	RANK
Oncorhynchus mykiss	34 c	1.53	0.05
Ambystoma gracile	225 e	2.35	0.14
Rana pipiens	248 e	2.39	0.23
Pteronarcys californica	17783 d	4.25	0.38
Gammarus fasciatus	17783 d	4.25	0.53
Chronic LOEL	20000 b	4.30	0.68
Pimephales promelas	20976 c	4.32	0.84
Daphnia magna	31805 c	4.50	1.00

				AQUIRE/AWQC DATA		
TAXA	CLASS	ORDER/ FAMILY	HABITAT CLASSIFICATION [f]	SPECIES ACUTE VALUE	SPECIES CHRONIC VALUE	ACUTE TO CHRONIC RATIO
Ambystoma gracile	AMPHIBIA	Ambystomatidae	6 pelagic	4073		
Rana pipiens	AMPHIBIA	Ranidae	6 pelagic	4460		
Gammarus fasciatus	CRUSTACEA	Amphipoda	3 benthic	100000		
Pteronarcys californica	INSECTA	Plecoptera	4 benthic	100000		
LOEL				118000	20000	5.9
Pimephales promelas	OSTEICHTHYES	Cyprinidae	5 pelagic	123758	20976	2.5
Oncorhynchus mykiss	OSTEICHTHYES	Salmonidae	8 pelagic	211069	34	6208
Daphnia magna	CRUSTACEA	Cladocera	8 pelagic	311373	31805	9.79

NOTES:

a. Derived from 12/94 download of acute data from AQUIRE database; see Table J–5. All values in μg/L.

b. Based on acute and chronic LOELs listed in USEPA, 1991.

c. Derived from 12/94 download of chronic data from AQUIRE database; see Table J–5. All values in μg/L.

d. Estimated from the species mean acute value using the following equation (daphnids for nonmetallic contaminants) provided in Suter et al., 1992:
log CV = 1.11 log LC50 – 1.30; 95 % prediction interval [PI] = 1.35.

e. Estimated from the species mean acute value using the following equation (fish for nonmetallic contaminants) provided in Suter et al., 1992:
log CV = 1.07 log LC50 – 1.51; 95 % prediction interval [PI] = 1.5.

f. Habitat classification based on approach presented in DiToro et al., c. 1990.