REMEDIAL
INVESTIGATION REPORT

HADCO CORPORATION
OWEGO, NEW YORK

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SECTION 1 - INTRODUCTION

1.1 General

This report presents the results of the Remedial Investigation (RI) activities recently completed by Blasland & Bouck Engineers, P.C., (Blasland & Bouck) for Hadco Corporation (Hadco) regarding their facility in Owego, New York. The initial scope of activities implemented for the RI of the Hadco facility was in accordance with the Remedial Investigation/Feasibility Study (RI/FS) Work Plan prepared by Groundwater Technology, Inc., dated April 5, 1990, as modified by the RI/FS Work Plan Addendum dated July 26, 1991, prepared by Blasland & Bouck. The RI activities also included supplemental investigation activities implemented by Blasland & Bouck to address data gaps identified on the basis of the results of the initial RI activities.

The modifications to the original scope of the RI incorporated in the work plan addendum, were designed to address the revised understanding of the subsurface conditions at the Hadco Site. An initial RI field task involving the establishment of a Project Compound List (PCL) was implemented by Ground Water Technology during February 1991. The data developed through this initial task indicated the potential for dense non-aqueous phase liquids (DNAPLs) to be present in the subsurface environment at this site. Furthermore, the previous hydrogeologic investigation results had yet to adequately characterize the hydrogeologic conditions underlying the site. Therefore, the initial RI scope was modified to allow for the further characterization of the shallow and deep water-bearing zones of the overburden materials as well as the upper water-bearing zone of the bedrock units underlying the site. Another objective of this program was to evaluate the potential contributions of off-site sources regarding the dissolved constituents observed in the ground water. The scope of the original

RI investigation also incorporated activities to assist in evaluating the potential source areas identified at this site.

The results of the initial RI activities were presented to the New York Department of Environmental Conservation (NYSDEC) in our Preliminary RI Report, dated April 1992. The NYSDEC identified a number of additional data needs regarding the characterization of the site and required a supplemental investigation to address these additional data needs. The activities required by the NYSDEC included:

1. Further delineation of constituents in ground-water at and beyond the southern boundary of the site;
2. Investigation of inorganic constituents at various locations at the facility;
3. Evaluation of potential exposure to inorganic constituents through surficial soil sampling; and
4. Implementation of an ecological assessment including the initial portion of a Fish and Wildlife Impact Analysis.

To address the additional data needs identified by the NYSDEC a supplemental investigation program was described within Blasland & Bouck's correspondence dated June 16, 1992. The supplemental RI activities specifically addressed the further characterization of the source area (former chemical storage area), characterization of soil in isolated areas for inorganic compounds and the further characterization of downgradient ground-water conditions. In addition, a vapor extraction pilot test and the installation and testing of a recovery well were performed to support the evaluation of remedial alternatives for this site.

1.2 Background

The Hadco Corporation facility is located at 1200 Taylor Road in the Town of Owego, New York (Figure 1). The facility occupies a property of approximately 17.3 acres which is bordered to the south by a municipal sewage treatment plant. The land to the west of the site is undeveloped while the land to the north and east has been developed for industrial use. The facility located immediately east (the Broadway Building) of the Hadco facility is leased by IBM. In addition, IBM owns and operates a large facility further to the east of the Hadco property. A complex of buildings referred to as the Victory Plaza is located northeast of the Hadco site. Previous investigations performed at the Victory Plaza and at the IBM facility have shown the presence of dissolved organic constituents in the ground water underlying these sites. In addition, testing of the adjacent Broadway Building has identified the presence of trichloroethylene in the former septic system of this facility. Given their location hydraulically upgradient of the Hadco site, these facilities are potential off-site contributors to the dissolved constituents observed underlying the Hadco site. The location of the Hadco site in relation to these surrounding facilities is illustrated on the Site Vicinity Map presented as Figure 2.

A discussion of the site history was included in the RI/FS Work Plan and detailed the past ownership and activities at the site. In summary, the original property was subdivided from the Taylor family farm in 1956 and sold to Mr. George Warneke. He then sold the property to the Owego Development Company which developed this and surrounding properties for industrial use. The property was then leased to Mutual Design which operated the first manufacturing operation at the facility through 1970. The organization which owned and operated this facility from 1970 through 1979 was Robintech, Incorporated. Robintech expanded the facility in 1975 and again in 1977. The Robintech facility and the original 3.6-acre parcel of land it occupied were purchased by Hadco in 1979. The size of the site was increased to its current size of 17.3 acres through the purchase of two adjacent parcels of land in 1981 (4.5 acres) and in 1984 (9.2 acres). Since acquiring the site, Hadco has expanded the facility five times, including two expansions in 1983, an addition in 1984, another in 1985, and most recently in 1990/1991. A separate building was also constructed south of the main facility to house an on-site biological wastewater treatment system.

The previous investigations implemented at the site have included: a Preliminary Site Evaluation; a Phase I Hydrogeologic Investigation; a Phase II Hydrogeologic Investigation; a Supplementary Hydrogeologic Investigation; and the performance of an initial RI task associated with the establishment of a site-specific Project Compound List (PCL). As part of these previous programs a network of sixteen monitoring wells (MW-1 through MW-15, and MW-17) was installed at the locations indicated on Figure 3. The analytical results of these previous investigations have shown dissolved volatile organic constituents in the ground water underlying this site.

1.3 Report Organization

This report is organized into sections consistent with the generally accepted format for RI reports. Section 1 provides a brief summary of relevant introductory and background information pertaining to the site. Section 2 presents a detailed discussion of the investigation activities performed in connection with this RI. An analysis of the physical characteristics of the site based on the information generated through the implementation of the RI is presented in Section 3. Section 4 presents a discussion of the nature and extent of the contamination identified at the Hadco site. A discussion of the Risk Assessment (RA) conducted for the site is presented in Section 5. The conclusions which may be drawn from the results of this and previous investigations are presented in Section 6.

SECTION 2 - INVESTIGATION ACTIVITIES

2.1 General

The three major components of the RI field program implemented at the Hadco facility are:

1. Source Area Investigation Activities;
2. Hydrogeologic Investigation Activities; and
3. Surface Water Evaluation Activities.

A detailed discussion of these initial RI activities and Supplemental RI activities performed in association with each component of this investigation is presented below. The sections pertaining to the source area and hydrogeologic investigations present the initial RI activities and the supplemental RI activities implemented at the site.

2.2 Source Area Investigation Activities

A review of the site history identified two areas at the site which were considered potential sources of chemical constituents to the subsurface environment. These potential source areas include:

1. A former septic system leach field located under the wet process area of the plant; and
2. A former Robintech chemical storage area located under the existing "clean room."

The former septic system leach field was identified on a set of facility plans predating the expansion of the facility by Robintech in 1975. These plans indicate the leach field was located under the northern portion of the 1975 facility expansion (Figure 4).

To evaluate whether possible historical discharges to this septic leach field have resulted in residual contamination of the subsurface materials in this area, the source area investigation included the drilling of two soil borings (HBW-1 and HBW-2). These borings were drilled through the facility floor along the downgradient edge of the former leach field. The locations at which these borings were drilled are also indicated on Figure 4.

The evaluation of the former chemical storage area located immediately south of the original facility was impeded by the current use of this area of the facility as a "clean room" in which photographic templates of printed circuit boards are prepared. To avoid excessive interference with operations in this area of the facility, the initial evaluation of this potential source area was accomplished by drilling a series of four soil borings (HB-1 through HB-4) along the exterior wall of the building immediately south of this area. The locations at which these boring were drilled are indicated on Figure 4.

The soil borings drilled to evaluate the potential source areas were accomplished using a tripod rig. Soil samples were collected continuously in each borehole from just below the floor slab to the water table or until refusal using a standard split-spoon sampler. To mitigate the potential for cross contamination, the sampling device was decontaminated between each use by washing with a detergent solution, rinsing with potable water, then triple rinsing with distilled water and allowing the sampler to air dry. Upon retrieval, each soil sample was screened for relative concentrations of total volatile organic compounds (VOCs) with an Organic Vapor Analyzer (OVA). Each sample was classified according to color, grain size, density, and relative moisture content of the materials encountered. This information was recorded in the field and is summarized on the boring logs presented in Appendix A.

Based on the results of the field screening and observations, one soil sample was selected from borings HBW-1, HBW-2, and HB-1 through HB-4 for laboratory analysis. The selected samples were submitted to Recra Environmental, Inc. to be analyzed for the constituents established on the Project Compound List (PCL). The PCL for this site includes analyses for volatile organic compounds by NYSDEC Method ASP 89-1 and the priority pollutant metals plus seven site-specific inorganics (including: aluminum, cobalt, iron, manganese, sodium, vanadium and magnesium) by NYSDEC Method ASP CLP-M.

Based on the identification of significant concentrations of VOCs in boring HB-3, Blasland & Bouck recommended that additional potential source area investigation be performed as part of the supplemental RI activities. The clean room operations were suspended over a weekend so that 12 borings could be drilled through the floor. These borings, CRB-1 through CRB-12, were located as shown on Figure 5. The same sampling procedures as for HB-1 through HB-4, and HBW-1 and HBW-2 were used with the exception that a photoionization detector (PID) rather than an OVA was used to screen the soil samples. One soil sample from each boring was selected for laboratory analysis. The analysis included volatile organic compounds (by NYSDEC Method ASP 89-1) and selected inorganic compounds (beryllium, chromium, copper, lead, and zinc, by NYSDEC Method ASP CLP-M).

The supplemental RI activities also included a shallow soil sampling program to address the potential concern associated with the identification of several inorganic constituents in ground-water samples collected from wells MW-3, MW-7, and MW-11. To evaluate the soil in the immediate vicinity of these well locations for evidence of a possible source of the observed inorganic constituents three soil borings were drilled adjacent to each of these wells (for a total of nine borings). Two samples at each boring were collected, the first interval being 0 to 4 inches and the second interval was 1 to 2 feet below grade. None of these locations appear to have been filled, therefore, the depths of the deeper samples did not have to be adjusted for the thickness of fill materials. Each of the samples was analyzed for beryllium, chromium, copper, lead, and zinc in accordance with NYSDEC ASP Method CLP-M.

2.3 Hydrogeologic Investigation Activities

To accomplish the objectives of the RI regarding further characterization of the hydrogeologic conditions and better definition of the nature and extent of the constituents identified in the ground water at this site, the following hydrogeologic investigation activities were initially implemented during September and October 1991:

1. Installation of four bedrock monitoring wells (MW-20, MW-21, MW-22, and MW-28);
2. Installation of five deep overburden monitoring wells (MW-18, MW-23, MW-24, MW-26, and MW-27);
3. Installation of two shallow overburden monitoring wells (MW-19 and MW-25);
4. In-situ hydraulic conductivity testing at selected wells;
5. Ground-water sample collection; and
6. Ground-water elevation measurements.

A total of four new bedrock monitoring wells were installed to assist in further characterizing hydrogeologic conditions within the bedrock aquifer in the site vicinity. The new bedrock wells were installed in clusters either adjacent to the existing overburden wells or in association with new overburden wells. These well clusters were installed to provide information relating to vertical hydraulic gradients. The locations at which these new bedrock wells were installed included: MW-21, located upgradient of the Hadco facility and adjacent to the existing overburden well MW-4; MW-20 and MW-22, located downgradient of the facility and adjacent to the existing overburden wells MW-8 and MW-11, respectively; and MW-28 at the new monitoring well cluster located along the boundary between the Hadco site and the adjacent IBM Broadway facility. These new bedrock monitoring well locations are indicated on Figure 3.

To assist in selecting a location for the new well cluster between the Hadco and IBM Broadway facilities, a soil gas survey was preformed on September 23, 1991. This soil gas survey involved the collection of a total of eight soil gas samples from a series of locations at a regular spacing of 25 feet along the property boundary between these facilities. These samples were obtained by driving a hollow probe to a depth of between 2 and 2.5 feet, then drawing the soil vapor from the soil with a air sampling pump. Each sample was then screened with a PID to determine the relative concentration of total volatile organic compounds present.

Drilling through the overburden materials in each of the bedrock boreholes was accomplished using a truck-mounted drilling rig and hollow-stem augers. Soil samples were collected using a standard split-barrel (split-spoon) sampler at 5-foot intervals. The results of the field screening performed on the soil samples at each of these locations indicated relatively low VOC concentrations at the top of the glacial till unit. As there was no indication of DNAPLs being present, it was not necessary to install a steel casing into the top of the till prior to drilling through the till at any of the new bedrock well locations. Upon encountering the bedrock in each of these boreholes, a 4-inch steel casing was set into the top of the bedrock to mitigate the potential for the borehole to function as a conduit for vertical migration of VOCs into the bedrock. The bedrock monitoring well was then completed by coring an open hole into the upper 20 feet of the bedrock using an HX (4-1/2-inch outside diameter) core barrel. All drilling cuttings and fluids were containerized in drums provided by Hadco during the drilling of these wells.

To evaluate ground-water quality in the deeper zone of the overburden immediately above the glacial till unit, five deep overburden monitoring wells were installed during the RI field investigation. The locations at which these wells were installed were: MW-24, located adjacent to the bedrock well, MW-17; MW-27 and MW-18, located adjacent to the existing wells MW-6 and MW-8, respectively; MW-23, installed at a new well cluster located immediately south of the main building between the existing wells MW-1 and MW-6; and MW-26 located at a new well cluster along the boundary between the Hadco site and the adjacent IBM Broadway facility. These locations are indicated on Figure 3. The deep overburden wells installed in the vicinity of the suspected on-site source areas also allow monitoring for DNAPLs that may be perched above the low permeability materials forming the basal till at these locations.

The boreholes for the deep overburden monitoring wells were advanced with a truck-mounted drilling rig using hollow-stem augers. Soil samples were collected at 5-foot intervals, or as directed by the supervising geologist, from the ground surface to the base of each borehole. However, soil sampling was performed in only the deepest of the boreholes drilled as part of each new well clusters installed. The soil samples were used to visually classify the subsurface materials encountered at these locations.

Three of the new deep overburden monitoring wells (MW-23, MW-24, and MW-27) were constructed with a 5-foot length of 4-inch-diameter PVC well screen installed to straddle the interface between the glacial till and the overlying water-bearing unit. An appropriate length of PVC riser pipe was used to extend the well to the ground surface. Given their location near the suspected source areas, these wells were selected to be constructed of 4-inch-diameter materials to facilitate their possible future use as ground-water recovery points. The remaining two deep overburden monitoring wells (MW-18 and MW-26) were constructed with 2-inch-diameter PVC well screens and riser pipe. The annulus around each well screen, extending to one foot above the top of the screened interval, was filled with a silica sand filter pack. A bentonite seal was installed above the filter pack to inhibit vertical flow along the borehole. The remainder of the annulus was grouted to within 2 feet of the ground surface. Each of the wells was completed at the ground surface with a protective steel casing set in a concrete pad.

Two shallow overburden monitoring wells were installed as part of the RI field investigation. New wells MW-19 and MW-25 were installed in association with the two new well clusters located south of the main building between MW-1 and MW-6 and along the boundary between the Hadco site and the adjacent IBM Broadway facility, respectively. The locations of these new wells are indicated on Figure 3. Each shallow overburden monitoring well was constructed with a 10-foot length of 2-inch-diameter PVC well screen installed such that the top of the screened interval intersects the water table. The remainder of the well installation details were the same as for the deep overburden monitoring wells.

The boring logs and well construction details for each of the new monitoring wells are presented in Appendix A. The well construction details for each of the newly installed wells are also summarized in Table 1. This table includes the available data regarding the well construction details for the existing wells at this site.

Following installation, the new monitoring wells were developed by surging and purging each well using a submersible pump and/or a stainless steel bailer. Development continued until the turbidity of the water removed from the well was reduced to the degree practical by this method. It should be noted that during the development of the new monitoring wells it become apparent that the new bedrock well MW-28, installed at the new well cluster location along the boundary between the Hadco property and the IBM Broadway facility, was not in good hydraulic communication with the bedrock aquifer. During development, this well was purged dry very quickly, and the well recovered very slowly. Furthermore, at the time of ground-water sampling, the water level in this well was 53.4 feet below grade, which is inconsistent with the other bedrock wells at the site.

Ground-water samples were collected from each of the 11 new monitoring wells installed as part of the RI between October 21 and 24, 1991. The collection of ground-water samples was not performed in any of the new monitoring wells for at least one week following their development to allow for equilibration of these new wells with the aquifer. Ground-water samples were also collected from each of the 18 existing monitoring wells at this site between October 21 and 24, 1991.

Each well was purged of at least three volumes of water prior to sample collection, with the exception of the new bedrock well MW-28. This well went dry and was allowed to recover twice prior to sampling. Each ground-water sample collected was obtained using a dedicated disposable bailer and a new length of polypropylene line. The samples were placed immediately into laboratory-provided appropriately labeled containers and were place on ice until delivery to the laboratory. Each of these samples were submitted to Recra Environmental to be analyzed for the constituents on the PCL.

In-situ hydraulic conductivity tests (slug tests) were performed on selected new monitoring wells to assist in evaluating the hydraulic characteristics of each water-bearing zone underlying the site. The wells in which slug tests were performed were MW-18, MW-20, MW-21, MW-23, MW-24, MW-25, MW-26, and MW-27. The performance of these tests involved either adding (falling head test) or removing (rising head test) a solid slug of known volume from the well being tested, then recording the rate at which the water level returned to the static level. The results of these slug tests were then reduced and evaluated using the Bouwer-Rice method of calculating the estimated hydraulic conductivity of the formation. However, due to excessively rapid recovery in wells MW-21, MW-25, and MW-26, the data generated through the performance of these slug tests were inadequate for use in calculating estimates of hydraulic conductivity. The data generated through the performance of the slug tests is presented in Appendix B.

The horizontal and vertical location of each of the new monitoring wells installed in 1991 were determined to the nearest 0.01 foot by licensed surveyors from Hawk Engineers of Binghamton, New York. All elevations were referenced to the same datum as the existing wells. The elevations of the existing and new monitoring wells at the site were also referenced to the same datum as that used for the wells located on the adjacent IBM facilities.

On October 30, 1991 complete rounds of water level measurements were obtained from the monitoring wells at the Hadco site. The measured depth to ground water and the calculated ground-water elevation at each well are summarized in Table 2.

Once the data from the above-described RI activities were evaluated, a preliminary RI Report was submitted to NYSDEC in April 1992. Although the initial RI results appeared to adequately characterize the extent of ground-water contamination on-site, the NYSDEC required further characterization of the vertical and horizontal extent of ground-water contamination at the downgradient site boundary and beyond. In addition, further hydraulic characterization of the overburden downgradient of the source area was identified as necessary to support the evaluation and design of potential ground-water remedial programs. To address these additional data needs Blasland & Bouck implemented the following supplemental hydrogeologic investigation activities during August and September 1992:

1. Installation of one deep overburden monitoring well (MW-29);

2. Installation of two monitoring well clusters (MW-30/31 and MW-32/33) located downgradient of the site;
3. Installation of one recovery well (PW-3); and
4. Performance of an aquifer test at PW-3.

The deep overburden ground-water monitoring well (MW-29) at the downgradient property boundary was installed adjacent to the existing cluster containing shallow overburden well MW-11 and bedrock well MW-22. The new off-site well clusters were installed approximately 400 feet downgradient of the site on the property of the Town of Owego Wastewater Treatment Facility. Each new well cluster consists of a shallow overburden monitoring well and a deep overburden monitoring well. The shallow wells were each constructed with 10 feet of 2-inch diameter PVC well screen set to straddle the water table, which was encountered within 5 feet of the ground surface of both locations. The new deep overburden monitoring wells at these cluster locations were each constructed with a 5 foot length of 2-inch diameter PVC screen set to monitoring the deepest hydraulically conductive unit above the top of bedrock. The new deep overburden well (MW-29) at the downgradient site boundary was constructed similarly with the exception that MW-29 was constructed with a 4-inch diameter PVC screen and riser pipe. Each of the well locations are shown on Figure 3.

The two shallow overburden ground-water monitoring wells, MW-31 and MW-32 were installed off-site to form well clusters with deep overburden wells MW-30 and MW-33, respectively. These wells were constructed with 2-inch diameter PVC. Figure 3 shows their location.

To support the evaluation of potential ground-water remediation at the facility, a new recovery well was installed as part of the supplemental RI program. This well, PW-3, was installed upgradient of the well cluster MW-25/MW-26/MW-28 which is downgradient from the former chemical storage area

(Figure 3). Twenty feet of 4-inch diameter PVC well screen was used in the construction of PW-3. The deep overburden water-bearing zone is monitored by this well.

The drilling, construction, and development used for these supplemental wells were the same as described for the other RI wells installed at the facility. The construction details are summarized in Table 1 and the subsurface logs for these wells are included in Appendix A.

An aquifer pumping test was conducted at new recovery well PW-3 to better characterize aquifer characteristics and to determine whether hydraulic control could be established in the suspected source area. A detailed discussion of the activities performed in connection with this pumping test is presented in Appendix C. The data collected during the test are also included in Appendix C.

As part of the supplemental RI program, 17 ground-water samples were collected from the 6 supplemental wells and 11 selected wells at the facility between August 31 and September 1, 1992.

The elevations of the newly installed wells were surveyed to the nearest 0.01-foot and were referenced to the existing datum at the facility by licensed surveyors from Blasland & Bouck Engineers, P.C.

On August 31, 1992 a partial round of ground-water measurements were collected. A full round of measurements which included all site wells was collected on October 21, 1992.

2.4 Surface Water Investigation Activities

This portion of the RI field investigation involved the collection of surface water samples and stream sediment samples from four locations along Barnes Creek. The purpose of these activities was to assist in evaluating potential impacts to this intermittent stream located along the eastern property boundary of the site. The actual locations at which these samples were collected are indicated as SW-1 through SW-4 on Figure 3. At each location, a stake was driven into the bank of the stream to mark the sampling point. Staff gauges were also installed at each of the sampling locations. These staff gauges were tied in by the surveyor so that the elevation of the surface water in the creek could be compared to the ground-water level measurements.

The water samples were collected using laboratory-provided sample containers as dippers that were carefully lowered into the center of the stream flow. Given the shallow nature of the flow in this stream, care had to be taken to minimize disturbing the sediments at the bottom of the stream bed during the water sampling. Field measurements of water quality parameters, including the pH, temperature, and specific conductivity, were recorded at the time of sample collection. The water samples were then placed on ice until they were delivered to the laboratory. The samples were submitted to Recra Environmental to be analyzed for the constituents on the PCL.

Sediment samples were also obtained at each of the four stream sampling locations identified on Figure 3. The sediment samples were each collected from the approximate center of the stream bed using a stainless steel spade that was decontaminated prior to use by the same procedure used to clean the split-spoon soil samplers. The samples were placed directly into laboratory provided containers. These samples were also placed on ice and delivered to Recra Environmental to be analyzed for the constituents on the PCL.

2.5 Vapor Extraction Pilot Tests

The supplemental RI activities included the performance of two vapor extraction pilot tests. These pilot tests were implemental to provide information necessary to evaluate the potential applicability of vapor extraction as a remedial technology for this site.

To facilitate the performance of the vapor extraction pilot tests, three soil gas monitoring probes were installed in the source area investigation boreholes at locations CRB-9, CRB-10, and CRB-11. These locations were selected on the basis of the field screening of the soil samples collected during the soil boring program. A vapor extraction well (VE-1) was then installed directly downgradient of the area observed to contain the highest level of VOCs to allow for the vapor extraction pilot test. Each of the vapor probes were constructed with 3/4-inch Schedule 20 PVC with a 2-foot section of 0.01-inch slotted PVC. These PVC sections were placed 6 feet below grade (above the water table), and the annular space around the slotted PVC was filled with a coarse sand filter pack. The remainder of the annular space was grouted with cement up to grade.

The vapor extraction well, VE-1, was constructed with a 3.5 foot length of 4-inch diameter 0.01-inch slotted PVC well screen set from 2 feet to 5.5 feet below grade. PVC riser pipe was used to extend the vapor extraction well to the ground surface. The annular space around the screen, from the base of the borehole to 2.0 feet below grade, was filled with a coarse sand filter pack. A 0.5-foot thick bentonite seal was then placed above the filter pack. Vapor extraction well was completed with a curb box set flush with the ground surface. The locations of VE-1 and the vapor extraction probes VP-1 through VP-3 are indicated on Figure 5. The construction details for the vapor probes and the extraction well are also summarized on Table 8.

The first vapor extraction pilot test was conducted over a period of five days from August 17 through 21, 1992. The second pilot test was conducted for only a short duration on August 22, 1992. A five horsepower (Hp) regenerative blower was used as a vacuum source for both tests. Vacuum readings at the extraction well (VE-1) and each of the soil probes (VP-1, VP-2, and VP-3) were recorded at regular intervals throughout the first test. The second vapor extraction test was performed using the vapor probe VP-3 as the extraction point and VE-1 was used as an observation point. The water level in ground-water monitoring well MW-19, adjacent to VE-1, was also monitored during the test to assess the amount of potential ground-water upwelling in the area as a result of the test.

To evaluate the potential rate at which VOCs may be removed from the subsurface through the use of a vapor extraction system, as well as to evaluate the potential constituent loading to a vapor-phase treatment system, air samples were collected from the exhaust of the vapor extraction test well. One air sample was collected 10 minutes into the test, and subsequent samples were collected at an interval of one each day over the duration the test. A final air sample was collected immediately prior to the test termination. Each air sample was analyzed by Target Laboratories, Inc. of Columbia, Maryland for trichloroethene (TCE), tetrachloroethene (PCE), 1,2-dichloroethene, and 1,1,1-trichloroethane (TCA), as well as for total VOCs.

SECTION 3 - PHYSICAL SITE CHARACTERISTICS

3.1 General

This section of the report presents a summary of the physical characteristics of the site that may be relevant to the remediation of the observed environmental concerns. This characterization of the site conditions was developed based on the results of this and previous investigations. This section of the report is subdivided according to topographic setting and surface water drainage, site geology, and site hydrogeology. Each of these aspects of the physical site characterization are discussed in detail below.

3.2 Topographic Setting and Surface Water Drainage

The Hadco site is located on the northern side of the Susquehanna River Valley, which is oriented generally east-west in the site vicinity. Steeply sloping valley walls are located just to the north of the site. The land surface continues to slope to the south across the site. However, the slope is noticeably less steep across the southern portion of the site. The topography in the facility vicinity is shown on Figure 1.

A small intermittent stream (Barnes Creek) is located along the eastern site boundary and has cut a gully along its path. A more detailed discussion of surface water resources in the vicinity of the site is presented in the Fish and Wildlife Impact Analysis (Section 5.2).

3.3 Site Geology

The geologic conditions in the immediate site vicinity have been characterized based on the observations of materials encountered during the drilling of the new monitoring wells at this site as well as through the evaluation of the geologic logs generated during the previous investigations. The drilling program completed as part of this RI included advancing a total of 17 new monitoring wells of various depths into the underlying geologic units. Most of these were located adjacent to either existing or new wells to form well clusters allowing for the monitoring of multiple water-bearing zones. Lithologic information on the unconsolidated materials forming the overburden deposits at each cluster location was obtained through the collection of split-spoon samples during the drilling of the deepest borehole at each location. While most of these boreholes were sampled at 5-foot intervals, selected boreholes located in the vicinity of the facility (MW-23, MW-24, MW-26, MW-27, and PW-3), were sampled continuously to provide a more detailed understanding of the overburden materials in the vicinity of the building. In addition, 21 shallow soil borings drilled during the source area investigation programs provide further insight into the fill material forming the unsaturated zone immediately underlying the facility.

The materials encountered in the overburden vary considerably across the site. The near-surface materials encountered across the majority of this site consist of glacial outwash deposits composed of sand, and gravel with varying degrees of silt. Underlying these glacial outwash deposits is a very compact basal till unit composed predominantly of silt, sand, and gravel. This glacial till was encountered above the bedrock at each of the drilling locations, with the exceptions of the boreholes for MW-22 and MW-29 located at the southern boundary of the site and MW-32 located off-site to the southwest of the facility. Till was however encountered in the borehole for MW-30 located off-site of the southeast. Due to the relatively low permeability of the till materials, the upper surface of this till unit could act as a surface upon which DNAPLs may be perched.

The geology of the overburden deposits changes at the southern end of the site from the glacially deposited till and outwash materials typical of the upland valley walls, to valley fill deposits primarily composed of layers of clay and silt, with some stringers of sand and gravel. The bedrock unit that was encountered immediately underlying the overburden deposits beneath this site consists of interbedded layers of siltstone and fine sandstone. A geologic section oriented along a line from north to south across this site is presented as Figure 6. The location of this section is indicated on Figure 7. This geologic section has been prepared to better illustrate the various geologic units forming the subsurface underlying this site. A contour map illustrating the surface of the glacial till unit that separates the overburden outwash deposits from the bedrock is presented as Figure 8. This figure indicates that the top of the till underlying the suspected source area slopes to the west-southwest.

3.4 Site Hydrogeology

The ground-water bearing units of concern to this investigation include the saturated overburden materials as well as the upper zone of the bedrock aquifer. The glacial outwash deposits, which predominantly form the water bearing materials in the overburden beneath this site, range in thickness from approximately 35 feet beneath the facility to over 60 feet under the southern property boundary. The monitoring well network installed at and in the vicinity of this site includes eight cluster well locations with both a shallow overburden monitoring well and a deep overburden monitoring well. (There are a total of nine well cluster locations). These cluster wells allow for the discrete monitoring of the surface and the base of the overburden water-bearing unit. Five well cluster locations include a bedrock well in addition to a shallow and/or deep overburden well that also allow the bedrock aquifer to be evaluated. The zone of the bedrock aquifer monitored by the monitoring well network at this site, is limited to the upper 20 feet of the aquifer.

To evaluate ground-water movement beneath this site, a complete round of water level measurements were recorded on October 30, 1991 and October 21, 1992; a partial round of water level measurements were obtained on August 31, 1992. The ground-water elevations calculated for each well are summarized in Table 2. Ground-water elevation contour maps illustrating the horizontal component of the hydraulic gradient within the shallow and deep water-bearing zones of the overburden aquifer are presented as Figures 9 through 12. These figures indicate that ground water in the overburden generally flows from northeast to southwest beneath the site in both the shallow and deep zones of this aquifer. However, a greater westerly component of flow appears to exist in the shallow zone as compared with the deep zone. Contour maps illustrating the piezometric surface of the bedrock aquifer are presented as Figures 13 and 14. These figures indicate that the direction of the ground-water flow within the bedrock aquifer also appears to be generally toward the southwest.

The ground-water elevations in the shallow versus deep overburden wells at the cluster locations were compared to determine the vertical hydraulic gradient between the upper and lower zones of the overburden aquifer. These measurements indicate that the vertical gradient varies beneath the site with an upward gradient at two locations (PW-1/MW-24 and MW-8/MW-18) and a downward gradient at six locations (MW-6/MW-27, MW-11/MW-29, MW-19/MW-23, MW-25/MW-26, MW-31/MW-30, and MW-33/MW-32). A comparison of the ground-water elevations in the overburden wells versus the bedrock wells at the cluster locations indicates a slightly upward vertical gradient at three locations (PW-1/MW-17, MW-8/MW-20, and MW-18/MW-20) and a slightly downward vertical gradient beneath the site at six locations (MW-4/MW-21, MW-11/MW-22, MW-24/MW-17, MW-25/MW-28, MW-26/MW-28, and MW-29/MW-22). The variability in the direction of vertical gradients across the site and the relatively slight gradients observed suggest that horizontal gradients are the principle hydraulic gradients influencing ground-water flow.

In-situ hydraulic conductivity tests (slug tests) were performed on eight of the monitoring wells to allow for the further characterization of the various water-bearing materials. The data developed through the implementation of these slug tests were evaluated using the Bouwer-Rice method to estimate hydraulic conductivity values for these formation materials. The results of the slug test data evaluations, along with summary tables of the raw slug test data and graphical representations of this data, are presented in Appendix B. The hydraulic conductivity values calculated for the deep overburden materials ranges from 2.3E-04 centimeters per second (cm/sec) to 1.7E-02 cm/sec. The data obtained through the performance of several attempted slug tests on the new shallow overburden well MW-25 were inadequate due to excessively rapid recovery of the well. Therefore, estimates of the hydraulic conductivity for the shallow overburden materials monitored by this well could not be calculated. The hydraulic conductivity of the bedrock unit monitored by MW-20 is estimated to be 8.3E-04 cm/sec based on the slug test performed on this well. These results suggest that the glacially deposited outwash deposits predominantly forming the overburden aquifer are moderately to highly conductive. The bedrock aquifer also appears to be moderately conductive based on these slug test results.

To further evaluate the hydraulic characteristics of the overburden aquifer underlying the site, a pump test was performed on the new 4-inch diameter recovery well installed during the supplemental RI. A detailed discussion of the pumping test data and analysis is presented in Appendix C. Based on the analysis of the pump test data, the transmissivity of the deep overburden materials in which PW-3 is screened is estimated to range from 1200 to 1900 gal/day/sq ft. The overall hydraulic conductivity of the overburden is estimated to range between 9.9 x 10^{-4} and 1.6 x 10^{-3}. The storativity of the deep overburden materials is estimated to range between 3.8 x 10^{-3} and 4.3 x 10^{-5}.

An analysis was performed using the estimated hydraulic parameters developed based on the pump test and a 4-layer numerical model to predict the capture zone after 60 days of sustained pumping at 11 gpm. A detailed discussion of the capture zone simulation modeling performed as part of this analysis is presented in Appendix D. The results of this analysis demonstrate that sustained pumping of the new recovery well PW-3 would hydraulically control the dissolved constituents observed to be migrating from the vicinity of the former chemical storage area.

3.5 Results of Vapor Extraction Pilot Testing

The information recorded during the implementation of the two vapor extraction pilot tests includes the pressure drop (vacuum) measurements observed at the extraction well (VE-1) and at the three vapor probes (VP-1, VP-2, and VP-3) and the vapor extraction flow rate measured at various times during the tests. This data is summarized in Appendix E.

A constant vacuum of approximately 34 inches of water was applied to the extraction point (VE-1) throughout the first pilot test. This resulted in a soil vapor withdrawal rate of approximately 120 cubic feet per minute (CFM). The second test was performed as a step test. For the first step of the test the application of a vacuum of 40 inches of water yielded a flow rate of 16 CFM. Increasing the vacuum to 67 inches of water for the second step resulted in an increase in the flow rate to 37 CFM. The final increase in vacuum to 74 inches of water resulted in a soil vapor flow rate of 48 CFM.

The 4-inch diameter extraction well has only a 3 foot long screened interval, therefore, we were able to maintain a vapor extraction rate of approximately 40 CFM per linear foot of screen during the first pilot test. While this is a relatively high rate of vapor extraction, the response observed at all three vapor probes was limited to pressure drops (vacuums) of only 0.02 to 0.055 inches of water throughout the test. An observed vacuum of approximately one percent of the applied vacuum of the extraction well may be considered a good indication that the observation point is within the effective radius of influence of the extraction well. However, the vacuums observed at the vapor probes during the first pilot test were at only one tenth of one-fifth of this level. This indicates that the effective radius of influence which could be established around VE-1 would not extend as far as the vapor probes.

To evaluate the effectiveness of using a vapor extraction point directly under the building, a second pilot test was performed. This test involved withdrawing soil vapor from the vapor probe VP-3. This test was performed as a step test such that the applied vacuum was increased in steps. The initial vacuum applied to the extraction point was approximately 40 inches of water. The vacuum was increased to 67 inches of water during the second step and finally to 74 inches of water during the third step. The response observed at the nearest observation point (VP-2) increased from 0.08 inches of water during the first step to 0.1 inches of water during the final step. The observed response to the second test also indicated that the effective radius of influence established did not extent to the nearest vapor probe located only 10 feet away. However, the second test was performed using a vapor probe constructed of 3/4 inch diameter PVC with only a 2 foot long screened interval. It would be reasonable to anticipate that a larger radius of influence could be established using an extraction well constructed with a larger screened interval and of larger diameter materials. The use of a coarser filter pack materials could also improve vapor recovery from the extraction wells.

Vapor samples were collected of the extracted soil vapors at regular intervals during both tests for volatile organic analyses. The analytical results of the vapor samples collected during the first long duration pilot test are summarized on Table 9. One vapor sample was collected each day over the period of this five day pilot test. In addition, one sample (PC-1) was collected from the off gas of the vapor phase carbon unit immediately before ending the first test to demonstrate that this unit was adequately treating the off gas from the pilot test. The concentration of total volatile organic compounds present in the extracted soil vapor increased to a maximum of 66 ug/L on the third day of the test, then decreased to a level of 34 ug/L at the end of the test.

The analytical results of the samples collected of the extracted soil vapor during the second pilot test are summarized on Table 10. The concentration of total volatile organic constituents in the soil vapor VP-3 during this short duration test ranged from 85 to 115 ug/L. The rate at which total VOCs were removed from the subsurface during the pilot test was estimated by multiplying the average concentration of VOCs in the extracted soil gas (100 ug/l) by the rate of vapor extraction (1,360 liters/min). This indicates that a removal rate of approximately 0.2 kg/day was maintained during the short duration pilot test. Given the observed extent and concentration of VOCs in the soil within the source area, the total mass of volatile constituents present may exceed 100 kg. Therefore, a full scale vapor extraction system capable of remediating the source area soil within a reasonable time frame would have to acheive much higher removal rates.

SECTION 4 - NATURE AND EXTENT OF CONTAMINATION

4.1 General

This section of the report presents the soil, ground-water, and surface water quality data developed through the performance of this investigation. This data, in conjunction with the previous investigation results, forms the basis for our current understanding of the nature and extent of contamination at the Hadco site.

4.2 Evaluation of Soil Quality Data

Soil borings were performed to characterize the physical and chemical nature of the overburden materials and to identify areas where soil is contributing to the ground-water contamination observed at this site.

A total of 21 shallow soil borings were performed to evaluate the two potential sources of contamination that have been identified during our review of the facility's operational history. These potential source areas include a former septic leach field located below the existing wet process area and a former chemical storage area located under the existing "clean room" area (Figure 4). The addition to the facility that overlies both of these areas was constructed in 1975 by Robintech. To evaluate the potential for the former septic leach field to be acting as a source of the dissolved constituents observed in the ground water at this site, two soil borings (HBW-1 and HBW-2) were drilled along the downgradient edge of this area. The locations at which these borings were drilled are indicated on Figure 4.

The evaluation of the former Robintech chemical storage area was complicated by the fact that the portion of the facility that overlies this area is operated as a "clean room" in which photographic processes are performed. To avoid disruption of the plant operations, the initial method of evaluating whether the former Robintech chemical storage area could be acting as a source of contamination, involved drilling four soil borings (HB-1 through HB-4) outside the building in the area immediately downgradient of the clean room. The locations at which these boring were drilled are indicated on Figure 4.

The results of the VOC analyses performed on the soil samples collected from the potential source area soil borings are summarized in Tables 6 and 7. The analytical results of soil samples from the former leach field area (HBW-1 and HBW-2) indicated only a trace concentration of trichloroethylene (TCE) (8 ug/kg) in one sample and no constituents were detected above the method quantification limit in the second sample. These results suggest that the former leach field is not acting as a source of the dissolved constituents observed at this site.

The analytical results of three of the four soil samples collected from the initial borings downgradient of the former chemical storage area (HB-1 through HB-4) also contained only trace concentrations of TCE. However, the sample collected from a depth of 6 to 8 feet at HB-3 contained 440 ug/kg of TCE as well as lesser concentrations of acetone, tetrachloroethylene (PCE), 1,2-dichloroethane, toluene, and xylenes. This boring is located closest to the former location of the chemical storage area. The results of the OVA screening performed on the soil samples collected during drilling of the new monitoring wells MW-19 and MW-23, which are also located downgradient of the former chemical storage area, indicated the presence of elevated levels of VOCs in the soil. These initial RI results suggested that residual contamination of the soil exists in the soil below the former chemical storage area and that this soil is acting as a continuing source of the dissolved constituents observed in the ground water. Therefore, the additional source area characterization activities were included in the Supplemental RI.

The supplemental program included the drilling of 12 additional borings within the clean room and the performance of a soil vapor extraction test. The location of these borings are shown on Figure 5.

Each of the soil borings performed for the source area investigation were sampled continuously from the ground surface to the water table or until refusal. One soil sample was selected for laboratory analysis from each boring based on the OVA concentrations (a PID was used during the supplemental program) measured for each sample as they were recovered. The selected soil samples were submitted to Recra Environmental to be analyzed for VOCs and the site-specific inorganic constituents included in the PCL. A complete set of the laboratory analytical results is presented in Appendix H.

The concentrations of inorganic constituents identified in the soil samples collected to evaluate the former chemical storage area soil borings are summarized in Tables 3 and 4. The concentrations of most of the inorganic constituents detected in these samples are within the range normally observed in this part of New York State. However, the range in concentrations of both chromium (51.8 to 2130 mg/kg) and copper (37 to 2680 mg/kg) in these soil samples were observed to extend above that which was expected for area-wide soil.

A summary of the volatile organic analytical results for the soil samples from these supplemental borings (CRB-1 through CRB-12) is presented in Table 7. These results indicated that borings CRB-1, CRB-2, CRB-5, CRB-6, and CRB-9 are nearest the source based on the concentrations of TCE in the soil. Several other VOCs were also detected at elevated concentrations in the soil samples from these borings. These compounds include: 1,1-dichloroethene (DCE), methylene chloride, PCE, toluene, TCA, and total xylenes. Figure 15 presents an isoconcentration contour map illustrating the distribution of total VOCs detected in the soil underlying the former chemical storage area based on the data from borings CRB-1 through CRB-12. While this data delineates the limited horizontal extent of VOCs in the soil to the north, west, and south, the extent of soil contamination toward the east requires further delineation.

The supplemental RI activities included the drilling of nine shallow soil borings to evaluate isolated occurrences of inorganic compounds near monitoring wells MW-3, MW-7, and MW-11. The locations of these wells are shown on Figure 3. Three borings were drilled at a distance of approximately 5 feet radially around each of these wells. Two soil samples were collected from each boring. One sample was collected from the depth interval of 0 to 4 inches and the second sample was collected from the depth interval of 1 to 2 feet below ground surface. Each of these samples were analyzed for chromium, copper, lead, zinc, and beryllium in accordance with NYSDEC ASP Method CLP-M. The analytical results of these samples are summarized on Table 5.

The concentrations of the inorganic compounds analyzed in the samples near monitoring wells MW-3, MW-7, and MW-11 are consistent with the normal range of expected background concentrations and do not indicate the soil in these areas would be the source of the inorganics detected in ground water.

4.3 Evaluation of Ground-Water Quality Data

The ground-water quality data was developed through an initial RI program and a supplemental RI program. The initial RI field investigation involved the installation of 11 additional monitoring wells. These wells include four bedrock wells (MW-20, MW-21, MW-22, and MW-28), five deep overburden wells (MW-18, MW-23, MW-24, MW-26, and MW-27), and two shallow overburden wells (MW-19 and MW-25). The supplemental RI field program involved the installation of six additional wells including: four new deep overburden wells (MW-29, MW-30, MW-32, and PW-3); and two new shallow overburden wells (MW-31 and MW-33). The location of each of these wells is indicated on Figure 3.

Ground-water samples were obtained during the initial RI from each of the 11 new wells, MW-18 through MW-28, and from each of the sixteen existing monitoring wells at the site (MW-1 through MW-15, and MW-17) between October 21-24, 1991. The second round of ground-water sampling was performed for the supplemental investigation program during August/September 1992. The wells sampled for this second round included the six new wells (MW-29 through MW-33, and PW-3) along with selected existing wells (MW-14, MW-17 through MW-20, and MW-22 through MW-27). Both rounds of ground-water samples were submitted to Recra Environmental for laboratory analysis of the volatile organic and inorganic constituents listed on the PCL.

The results of the inorganic chemical analyses performed on the ground-water samples collected during the October 1991 and the August/September 1992 sampling events are summarized in Tables 11 and 12, respectively. These results indicate the presence of a number of inorganic constituents in the ground water that exceed their respective New York State Ambient Water Quality Standards (Table 13). Most of the inorganic constituents observed at concentrations above the standards (such as iron, magnesium, manganese and sodium) appear to be either naturally occurring or appear to be the result of an upgradient source. The concentration of these constituents were also observed at elevated levels in the upgradient monitoring wells. However, several inorganic constituents (including arsenic, beryllium, chromium, copper, lead, and zinc) were observed at concentrations that do not appear to be attributable to background conditions.

The well at which the highest concentration of arsenic was observed during the October 1991 sampling was MW-11. The only well in which the August/September 1992 sampling results confirmed an arsenic concentration exceeding the NYS Standard was MW-14. Both these wells are located downgradient of the source area, and near the southern and south-western facility boundaries, respectively. Other wells with elevated arsenic concentrations include: MW-6, MW-19, MW-28, and PW-1. Upgradient well MW-10 had an arsenic concentration of 19 ug/L in October 1991 and MW-9 had a concentration of 6 ug/L. This illustrates that arsenic is present at background concentrations of up to these values. The shallow well MW-19 in the immediate vicinity of the former chemical storage area had at least one sample collected that had no arsenic detected, while wells away from this suspected source area did have detections of arsenic (such as MW-7, MW-8, MW-11, MW-20, MW-22, MW-29, MW-31, and MW-33).

Beryllium concentrations in excess of the NYS Standard were observed at MW-6, MW-11, MW-14, MW-19, and MW-20. None of the other wells at this site have had any detections of beryllium. The highest concentration of beryllium was detected in October 1991 at well MW-11 (0.011 mg/l).

Copper was observed during both sampling events at the highest concentrations in shallow overburden well MW-19, located immediately downgradient of the former chemical storage area. This well also contained elevated concentrations of arsenic, beryllium, cadmium, chromium, lead, and zinc. Nine other wells (MW-6, MW-11, MW-13, MW-14, MW-20, MW-25, MW-28, MW-33, and PW-1) also had elevated copper concentrations.

The wells at which the highest levels of chromium and zinc were detected were MW-7 and MW-13, respectively. Both of these wells are located to the west of the facility. As discussed in the section regarding soil quality, the results of the supplemental soil boring program found no indication that the soil in the vicinity of MW-7 is acting as a source of these observed inorganic constituents.

Chromium concentrations were observed to exceed ground-water standards in 21 of the 34 wells sampled for this RI including five wells located upgradient or sidegradient of the former chemical storage area. It should also be noted that the analyses performed to establish the PCL included analyses for hexavalent chromium. As these analyses were all negative, the chromium identified at this site consists of the less toxic trivalent chromium form. Zinc concentrations in excess of ambient ground-water quality standards were also observed at MW-11, MW-14, MW-19, MW-20, and MW-28. Zinc concentrations at upgradient wells were detected as high as 266 ug/L at MW-10 in October 1991, which is also approaching the NYS Standard of 300 ug/L.

Lead concentrations at 15 of the wells (MW-3, MW-6, MW-8 through MW-11, MW-13, MW-14, MW-18 through MW-20, MW-28, MW-29, MW-31, and MW-33) exceeded the NYS Guidance Value, however, three of these wells (MW-3, MW-9, and MW-10) are upgradient wells. The distribution of lead concentrations are similar to those observed for the other inorganic compounds discussed above, in that no direct correlation to one source area can be made.

In summary, a number of dissolved inorganic constituents have been observed in the ground water at concentrations exceeding NYSDEC Ambient Water Quality Standards. The identification of elevated chromium and copper in the soil samples from the former chemical storage area indicates that this area may be contributing to these specific inorganics in the ground water. This investigation has not identified any other sources of the inorganics constituents observed at this site.

The results of the VOC analyses performed on the ground-water samples collected at this site are summarized in Tables 14 and 15. The volatile constituent observed at the highest concentration was TCE, which was detected at 630 mg/L in the October 1991 sample from the shallow overburden monitoring well MW-19. This well is located immediately downgradient of the former chemical storage area. Other VOCs observed in this October 1991 sample include 1,1,1-trichloroethane (TCA) at 190 mg/L, 1,2-dichloroethylene (DCE) at 23 mg/L, toluene at 24 mg/L, methylene chloride at 4.7 mg/L, xylenes at 2.9 mg/L and PCE at 2.1 mg/L. A number of additional VOCs were also detected in this sample at concentrations below 1 mg/L. The ground-water sample collected from MW-19 in August/September 1992 had the same compounds detected, but at lower concentrations. The ground-water sample collected from the deep overburden well MW-23, which is located adjacent to MW-19, demonstrates that the concentrations of these VOCs attenuate with depth in the immediate vicinity of the source area. However, the concentrations of TCE, TCA, and the other chlorinated organic compounds observed in the sample from this deep overburden well indicate these dissolved constituents have vertically migrated downward to the base of the overburden aquifer. The nearest bedrock monitoring well to this suspected source area is MW-17. Although the October 1991 concentrations of TCE (18 mg/L), TCA (11 mg/L), and other chlorinated organic compounds observed in this sample show further attenuation, these analytical results demonstrate that dissolved volatile organic constituents have migrated into the bedrock formation underlying this site. The ground-water concentrations of VOCs in the August/September 1992 samples were lower at MW-23 however they were higher at MW-17.

The horizontal distribution of total VOC concentrations in ground water within the shallow and deep overburden water-bearing zones are illustrated on Figures 16 through 19. These figures also illustrate the distribution of TCE concentrations in the ground water. The presence of TCE in the ground water in the shallow overburden wells located upgradient of the Hadco facility clearly indicates that an upgradient off-site TCE source exists. However, the principle source of VOCs in the ground water at the Hadco site appears to be in the vicinity of the former chemical storage area immediately upgradient of MW-19. A comparison of these VOC distribution figures indicates that the concentration of dissolved VOCs tends to be higher in the deep overburden zone than in the shallow overburden zone downgradient of the suspected source area. However, in the immediate vicinity of the suspected source area, the concentration observed in the shallow overburden well (MW-19) is an order of magnitude higher than in the adjacent deep overburden well (MW-23). The concentration of TCE observed in the shallow well MW-19 is near 50 percent of the solubility of TCE in water. This strongly suggests the presence of separate phase TCE in the soil near to this well.

The analytical results of the ground-water samples collected from the off-site well clusters installed downgradient of the site during the supplemental RI activities indicate the total VOC concentrations in both the shallow and deep water-bearing zones of the overburden attenuate downgradient of the site. This is illustrated by comparing the concentration of total VOCs in the deep overburden well MW-29 at the downgradient property boundary (1,408 ug/L) with the highest total VOC concentration detected in the new downgradient off-site well MW-33 (64.2 ug/L).

The distribution of total VOCs and TCE in the bedrock wells at this site is illustrated on Figures 20 and 21. The highest concentration of VOCs and TCE in the bedrock ground-water samples was observed at MW-17, located within 150 feet of the former chemical storage area. This figure shows that the total VOC concentrations in the bedrock ground-water attenuate downgradient of the source area. The bedrock ground water at the downgradient property boundary (MW-22) was observed to contain a total volatile concentration of only 44 ug/L in October 1991. Therefore, no downgradient bedrock monitoring wells were installed during the supplemental RI program. However, the concentration of total VOCs increased to 1,256 ug/L in the August/September 1992 sample from this well.

4.4 Surface Water Quality Considerations

The RI field investigation program included the collection of samples from four locations along Barnes Creek for the purpose of evaluating the potential impacts to surface water associated with the Hadco site. These four stream sampling locations are indicated on Figure 3. Each of the surface water samples were submitted for laboratory analysis of the volatile organic and inorganic constituents on the PCL. In addition, a sediment sample was collected at each of the locations at which the surface water samples were obtained. These sediment samples were also analyzed for VOCs and the inorganic constituents on the PCL.

The results of the inorganic analyses performed on the surface water samples are summarized in Table 16. The concentrations of inorganic constituents observed in the samples collected adjacent to and downstream of the Hadco facility are generally consistent with the concentrations observed in the samples collected upstream. The results of the VOC analyses performed on these surface water samples are summarized in Table 17. These results show concentrations of TCE below the method quantification limit in both the sample collected upstream of the site and the sample collected immediately adjacent to the upstream edge of the site. These results suggest that some source upstream of the Hadco site is contributing trace levels of TCE to Barnes Creek. These results do not indicate any contribution of TCE to the creek from the Hadco site.

The results of the inorganic analyses performed on the sediment samples collected from Barnes Creek are summarized in Table 18. A comparison of these results shows the concentrations of inorganic constituents in the samples collected upstream of the site are generally consistent with the samples collected adjacent to and downstream of the site. The results of the volatile organic analyses performed on the sediment samples are summarized in Table 19. These results indicated the presence of trace concentrations of several volatile constituents in the stream sediments. Acetone was detected in the samples collected upstream of the site and adjacent to the upstream site boundary as well as in the duplicate sample collected immediately adjacent to the facility. However, the concentration of acetone detected in all three of these samples was below the method quantification level. Furthermore, acetone was also detected in the method blank, indicating that the detection of acetone may have been due to laboratory-induced contamination of the samples. Trace concentrations of benzene, methylene chloride, and TCE were also detected in the samples collected from stream sampling location SW-3 located adjacent to the facility. However, each of these detections were at concentrations below method quantification limits. The results of the surface water investigation activities indicate that the Hadco site is not adversely impacting Barnes Creek.

SECTION 5 - RISK ASSESSMENT

The risk assessment presented in this section is composed of a human health risk assessment (RA) and an ecological assessment. By prior request of NYSDEC, the ecological assessment reflects NYSDEC guidelines for Fish and Wildlife Impact Assessment, (FWIA) Steps I through IIA.

5.1 Human Health Risk Assessment

The purpose of the RA is to evaluate the potential human health risks associated with the Hadco Corporation site under baseline conditions. This RA has been prepared in conjunction with an RI/FS for the site. The format for the RA is based on USEPA guidance documents, including Risk Assessment Guidance for Superfund-Human Health Evaluation Manual (USEPA, 1989a) and Supplemental Guidance (USEPA, 1991a).

The major components of the RA are: Data Evaluation, Exposure Assessment, Toxicity Assessment, and Risk Characterization. The objective of the Data Evaluation section is to identify chemicals of interest for subsequent efforts in the risk assessment process. The objectives of the Exposure Assessment are to identify actual or potential exposure pathways under both baseline and hypothetical future use conditions, to characterize the potentially exposed populations, and to estimate the extent of exposure. The Toxicity Assessment summarizes acceptable levels of intake for specific chemicals based on toxicological data from the scientific literature and USEPA guidance documents (i.e., Health Effects Assessment Summary Tables) and on-line databases (i.e., Integrated Risk Information System - IRIS). Risk Characterization is the final component of the risk assessment process, wherein information provided by previous components is integrated to address the potential for adverse human health effects for each of the potentially exposed receptor populations.

5.1.1 Data Evaluation

The potential sources of on-site contamination include a former septic system leach field, and a former chemical storage area. These source areas are described in the detailed site history and discussion of physical features which are presented in the Groundwater Technology, Inc. (GTI) Workplan for RI/FS (Groundwater Technology 1990), the Blasland & Bouck (B&B) RI/FS Workplan Addendum (Blasland and Bouck Engineers, P.C., 1991), and in Section 1 of this report.

The size of the Hadco Corporation site is approximately 17.3 acres. It is an active manufacturing facility which produces printed circuit boards. The area within a one-half mile radius of the Hadco site primarily supports additional electronics manufacturing industries (Groundwater Technology Inc., 1990). The concentrations of some constituents (i.e., TCE) at the Hadco site may be due to an off-site upgradient source. The on-site former chemical storage area, however, appears to be the primary source of chemicals, including TCE, as discussed in Section 4.

5.1.1.1 Analytical Database

This section presents a summary and discussion of the environmental data employed in this RA. Previous ground-water sampling was conducted by Lancy Laboratories and Groundwater Technology, Inc. A description of site geology and results of previous hydrogeologic investigations are presented in Section 3 of this report, and the GTI Workplan (Groundwater Technology Inc., 1990). Blasland & Bouck Engineers, P.C., conducted additional sampling during October 1991, as discussed in Section 2. Ground-water and soil samples from the site, and surface water and sediment samples from Barnes Creek, were collected and analyzed for the Project Compound List (PCL) constituents. The most recent analytical data generated by the 1991 RI sampling efforts are employed in this assessment to provide a representative evaluation of current site conditions.

Ground Water

The ground-water data base employed in this RA consists of results of ground-water sampling conducted during October 1991 and September 1992. Selected monitoring wells were chosen to develop reasonable maximum exposure (RME) concentrations (USEPA, 1989a) for use in quantitative risk calculations. Overburden wells were chosen as the basis for evaluating risks to ground water because the overburden aquifer is a sole source aquifer. Wells which are generally located downgradient of the on-site source areas in both shallow and deep overburden were chosen. These wells include MW-8, MW-11, MW-14, MW-15, MW-18, MW-29, MW-30, MW-31, MW-32, and MW-33. Characteristics of these monitoring wells, and analytical results are discussed in detail in Section 3 and Section 4 of this report. Ground water analytical results are presented in Table 11 through 15.

Soils

The soils data base employed in this RA consists of results of sampling by B&B, during July 1991. Subsurface samples from six soil borings were analyzed for PCL constituents. Analytical results for these samples are presented in Tables 3 through 6. Soil samples collected beneath the building in 1992 were not considered in the RA since pathways involving human contact with these soils are not possible.

Surface Water and Stream Bottom Sediments

Barnes Creek is located within approximately 50 feet of the eastern perimeter of the site. Although Barnes Creek is reportedly an intermittent stream (Section 2), streamflow was available for sampling during the October 1991 field investigations. The samples consisted of water column and stream bottom sediments at four locations along Barnes Creek as described in Section 2. Analytical results from surface water samples are presented in Table 16 and Table 17. Analytical results from stream bottom sediment samples are presented in Table 18 and Table 19.

Air

No volatile organic compounds (VOCs) were detected in breathing zone air during site walkovers and sampling activities at the site. Evaluations were conducted using an Organic Vapor Analyzer (OVA). Consequently, inhalation of organic vapors from ambient air is not considered a complete exposure pathway at the site. Therefore, neither this pathway nor air quality associated with VOCs will be addressed further in this report.

5.1.1.2 Selection of Chemicals of Interest

The chemicals of interest at the site consist of all chemicals reported above detection limits in ground water and soils with the following exceptions. Chemicals which are considered essential nutrients are not included as per USEPA (1989a) guidance.

In addition, because chemical-specific toxicity criteria are required to perform quantitative risk calculations, those chemicals which lack suitable criteria are not considered chemicals of interest in this RA. Chemicals of interest in each of the relevant environmental media are summarized in Table 20 and Table 21.

Exposure concentrations are combined with human exposure estimates to calculate human intakes for each exposure pathway.

5.1.2 Exposure Assessment

The objective of the Exposure Assessment is to identify potential receptor populations and complete exposure pathways. Potential receptors and pathways are evaluated on the basis of site physical characteristics, land use information, and environmental fate and transport properties of the chemicals of interest. An exposure pathway is considered to be complete if: 1) there is a source of contamination or release from a source; 2) there is an exposure point where human contact can occur; and 3) there is a viable route of exposure (i.e., oral, dermal contact, inhalation) by which the chemical can be taken into the body. Health risks associated with these exposures are quantified in Section 5.5 (Risk Characterization).

5.1.2.1 Environmental Fate and Transport Properties

This section provides a brief overview of the environmental fate and transport mechanisms which regulate the distribution of chemicals in the environment. Chemical-specific environmental fate and transport characteristics of the chemicals of interest are presented in Appendix F. Site-specific fate and transport properties are discussed in Section 5.1.2.2.

In general, soils are likely to retain and immobilize organics with low water solubility, and many metals. Both categories of chemicals generally have strong affinities for soil organic materials. Metals may also be retained in the solid phase via adsorption with charged surfaces on clays and metal oxides, precipitation of insoluble species, co-precipitation with other inorganic materials, complexation with organic materials, and fixation within crystalline lattices. In general, the conditions promoting soil adsorption include near-neutral pH (6 to

8) and high organic content, which also implies a high cation exchange capacity. Conversely, acidic mineral soils (low in organic matter) do not bind readily with metallic ions, increasing their tendency to migrate to underlying ground water. Substances retained in surficial soil may be subject to transport via overland stormwater runoff and atmospheric transport with dusts.

Some compounds not strongly retained by soils (e.g. VOCs) may volatilize to the atmosphere. Volatilization rates from soils are dependent on the chemical's vapor pressure and water solubility, as well as site-specific conditions. Volatilization is generally important only within surficial soil. Disturbance of the soil (i.e., during excavation) may promote volatilization of chemicals found in subsurface soils.

In general, surface waters and sediments may serve as intermediate or ultimate repositories for a wide variety of compounds. Organic and inorganic compounds in the environment to enter surface water via a number of pathways including direct discharge, overland flow, soil erosion, atmospheric fall out, and ground-water discharge. Within the water body, the chemicals may be subject to a number of dynamic fate and transport processes including adsorption/desorption, sedimentation/resuspension, dispersion, dilution, biodegradation, and chemical degradation. The distribution of chemicals between the dissolved and solid phases, and their persistence depend upon each chemical's physical/chemical properties and site-specific factors.

Natural biodegradation may be an important fate process in soils, surface water, sediment, or ground water. Biodegradation occurs as a result of microbial metabolism and enzymatic reactions, and may proceed under both aerobic and anaerobic conditions when a sufficient microbial population and readily available energy source are present.

5.1.2.2 Site-Specific Fate and Transport Properties of the Chemicals of Interestt

The primary source of contamination was identified as the former storage area. The contaminated soils are at subsurface locations (i.e., underlying buildings), thus limiting volatilization to the atmosphere.

Soils at the site are potential sources of chemicals in the overburden ground-water system. The mobile chemicals of interest may leach from soils and enter the ground water in overburden. If excavation activities at the site were to occur in the future, subsurface soils could be disturbed to the extent that significant dust generation could occur. Strong winds, especially during dry conditions, could also contribute to the transport of chemicals of interest with dust. Winds and warm weather also tend to increase volatilization in soils that are exposed to the atmosphere.

5.1.2.3 Exposure Pathways

Exposure pathways are evaluated for the following site-related media: soils, ground water, surface water and sediments. Exposure pathways are summarized in Table 22 and are evaluated further in Section 5.1.4 (Risk Characterization).

Potential exposures to subsurface soils exist only under hypothetical future use conditions. Although health and safety precautions would be employed, excavation workers could be exposed to the chemicals of interest via direct dermal contact and incidental ingestion of soils, if excavation activities were to occur.

During dry conditions, the uplift of particulates with wind could result in exposures via inhalation of dust.

Residences located downgradient of the site are believed to use private wells for potable water supply purposes. If environmental conditions permit the transport of the chemicals of interest, potential exposure to site-related contaminants in ground water might occur via ingestion of water from private wells at downgradient residences. Although there is no evidence to suggest that site-related chemicals have reached these water supplies, the drinking water pathway is identified for further evaluation in the risk assessment.

5.1.2.4 Potential Receptor Populations and Potential Exposure

Potential receptors and exposure pathways are identified in this section on the basis of land use information, the potential sources of contamination, and the most probable transport routes of the chemicals of interest. Potential receptors are identified for both on-site and off-site exposures, and for both hypothetical baseline and future use conditions.

Current On-Site Exposure

There is no potential for direct contact with the chemicals of interest in ground water or soils at the site because they are confined to subsurface locations. There is no surficial expression of ground water (i.e., seeps), and ground water is not used as a potable water supply at the site.

Current Off-Site Exposure

The City of Owego is served by a municipal water supply. It is conservatively assumed that some downgradient private wells exist, and that they will have the potential to utilize ground water impacted by the site as a potable water supply source. Therefore, the use of ground water for drinking water purposes is retained as a pathway of exposure for further evaluation in the RA. Ground water ingestion exposure is evaluated for hypothetical baseline conditions.

Contaminated soils are confined to subsurface locations, and thus no off-site transport of soils is likely to occur.

Hypothetical Future On-Site Exposure

The potential exists for future use of the site to include excavation activities. Some form of excavation would likely be a prelude to any major changes at the site, and could be associated with facility expansion activities in the future. Under such circumstances, excavation workers are assumed to be the most-exposed individuals (MEI) (USEPA, 1989a) to chemicals in subsurface soils. Any future development of the site would probably be restricted to industrial purposes, due to the site history and surrounding land uses. Excavation workers are not likely to experience significant contact with ground water during excavation activities.

5.1.2.5 Quantification of Exposure: Exposure Point Concentrations

Exposure concentrations are developed from the analytical data described in Section 5.1.1.1 - Analytical Database. Exposure point concentrations represent the concentration of a given chemical at the location where human contact might occur. As per USEPA (1989a) guidance, the reasonable maximum exposure (RME) concentrations were calculated as 95 percent upper bound confidence limit of the arithmetic mean concentration for each chemical of interest. In cases where the 95 percent upper bound value exceeds the maximum observed concentration, the maximum observed concentration is used as the exposure point concentration (USEPA, 1989a). When calculating the arithmetic mean concentrations, one-half the sample quantitation limit is used as a proxy concentration for non-detected results (USEPA, 1989a).

Observed concentration ranges, arithmetic mean concentrations, and RME concentrations of the chemicals of interest in ground water and soils are presented in Table 23 and Table 24, respectively.

Exposure concentrations are combined with human exposure estimates to calculate human intakes for each exposure pathway.

5.1.2.6 Quantification of Exposure: Human Intakes

In general, the exposure assumptions employed in risk calculations in this RA are conservative and tend to overestimate the actual levels of potential exposure. They are designed to provide conservative estimates of potential health risks associated with receptor exposure to the chemicals of interest.

Incidental Ingestion/Dermal Contact with Soils

Several conservative assumptions are used to estimate exposure via incidental ingestion/dermal contact with soils. In accordance with USEPA (1991a) guidance, a daily ingestion rate of 50 mg/day is used, with 100 percent of this daily rate derived from the site, as a conservative assumption. Under a hypothetical future use scenario involving excavation activities, a 70 kg excavation worker is assumed to be exposed for 200 days in a one-year period.

Soil ingestion exposure is quantified using the following equation developed by USEPA (1989a):

Soil Intake (mg/kg/day) =

$$(CS \times IR \times CF \times EF \times ED) / (BW \times AT)$$

Where:

CS = chemical concentration in soil (mg/kg)
IR = ingestion rate (mg/day)
CF = conversion factor (10^{-6} mg/kg)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

Values for these variables are presented in Table 25.

Uptake of chemical compounds via dermal absorption is limited by the permeability of the skin and the tendency of compounds present in soil to adsorb to the skin. The absorption factor for volatiles is assumed to be 10 percent (USEPA, 1991c), while dermal absorption of inorganics is assumed to be negligible (i.e., 0 percent)(Casarett & Doull, 1986). A dust adherence factor of 1.0 mg/cm^2 is incorporated in the dermal exposure estimate (USEPA, 1991c). Other assumptions used in this calculation include a skin surface area of 3120 cm^2, which represents the total surface area of the hands and arms of an adult male (USEPA, 1989a).

Dermal exposure to soil is estimated with the following equation developed by USEPA (1989a):

Absorbed Dose from Soil (mg/kg/day) =

(CS x CF x SA x AF x ABS x EF x ED) / (BW x AT)

Where:

CS = chemical concentration in soil (mg/kg)

CF = conversion factor (10^{-6} mg/kg)

SA = skin surface area (cm^2/event)

AF = soil/dust to skin adherence factor (mg/cm^2)

ABS = absorption factor (percent)

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight (kg)

AT = averaging time (days)

Values for these variables are presented in Table 25.

Excavation activities are assumed to take place on 200 days within a one-year period. The hands and arms are the body parts most likely to be available for dermal contact exposure and are associated with a total skin surface area of 3120 cm^2. A daily soil ingestion rate of 50 mg/day is attributed to soils from the site (USEPA, 1991a). This exposure scenario is a conservative RME estimation of receptor exposure when the following points are considered:

- o Soils contamination is located under existing buildings. Excavation activities in the future would likely occur in other areas of the site, as a prelude to additional building construction;
- o Excavation activities associated with future use may not occur for a duration as long as 200 days;

- Weather and seasonal conditions affect the extent of dust generation;
- Dust suppression measures (i.e., soil wetting) would be implemented if excessive dust resulted from excavation activities; and
- Health and safety precautions (i.e., protective clothing) would necessarily be taken if excavation activities occurred at the site.

With the exception of inorganics, risks associated with dermal contact and ingestion exposure are combined; the two exposure estimates are summed to evaluate the total risk associated with these routes of exposure to soils. The inorganic chemicals of interest are not evaluated for the dermal exposure route because inorganics in general, are poorly absorbed through the skin (Casarett & Doull, 1986).

Inhalation of Dust from Soils

Inhalation exposures are evaluated separately from dermal and ingestion exposure because USEPA has developed distinct reference toxicity criteria for inhalation exposures. In cases of exposure to particulate matter (i.e., dust), the amount of respirable particulate matter in the air is assumed to be 0.07 mg/m^3 (Hawley, 1985), which is a conservative estimate of fugitive dust emissions from on-site soils.

The concentrations of the chemicals of interest in air are derived by multiplying the RME soil concentration by the concentration of respirable dust particles in air.

An inhalation exposure dosage can be calculated using the following equation developed by USEPA (1989a):

Intake (mg/kg/day) =

$$(CA \times IR \times ET \times EF \times ED) / (BW \times AT)$$

Where:

CA = chemical concentration in air (mg/m^3)
IR = inhalation rate (m^3/hour)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (days)

A RME scenario for inhalation of dust from on-site soils is described in Table 26. As discussed previously, excavation activities are assumed to take place on 200 days within a one-year period. A typical workday of 8 hours and an inhalation rate of 2.6 m^3/hour (moderate activity level) are assumed for excavation workers. This exposure scenario is a conservative RME estimation of receptor exposure for reasons cited in the previous subsection (5.1.2.6.1).

Ingestion of Ground Water

USEPA (1989a) recommends 2 liters per day as a 90th percentile upper bound drinking water ingestion rate for adults in residential settings. As a conservative assumption, exposure concentrations at the tap are presumed equivalent to the RME ground-water concentrations for the chemicals of interest detected in the overburden aquifer downgradient of the site.

Drinking water ingestion exposure is quantified using the following equation developed by USEPA (1989a):

Water Intake (mg/kg/day) = (CW x IR x EF x ED) / (BW x AT)

Where:

CW = chemical concentration in water (mg/liter)
IR = ingestion rate (liters/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight
AT = averaging time (days)

A RME scenario for this receptor population and exposure pathway is described in Table 27. Residents are assumed to ingest 2 liters of water per day for 350 days per year (USEPA, 1991a). The duration of exposure is assumed to be 30 years (USEPA, 1991a). Residents are represented by a 70 kg adult (USEPA, 1991a).

This exposure scenario is a conservative RME estimation of receptor exposure when the following points are considered:

- The closest private wells are located approximately 1500 feet from the site. Most of the area is served by the Town of Owego municipal water supply;
- There is no evidence to suggest that site contaminants have migrated to downgradient off-site wells; and
- It is extremely conservative to assume that concentrations at the tap are equivalent to RME concentrations in ground-water monitoring wells immediately downgradient of the site.

5.1.3 Toxicity Assessment

This section provides a brief summary of the toxicological properties of the chemicals of interest and identifies the reference toxicity values for these chemicals. Reference toxicity values are based on toxicological data from the scientific literature and USEPA guidance documents (i.e., Health Effects Assessment Summary Tables) and on-line data bases (i.e., Integrated Risk Information System - IRIS). In general, the reference toxicity values have been derived from results of experimental exposures of laboratory animals or occupational exposures of humans. These values are used in the Risk Characterization.

Reference toxicity values for the chemicals of interest are presented in Table 28 and Table 29. Slope Factors (SFs) are presented for compounds which are considered by USEPA to be potential carcinogens. The SF is expressed in units of inverse dosage, i.e., (mg/kg/day)$^{-1}$. The SF represents the increase in cancer risk per unit of exposure dosage. In most cases, the SFs are derived by USEPA using data from animal experiments and applying an appropriate low-dose extrapolation model.

For compounds not regarded as potential carcinogens, a reference dose (RfD) is presented. This value represents the dosage of a compound, in units of mg/kg/day, which if consumed daily throughout a person's lifetime, would not result in any adverse health effects. The RfD is usually derived on the basis of animal data which define a no-effect dosage or threshold for toxicity. This threshold value is divided by safety factors, typically 100 or 1,000, to arrive at a RfD for humans.

Toxicity reference values are not available for all routes of exposure. Most of the available toxicity values are for oral exposure, and some are available for the inhalation route. No toxicity values are currently available for dermal exposure, due to a lack of scientific studies to quantify dermal toxicity and carcinogenic potential for most chemicals. Oral toxicity reference values are applied in this RA to evaluate dermal exposures as per USEPA (1989) guidance. Dermal absorption factors are used as described in Section 5.1.2.6.1 and oral absorption is assumed to be 100 percent.

Toxicological profiles for the chemicals of interest are presented in Appendix G.

5.1.4 Risk Characterization

The purpose of this section is to integrate the results of the previous sections to evaluate potential risks associated with exposure to the chemicals of interest. Estimated RME exposure levels are compared to reference toxicity values to quantify potential risks.

5.1.4.1 Carcinogenic Effects

Carcinogenic risk is expressed as a probability of developing cancer as a result of lifetime exposure. For exposures to multiple carcinogens, USEPA assumes that the risk associated with multiple exposures is equivalent to the sum of their individual risks. USEPA's acceptable target range for carcinogenic risk associated with Superfund sites is one-in-ten-thousand (10^{-4}) to one-in-one-million (10^{-6})(USEPA, 1991b). Total site risk in excess of 10^{-4} normally serves as a trigger for remediation (OSWER Directive 9355.0-30, April 22, 1992).

In this assessment, carcinogenic risk has been calculated for each chemical and pathway of exposure. These values are presented in Tables 30A-32A. A summary of pathway-specific risks is presented in Table 33, and total risks for all pathways for each receptor group are summarized in Table 34.

For hypothetical on-site excavation workers under future use conditions, all of the pathway-specific carcinogenic risks, as well as the sum of the carcinogenic risks for all pathways, are below USEPA's target range for acceptable risk at Superfund sites.

The carcinogenic risk associated with hypothetical ingestion of ground water by residents is 6×10^{-4}. This risk is due primarily to the presence of beryllium, (estimated risk of 5×10^{-4}) and 1,1-

dichloroethene (estimated risk of 3 x 10^{-4}). The RME concentration of beryllium (0.005 mg/L) also exceeds the federal proposed MCL of 0.001 mg/L, and the NYSDEC TOGS guidance value of 0.003 mg/L. The RME concentration for 1,1-dichloroethene (0.04 mg/L) exceeds both the Federal MCL (0.007 mg/L) and the NYSDEC Class GA ground water value (0.005 mg/L).

5.1.4.2 Noncarcinogenic Effects

In order to characterize the overall potential for noncarcinogenic effects associated with exposure to multiple chemicals, USEPA has developed a Hazard Index (HI) approach. This approach assumes that simultaneous sub-threshold chronic exposures to multiple chemicals are additive and could result in an adverse health effect.

In this assessment, exposures are evaluated with chronic RfDs. Calculation of a Hazard Index in excess of unity indicates the potential for adverse health effects. Indices greater than one will be generated when intake of any chemical exceeds its RfD. However, given a sufficient number of chemicals under consideration, it is also possible to generate a Hazard Index greater than one, even if none of the individual chemical intakes exceed their respective RfDs.

In this assessment, Hazard Indices were generated for each exposure pathway and are presented in Tables 30B-32B. A summary of pathway-specific Hazard Indices is presented in Table 33, and total Hazard Indices for all pathways for each receptor group are summarized in Table 34. As shown in Table 33, the Hazard Index for the ingestion/dermal contact route for hypothetical on-site excavation workers is less than 1. The Hazard Index for inhalation exposure of these receptors to dust from soils at the site yields a Hazard Index which is greater than one, due solely to chromium.

The Hazard Index for hypothetical ingestion of ground water by off-site residents is 7 when exposure concentrations are based on the concentrations of chemicals detected in downgradient monitoring wells at the property boundary. The elevated Hazard Index for this pathway is primarily due to the presence of arsenic and manganese with significant contributions also from trichloroethene, 1,1-dichloroethene, cadmium, copper, and nickel. The upper 95 percent confidence limit concentration for arsenic exceeds the federal MCL, and NYSDEC TOGS value for Class GA waters.

At this time, the extent to which these metals may have impacted any existing private wells is unknown. A Hazard Index associated with ingestion of ground water, based solely on the detected volatile organic chemicals would be less than 1.

5.1.4.3 Uncertainty Analysis

It should be noted that there are several sources of uncertainty in the risk calculations. These include uncertainties associated with:

- Exposure Scenarios
- Exposure Concentrations
- Reference Toxicity Values

The exposure scenarios used in this assessment are "standard" scenarios commonly used in baseline Superfund risk assessments. Although the scenarios used here are tailored as much as possible to the existing site-specific information, actual exposures could deviate from those calculated due to differences in exposure frequencies, contact rates, absorption efficiencies (dermal exposure), exposure durations, body weight, and life span. Most notably, estimates of dermal exposure should be viewed as tentative at best due to a general lack of reliable scientific information to quantify exposure via this route.

The exposure point concentrations used in this assessment are upper 95 percent confidence limits derived from analytical sampling data. Although these data meet Quality Assurance (QA) standards, they provide only a brief "snapshot" in time. Concentrations to which a person could be exposed over a lifetime could vary considerably from these values.

Another source of uncertainty in this assessment concerns the presence of metals in ground water. At this time, we have no information regarding the extent to which these metals are present due to well development or other non-site-related factors. We also do not know whether the chemicals detected in the downgradient monitoring wells have impacted any private wells. The estimates of ground-water risks presented in this assessment are based solely on the concentrations detected in the downgradient monitoring wells located on the site.

The reference toxicity values used in this assessment are the most current values approved by USEPA. It should be noted that reference toxicity values are not available for all compounds to which receptors could be exposed nor for all routes of exposure. In particular, the use of oral toxicity values in the estimation of dermal toxicity should be viewed with a great deal of uncertainty, due to the lack of scientific consensus regarding our ability to characterize dermal exposure. In this assessment, the lack of available toxicity values for dermal exposure to inorganics, and the lack of an oral slope factor for ingestion of arsenic in soils should be taken into consideration.

Generally, USEPA does not derive an SF for a chemical unless a dose-related statistically-significant increase in tumor incidence is observed in at least one strain or species of animal. None of the available oral studies with beryllium provide the sort of evidence USEPA generally requires for classification as a possible human carcinogen (Group C). However, since beryllium has been shown to be carcinogenic by other routes, it is believed potentially carcinogenic by the oral route. The SF of 4.3 $(mg/kg/day)^{-1}$ is based on a non-statistically significant increase in tumors observed in a single beryllium-exposed group of rats (IRIS, 1992). Given the questionable classification of beryllium as a carcinogen via oral exposure, the estimate of carcinogenic risks associated with ingestion of ground water may be over-estimated by a factor of five.

5.2 FISH AND WILDLIFE IMPACT ANALYSIS

This section has been prepared using the NYSDEC Fish and Wildlife Impact Analysis (FWIA) guidelines (NYSDEC, 1991a). By previous agreement, this FWIA addresses Steps I through Step 2A of the guidelines. The general ecological features of the site and adjacent areas described in this section include: 1) physical characteristics such as topography and land use; 2) identification of vegetative cover; 3) qualitative assessment of habitat value to wildlife; 4) identification of fish and wildlife species typical of the area; 5) identification of special resources including surface waters, wetlands, critical habitats, and threatened or endangered species; and 6) evaluation of potential pathways for exposure of resources to site-related chemicals.

Topographic and regional maps were initially referenced to identify the general physical and ecological features of the site and surrounding area. Information from the NYSDEC Natural Heritage Program database was also reviewed as part of the investigation. This information was field-verified and supplemented during a site visit conducted by a qualified environmental biologist of Blasland & Bouck Engineers on October 22, 1992.

5.2.1 Physical Characteristics: Site Topography and Land Use

The Hadco Site consists of approximately 17 acres of mostly flat to slightly sloping, primarily open land in a mixed commercial/industrial land use area. The site configuration is irregular with a narrowed width area separating two broader portions of the site (Figure 22). The northernmost section supports most of the developed areas of the site, while the southernmost section is relatively undeveloped. Approximately 55 percent of the site (i.e., 9.5 acres) is devoted to buildings, sidewalks, paved parking areas, and landscaped grounds. The remaining 45 percent of the site (i.e., 8 acres) is generally vegetated with native and naturally-growing woody and herbaceous plants. A paved entrance road runs south from Taylor Road along the eastern site perimeter and leads to the Town of Owego Wastewater Treatment facility (POTW) and what is known as the Broadway Building. The undeveloped portions of the site include the southwest tract of open fields, and a fringe of woods just west of the entrance road to the site (Figure 22). The areas close to the building and parking lots (i.e., within several hundred yards) are subject to landscape maintenance, and the vegetative cover consists of cultivated grasses and ornamental trees and shrubs.

There are residential homes, commercial businesses, agricultural fields, transportation routes, and other manufacturing facilities within a 0.5 mile radius of the site. Properties immediately adjacent to the site along Taylor Road (i.e. to the east, west and due north) support commercial and manufacturing businesses. The southern site perimeter is bounded by the Town of Owego POTW. Active agricultural fields are located immediately west of the undeveloped southwest tract. The off-site area immediately west of the Hadco building and parking lots and adjacent to Taylor Road consists of an abandoned farm field and barn.

5.2.2 Vegetative Covertype/Habitat Value Assessment

A list of vegetative species observed within 0.5 miles of the site or typical of the region is presented in Table 35. A list of wildlife species typical of the area is presented in Table 36. General covertypes and habitat values for areas within a 0.5 mile radius of the site are described on Figure 22.

The qualitative determination of habitat values relies on field observations, research, and professional judgement. Habitat values were assigned using an assumed range as follows:

- No Value: areas such as buildings and paved parking areas;
- Low and Moderate Value: areas with gradations of habitat quality from that marginally supporting a minimal number and diversity of low quality species, to that which supports a variety of quality species with little or no stress related to human disturbance;
- High Value: critical habitats for rare species and/or extensive undeveloped habitat supporting a great diversity and abundance of wildlife without functional constraints imposed by human disturbance.

The assessment of habitat value, vegetative covertype, and associated fish and wildlife species within 0.5 miles of the site is based on a single walkover of the site and adjacent areas completed on October 22, 1992, and thus reflects a "snapshot" evaluation. No on-site or off-site areas were observed to exhibit stressed vegetation or evidence of negative effects on wildlife.

5.2.2.1 On-site Developed Area

The on-site developed area of the site is defined as the northernmost half of the site which supports manufacturing activities and administrative functions. The manufacturing building and paved parking areas are the primary features of this portion of the site (Figure 22). The vegetated portion of the developed area consists of cultivated grasses/lawn, and ornamental trees and shrubs. This area is subject to landscape maintenance and routine human disturbance, and thus is considered to be of low habitat value. Paved/concrete areas such as the parking lots, sidewalks and the entrance road provide no habitat support or value (Figure 22). In general, the vegetation and habitat provided by the developed area of the site is probably best exploited by songbirds and a limited number and diversity of small mammals (i.e., woodchucks, rabbits).

5.2.2.2 On-site Undeveloped Area

The area referred to as the on-site undeveloped area consists of the southwest portion of the site. This area is best characterized as a fallow farm field. This area is vegetated with old-field type vegetation (i.e., successional grasses and weeds) with some small trees and shrubs. Vegetative growth is fairly dense (i.e., ground cover of approximately 90 percent). There is adequate food and cover for open meadow bird species and small mammals in the undeveloped area, and larger mammals such as white-tailed deer may also use this area. In general, the undeveloped portion of the site provides habitat of moderate value to wildlife since vegetation is of sufficient density and diversity to provide for a variety of birds and mammals.

5.2.2.3 Off-Site Areas

Off-site areas in the vicinity of the site offer a diversity of vegetative covertypes and relative values to wildlife which differ according to land use and habitat types. Some fairly extensive wooded and undeveloped areas exist within a 2-mile radius of the site, as well as hedgerows (which provide an opportunity for ecological edge effects) and wetland and surface water features. Surface waters and wetlands are discussed in detail in Sections 5.2.4.1 and 5.2.4.2, respectively, and are depicted on Figures 22 and 23.

East

Barnes Creek is within 100 yards east of the site, and the streambanks and fringe areas of the creek support a variety of woody and herbaceous plants. The vegetated streambank areas of Barnes Creek and the stream channel provide moderate value to wildlife. Crayfish and other benthic invertebrates are likely to reside in the creek and provide food for various wildlife species (e.g., birds, raccoons). The property east of Barnes Creek consists of a commercial plaza/bowling lanes and paved parking areas and provides no value to wildlife. Farther east is another extensive industrial manufacturing facility with an associated complex of buildings, roads, parking lots and landscaped areas which provide no to low habitat value. Some residential areas are located farther east of this facility from approximately 0.5 miles east of the Hadco site along Taylor Road/Bodle Hill Road and along Day Hollow Road which runs near Little Nanticoke Creek between Bodle Road and Route 17C (Figure 23). The acreage associated with these residences (e.g., 0.5+ acres) may provide low habitat value to wildlife.

South

The Town of Owego POTW property is located at the southern perimeter of the Hadco site, and a chainlink fence separates the properties. The vegetation in this area primarily consists of successional grasses and weeds and scrub shrubs. The area is routinely subject to human activities and provides low value to wildlife. An approximately 2-acre wooded area is located just south of the biological treatment plant. This area is vegetated with forest species (i.e., shagbark hickory) and supports a number of mature forest trees (e.g., heights over 80 feet). This area provides moderate habitat value. The Erie-Lackawanna railroad tracks are located farther south approximately 0.25 mile from the site. The area where the railroad tracks are located is generally not well-drained, and the railroad bed is raised above the level of the ground surface. Vegetation characteristic of wetland conditions is present at the base of the railroad bed and along Route 17C south of the site. The area immediately adjacent to the railroad tracks is fairly inaccessible to humans due to wet conditions and thus provides some undisturbed habitat for wildlife; however, the intermittent disturbance associated with railroad transportation likely has a negative impact on habitat use by various wildlife species. The area immediately adjacent to the railroad tracks is considered of low value to wildlife. Commercial businesses dominate the land use along Route 17C south of the Hadco facility and just south of the railroad tracks. This area has no value to wildlife other than to support low quality songbird species (i.e., house sparrow). The entrance to the Town of Owego's Hickories Park is located off Route 17C nearly one-mile south of the Hadco facility. The park consists of recreational areas, picnic shelters, mowed fields and playgrounds. Some wooded areas are located within the park which overall provides low to moderate value to wildlife. Barnes Creek is tributary to Little Nanticoke Creek just upstream of its confluence with the Susquehanna River within the park boundaries. Shoreline fishing access to the Susquehanna River is readily available within the park. As the largest surface water system in the region, the Susquehanna River provides moderate habitat value for fish and wildlife.

West

Agricultural crop fields (i.e., cornfields) are located immediately west of the undeveloped southwest tract of the site. These fields provide low value to wildlife due to active agricultural practices (i.e., tilling, plowing, planting and harvesting) during the growing season, and the lack of vegetative diversity. Wildlife species may derive benefit from this area through consumption of unharvested corn during the winter months, but this land probably does not consistently provide valuable habitat for wildlife on a year-round basis. The off-site area immediately west of the Hadco building and parking lots and adjacent to Taylor Road consists of an abandoned farm field and barn. This area is mostly vegetated with successional grasses and weed species and provides low to moderate value to wildlife. Farther west along Taylor Road towards the City of Owego are commercial establishments and some private residences. Davis Road runs north from Taylor Road and supports some residential development which has low to moderate habitat value. The approximately 20+ acre Brick Pond Wetlands Wildlife Sanctuary is located within 2 miles west of the site and is administered by the Waterman Conservation Education Center of Apalachin, New York (Figure 23). This area may attract migratory waterfowl and currently supports a beaver population. Although this area is fairly close to the urban areas of Owego (i.e., within 0.25 mile) it provides moderate value to wildlife and is part of a NYSDEC-regulated wetland.

North

The area immediately north of the Hadco site along Taylor Road supports an administration building for another industrial manufacturing facility, and just to the northeast along Taylor Road is a church and an electrical power substation. Barnes Creek Road is north of Taylor Road just east of these landmarks. Barnes Creek Road does not provide through access, and much of the land along the road is undeveloped. The headwaters of Barnes Creek are located at the topographic divide north of the upper end of Barnes Creek Road. Barnes Creek flows south down the steep slope just west of Barnes Creek Road. The hillslope drainage area for Barnes Creek is heavily forested and provides a moderate degree of value to wildlife. Deer and forest birds are likely to find adequate habitat in this area. The area along Barnes Creek Road and Barnes Creek provides moderate value to wildlife. Ivory Foster Road is accessed off Barnes Creek Road and runs to the east roughly parallel to Bodle Hill Road. Much of this area is devoted to residential development (i.e., subdivision), although a large private recreational park/picnic grounds are located in this area, and extensive wooded areas fringe the northern portion of the park. A NYSDEC-regulated wetland is located east of the park, and open fields and woodlands are fairly extensive along the eastern sections of Ivory Foster Road. In general, the area provides low to moderate habitat value for wildlife.

5.2.3 Wildlife Species/Habitat Value Summary

A list of wildlife species typical of the area is presented in Table 36. No threatened/endangered wildlife species or significant habitats have been documented in the general vicinity of the site by NYSDEC (1992a).

In general, the wildlife species inhabiting or utilizing the site are likely to consist of common species which are typical of upstate New York. Eastern cottontail rabbits and woodchucks have been observed within the site boundaries, and the on-site habitat probably supports a number of other small mammals (e.g., mice, voles). Larger mammals such as white-tailed deer may sometimes utilize the site habitat. Birds are the most prolific group of wildlife at the site.

Based on the vegetative characteristics of the site, the percentage of developed land at the site, and general land use characteristics of the surrounding area, Blasland & Bouck scientists have determined that the site offers low value as wildlife habitat. The degree of man-made on-site physical disturbance and lack of continuous quality habitat in adjacent areas restrict the extent of wildlife use. Results of the qualitative assessment of the value of the site habitat and that of the surrounding area to wildlife are presented on Figure 22.

5.2.4 Identification of Significant Natural Resources

Significant natural resources for purposes of this report include surface waters, wetlands, and rare species/critical habitats within a 2-mile radius of the site and along Barnes Creek, Little Nanticoke Creek, and the Susquehanna River.

5.2.4.1 Surface Waters

The north slope drainage area of the Susquehanna River which encompasses the Hadco site contains the following tributary streams within a 2-mile radius of the site: Barnes Creek, Little Nanticoke

Creek, Huntington Creek and the Susquehanna River. Pumpelly Creek is located within 2 miles of the site but is across the Susquehanna River and drains another upland area. Barnes Creek is the closest surface water to the site and is within 100 yards of the eastern site perimeter. The average width of Barnes Creek in the site vicinity is approximately 4 feet. The channel banks slope down approximately 8-10 feet in the site vicinity, and the substrate is comprised of rocks and gravel. Much vegetation (e.g., branches, trees, and tree roots) is located within the stream channel forming knickpoints and divergent channel flows. Barnes Creek is tributary to Little Nanticoke Creek just upstream of the confluence of Little Nanticoke Creek with the Susquehanna River. As a hillslope drainage stream, Barnes Creek is subject to much seasonal variation in streamflow regimen, and discharge reflects precipitation events in the reach near the site. The NYSDEC best usage classification for Barnes Creek in the reach adjacent to the site, downstream to the mouth at Little Nanticoke Creek, and upstream to Pond 19 (Figure 23) is Class C (NYSDEC, 1992b). According to NYSDEC (1991b), the best usage of Class C waters is fishing. NYSDEC (1991b) also states that "the water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes." The stream is designated Class A upstream of Pond 19 to the headwaters (NYSDEC, 1992b). According to NYSDEC (1991b) the best usages of Class A waters "are: a source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing." NYSDEC (1991b) also states that "the waters shall be suitable for fish propagation and survival" and that "if subjected to approved treatment equal to coagulation, sedimentation, filtration and disinfection, with additional treatment if necessary to reduce naturally present impurities, meet or will meet New York State Department of Health drinking water standards and are or will be considered safe and satisfactory for drinking water purposes."

Little Nanticoke Creek is tributary to the Susquehanna River within the boundaries of the Town of Owego's Hickories Park. Little Nanticoke Creek derives streamflow from hillslope drainage northeast of the Hadco site, and the reach in closest proximity to the site is within approximately 0.75 mile to the southeast. The upper reaches of Little Nanticoke Creek are roughly parallel to the upper reaches of Barnes Creek as their drainage patterns follow topographic divides. The NYSDEC best usage classification for Little Nanticoke Creek throughout its entire length is Class C (NYSDEC, 1992b). According to NYSDEC (1991b) the best usage of Class C waters is fishing. NYSDEC (1991b) also states that, "the water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes." Huntington Creek is approximately one mile from the Hadco site. Huntington Creek flows to the west and is tributary to Owego Creek in the Susquehanna River basin. The NYSDEC best usage classification for Huntington Creek is also Class C (NYSDEC, 1992b).

The Susquehanna River is within approximately one mile of the site and drains an area of approximately 4,200 square miles in the reach near Owego (USGS, 1992). The NYSDEC best usage classification for the Susquehanna River within a 2-mile radius of the site (including the reach south of the site into which Little Nanticoke Creek drains) is Class B (NYSDEC, 1992b). The Class B designation applies to the river channel from the Tioga-Broome County boundary line downstream (i.e., west) to the eastern boundary of the Town of Owego (Figure 23). The best usage classification for the Susquehanna River changes to Class C from the eastern boundary of the Town of Owego to 3 miles downstream of the western boundary of the Town of Owego. Downstream of the western edge of Owego the classification becomes Class B again. According to NYSDEC (1991b) the best usages of Class B waters are "primary and secondary contact recreation and fishing." NYSDEC (1991b) also states that, "these waters shall be suitable for fish propagation and survival." The Susquehanna River supports fishing and provides other recreational opportunities in the Owego area.

5.2.4.2 Wetlands

The location of wetlands in the vicinity of the site have been determined on the basis of USGS topographic quadrangle maps, NYSDEC Freshwater Wetland Maps, and a field visit to the area. Wetland areas are indicated on Figures 22 and 23. No areas of the site are considered regulated wetlands or adjacent areas according to (NYSDEC (1992c). The Brick Pond Wetlands Wildlife Sanctuary is located within 2 miles west of the site between Taylor Road and the Erie-Lackawanna Railroad tracks and is administered by the Waterman Conservation Education Center of Apalachin, New York (Figure 22). This area has a large (e.g., approximately 15 acre) open water component and is part of NYSDEC-regulated Class II wetland #A-2 (NYSDEC, 1992c). The only other NYSDEC-regulated wetland within a 2-mile radius of the site is Class II wetland #A-1 (NYSDEC, 1992c) which is located north of Ivory Foster Road to the northeast of the Hadco site (Figure 23). Other wetland areas within a 2-mile radius of the site are associated with freshwater streams, ponds, and the

Susquehanna River (Figure 23), but are not NYSDEC-regulated wetlands.

The NYSDEC wetland classification system ranks wetland areas based primarily on the presence of certain plant species. Wetland classifications range from Class I (significant wetlands and most restrictive towards modifications) to Class IV (less significant and least restrictive towards modifications). The NYSDEC-regulated wetlands in the vicinity of the site are designated as Class II wetlands (NYSDEC, 1992c).

5.2.4.3 Threatened/Endangered Species/Critical Habitats

Information provided by the NYSDEC Significant Habitat Unit and Natural Heritage Program (NYSDEC, 1992a) indicate that no "endangered, threatened or special concern wildlife species, rare plant, animal or natural community occurrences, or other significant habitats" are identified in the vicinity of the site (i.e, within a 2-mile radius).

5.2.5 Current and Future Potential Use of Fish and Wildlife Resources by Humans

The current potential uses of fish and wildlife resources by humans in the vicinity of the site are likely to remain consistent in the future. Current human use includes small game and deer hunting, fishing along the Susquehanna River, hiking, and wildlife observation. These uses are associated with moderately high resource values and are not likely to be impacted by site-related conditions. Agricultural and forestry practices in the vicinity of the site are not likely to be affected by activities or conditions at the site.

5.2.6 Potential Exposure Pathway Analysis

The potential exposure of natural resources, especially fish and wildlife, to site-related chemicals is addressed in this section. Natural resources are evaluated in this section according to the following categories: vegetation, birds, mammals, and aquatic biota (including fish). The pathway analysis is based on the presence of site-related chemicals in environmental media, the potential migration of these chemicals, and field observations of site conditions.

Fish and wildlife resources may potentially be exposed to site-related chemicals in ground water, soils, and the area surface waters downgradient of the site (i.e., Barnes Creek, Little Nanticoke Creek and the Susquehanna River). The potential routes of exposure to site-related chemicals for fish and wildlife resources are: inhalation, ingestion, and direct dermal contact. A summary of potential exposure routes and exposure pathways is presented in Table 37.

Air is not considered a significant potential exposure pathway because no volatile organic chemicals were detected in breathing zone air during sampling activities at the site. The potential for ecological receptor exposure to ground water is also considered insignificant because access to ground water is constrained by a lack of surface discharges or seeps in the immediate site vicinity. There is a low potential for contact with site-related chemicals in soils at the site because these chemicals are at subsurface locations (i.e., underlying buildings and paved parking lots); however, soils at the site are a potential source of chemicals in ground water and thus, possibly a source of chemicals in receiving surface waters in the area. The potential for exposure for birds and mammals to chemicals in ground water, air and soils are considered to provide low potentials for exposure, and surface waters are considered to provide moderate potentials for exposure (Table 37).

5.2.7 Criteria-Specific Analysis

The criteria-specific analysis requires the use of numerical criteria for chemical constituents associated with specific media or biota (NYSDEC, 1991a). If chemical concentrations are below criteria, impacts on the resource are considered minimal (NYSDEC, 1991a). Since surface waters generally serve as intermediate or ultimate repositories for a variety of compounds, and the potential for transport of site-related chemicals from soils and ground water exists, results of Barnes creek surface water analyses are compared to NYSDEC Ambient Water Quality Criteria (Table 38) to determine if site-related chemicals may result in adverse ecological impacts.

As shown in Table 38, maximum detected concentrations of site-related chemicals do not exceed any available NYSDEC Ambient Water Quality Criteria for Aquatic Toxicity (NYSDEC, 1991c). With regard to TCE, a primary chemical of interest at the facility, all observed concentrations of TCE in Barnes Creek are below the method quantification limit. It should be noted that the results of analyses of surface water samples collected from Barnes Creek in areas adjacent to and downstream of the Hadco facility are generally consistent with the concentrations observed in samples collected upstream of the site. The presence of TCE in the background sample (i.e., from upstream of the site) indicates an upstream off-site source of the TCE in Barnes Creek, and analytical results do not indicate any contribution of TCE to the creek from the Hadco site.

SECTION 6 - CONCLUSIONS

6.1 General

This section presents the conclusions relevant to the objectives of this investigation as derived from the data generated by this and previous investigations. The following conclusions are presented according to the investigation objectives that they address.

6.2 Conclusions Regarding Potential Source Areas

The following conclusions have been developed based on the available data regarding the potential on-site and off-site sources of the constituents observed in the subsurface at this site:

1. The principle source of the VOCs observed in the subsurface at this site appears to be the former chemical storage area. While the horizontal extent of the residual soil contamination in this area has been shown to be limited to the north, west, and south, the extent of residual contamination toward the east has yet to be determined.
2. The former Robintech septic leach field, that was also identified as a potential source area, does not appear to be acting as a source of constituents to the subsurface.
3. Dissolved TCE continues to be observed in the overburden groundwater monitoring wells located upgradient of the Hadco facility. This demonstrates that an off-site source of dissolved TCE exists upgradient of the Hadco site. The apparent contribution of this off-site source is relatively small in comparison to the concentrations of TCE and other organics observed emanating from the vicinity of the former chemical storage area.

4. Although VOCs were previously demonstrated to be present in the septic system of the Broadway Building located immediately east of the site, this investigation does not provide an adequate basis for evaluating the relative contributions of dissolved constituents from this source area to the ground water underlying the Hadco site.
5. The presence of chromium and copper concentrations above background levels in the soil samples from the former chemical storage area suggests that this area may act as a contributing source of dissolved chromium and copper observed in ground water downgradient of the area.
6. The analytical results of the soil samples collected to evaluate potential sources of the dissolved inorganics observed in wells MW-3, MW-7, and MW-11 did not indicate the presence of a source area in the vicinity of these wells.

6.3 Conclusions Regarding Ground-Water Quality

The following conclusions are related to the investigation objectives regarding ground-water quality issues:

1. The nature of the dissolved constituents in the ground water underlying the Hadco site appears to include a number of halogenated volatile organic compounds (principally TCE, TCA, and DCE) and several aromatic hydrocarbons (including toluene, ethylbenzene, and xylenes).
2. Several inorganic constituents (including chromium, copper, lead, and zinc) were identified in ground-water samples at concentrations which exceed their respective NYS Guidance Values by an order of magnitude or more, and which are not indicative of background conditions. The presence of chromium and copper in the soil of

the former chemical storage area suggest this area is a contributing source of these inorganic constituents in ground water. The source(s) of the other inorganics not attributable to background conditions has not been identified.

3. The horizontal distribution of the dissolved VOCs observed in the shallow overburden aquifer extends the length of the site. The concentrations observed in the upgradient wells were consistently low. The highest concentrations of VOCs were observed immediately downgradient of the former chemical storage area. These high concentrations were observed to attenuate downgradient of the source area.
4. The analytical results of the ground-water samples show that dissolved VOCs have migrated vertically into the deeper zones of the overburden aquifer. The concentrations observed in the deep overburden wells near the former chemical storage area may suggest the movement of DNAPLs through the subsurface in this vicinity.
5. The analytical results of the ground-water samples from the new off-site well clusters located downgradient of the site show the attenuation of the dissolved constituents of concern to relatively low concentrations.
6. The results of the initial RI data suggested the impact to ground water in the bedrock downgradient of the site was limited to only low concentrations of volatile organic compounds, however, increased concentration of VOC were observed in the bedrock well at the downgradient property boundary in August/September 1992.

6.4 Conclusions Regarding Surface Water Quality

The results of the surface water investigation activities implemented as part of the RI support the following conclusions:

1. The analytical results of the surface water samples show no indication of any adverse impacts to the Barnes Creek from the Hadco site. However, the upstream water samples did indicate the presence of trace concentrations of TCE from some upstream source.
2. The results of both the volatile organic and inorganic analyses performed on the sediment samples collected from Barnes Creek also showed no indication of adverse impacts associated with the site.

Respectfully Submitted;

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HADCO CORPORATION
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TABLE 1

SUMMARY OF WELL CONSTRUCTION DETAILS

HADCO CORPORATION
OWEGO, NEW YORK

WELL NO.	GROUND ELEV.	TOP OF WELL ELEV.	TOP OF PROTECTIVE CASING ELEV.	TOTAL DEPTH OF WELL	WELL COMPLETION	MONITORED ZONE	CASING MATERIAL	WELL DIAMETER (INCHES)	SCREEN SLOT SIZE (INCHES)	SCREEN INTERVAL BGS
MW-1	841.62	--	842.22	25	Stickup	Outwash	Steel	4	0.01	15.0 to 25.0
MW-2	--	841.13	841.78	25	Flush mount	Outwash	Steel	4	0.01	17.33 to 27.33
MW-3	850.64	--	853.80	22	Stickup	Ow/Till	Steel	4	0.015	11.8 to 21.8
MW-4	--	855.11	855.27	39.5	Flush mount	Outwash	Steel	4	0.015	9.5 to 39.5
MW-5	846.28	--	845.75	21	Flush mount	Outwash	Steel	4	--	10.5 to 15.5
MW-6	841.49	--	841.25	56	Flush mount	Outwash	Steel	4	--	10.5 to 30.5
MW-7	840.7	--	843.43	41.5	Stickup	Outwash	Steel	4	--	17.0 to 37.0
MW-8	827.42	--	830.07	46.5	Stickup	Outwash	Steel	4	--	7.0 to 17.0
MW-9	--	857.75	857.97	33.5	Stickup	Outwash	Fiberglass	2	0.01	21.5 to 33.5
MW-10	--	845.68	845.88	40	Flush mount	Outwash	Fiberglass	2	0.01	28.0 to 40.0
MW-11	--	821.33	821.56	70	Stickup	Outwash	Fiberglass	2	0.01	8.5 to 20.5
MW-12	--	844.59	844.77	27	Flush mount	Till	Fiberglass	2	0.01	18.0 to 30.0
MW-13	--	840.81	840.86	52	Stickup	Outwash	Fiberglass	2	0.01	32.0 to 43.0
MW-14	--	827.65	827.89	62	Stickup	Outwash	Fiberglass	2	0.01	31.0 to 43.0
MW-15	--	822.03	822.81	52	Stickup	Outwash	Fiberglass	2	0.01	31.0 to 43.0
MW-17	--	840.38	--	86.5	Flush mount	Bedrock	Steel	4	Open hole	73.0 to 86.5
MW-18	--	829.35	829.53	73	Stickup	Outwash	PVC	2	0.01	67.2 to 72.2
MW-19	--	841.26	841.57	20	Flush mount	Outwash	PVC	2	0.01	9.5 to 19.5
MW-20	--	--	829.41	98.8	Stickup	Bedrock	Steel	4	Open hole	78.8 to 98.8
MW-21	--	854.85	855.00	66.5	Stickup	Bedrock	Steel	4	Open hole	46.5 to 66.5
MW-22	--	819.39	821.14	116.8	Stickup	Bedrock	Steel	4	Open hole	96.5 to 116.8

TABLE 1
(Cont'd.)

SUMMARY OF WELL CONSTRUCTION DETAILS

HADCO CORPORATION
OWEGO, NEW YORK

WELL NO.	GROUND ELEV.	TOP OF WELL ELEV.	TOP OF PROTECTIVE CASING ELEV.	TOTAL DEPTH OF WELL	WELL COMPLETION	MONITORED ZONE	CASING MATERIAL	WELL DIAMETER (INCHES)	SCREEN SLOT SIZE (INCHES)	SCREEN INTERVAL BGS
MW-23	--	841.32	841.61	35	Flush mount	Ow/Till	PVC	4	0.01	30.0 to 35.0
MW-24	--	840.65	840.89	56	Flush mount	Outwash	PVC	4	0.01	49.5 to 54.5
MW-25	--	837.67	837.84	20	Stickup	Outwash	PVC	2	0.01	5.0 to 15.0
MW-26	--	837.73	837.91	62	Stickup	Outwash	PVC	2	0.01	57.0 to 62.0
MW-27	--	840.96	841.28	53	Flush mount	Ow/Till	PVC	4	0.01	47.5 to 52.5
MW-28	--	837.91	837.91	115	Stickup	Bedrock	Steel	4	Open hole	75.0 to 115.0
MW-29	818.8	820.63	820.86	87	Stickup	Outwash	PVC	4	0.02	82.0 to 87.0
MW-30	813.2	815.13	815.36	95	Stickup	Outwash	PVC	2	0.01	90.0 to 95.0
MW-31	813.3	815.25	815.42	13	Stickup	Outwash	PVC	2	0.01	3.0 to 13.0
MW-32	814.7	816.17	816.41	95	Stickup	Outwash	PVC	2	0.01	90.0 to 95.0
MW-33	814.4	815.77	816.03	14	Stickup	Outwash	PVC	2	0.01	4.0 to 14.0
PW-1	--	842.09	--	34	Stickup	Outwash	Steel	4	0.02	24.0 to 34.0
PW-2	--	839.71	--	45	Flush mount	Outwash	Fiberglass	4	0.02	20.0 to 40.0
PW-3	837.24	836.96	837.24	69	Flush mount	Outwash	PVC	4	0.02	54.0 to 69.0

Notes:
N/A = Not applicable.
-- = Data not available.
All measurements are reported in feet except where otherwise indicated.
Elevation in feet above mean sea level based on NGS.
BGS = Below Ground Surface.

TABLE 2

SUMMARY OF GROUND−WATER ELEVATION DATA

HADCO CORPORATION
OWEGO, NEW YORK

Well I.D.	Water Bearing Zone Monitored	Reference Elevation*	10/30/91		8/31/92		10/21/92	
			Depth to Water	Ground Water Elevation	Depth to Water	Ground Water Elevation	Depth to Water	Ground Water Elevation
MW−1	Shallow Overburden	842.22	7.69	834.53	−−−	−−−	9.66	832.56
MW−2	Shallow Overburden	841.13	11.53	829.60	−−−	−−−	10.25	830.88
MW−3	Shallow Overburden	853.80	16.29	837.51	15.44	838.36	14.63	839.17
MW−4	Shallow Overburden	855.11	14.26	840.85	13.55	841.56	12.93	842.18
MW−5	Shallow Overburden	848.75	7.74	841.01	−−−	−−−	6.90	841.85
MW−6	Shallow Overburden	841.25	9.66	831.59	−−−	−−−	8.33	832.92
MW−7	Shallow Overburden	843.43	14.75	828.68	14.82	828.61	13.53	829.90
MW−8	Shallow Overburden	830.07	16.24	813.83	12.46	817.61	12.30	817.77
MW−9	Shallow Overburden	857.75	20.40	837.35	19.02	838.73	18.25	839.50
MW−10	Shallow Overburden	845.68	8.36	837.32	−−−	−−−	7.67	838.01
MW−11	Shallow Overburden	821.33	19.08	802.25	12.35	808.98	10.25	811.08
MW−12	Shallow Overburden	844.59	7.90	836.69	−−−	−−−	8.06	836.53
MW−13	Shallow Overburden	840.81	21.88	818.93	18.69	822.12	18.79	822.02
MW−14	Deep Overburden	827.65	16.21	811.44	11.70	815.95	11.50	816.15
MW−15	Deep Overburden	822.03	23.73	798.30	18.83	803.20	18.00	804.03
MW−17	Bedrock	840.38	9.88	830.50	8.88	831.50	8.49	831.89
MW−18	Deep Overburden	829.35	13.94	815.41	10.59	818.76	10.53	818.82
MW−19	Shallow Overburden	841.26	9.12	832.14	6.89	834.37	6.67	834.59
MW−20	Bedrock	829.41	14.35	815.06	10.80	818.61	10.55	818.86
MW−21	Bedrock	854.85	16.65	838.20	14.30	840.55	13.96	840.89
MW−22	Bedrock	819.39	22.55	796.84	19.46	799.93	17.70	801.69
MW−23	Deep Overburden	841.32	8.31	833.01	7.29	834.03	7.06	834.26
MW−24	Deep Overburden	840.65	9.84	830.81	9.00	831.65	8.75	831.90
MW−25	Shallow Overburden	837.67	12.33	825.34	11.67	826.00	11.57	826.10
MW−26	Deep Overburden	837.73	13.67	824.06	12.53	825.20	12.45	825.28
MW−27	Deep Overburden	840.96	9.40	831.56	8.42	832.54	8.25	832.71
MW−28	Bedrock	837.91	88.38	749.53	−−−	−−−	37.05	800.86
MW−29	Deep Overburden	NI	NI	NI	19.20	NI	18.70	801.93
MW−30	Deep Overburden	NI	NI	NI	23.42	NI	22.14	792.99
MW−31	Shallow Overburden	NI	NI	NI	7.84	NI	6.95	808.30
MW−32	Deep Overburden	NI	NI	NI	17.20	NI	16.68	799.49
MW−33	Shallow Overburden	NI	NI	NI	7.31	NI	6.40	809.37
PW−1	Overburden	842.09	11.52	830.57	−−−	−−−	10.73	831.36
PW−2	Overburden	839.71	−−−	−−−	−−−	−−−	−−−	−−−
PW−3	Deep Overburden	NI	−−−	−−−	11.69	NI	11.60	825.36

Notes:
* = Elevations are referenced to plant datum.
−−− = Depth to water not recorded; ground−water evaluation not calculated.
NI = Well not installed at time of measurement.

TABLE 3

SUMMARY OF SOIL BORINGS ANALYTICAL RESULTS – INORGANICS

HADCO CORPORATION
OWEGO, NEW YORK

SAMPLE I.D. (sample depth)	HB–1 (6 to 8 ft.)	HB–2 (4 to 6 ft.)	HB–3 (6 to 8 ft.)	HB–4 (4 to 6 ft.)	HBW–1 (6 to 8 ft.)	HBW–2 (6 to 8 ft.)
Analyte						
Aluminum	15500	13000	12800	15500	6140	14100
Antimony	1.1 U	1.1 U	1.1 U	1 U	0.96 U	1.1 U
Arsenic	27	11	5.8	13.2	3.1	1.1 U
Beryllium	1.1 U	1 U	1.1 U	1.1 U	0.95 U	1.1 U
Cobalt	19.5	13.9	11.5 U	16.2	9.5 U	12.5
Cadmium	1.1 U	1 U	1.1 U	1.1 U	0.95 U	1.1 U
Chromium	146	139	123	30.9	13.3	198
Copper	283	973	327	37	81.5	964
Iron	40600	35300	33500	37900	16300	36100
Lead	45.4	315	73.8	24.5	13.1	27.4
Magnesium	5530	4090	4700	4940	9640	5240
Manganese	1000	717	464	769	427	412
Mercury	0.09 U	0.1 U	0.1 U	0.09 U	0.09 U	0.1 U
Nickel	60.7	52.6	50.1	46.1	21.3	48.7
Selenium	1.1 U	1.1 U	1.1 U	1 U	0.96 U	1.1 U
Silver	9	6.9	6.4	3.6	13.7	10.4
Sodium	142 B	96.9 B	134 B	86.8 B	189 B	276 B
Thallium	1.1 U	1.1 U	1.1 U	1 U	0.96 U	1.1 U
Vanadium	20.9	15.8	19.7	19.1	7.2 B	17.6
Zinc (total)	87.8	76.6	75.6	74.8	54.2	78.9

Notes:
All concentrations reported in mg/kg, dry weight (ppm).
B = Compound determined to be present in the blanks as well as in the sample.
U = Compound was analyzed for but not detected.

TABLE 4

SUMMARY OF SOURCE AREA SOIL BORING ANALYTICAL RESULTS – INORGANICS

HADCO CORPORATION
OWEGO, NEW YORK

SAMPLE ID	CRB-1	CRB-2	CRB-3	CRB-4	CRB-5	CRB-6	CRB-7	CRB-8	CRB-9	CRB-10	CRB-11	CRB-12
(SAMPLE DEPTH)	(7 to 8 ft.)	(7 to 8 ft.)	(7 to 8 ft.)	(5 to 6 ft.)	(6 to 7 ft.)	(7 to 8 ft.)	(3 to 4 ft.)	(8 to 9 ft.)	(6 to 7ft.)	(6 to 7ft.)	(6 to 7ft.)	(7 to 8ft.)
Analyte												
Beryllium	1.1 U	1.1 U	1.1 U	1.0 U	1.2 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Chromium	485	220	1,560	51.3	886	169	46.7	810	2,130	712	980	432
Copper	290	257	410	172	374	490	775	2,680	415	170	1,450	141
Lead	255	50.7	97.9	120	2,050	68.7	184	81.8	49.4	256	34.7	41.3
Zinc	20.6	73.5	56.7	61.2	41.4	70.2	21.5	71.3	61.6	21.7	58.4	78.3

Notes:
All concentrations reported in mg/kg, dry weight (ppm).
U = Compound was analyzed for but not detected at the detection limit indicated.

TABLE 5

SUMMARY OF ISOLATED AREAS SOIL SAMPLE ANALYTICAL RESULTS – INORGANICS

HADCO CORPORATION
OWEGO, NEW YORK

WELL NUMBER:	MW–3	MW–3	MW–3	MW–3	MW–3	MW–3	MW–7	MW–7	MW–7
DIRECTION:	NORTH	NORTH	S. EAST	S. EAST	S. WEST	S. WEST	NORTH	NORTH	SOUTH
DEPTH (FEET):	(0 – 0.5)	(1 – 2)	(0 – 0.5)	(1 – 2)	(0 – 0.5)	(1 – 2)	(0 – 0.5)	(1 – 2)	(0 – 0.5)
<u>ANALYTE</u>									
Beryllium	1.1 U	1.1 U	1.2 U	1.2 U	1.1 U	1.1 U	1.0 U	1.0 U	1.1 U
Chromium	15.5	18.0	12.5	10.1	17.3	16.0	14.7	13.3	16.5
Copper	27.9	33.3	22.1	18.6	25.5	30.3	26.8	28.3	47.3
Lead	22.8	24.4	29.6	15.5	42.8	60.1	30.8	42.2	23.8
Zinc	82.8	79.0	65.9	54.5	159	85.5	69.3	73.8	80.0

WELL NUMBER:	MW–7	MW–7	MW–7	MW–11	MW–11	MW–11	MW–11	MW–11	MW–11
DIRECTION:	SOUTH	EAST	EAST	NORTH	NORTH	S. EAST	S. EAST	S. WEST	S. WEST
DEPTH (FEET):	(1 – 2)	(0 – 0.5)	(1 – 2)	(0 – 0.5)	(1 – 2)	(0 – 0.5)	(1 – 2)	(0 – 0.5)	(1 – 2)
<u>ANALYTE</u>									
Beryllium	1.1 U	1.1 U	1.1 U	1.2 U	1.2 U	1.2 U	1.2 U	1.1 U	1.1 U
Chromium	17.7	12.5	16.0	17.6	17.9	15.1	14.7	14.1	18.0
Copper	44.4	28.1	32.4	27.1	24.6	28.4	25.9	19.4	19.3
Lead	24.5	19.4	18.8	45.7	19.9	29.4	30.1	45.1	35.8
Zinc	81.2	66.1	77.1	93.2	84.0	105	89.4	68.5	66.4

Notes:
All concentrations reported in mg/kg (ppm), dry weight.
U – Compound was analyzed for but not detected at the detection limit indicated.

TABLE 6

SUMMARY OF SOIL BORINGS ANALYTICAL RESULTS – VOLATILE ORGANICS

HADCO CORPORATION
OWEGO, NEW YORK

SAMPLE ID (sample depth)	HB-1 (6 to 8 ft.)	HB-2 (4 to 6 ft.)	HB-3 (6 to 8 ft.)	HB-4 (4 to 6 ft.)	HBW-1 (6 to 8 ft.)	HBW-2 (6 to 8 ft.)
<u>Compound</u>						
Acetone	--	--	89	14	7 J	--
Benzene	--	--	--	--	--	--
Bromomethane	--	--	--	--	--	--
Bromodichloromethane	--	--	--	--	--	--
Bromoform	--	--	--	--	--	--
2-Butane	--	--	--	--	--	--
Carbon disulfide	--	--	--	--	--	--
Carbon tetrachloride	--	--	--	--	--	--
Chlorobenzene	--	--	--	--	--	--
Chloroethane	--	--	--	--	--	--
Chloroform	--	--	--	--	--	--
Chloromethane	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--
1,1-Dichloroethane	--	--	--	--	--	--
1,2-Dichloroethane	--	--	43	--	--	--
1,2-Dichloroethane (total)	--	--	--	--	--	--
1,1-Dichloroethene	--	--	--	--	--	--
1,2-Dichloropropane	--	--	--	--	--	--
cis-1,3-Dichloropropene	--	--	--	--	--	--
trans-1,3-Dichloropropen	--	--	--	--	--	--
Ethyl benzene	--	--	3 J	--	--	--
2-Hexanone	--	--	--	--	--	--
Methylene chloride	--	--	0.9 J	--	--	--
4-Methyl-2-pentanone	--	--	--	--	--	--
Styrene	--	--	--	--	--	--
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--
Tetrachloroethene	--	--	58	--	--	--
Toluene	--	--	26	--	1 J	--
1,1,1-Trichloroethane	--	--	3 J	--	--	--
1,1,2-Trichloroethane	--	--	--	--	--	--
Trichloroethene	9	5 J	440 D	2 J	2 J	8
Vinyl acetate	--	--	--	--	--	--
Vinyl chloride	--	--	--	--	--	--
Xylene (total)	--	--	18	--	--	--

<u>Notes:</u>

All concentrations reported in ug/kg, dry weight (ppb).

B = Compound determined to be present in the blanks as well as in the sample.

U = Compound was analyzed for but not detected.

J = Estimated value; concentration less than quantitation limit but greater than zero.

D = Compounds identified at a secondary dilution factor.

-- = Not detected.

TABLE 7

SUMMARY OF SOURCE AREA SOIL BORING ANALYTICAL RESULTS – VOLATILE ORGANICS

HADCO CORPORATION
OWEGO, NEW YORK

SAMPLE ID (SAMPLE DEPTH)	CRB–1 (7 to 8 ft.)	CRB–2 (7 to 8 ft.)	CRB–3 (7 to 8 ft.)	CRB–4 (5 to 6 ft.)	CRB–5 (6 to 7 ft.)	CRB–6 (7 to 8 ft.)	CRB–7 (3 to 4 ft.)	CRB–8 (8 to 9 ft.)	CRB–9 (6 to 7ft.)	CRB–10 (6 to 7ft.)	CRB–11 (6 to 7ft.)	CRB–12 (7 to 8ft.)
<u>Compound</u>												
Acetone	--	--	54	18	--	--	--	18	--	6 J	14	13
Benzene	--	--	--	--	--	--	--	--	--	--	--	--
Bromomethane	--	--	--	--	--	--	--	--	--	--	--	--
Bromodichloromethane	--	--	--	--	--	--	--	--	--	--	--	--
Bromoform	--	--	--	--	--	--	--	--	--	--	--	--
2–Butanone	--	--	11	13	--	--	--	--	--	--	--	--
Carbon Disulfide	--	--	--	--	--	--	--	--	--	--	--	--
Carbon Tetrachloride	--	--	--	--	--	--	--	--	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--	--	--	--	--	--
Chloroethane	--	--	--	--	--	--	--	--	--	--	--	--
Chloroform	--	--	--	--	--	--	--	--	--	--	--	--
Chloromethane	--	--	--	--	--	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--	--	--	--	--	--	--
1,1–Dichloroethane	--	--	--	--	--	--	--	2 J	--	--	--	--
1,2–Dichloroethane	--	--	--	--	--	--	--	--	--	--	--	--
1,1–Dichloroethene	43,000 J	--	--	--	45,000 J	--	--	--	--	--	--	--
1,2–Dichloroethene (total)	--	49 BJ	4 J	--	--	--	--	31	--	--	--	2 J
1,2–Dichloropropane	--	--	--	--	--	--	--	--	--	--	--	--
cis–1,3–Dichloropropene	--	--	--	--	--	--	--	--	--	--	--	--
trans–1,3–Dichloropropene	--	--	--	--	--	--	--	--	--	--	--	--
Ethylbenzene	--	--	--	--	--	--	--	--	--	--	--	--
2–Hexanone	--	--	--	9	--	--	--	--	--	--	--	--
Methylene Chloride	21,000 BJ	100 BJ	2 BJ	2 BJ	22,000 BJ	740 BJ	2 BJ	2 BJ	83 BJ	2 BJ	2 BJ	2 BJ
4–Methyl–2–Pentanone	--	--	--	8	--	--	--	--	--	--	--	--
Styrene	--	--	--	--	--	--	--	--	--	--	--	--
1,1,2,2–Tetrachloroethane	--	--	--	1	--	--	--	--	--	--	--	--
Tetrachloroethene	110,000 J	190 J	--	--	31,000 J	--	--	--	810 J	--	--	--
Toluene	200,000 J	610 BJ	1 J	--	150,000 J	3,400 J	--	--	680 J	--	--	--
1,1,1–Trichloroethane	190,000 J	99 J	--	--	210,000 J	5,000 J	--	--	800 J	--	--	--
1,1,2–Trichloroethane	--	--	--	--	--	--	--	--	--	--	--	--
Trichloroethene	17,000,000 D	8,300	99	52	15,000,000 D	170,000	66	3 J	26,000 D	41	39	83
Vinyl Chloride	--	--	--	--	--	--	--	5 J	--	--	--	--
Xylene (total)	10,000 J	--	--	--	--	--	--	--	--	--	--	--
Total VOCs	17,574,000	9,348	171	103	15,458,000	179,140	68	61	28,373	49	55	100

<u>Notes:</u>

All concentrations reported in ug/kg, dry weight (ppb).

B = Compound determined to be present in the blanks as well as in the sample.

J = Estimated value; concentration less than the quantitation limit but greater than zero.

D = Coumpounds identified at a secondary dilution factor.

-- = Not detected.

Total VOCs is the sum of the concentrations for the volatile organic compounds listed.

TABLE 8

SUMMARY OF VAPOR PROBE CONSTRUCTION DETAILS

HADCO CORPORATION
OWEGO, NEW YORK

VAPOR PROBE NUMBER	TOTAL DEPTH OF PROBE (FT)*	VAPOR PROBE COMPLETETION	MONITORED ZONE	CASING MATERIAL	PROBE DIAMETER (INCHES)	SCREEN SLOT SIZE (INCHES)	SCREENED INTERVAL (FT)*
VE–1	5.5	Flush–mount	Outwash	PVC	4	0.010	2.5 – 5.5
VP–1	5.3	Flush–mount	Outwash	PVC	3/4	0.010	3.3 – 5.3
VP–2	5.3	Flush–mount	Outwash	PVC	3/4	0.010	3.3 – 5.3
VP–3	5.5	Flush–mount	Outwash	PVC	3/4	0.010	3.5 – 5.5

Notes:

* Below ground suface.

TABLE 9

SUMMARY OF VAPOR EXTRACTION ANALYTICAL DATA
LONG TERM PILOT TEST
AUGUST 17–21, 1992

HADCO CORPORATION
OWEGO, NEW YORK

		SAMPLE ID:	VS–1	VS–2	VS–2*	VS–3	VS–4	VS–4*	VS–5	PC–1
	REPORTING	DATE:	8/17/92	8/18/92	8/18/92	8/19/92	8/20/92	8/20/92	8/21/92	8/21/92
COMPOUND:	LIMITS	TIME:	8:09 am	3:32 pm	3:32 pm	3:35 pm	3:30 pm	3:30 pm	11:07 am	11:10 am
trans–1,2–Dichloroethene	1.0		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis–1,2–Dichloroethene	1.0		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1,1–Trichloroethane	1.0		2.4	3.5	3.5	3.2	3.1	3.1	2.3	<1.0
Trichloroethene	1.0		16	52	52	63	60	60	32	<1.0
Tetrachloroethene	1.0		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Volatiles (+)	1.0		18	56	56	66	63	63	34	<1.0

Notes:

All concentrations reported in ug/L.
All samples obtained from sample port on vapor extraction unit, except for PC–1 which was taken from carbon filter exhaust.
* – Duplicate sample.
(+) – Total volatiles was calculated by summing the reported concentrations of the specific analytes listed above.
Test commenced at 7:35 am August 17, 1992 and was ended at 11:10 am August 21, 1992.

TABLE 10

SUMMARY OF VAPOR EXTRACTION ANALYTICAL DATA
SHORT TERM PILOT TEST
AUGUST 22, 1992

HADCO CORPORATION
OWEGO, NEW YORK

		SAMPLE ID:	VS-6	VS-7	VS-7*
	REPORTING	DATE:	8/22/92	8/22/92	8/22/92
COMPOUND:	LIMITS	TIME:	9:40 am	10:20 am	10:20 am
trans-1,2-Dichloroethene	1.0		<1.0	<1.0	<1.0
cis-1,2-Dichloroethene	1.0		<1.0	<1.0	<1.0
1,1,1-Trichloroethane	1.0		5.3	5.9	5.9
Trichloroethene	1.0		78	109	109
Tetrachloroethene	1.0		<1.0	<1.0	<1.0
Total Volatiles (+)	1.0		85	116	116

Notes:

All concentrations reported in ug/L

All samples obtained from sample port on vapor extraction unit at VP-3.

(+) - Total volatiles was calculated by summing the reported concentrations of the specific analytes listed above.

* - Duplicate sample.

Test commenced at 9:19 am and ended at 10:20 am, August 22, 1992.

TABLE 11

SUMMARY OF GROUND-WATER
ANALYTICAL RESULTS – INORGANICS
OCTOBER 1991

HADCO CORPORATION
OWEGO, NEW YORK

ANALYTE	SAMPLE I.D.									
	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10
Aluminum	0.176 B	5.64	4.02	0.05	5.36	5.6	1.43	26.6	15.1	31.4
Antimony	0.01 U	0.01 U	0.005 U	0.005 U	0.01 U	0.01 U	0.005 U	0.005 U	0.005 U	0.01 U
Arsenic	0.005 U	0.009 B	0.005 U	0.005 U	0.005 U	0.041	0.019	0.02	0.006 B	0.019
Beryllium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.0053	0.005 U	0.005 U	0.005 U	0.005 U
Cadmium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Chromium	0.01 U	0.124	3.47	0.076	0.567	0.803	18.1	0.446	0.017	0.0507
Cobalt	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.0289 B	0.0211 B	0.0268 B	0.021 B	0.0353 B
Copper	0.01 U	0.101	0.0639	0.029	0.0273	0.738	0.0952	0.179	0.0759	0.0844
Iron	4.36	29.4	89.2	0.304	15.7	69.1	51.9	55.6	27.7	61
Lead	0.003	0.023	0.029	0.003	0.0171	0.18	0.01	0.0468	0.029	0.0985
Magnesium	8.28	18.3	11.7	18.9	5.38	17.8	6.24	17.8	14.6	44.5
Manganese	1.16	5.32	0.442	0.005 U	0.657	5.69	0.204	1.07	3.42	18.5
Mercury	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0013	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Nickel	0.0368 B	0.086	0.0491	0.02 U	0.177	0.156	0.868	0.155	0.0905	0.343
Selenium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.05 U	0.005 U	0.05 U	0.05 U	0.05 U
Silver	0.027	0.01 U	0.006 U	0.006 U	0.01 U	0.0144	0.006 U	0.006 U	0.006 U	0.026
Sodium	28.3	31.6	30.4	89.5	73.7	43.8	33.4	36.2	39.9	99.4
Thallium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Vanadium	0.03 U	0.03 U	0.03 U	0.03 U	0.03 U	0.0419 B	0.0401 B	0.0321 B	0.03 U	0.03 U
Zinc (total)	0.0167 B	0.0474	0.0395	0.0184 B	0.0578	0.225	0.0819	0.178	0.221	0.266

Notes:

All concentrations reported in mg/l (ppm).

B – Compound determined to be present in the blanks as well as in the sample.

U – Compound was analyzed for but not detected.

TABLE 11
(Cont'd.)

SUMMARY OF GROUND-WATER ANALYTICAL RESULTS – INORGANICS OCTOBER 1991

HADCO CORPORATION OWEGO, NEW YORK

ANALYTE	SAMPLE I.D.									
	R MW-11	MW-12	MW-13	MW-14	MW-15	MW-17	MW-18	MW-19	MW-20	MW-21
Aluminum	315	2.45	63.3	104	9.24	0.568	18.9	92.3	74.7	7.55
Antimony	0.005 U	0.01 U	0.005 U	0.01 U	0.01 U	0.01 U	0.005 U	0.01 U	0.005 U	0.005 U
Arsenic	0.066	0.005 U	0.019	0.019	0.007 B	0.012	0.009 B	0.052	0.016	0.005 U
Beryllium	0.011	0.005 U	0.005 U	0.006	0.005 U	0.005 U	0.005 U	0.0098	0.0065	0.005 U
Cadmium	0.005 U	0.005 U	0.005 U	0.005	0.006	0.005 U	0.005 U	0.012	0.005 U	0.005 U
Chromium	5.86	0.01 U	0.04	0.345	0.063	0.01 U	0.078	17.6	0.587	0.011
Cobalt	0.322	0.02 U	0.0395 B	0.103	0.0233 B	0.02 U	0.0229 B	0.129	0.0803	0.02 U
Copper	1.44	0.01 U	0.664	0.3	0.0717	0.118	0.0441	22.5	0.292	0.0814
Iron	710	4.45	68	202	17.4	36.1	35.1	128	173	15.2
Lead	0.33	0.004	0.051	0.18	0.023	0.011	0.0509	0.113	0.126	0.017
Magnesium	714	8.67	19	47.2	42	9	21.9	53.5	46.1	31.2
Manganese	19.7	0.561	15.4	9.68	1.65	2.62	0.383	12.2	2.34	1.4
Mercury	0.0015	0.0002 U	0.0002 U	0.00042	0.0002 U	0.0002 U	0.0002 U	0.0014	0.0002 U	0.0002 U
Nickel	1.006	0.0355 B	0.343	0.315	0.0254 B	0.0327 B	0.0338 B	1.07	0.195	0.0392 B
Selenium	0.005 U	0.005 U	0.05 U	0.05 U	0.005 U	0.005 U	0.05 U	0.05 U	0.05 U	0.05 U
Silver	0.011	0.01 U	0.0063 B	0.0116	0.012	0.01 U	0.006 U	0.0162	0.006 U	0.0061 B
Sodium	31.7	29.7	28	128	37.1	35.3	19	83	16.5	22.5
Thallium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Vanadium	0.425	0.03 U	0.0398 B	0.118	0.03 U	0.03 U	0.03 U	0.0777	0.0833	0.03 U
Zinc (total)	1.628	0.0445	2.01	0.602	0.125	0.0631	0.107	0.873	0.525	0.097

Notes:

All concentrations reported in mg/l (ppm).

B – Compound determined to be present in the blanks as well as in the sample.

U – Compound was analyzed for but not detected.

TABLE 11
(Cont'd.)

SUMMARY OF GROUND-WATER ANALYTICAL RESULTS - INORGANICS
OCTOBER 1991

HADCO CORPORATION
OWEGO, NEW YORK

ANALYTE	SAMPLE I.D.									
	MW-22	MW-23	MW-24	MW-25	MW-26	MW-27	MW-28	PW-1	MW-8A DUP MW-8	MW-19A DUP MW-19
Aluminum	1.18	1.76	0.194 B	7.88	1.02	0.762	179	8.34	13.1	56.7
Antimony	0.005 U	0.01 U	0.01 U	0.005 U	0.005 U	0.01 U	0.005 U	0.01 U	0.005 U	0.01 U
Arsenic	0.007 B	0.05 U	0.005 U	0.005 U	0.005 U	0.005 U	0.048	0.026	0.006 B	0.016
Beryllium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.0083
Cadmium	0.005 U	0.006	0.005 U	0.005 U	0.005 U	0.009	0.05 U	0.005 U	0.005 U	0.005 U
Chromium	0.01 U	0.029	0.01 U	0.522	0.06	0.098	0.644	0.26	0.028	8.56
Cobalt	0.02 U	0.0224 B	0.02 U	0.02 U	0.02 U	0.02 U	0.176	0.02 U	0.02 U	0.108
Copper	0.066	0.0517	0.0182 B	0.417	0.0405	0.0251	2.39	0.334	0.0493	19.8
Iron	26.5	1.43	0.207	10.5	2.66	1.43	1860	57.1	22.9	32.3
Lead	0.01	0.009	0.003	0.013	0.008	0.011	0.35	0.016	0.016	0.025
Magnesium	11.1	50.3	10.3	13.8	17.7	13.6	94.1	33.6	19.3	41.2
Manganese	1.16	2.11	0.788	2.66	0.888	1.28	12.3	35.4	0.253	11
Mercury	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.00034
Nickel	0.0207 B	0.0751	0.02 U	0.121	0.0207 B	0.02 U	0.644	0.542	0.0392 B	1.02
Selenium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.05 U	0.05 U
Silver	0.006 U	0.01 U	0.01 U	0.006 U	0.006 U	0.01 U	0.0093 B	0.0165	0.006 U	0.01 U
Sodium	29	203	39.2	49.5	53.5	45.3	443	70.2	19.3	81.4
Thallium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Vanadium	0.03 U	0.03 U	0.03 U	0.03 U	0.03 U	0.03 U	0.3 U	0.03 U	0.03 U	0.03 U
Zinc (total)	0.185	0.0397	0.01 U	0.0625	0.0557	0.0528	1.48	0.045	0.0889	0.764

Notes:

All concentrations reported in mg/l (ppm).

B – Compound determined to be present in the blanks as well as in the sample.

U – Compound was analyzed for but not detected.

TABLE 12

SUMMARY OF GROUND-WATER ANALYTICAL RESULTS – INORGANICS
AUGUST/SEPTEMBER 1992

HADCO CORPORATION
OWEGO, NEW YORK

	WELL NUMBER								
	D	R	D	S	R	R	D	D	S
	MW-14	MW-17	MW-18	MW-19	MW-20	MW-22	MW-23	MW-24	MW-25
Analyte									
Arsenic	0.0338	0.015	0.006 B	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Beryllium	0.005	0.005 U	0.005 U	0.007	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Cadmium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Chromium	0.294	0.013	0.010 U	6.72	0.010 U	0.010 U	0.022	0.028	0.170
Copper	0.303	0.010 U	0.162	18.4	0.142	0.100	0.034	0.010 U	0.199
Lead	0.158	0.005	0.017	0.011	0.004	0.003 U	0.004	0.004	0.004
Manganese	5.72	3.1	0.103	10.2	0.212	0.058	2.04	0.149	0.229
Mercury	0.00023	0.00020 U	0.00020 U	0.00068	0.00020 U	0.00020 U	0.00020 U	0.00020 U	0.00020 U
Nickel	0.218	0.039 B	0.030 U	0.956	0.030 U	0.030 B	0.314	0.030 U	0.061
Silver	0.024	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U
Zinc	0.683	0.010 U	0.223	0.767	0.098	0.097	0.032	0.010 U	0.020

	WELL NUMBER							
	D	D	D	D	D	D	S	D
	MW-26	MW-27	MW-29	MW-30	MW-31	MW-32	MW-33	PW-3
Analyte								
Arsenic	0.005 B	0.005 U	0.013	0.005 U	0.020	0.005 U	0.014	0.005 U
Beryllium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Cadmium	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Chromium	0.033	0.108	0.054	0.048	0.032	0.014	0.309	0.01 U
Copper	0.035	0.015 B	0.106	0.065	0.142	0.022 B	0.264	0.01 U
Lead	0.021	0.006	0.056	0.012	0.060	0.011	0.069	0.004
Manganese	2.16	1.41	2.05	1.28	1.91	0.125	6.88	0.583
Mercury	0.00020 U	0.00020 U	0.00020 U	0.00020 U	0.00020 U	0.00020 U	0.00020 U	0.00020 U
Nickel	0.031 B	0.030 U	0.088	0.074	0.080	0.030 U	0.124	0.030 U
Silver	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Zinc	0.058	0.015 B	0.198	0.093	0.216	0.038	0.220	0.021

Notes:

All concentrations reported in mg/L (ppm).
U = Compound was analyzed for but not detected at the detection limit indicated.
B = Analyte found in the associated blank as well as the sample.

TABLE 13

NEW YORK STATE AMBIENT WATER QUALITY STANDARDS

HADCO CORPORATION
OWEGO, NEW YORK

Compound	CAS NO.*	Class GA Ground Water	Class D Surface Water
Volatile Organics			
Acetone	67-64-1	--	--
Benzene	71-43-2	0.7	6(G)
Bromomethane	74-83-9	--	--
Bromodichloromethane	75-27-4	50(G)	--
Bromoform	75-25-2	50(G)	--
2-Butanone	78-93-3	--	--
Carbon disulfide	75-15-0	--	--
Carbon tetrachloride	56-23-5	5	--
Chlorobenzene	108-90-7	5	50
Chloroethane	75-00-3	--	--
Chloroform	67-66-3	7	--
Chloromethane	74-87-3	--	--
Dibromochloromethane	124-48-1	50(G)	--
1,1-Dichloroethane	75-34-3	5	--
1,2-Dichloroethane	107-06-2	5	--
1,2-Dichloroethene (total)	540-59-0	--	--
1,1-Dichloroethene (DCE)	75-35-4	5	--
1,2-Dichloropropane	78-87-5	5	--
cis-1,3-Dichloropropene	10061-01-5	--	--
trans-1,3-Dichloropropene	10061-02-6	--	--
Ethylbenzene	100-41-4	5	--
2-Hexanone	591-78-6	50(G)	--
Methylene chloride	75-09-2	5	--
4-Methyl-2-pentanone	108-10-1	--	--
Styrene	100-42-5	5	--
1,1,2,2-Tetrachloroethane	79-34-5	5	--
Tetrachloroethene (PCE)	127-18-4	5	1(G)
Toluene	108-88-3	5	--
1,1,1-Trichloroethane (TCA)	71-55-6	5	--
1,1,2-Trichloroethane	79-00-5	5	--
Trichloroethene (TCE)	79-01-6	5	11(G)
Vinyl chloride	75-1-4	2	--
Xylene (total)	1330-20-7	5	--

TABLE 13
(Cont'd.)
NEW YORK STATE AMBIENT WATER QUALITY STANDARDS

HADCO CORPORATION
OWEGO, NEW YORK

Compound	CAS NO.*	Class GA Ground Water	Class D Surface Water
Inorganics			
Aluminum	N/A	--	--
Antimony	N/A	3(G)	--
Arsenic	N/A	25	360 (dissolved)
Beryllium	N/A	3(G)	--
Cadmium	N/A	10	(A)
Chromium	N/A	50	(B)
Cobalt	N/A	--	110(G)(+)
Copper	N/A	200	(C)
Iron	N/A	300(++)	300
Lead	N/A	25	(D)
Magnesium	N/A	35,000(G)	--
Manganese	N/A	300(++)	--
Mercury	N/A	2	0.2(G)
Nickel	N/A	--	E
Selenium	N/A	10	--
Silver	N/A	50	F
Sodium	N/A	20,000	--
Thallium	N/A	4(G)	20
Vanadium	N/A	--	190(+)
Zinc (total)	N/A	300	(H)

Notes:

These standards and guidance values are from the November 15, 1991 Division of Water Technical and Operational Guidance Series (1.1.1).

Classes of ground water and surface water are based on the definitions found in Title 6 Part 701 New York State Environmental Law.

All concentrations in units of micrograms per liter (ug/L; ppb).

-- = No standard or guidance value listed.

* = Chemical Abstracts Reference Number.

(A) = exp(1.128 [ln (ppm hardness)]-3.828); acid-soluble form.

(B) = exp(0.819 [ln (ppm hardness)]+3.688); acid-soluble form.

(+) = Acid-soluble form.

(C) = exp(0.9422 [ln (ppm hardness)]-1.464); dissolved form.

(++) = The value listed applies to the sum of iron and manganese concentrations.

(D) = exp(1.266 [ln (ppm hardness)]-1.416); acid-soluble form.

(E) = exp(0.76 [ln (ppm hardness)]+4.02); acid-soluble form.

(F) = exp(1.72 [ln (ppm hardness)]-6.52); acid-soluble form.

(G) = Guidance Value.

(H) = exp(0.83 [ln (ppm hardness)]+1.95); acid-soluble form.

TABLE 14

SUMMARY OF GROUND-WATER
ANALTICAL RESULTS – VOLATILE ORGANICS
OCTOBER 1991

HADCO CORPORATION
OWEGO, NEW YORK

WELL I.D.	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9	MW-10	MW-11	MW-12	MW-13	MW-14	MW-15
Acetone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bromomethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bromodichloromethane	--	--	--	--	0.5 J	--	--	--	--	--	--	0.3 J	--	--	--
Bromoform	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2-Butanone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carbon disulfide	6	--	--	--	--	--	--	--	48	--	--	--	--	--	--
Carbon tetrachloride	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chloroform	--	--	--	--	0.5 J	--	--	--	--	--	0.2 J	0.5 J	--	1 J	--
Chloromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1,1-Dichloroethane	--	7	--	--	--	5	--	5	--	--	14	--	--	11	11
1,2-Dichloroethane	--	--	--	--	--	--	--	--	--	--	0.7 J	--	--	--	--
1,2-Dichloroethene (total)	--	21	--	--	--	68	--	14	--	--	52	--	--	110	11
1,1-Dichloroethene	--	2 J	--	--	--	0.9 J	--	3 J	--	--	5	--	--	37	1 J
1,2-Dichloropropene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
cis-1,3-Dichloropropene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trans-1,3-Dichloropropene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ethyl benzene	--	--	--	--	--	0.3 J	--	--	--	--	--	--	--	--	--
2-Hexanone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Methylene chloride	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4-Methyl-2-pentanone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Styrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tetrachloroethene	--	--	--	--	--	--	--	--	--	--	--	--	--	1 J	--
Toluene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	12	--	--	--	--	--	21	--	--	39	--	2 J	140	5
1,1,2-Trichloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trichloroethene	4 J	83	--	50	4 J	27	0.7 J	110	12	0.7 J	260 D	--	6	660 D	120
Vinyl acetate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vinyl chloride	--	7 J	--	--	--	39	--	--	--	--	--	--	--	--	--
Xylene (total)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total VOCs	10	132	0	50	5	140.2	0.7	153	60	0.7	370.9	0.8	8	960	148

TABLE 14
(Cont'd.)

SUMMARY OF GROUND-WATER
ANALTICAL RESULTS - VOLATILE ORGANICS
OCTOBER 1991

HADCO CORPORATION
OWEGO, NEW YORK

WELL I.D.	MW-17	MW-18	MW-19	MW-20	MW-21	MW-22	MW-23	MW-24	MW-25	MW-26	MW-27	MW-28	PW-1	MW-8A DUP MW-8	MW-19A DUP MW-19
Acetone	110	--	320	--	--	--	63	--	--	--	10	110	89	--	350
Benzene	40	--	340	--	--	--	47	--	--	3 J	--	--	0.7 J	--	340
Bromomethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bromodichloromethane	--	--	10 J	--	--	--	--	--	--	--	--	--	--	--	--
Bromoform	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2-Butanone	57	--	--	--	--	--	--	--	--	--	--	--	300 D	--	--
Carbon disulfide	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carbon tetrachloride	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	1 J	--	--	--	--	--	--	--	--
Chloroethane	52	--	--	--	--	--	4 J	--	--	--	--	--	17	--	--
Chloroform	10	0.7 J	79 J	--	--	--	16	--	2 J	1 J	0.3 J	--	--	--	82 J
Chloromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1,1-Dichloroethane	8700 D	86	120	9	--	1 J	1400 D	11	7 J	200 D	21	21	47	6	120
1,2-Dichloroethane	57	3	100	--	--	--	14	--	--	7	--	--	--	--	110
1,2-Dichloroethene (total)	470 DJ	48	340	3 J	--	7	1400 D	110	74	200 D	110	38	77	18	380
1,1-Dichloroethene	170 DJ	75	23000 DJ	5	--	2 J	1100 D	10	10	180	25	16	--	4 J	21000 DJ
1,2-Dichloropropane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
cis-1,3-Dichloropropene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trans-1,3-Dichloropropene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ethyl benzene	190 DJ	--	770	--	--	--	59	--	--	--	--	--	22	--	730
2-Hexanone	--	--	--	--	--	--	66	--	--	--	--	--	--	--	--
Methylene chloride	18	--	4700 DJ	--	--	--	250 DJ	--	--	1 J	0.8 J	--	1 J	--	5100 DJ
4-Methyl-2-pentanone	230 E	--	320	--	--	--	59	--	--	--	--	--	--	--	350
Styrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tetrachloroethene	23	--	2100	--	--	--	170 DJ	--	0.3 J	2 J	2 J	--	--	--	2300
Toluene	3800 D	--	24000 DJ	--	--	--	1100 D	--	--	--	4 J	--	170	--	22000 DJ
1,1,1-Trichloroethane	11000 D	420 D	190000 D	110	--	11	9300 D	210	52	1300 D	83	180	2 J	26	180000 D
1,1,2-Trichloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trichloroethene	18000 BD	720 D	630000 BD	19	--	23	57000 BD	320 B	350 D	2100 D	890 BD	360	3 J	160	600000 BD
Vinyl acetate	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vinyl chloride	29	--	--	--	--	--	7 J	38	--	27	38	2 J	11	--	--
Xylene (total)	1200 D	--	2900	--	--	--	340	--	--	--	--	--	62	--	2800
Total VOCs	44,156	1,352.7	879,099	146	0	44	72,396	699	495.3	4,021	1,184.1	727	801.7	214	835,662

Notes:
Units in ug/L.
All concentrations reported in ug/L (ppb).
B = Compound determined to be present in the blanks as well as in the sample.
D = Compounds identified at a secondary dilution factor.
E = Identifies compounds whose concentations exceed the calibration range of the GC/MS instrument for that specific analysis.
J = Indicates an estimated value.
U = Compound was analyzed for but not detected.
Dates = October 21, 1991 - October 24, 1991.
-- = Not detected.
Total VOCs is the sum of the concentration for the organic compounds listed.

TABLE 15

SUMMARY OF GROUND-WATER ANALYTICAL RESULTS – VOLATILE ORGANICS
AUGUST/SEPTEMBER 1992

HADCO CORPORATION
OWEGO, NEW YORK

	WELL NUMBER																
Compound	MW-14	MW-17	MW-18	MW-19	MW-20	MW-22	MW-23	MW-24	MW-25	MW-26	MW-27	MW-29	MW-30	MW-31	MW-32	MW-33	PW-3
Acetone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzene	--	--	--	--	--	--	--	--	--	7 J	--	--	--	--	--	9 J	8 J
Bromomethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Bromodichloromethane	--	--	--	--	--	--	--	--	0.6 J	--	--	--	--	--	--	--	--
Bromoform	--	--	--	--	--	--	--	--	0.3 J	--	--	--	--	--	--	--	--
2-Butanone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carbon Disulfide	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Carbon Tetrachloride	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.3 BJ	--
Chloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chloroform	--	--	0.5 J	--	--	--	--	--	2 J	4 J	--	--	--	--	0.1 J	--	3 J
Chloromethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--	--	--	--	0.7 J	--	--	--	--	--	--	--	--
1,1-Dichloroethane	--	2000	81	--	24	29 J	190 J	4 J	3 J	410 DJ	--	18 J	--	--	2 J	1 J	570 DJ
1,2-Dichloroethane	--	--	3 J	--	--	--	--	--	0.2 J	13	--	--	--	--	--	--	13
1,1-Dichloroethene	--	440 J	62	16000 J	22	64	1500 J	4 J	8 J	640 D	--	49 J	--	--	4 J	--	310 DJ
1,2-Dichloroethene (total)	59 J	3600	41 J	--	11	130	1500 J	15	34	710 D	53 J	92 J	--	--	4 J	3 J	360 DJ
1,2-Dichloropropane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
cis-1,3-Dichloropropene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
trans-1,3-Dichloropropene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ethylbenzene	--	270 J	--	520 J	--	--	--	--	--	--	--	--	--	--	--	0.3 J	12
2-Hexanone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Methylene Chloride	--	--	5 BJ	8100 BJ	--	3 BJ	270 BJ	--	1 BJ	4 J	--	7 BJ	0.5 BJ	0.6 BJ	--	--	5 J
4-Methyl-2-Pentanone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Styrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1,1,2,2-Tetrachloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Tetrachloroethene	--	--	--	2200 J	--	--	48 J	0.9 J	0.7 J	12	--	5 J	--	--	--	0.6 J	10
Toluene	8 J	5600	--	20000 J	--	--	400 J	2 J	--	--	--	10 J	--	--	--	1 J	92
1,1,1-Trichloroethane	110	54000 D	480	120000	230 D	230	8000	110	48	5200 D	34 J	220	4 J	--	24	2 J	6700 D
1,1,2-Trichloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Trichloroethene	1100 B	51000 BD	720	470000	89	800	29000	240 BD	330 D	9100 D	1700 B	1000	4 J	1 J	2 J	31	7900 BD
Vinyl Chloride	--	--	--	--	--	--	--	--	--	56	--	--	--	--	--	--	28
Xylene (total)	--	1100	--	2400 J	--	--	100 J	0.9 J	--	--	--	7 J	--	--	0.5 J	16	48
Total VOCs	1277	118010	1392.5	639220	376	1256	41008	376.8	428.5	16156	1787	1408	8.5	1.6	36.6	64.2	16059

Notes:

All concentrations reported in ug/L (ppb).

B = Compound determined to be present in the blanks as well as in the sample.

J = Estimated value; concentration less than the quantitation limit but greater than zero.

D = Coumpounds identified at a secondary dilution factor.

-- = Not detected.

Total VOCs is the sum of the concentrations for the volatile organic compounds listed.

TABLE 16

SUMMARY OF SURFACE WATER ANALYTICAL RESULTS – INORGANICS

HADCO CORPORATION
OWEGO, NEW YORK

ANALYTE	SAMPLE I.D. SW–1	SW–2	SW–3	SW–4	SW–5
Aluminum	60 U	60 U	60 U	87.9 B	60 U
Antimony	10 U	10 U	10 U	10 U	10 U
Arsenic	5 U	5 U	5 U	5 U	5 U
Beryllium	5 U	5 U	5 U	5 U	5 U
Cobalt	20 U	20 U	20 U	20 U	20 U
Cadmium	5 U	5 U	5 U	5 U	5 U
Chromium	10 U	10 U	10 U	10 U	10 U
Copper	10 U	10 U	10 U	10 U	10 U
Iron	67.3 B	61.9 B	51.4 B	82.9 B	47.8 B
Lead	3 U	3 U	3 U	3	3 U
Magnesium	5990	6040	8260	8820	8240
Manganese	27.4	14.4 B	14.8 B	41	5.8 B
Mercury	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
Nickel	20 U	21 B	20 U	20 U	20 U
Selenium	5 U	5 U	5 U	5 U	5 U
Silver	10 U	10 U	10 U	10 U	10 U
Sodium	9310	14000	20400	27300	21200
Thallium	5 U	5 U	5 U	5 U	5 U
Vanadium	30 U	30 U	30 U	30 U	30 U
Zinc (total)	10 U	10 U	10 U	10 U	10 U

Notes:
All concentrations reported in ug/l (ppb).
B – Compound determined to be present in the blanks as well as in the sample.
U – Compound was analyzed for but not detected.

TABLE 17

SUMMARY OF SURFACE WATER ANALYTICAL RESULTS
VOLATILE ORGANICS

HADCO CORPORATION
OWEGO, NEW YORK

SAMPLE I.D.	SW-1	SW-2	SW-3	SW-4	SW-5 DUP SW-3
COMPOUND					
Acetone	--	--	--	--	--
Benzene	--	--	--	--	--
Bromomethane	--	--	--	--	--
Bromodichloromethane	--	--	--	--	--
Bromoform	--	--	--	--	--
2-Butane	--	--	--	--	--
Carbon disulfide	--	--	--	--	--
Carbon tetrachloride	--	--	--	--	--
Chlorobenzene	--	--	--	--	--
Chloroethane	--	--	--	--	--
Chloroform	--	--	--	--	--
Chloromethane	--	--	--	--	--
Dibromochloromethane	--	--	--	--	--
1,1-Dichloroethane	--	--	--	--	--
1,2-Dichloroethane	--	--	--	--	--
1,2-Dichloroethane (total)	--	--	--	--	--
1,1-Dichloroethene	--	--	--	--	--
1,2-Dichloropropane	--	--	--	--	--
cis-1,3-Dichloropropene	--	--	--	--	--
trans-1,3-Dichloropropene	--	--	--	--	--
Ethyl benzene	--	--	--	--	--
2-Hexanone	--	--	--	--	--
Methylene chloride	--	--	--	--	--
4-Methyl-2-pentanone	--	--	--	--	--
Styrene	--	--	--	--	--
1,1,2,2-Tetrachloroethane	--	--	--	--	--
Tetrachloroethene	--	--	--	--	--
Toluene	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--
1,1,2-Trichloroethane	--	--	--	--	--
Trichloroethene	3 J	2 J	--	--	--
Vinyl acetate	--	--	--	--	--
Vinyl chloride	--	--	--	--	--
Xylene (total)	--	--	--	--	--

Notes:
All concentrations reported in ug/l (ppb).
J = Estimated value; concentration less than the sample quantitation limit but greater than zero.
-- = Not detected.

TABLE 18

SUMMARY OF STREAM SEDIMENT ANALYTICAL RESULTS – INORGANICS

HADCO CORPORATION
OWEGO, NEW YORK

	SAMPLE I.D.				
ANALYTE	SED–1	SED–2	SED–3	SED–4	SED–5
Aluminum	12900	15200	10600	15100	10700
Antimony	2.3 U	2.5 U	23.5 U	2.4 U	2.3 U
Arsenic	10	20.8	12.6	17.4	11.8
Beryllium	1.1 U	1.3 U	1.2 U	1.2 U	1.1 U
Cobalt	12.2	14.6	9.6	16.6	8.9 B
Cadmium	1.1 U	1.3 U	1.2	1.2 U	1.1 U
Chromium	17.7	19	14.6	22.5	15.2
Copper	30.3	27.3	18.6	59.4	28.7
Iron	33800	37500	25700	36200	25400
Lead	10.2	27.5	15.7	41.4	12.9
Magnesium	4310	5000	3620	5180	3510
Manganese	704	1000	472	1430	331
Mercury	0.1 U	0.11 U	0.11 U	0.11 U	0.1 U
Nickel	37.6	46.3	29.4	49.3	25.7
Selenium	1.2 U	1.3 U	1.2 U	1.2 U	1.1 U
Silver	15.4	12.8	2.9	2.4	2.3 U
Sodium	246 B	274 B	231 B	259 B	235 B
Thallium	1.2 U	1.3 U	1.2 U	1.2 U	1.1 U
Vanadium	12.4	15.9	10.1 B	16.1	10 B
Zinc (total)	78.8	89.2	60.7	104	62.7

Notes:
All concentrations reported in mg/kg, dry weight (ppm).
B = Compound determined to be present in the blanks as well as in the sample.
U = Compound was analyzed for but not detected.

TABLE 19

SUMMARY OF STREAM SEDIMENT ANALYTICAL RESULTS – VOLATILE ORGANICS

HADCO CORPORATION
OWEGO, NEW YORK

SAMPLE I.D.	SED–1	SED–2	SED–3	SED–4	SED–5 DUP SED3
Compound					
Acetone	11 BJ	12 BJ	––	––	6 BJ
Benzene	––	––	1 J	––	––
Bromomethane	––	––	––	––	––
Bromodichloromethane	––	––	––	––	––
Bromoform	––	––	––	––	––
2–Butane	––	––	––	––	––
Carbon disulfide	––	––	––	––	––
Carbon tetrachloride	––	––	––	––	––
Chlorobenzene	––	––	––	––	––
Chloroethane	––	––	––	––	––
Chloroform	––	––	––	––	––
Chloromethane	––	––	––	––	––
Dibromochloromethane	––	––	––	––	––
1,1–Dichloroethane	––	––	––	––	––
1,2–Dichloroethane	––	––	––	––	––
1,2–Dichloroethane (total)	––	––	––	––	––
1,1–Dichloroethene	––	––	––	––	––
1,2–Dichloropropane	––	––	––	––	––
cis–1,3–Dichloropropene	––	––	––	––	––
trans–1,3–Dichloropropene	––	––	––	––	––
Ethyl benzene	––	––	––	––	––
2–Hexanone	––	––	––	––	––
Methylene chloride	––	––	0.8 J	––	––
4–Methyl–2–pentanone	––	––	––	––	––
Styrene	––	––	––	––	––
1,1,2,2–Tetrachloroethane	––	––	––	––	––
Tetrachloroethene	––	––	––	––	––
Toluene	––	––	––	––	––
1,1,1–Trichloroethane	––	––	––	––	––
1,1,2–Trichloroethane	––	––	––	––	––
Trichloroethene	––	––	––	––	2 J
Vinyl acetate	––	––	––	––	––
Vinyl chloride	––	––	––	––	––
Xylene (total)	––	––	––	––	––

Notes:
All concentrations reported in ug/kg, dry weight (ppb).
B = Compound determined to be present in the blanks as well as in the sample.
J = Estimated value; concentration less than the sample quantitation limit but greater than zero.
–– = Not detected.

TABLE 20

HADCO SITE

SUMMARY OF CHEMICALS OF INTEREST IN GROUND WATER

Volatiles

1,1-dichloroethane
1,2-dichloroethane
1,1-dichloroethene
1,2-dichloroethene
benzene
chlorobenzene
chloroform
ethylbenzene
methylene chloride
tetrachloroethene
toluene
1,1,1-trichloroethane
trichloroethene
xylenes (total)

Inorganics

arsenic
beryllium
cadmium
chromium
copper
lead
manganese
mercury
nickel
silver
zinc

TABLE 21

HADCO SITE

SUMMARY OF CHEMICALS OF INTEREST IN SOILS

Volatiles

- methylene chloride
- tetrachloroethene
- acetone
- toluene
- xylenes (total)
- trichloroethene
- 1,2-dichloroethane
- ethylbenzene
- 1,1,1-trichloroethane

Inorganics

- arsenic
- chromium
- copper
- manganese
- nickel
- silver
- zinc

TABLE 22

HADCO CORPORATION
OWEGO, NEW YORK

IDENTIFICATION OF SIGNIFICANT EXPOSURE PATHWAYS

	Ground Water			Soils				Stream Bottom Sediments				Surface Water		
	IG	D	IHo	IG	D	IHo	IHp	IG	D	IHo	IHp	IG	D	IHo
Baseline Receptor Populations														
Off-Site Human Resident	H	L	L	A	A	A	A	L	L	A	A	L	L	L
Future Use Receptor Populations														
On-Site Human Excavation Worker	L	L	L	M	M	L	M	A	A	A	A	A	A	A

Key to Exposure Levels:

– denotes a potentially significant exposure pathway which will be evaluated in the risk assessment

H – probability of exposure is high
M – probability of exposure is moderate
L – probability of exposure is low
A – probability of exposure is absent

Key to Exposure Pathways:

IG – Ingestion
D – Dermal Contact
IHo–Inhalation exposure to organic vapors
IHp–Inhalation exposure to airborne particulates

TABLE 23

HADCO CORPORATION
OWEGO, NEW YORK

SUMMARY OF EXPOSURE CONCENTRATIONS
CHEMICALS OF INTEREST IN GROUND WATER(1)

	Range of Concentrations (mg/l)	Frequency of Detection	Arithmetic Mean Concentration (2) (mg/l)	95% Upper Bound Concentration (3) (mg/l)	RME Concentration (4) (mg/l)
VOLATILE ORGANIC COMPOUNDS					
Benzene	ND – 0.009	1 / 12	0.0041	0.0054	0.0054
Chlorobenzene	ND – 0.0009	1 / 12	0.0032	0.0040	0.0009
Chloroform	ND – 0.001	5 / 12	0.0025	0.0037	0.0010
1,1–Dichloroethane	ND – 0.086	9 / 12	0.0218	0.0405	0.0405
1,2–Dichloroethane	ND – 0.003	3 / 12	0.0034	0.0043	0.0030
1,2–Dichloroethene (total)	ND – 0.11	10 / 12	0.0372	0.0593	0.0593
1,1–Dichloroethene	ND – 0.075	8 / 12	0.0229	0.0396	0.0396
Ethylbenzene	ND – 0.0003	1 / 12	0.0031	0.0040	0.0003
Methylene Chloride	ND – 0.007	4 / 12	0.0032	0.0045	0.0045
Tetrachloroethene	ND – 0.005	3 / 12	0.0032	0.0042	0.0042
Toluene	ND – 0.01	3 / 12	0.0042	0.0059	0.0059
1,1,1–Trichloroethane	0.002 – 0.48	12 / 12	0.1227	0.2247	0.2247
Trichloroethene	0.001 – 1.1	12 / 12	0.3961	0.6490	0.6490
Xylenes (total)	ND – 0.016	3 / 12	0.0046	0.0073	0.0073
INORGANIC COMPOUNDS					
Arsenic	ND – 0.066	11 / 12	0.0172	0.0279	0.0279
Beryllium	ND – 0.011	3 / 12	0.0037	0.0053	0.0053
Cadmium	ND – 0.006	2 / 12	0.0030	0.0037	0.0037
Chromium	ND – 5.86	11 / 12	0.6116	1.6200	1.6200
Copper	0.022 – 1.44	12 / 12	0.2528	0.4878	0.4878
Lead	0.011 – 0.33	12 / 12	0.0844	0.1419	0.1419
Manganese	0.103 – 19.7	12 / 12	4.1785	7.6834	7.6834
Mercury	ND – 0.0015	3 / 12	0.0003	0.0005	0.0005
Nickel	ND – 1.006	10 / 12	0.1743	0.3425	0.3425
Silver	ND – 0.024	4 / 12	0.0079	0.0115	0.0115
Zinc	0.038 – 1.628	12 / 12	0.3555	0.6277	0.6277

Notes:

(1) Results derived from overburden monitoring wells MW–8, MW–11, MW–14, MW–15, MW–18, MW–29, MW–30, MW–31, MW–32, and MW–33.

(2) Value represents the arithmetic mean of detected concentrations using one–half the detection limit for non–detect samples.

(3) Value represents the upper bound 95 percent confidence limit on the arithmetic mean concentration.

(4) Reasonable maximum exposure (RME) concentration is the lesser of the 95 percent upper bound concentration or the maximum detected concentration (USEPA, 1989a).

ND = Not detected.

TABLE 24

HADCO CORPORATION
OWEGO, NEW YORK

SUMMARY OF EXPOSURE CONCENTRATIONS
CHEMICALS OF INTEREST IN SOILS

	Range of Concentrations (mg/kg)	Frequency of Detection	Arithmetic Mean Concentration (1) (mg/kg)	95% Upper Bound Concentration (2) (mg/kg)	RME Concentration (3) (mg/kg)
VOLATILE ORGANIC COMPOUNDS					
Acetone	ND – 0.089	3 / 6	0.0209	0.0576	0.0576
1,2–Dichloroethane	ND – 0.043	1 / 6	0.0093	0.0276	0.0276
Ethylbenzene	ND – 0.003	1 / 6	0.0026	0.0028	0.0028
Methylene Chloride	ND – 0.001	1 / 6	0.0022	0.0030	0.0009
Tetrachloroethene	ND – 0.058	1 / 6	0.0118	0.0370	0.0370
Toluene	ND – 0.026	2 / 6	0.0062	0.0171	0.0171
1,1,1–Trichloroethane	ND – 0.003	1 / 6	0.0026	0.0028	0.0028
Trichloroethene	0.002 – 0.44	6 / 6	0.0777	0.2758	0.2758
Xylene (total)	ND – 0.018	1 / 6	0.0051	0.0121	0.0121
INORGANICS					
Arsenic	ND – 27	5 / 6	10.1	15.1	15.1
Chromium	13.3 – 198	6 / 6	108	186	186
Copper	37 – 973	6 / 6	444	832	832
Manganese	412 – 1000	6 / 6	632	785	785
Nickel	21.3 – 60.7	6 / 6	46.6	58.9	58.9
Silver	ND – 10.4	5 / 6	7.19	9.73	9.73
Zinc	54.2 – 87.8	6 / 6	74.7	84.9	84.9

Notes:

(1) Value represents the arithmetic mean of detected concentrations using one–half the detection limit for non–detect samples.
(2) Value represents the upper bound 95 percent confidence limit on the arithmetic mean concentration.
(3) Reasonable maximum exposure (RME) concentration is the lesser of the 95 percent upper bound concentration or the maximum detected concentration (USEPA, 1989a).
ND = Not detected.

TABLE 25

HADCO SITE

INCIDENTAL INGESTION AND DERMAL CONTACT WITH SOILS EXPOSURE SCENARIO - HYPOTHETICAL FUTURE USE CONDITIONS

	Receptor Group	On-Site Excavation Worker
*	Body weight	70 kg
	Frequency of Event	200 days/year
	Duration of Exposure	1 year
*	Area of skin exposed to dust/soils	3120 cm^2
	Body parts exposed to dust/soils	Hands and arms
*	Absorption factor	10% (volatiles) 0% (inorganics)
**	Ingestion rate	50 mg/day
***	Adherence factor	1.0 mg/cm^2
*	Averaging time:	25,550 days for carcinogens; 365 days for noncarcinogens
	Data set:	On-Site Soils

Notes:

* USEPA, 1989a. Risk Assessment Guidance for Superfund - Vol. 1, Human Health Evaluation Manual, EPA/540/1-89/002.

** USEPA, 1991a. (OSWER Directive 9285.6-03).

*** USEPA, 1991c. (Interim Guidance for Dermal Exposure Assessment).

TABLE 26

HADCO SITE

INHALATION OF DUST FROM SOILS EXPOSURE SCENARIO - HYPOTHETICAL FUTURE USE CONDITIONS

	Receptor Group	On-Site Excavation Worker
*	Body weight	70 kg
**	Inhalation rate:	2.6 m^3/hour
	Frequency of Event	1 hour/day for 200 days/year
	Duration of Exposure	1 year
***	Concentration of respirable dust particles in ambient air:	0.07 mg/m^3
*	Averaging time:	25,550 days for carcinogens; 365 days for noncarcinogens
	Data set:	On-Site Soils

<u>Notes</u>:

* USEPA, 1989a. Risk Assessment Guidance for Superfund - Vol. 1, Human Health Evaluation Manual, EPA/540/1-89/002.

** USEPA, 1988. Superfund Exposure Assessment Manual, EPA/540/1-88/001.

*** Hawley, 1987.

TABLE 27

HADCO SITE

INGESTION EXPOSURE TO GROUND WATER EXPOSURE SCENARIO - HYPOTHETICAL BASELINE CONDITIONS

	Receptor Group	Off-Site Residents
*	Body weight	70 kg
**	Frequency of Event	350 days/year
**	Duration of Exposure	30 years
**	Ingestion rate	2 liters/day
*	Averaging time:	25,550 days for carcinogens; 10,950 days for noncarcinogens
	Data set:	Ground Water

<u>Notes</u>:

* USEPA, 1989a. Risk Assessment Guidance for Superfund - Vol. 1, Human Health Evaluation Manual, EPA/540/1-89/002.

** USEPA, 1991a. (OSWER Directive 9285.6-03).

TABLE 28

HADCO CORPORATION
OWEGO, NEW YORK

TOXICITY CRITERIA FOR POTENTIAL NONCARCINOGENIC HEALTH EFFECTS

CHEMICAL	Oral RfD (mg/kg/day)	Reference	Inhalation RfD (mg/kg/day)	Reference
VOLATILE ORGANIC COMPOUNDS				
Benzene				
Chlorobenzene	2.00E-02	*	5.00E-03	**
Chloroform	1.00E-02	*		
1,1-Dichloroethane	1.00E-01	**		
1,2-Dichloroethane				
1,2-Dichloroethene (total)	2.00E-02	*		
1,1-Dichloroethene	9.00E-03	**		
Ethylbenzene	1.00E-01	*	2.86E-01	*
Methylene Chloride	6.00E-02	**	8.60E-01	**
Tetrachloroethene	1.00E-02	*		
Toluene	2.00E-01	*	5.71E-01	**
1,1,1-Trichloroethane	9.00E-02	**	3.00E-01	**
Trichloroethene				
Xylenes (total)	2.00E+00	*	8.57E-02	**
INORGANIC COMPOUNDS				
Arsenic	3.00E-04	*		
Beryllium	5.00E-03	*		
Cadmium	5.00E-04	*		
Chromium III	1.00E+00	*	5.70E-07	**
Copper	3.70E-02	**		
Lead				
Manganese	1.00E-01	*	1.14E-04	*
Mercury	3.00E-04	**	8.57E-05	**
Nickel	2.00E-02	*		
Silver	5.00E-03	**		
Zinc	2.00E-01	**		

Notes:

* IRIS, 1992
** USEPA, 1991d

TABLE 29

HADCO CORPORATION
OWEGO, NEW YORK

TOXICITY CRITERIA FOR POTENTIAL CARCINOGENIC HEALTH EFFECTS

CHEMICAL	USEPA Weight of Evidence	Oral SF 1/(mg/kg/day)	Reference	USEPA Weight of Evidence	Inhalation SF 1/(mg/kg/day)	Reference
VOLATILE ORGANIC COMPOUNDS						
Benzene	A	2.9E–02	*	A	2.9E–02	*
Chlorobenzene	D			D		
Chloroform	B2	6.1E–03		B2	8.1E–02	
1,1–Dichloroethane	D			D		
1,2–Dichloroethane	B2	9.1E–02	*	B2	9.1E–02	*
1,2–Dichloroethene (total)	D			D		
1,1–Dichloroethene	C	6.0E–01		C	1.2E+00	*
Ethylbenzene	D			D		
Methylene Chloride	B2	7.5E–03		B2	1.7E–03	*
Tetrachloroethene	B2–C	5.1E–02	**	B2–C	1.8E–03	**
Toluene	D			D		
1,1,1–Trichloroethane	D			D		
Trichloroethene	B2–C	1.1E–02	**	B2–C	1.7E–02	**
Xylenes (total)	D			D		
INORGANIC COMPOUNDS						
Arsenic	A		*	A	5.0E+01	*
Beryllium	B2	4.3E+00		B2	8.4E+00	*
Cadmium	D		*	B1	6.3E+00	*
Chromium III	D			D		
Copper	D			D		
Lead	B2	ND	*	B2	ND	*
Manganese	D					
Mercury	D					
Nickel (refinery dust)	D			A	1.7E+00	**
Silver	D			D		
Zinc	D			D		

Notes:
* IRIS, 1992
** USEPA, 1991d
ND = Not Determined

TABLE 30A

HADCO CORPORATION
OWEGO, NEW YORK

OFF-SITE RESIDENT – HYPOTHETICAL BASELINE CONDITIONS
INGESTION OF GROUND WATER

Chemical	Exposure Concentration (mg/l)	Ingestion Exposure Dosage (mg/kg/day)	Oral Slope Factor (mg/kg/day)−1	Risk
CARCINOGENIC EFFECTS				
VOLATILES				
chloroform	1.00E−03	1.17E−05	6.10E−03	7.16E−08
benzene	5.40E−03	6.34E−05	2.90E−02	1.84E−06
methylene chloride	4.50E−03	5.28E−05	7.50E−03	3.96E−07
trichloroethene	6.49E−01	7.62E−03	1.10E−02	8.38E−05
tetrachloroethene	4.20E−03	4.93E−05	5.10E−02	2.52E−06
1,1−dichloroethene	3.96E−02	4.65E−04	6.00E−01	2.79E−04
1,2−dichloroethane	3.00E−03	3.52E−05	9.10E−02	3.21E−06
INORGANICS				
arsenic	2.79E−02	3.28E−04	ND	
beryllium	5.30E−03	6.22E−05	4.30E+00	2.68E−04
TOTAL:			Pathway Risk =	6E−04

TABLE 30B

HADCO CORPORATION
OWEGO, NEW YORK

OFF–SITE RESIDENT – HYPOTHETICAL BASELINE CONDITIONS
INGESTION OF GROUND WATER

Chemical	Exposure Concentration (mg/l)	Ingestion Exposure Dosage (mg/kg/day)	Oral RfD (mg/kg/day)	Hazard Quotient
NONCARCINOGENIC EFFECTS				
VOLATILE ORGANIC COMPOUNDS				
Benzene	0.0054	1.47E–04		
Chlorobenzene	0.0009	2.47E–05	2.00E–02	1.23E–03
Chloroform	0.0010	2.74E–05	1.00E–02	2.74E–03
1,1–Dichloroethane	0.0405	1.11E–03	1.00E–01	1.11E–02
1,2–Dichloroethane	0.0030	8.22E–05		
1,2–Dichloroethene (total)	0.0593	1.63E–03	2.00E–02	8.13E–02
1,1–Dichloroethene	0.0396	1.08E–03	9.00E–03	1.21E–01
Ethylbenzene	0.0003	8.22E–06	1.00E–01	8.22E–05
Methylene Chloride	0.0045	1.22E–04	6.00E–02	2.04E–03
Tetrachloroethene	0.0042	1.15E–04	1.00E–02	1.15E–02
Toluene	0.0059	1.61E–04	2.00E–01	8.06E–04
1,1,1–Trichloroethane	0.2247	6.15E–03	9.00E–02	6.84E–02
Trichloroethene	0.6490	1.78E–02	2.00E–02	8.89E–01
Xylenes (total)	0.0073	1.99E–04	2.00E+00	9.94E–05
INORGANIC COMPOUNDS				
Arsenic	0.0279	7.65E–04	3.00E–04	2.55E+00
Beryllium	0.0053	1.45E–04	5.00E–03	2.89E–02
Cadmium	0.0037	1.02E–04	5.00E–04	2.04E–01
Chromium	1.6200	4.44E–02	1.00E+00	4.44E–02
Copper	0.4878	1.34E–02	3.70E–02	3.61E–01
Lead	0.1419	3.89E–03	1.00E–01	3.89E–02
Manganese	7.6834	2.11E–01	1.00E–01	2.11E+00
Mercury	0.0005	1.37E–05	3.00E–04	4.56E–02
Nickel	0.3425	9.38E–03	2.00E–02	4.69E–01
Silver	0.0115	3.16E–04	5.00E–03	6.32E–02
Zinc	0.6277	1.72E–02	2.00E–01	8.60E–02
			Hazard Index =	7E+00

TABLE 31A

HADCO CORPORATION
OWEGO, NEW YORK

ON-SITE EXCAVATION WORKER – HYPOTHETICAL FUTURE USE CONDITIONS
INCIDENTIAL INGESTION AND DERMAL CONTACT
SOILS

Chemical	Exposure Concentration (mg/kg)	Ingestion Exposure Dosage (mg/kg/day)	Dermal Exposure Dosage (mg/kg/day)	Total Exposure Dosage (mg/kg/day)	Oral Slope Factor (mg/kg/day)-1	Risk
CARCINOGENIC EFFECTS						
VOLATILES						
methylene chloride	0.0009	5.03E-12	3.14E-11	3.64E-11	7.50E-03	2.7E-13
tetrachloroethene	0.037	2.07E-10	1.29E-09	1.50E-09	5.10E-02	7.6E-11
trichloroethene	0.002	1.12E-11	6.98E-11	8.10E-11	1.10E-02	8.9E-13
1,2-dichloroethane	0.028	1.54E-10	9.63E-10	1.12E-09	6.00E-01	6.7E-10
TOTAL:					Pathway Risk =	8E-10

TABLE 31B

HADCO CORPORATION
OWEGO, NEW YORK

ON–SITE EXCAVATION WORKER – HYPOTHETICAL FUTURE USE CONDITIONS
INCIDENTIAL INGESTION AND DERMAL CONTACT
SOILS

Chemical	Exposure Concentration (mg/kg)	Ingestion Exposure Dosage (mg/kg/day)	Dermal Exposure Dosage (mg/kg/day)	Total Exposure Dosage (mg/kg/day)	Oral RfD (mg/kg/day)	Hazard Quotient
NONCARCINOGENIC EFFECTS						
VOLATILES						
methylene chloride	0.0009	3.52E−10	2.20E−09	2.55E−09	6.00E−02	4.3E−08
acetone	0.058	2.25E−08	1.41E−07	1.63E−07	1.00E−01	1.6E−06
toluene	0.017	6.69E−09	4.18E−08	4.85E−08	2.00E−01	2.4E−07
xylenes (total)	0.012	4.74E−09	2.96E−08	3.43E−08	2.00E+00	1.7E−08
ethylbenzene	0.003	1.10E−09	6.84E−09	7.93E−09	1.00E−01	7.9E−08
1,1,1,−trichloroethane	0.003	1.10E−09	6.84E−09	7.93E−09	9.00E−02	8.8E−08
tetrachloroethene	0.037	1.45E−08	9.04E−08	1.05E−07	1.00E−02	1.0E−05
INORGANICS						
arsenic	15.07	5.90E−06	−−−	5.90E−06	3.00E−04	2.0E−02
chromium (total)	186.4	7.30E−05	−−−	7.30E−05	1.00E+00	7.3E−05
copper	832.4	3.26E−04	−−−	3.26E−04	3.70E−02	8.8E−03
manganese	784.8	3.07E−04	−−−	3.07E−04	1.00E−01	3.1E−03
nickel	58.9	2.31E−05	−−−	2.31E−05	2.00E−02	1.2E−03
silver	9.73	3.81E−06	−−−	3.81E−06	5.00E−03	7.6E−04
zinc	84.88	3.32E−05	−−−	3.32E−05	2.00E−01	1.7E−04
TOTAL:					Hazard Index =	3E−02

TABLE 32A

HADCO CORPORATION
OWEGO, NEW YORK

ON–SITE EXCAVATION WORKER – HYPOTHETICAL FUTURE USE CONDITIONS
INHALATION – DUST FROM SOILS

Chemical	Exposure Concentration (mg/kg)	Inhalation Exposure Dosage (mg/kg/day)	Inhalation Slope Factor (mg/kg/day) –1	Risk
CARCINOGENIC EFFECTS				
VOLATILES				
methylene chloride	0.0009	1.47E–13	1.65E–03	2.4E–16
tetrachloroethene	0.037	6.02E–12	1.82E–03	1.1E–14
trichloroethene	0.002	3.26E–13	1.70E–02	5.5E–15
1,2–dichloroethane	0.028	4.56E–12	---	---
TOTAL:			Pathway Risk =	2E–14

TABLE 32B

HADCO CORPORATION
OWEGO, NEW YORK

ON–SITE EXCAVATION WORKER – HYPOTHETICAL FUTURE USE CONDITIONS
INHALATION – DUST FROM SOILS

Chemical	Exposure Concentration (mg/kg)	Inhalation Exposure Dosage (mg/kg/day)	Inhalation RfC (mg/kg/day)	Hazard Quotient
NONCARCINOGENIC EFFECTS				
VOLATILES				
methylene chloride	0.0009	1.03E–11	8.60E–01	1.2E–11
acetone	0.058	6.61E–10	---	---
toluene	0.017	1.94E–10	5.71E–01	3.4E–10
xylenes (total)	0.012	1.37E–10	8.57E–02	1.6E–09
ethylbenzene	0.003	3.42E–11	2.86E–01	
1,1,1–trichloroethane	0.003	3.42E–11	3.00E–01	
tetrachloroethene	0.037	4.22E–10	---	---
INORGANICS				
arsenic	15.07	1.72E–07	---	---
chromium (total)	186.4	2.12E–06	5.70E–07	3.7E+00
copper	832.4	9.49E–06	---	---
manganese	784.8	8.94E–06	1.14E–04	7.8E–02
nickel	58.90	6.71E–07	---	---
silver	9.73	1.11E–07	---	---
zinc	84.88	9.67E–07	---	---
TOTAL:			Hazard Index =	4E + 00

TABLE 33

HADCO CORPORATION
OWEGO, NEW YORK

PATHWAY–SPECIFIC RISK CHARACTERIZATION SUMMARY

Receptor	Medium	Route	Summation of Chemical–Specific Carcinogenic Risks	Summation of Chemical–Specific Hazard Indices
Off–Site Residents	Ground Water	Ingestion of Well Water	6E–04	7.0E+00
On–Site Excavation Workers	Soils	Incidental Ingestion & Dermal Contact	8E–10	3E–02
On–Site Excavation Workers	Soils	Inhalation of of Dust from Soils	2E–14	4E+00

TABLE 34

HADCO CORPORATION
OWEGO, NEW YORK

TOTAL PATHWAYS RISK CHARACTERIZATION SUMMARY

Receptor	Medium	Route	Summation of Carcinogenic Risks All Pathways	Summation of Hazard Indices All Pathways
Off-Site Residents	Ground Water	Ingestion of Well Water	6E-04	7E+00
On-Site Excavation Workers	Soils	Incidental Ingestion, Dermal Contact & Inhalation	8E-10	4E+00

TABLE 35

HADCO CORPORATION
OWEGO, NEW YORK

VEGETATIVE SPECIES OBSERVED OR TYPICAL OF THE AREA

Common Name	Scientific Name
I. Trees/Shrubs	
Sugar maple	Acer sacharum
Staghorn sumac	Rhus typhina
White oak	Quercus alba
Black cherry	Prunus serotina
Choke cherry	Prunus virginiana
Flowering dogwood	Cornus florida
Red-osier dogwoon	Cornus stolonifera
Paper birch	Betula papyrifera
White pine	Pinus strobus
White spruce	Picea glauca
American elm	Ulmus americana
American sycamore	Platinus occidentalis
Honeylocust	Gleditsia traicanthos
Hawthorne	Crataegus sp.
Quaking aspen	Populus tremuloides
Shagbark hickory	Carya ovata
American beech	Fagus grandifolia
Poplar sp.	Populus sp.
Willow sp.	Salix sp.
Elderberry	Sambucus canadensis
Northern white cedar	Thuja occidentalis
boxelder	Acer negundo
Yew	Taxus sp.
Staghorn sumac	Rhus typhina
II. Herbaceous Vegetation	
Vetch	Vicia sp.
Violet	Viola sp.
Red stem aster	Aster puniceus
Alfalfa	Medicago sativa
Common fleabane	Erigeron philadepphicus
Meadow fescue	Festuca elatior (gramineae sp)
Stinging nettle	Urtica dioica
Virgins bower	Clematis virginiana
Pokeweed	Phytolacca americana
Mullein	Verbascum thapsus
Dandelion	Taraxacum officiale
Bramble	Rubus sp.
Vervain	Verbena sp.

TABLE 35 (Cont'd)

Teasel	Dipsacus laciniatus
Field thistle	cirsium discolor
foxtail	Alopecurus sp.
Strawberry	Fragaria virginiana
Burdock	Artium minus
Bush clover	Lespedeza sp.
Virburnum	Virburnum sp.
Goldenrod	Solidago sp.
Wild grapes	Vitis sp.
Multiflora rose	Rosa multiflora
Grasses	Gramineae sp.

TABLE 36

WILDLIFE SPECIES OBSERVED OR TYPICAL OF THE AREA

HADCO CORPORATION
OWEGO, NEW YORK

Common Name	Scientific Name
Birds	
Blue jay	Cyanocitta cristata
Red-eyed vireo	Vireo olivaceus
American robin	Turdus migratorius
Black-capped chickadee	Parus atricapillus
Red-winged blackbird	Agelaius phoeniceus
White-breasted nuthatch	Sitta carolinensis
Cardinal	Richmondena cardinalis
Eastern phoebe	Sayornis phoebe
Common crow	Corvus brachyrhynchos
House sparrow	Passer domesticus
Common grackle	Quiscalus quiscala
American goldfinch	Spinus tristis
Common yellowthroat	Geothylpis trichas
Red-tailed hawk	Buteo jamaicensis
Sharp-shinned hawk	Accipter striatus
Kestrel	Falco sparverius
Great blue heron	Ardea herodias
Mallard	Anas platyrhynchos
Killdeer	Charadrius vociferus
Mammals	
Eastern cottontail rabbit	Sylvilagus floridanus
Woodchuck	Marmota monax
Raccoon	Procyon lotor
White-tailed deer	Odocoileus virginiana
Opposum	Didelphis marsupialis
Mouse (sp.)	Peromyscus sp.
Vole (sp.)	Sorex sp., Blarina sp.
Bats (sp.)	Chiroptera
Other:	
Herptiles	
Invertebrates	

TABLE 37

POTENTIAL EXPOSURE PATHWAY ANALYSIS

HADCO CORPORATION
OWEGO, NEW YORK

ENVIRONMENTAL MEDIA (1)	BIRDS			MAMMALS			AQUATIC BIOTA		
Route (2)	Ig	D	Ih	Ig	D	Ih	Ig	D	Ih
Ground water	L	L	L	L	L	L	L	L	L
Soils	L	L	L	L	L	L	L	L	L
Surface waters	M	M	NA	M	M	NA	H	H	NA
Aquatic sediments	M	M	NA	M	M	NA	H	H	NA
Air	L	L	L	L	L	L	L	L	L

Notes:

(1) Potential contaminant migration pathways include ground water, soils, surface waters, and aquatic sediments.

(2) Potential exposure routes include:

Ig = Ingestion
D = Dermal contact
Ih = Inhalation

L = Low potential for exposure
M = Moderate potential for exposure
H = High potential for exposure
NA = Not Applicable

TABLE 38

HADCO CORPORATION
OWEGO, NEW YORK

COMPARISON OF BARNES CREEK WATER DATA TO NYSDEC AMBIENT WATER QUALITY CRITERIA FOR AQUATIC TOXICITY

	Maximum Detected Concentration[1] (ug/L)	NYSDEC Ambient Water Quality Criteria for Aquatic Toxicity[2] (ug/L)
Volatile Organics		
Trichloroethene	2	11
Inorganics		
Aluminum	87.9	100
Iron	82.9	300
Lead	3	3
Magnesium	8820	--
Manganese	41	--
Nickel	21	92
Sodium	27300	--

Notes:

--	Not available
1	Maximum detected concentration of Barnes Creek surface water samples SW-2, SW-3, SW-4, SW-5.
2	Hardness-dependent criteria for lead and nickel are calculated using a site-specific hardness value of 95.6 mg/l (NYSDEC, 1991c).

TABLE 39

HADCO CORPORATION
OWEGO, NEW YORK

COMPARISON OF BARNES CREEK SEDIMENT DATA TO NYSDEC AQUATIC TOXICITY-BASED SEDIMENT CRITERIA

	Maximum Detected Concentration[1] (mg/kg)	NYSDEC Draft Aquatic Toxicity Sediment Quality Criteria[2] (mg/kg)	NYSDEC Draft Limit of Tolerance[3] (mg/kg)
Organics			
Benzene	0.001		--
Methylene chloride	0.008		--
Trichloroethene	0.002		--
Inorganics			
Aluminum	15200	--	--
Arsenic	20.8	5	33
Cobalt	16.6	--	--
Cadmium	1.2	0.8	10
Chromium	22.5	26	111
Copper	59.4	19	114
Iron	37500	24000	40000
Lead	41.4	27	250
Magnesium	5180	--	--
Manganese	1430	428	1100
Nickel	49.3	22	90
Silver		--	--
Vanadium	16.1	--	--
Zinc (total)	104	88	800

Notes:

-- Not Available

[1] Maximum detected concentration of Barnes Creek sediment samples SED-2 - SED-5

[2] A sediment total organic carbon content of _____ (NYSDEC, 1991) is assumed for organics.

[3] Represents a concentration detrimental to benthic species.

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 7/3/91 CLASSIFIED BY: DLG	# BORING HB-1
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 253.05
DATE STARTED: 7/3/91	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5													
0	▨	1	0.33	27	25						▨	ASPHALT	
	▨										▨	Dark brown-gray fine to medium SAND and GRAVEL, moist, (FILL).	
	▨	2	0.5	18	10						▨	Dark brown-gray fine to medium SAND and SILT, some Gravel, trace Clay, loose, moist to wet, (FILL).	
	▨	3	0.17	14							▨	Dark brown to dark gray, fine to medium SAND and SILT, trace Clay and small rounded Grael, loose to compact, moist to wet.	
-5	▨										▨		
	▨	4	0.42	53	40						▨	Wet at approximentely 7.8 feet.	
												Bottom of boring 8 Feet.	
-10												NOTES: Boring advance with tripod rig and standard 2 in x 2 ft split spoon samplers. Boring grouted to surface on 7/3/91.	
-15													
-20													
-25													

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 7/3/91 CLASSIFIED BY: DLG	# BORING HB-2
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 253.05
DATE STARTED: 7/3/91	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

			SOIL DATA			ROCK DATA							
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5													
0	▩	1	0.25	16	10							ASPHALT Dark brown to gray fine to coarse SAND and GRAVEL, some Silt, trace Clay, loose, dry to wet, (FILL).	
	▩	2	0.17	12	10								
	▩	3	0.5	19	15							Light brown-gray fine to medium SAND and SILT, some Clay and Gravel, firm, moist to wet.	
-5	▩												
	▩	4	0.67	47	200							Golden brown fine SAND and SILT, compact, dry.	
												Bottom of boring 8 feet.	
-10													
-15													
-20													
-25													

NOTES:

Boring advance with tripod rig and standard 2 in x 2 ft split spoon samples.
Boring grouted to surface 7/3/91.

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 7/3/91 CLASSIFIED BY: DLG	# BORING HB-3
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 7/3/91	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5													
0	▨	1	0.17	37	60							ASPHALT Brown to gray fine to coarse SAND and GRAVEL, some Silt, trace Clay, loose to firm, dry to moist, (FILL).	
	▨	2	0.5	19	6								
	▨	3	0.33	23	1.0							Light brown to gray medium SAND and SILT, some Gravel, loose, moist to wet.	
-5	▨												
	▨	4	0.67	58	300							Golden brown, fine SAND and SILT, some Gravel, firm, dry.	
												Bottom of boring 8 feet.	
-10													
-15													
-20													
-25													

NOTES:

Boring advance with tripod rig and standard 2 in x 2 ft split spoon samples.
Boring grouted to surface 7/3/91.

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 7/3/91 CLASSIFIED BY: DLG	**BORING HB-4**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 7/3/91	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5													
0		1	0.5	21								ASPHALT	
												Light brown to black fine to coarse SAND and GRAVEL, some Silt, trace Clay, loose, moist, (FILL).	
		2	0.42	16	20								
		3	0.83	27	25							Light brown to dark gray, fine to medium SAND and SILT, some Gravel, trace Clay, firm, moist.	
-5													
		4	0.75	62	120							Golden brown to gray fine to medium SAND and SILT, some Pebbles and Clay, moist. Wet at approximentely 7.8 feet.	
												Bottom of boring 8 feet.	
-10												NOTES: Boring advance with tripod rig and standard 2 in x 2 ft split spoon samples. Boring grouted to surface on 7/3/91	
-15													
-20													
-25													

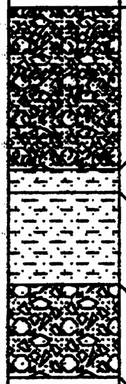
BLASLAND & BOUCK ENGINEERS, P.C.

BORING HBW-1

SURFACE ELEVATION:		DATE COMPLETED	7/3/91
DATE STARTED:	7/3/91	CLASSIFIED BY:	DLG
PROJECT:	HADCO CORPORATION	PROJECT NO.:	263.05
LOCATION:	Owego, NY	PAGE:	1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5													
0	▨	1	0.67	29	40							Brown-gray, medium to coarse SAND and GRAVEL, some Silt, loose, moist, (FILL).	
	▨	2	0.83	82	35							Light gray to gray, fine SAND and SILT, some large rounded Gravel firm, dry.	
	▨	3	1.0	182	150							Brown to light brown, fine to medium SAND and SILT, some small to medium rounded Gravel and pebbles, compact, dry.	
-5													
	▨	4	0.67	227	150							Dark brown to gray medium to coarse SAND and GRAVEL, some Silt, compact, dry.	
												Bottom of boring 8 feet.	
-10													
-15													
-20													
-25													



NOTES:

Boring advance with tripod rig and standard 2 in x 2 ft split spoon samples.
Boring grouted to surface on 7/3/91.

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 7/3/91 CLASSIFIED BY: DLG	**BORING HBW-2**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 7/3/91	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA			ROCK DATA				WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
			RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)				
5													
0	▒	1	0.42	25	25						▨	Light brown to gray, fine to coarse SAND, some Silt, some small to medium rounded Gravel, loose to firm, moist, (FILL).	
	▒	2	0.5	51	10								
	▒	3	0.5	46	70								
-5	▒												
	▒	4	0.58	67	50						░	Dark brown to gray, fine to medium SAND, some Silt, some Gravel, compact, dry to moist.	
	▒										▤	Brown to gray fine to medium SAND and SILT, some pebbles, firm, moist to wet.	
	▒	5	0.42	100									
-10												Bottom of boring 10 Feet. NOTES: Boring advance with tripod rig and standard 2 in x 2 ft split spoon samples. Boring grouted to surface on 7/3/91.	
-15													
-20													
-25													

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 6/20/92	BORING CRB-1
	CLASSIFIED BY: KLR	
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 6/20/92	LOCATION: Owego, NY	PAGE: 1 of 1

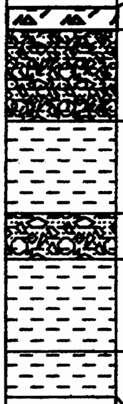
SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SOIL DATA				ROCK DATA				WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
		SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	PID HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)				
5													
												CONCRETE	
0		1	0.5	10 8	37							Brown SILT and GRAVEL, loose, moist, (FILL).	
		2	0.2	8 12	6.4								
		3	0.4	18 26	4.3							Grades to damp	
		4	0.35	21 48	3.1							Light brown SILT and GRAVEL, loose, dry to damp.	
		5	0.2	56 28	6.7								
-5		6	0.6	44 31	401							Brown SILT and GRAVEL, little Clay, compact, damp to moist.	
∇		7	0.55	34 36	3066								
		8	0.4	26 34	3637							Brown SILT and GRAVEL, loose, wet.	
												Bottom of boring 8 feet.	
-10													
												NOTES: Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers. Boring grouted to surface upon completion. Sample No. 8 submitted to laboratory for analysis.	
-15													
-20													
-25													

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 6/20/92 CLASSIFIED BY: KLR	**BORING CRB-2**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 6/20/92	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN
5											
0		1	0.9	17 22	0.2						
		2	0.8	29 30	1.2						
		3	0.45	51 53	0.7						
		4	0.2	144 54	6.4						
		5	0.7	57 43	1.2						
-5		6	0.75	29 21	2.0						
		7	0.8	70 48	30.8						
∇		8	0.85	31 26	4350						
-10											
-15											
-20											
-25											



SOIL/ROCK CLASSIFICATION

CONCRETE

Brown SILT and GRAVEL, loose, damp, (FILL).

Brown SILT, some Gravel, loose, damp.

Cobble in end of spoon

Light brown/gray SILT and GRAVEL, loose, dry.

Brown SILT, some Gravel, loose, damp.

Brown SILT, some Gravel, little Clay, firm, moist to wet.

Bottom of boring 8 feet.

NOTES:

Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers.
Boring grouted to surface upon completion.
Sample No. 8 submitted to laboratory for analysis.

ROCK FEATURES

BLASLAND & BOUCK ENGINEERS, P.C.

DATE COMPLETED 6/20/92
CLASSIFIED BY: KLR

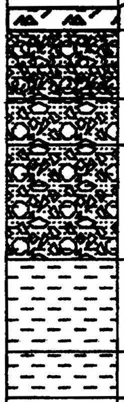
BORING CRB-3

SURFACE ELEVATION:
DATE STARTED: 6/20/92
PROJECT: HADCO CORPORATION
LOCATION: Owego, NY
PROJECT NO.: 263.05
PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SOIL DATA: SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)	WELL COLUMN	ROCK FEATURES
5											
0		1	0.45	16	16.0						
				11							
		2	0.3	17	10.2						
				14							
		3	0.25	26	28.5						
				17							
		4	0.55	18	34.7						
				29							
		5	0.65	39	3.1						
				25							
-5		6	0.85	32	6.1						
				18							
		7	0.7	30	8.2						
▽				21							
	◣	8	0.8	58	80.1						
				47							
-10											
-15											
-20											
-25											

GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

CONCRETE

Brown SILT and GRAVEL, Some Clay, loose, moist, (FILL).

Brown GRAVEL, little Silt, loose, damp to moist.

Brown SILT and fine to coarse GRAVEL, loose, damp.

Brown SILT, some fine to coarse Gravel, little Clay, firm, moist.

Brown/gray SILT, some Gravel, some Clay, firm, wet.

Bottom of boring 8 feet.

NOTES:

Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers.
Boring grouted to surface upon completion.
Sample No. 8 submitted to laboratory for analysis.

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 6/20/92 CLASSIFIED BY: KLR	**BORING CRB-4**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 6/20/92	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

SOIL/ROCK CLASSIFICATION

DEPTH (FT)	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)
5								
0	1	0.4	12	3.0				
			11					
	2	0.15	41	1.9				
			13					
	3	0.1	13	2.5				
			13					
	4	0.55	15	2.3				
			18					
	5	0.9	27	3.7				
			24					
-5	6	0.3	15	8.9				
			89					
▽	7	0.5	46	6.7				
			25					
	8	0.85	103	8.9				
			80					
-10								
-15								
-20								
-25								

WELL COLUMN

GEOLOGIC COLUMN

CONCRETE

Brown SILT and GRAVEL, loose, moist to damp, (FILL)

Cobble in end of spoon

Cobble in end of spoon

Cobble in end of spoon

Light brown/gray SILT and GRAVEL, loose, dry to damp.

Brown/gray SILT and GRAVEL, some Clay, firm, wet.

Bottom of boring 8 feet.

NOTES:

Boring advanced with tripod rig and standard 2 in x 2 ft split spoon samplers.
Boring grouted to surface upon completion.
Sample No. 6 submitted to laboratory for analysis.

ROCK FEATURES

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 6/20/92 CLASSIFIED BY: KLR	**BORING CRB-5**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 6/20/92	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	ROCK FEATURES
5												
0		1	0.65	17 14	2.7							
		2	0.55	19 19	0.8							
		3	0.5	21 14	2.0							
		4	0.5	18 34	111							
		5	0.25	44 43	72.2							
-5		6	0.3	43 27	151							
		7	0.6	27 10	5527							
		8	0.3	31 12	5260							
∇		9	0.65	36 26	4883							
-10												
-15												
-20												
-25												

SOIL/ROCK CLASSIFICATION

CONCRETE

Brown SAND and SILT, little Gravel, loose, moist to damp, (FILL).

Brown/gray SILT and GRAVEL, loose, dry to damp.

Brown SILT, some Gravel, loose, dry to damp.

Brown GRAVEL, little Silt, loose, damp.

Brown SILT, some Sand, some Gravel, firm, damp, cobble in end of spoon.
Chemical odor.

Chemical odor.

Brown SILT, some Gravel, little Clay, compact, moist to wet, slight chemical odor.

Bottom of boring 9 feet.

NOTES:

Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers.
Boring grouted to surface upon completion.
Sample No. 6 submitted to laboratory for analysis.

BLASLAND & BOUCK ENGINEERS, P.C.

DATE COMPLETED	6/20/92		
CLASSIFIED BY:	DLG		
SURFACE ELEVATION:		PROJECT:	HADCO CORPORATION
DATE STARTED:	6/20/92	LOCATION:	Owego, NY

BORING CRB-6

PROJECT NO.: 263.05
PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5													
0												CONCRETE	
		1	0.3	12 75	53							Brown/gray SILT, some medium angular Gravel, trace Clay, loose, moist to damp, (FILL).	
		2	0.4	60 26	22							Brown/gray SILT and fine to medium GRAVEL, trace Clay, firm, moist.	
		3	0.8	39 34	20.7								
		4	0.6	32 45	15.7								
		5	0.5	26 16	51.8							Brown SILT, some fine Sand, some fine rounded Gravel, trace Clay, loose, moist.	
-5		6	0.4	24 22	38.0								
∇		7	0.4	33 27	843							Brown SILT, some fine to coarse angular Gravel, trace Clay, compact to loose, moist to wet, chemical odor.	
		8	0.5	113 27	4114								
												Bottom of boring 8 feet.	
-10													
-15													
-20													
-25													

NOTES:

Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers.
Boring grouted to surface upon completion.
Sample No. 8 submitted to laboratory for analysis.

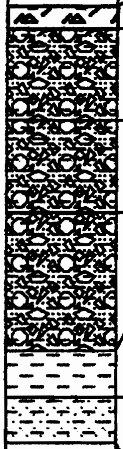
BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED: 6/20/92 CLASSIFIED BY: DLG		**BORING CRB-7**
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 6/20/92	LOCATION:	Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	PID HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)
5									
0	╲	1	0.4	6	134				
				11					
	╲	2	0.2	8	1114				
				5					
	╲	3	0.2	6	2100				
				4					
	◣	4	0.3	6	5300				
				7					
	╲	5	0.3	10	630				
-5				16					
	╲	6	0.5	17	1200				
				17					
	╲	7	0.6	30	2400				
				47					
	╲	8	0.8	28	3600				
▽				34					
	╲	9	0.7	34	4020				
				26					
-10									
-15									
-20									
-25									

WELL COLUMN

GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

CONCRETE

Brown/gray SILT and fine to medium GRAVEL, trace fine Sand, loose, damp.

Brown/gray SILT and GRAVEL, trace fine Sand, trace Clay, loose, dry to moist.

Brown SILT and GRAVEL fragments (powery), loose, dry.

Brown to reddish brown SILT, some fine Sand, trace to some fine Gravel, trace Clay, loose, moist, chemical odor.

Brown/gray SILT, fine SAND, some fine to medium Gravel, trace Clay, loose, moist to wet, chemical odor.

Bottom of boring 9 feet.

NOTES:

Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers.
Boring grouted to surface upon completion.
Sample No. 4 submitted to laboratory for analysis.

ROCK FEATURES

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 6/20/92 CLASSIFIED BY: DLG	**BORING CRB-8**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 6/20/92	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN
5											
0		1	0.4	11	—						
				9							
		2	NR	11	—						
				7							
		3	NR	11	—						
				6							
		4	NR	9	—						
				9							
		5	0.3	19	0.1						
				30							
-5		6	0.2	26	10.0						
				37							
		7	0.4	37	17.5						
				39							
		8	0.9	48	28.4						
∇				32							
		9	1.0	21	32.7						
				22							
-10											
-15											
-20											
-25											

SOIL/ROCK CLASSIFICATION

CONCRETE

Brown/gray fine SAND and SILT, some Gravel fragments, trace Clay loose, moist.

Cobble in end of spoon.
Cobble in end of spoon.

Brown/gray SILT and fine SAND, some angular Gravel, compact, dry.

Brown/light gray SILT, some Gravel fragments, loose, dry to moist.

Light brown/gray SILT, some fine Sand, some fine to medium Gravel, trace Clay, loose, dry to moist.

Brown to reddish brown SILT, some Clay, trace fine to medium Gravel, loose, wet.

Bottom of boring 9 feet.

NOTES:

Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers.
Boring grouted to surface upon completion.
Sample No. 9 submitted to laboratory for analysis.

ROCK FEATURES

BLASLAND & BOUCK ENGINEERS, P.C.

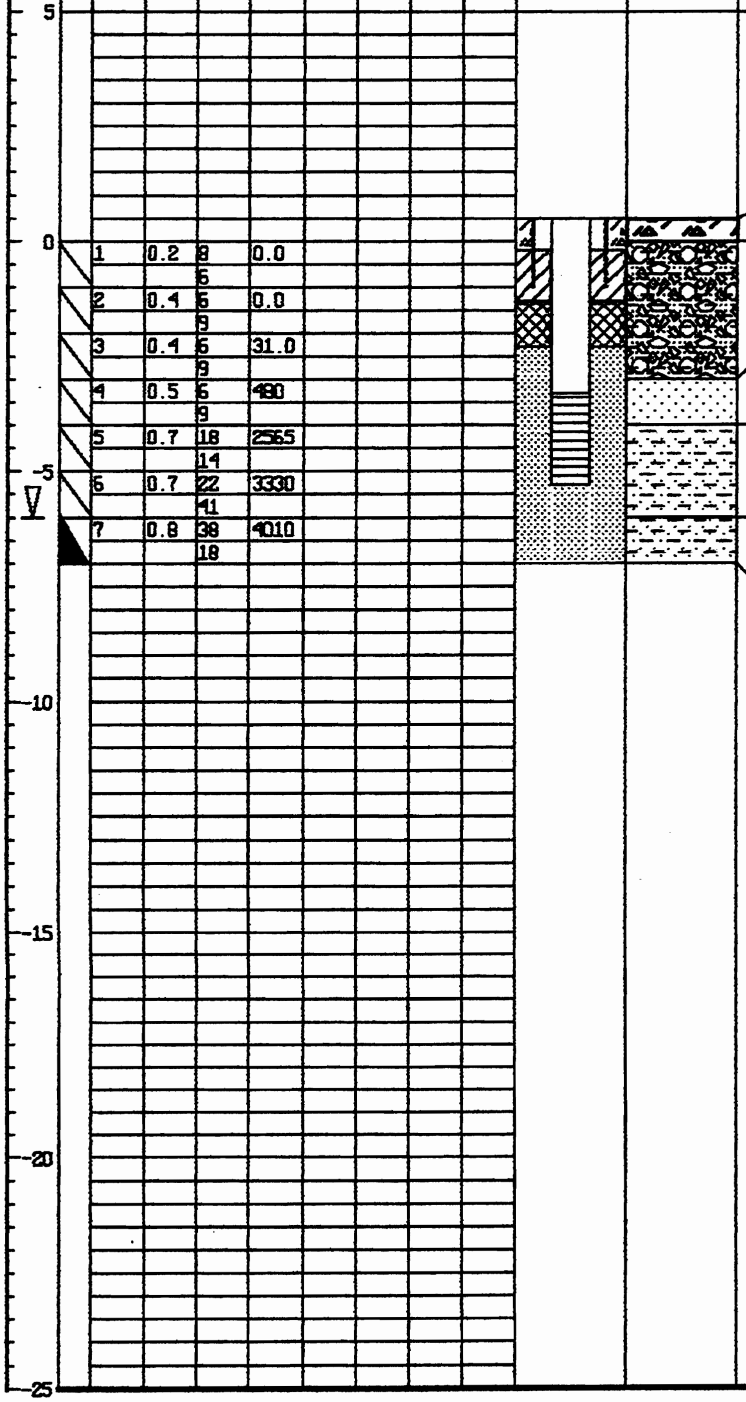
DATE COMPLETED 6/20/92
CLASSIFIED BY: DLG

BORING CRB-9 (VP-1)

SURFACE ELEVATION:
DATE STARTED: 6/20/92
PROJECT: HADCO CORPORATION
LOCATION: Owego, NY
PROJECT NO.: 263.05
PAGE: 1 of 1

SUBSURFACE LOG

SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	AVERAGE RATE (MIN./FT)
1	0.2	8 6	0.0				
2	0.4	6 9	0.0				
3	0.4	6 9	31.0				
4	0.5	6 9	480				
5	0.7	18 14	2565				
6	0.7	22 41	3330				
7	0.8	38 18	4010				



SOIL/ROCK CLASSIFICATION

CONCRETE

Brown/gray SILT and medium to coarse GRAVEL, trace fine Sand, compact, dry to moist.

Dark brown fine to medium SAND, some medium Gravel, trace Silt, loose, dry to moist.

Brown/gray fine SAND and SILT, some fine Gravel, trace Clay, loose, moist.

Brown/gray fine SAND and SILT, some Clay, trace fine Gravel, compact, wet.

Bottom of boring 7 feet.

NOTES:

Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers.
Sample No. 7 submitted to laboratory for analysis.

VAPOR PROBE CONSTRUCTION DETAILS

3/4-inch diameter, SCH 20 PVC riser 3.3' - 0.0'
3/4-inch diameter schedule 20 PVC 0.01 slot screen 5.3' - 3.3'
0 Grade sand 6.5' - 2.3'
hydrated/bentonite seal 2.3' - 1.3'
Cement/bentonite grout 1.3' - 0.2'
Probe completed with a 4-inch diameter flush mount cover and a press on cap: on top of riser (All measurments for vapor probe taken from bottom of concrete.)

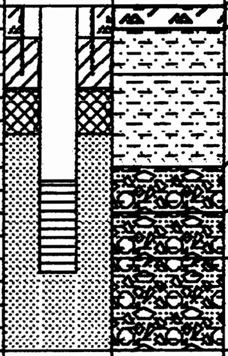
BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 6/20/92 CLASSIFIED BY: DLG	**BORING CRB-10 (VP-2)**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 6/20/92	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	AVERAGE RATE (MIN./FT)
5									
0		1	0.4	10 10	0.0				
		2	0.6	7 8	33.5				
		3	0.5	5 4	12.5				
		4	0.7	6 8	13.0				
		5	0.7	17 21	140				
-5		6	0.9	25 55	280				
∇		7	0.7	54 38	560				
-10									
-15									
-20									
-25									

WELL COLUMN

GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

CONCRETE

Brown/gray fine SAND and SILT, some medium to coarse Gravel, loose, moist.

Brown/gray fine SAND and SILT, some medium Gravel, trace reddish brown Clay, loose, dry to moist.

Brown SILT and GRAVEL, trace Clay, loose, moist to dry.

Brown SILT and fine to medium GRAVEL, trace fine Sand, loose, moist to dry.

Brown, reddish brown SILT and fine GRAVEL, some fine Sand, trace Clay, loose, moist. Grades to wet.

Bottom of boring 7 feet.

NOTES:

Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers. Sample No. 7 submitted to laboratory for analysis.

VAPOR PROBE CONSTRUCTION DETAILS

3/4-inch diameter, SCH 20 PVC riser 3.3' - 0.0'
3/4-inch diameter schedule 20 PVC 0.01 slot screen 5.3' - 3.3'
0 Grade sand 6.5' - 2.3'
Hydrated/bentonite seal 2.3' - 1.3'
Cement/bentonite grout 1.3' - 0.2'
Probe completed with a 4-inch diameter flush mount cover and a press on cap: on top of riser
(All measurments for vapor probe taken from bottom of concrete.)

ROCK FEATURES

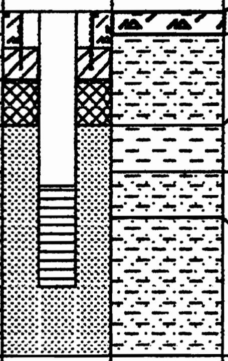
BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 6/20/92 CLASSIFIED BY: DLG	**BORING CRB-11 (VP-3)**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 6/20/92	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	AVERAGE RATE (MIN./FT)
5									
0		1	0.3	11	0.0				
				9					
		2	NR	7	0.0				
				7					
		3	0.4	7	0.1				
				6					
		4	0.5	6	0.1				
				6					
		5	0.7	16	3.0				
				19					
-5		6	0.7	20	6.3				
▽				21					
		7	0.5	32	7.8				
				39					
-10									
-15									
-20									
-25									

WELL COLUMN

GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

CONCRETE

Brown/gray fine SAND and SILT, some medium to coarse Gravel, loose, dry.

Brown/gray SILT, some fine Sand and Gravel, loose, dry.

Brown/gray SILT and fine SAND, some medium Gravel, loose, dry to moist.

Brown/gray fine SAND and SILT, some fine to medium angular Gravel, loose, moist.

Grades to wet.

Bottom of boring 7 feet.

NOTES:

Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers. Sample No. 7 submitted to laboratory for analysis.

VAPOR PROBE CONSTRUCTION DETAILS

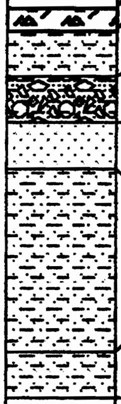
3/4-inch diameter, SCH 20 PVC riser 3.5' - 0.0'
3/4-inch diameter schedule 20 PVC 0.01 slot screen 5.5' - 3.5'
0 Grade sand 6.6' - 2.0'
Hydrated/bentonite seal 2.0' - 1.0'
Cement/bentonite grout 1.0' - 0.3'
Probe completed with a 4-inch diameter flush mount cover and a press on cap: on top of riser (All measurments for vapor probe taken from bottom of concrete.)

ROCK FEATURES

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 6/20/92 CLASSIFIED BY: DLS	**BORING CRB-12**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 6/20/92	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5													
0		1	0.3	11 11	0.0								
		2	0.1	11 8	0.0								
		3	0.2	11 13	0.1								
		4	0.3	11 26	0.0								
		5	0.8	19 25	0.1								
-5		6	0.7	26 40	0.5								
▽		7	0.9	40 34	8.4								
	■	8	0.7	27 21	13.7								
-10													
-15													
-20													
-25													



CONCRETE

Brown fine SAND and SILT, some coarse angular Gravel, loose, moist.

Brown/gray SILT and medium to coarse GRAVEL, trace Clay, loose, moist.

Brown fine to medium SAND, some Silt, trace fine to medium Gravel, loose, moist.

Brown fine SAND and SILT, trace fine Gravel, trace reddish brown Clay, loose, moist.

Light brown fine SAND and SILT, some medium to coarse Gravel, loose, wet.

Bottom of boring 8 feet.

NOTES:

Boring advanved with tripod rig and standard 2 in x 2 ft split spoon samplers.
Boring grouted to surface upon completion.
Sample No. 8 submitted to laboratory for analysis.

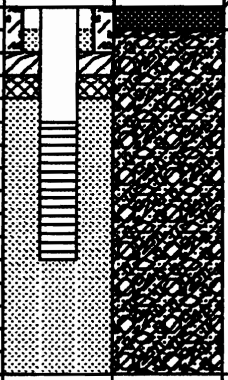
BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/10/92 CLASSIFIED BY: DWL	**EXTRACTION POINT VE-1**	
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05	
DATE STARTED: 8/10/92	LOCATION: Owego, NY	PAGE: 1 of 1	

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	PID HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5											
0										ASPHALT	
		1	0.4	2	0.0					Brown fine to coarse CLAY and fine to medium GRAVEL, some Silt, trace Clay, semi-compact, moist.	
				3							
				3							
		2	0.2	3	19.7						
				2							
				1							
				2							
		3	0.5	4	0.5						
				4							
-5				4							
				5						-Wet	
		4	1.0	8	8.3					-Grades gray, chemical odor.	
				10							
				10							
				9							
										Bottom of boring 8.0 feet.	
-10											
-15											
-20											
-25											

WELL COLUMN

GEOLOGIC COLUMN



NOTES:

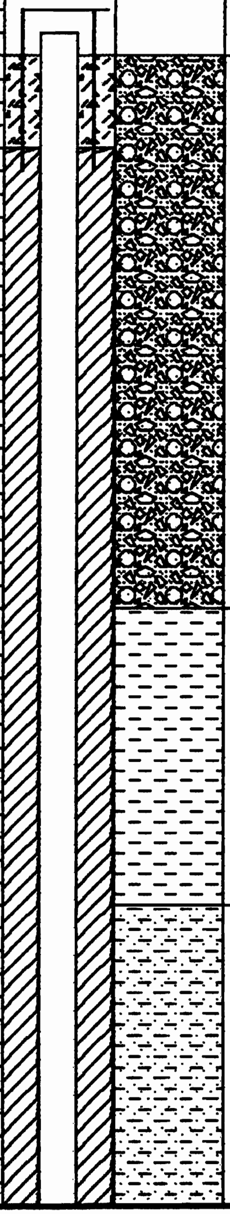
Augered through 0.5' of asphalt.

WELL CONSTRUCTION DETAILS

4-inch diameter schedule 40 PVC riser 2.5' - 0.5'
4-inch diameter, SCH 40 PVC 0.010 inch slot screen 5.5' - 2.5'
Grade 0 silica Sand pack 6.9' - 2.0'
Hydrated/bentonite seal 2.0' - 1.5'
Cement/bentonite grout 1.5' - 1.0'
Well completed with a 4-inch diameter flush mount cover set in a 1.5' diameter concrete pad.

BLASLAND, BOUCK & LEE	DATE COMPLETED 9/24/91 CLASSIFIED BY: PDD/JDD	**WELL MW-18**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/23/91	LOCATION: Owego, NY	PAGE: 1 of 3

SUBSURFACE LOG



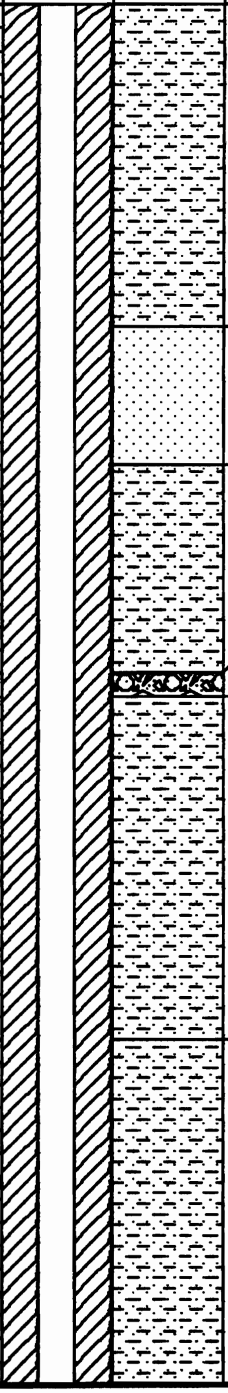
			SOIL DATA			ROCK DATA							
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5													
0	▨	1	0.5	4	0.0							Brown fine to coarse SAND and moderately well rounded fine GRAVEL, little Silt, trace organics, barely moist, firm.	
	▨			6									
	▨			13									
	▨			17									
-5	▨	2	0.9	4	0.0							grades to same except coarse Sand, some Silt, (Gravel embedded in Silt), firm, moist.	
	▨			6									
	▨			16									
	▨			10									
-10	▨	3	1.3	13	0.0								
	▨			20									
	▨			15									
	▨			10								wet	
												Brown-gray SILT, little Clay, moist, hard.	
-15	▨	4	1.6	7	16.0							grades to same with little fine Sand, wet, medium.	
	▨			8									
	▨			7									
	▨			9									
												Green-gray fine SAND and SILT, loose to medium, saturated.	
-20	▨	5	1.4	4	0.0								
	▨			4									
	▨			6									
	▨			3									
-25													

BLASLAND, BOUCK & LEE	DATE COMPLETED 9/24/91 CLASSIFIED BY: PDD/JDD		**WELL MW-18**
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/23/91	LOCATION:	Owego, NY	PAGE: 2 of 3

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
25	▨	6	1.6	4	0.0					Green-gray fine SAND and SILT, loose to medium dense, saturated.	
	▨			4							
	▨			6							
	▨			6							
30	▨	7	1.3	WOH	1.0						
	▨			4							
	▨			5							
	▨			4							
										Dark brown fine SAND, with trace brown-red banding (oxidation) loose, wet.	
35	▨	8	1.3	3	0.0					Green-gray fine SAND and SILT, saturated, loose to medium dense.	
	▨			5							
	▨			4							
	▨			3							
										Brown coarse SAND and fine moderately well rounded GRAVEL, saturated, firm.	
40	▨	9	1.5	8	2.0					Brown SILT and very fine SAND, some coarse Sand embedded, saturated, hard.	
	▨			10							
	▨			16							
	▨			8							
45	▨	10	1.3	27	6.0					Grades to same with some fine angular Gravel embedded, saturated.	
	▨			28							
	▨			22							
	▨			23							
										Brown SILT and very fine SAND, some coarse Sand, saturated, firm.	
50	▨	11	1.4	8	2.0					Brown-green Silt and very fine Sand, some coarse Sand and fine Gravel (moderately well rounded,) saturated, very compact.	
	▨			23							
	▨			29							
	▨			35							
55											

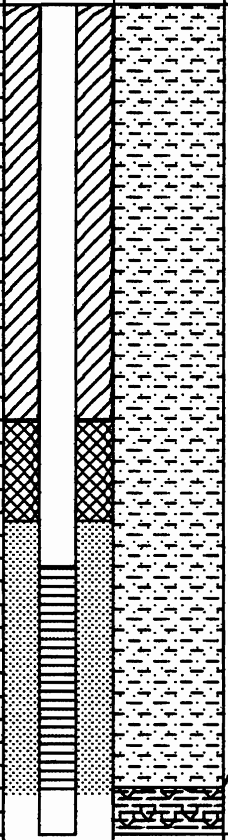
WELL COLUMN GEOLOGIC COLUMN



BLASLAND, BOUCK & LEE	DATE COMPLETED 9/24/91	WELL MW-18
	CLASSIFIED BY: PDD/JDD	
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/23/91	LOCATION: Owego, NY	PAGE: 3 of 3

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)
55	▨	12	1.2	8 23 38 42	9.0				
60	▨	13	1.6	8 14 18 24	1.0				
65	▨	14	1.2	9 11 18 25	9.0				
70	▨	15	1.25	11 16 24 51	5.0				
	▨	16	1.0	60 85	2.0				
75									
80									
85									



SOIL/ROCK CLASSIFICATION

Brown-green SILT and very fine SAND, some coarse Sand, saturated, hard.

Grades to same except trace (moderately well rounded) coarse Sand embedded, wet, compact.

Same except brown-green, trace dark brown partings.

Dark gray fractured SHALE, brown Silt and fine Sand, some Clay, wet, very compact, (TILL).

Bottom of boring 73'.

WELL CONSTRUCTION DETAILS

2-inch diameter, SCH 40 PVC 0.010 inch
slot screen 72.2' - 67.2'
Blank PVC cap on bottom of screen
Grade 0 Sand - filter pack 72.2' - 66.2'
Bentonite slurry 66.2' - 64.0'
Cement/bentonite grout 64.0' - 2.0'
Well completed with steel protective
casing with aluminum locking cap.
Set in a 2 foot square
by 2 foot thick concrete pad.

ROCK FEATURES

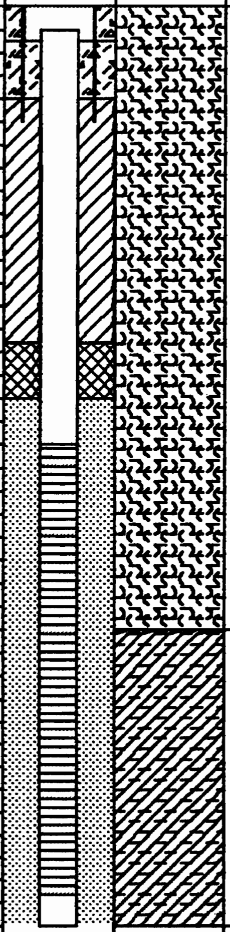
BLASLAND, BOUCK & LEE

WELL MW-19

SURFACE ELEVATION:		DATE COMPLETED	9/24/91
DATE STARTED:	9/23/91	CLASSIFIED BY:	PDD/JDD
PROJECT:	HADCO CORPORATION	PROJECT NO.:	253.05.05
LOCATION:	Owego, NY	PAGE:	1 of 2

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5											
0										Brown/gray SILT, coarse Sand and fine to medium angular Gravel, barely moist, compact. (FILL).	
-5	▨	1	0.9	12 10 37 15	30.0						
-10	▨	2	1.3	10 8 12 14	>1000					Same except yellow/brown, barely moist to moist, firm.	
										Yellow/brown SILT and CLAY, wet to saturated.	
-15	▨	3	0.7	1 1 1 1	>1000						
-20										Bottom of boring 20'.	
-25											



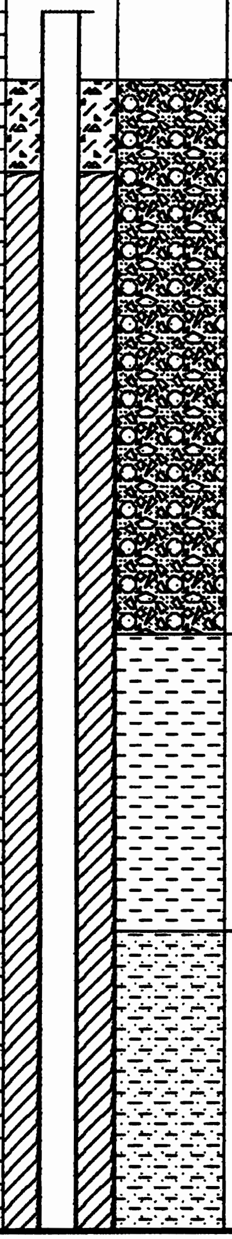
BLASLAND, BOUCK & LEE	DATE COMPLETED 9/24/91 CLASSIFIED BY: PDD/JDD	**WELL MW-19**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/23/91	LOCATION: Owego, NY	PAGE: 2 of 2

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA			ROCK DATA				WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
			RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)				
25												WELL CONSTRUCTION DETAILS 2-inch diameter, SCH 40 PVC 0.010 inch slot screen 19.5' - 9.5' Blank PVC cap on bottom of screen Grade 0 Sand pack 19.5' - 8.5' Bentonite pellet seal (hydrated) 8.5' - 7.3' Cement/bentonite grout 7.3' - 2.0' Flush mount well cover with 2 diameter inch locking PVC pressure fit cap. Well completed with 2 foot square by 2 foot thick concrete pad.	
30													
35													
40													
45													
50													
55													

BLASLAND, BOUCK & LEE	DATE COMPLETED 9/26/91 CLASSIFIED BY: PDD/JDD	**WELL MW-20**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/25/91	LOCATION: Owego, NY	PAGE: 1 of 4

SUBSURFACE LOG

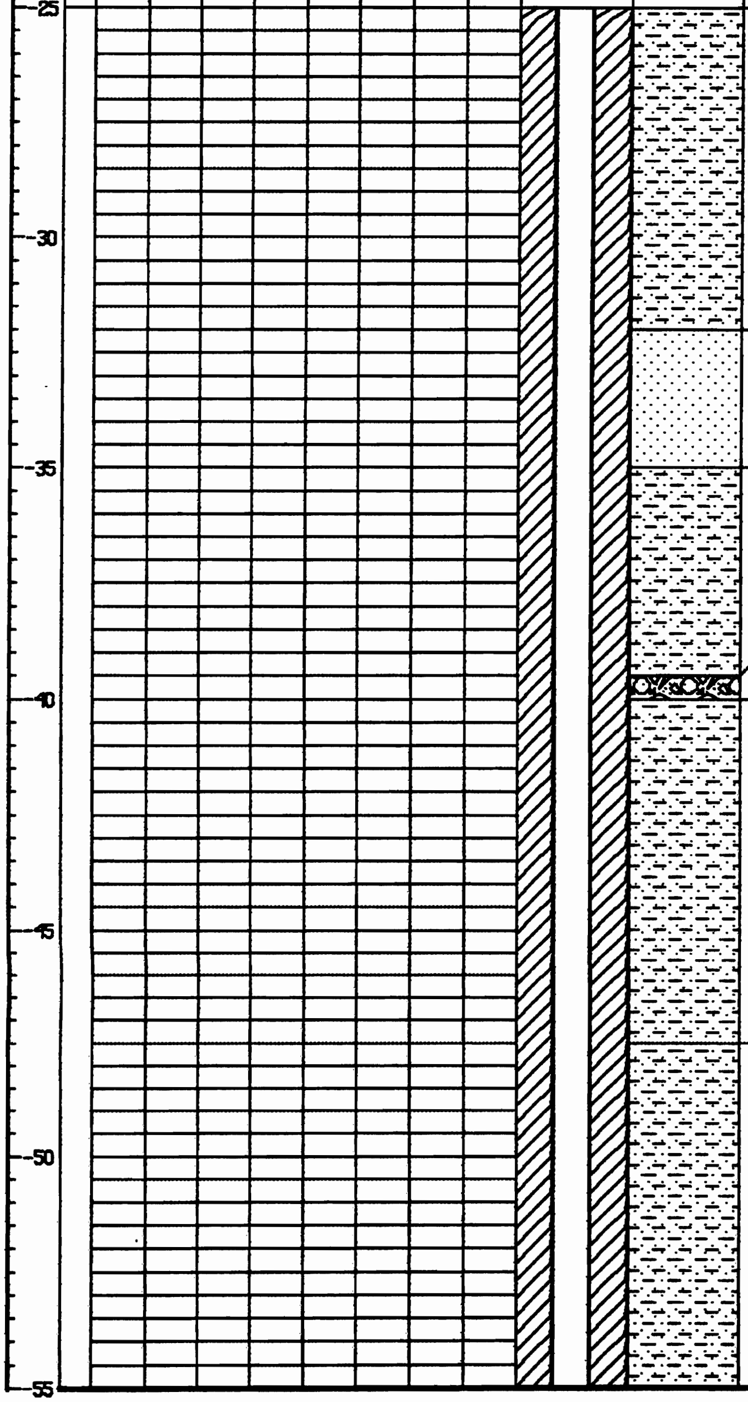


DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5											
0										Brown fine to coarse SAND and moderately well rounded fine GRAVEL, little Silt, trace organics, barely moist, firm.	
-5										grades to some except coarse Sand, some Silt, (Gravel embedded in Silt), firm, moist.	
-10										wet	
										Brown-gray SILT, little Clay, moist, hard.	
-15										grades to same with little fine Sand, wet, medium.	
										Green-gray fine SAND and SILT, loose, medium, saturated.	
-20											
-25											

BLASLAND, BOUCK & LEE	DATE COMPLETED 9/26/91 CLASSIFIED BY: PDD/JDD	**WELL MW-20**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/25/91	LOCATION: Owego, NY	PAGE: 2 of 4

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: OVA HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES



Green-gray fine SAND and SILT, loose to medium, saturated.

Dark brown fine SAND, with trace brown-red banding (oxidation) loose, wet.

Green-gray fine SAND and SILT, saturated, loose to medium.

Brown coarse SAND and fine moderately well rounded GRAVEL, saturated, firm.

Brown SILT and very fine SAND, some coarse Sand embedded, saturated, hard.

Grades to same with some fine angular Gravel embedded, saturated.

Brown SILT and very fine SAND, some coarse Sand, saturated, firm.

Brown-green Silt and very fine Sand, some coarse Sand and fine Gravel (moderately well rounded, saturated, very compact.

BLASLAND, BOUCK & LEE	DATE COMPLETED 9/30/91 CLASSIFIED BY: PDD/JDD	**WELL MW-20**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/30/91	LOCATION: Owego, NY	PAGE: 4 of 4

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
-85						89.8				Dark gray fine grained SILTSTONE, soft.	45
									15		HZ.
									15		HZ.
									15		
									15		VF HZ
						89.8	100	23			
						94.8			10		
-90											
									10		
									10		
									10		HF. HF. HF.
									10		
						94.8	100	19			
						98.8			9		
-95											
									9		
									9		
									8		
										Bottom of boring 98.8'.	
-100											
-105											
-110											
-115											

WELL CONSTRUCTION DETAILS

4 inch diameter black iron casing
set from 78.8' to 0.5 feet above ground.
Cement/bentonite grout 78.8' - 2.0'
3.9" diameter open corehole 98.8' - 78.8'
Well completed with 4" dimeter locking cap.

DRILLING PROCEDURE

Augered through overburden material to 78.8 feet using 4 1/4 inch I.D. hollow stem augers.
Cored from 78.8' - 98.8' using HX core barrel

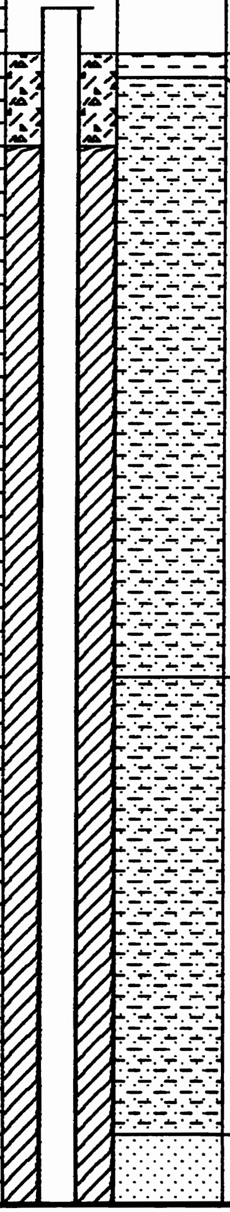
NOTES:

Description of overburden materals based on samples collected from adjacent borehole MW-18.

BLASLAND, BOUCK & LEE	DATE COMPLETED 9/30/91 CLASSIFIED BY: PDD/JDD		**WELL MW-21**
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/27/91	LOCATION:	Owego, NY	PAGE: 1 of 3

SUBSURFACE LOG

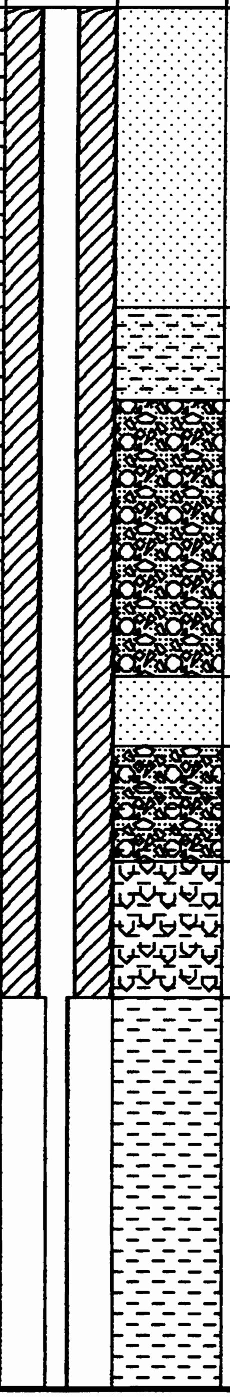
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA			ROCK DATA				SOIL/ROCK CLASSIFICATION	ROCK FEATURES
			RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)		
5											
0	▨	1	1.3	6 17 37 24	0.1					Dark brown SILT, some coarse Sand and subangular fine Gravel, moist, hard Dark brown SILT and very fine SAND, some coarse Sand and subangular fine Gravel embedded, barely moist, very hard.	
-5	▨	2	1.25	14 18 16 17	0.7					grades to some with trace subangular medium Gravel, hard.	
-10	▨	3	1.6	50 40 42 20	1.3					Grades to some with trace fine Gravel and little coarse Sand, very hard.	
										Dark brown SILT and fine to medium SAND, little coarse Sand and trace moderately well rounded fine Gravel, wet, stiff.	
-15	▨	4	1.35	12 8 10 14	6.5						
-20	▨	5	0.6	14 12 12 10	10.7					grades to some with some moderately well rounded fine Gravel.	
										Light brown medium to coarse SAND, wet, firm.	
-25											



BLASLAND, BOUCK & LEE	DATE COMPLETED 9/30/91 CLASSIFIED BY: PDD/JDD		**WELL MW-21**
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 253.05.05
DATE STARTED: 9/27/91	LOCATION:	Owego, NY	PAGE: 2 of 3

SUBSURFACE LOG

DEPTH (FT)	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	AVERAGE RATE (MIN./FT)
25	6	2.0	10	8.7				
			12					
			15					
			16					
30	7	1.9	11	7.1				
			15					
			15					
			14					
35	8	0.85	12	4.9				
			12					
			15					
			19					
40	9	1.3	17	3.9				
			20					
			35					
			50					
45	10	0.2	50	7.9				
			/0.2					
					46.5	100	42	7
					49.5			
								4
								9
50					49.5	71	32	
					53.5			
								13
								10
								10
					53.5	96	43	11
					58.5			
55								17



SOIL/ROCK CLASSIFICATION

Light brown medium and coarse SAND, wet, firm. Grades to fine to medium Sand, trace Silt, trace coarse Sand and fine Gravel.

Grades to fine to medium Sand.

Brown SILT and fine SAND, little moderately well rounded fine to medium Gravel, wet, firm.

Brown subangular fine to meduim GRAVEL, little fine Sand, trace Silt and dark brown staining (natural) wet, firm.

Brown fine to medium SAND, trace Gravel, wet, very compact.

Brown SILT and subangular fine GRAVEL, moist, hard.

Gray SILT, little fine Sand, some angular fine Gravel, (shale fragments), wet, hard (BASAL TILL).

Dark gray fine grained SILTSTONE, soft.

Trace fossils at 49.5 feet.

ROCK FEATURES

H.F. I
is

HF
HF
HF

VF
IS

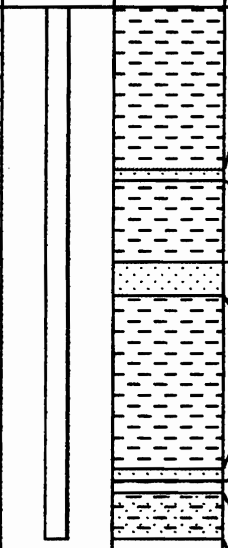
BLASLAND, BOUCK & LEE	DATE COMPLETED 9/30/91 CLASSIFIED BY: PDD/JDD	**WELL MW-21**	
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 253.05.05	
DATE STARTED: 9/27/91	LOCATION: Owego, NY	PAGE: 3 of 3	

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)
55									
									18
									17
									13
						58.5 63.5	100	77	15
									13
60									
									12
									15
									13
						63.5 66.5	98	62	10
									10
65									
									10
70									
75									
80									
85									

WELL COLUMN

GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

Dark gray fine grained SILTSTONE, soft.

Light gray fine SANDSTONE, (calcareous cement), some fossils, medium hard.

Dark gray fine grained SILTSTONE, trace vertical calcite veins, soft.

Light gray fine SANDSTONE, calcareous cement, medium hard.

Dark gray fine grained SILTSTONE, soft. Grades to medium grained, light gray.

Light gray fine SANDSTONE, calcareous cement, medium hard.

Dark gray fine grained SILTSTONE, soft.

Light gray fine SANDSTONE, some dark gray fine grained SILTSTONE, layers.

Bottom of corehole 66.5'.

ROCK FEATURES

V.F.
M 15
HF
HF
M'
VF
IS

WELL CONSTRUCTION DETAILS

4 inch diameter black iron casing
set from 46.5 to 0.2' below grade
Cement/bentonite grout 64.5' - 2.0'
3.9" diameter open corehole 46.5' - 66.5'
Well completed with 2 foot square by 2 foot
thick concrete pad. Flush mount cover
with 4 inch diameter locking pressure cap.

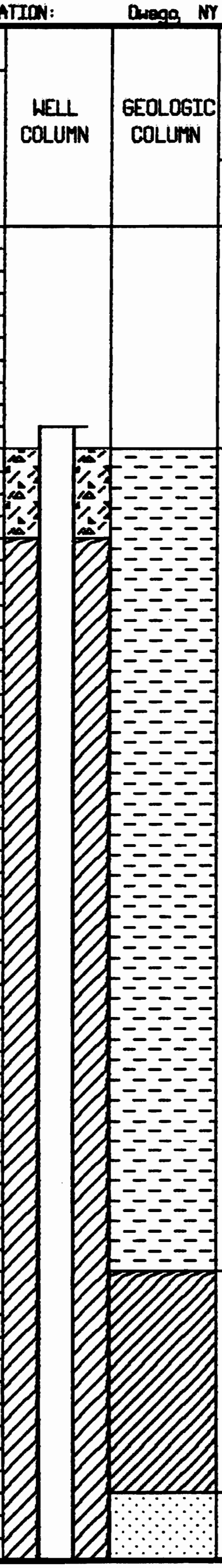
DRILLING PROCEDURE

Augered through overburden material to
46.5 feet using 4 1/4 inch I.D. hollow
stem augers.
Cored from 46.5' - 66.5' using HX core
barrel

BLASLAND, BOUCK & LEE	DATE COMPLETED: / /91 CLASSIFIED BY: PDD/JDD	**WELL MW-22**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/30/91	LOCATION: Owego, NY	PAGE: 1 of 5

SUBSURFACE LOG

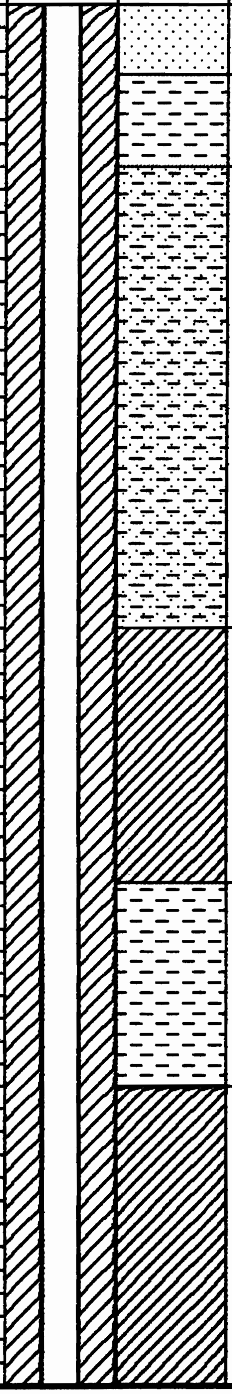
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5											
0	▩	1	2.0	8 10 10 15	0.0					Dark brown SILT, some coarse Sand, some fine Gravel, trace organics, barely moist, stiff. Grades to Silt, fine Sand and subangular fine Gravel.	
-5	▩	2	1.1	17 30 38 25	0.0						
-10	▩	3	0.9	3 5 7 9	0.0					Grades to alternating Silt and fine Sand trace Clay, wet.	
-15	▩	4	1.3	3 4 5 4	0.0						
										Red/brown CLAY, trace Silt, moist, soft.	
-20	▩	5	0.7	1 2 1 2	0.0						
										Gray fine SAND, wet, loose.	
-25											



BLASLAND, BOUCK & LEE	DATE COMPLETED	/ /91	**WELL MW-22**	
	CLASSIFIED BY:	PDD/JDD		
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.:	263.05.05
DATE STARTED: 9/30/91	LOCATION:	Owego, NY	PAGE:	2 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % ROD	ROCK DATA AVERAGE RATE (MIN./FT)
-25	▨	6	0.5	5	0.1				
	▨			3					
	▨			4					
	▨			4					
-30	▨	7	1.1	4	0.2				
	▨			5					
	▨			5					
	▨			7					
-35	▨	8	1.5	4	0.3				
	▨			4					
	▨			4					
	▨			4					
-40	▨	9	2.0	3	0.2				
	▨			3					
	▨			4					
	▨			7					
-45	▨	10	1.0	5	0.2				
	▨			7					
	▨			7					
	▨			8					
-50	▨	11	2.0	2	0.7				
	▨			3					
	▨			6					
	▨			7					
-55									



SOIL/ROCK CLASSIFICATION

Gray fine SAND, wet, loose.

Red/brown SILT, some Clay, wet.

Red/brown SILT and fine SAND, little Clay, wet.

Gray fine SAND and red/brown CLAY (alternating layers), wet, medium stiff.

Gray SILT, some Clay, wet, medium.

Red/brown fine SAND and CLAY, trace Silt, wet, medium stiff.

Same except fine Sand and Clay alternate.

ROCK FEATURES

BLASLAND, BOUCK & LEE	DATE COMPLETED: / /91 CLASSIFIED BY: PDD/JDD	**WELL MW-22**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/30/91	LOCATION: Owego, NY	PAGE: 3 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
-55		12	1.8	4 5 5 6	0.3							Red/brown fine SAND and CLAY, trace Silt, wet, medium.	
-60		13	2.0	4 6 6 8	0.5								
-65		14	0.9	6 6 10 11	0.4							Grades to fine Sand, trace Clay, firm.	
												Red/brown fine SAND, firm wet.	
-70		15	1.6	6 7 7 10	0.4								
-75		16	0.3	9 16 16 15	0.5							Light brown SILT and fine SAND, wet, hard. Grades to Silt, some Sand.	
-80		17	1.7	10 15 19 22	1.6								
-85													

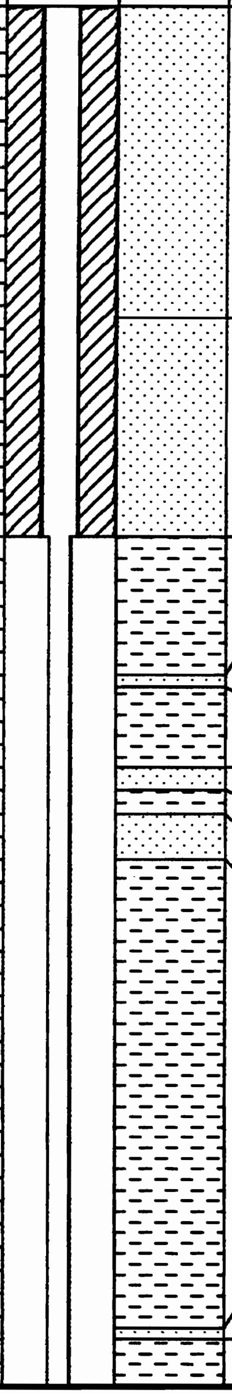
BLASLAND, BOUCK & LEE	DATE COMPLETED / /91		**WELL MW-22**
	CLASSIFIED BY: PDD/JDD		
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 253.05.05
DATE STARTED: 9/30/91	LOCATION:	Owego, NY	PAGE: 4 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)
85	18	1.6	7	0.8				
			9					
			10					
			13					
90	19	1.7	28	0.6				
			18					
			10					
			16					
95	20	NR	50/0.	NA				
					96.8	80	22	15
					101.8			
								11
								15
100								8
								12
					101.8	100	80	10
					106.8			
								13
								11
105								10
								11
					106.8	100		11
					111.8			
								14
								12
110								15
								15
					111.8	100	33	15
					116.8			
								15
								13
115								12

WELL COLUMN

GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

Brown fine SAND, some Silt, wet, firm.

Grades to very fine Sand, some Silt, wet, firm.

Grades to very fine Sand and Silt, trace Shale fragments

Brown medium to coarse SAND, some Shale fragments, little Silt.

Dark gray fine grained SILTSTONE, soft.

Light gray fine grained SANDSTONE, gray Silt clasts, calcarous cement, medium hard.

Dark gray fine grained SILTSTONE, soft.

Light gray fine SANDSTONE, fossils and Clasts.

Dark gray fine grained SILTSTONE, soft.

Light gray fine SANDSTONE, medium hard.

Dark gray fine grained SILTSTONE, soft.

Light gray fine SANDSTONE, medium hard.

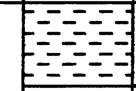
Dark gray fine grained SILTSTONE, soft.

ROCK FEATURES

HF
IS
IF
HF
IS
VF
VF
HF
HF
HF
HF
VF
BKZN
HF
HB
VF
VF
HZ
HI
VF
HF
VF
HF
BRZN

BLASLAND, BOUCK & LEE	DATE COMPLETED 9/30/91		**WELL MW-22**
	CLASSIFIED BY: POD/JDD		
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 253.05.05
DATE STARTED: 9/30/91	LOCATION:	Owego, NY	PAGE: 5 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA			ROCK DATA				WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
			RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)				
115									12			Dark gray fine grained SILTSTONE, soft.	HF
												Bottom of corehole 116.8'.	
120													
125													
130													
135													
140													
145													

WELL CONSTRUCTION DETAILS

4 inch diameter black iron casing
set from 96.5' to 0.5 feet above ground.
Cement/bentonite grout 96.5' - 2.0'
3.9 " diameter open corehole 116.5' - 96.5'
Well completed with 6" locking steel protective
casing set in 2 foot thick concrete pad.

DRILLING PROCEDURE

Augered through overburden material to
96.5 feet using 4 1/4 inch I.D. hollow
stem augers.
Cored from 116.5' - 96.5' using HX core
barrel

BLASLAND, BOUCK & LEE

SURFACE ELEVATION:
DATE STARTED: 9/30/91

DATE COMPLETED 10/2/91
CLASSIFIED BY: PDD/JDD
PROJECT: HADCO CORPORATION
LOCATION: Owego, NY

WELL MW-23

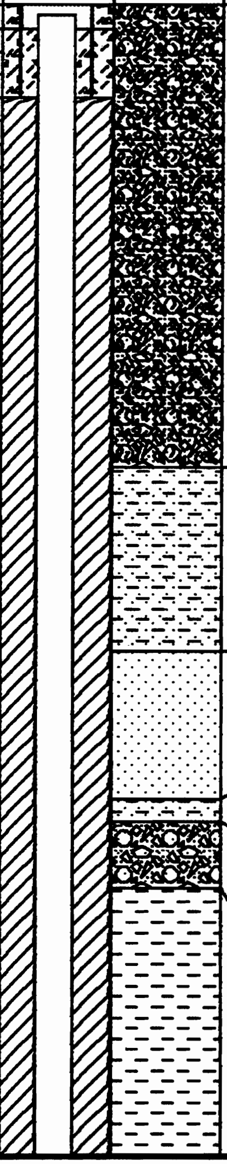
PROJECT NO.: 253.05.05
PAGE: 1 of 2

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	AVERAGE RATE (MIN./FT)
5									
0									
	▩	1	0.85	12	1.2				
	▩			11					
	▩			6					
	▩	2	0.4	6	0.2				
	▩			6					
	▩			4					
	▩			5					
	▩	3	0.4	6	14.7				
	▩			1					
-5	▩			29					
	▩			14					
	▩	4	1.0	15	2.7				
	▩			17					
	▩			19					
	▩			21					
	▩	5	1.0	16	>1000				
	▩			26					
	▩			29					
	▩			38					
-10	▩	6	0.9	10	>1000				
	▩			12					
	▩			9					
	▩			5					
	▩	7	0.9	3	>1000				
	▩			12					
	▩			11					
	▩			12					
	▩	8	1.0	6	>1000				
	▩			5					
-15	▩			7					
	▩			7					
	▩	9	1.6	5	498				
	▩			7					
	▩			15					
	▩			17					
	▩	10	0.9	6	>1000				
	▩			8					
	▩			7					
	▩			7					
-20	▩	11	1.0	6	>1000				
	▩			11					
	▩			18					
	▩			12					
	▩	12	0.7	19	338				
	▩			28					
	▩			22					
	▩			18					
	▩	13	0.9	12	118				
-25	▩			15					

WELL COLUMN

GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

Brown fine subangular GRAVEL and coarse SAND, some Silt, barely moist, firm. (FILL).

Grades wet.

Brown fine SAND and SILT, trace coarse Sand, wet, firm, some brown staining, (odor).

grades to same except some coarse Sand and moderately well rounded fine gravel. Light brown.

Dark brown fine to medium SAND, little Silt, wet, firm, some yellow/brown staining, (odor).

grades to same except some Silt, no staining.

Alternating layers red SILT and light brown fine SAND

Brown coarse SAND and fine GRAVEL, some Silt, wet, firm.

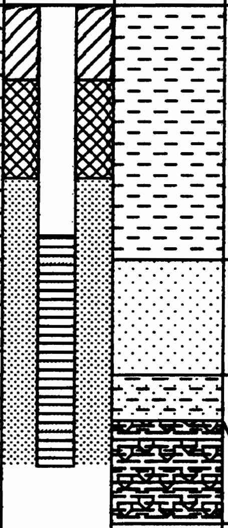
Brown/gray SILT, some fine to coarse Sand and moderatly well rounded fine Gravel, wet, medium stiff, some staining, odor.

ROCK FEATURES

BLASLAND, BOUCK & LEE	DATE COMPLETED 10/2/91 CLASSIFIED BY: PDD/JDD	**WELL MW-23**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/30/91	LOCATION: Owego, NY	PAGE: 2 of 2

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	AVERAGE RATE (MIN./FT)
25				17					
				13					
		14	0.8	12	498				
				19					
				17					
				19					
		15	0.9	10	598				
				22					
				28					
				18					
30		16	1.4	17	98				
				13					
				12					
				12					
		17	1.0	17	32				
				15					
				13					
				12					
		18	0.6	24	36				
				77/0.2					
35									
		19	0.25		14				
				100/0.25					
40									
45									
50									
55									



SOIL/ROCK CLASSIFICATION

Grades to same except no Clay, some Shale fragments.

Gray/brown fine to medium SAND, little coarse Sand, trace Silt, wet, firm.

Gray/brown SILT, some coarse SAND and moderately well rounded fine Gravel embedded, moist, hard.

(BASAL TILL) Gray SILT angular coarse SHALE fragments embedded, trace Clay, wet, hard.

Bottom of boring 35'.
Samples to 36.25'.

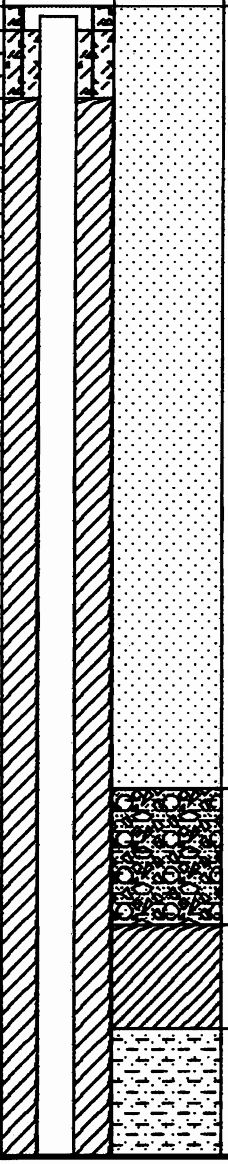
WELL CONSTRUCTION DETAILS

4-inch diameter, SCH 40 PVC 0.010 inch slotted screen 35.0' - 30.0'
Silica Sand - filter pack 35.0' - 28.75'
Bentonite pellet seal (hydrated) 28.75' - 26.6'
Cement/bentonite grout 26.6' - 2.0'
Flush mount cover with 4 inch diameter locking pressure cap.
Well completed with 2 foot square by 2 foot thick concrete pad.

ROCK FEATURES

BLASLAND, BOUCK & LEE	DATE COMPLETED 10/3/91 CLASSIFIED BY: PDD/JDD		**WELL MW-24**
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 10/2/91	LOCATION:	Owego, NY	PAGE: 1 of 3

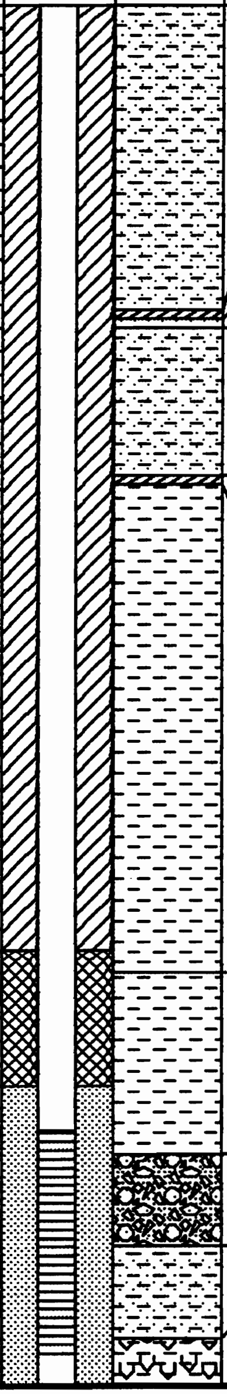
SUBSURFACE LOG



			SOIL DATA			ROCK DATA					
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5											
0											
	▒	1	0.9	13	0.8					Brown fine to coarse SAND, little to some Silt, trace to little moderately well rounded fine Gravel, moist, firm.	
				15							
				8							
	▒	2	0.9	5	1.6						
				8							
				9							
				9							
	▒	3	1.0	10	0.3						
				10							
-5				10							
				16							
	▒	4	1.0	15	0.4						
				22							
				20							
				19							
	▒	5	0.85	25	0.5						
				24							
				21							
				20							
-10	▒	6	1.0	10	85.8					Grades wet	
				13							
				12							
				16							
	▒	7	1.0	13	145.8						
				11							
				18							
				23							
	▒	8	0.85	13	195.8						
				12							
-15				12							
				18							
	▒	9	1.0	23	315.8						
				21							
				19						Gray/brown SILT and coarse SAND and fine GRAVEL, wet, compact, slight odor.	
				16							
	▒	10	0.6	8	5.2						
				9							
				8							
				9							
-20	▒	11	1.1	WOH	3.2					Light brown CLAY, trace Silt, wet, very soft.	
				1.0							
				1							
				3							
	▒	12	0.8	7	9.6					Light brown SILT and fine SAND, some coarse Sand and moderately well rounded fine Gravel, wet, firm.	
				15							
				15							
				18							
	▒	13	0.8	11	0.7						
				13							
-25											

BLASLAND, BOUCK & LEE			WELL MW-24
	DATE COMPLETED	10/3/91	
	CLASSIFIED BY:	PDD/JDD	
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 253.05.05
DATE STARTED: 10/2/91	LOCATION:	Owego, NY	PAGE: 2 of 3

SUBSURFACE LOG



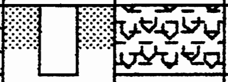
DEPTH (FT)	SOIL DATA				ROCK DATA				SOIL/ROCK CLASSIFICATION	ROCK FEATURES
	SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)		
-25			18						Light brown SILT and fine SAND, some coarse Sand and moderately well rounded fine Gravel embedded, wet, compact.	
			18							
	14	0.8	18	0.6						
			18							
			17							
			20						Grades firm.	
	15	0.9	9	1.5						
			12							
			12							
			12							
-30	16	0.4	8	13.5					Brown CLAY, trace Silt. wet, stiff.	
			13							
			12							
			11						Brown/gray SILT and fine to coarse SAND, wet.	
	17	0.2	12	0.5					Light brown SILT and fine SAND, some coarse Sand and moderately well rounded fine Gravel, wet, compact.	
			6							
			6							
			5							
	18	0.8	8	3.5					Grades to same with some fine to coarse Sand, trace fine Gravel.	
			11							
-35			17							
			19						Brown CLAY, trace coarse Sand, wet, hard.	
	19	0.3	12	5.5						
			11						Gray/brown SILT, some coarse Sand and fine Gravel, wet, hard.	
			13							
			15						Grades to same except with trace fine Gravel, stiff.	
	20	0.6	12	4.5						
			8							
			7							
			6							
-40	21	0.7	5	1.5					Same except red/brown Silt, stiff.	
			9							
			10							
			11							
	22	0.7	12	0.5						
			14						Grades hard.	
			17							
			17							
	23	0.7	11	3.5						
			13							
-45			14							
			13							
	24	0.9	13	6.5					Gray/brown SILT, some coarse Sand and moderately well rounded medium Gravel, wet, hard.	
			16							
			18							
			20							
	25	0.6	10	2.0						
			14							
			16							
			19							
-50	26	0.4	12	4.5					Gray medium to coarse SAND and moderately well rounded fine GRAVEL, wet, firm.	
			14							
			13							
			25							
	27	1.1	12	7.5					Brown SILT and fine to coarse SAND, moderately well rounded fine Gravel, wet, compact.	
			17							
			15							
			57						Brown/gray SILT, little fine Sand, subangular Shale fragments embedded, wet, hard (Basal TILL).	
	28	0.3		9.5						
			200/0.3							
-55										

BLASLAND, BOUCK & LEE	DATE COMPLETED 10/3/91 CLASSIFIED BY: PDD/JDD		**WELL MW-24**
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 10/2/91	LOCATION:	Owego, NY	PAGE: 3 of 3

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	AVERAGE RATE (MIN./FT)
55									
	▨	29	0.3		NA				
				247/0.5					
60									
65									
70									
75									
80									
85									

WELL COLUMN | GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

Brown/gray SILT, little fine Sand, subangular Shale fragments enbedded, wet, hard (Basal TILL).

Bottom of boring 56'.
Sampled to 56.5'.

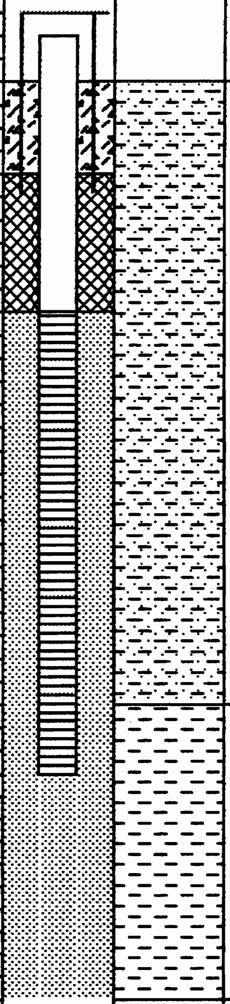
WELL CONSTRUCTION DETAILS

4-inch diameter, SCH 40 PVC 0.010 inch slot screen 54.5' - 49.5'
Grade 0 Sand - filter pack 56' - 48.5'
Bentonite slurry 48.5' - 45.5'
Cement/bentonite grout 45.5' - 2.0'
Flush mount cover with 4 inch diameter locking pressure fit cap.
Well completed with 2 foot square by 2 foot thick concrete pad.

ROCK FEATURES

BLASLAND, BOUCK & LEE	DATE COMPLETED 10/3/91		**WELL MW-25**
	CLASSIFIED BY: PDD/JDD		
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 10/3/91	LOCATION:	Owego, NY	PAGE: 1 of 2

SUBSURFACE LOG



DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5											
0	▩	1	0.8	8 6 10 12	0.0					Brown SILT and fine SAND, some fine to medium moderatly well rounded Gravel, moist, firm.	
-5	▩	2	0.6	6 4 20 17	0.0						
-10	▩	3	1.1	12 15 23 19	0.0					Grades to compact, wet.	
										Brown/tan SILT, some fine and coarse Sand and moderatly well rounded Gravel, wet, stiff.	
-15	▩	4	0.7	16 10 11 11	0.0						
-20										Bottom of boring 20'.	
-25											

BLASLAND, BOUCK & LEE	DATE COMPLETED 10/3/91 CLASSIFIED BY: PDD/JDD		**WELL MW-25**
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 10/3/91	LOCATION:	Owego, NY	PAGE: 2 of 2

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: OVA HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
-25													
-30												WELL CONSTRUCTION DETAILS 2-inch diameter, SCH 40 PVC. 0.010 inch slot screen 15.0' - 5.0'. Silica Sand pack 20.0' - 5.0'. Bentonite pellets 5.0' - 2.0'. Well completed with 4 inch diameter protective steel casing set in a 2 foot square by 2 foot thick concrete pad.	
-35													
-40													
-45													
-50													
-55													

BLASLAND, BOUCK & LEE

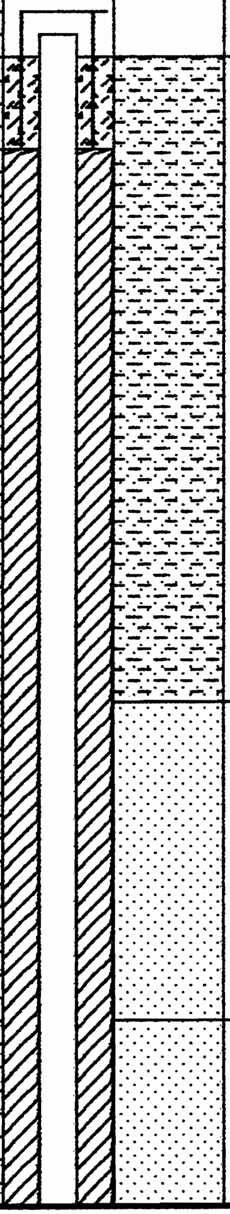
DATE COMPLETED 10/3/91
CLASSIFIED BY: PDD/JDD

WELL MW-26

SURFACE ELEVATION:
DATE STARTED: 10/3/91
PROJECT: HADCO CORPORATION
LOCATION: Owego, NY
PROJECT NO.: 263.05.05
PAGE: 1 of 3

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	AVERAGE RATE (MIN./FT)
5									
0		1	0.6	8 15 32 37	0.0				
		2	0.5	12 15 20 31	0.0				
-5		3	0.6	8 10 12 11	0.0				
		4	0.9	8 16 15 11	0.0				
		5	1.3	8 15 17 20	0.3				
-10		6	0.3	9 15 17 17	0.0				
		7	0.8	12 12 14 19	0.9				
-15		8	0.5	6 10 8 8	0.3				
		9	0.6	8 10 12 8	0.3				
		10	0.5	6 8 8 10	0.25				
-20		11	0.5	7 12 16 17	0.0				
		12	0.6	4 6 6 8	0.25				
-25		13	1.0	1 2	1.5				



SOIL/ROCK CLASSIFICATION

Brown SILT and fine to coarse SAND, little fine subangular Gravel, trace organics, moist, compact.

Grades wet.

Brown/gray medium to coarse SAND, some fine subangular Gravel, little Silt, wet, firm.

Grades to red/brown in color.

Grades to light brown in color.

Brown fine to coarse SAND, little Silt, wet, firm.

Grades loose.

ROCK FEATURES

BLASLAND, BOUCK & LEE	DATE COMPLETED 10/3/91 CLASSIFIED BY: PDD/JDD	**WELL MW-26**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 10/3/91	LOCATION: Owego, NY	PAGE: 2 of 3

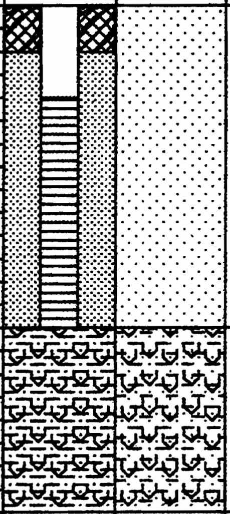
SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SOIL DATA				ROCK DATA				WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
		SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)				
25				6								Brown fine to coarse Sand, little Silt, wet.	
				10								Brown SILT and fine SAND, some fine Gravel, wet, soft	
		14	0.5	8	0.0							Brown fine to coarse SAND, some moderately well rounded Gravel, wet, hard.	
				10									
				12									
				14									
		15	1.0	3	2.25								
				4									
				8									
				14									
30		16	1.2	8	0.0								
				13									
				15									
				13								Brown SILT and fine SAND, some fine well rounded Gravel, wet, very hard.	
		17	0.8	18	0.0								
				23									
				15								Grades to same except fine to coarse Sand.	
				27									
		18	0.9	15	0.0								
				17									
35				16									
				20									
		19	0.7	13	0.0								
				20									
				27									
				35									
		20	0.6	13	0.0							Brown fine to coarse SAND, little Silt and well rounded fine Gravel, wet, compact.	
				15									
				13									
				11									
40		21	1.1	12	1.0								
				10									
				14									
				10									
		22	1.0	12	1.0								
				15									
				19									
				22									
		23	1.2	10	1.25								
				12									
45				15									
				19									
		24	1.1	13	1.25								Grades to same except some angular Shale fragments.	
				19									
				21									
				26									
		25	1.0	15									
				18									
				38									
				30									
50		26	1.2	16	0.0								
				20									
				35									
				30									
		27	0.7	20	0.0								
				25									
				32									
				26									
		28	0.7	18	0.0								
				27									
55													

BLASLAND, BOUCK & LEE	DATE COMPLETED 10/3/91 CLASSIFIED BY: PDD/JDD	**WELL MW-26**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 10/3/91	LOCATION: Owego, NY	PAGE: 3 of 3

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)
55	▨			25					
	▨			31					
	▨	29	1.2	17	0.0				
	▨			20					
	▨			28					
	▨			15					
	▨	30	1.0	10	0.0				
	▨			12					
	▨			10					
	▨			14					
60	▨	31	0.6	20	2.25				
	▨			27					
	▨			35					
	▨			62					
	▨	32	0.4		0.0				
	▨			100/0.4					
	▨								
	▨								
	▨	33	0.3	65	0.0				
	▨			/0.3					
65	▨								
	▨								
70									
75									
80									
85									



SOIL/ROCK CLASSIFICATION

Brown fine to coarse SAND, little Silt and fine Gravel (angular Shale fragments), wet, compact.

Gray fine SAND and SILT, some angular gray Shale - embedded wet, compact (BASAL TILL).

Bottom of boring 62'.
Sampled to 66'.

WELL CONSTRUCTION DETAILS

2-inch diameter, SCH 40 PVC 0.010 inch slot screen 62.0' - 57.0'
Bentonite slurry 62' - 66'
2-inch diameter schedule 40 PVC riser 57.0' - 0.5' above grade.
Grade 0 silica Sand pack 62' - 56'
Bentonite pellets 56.0' - 53.8'
Cement/bentonite grout 56.0' - 2.0'
5' 4" steel protective casing with aluminum locking cap.
Well completed with 2 foot square by 2 foot thick concrete pad.

ROCK FEATURES

BLASLAND, BOUCK & LEE

SURFACE ELEVATION:
DATE STARTED: 10/3/91

DATE COMPLETED: 10/7/91
CLASSIFIED BY: PDD/JDD
PROJECT: HADCO CORPORATION
LOCATION: Owego, NY

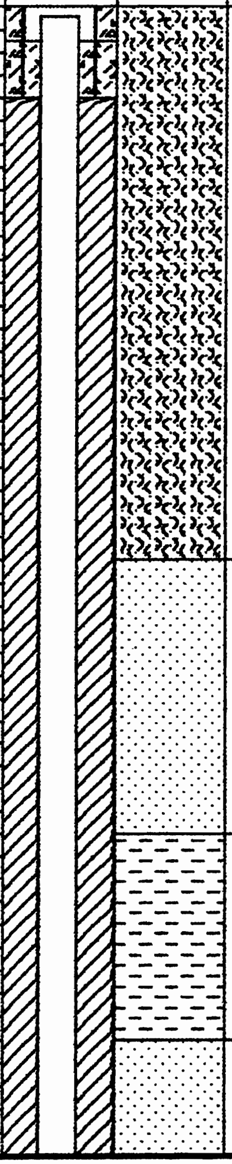
WELL MW-27

PROJECT NO.: 253.05.05
PAGE: 1 of 3

SUBSURFACE LOG

DEPTH (FT)	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	AVERAGE RATE (MIN./FT)
5								
0	1	0.5	9 11 8	0.0				
	2	0.3	9 10 6 10	0.0				
	3	1.2	14 15 14 14	0.0				
-5	4	1.2	11 12 11 11	0.0				
	5	0.8	9 11 12 14	0.8				
-10	6	1.2	11 12 13 15	39.8				
	7	0.9	15 8 8 8	59.8				
	8	1.3	11 12 13 11	12.8				
-15	9	0.9	11 12 11 12	4.8				
	10	0.3	5 1 4 6	10.8				
-20	11	0.3	11 12 14 13	6.0				
	12	0.9	18 18 16 14	25.0				
-25	13	0.6	6 12	22.0				

WELL COLUMN / GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

Light brown fine to coarse SAND, some subangular fine Gravel and Silt, moist, firm. (FILL).

Grades wet

Trace dark purple staining.

Gray fine to coarse SAND, some fine subangular Gravel, some Silt, moist, firm.

Gray SILT, some coarse Sand, and moderately well rounded fine Gravel, some red/brownClay, wet, soft.

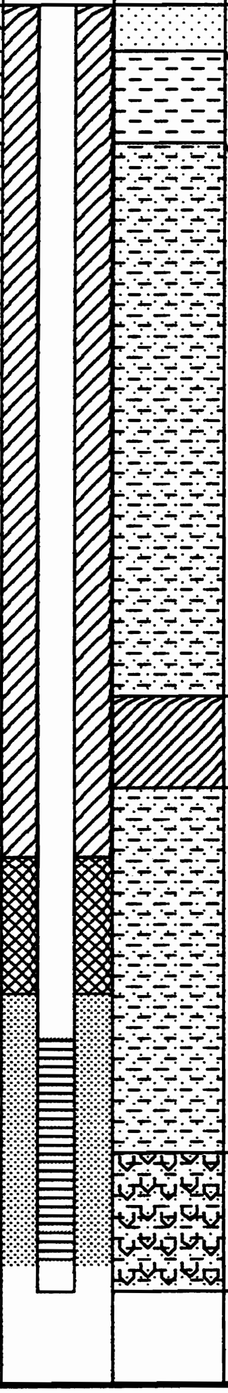
grades to stiff

Gray fine to coarse SAND, some moderately well rounded fine Gravel, some Silt, wet, compact.

ROCK FEATURES

BLASLAND, BOUCK & LEE	DATE COMPLETED 10/7/91 CLASSIFIED BY: PDD/JDD	**WELL MW-27**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 10/3/91	LOCATION: Owego, NY	PAGE: 2 of 3

SUBSURFACE LOG



			SOIL DATA			ROCK DATA					
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
-25	▨			14						Gray fine to coarse SAND, some moderately well rounded fine Gravel, some Silt, wet, compact.	
	▨			16							
	▨	14	0.8	16	12.0						
	▨			16							
	▨			19						Gray SILT, some fine to coarse Sand, little moderately well rounded fine Gravel, wet, hard.	
	▨			17							
	▨	15	0.3	9	0.2						
	▨			14							
	▨			17						Red/brown SILT and fine to coarse SAND, trace moderately well rounded fine Gravel, moist to wet, compact.	
	▨			16							
-30	▨	16	NA	NA							
	▨				NA						
	▨										
	▨										
	▨	17	NA	NA	NA						
	▨										
	▨										
	▨										
	▨	18	0.8	10	14.8						
	▨			8						Grades to same with some moderately well rounded fine Gravel embedded, wet, firm.	
-35	▨			12							
	▨			12							
	▨	19	0.6	18	4.8						
	▨			16							
	▨			19							
	▨			20							
	▨	20	1.1	10	5.8						
	▨			13							
	▨			16							
	▨			11							
-40	▨	21	0.8	10						Red/brown CLAY, wet, stiff.	
	▨			12	2.0						
	▨			13							
	▨			9							
	▨	22	0.7	9	3.0					Red/brown SILT and fine to coarse SAND, some moderately well rounded fine Gravel embedded, wet, firm.	
	▨			10							
	▨			5							
	▨			7							
	▨	23	1.0	10	3.0						
	▨			12							
-45	▨			11							
	▨			12							
	▨	24	1.0	13	1.2						
	▨			15							
	▨			22						Grades compact	
	▨			15							
	▨	25	1.0	23	0.0						
	▨			46							
	▨			80							
	▨			50							
-50	▨	26	1.2	14						Light brown SILT and fine to coarse SAND, some moderately well rounded fine Gravel enbedded, moist, very compact, (BASAL TILL).	
	▨			24	1.0						
	▨			64							
	▨										
		27	0.5	160/0.21							
	▨				0.0					Bottom of boring 53'. sampled to 53.5'.	
	▨			100/0.5							
-55											

U

BLASLAND, BOUCK & LEE	DATE COMPLETED 10/7/91 CLASSIFIED BY: PDD/JDD	**WELL MW-27**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 10/3/91	LOCATION: Owego, NY	PAGE: 3 of 3

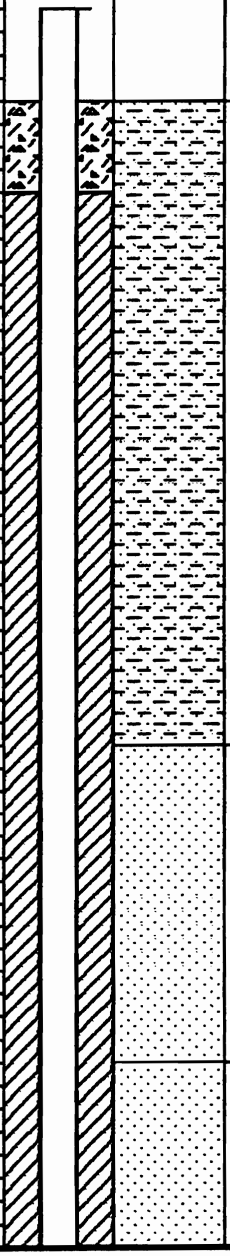
SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
-55												**WELL CONSTRUCTION DETAILS** 4-inch diameter, SCH 40 PVC 0.010 inch slotted screen 52.5' - 47.5' 0 grade Silica Sand - filter pack 52.5' - 46.5' Bentonite pellets 46.5' - 43.5' Cement/bentonite grout 43.5' - 2.0' Well completed with a flush mount cover with 4 inch diameter locking pressure cap set in a 2 foot square by 2 foot thick concrete pad.	
-60													
-65													
-70													
-75													
-80													
-85													

BLASLAND, BOUCK & LEE	DATE COMPLETED 10/3/91 CLASSIFIED BY: PDD/JDD/DWL	**WELL MW-28**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 253.05.05
DATE STARTED: 10/3/91	LOCATION: Owego, NY	PAGE: 1 of 5

SUBSURFACE LOG

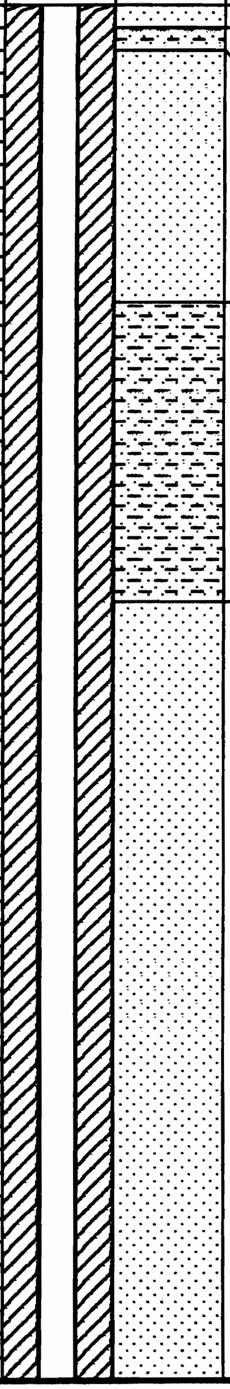
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA			ROCK DATA				WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
			RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)				
5													
0												Brown SILT and fine to coarse SAND, little fine subangular Gravel, trace organics, moist, compact.	
-5													
-10												Grades wet.	
-15												Brown/gray medium to coarse SAND, some fine subangular Gravel, little Silt, wet, firm. Grades red/brown in color.	
-20												Light brown in color. Brown fine to coarse SAND, little Silt, wet, firm. Grades loose.	
-25													



BLASLAND, BOUCK & LEE	DATE COMPLETED: //91 CLASSIFIED BY: PDD/JDD/DWL	WELL MW-28
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: //91	LOCATION: Owego, NY	PAGE: 2 of 5

SUBSURFACE LOG

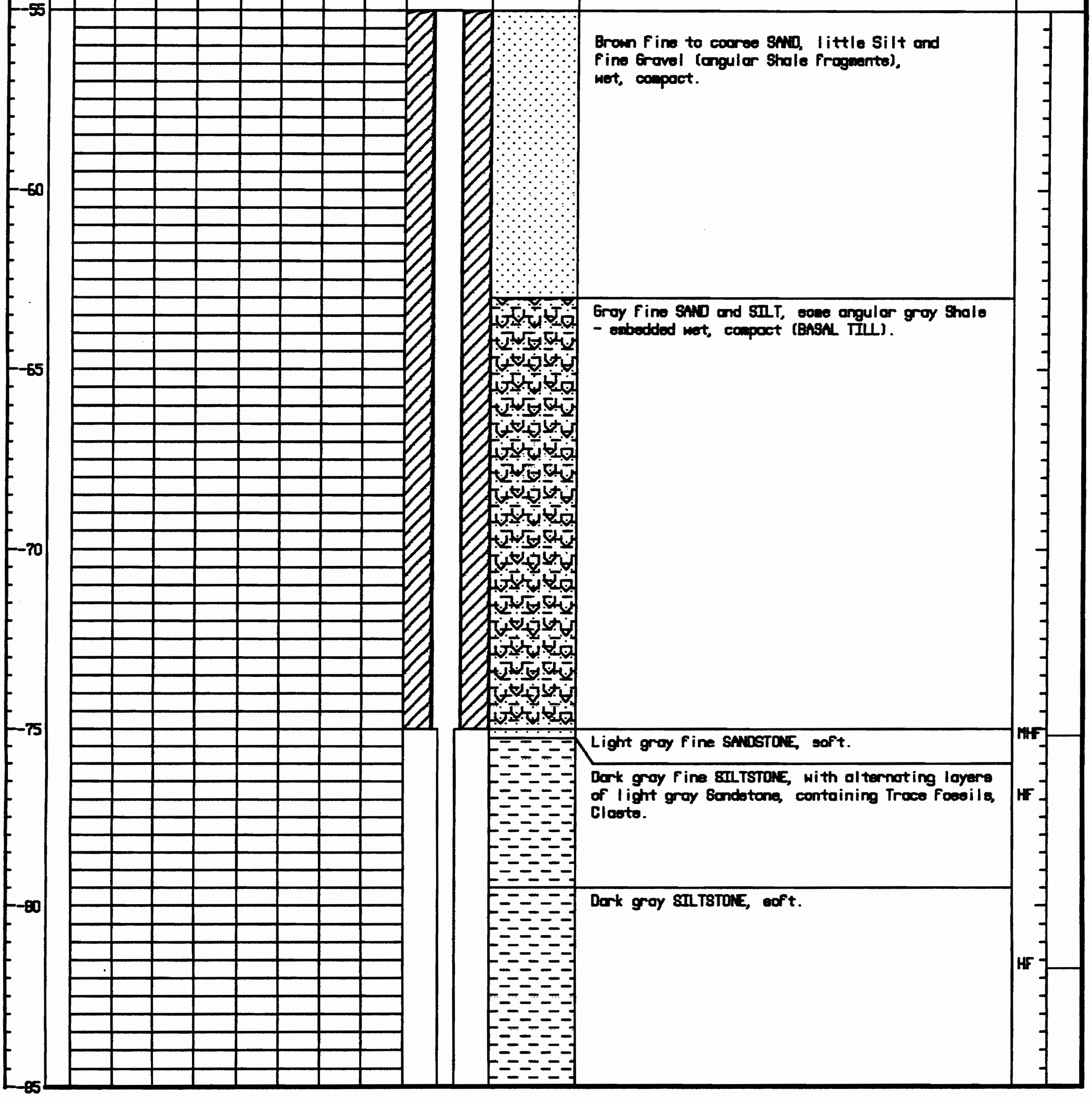
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
25												Brown fine to coarse Sand, little Silt, wet, firm.	
												Brown SILT and fine SAND, some fine Gravel, wet, soft	
												Brown fine to coarse SAND, some moderately well rounded Gravel, wet, hard.	
30													
												Brown SILT and fine SAND, some fine well rounded Gravel, wet, very hard. Grades to same except fine to coarse Sand.	
35													
												Brown fine to coarse SAND, little Silt and well rounded fine Gravel, wet, compact.	
40													
45												Grades to same except some angular Shale fragments.	
50													
55													



BLASLAND, BOUCK & LEE	DATE COMPLETED //91 CLASSIFIED BY: PDD/JDD/DWL		**WELL MW-28**
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: //91	LOCATION:	Owego, NY	PAGE: 3 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: OVA HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES



Brown fine to coarse SAND, little Silt and fine Gravel (angular Shale fragments), wet, compact.

Gray fine SAND and SILT, some angular gray Shale - embedded wet, compact (BASAL TILL).

Light gray fine SANDSTONE, soft.

Dark gray fine SILTSTONE, with alternating layers of light gray Sandstone, containing Trace Fossils, Clasts.

Dark gray SILTSTONE, soft.

BLASLAND, BOUCK & LEE	DATE COMPLETED //91 CLASSIFIED BY: PDD/JDD/DWL	**WELL MW-28**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: //91	LOCATION: Owego, NY	PAGE: 5 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA			ROCK DATA				WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
			RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)				
115													
120													
125													
130													
135													
140													
145													

WELL CONSTRUCTION DETAILS

4 inch diameter black iron casing
set from 75.0' to 2.0 feet above grade.
Cement/bentonite grout 75.0' - 2.0'
3.9" diameter open corehole 75.0' - 115.0'
Well completed with locking cap in casing
casing set in 2 foot thick concrete pad.

DRILLING PROCEDURE

Augered through overburden material to
75.0 feet using 4 1/4 inch I.D. hollow
stem augers.
Cored from 75.0' - 115.0' using HX core
barrel

NOTES:

94.5' - 115.0' interval was cored from
8/14/92 to 8/17/92

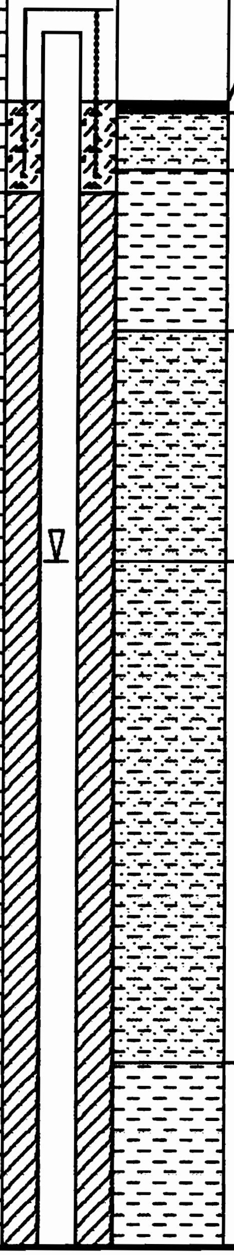
BLASLAND & BOUCK ENGINEERS, P.C.

DATE COMPLETED 8/11/92
CLASSIFIED BY: DWL

WELL MW-29

SURFACE ELEVATION:
DATE STARTED: 8/10/92
PROJECT: HADCO CORPORATION
LOCATION: Owego, NY
PROJECT NO.: 253.05
PAGE: 1 of 4

SUBSURFACE LOG



DEPTH (FT)	SAMPLES	SOIL DATA: SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5													
												Dark brown SILT and fine to coarse SAND, loose, damp, (TOPSOIL).	
0		1	1.8	9	0.0							Light brown SILT and fine to coarse SAND, some fine to medium Gravel, loose, damp.	
				10									
				7									
				3								Brown/gray SILT, some fine Sand, compact, moist.	
-5		2	2.0	13	0.0							Brown fine to coarse SAND and SILT, some fine to medium Gravel, compact, damp.	
				19									
				16									
				11									
-10		3	1.7	1	5.7							Brown SILT and fine SAND, compact, moist to wet.	
				1									
				1									
				4									
-15		4	2.0	2	9.5								
				3									
				3									
				3									
												Grades with Clay	
-20		5	1.5	WOH	0.4								
				WOH									
				1								Gray SILT, trace fine Sand, trace Clay, compact, wet.	
				2									
-25													

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/11/92 CLASSIFIED BY: DWL	# WELL MW-29
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/10/92	LOCATION: Owego, NY	PAGE: 2 of 4

SUBSURFACE LOG

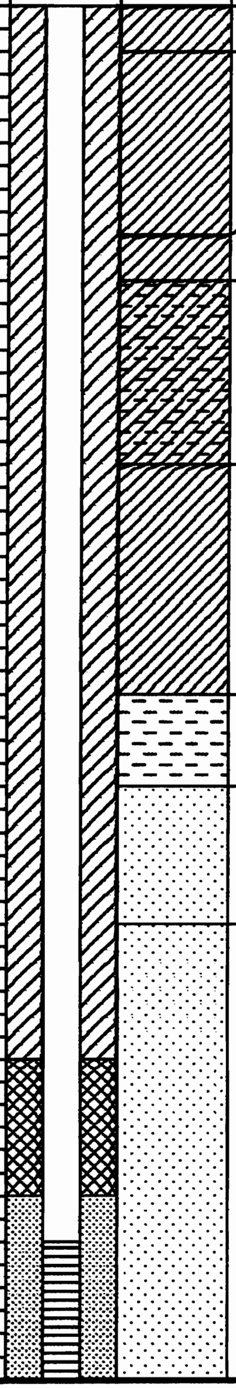
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
25		6	2.0	WOH	2.0							Brown SILT and Fine SAND, some Clay, compact, wet.	
				WOH									
				WOH								Gray SILT and fine SAND, trace Clay, laminated, compact, wet. -1-inch layer of green medium SAND.	
				2									
30		7	1.5	WOH	1.1							Gray/brown CLAY, some Silt, compact, wet.	
				WOH									
				1								Gray SILT and fine SAND, trace Clay, compact, wet.	
				2									
35		8	2.0	WOH	0.0							Gray/brown CLAY, some Silt, compact, wet. -Gray Silt lenses.	
				1									
				2									
				2									
40		9	1.8	2	0.0							Gray/brown SILT, little Clay, compact, wet.	
				2									
				2									
				2									
45		10	1.5	3	0.0							Brown/gray CLAY lense.	
				2									
				3								Brown CLAY, trace fine Sand, compact, wet.	
				5									
												Brown/gray SILT and CLAY, compact, wet.	
50		11	2.0	WOH	0.0							Brown CLAY, trace fine Sand, compact, wet. Sand and Clay lenses throughout sample.	
				2									
				3									
				4									
55													

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/11/92 CLASSIFIED BY: DWL	**WELL MW-29**	
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05	
DATE STARTED: 8/10/92	LOCATION: Owego, NY	PAGE: 3 of 4	

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)
55		12	2.0	1 3 4 5	0.0				
60		13	1.8	WOH 2 6 6	0.0				
65		14	1.5	3 3 4 6	0.0				
70		15	1.0	3 5 7 7	9.0				
75		16	1.3	2 3 5 8	10.4				
80		17	1.2	5 5 6 8	5.5				
85									

WELL COLUMN | GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

Brown CLAY, compact, wet.

Brown CLAY, some fine Sand, compact, wet.
Grades to fine SAND, some Clay, loose, wet.

Brown CLAY, compact, wet.
Fine Sand lense at 60.5 feet.

Brown/gray fine SAND, SILT, and CLAY, semi-compact, wet.

Brown SAND and CLAY layers, trace Silt, compact, wet.
Gray Sand layers.

Green SILT, compact, wet.

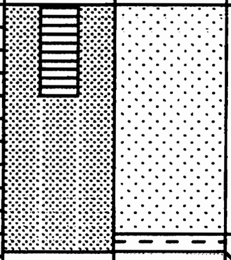
Green/black fine SAND, compact, wet.

Brown/green fine SAND, some Silt, compact, wet.

ROCK FEATURES

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/11/92 CLASSIFIED BY: DWL	**WELL MW-29**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/10/92	LOCATION: Owego, NY	PAGE: 4 of 4

SUBSURFACE LOG



DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
85		18	2.0	WOH WOH WOH 2	1.9					Brown fine SAND, some Silt, semi-compact, wet.	
90		19	NR	75/.4	—					SILT and SILTSTONE fragments, (weathered SILTSTONE)	
										Auger refusal at 90.4 feet. (Top of rock)	
95											
100											
105											
110											
115											

WELL CONSTRUCTION DETAILS

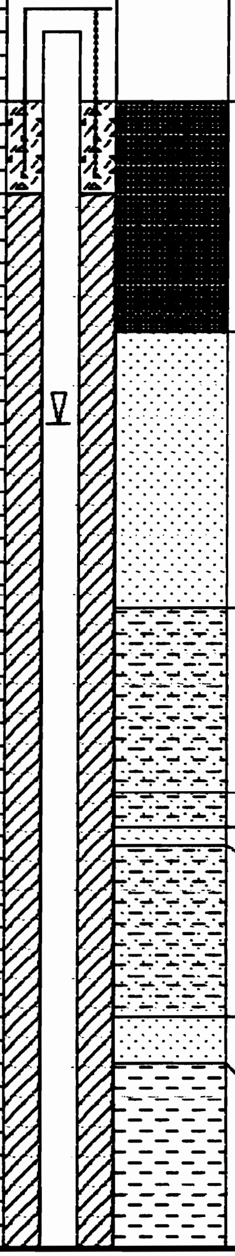
4-inch diameter schedule 40 PVC riser 82.0' to above ground surface.
4-inch diameter, SCH 40 PVC 0.020 inch slot screen 87.0' - 82.0'
Grade 0 silica Sand pack 90.4' - 81.0'
Hydrated/bentonite seal 81.0' - 78.0'
Cement/bentonite grout 78.0' - 2.0'
Cement 2.0' - 0.0'
Well completed with a steel protective casing set in a concrete pad.

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/18/92 CLASSIFIED BY: DWL	**WELL MW-30**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/17/92	LOCATION: Owego, NY	PAGE: 1 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	PID HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5											
0		1	1.5	2 2 2 4	0.0					Brown fine SAND, some Silt, trace organics, compact, moist, (TOPSOIL).	
-5		2	1.3	6 8 7 14	0.0					Brown fine SAND, some Silt, little medium to coarse Sand, trace fine to medium Gravel, compact, moist to wet.	
-10		3	1.8	3 3 4 3	0.0					Brown fine SAND and SILT, trace medium to coarse Sand, semi-compact, wet.	
-15		4	2.0	4 5 5 7	0.0					Brown fine SAND and SILT, compact, wet. Brown fine to medium SAND, loose, wet. Brown fine SAND and SILT, compact, wet.	
-20		5	1.5	4 6 9 9	0.0					Brown fine to coarse SAND, trace Silt, trace Gravel, semi-compact, wet. Light brown SILT, compact, wet.	
-25											

WELL COLUMN / GEOLOGIC COLUMN



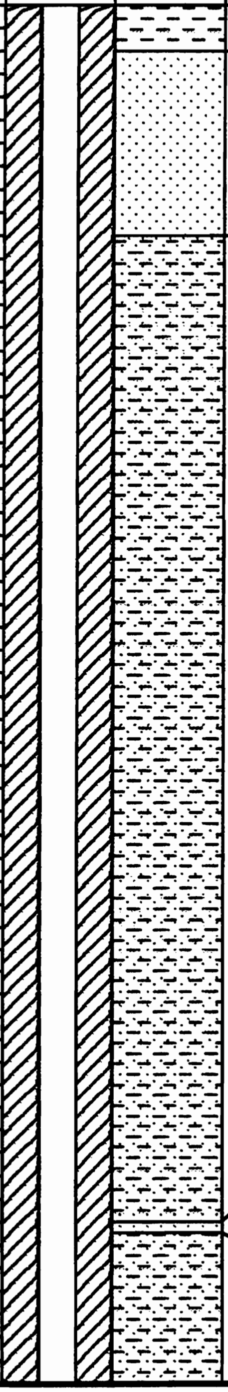
BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/18/92 CLASSIFIED BY: DWL	# WELL MW-30
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/17/92	LOCATION: Owego, NY	PAGE: 2 of 5

SUBSURFACE LOG

			SOIL DATA			ROCK DATA							
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	PID HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
25		6	1.8	2 3 5 6	0.0							Brown fine to medium SAND, little Silt, trace coarse Sand, trace Clay, very compact, wet.	
												Light brown SILT, compact, wet.	
30		7	1.8	3 3 4 3	0.0							Brown fine SAND, trace coarse Sand, trace Gravel, loose, wet.	
												Gray SILT, some fine Sand, occasional Clay lenses, semi-compact, wet.	
35		8	1.5	WOH WOH 1 2	0.0								
40		9	1.8	1 3 2 3	0.0								
45		10	1.2	3 2 3 3	0.0								
												-Grades with more fine Sand.	
50		11	1.5	3 4 5 5	0.0								
55													

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/18/92 CLASSIFIED BY: DWL	# WELL MW-30
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/17/92	LOCATION: Owego, NY	PAGE: 3 of 5

SUBSURFACE LOG



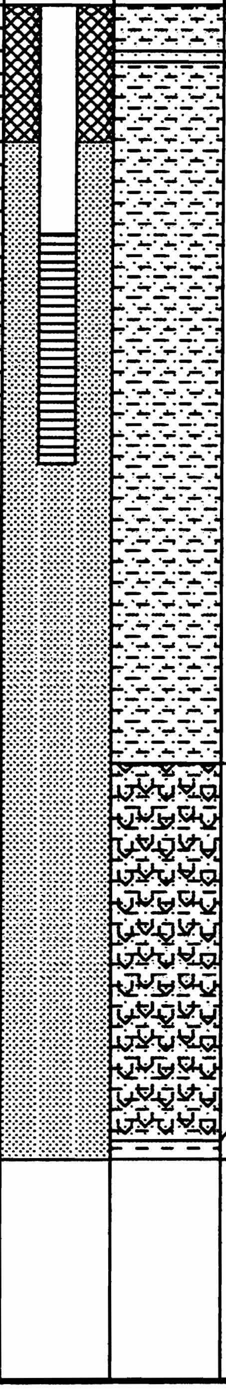
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
55		12	1.2	4 6 9 10	0.0						
										Gray fine SAND, little Silt, very compact, wet.	
60		13	1.5	6 6 6 7	0.0					Gray fine SAND and SILT, compact, wet.	
65		14	1.5	2 2 6 7	0.0						
70		15	1.3	4 5 6 6	0.0						
75		16	2.0	6 9 11 11	0.0						
80		17	2.0	4 6 7 8	0.0						
										Gray fine to coarse SAND, compact, wet.	
										Gray fine SAND and SILT, compact, wet.	
85											

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/18/92 CLASSIFIED BY: DWL	# WELL MW-30
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/17/92	LOCATION: Owego, NY	PAGE: 4 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)
85		18	1.0	3	66.8				
				4					
				4					
				4					
90		19	0.8	2	0.0				
				3					
				3					
				4					
95		20	2.0	2	45.6				
				3					
				3					
				2					
100		21	2.0	7	0.0				
				16					
				12					
				14					
105		22	1.0	18	0.0				
				16					
				17					
				18					
110		23	0.5	100	0.0				
				/.2					
115									

WELL COLUMN / GEOLOGIC COLUMN



SOIL/ROCK CLASSIFICATION

Gray fine SAND and SILT, compact, wet.

gray fine to medium SAND, compact, wet.

Gray fine SAND and SILT, compact, wet.

-Grades to more Sand.

-Grades to more Silt, trace Gravel.

Gray fine to coarse SAND and SILT, trace Gravel, compact, wet, (TILL).

-Grades to some Gravel.

Gray SILTSTONE fragments, weathered SILTSTONE.

Bottom of boring 110.2 Feet.

ROCK FEATURES

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED: 8/18/92 CLASSIFIED BY: DWL	**WELL MW-30**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/17/92	LOCATION: Owego, NY	PAGE: 5 of 5

SUBSURFACE LOG

			SOIL DATA			ROCK DATA							
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	PID HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
-115													
-120													
-125													
-130													
-135													
-140													
-145													

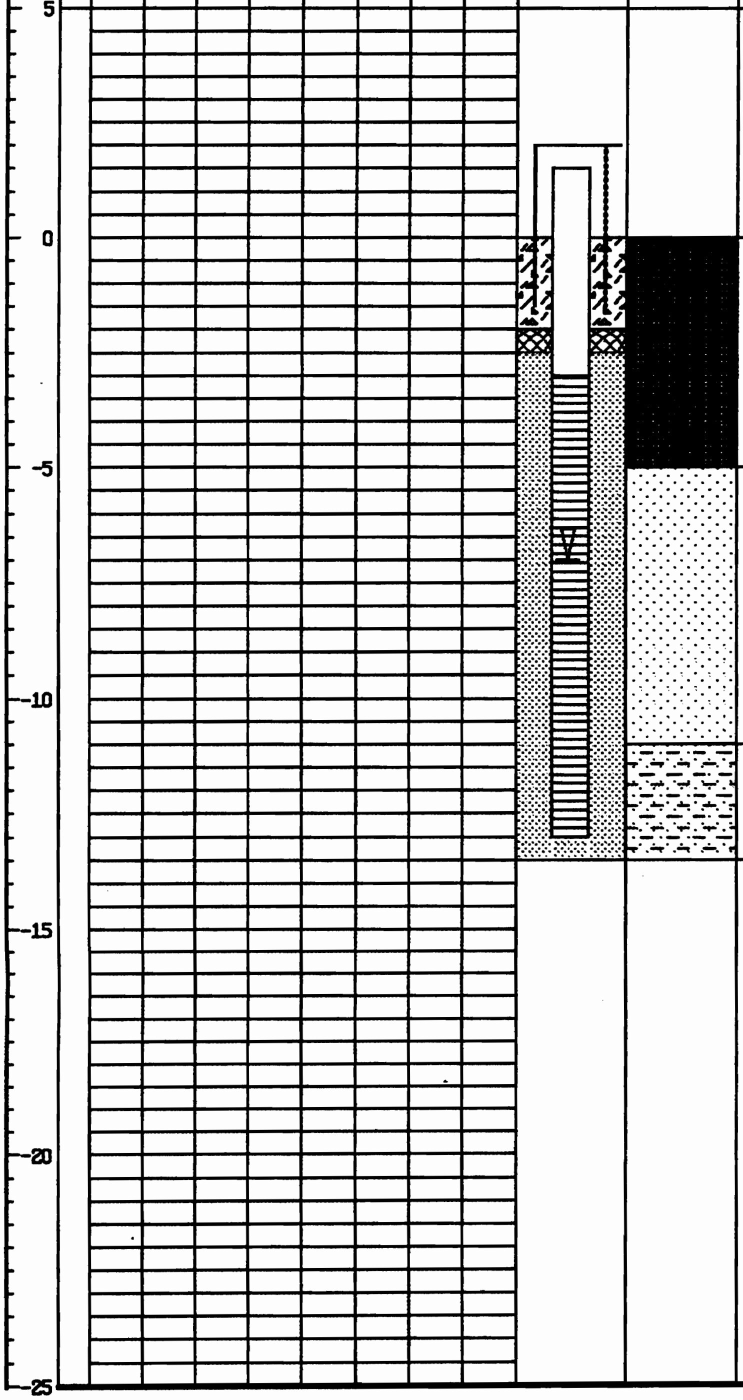
WELL CONSTRUCTION DETAILS

2-inch diameter schedule 40 PVC riser 90.0'
to above ground surface.
2-inch diameter, SCH 40 PVC 0.010 inch
slot screen 95.0' - 90.0'
Grade 0 silica Sand pack 110.2' - 88.0'
Hydrated/bentonite seal 88.0' - 85.0'
Cement/bentonite grout 85.0' - 2.0'
Cement 2.0' - 0.0'
Well completed with a steel protective casing
set in a concrete pad.

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/13/92 CLASSIFIED BY: DWL	# WELL MW-31
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/13/92	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES



Brown fine SAND, some Silt, trace organics, compact, moist, (TOPSOIL).

Brown fine SAND, some Silt, little medium to coarse Sand, trace fine to medium Gravel, compact, moist to wet.

Brown fine SAND and SILT, trace medium to coarse Sand, semi-compact, wet.

Bottom of boring 13.5 feet.

WELL CONSTRUCTION DETAILS

2-inch diameter schedule 40 PVC riser 3.0' to above ground surface.
2-inch diameter, SCH 40 PVC 0.010 inch slot screen 13.0' - 3.0'
Grade 0 silica Sand pack 13.5' - 2.5'
Hydrated/bentonite seal 2.5' - 2.0'
Cement 2.0' to ground surface.
Well completed with a steel proctective casing set in a concrete pad.

NOTES:

Augered to a depth of 13.5' with a 4 1/4-inch diameter hollow stem auger
Descriptions derived from the boring log of the adjcent well, MW-30.

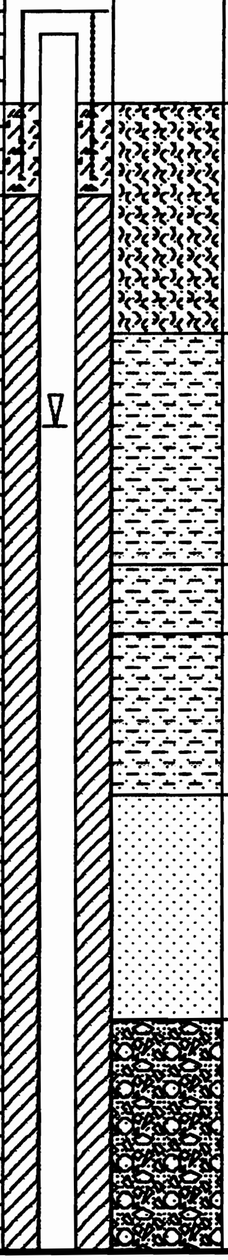
BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/19/92 CLASSIFIED BY: DWL	# WELL MW-32
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/19/92	LOCATION: Owego, NY	PAGE: 1 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
5											
0	\	1	—	—	—					Brown fine to coarse SAND, some fine to medium Gravel, trace Cobbles, loose, moist, (FILL).	
-5	\	2	0.5	4 2 3 3	0.0					Brown fine to coarse SAND and SILT, trace Gravel, compact, moist. Wet at 7.0 Feet.	
-10	\	3	1.0	1 2 3 2	19.2					Brown SILT and fine SAND, trace Clay, compact, moist.	
										Brown fine to coarse SAND and SILT, trace Clay, trace Gravel, loose, wet.	
-15	\	4	0.5	8 5 5 5	6.8					Brown fine to coarse SAND, some Silt, trace Gravel, loose, wet.	
-20	\	5	0.3	4 4 6 5	0.0					Brown fine to coarse SAND and GRAVEL, little Silt, loose, wet.	
-25											

WELL COLUMN

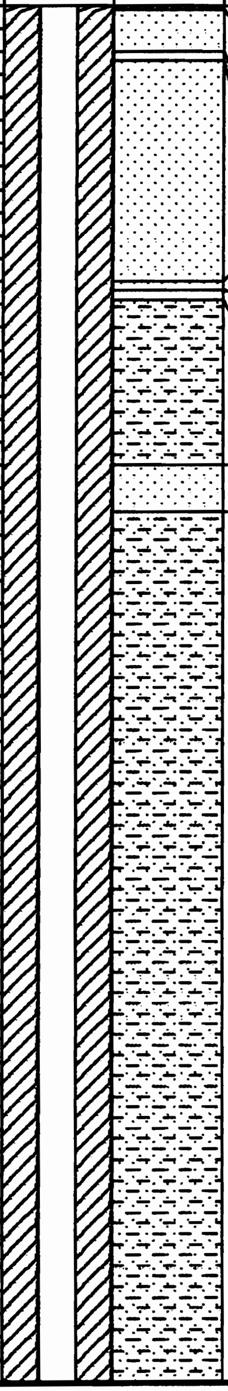
GEOLOGIC COLUMN



BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/19/92 CLASSIFIED BY: DWL		**WELL MW-32**
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/19/92	LOCATION:	Owego, NY	PAGE: 2 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	AVERAGE RATE (MIN./FT)
25		6	0.4	2 3 3 4	0.0				
30		7	1.2	3 3 3 3	3.2				
35		8	1.5	1 1 3 2	0.0				
40		9	2.0	1 2 2 2	0.0				
45		10	1.5	2 2 2 2	0.0				
50		11	1.3	1 2 1 2	0.0				
55									



SOIL/ROCK CLASSIFICATION

Brown CLAY lense, compact, wet.

Brown fine to medium SAND, little Silt, trace coarse Sand, loose, wet.

Green SILT, compact, wet.

Brown fine to medium SAND, trace Silt, trace coarse Sand, loose, wet.

Gray fine SAND and SILT, loose, wet.

Brown laminated SILT, compact, wet.

Brown fine SAND and SILT, semi-compact, wet.

Brown fine to medium SAND, trace Silt, loose, wet.

Brown fine SAND and SILT, compact, wet.
-Grades to gray.

-Clay lenses.
-Grades to more Sand.

-Clay lenses.

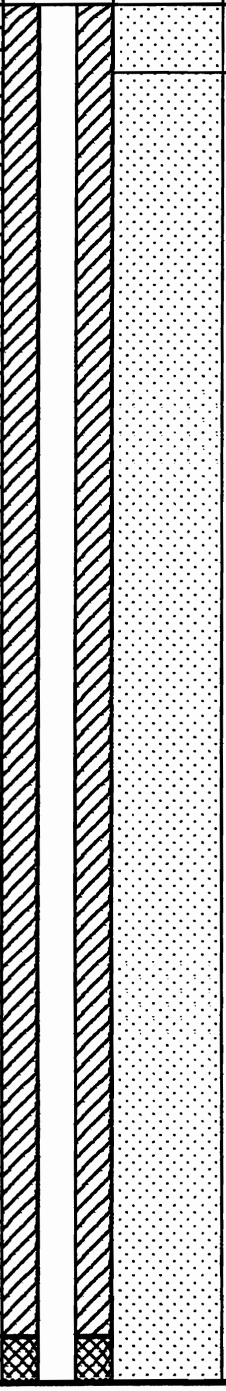
-Clay lenses.

ROCK FEATURES

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/19/92 CLASSIFIED BY: DWL	# WELL MW-32
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/19/92	LOCATION: Owego, NY	PAGE: 3 of 5

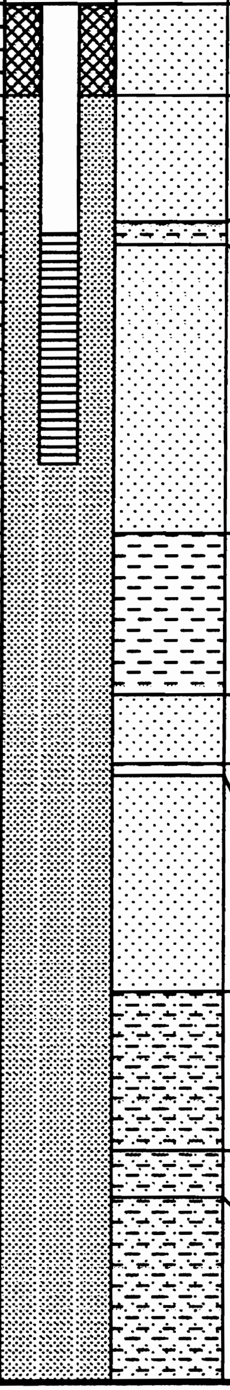
SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	BLOWS/6 IN.	PID HEADSPACE (ppm)	ROCK DATA FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
55		12	1.8	2	0.9					Brown fine to medium SAND, little Silt, loose, wet.	
				2							
				2							
				2						Gray fine SAND, some Silt, compact, wet.	
60		13	1.2	2	0.0					-Grades from brown to gray fine SAND, some Silt, compact, wet.	
				2							
				3							
				3							
65		14	0.5	1	0.0					-Grades from more Silt to more Sand.	
				2							
				1							
				2							
70		15	2.0	2	0.0					-Grades from fine SAND to fine SAND and SILT.	
				3							
				3							
				5							
75		16	1.5	1	0.0					-Grades from more Silt to more Fine Sand.	
				2							
				1							
				2							
80		17	2.0	WOH							
				WOH							
				1							
				2							
85											



BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/19/92 CLASSIFIED BY: DWL	# WELL MW-32
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/19/92	LOCATION: Owego, NY	PAGE: 4 of 5

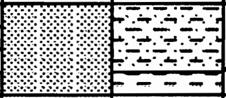
SUBSURFACE LOG



DEPTH (FT)	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
85	18	1.5	4 4 6 11	0.0					Gray fine SAND, some Silt, compact, wet. -Grades to brown fine SAND and SILT, compact, wet.	
									Brown fine to coarse SAND, some Silt, trace Gravel, compact, wet.	
									Brown fine SAND and SILT, compact, wet.	
90	19	1.6	6 10 21 24	0.0					Brown fine to coarse SAND, little Silt, trace fine to medium Gravel, compact, wet.	
95	20	1.5	6 6 11 14	0.0						
									Brown SILT, some fine Sand, Clay lense, compact, moist.	
100	21	1.4	6 8 11 8	0.0					Brown fine to medium SAND, some Silt, trace coarse Sand, compact, wet.	
									Gray SILT with Siltstone fragment, very compact, wet.	
									Brown fine to medium SAND, some Silt, compact, wet.	
105	22	1.0	4 5 6 6	0.0						
									Brown fine SAND and SILT, compact, wet.	
110	23	1.5	5 7 9 14	0.0					Gray fine to medium SAND and SILT, trace Gravel, compact, wet.	
									Gray fine SAND and SILT, compact, wet.	
115										

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/19/92 CLASSIFIED BY: DWL		# WELL MW-32
SURFACE ELEVATION:	PROJECT:	HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/19/92	LOCATION:	Owego, NY	PAGE: 5 of 5

SUBSURFACE LOG



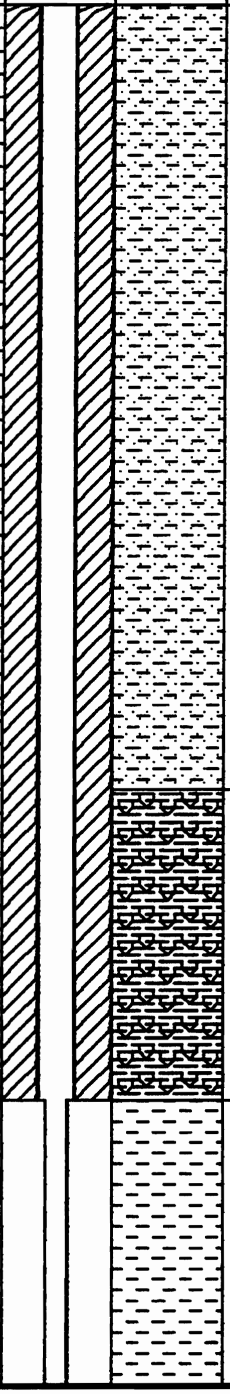
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % ROD	ROCK DATA AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
115		24	1.0	35	0.0							Gray fine SAND and SILT, compact, wet.	
				30									
				32								Weathered SILTSTONE.	
				43									
												Bottom of boring 117.0 feet.	
120													
125													
130													
135													
140													
145													

WELL CONSTRUCTION DETAILS

2-inch diameter schedule 40 PVC riser 90.0' to above ground surface.
2-inch diameter, SCH 40 PVC 0.010 inch slot screen 95.0' - 90.0'
Grade 0 silica Sand pack 117.0' - 87.0'
Hydrated/bentonite seal 87.0' - 84.0'
Cement/bentonite grout 84.0' - 2.0'
Cement 2.0' - 0.0'
Well completed with a steel protective casing set in a concrete pad.

BLASLAND, BOUCK & LEE	DATE COMPLETED: 9/26/91 CLASSIFIED BY: PDD/JDD	**WELL MW-20**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: 9/25/91	LOCATION: Owego, NY	PAGE: 3 of 4

SUBSURFACE LOG



			SOIL DATA			ROCK DATA					
DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	RECOVERY (FT)	BLOWS/6 IN.	OVA HEADSPACE (ppm)	FROM/TO	% RECOVERY	% RQD	AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
-55										Brown-green SILT and very fine SAND, some coarse Sand, saturated, hard.	
-60										Grades to same except trace (moderately well rounded) coarse Sand embedded, wet, compact.	
-65										Same except brown-green, trace dark brown partings.	
-70											
										Dark gray fractured SHALE, brown Silt and fine Sand, some Clay, wet, very compact, (TILL).	
-75											
						78.8	97	37	NA		
						81.8				Bedrock at 78.8' dark gray fine grained SILTSTONE, soft.	
									10		HF
-80											
									8.5		HF
						81.8	93	0.0	15		
						84.8					VF 45
									14		
									15		
						84.8	98	17	16		VF
-85											

BLASLAND, BOUCK & LEE	DATE COMPLETED //91 CLASSIFIED BY: PDD/JDD/DWL	**WELL MW-28**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05.05
DATE STARTED: //91	LOCATION: Owego, NY	PAGE: 4 of 5

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA OVA HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)
85									
90									
						94.5	50	100	10
						95.0			
95						95.0	77	100	9
						100.0			
									6
									5
									4
									5
100						100.0	104	100	6
						105.0			
									6
									6
									7
									5
105						105.0	97	100	-
						110.0			
									-
									5
									8
									10
110						110.0	102	100	8
						115.0			
									7
									9
									8
									9
115									

WELL COLUMN

GEOLOGIC COLUMN

SOIL/ROCK CLASSIFICATION

Dark gray SILTSTONE, soft.

Light gray fine grained SANDSTONE, medium hard.

Dark gray SILTSTONE, soft.

Light gray fine grained SANDSTONE, medium hard.

Dark gray SILTSTONE, soft.

Bottom of boring 115.0'.

ROCK FEATURES

HF

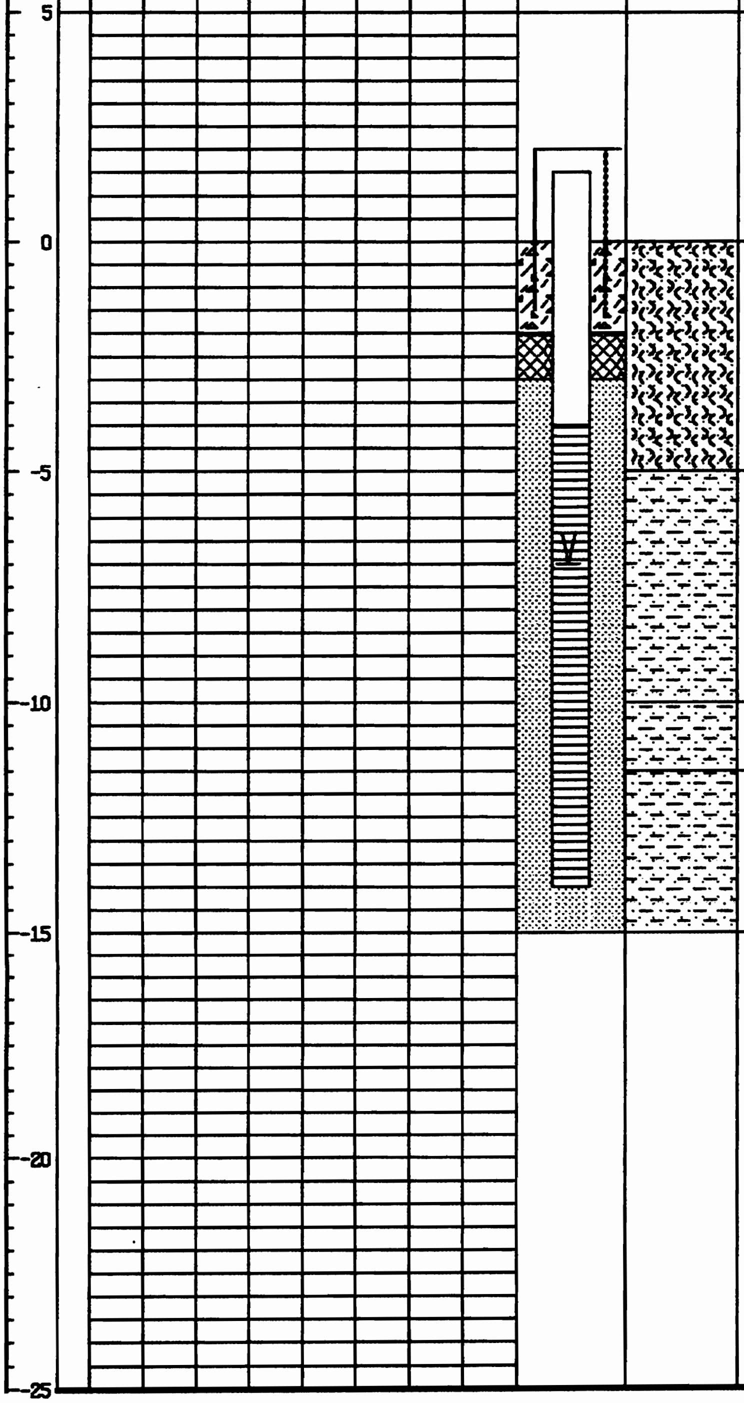
VF
35

J45//F

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/19/92 CLASSIFIED BY: DWL	# WELL MW-33
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/19/92	LOCATION: Owego, NY	PAGE: 1 of 1

SUBSURFACE LOG

DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES



Brown fine to coarse SAND, some fine to medium Gravel, trace Cobbles, loose, moist, (FILL).

Brown fine to coarse SAND and SILT, trace Gravel, compact, moist.

Wet at 7.0 Feet.

Brown SILT and fine SAND, trace Clay, compact, moist.

Brown fine to coarse SAND and SILT, trace Clay, trace Gravel, loose, wet.

Bottom of boring 15.0 feet.

WELL CONSTRUCTION DETAILS

2-inch diameter schedule 40 PVC riser 4.0' to above ground surface.
2-inch diameter, SCH 40 PVC 0.010 inch slot screen 14.0' - 4.0'
Grade 0 silica Sand pack 15.0' - 3.0'
Hydrated/bentonite seal 3.0' - 2.0'
Cement 2.0' to ground surface.
Well completed with a steel proctective casing set in a concrete pad.

NOTES:

Augered to a depth of 15.0' with a 4 1/4-inch diameter hollow stem auger
Descriptions derived from the boring log of the adjcent well, MW-33.

APPENDIX B

IN-SITU HYDRAULIC CONDUCTIVITY TESTING DATA AND ANALYSIS

Project: HADCO CORPORATION -- OWEGO, NEW YORK
Project No.: 263.05
Well No.: MW-18 #1
Test Date: 10/14/91
Formation Tested: Overburden
Rising Head Slug Test

		(cm)
Stickup (ft)	1.5	45.72
Static Water Level (ft)	13.80	420.62
Depth to bottom of screen (ft from ground level)	72.2	2200.66
Boring Diameter (in)	8.25	20.96
Casing Diameter (in)	2.0	5.08
Screen Diameter (in)	2.0	5.08
Screen Length (ft)	5.0	152.40
Depth to Boundary	72.0	2194.56
Delta H at time 0 (ft)	1.99	60.66
Delta H at Time t (ft)	0.02	0.61
Time t (seconds)	1405.9	
Ratio Kh/Kv	1	
Porosity of Filter Pack	0.3	

	cm/sec	gpd/ft2
K (Bouwer-Rice)	2.3E-04	4.9

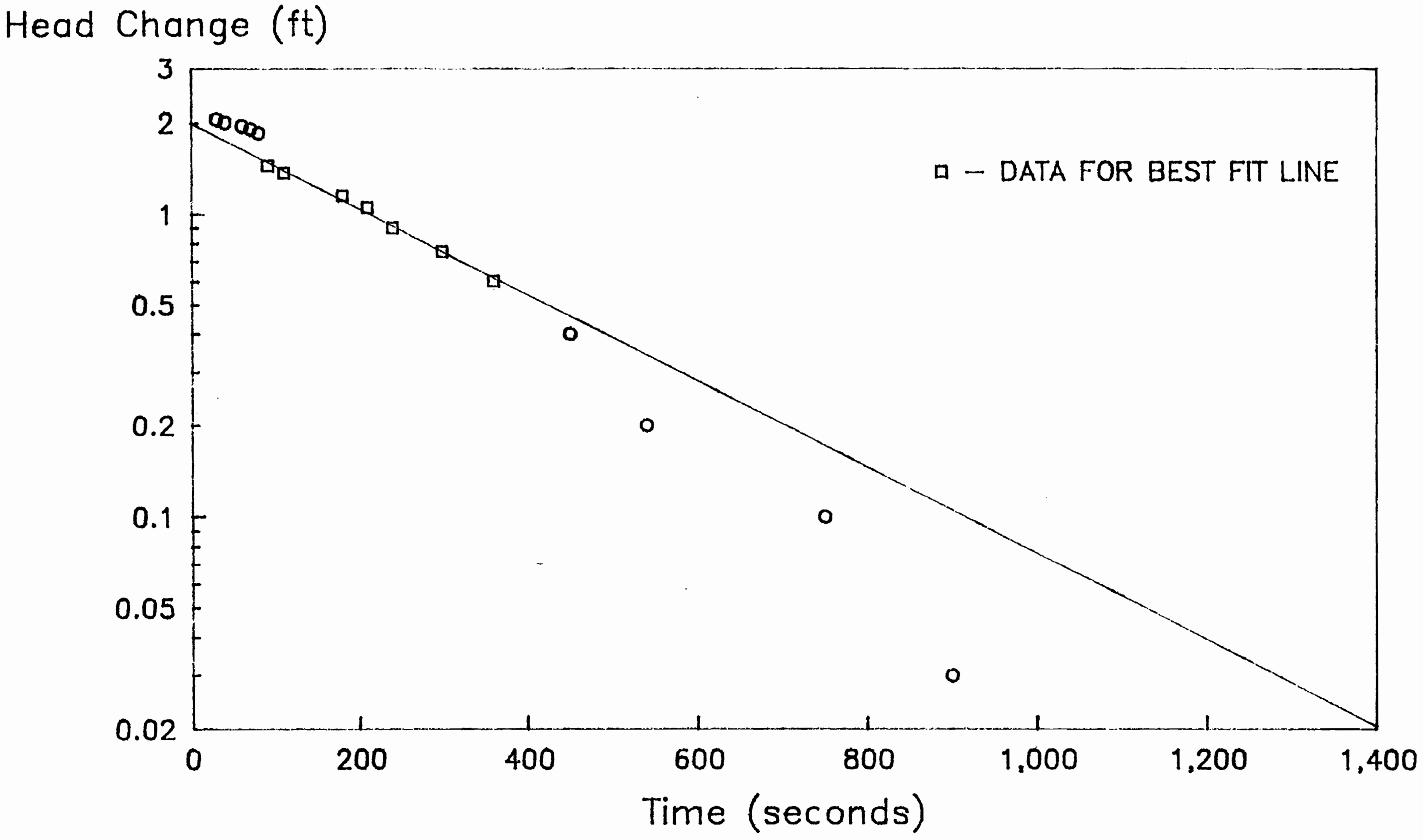
WELL: MW-18, TEST #1
DATE: OCTOBER 14, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION -- OWEGO, NEW YORK
RISING HEAD TEST: 2-INCH DIAM. S.S. BAILER

Initial Depth to water (ft):	13.80
Initial Time (seconds):	0.00

Clock Time			Depth to water		Elapsed Time in Seconds	Head Change in feet	Head Change in cm.
HR	MN	Sec	FT	IN			
		0	13.80		0.00	0.00	0.00
		30	15.85		30.00	2.05	62.28
		40	15.80		40.00	2.00	60.76
	1	0	15.75		60.00	1.95	59.24
	1	10	15.71		70.00	1.91	58.03
	1	20	15.65		80.00	1.85	56.20
	1	30	15.25		90.00	1.45	44.05
	1	50	15.17		110.00	1.37	41.62
	3	0	14.95		180.00	1.15	34.94
	3	30	14.85		210.00	1.05	31.90
	4	0	14.70		240.00	0.90	27.34
	5	0	14.55		300.00	0.75	22.79
	6	0	14.40		360.00	0.60	18.23
	7	30	14.20		450.00	0.40	12.15
	9	0	14.00		540.00	0.20	6.08
	12	30	13.90		750.00	0.10	3.04
	15	0	13.83		900.00	0.03	0.91

MW-18, TEST #1

IN-SITU HYDRAULIC CONDUCTIVITY TEST -- 10/14/91
HADCO CORPORATION -- OWEGO, NEW YORK



Project: HADCO CORPORATION -- OWEGO, NEW YORK
Project No.: 263.05
Well No.: MW-18 #2
Test Date: 10/15/91
Formation Tested: Overburden
Rising Head Slug Test

		(cm)
Stickup (ft)	1.5	45.72
Static Water Level (ft)	7.75	236.22
Depth to bottom of screen (ft from ground level)	72.2	2200.66
Boring Diameter (in)	8.25	20.96
Casing Diameter (in)	2.0	5.08
Screen Diameter (in)	2.0	5.08
Screen Length (ft)	5.0	152.40
Depth to Boundary	72.0	2194.56
Delta H at time 0 (ft)	1.19	36.17
Delta H at Time t (ft)	0.01	0.30
Time t (seconds)	1284.6	
Ratio Kh/Kv	1	
Porosity of Filter Pack	0.3	

	cm/sec	gpd/ft2
K (Bouwer-Rice)	2.6E-04	5.6

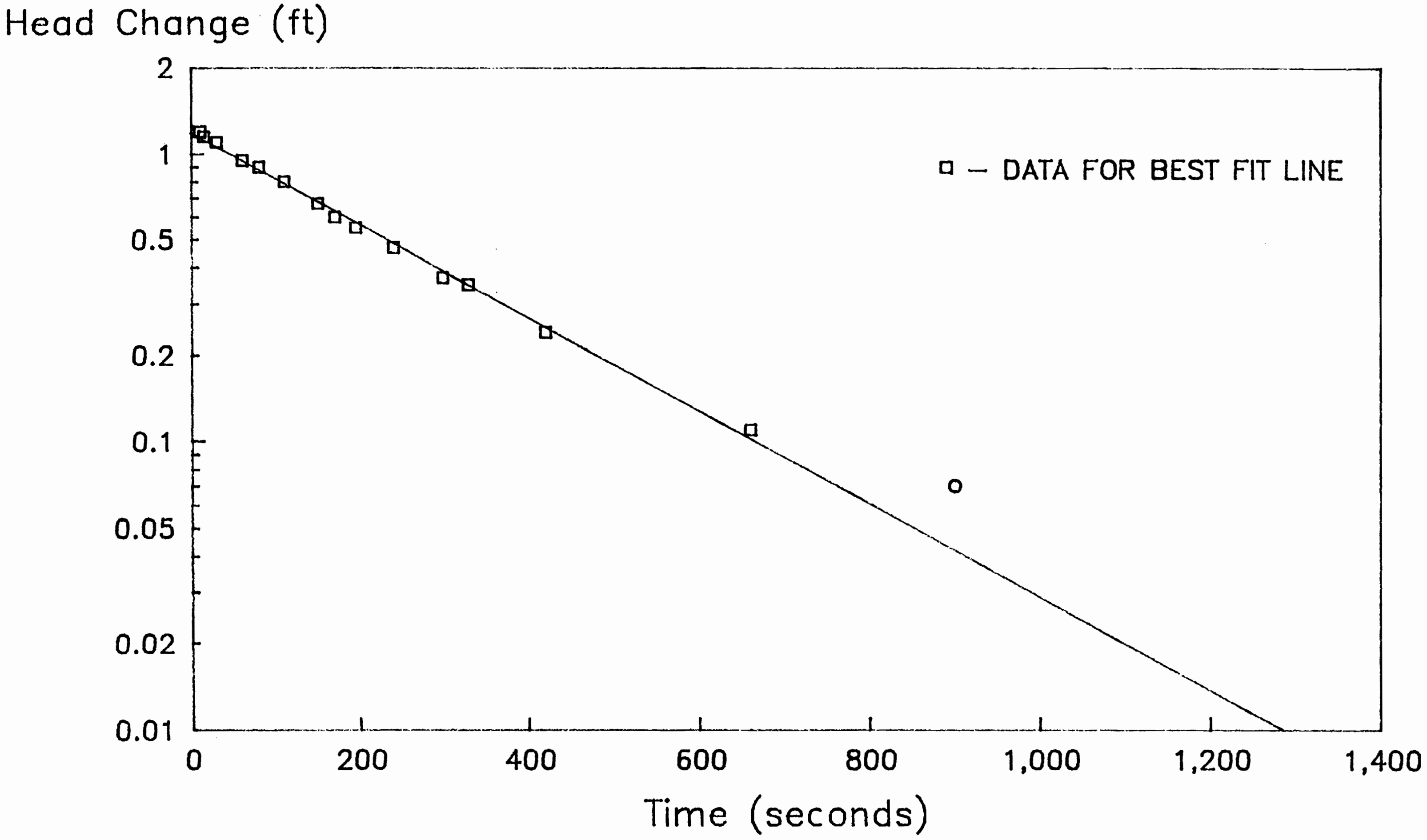
WELL: MW-18, TEST #2
DATE: OCTOBER 15, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION -- OWEGO, NEW YORK
RISING HEAD TEST: 2-INCH DIAM. S.S. BAILER

Initial Depth to water (ft):	7.75
Initial Time (seconds):	0.00

Clock Time			Depth to water		Elapsed Time in Seconds	Head Change in feet	Head Change in cm.
HR	MN	Sec	FT	IN			
		0	7.75		0.00	0.00	0.00
		10	8.95		10.00	1.20	36.46
		15	8.90		15.00	1.15	34.94
		30	8.85		30.00	1.10	33.42
	1	0	8.70		60.00	0.95	28.86
	1	20	8.65		80.00	0.90	27.34
	1	50	8.55		110.00	0.80	24.30
	2	30	8.42		150.00	0.67	20.35
	2	50	8.35		170.00	0.60	18.23
	3	15	8.30		195.00	0.55	16.71
	4	0	8.22		240.00	0.47	14.28
	5	0	8.12		300.00	0.37	11.24
	5	30	8.10		330.00	0.35	10.63
	7	0	7.99		420.00	0.24	7.29
	11	0	7.86		660.00	0.11	3.34
	15	0	7.82		900.00	0.07	2.13
	19	0	7.75		1140.00	0.00	0.00

MW-18, TEST #2

IN-SITU HYDRAULIC CONDUCTIVITY TEST -- 10/15/91
HADCO CORPORATION -- OWEGO, NEW YORK



Project:	HADCO CORPORATION -- OWEGO, NEW YORK
Project No.:	263.05
Well No.:	MW-20 #1
Test Date:	10/14/91
Formation Tested:	Bedrock

Rising Head Slug Test

		(cm)
Stickup (ft)	1.5	45.72
Static Water Level (ft)	13.80	420.62
Depth to bottom of screen (ft from ground level)	98.8	3011.42
Boring Diameter (in)	4.25	10.80
Casing Diameter (in)	4.0	10.16
Screen Diameter (in)	3.9	9.91
Screen Length (ft)	20.0	609.60
Depth to Boundary	72.0	2194.56
Delta H at time 0 (ft)	1.09	33.10
Delta H at Time t (ft)	0.03	0.91
Time t (seconds)	419.44	
Ratio Kh/Kv	1	
Porosity of Filter Pack	0.3	

	cm/sec	gpd/ft2
K (Bouwer-Rice)	8.4E-04	17.7

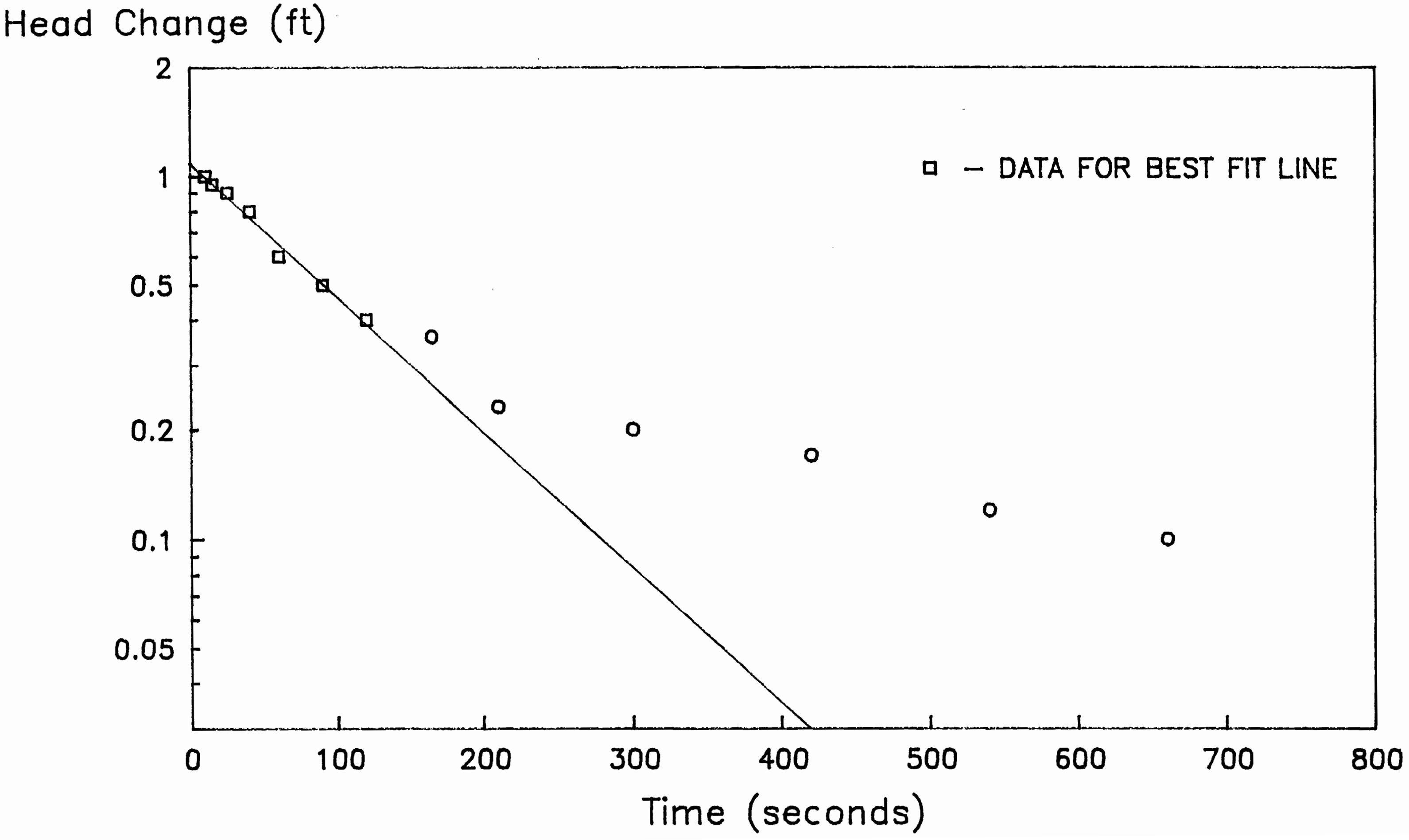
WELL: MW–20, TEST #1
DATE: OCTOBER 14, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION –– OWEGO, NEW YORK
FALLING HEAD TEST: 2' LONG, 3 1/2" DIAM. PVC SLUG

Initial Depth to water (ft):	13.80
Initial Time (seconds):	0.00

Clock Time HR	MN	Sec	Depth to water FT	IN	Elapsed Time in Seconds	Head Change in feet	Head Change in cm.
		0	13.80		0.00	0.00	0.00
		10	12.80		10.00	1.00	30.38
		15	12.85		15.00	0.95	28.86
		25	12.90		25.00	0.90	27.34
		40	13.00		40.00	0.80	24.30
	1	0	13.20		60.00	0.60	18.23
	1	30	13.30		90.00	0.50	15.19
	2	0	13.40		120.00	0.40	12.15
	2	45	13.44		165.00	0.36	10.94
	3	30	13.57		210.00	0.23	6.99
	5	0	13.60		300.00	0.20	6.08
	7	0	13.63		420.00	0.17	5.16
	9	0	13.68		540.00	0.12	3.65
	11	0	13.70		660.00	0.10	3.04
	13	30	13.80		810.00	0.00	0.00

MW–20, TEST #1

IN–SITU HYDRAULIC CONDUCTIVITY TEST –– 10/14/91
HADCO CORPORATION –– OWEGO, NEW YORK



WELL: MW-21
DATE: OCTOBER 15, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION -- OWEGO, NEW YORK
FALLING HEAD TEST: 2' LONG, 3 1/2" DIAM. PVC SLUG

Initial Depth to water (ft):	16.60
Initial Time (seconds):	0.00

Clock Time			Depth to water		Elapsed Time in	Head Change	Head Change
HR	MN	Sec	FT	IN	Seconds	in feet	in cm.
		0	16.60		0.00	0.00	0.00
		20	15.60		20.00	1.00	30.38
		32	15.65		32.00	0.95	28.86
		40	15.95		40.00	0.65	19.75
	1	10	16.20		70.00	0.40	12.15
	1	40	16.70		100.00	0.10	3.04
	2	15	16.85		135.00	0.25	7.60
	3	0	16.90		180.00	0.30	9.11
	4	0	16.99		240.00	0.39	11.85
	4	30	17.00		270.00	0.40	12.15
	7	0	17.10		420.00	0.50	15.19
	10	0	17.15		600.00	0.55	16.71
	12	0	17.15		720.00	0.55	16.71
	15	0	17.15		900.00	0.55	16.71

Project: HADCO CORPORATION -- OWEGO, NEW YORK
Project No.: 263.05
Well No.: MW-23 #1
Test Date: 10/15/91
Formation Tested: Overburden
Rising Head Slug Test

		(cm)
Stickup (ft)	0.0	0.00
Static Water Level (ft)	9.74	296.88
Depth to bottom of screen (ft from ground level)	35.0	1066.80
Boring Diameter (in)	12.00	30.48
Casing Diameter (in)	4.0	10.16
Screen Diameter (in)	4.0	10.16
Screen Length (ft)	5.0	152.40
Depth to Boundary	34.0	1036.32
Delta H at time 0 (ft)	2.02	61.57
Delta H at Time t (ft)	1.00	30.48
Time t (seconds)	598.33	
Ratio Kh/Kv	1	
Porosity of Filter Pack	0.3	

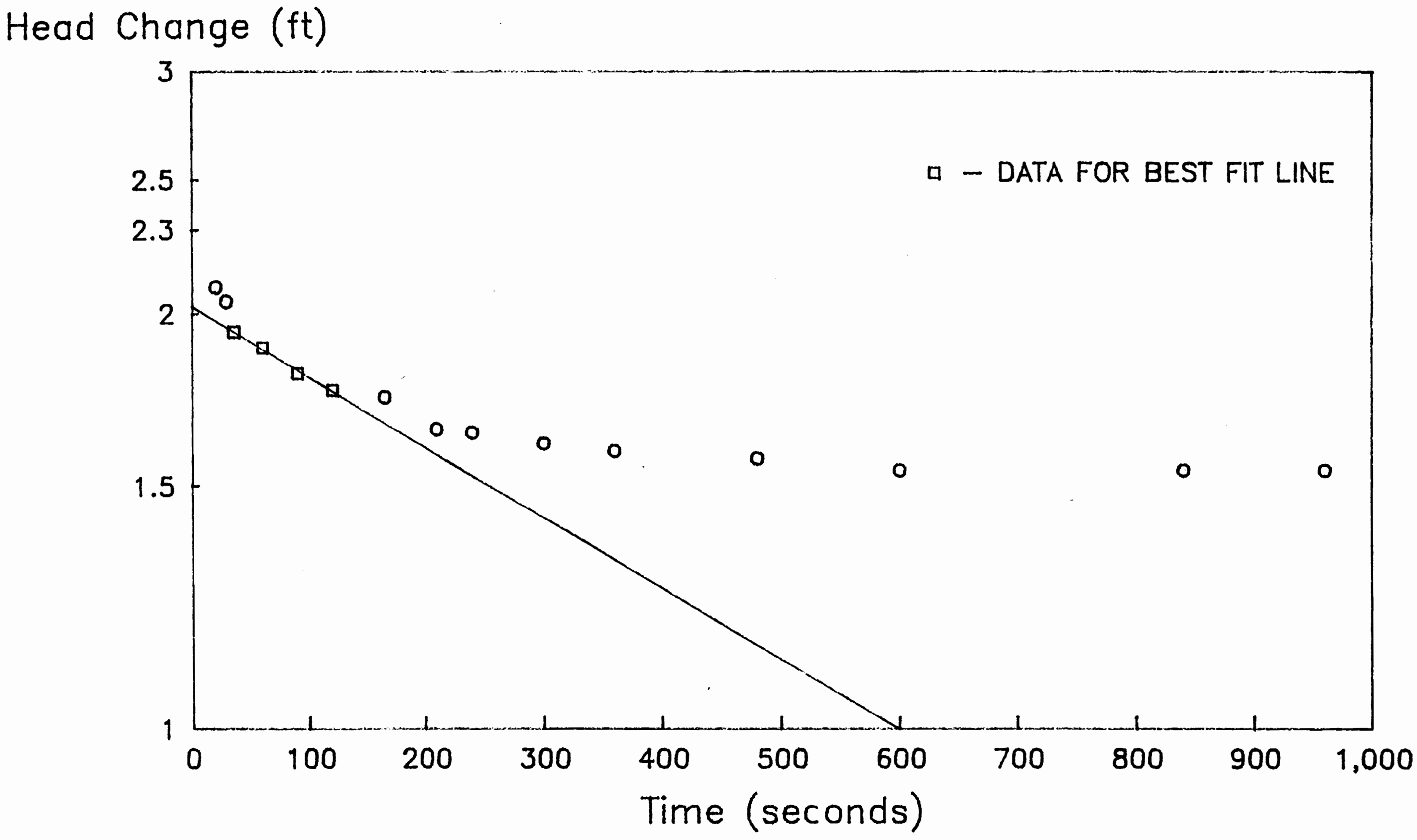
	cm/sec	gpd/ft2
K (Bouwer-Rice)	2.5E-04	5.4

WELL: MW–23, TEST #1
DATE: OCTOBER 15, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION –– OWEGO, NEW YORK
FALLING HEAD TEST: 2' LONG, 3 1/2" DIAM. PVC SLUG

Initial Depth to water (ft):	9.74
Initial Time (seconds):	0.00

Clock Time			Depth to water		Elapsed Time in Seconds	Head Change in feet	Head Change in cm.
HR	MN	Sec	FT	IN			
		0	9.74		0.00	0.00	0.00
		20	7.65		20.00	2.09	63.49
		29	7.70		29.00	2.04	61.98
		35	7.80		35.00	1.94	58.94
	1	0	7.85		60.00	1.89	57.42
	1	30	7.93		90.00	1.81	54.99
	2	0	7.98		120.00	1.76	53.47
	2	45	8.00		165.00	1.74	52.86
	3	30	8.09		210.00	1.65	50.13
	4	0	8.10		240.00	1.64	49.82
	5	0	8.13		300.00	1.61	48.91
	6	0	8.15		360.00	1.59	48.30
	8	0	8.17		480.00	1.57	47.70
	10	0	8.20		600.00	1.54	46.79
	14	0	8.20		840.00	1.54	46.79
	16	0	8.20		960.00	1.54	46.79

MW-23, TEST #1
IN-SITU HYDRAULIC CONDUCTIVITY TEST -- 10/15/91
HADCO CORPORATION -- OWEGO, NEW YORK



Project: HADCO CORPORATION -- OWEGO, NEW YORK
Project No.: 263.05
Well No.: MW-24 #1
Test Date: 10/15/91
Formation Tested: Overburden
Rising Head Slug Test

		(cm)
Stickup (ft)	0.0	0.00
Static Water Level (ft)	10.38	316.38
Depth to bottom of screen (ft from ground level)	54.5	1661.16
Boring Diameter (in)	12.00	30.48
Casing Diameter (in)	4.0	10.16
Screen Diameter (in)	4.0	10.16
Screen Length (ft)	5.0	152.40
Depth to Boundary	54.0	1645.92
Delta H at time 0 (ft)	0.75	22.86
Delta H at Time t (ft)	0.01	0.30
Time t (seconds)	61.88	
Ratio Kh/Kv	1	
Porosity of Filter Pack	0.3	

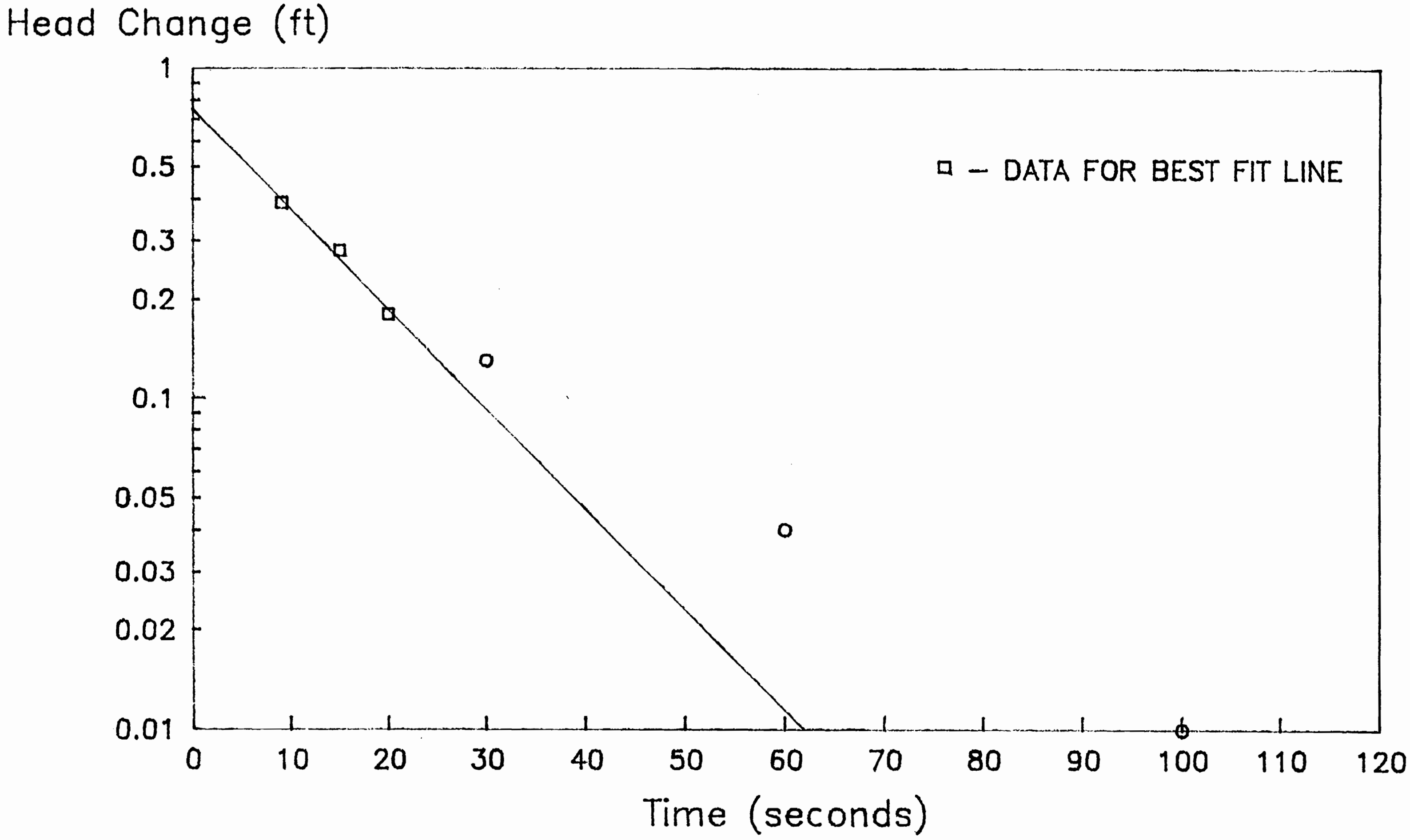
	cm/sec	gpd/ft2
K (Bouwer-Rice)	1.7E-02	352.3

WELL: MW-24, TEST #1
DATE: OCTOBER 15, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION -- OWEGO, NEW YORK
FALLING HEAD TEST: 2' LONG, 3 1/2" DIAM. PVC SLUG

Initial Depth to water (ft):	10.38
Initial Time (seconds):	0.00

Clock Time			Depth to water		Elapsed Time in	Head Change	Head Change
HR	MN	Sec	FT	IN	Seconds	in feet	in cm.
		0	10.38		0.00	0.00	0.00
		9	9.99		9.00	0.39	11.85
		15	10.10		15.00	0.28	8.51
		20	10.20		20.00	0.18	5.47
		30	10.25		30.00	0.13	3.95
	1	0	10.34		60.00	0.04	1.22
	1	40	10.37		100.00	0.01	0.30
	2	0	10.38		120.00	0.00	0.00

MW-24, TEST #1
IN-SITU HYDRAULIC CONDUCTIVITY TEST -- 10/15/91
HADCO CORPORATION -- OWEGO, NEW YORK



WELL: MW–25 TEST #1
DATE: OCTOBER 14, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION –– OWEGO, NEW YORK
RISING HEAD TEST: 2–INCH DIAM. S.S. BAILER

Initial Depth to water (ft):	12.40
Initial Time (seconds):	0.00

Clock Time			Depth to water		Elapsed Time in Seconds	Head Change in feet	Head Change in cm.
HR	MN	Sec	FT	IN			
		0	12.40		0.00	0.00	0.00
		18	12.45		18.00	0.05	1.52
		24	12.43		24.00	0.03	0.91
		33	12.42		33.00	0.02	0.61
	1	0	12.40		60.00	0.00	0.00
	1	30	12.40		90.00	0.00	0.00
	1	50	12.39		110.00	–0.01	–0.30
	2	10	12.39		130.00	–0.01	–0.30
	2	50	12.39		170.00	–0.01	–0.30
	3	30	12.39		210.00	–0.01	–0.30

WELL: MW-25 TEST #2
DATE: OCTOBER 14, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION -- OWEGO, NEW YORK
RISING HEAD TEST: 2-INCH DIAM. S.S. BAILER

Initial Depth to water (ft):	12.39
Initial Time (seconds):	0.00

Clock Time			Depth to water		Elapsed Time in Seconds	Head Change in feet	Head Change in cm.
HR	MN	Sec	FT	IN			
		0	12.39		0.00	0.00	0.00
		15	12.48		15.00	0.09	2.73
		20	12.46		20.00	0.07	2.13
		40	12.44		40.00	0.05	1.52
	1	0	12.42		60.00	0.03	0.91
	1	10	12.40		70.00	0.01	0.30
	2	0	12.40		120.00	0.01	0.30

WELL: MW–25 TEST #3
DATE: OCTOBER 14, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION –– OWEGO, NEW YORK
RISING HEAD TEST: 2–INCH DIAM. S.S. BAILER

Initial Depth to water (ft):	12.39
Initial Time (seconds):	0.00

Clock Time			Depth to water		Elapsed Time in Seconds	Head Change in feet	Head Change in cm.
HR	MN	Sec	FT	IN			
		0	12.39		0.00	0.00	0.00
		15	12.47		15.00	0.08	2.43
		30	12.45		30.00	0.06	1.82
		45	12.43		45.00	0.04	1.22
	1	0	12.42		60.00	0.03	0.91
	1	13	12.40		73.00	0.01	0.30

WELL: MW–26 TEST #1
DATE: OCTOBER 14, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION –– OWEGO, NEW YORK
RISING HEAD TEST: 2–INCH DIAM. S.S. BAILER

Initial Depth to water (ft):	13.40
Initial Time (seconds):	0.00

Clock Time HR	Clock Time MN	Clock Time Sec	Depth to water FT	Depth to water IN	Elapsed Time in Seconds	Head Change in feet	Head Change in cm.
		0	13.40		0.00	0.00	0.00
		17	13.69		17.00	0.29	8.81
		23	13.67		23.00	0.27	8.20
		30	13.67		30.00	0.27	8.20
		35	13.66		35.00	0.26	7.90
		47	13.66		47.00	0.26	7.90
		54	13.66		54.00	0.26	7.90
	1	0	13.66		60.00	0.26	7.90
	1	40	13.66		100.00	0.26	7.90
	2	0	13.66		120.00	0.26	7.90
	3	0	13.65		180.00	0.25	7.60
	3	50	13.65		230.00	0.25	7.60
	5	0	13.65		300.00	0.25	7.60
	6	30	13.65		390.00	0.25	7.60
	11	0	13.65		660.00	0.25	7.60
	15	0	13.65		900.00	0.25	7.60
	22	0	13.65		1320.00	0.25	7.60
	24	0	13.64		1440.00	0.24	7.29
	34	0	13.64		2040.00	0.24	7.29
	47	30	13.63		2850.00	0.23	6.99
	55	0	13.63		3300.00	0.23	6.99
	60	0	13.63		3600.00	0.23	6.99

WELL: MW–26 TEST #2
DATE: OCTOBER 14, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION –– OWEGO, NEW YORK
RISING HEAD TEST: 2–INCH DIAM. S.S. BAILER

Initial Depth to water (ft):	13.65
Initial Time (seconds):	0.00

Clock Time			Depth to water		Elapsed Time in	Head Change	Head Change
HR	MN	Sec	FT	IN	Seconds	in feet	in cm.
		0	13.65		0.00	0.00	0.00
		19	13.66		19.00	0.01	0.30
		25	13.66		25.00	0.01	0.30
		58	13.67		58.00	0.02	0.61
	1	10	13.65		70.00	0.00	0.00

WELL: MW-26 TEST #3
DATE: OCTOBER 14, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION -- OWEGO, NEW YORK
RISING HEAD TEST: 2-INCH DIAM. S.S. BAILER

Initial Depth to water (ft): 13.65
Initial Time (seconds): 0.00

Clock Time			Depth to water		Elapsed Time in Seconds	Head Change in feet	Head Change in cm.
HR	MN	Sec	FT	IN			
		0	13.65		0.00	0.00	0.00
		10	13.71		10.00	0.06	1.82
		15	13.69		15.00	0.04	1.22
		24	13.69		24.00	0.04	1.22
		30	13.68		30.00	0.03	0.91
		49	13.68		49.00	0.03	0.91
	1	0	13.68		60.00	0.03	0.91
	1	15	13.67		75.00	0.02	0.61
	1	30	13.67		90.00	0.02	0.61
	2	30	13.66		150.00	0.01	0.30
	4	30	13.66		270.00	0.01	0.30
	10	0	13.65		600.00	0.00	0.00
	20	0	13.64		1200.00	-0.01	-0.30
	30	0	13.64		1800.00	-0.01	-0.30

Project: HADCO CORPORATION -- OWEGO, NEW YORK
Project No.: 263.05
Well No.: MW-27 #1
Test Date: 10/15/91
Formation Tested: Overburden
Rising Head Slug Test

		(cm)
Stickup (ft)	0.0	0.00
Static Water Level (ft)	9.60	292.61
Depth to bottom of screen (ft from ground level)	52.5	1600.20
Boring Diameter (in)	12.00	30.48
Casing Diameter (in)	4.0	10.16
Screen Diameter (in)	4.0	10.16
Screen Length (ft)	5.0	152.40
Depth to Boundary	50.0	1524.00
Delta H at time 0 (ft)	0.75	22.86
Delta H at Time t (ft)	0.01	0.30
Time t (seconds)	343.99	
Ratio Kh/Kv	1	
Porosity of Filter Pack	0.3	

	cm/sec	gpd/ft2
K (Bouwer-Rice)	3.0E-03	63.1

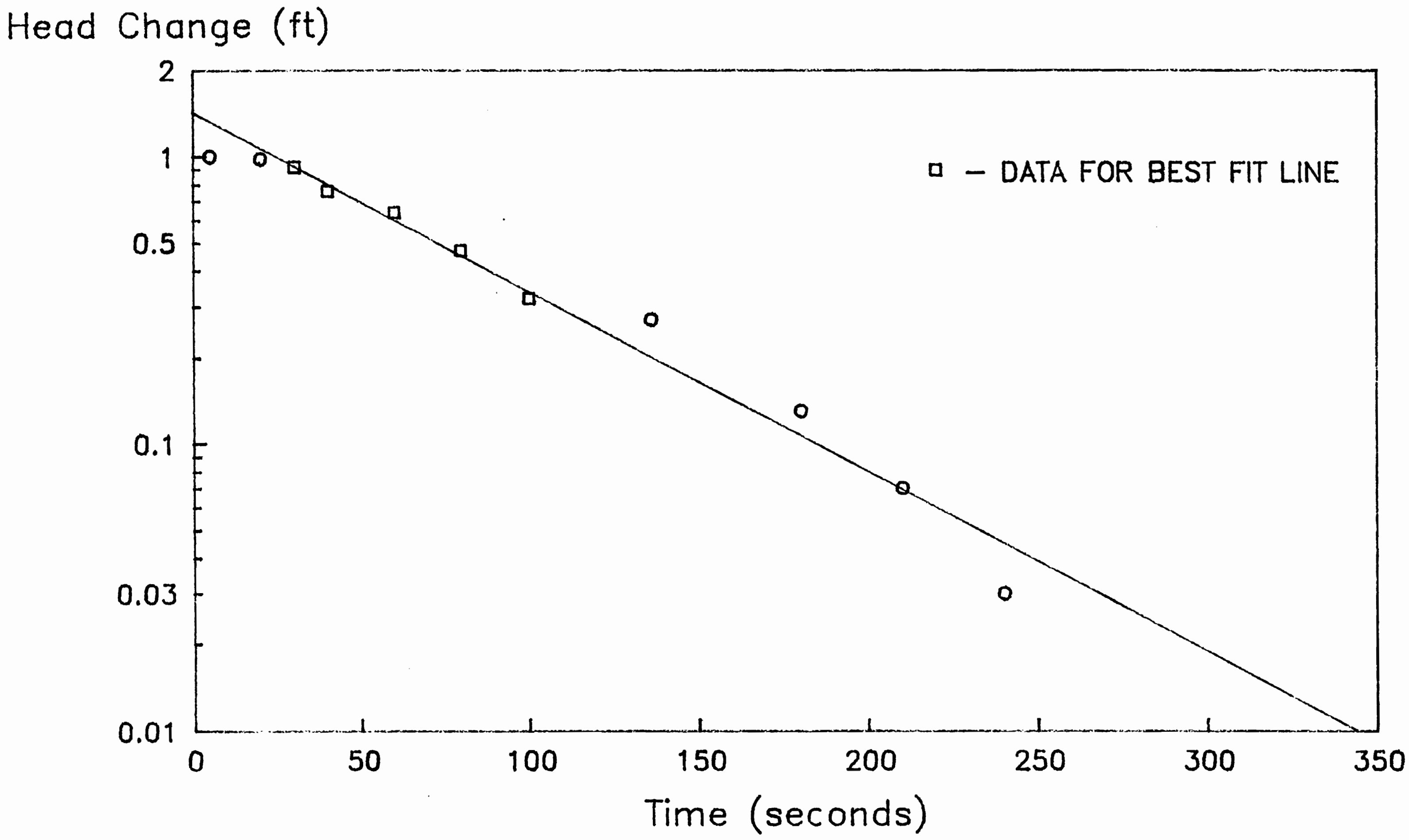
WELL: MW–27, TEST #1
DATE: OCTOBER 15, 1991
SLUG TEST DATA REDUCTION
HADCO CORPORATION – – OWEGO, NEW YORK
FALLING HEAD TEST: 2' LONG, 3 1/2" DIAM. PVC SLUG

Initial Depth to water (ft): 9.60
Initial Time (seconds): 0.00

Clock Time			Depth to water		Elapsed Time in Seconds	Head Change in feet	Head Change in cm.
HR	MN	Sec	FT	IN			
		0	9.60		0.00	0.00	0.00
		5	8.60		5.00	1.00	30.38
		20	8.62		20.00	0.98	29.77
		30	8.68		30.00	0.92	27.95
		40	8.84		40.00	0.76	23.09
	1	0	8.96		60.00	0.64	19.44
	1	20	9.13		80.00	0.47	14.28
	1	40	9.28		100.00	0.32	9.72
	2	10	9.33		136.00	0.27	8.20
	3	0	9.47		180.00	0.13	3.95
	3	30	9.53		210.00	0.07	2.13
	4	0	9.57		240.00	0.03	0.91
	5	0	9.60		300.00	0.00	0.00

MW-27, TEST #1

IN-SITU HYDRAULIC CONDUCTIVITY TEST -- 10/15/91
HADCO CORPORATION -- OWEGO, NEW YORK



APPENDIX C

PUMPING TEST DATA AND ANALYSIS

APPENDIX C

Introduction

To provide additional hydraulic characterization of the geologic formation at the site, a pumping test of deep overburden pumping well PW-3 was performed on August 18, 1992. The test entailed pumping PW-3 at a constant rate of approximately 10.75 gallons per minute (gpm) for 10 hours and monitoring water-level changes at PW-3, plus seven observation wells within the area, during drawdown and recovery of PW-3. Based on the results of the pumping test, the deep overburden transmissivity and storativity were estimated as approximately 1200-1900 gal/day/sqft and approximately 3.8×10^{-3} to 4.3×10^{-5} respectively.

Pumping Test Implementation

Based on a preliminary pumping evaluation of PW-3 on August 14, 1992, a sustainable pumping rate of approximately 11 gpm was identified for use during the pumping test on August 18, 1992. Prior to the pumping test of PW-3, static water-level measurements were obtained on August 18, 1992 at pumping well PW-3, plus observation wells MW-17, MW-19, MW-23, MW-24, MW-25, MW-26, and MW-27. The pumping test began at 12:19 on August 18, 1992. Flow rates were checked frequently using a calibrated bucket and stopwatch during the initial portion of the drawdown phase. During the first five minutes of the test the pumping rate declined slightly from 11.0 to 10.75 gpm, and remained at 10.75 gpm throughout the remainder of the 10-hour drawdown phase. After the steady rate of 10.75 gpm was established, flow rates were checked approximately every hour throughout the drawdown phase. Water-level data were recorded at wells PW-3, MW-25, and MW-26 using pressure transducers and an electronic data logger manufactured by Instrumentation Northwest of Redmond, Washington.

Water levels were also monitored manually at wells MW-17, MW-19, MW-23, MW-24, and MW-27 using an electronic water-level indicator. Throughout the drawdown phase, ground water was removed from PW-3 using a Red Jacket Renegade submersible pump. The ground water generated during the drawdown phase was routed directly through an activated carbon filtration unit and discharged to the facilities sanitary sewer line at a manhole approximately 220 feet southwest of PW-3.

The pump at PW-3 was shut off at 22:14 on August 18, 1992, ending the 10-hour drawdown phase and initiating the recovery phase of the test. During the recovery phase, water level measurements were obtained at the same array of wells used during the drawdown phase. Recovery phase data acquisition continued for 1.5 hours after the pump was shut off.

Qualitative Evaluation of Pumping Test Results

The data generated during the August 18, 1992, pumping test of PW-3 include water-level readings obtained by automatic transducers plus manual electronic water-level indicators. Data obtained from transducers at pumping well PW-3, shallow overburden observation well MW-25, and deep overburden observation well MW-26 during the drawdown phase and the recovery phase are presented in this appendix as Tables C-1 and C-2, respectively. These data are reduced to values of apparent drawdown in Tables C-3 through C-8, and are plotted on Figures C-1 through C-7. Manual drawdown and recovery phase water-level measurements obtained at observation wells MW-17, MW-19, MW-23, MW-24, and MW-27 are reduced to values of apparent drawdown in Tables C-9 through C-13.

Based on a qualitative evaluation of the apparent drawdown data, relatively systematic responses to pumping from PW-3 were observed in the deep overburden to a distance of 243 feet from PW-3, as well as in the shallow overburden approximately 60 feet from PW-3. Because the sand filter-pack intake zone of pumping well PW-3 is completed in the deep overburden approximately 51-72 feet below grade, drawdown responses to pumping from PW-3 were anticipated primarily in the nearby deep overburden observation wells. During the pumping test of PW-3, potentiometric responses of approximately 2.89 feet to 0.05 feet were observed at deep overburden observation wells MW-26, MW-24, and MW-27 located approximately 56-feet, 168 feet, and 243 feet from PW-3. These responses are directly attributed to pumping from PW-3, because they increased during the drawdown phase and diminished during the recovery phase. The response at deep overburden observation well MW-23, located approximately 270 feet from PW-3, was negligible. A deep overburden radius of influence of between 243 and 270 feet after 10 hours of pumping from PW-3, therefore, may be delineated.

Water-level data from a transducer in shallow overburden observation well MW-25, located 60 feet from PW-3, indicated a drawdown of approximately 0.2 feet. This result indicates a hydraulic connection between the shallow overburden and deep overburden, and is compatible with site-specific hydrogeologic data from boreholes that indicated no apparent confining unit separating the shallow and deep portions of the overburden. Negligible response was observed at shallow overburden observation well MW-19, 275 feet from PW-3, and at bedrock well MW-17 located 170 feet from PW-3.

The drawdown responses recorded by transducers at pumping well PW-3, shallow overburden observation well MW-25, and deep overburden observation well MW-26 are plotted on Figures C-1 through C-3. These plots all exhibit negligible increase in drawdown after approximately 2000 to 3000 seconds of pumping during the drawdown phase. This steady-state drawdown condition during continued pumping suggests the presence of a recharge boundary in the vicinity of the pumping well. Surface water bodies such as lakes and rivers near a pumping well typically behave as recharging boundaries. In this case, however, the only surface water body in the vicinity of the site is a stream approximately 400 feet from PW-3. Because no response to pumping was observed in shallow overburden observation well MW-19, within 275 feet of PW-3, negligible recharge would be expected from the stream. An isolated zone of highly permeable material such as a lens of relatively clean sand and/or gravel in the vicinity of the pumping well PW-3 may also behave similar to a recharge boundary. Hydrogeologic data obtained from monitoring well boreholes drilled at the site suggest that layers of relatively clean, coarse material are present within the heterogeneous overburden groundwater flow system. Such a highly permeable lens may respond as a recharge boundary. If a recharge boundary does exist in the vicinity of PW-3, the boundary would limit the magnitude of drawdown and the size of the capture zone achieved during pumping from PW-3. This affect was seen at the three transducer monitored wells during the pumping test of PW-3.

Parameter Estimation based on Time-Drawdown Analysis

The temporal potentiometric response observed during the drawdown at deep overburden observation well MW-26 enables estimation of the deep overburden hydraulic parameters. Because routine data evaluation methods were developed for confined rather than unconfined aquifers, drawdown data obtained from pumping tests in unconfined aquifers may need to be corrected. The greatest drawdown at MW-26 (2.9 feet), however, represents only 5 percent of the initial saturated overburden thickness so that data correction is unnecessary.

In conformance with the Jacob time-drawdown method (in e.g., Kruseman & de Ridder, 1990), the MW-26 drawdown data are plotted versus the logarithm of time (Figure C-3). This method of data plotting ideally should yield a straight-line relationship after a certain lag time. As shown in Figure C-3, a straight-line trend of data, is observed after approximately 100 seconds. A best-fit line is visually selected for the linear portion of the data. The transmissivity of the deep overburden formation may be calculated from the slope of this best fit line by the equation

$$T = 264\ Q\ /\ s,$$

where: T = transmissivity (gal/day/sqft);

Q = pumping rate (10.75 gal./min); and

s = drawdown change for one log cycle (1.5 ft.)

(Driscoll, 1986). Using the above equation, a transmissivity value of approximately 1900 gal/day/sqft is estimated. If the entire overburden may be assumed to consist of comparably permeable materials, an overburden hydraulic conductivity ($K = T\ /\ H$) of approximately 1.6×10^{-3} cm/sec may be deduced for the 57-foot thick (H = 57 ft) aquifer. The deep overburden storativity may be estimated based on the intercept of the best-fit line with the time axis by the equation

$$S = 0.3\ T\ t\ /\ r^2,$$

where: S = storativity (dimensionless);

T = transmissivity (1900 gal/day/sqft);

t = intercept with time axis (0.00023 days); and

r = distance to observation well (56 feet).

A deep overburden storativity value of approximately 4.3×10^{-5} is therefore estimated.

Parameter Estimation based on Distance-Drawdown Analysis

Another Jacob straight-line technique, using distance-drawdown data, may provide a check of the deep overburden hydraulic parameters estimated by time-drawdown analysis. In the Jacob distance-drawdown method, data from similarly-constructed wells that demonstrated a potentiometric response to pumping are plotted versus the logarithm of distance from the pumping well. Thus the drawdowns observed at deep overburden observation wells MW-23, MW-24, and MW-26 are plotted on Figure C-4. Because this method of data plotting should yield a straight-line relationship, a best-fit line is visually fitted to the plotted data. The transmissivity of the deep overburden formation may be calculated from the slope of this best fit line by the equation

$$T = 528\ Q\ /\ s,$$

where: T = transmissivity (gal/day/sqft);
Q = pumping rate (10.75 gal./min); and
s = drawdown change for one log cycle (4.7 ft.)

(Driscoll, 1986). Using the above equation, a transmissivity value of approximately 1200 gal/day/sqft is estimated, suggesting an overburden hydraulic conductivity (K = T / H) of approximately 9.9 x 10^{-4} cm/sec. These results are reasonably comparable to the transmissivity and hydraulic conductivity values of 1900 gal/day/sqft and 1.6 x 10^{-3} cm/sec estimated based on the time-drawdown response at MW-26, confirming the earlier estimates. The deep overburden storativity may be estimated based on the intercept of the best-fit line with the zero drawdown line by the equation

$$S = 0.3\ T\ t\ /\ r^2,$$

where: S = storativity (dimensionless);
T = transmissivity (1200 gal/day/sqft);
t = pumping time (0.42 days); and
r = projected distance to zero drawdown (200 feet).

A deep overburden storativity value of approximately 3.8 x 10^{-3} cm/sec is therefore estimated based on the distance-drawdown analysis.

Summary of Estimated Hydraulic Parameters

Based on the analyses presented above, the hydraulic parameters estimated for the overburden formation may be summarized as follows:

- deep overburden transmissivity = 1200 to 1900 gal/day/sqft;
- whole overburden hydraulic conductivity = 9.9×10^{-4} to 1.6×10^{-3} cm/sec; and
- deep overburden storativity = 3.8×10^{-3} to 4.3×10^{-5}.

Because hydraulic parameters for natural geologic formations typically range by several orders of magnitude, these results can be considered reasonably consistent. Storativity values estimated using drawdown data from unconfined aquifers have been found to be unrealistically low (Nwankwor et al., 1984), therefore, the range in storativity estimates above should be considered only a rough approximation for the deep overburden storativity.

TABLE C-1

Drawdown Phase Transducer Data (1 of 2)

```
PlotFile B:\HADCO301.PRN
DataFile C:\HADCO3.DAT
HADCO -  OWEGO, NY
Time of First Log in Specified Window
 08/18/92  12:17:45

                           Analog#01  Analog#02  Analog#03
                          pw-3...... mw-26..... mw-25.....
 Date       Time          ft........ ft........ ft........

 08/18/92  12:17:45          21.044      7.785      4.123
 08/18/92  12:18:39          21.021      7.785      4.135
 08/18/92  12:18:41          21.044      7.785      4.135
 08/18/92  12:18:43          21.044      7.785      4.135
 08/18/92  12:18:45          21.044      7.785      4.135
 08/18/92  12:18:46          21.021      7.785      4.135
 08/18/92  12:18:47          20.721      7.762      4.135
 08/18/92  12:18:48          20.744      7.785      4.135
 08/18/92  12:18:49          20.443      7.762      4.135
 08/18/92  12:18:50          20.282      7.762      4.135
 08/18/92  12:18:55          19.543      7.692      4.135
 08/18/92  12:19:00          19.081      7.623      4.135
 08/18/92  12:19:05          18.803      7.531      4.123
 08/18/92  12:19:10          18.688      7.438      4.123
 08/18/92  12:19:15          18.503      7.369      4.123
 08/18/92  12:19:20          18.457      7.300      4.123
 08/18/92  12:19:25          18.364      7.253      4.123
 08/18/92  12:19:30          18.249      7.207      4.112
 08/18/92  12:19:35           18.18      7.138      4.112
 08/18/92  12:19:40          18.157      7.115      4.100
 08/18/92  12:19:50          18.018      7.022      4.100
 08/18/92  12:20:00          17.926      6.953      4.100
 08/18/92  12:20:10          17.833      6.884      4.100
 08/18/92  12:20:20          17.718      6.815      4.100
 08/18/92  12:20:30          17.695      6.768      4.112
 08/18/92  12:20:40          17.648      6.699      4.112
 08/18/92  12:20:50          17.533      6.653      4.112
 08/18/92  12:21:00          17.464      6.607      4.112
 08/18/92  12:21:10          17.394      6.560      4.100
 08/18/92  12:21:20          17.394      6.514      4.100
 08/18/92  12:21:50          17.233      6.399      4.089
 08/18/92  12:22:20           17.14      6.306      4.100
 08/18/92  12:22:50          17.025      6.237      4.112
 08/18/92  12:23:20          17.048      6.168      4.112
 08/18/92  12:23:50          16.932      6.098      4.123
 08/18/92  12:24:20          16.886      6.029      4.146
 08/18/92  12:24:50          16.747      5.983      4.170
 08/18/92  12:25:20          16.724      5.914      4.170
 08/18/92  12:25:50          16.609      5.867      4.158
 08/18/92  12:26:20          16.586      5.821      4.123
 08/18/92  12:27:20          16.586      5.752      4.077
 08/18/92  12:28:20          16.447      5.683      4.066
 08/18/92  12:29:20          16.424      5.636      4.043
 08/18/92  12:30:20          16.401      5.567      4.019
 08/18/92  12:31:20          16.285      5.521      3.985
 08/18/92  12:32:20          16.216      5.475      3.973
 08/18/92  12:33:20          16.239      5.452      3.962
 08/18/92  12:34:20          16.147      5.405      3.950
 08/18/92  12:35:20          16.193      5.359      3.950
 08/18/92  12:36:20          16.147      5.336      3.962
 08/18/92  12:38:20          16.054      5.290      3.973
```

TABLE C-1

Drawdown Phase Transducer Data (2 of 2)

PlotFile B:\HADCO301.PRN
DataFile C:\HADCO3.DAT
HADCO - OWEGO, NY
Time of First Log in Specified Window
08/18/92 12:17:45

Date	Time	Analog#01 pw-3...... ft........	Analog#02 mw-26..... ft........	Analog#03 mw-25..... ft........
08/18/92	12:40:20	16.008	5.221	3.939
08/18/92	12:42:20	15.962	5.198	3.939
08/18/92	12:44:20	15.939	5.151	3.939
08/18/92	12:46:20	15.87	5.128	3.915
08/18/92	12:48:20	15.87	5.082	3.927
08/18/92	12:50:20	15.87	5.059	3.915
08/18/92	12:52:20	15.777	5.036	3.939
08/18/92	12:54:20	15.708	5.013	3.939
08/18/92	12:56:20	15.685	4.990	3.927
08/18/92	13:01:20	15.639	4.943	3.939
08/18/92	13:06:20	15.616	4.920	3.904
08/18/92	13:11:20	15.592	4.897	3.939
08/18/92	13:16:20	15.569	4.874	3.996
08/18/92	13:21:20	15.546	4.874	3.939
08/18/92	13:26:20	15.569	4.851	4.008
08/18/92	13:31:20	15.546	4.851	3.904
08/18/92	13:36:20	15.592	4.851	3.996
08/18/92	13:41:20	15.592	4.828	3.939
08/18/92	13:46:20	15.569	4.828	3.962
08/18/92	13:56:20	15.616	4.828	3.904
08/18/92	14:06:20	15.569	4.805	3.973
08/18/92	14:16:20	15.5	4.805	3.973
08/18/92	14:26:20	15.523	4.828	3.973
08/18/92	14:36:20	15.616	4.828	3.973
08/18/92	14:46:20	15.569	4.828	3.985
08/18/92	14:56:20	15.592	4.805	3.950
08/18/92	15:06:20	15.569	4.828	3.858
08/18/92	15:16:20	15.639	4.828	3.846
08/18/92	15:26:20	15.616	4.828	3.881
08/18/92	15:46:20	15.569	4.805	3.858
08/18/92	16:06:20	15.546	4.805	3.962
08/18/92	16:26:20	15.569	4.805	3.973
08/18/92	16:46:20	15.5	4.805	3.904
08/18/92	17:06:20	15.5	4.805	3.869
08/18/92	17:26:20	15.546	4.805	3.985
08/18/92	17:46:20	15.5	4.805	3.950
08/18/92	18:06:20	15.616	4.851	3.962
08/18/92	18:26:20	15.616	4.874	3.892
08/18/92	18:46:20	15.685	4.897	3.950
08/18/92	19:26:20	15.708	4.920	3.950
08/18/92	20:06:20	15.685	4.897	3.939
08/18/92	20:46:20	15.685	4.897	3.939
08/18/92	21:26:20	15.569	4.897	3.939
08/18/92	22:06:20	15.569	4.897	3.939

TABLE C-2

Recovery Phase Transducer Data (1 of 2)

```
PlotFile B:\HADCO301.PRN
DataFile C:\HADCO3.DAT
HADCO -  OWEGO, NY
Time of First Log in Specified Window
 08/18/92  12:17:45

                              Analog#01  Analog#02  Analog#03
                             pw-3...... mw-26..... mw-25.....
 Date       Time             ft........ ft........ ft........

 08/18/92   22:14:49           18.942      5.660      3.927
 08/18/92   22:14:51           18.965      5.660      3.927
 08/18/92   22:14:52           18.965      5.660      3.927
 08/18/92   22:14:53           18.988      5.683      3.927
 08/18/92   22:14:53           18.988      5.683      3.927
 08/18/92   22:14:55           19.011      5.706      3.927
 08/18/92   22:14:55           19.011      5.706      3.927
 08/18/92   22:14:57           19.034      5.729      3.927
 08/18/92   22:14:58           19.034      5.729      3.927
 08/18/92   22:14:59           19.034      5.729      3.927
 08/18/92   22:14:59           19.057      5.729      3.927
 08/18/92   22:15:05           19.104      5.798      3.927
 08/18/92   22:15:10            19.15      5.821      3.927
 08/18/92   22:15:15           19.173      5.867      3.927
 08/18/92   22:15:20           19.219      5.914      3.927
 08/18/92   22:15:25           19.242      5.937      3.927
 08/18/92   22:15:30           19.288      5.960      3.927
 08/18/92   22:15:35           19.312      6.006      3.939
 08/18/92   22:15:40           19.358      6.029      3.939
 08/18/92   22:15:45           19.404      6.052      3.939
 08/18/92   22:15:50           19.427      6.098      3.939
 08/18/92   22:16:00           19.519      6.145      3.939
 08/18/92   22:16:10           19.658      6.191      3.939
 08/18/92   22:16:20           19.727      6.260      3.950
 08/18/92   22:16:30           19.635      6.306      3.950
 08/18/92   22:16:40           19.635      6.329      3.950
 08/18/92   22:16:50           19.658      6.353      3.950
 08/18/92   22:17:00           19.658      6.399      3.962
 08/18/92   22:17:10           19.704      6.422      3.962
 08/18/92   22:17:20           19.727      6.445      3.962
 08/18/92   22:17:30            19.75      6.468      3.962
 08/18/92   22:18:00            19.82      6.537      3.973
 08/18/92   22:18:30           19.889      6.607      3.973
 08/18/92   22:19:00           19.958      6.676      3.985
 08/18/92   22:19:30           20.005      6.722      3.996
 08/18/92   22:20:00           20.051      6.768      3.996
 08/18/92   22:20:30           20.097      6.815      3.996
 08/18/92   22:21:00           20.143      6.861      4.008
 08/18/92   22:21:30           20.189      6.907      4.008
 08/18/92   22:22:00           20.212      6.930      4.019
 08/18/92   22:22:30           20.259      6.976      4.019
 08/18/92   22:23:30           20.328      7.046      4.031
 08/18/92   22:24:30           20.374      7.092      4.043
 08/18/92   22:25:30            20.42      7.138      4.043
 08/18/92   22:26:30           20.467      7.184      4.054
 08/18/92   22:27:30           20.513      7.230      4.054
 08/18/92   22:28:30           20.559      7.253      4.066
 08/18/92   22:29:30           20.582      7.300      4.066
 08/18/92   22:30:30           20.605      7.323      4.077
 08/18/92   22:31:30           20.628      7.346      4.077
 08/18/92   22:32:30           20.674      7.369      4.089
```

TABLE C-2

Recovery Phase Transducer Data (2 of 2)

```
PlotFile B:\HADCO301.PRN
DataFile C:\HADCO3.DAT
HADCO -   OWEGO, NY
Time of First Log in Specified Window
 08/18/92   12:17:45

                            Analog#01  Analog#02  Analog#03
                           pw-3...... mw-26..... mw-25.....
 Date         Time         ft........ ft........ ft........

 08/18/92    22:34:30        20.721      7.415      4.089
 08/18/92    22:36:30        20.767      7.461      4.089
 08/18/92    22:38:30         20.79      7.508      4.100
 08/18/92    22:40:30        20.836      7.531      4.112
 08/18/92    22:42:30        20.859      7.554      4.112
 08/18/92    22:44:30        20.882      7.577      4.112
 08/18/92    22:46:30        20.905      7.600      4.123
 08/18/92    22:48:30        20.929      7.623      4.123
 08/18/92    22:50:30        20.952      7.646      4.123
 08/18/92    22:52:30        20.952      7.646      4.123
 08/18/92    22:57:30        20.998      7.692      4.135
 08/18/92    23:02:30        21.021      7.715      4.146
 08/18/92    23:07:30        21.021      7.739      4.146
 08/18/92    23:12:30        21.044      7.762      4.146
```

DRAWDOWN DATA
WELL PW-3 HADCO INC.
AUGUST 18, 1992

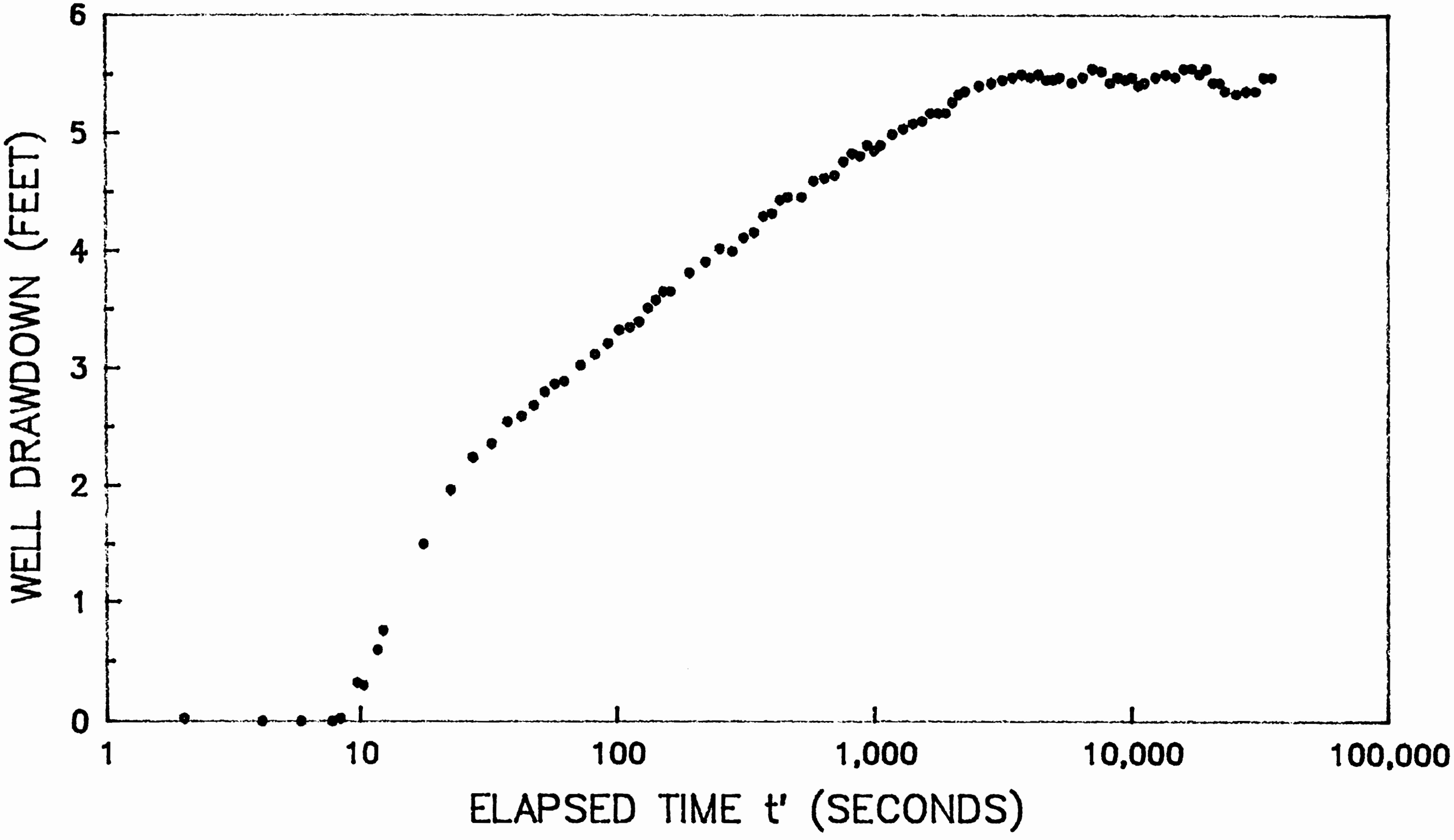


Figure C-1

Figure C-2

DRAWDOWN DATA
WELL MW-25, HADCO INC.
AUGUST 18, 1992

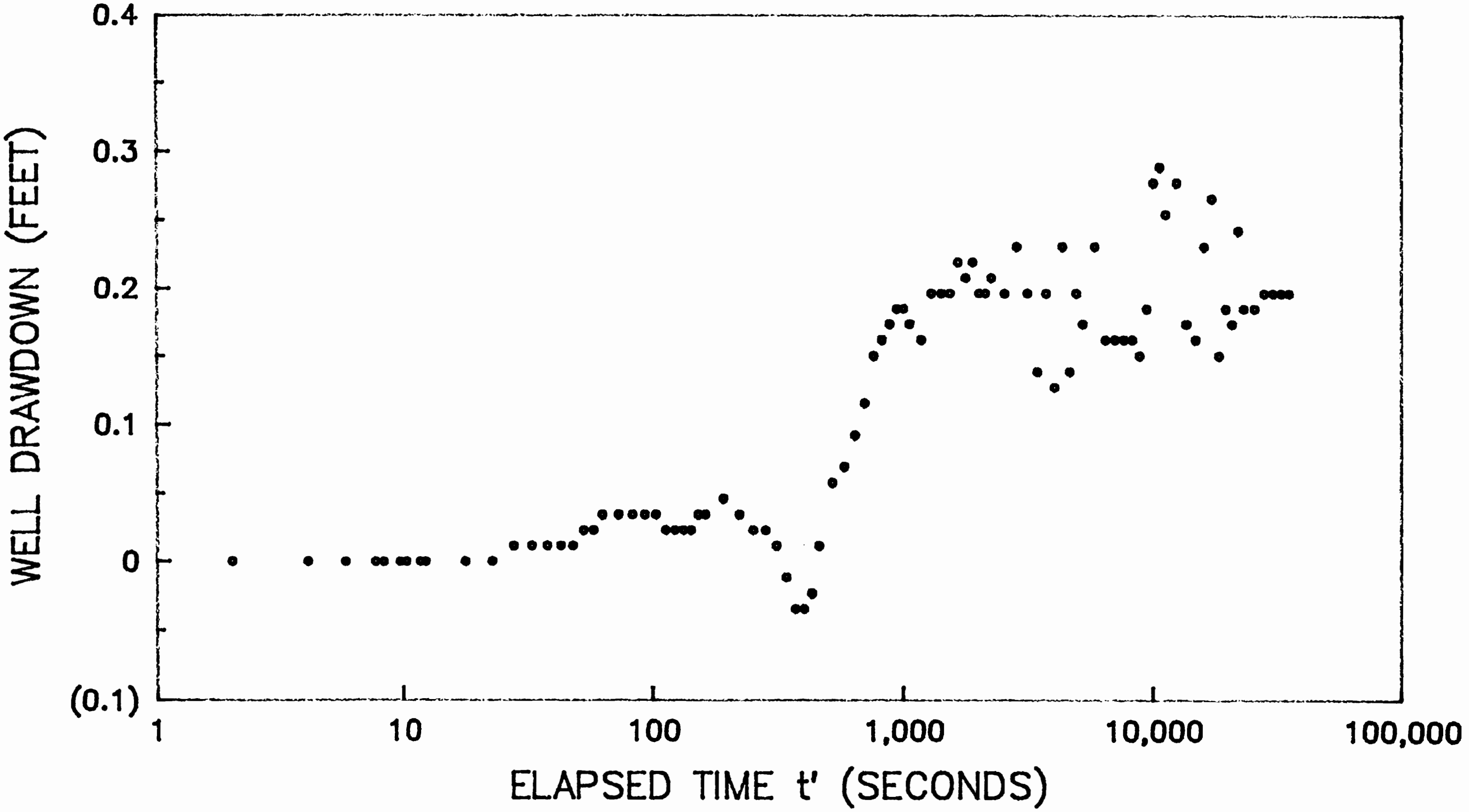
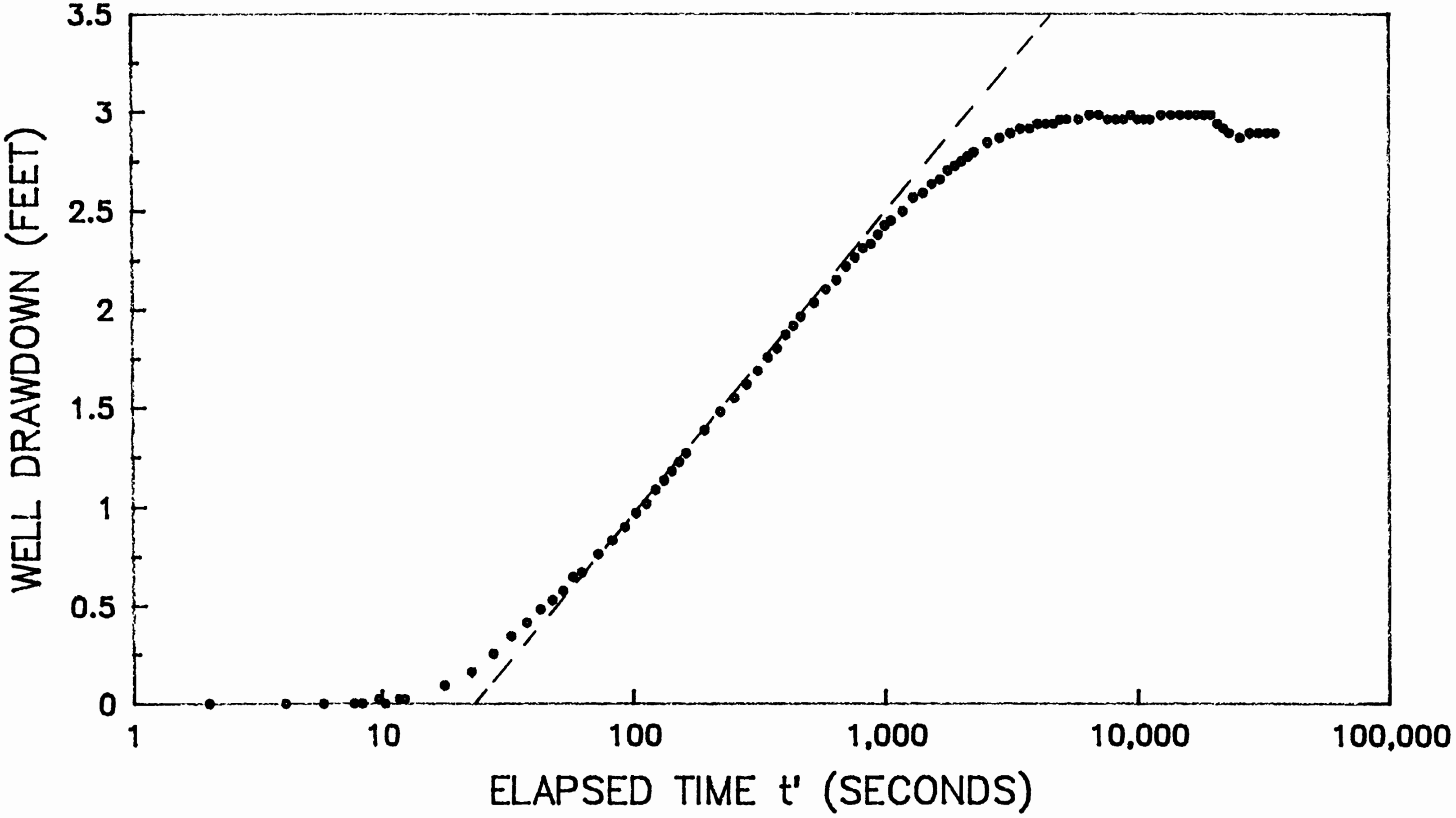
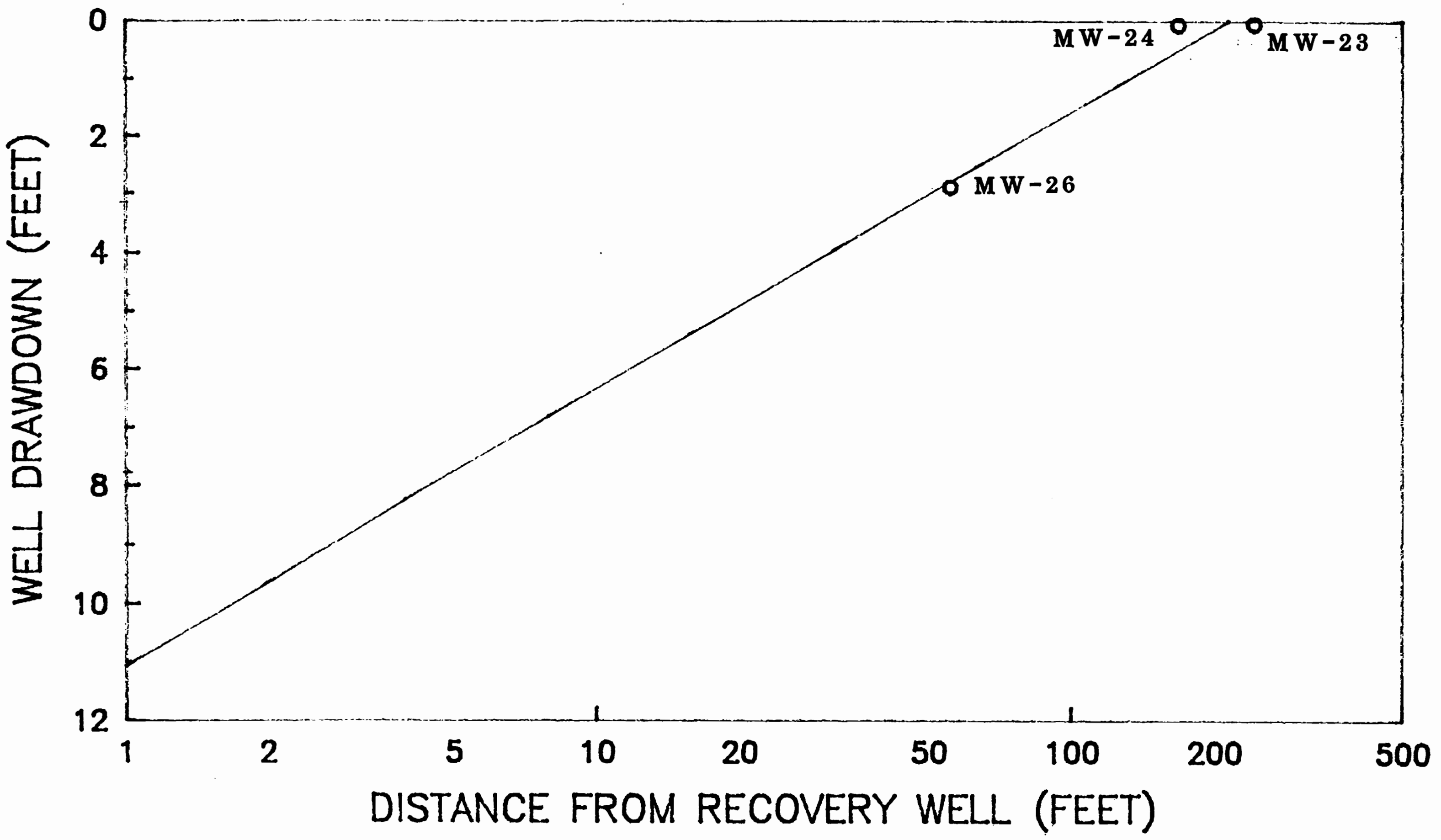


Figure C-3

DRAWDOWN DATA
WELL MW-26, HADCO INC.
AUGUST 18, 1992





DISTANCE DRAWDOWN DATA
HADCO, INC.
AUGUST 18, 1992

Figure C-4

Figure C-5

RECOVERY DATA
WELL PW-3 HADCO, INC.
AUGUST 18, 1992

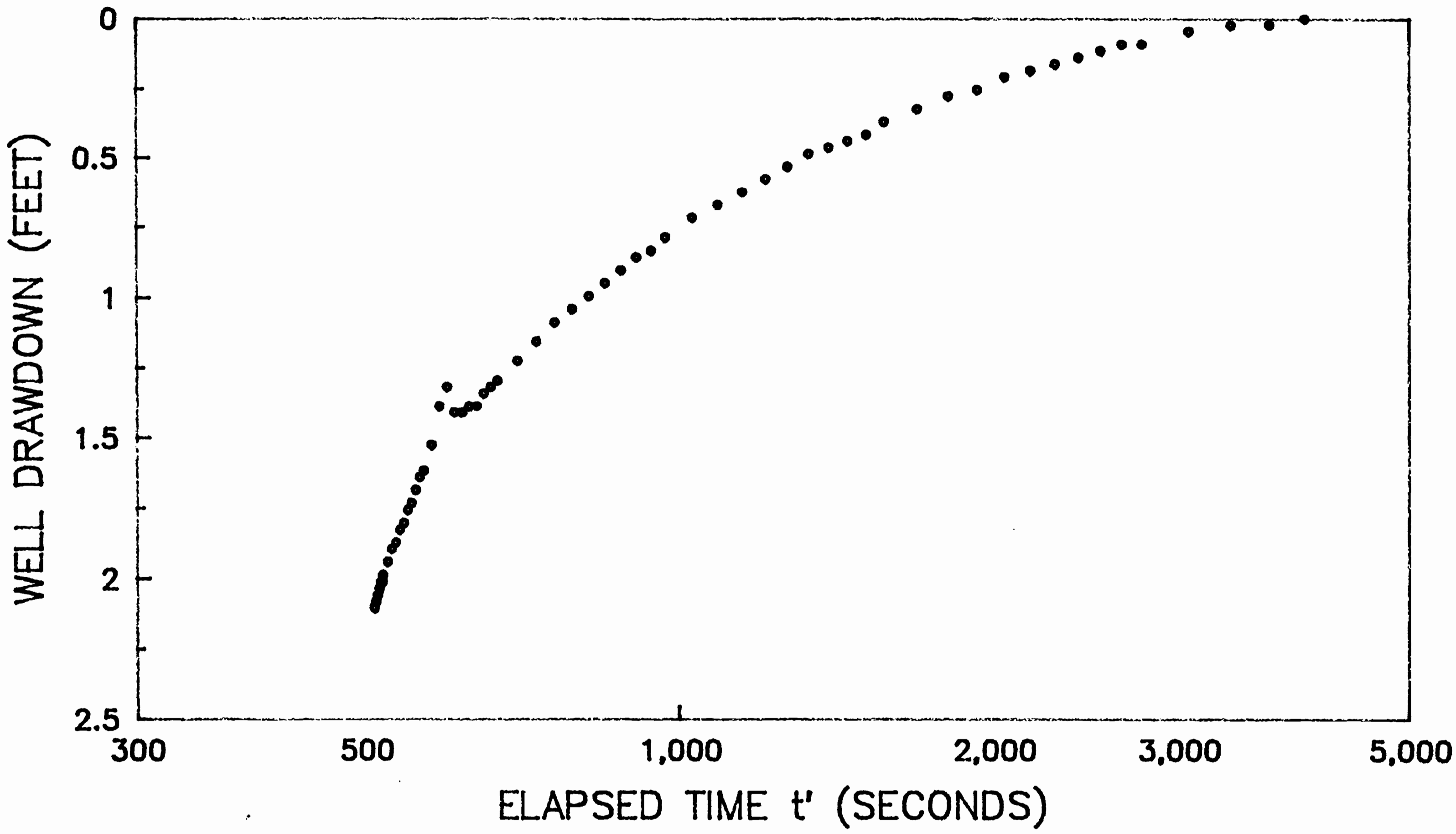
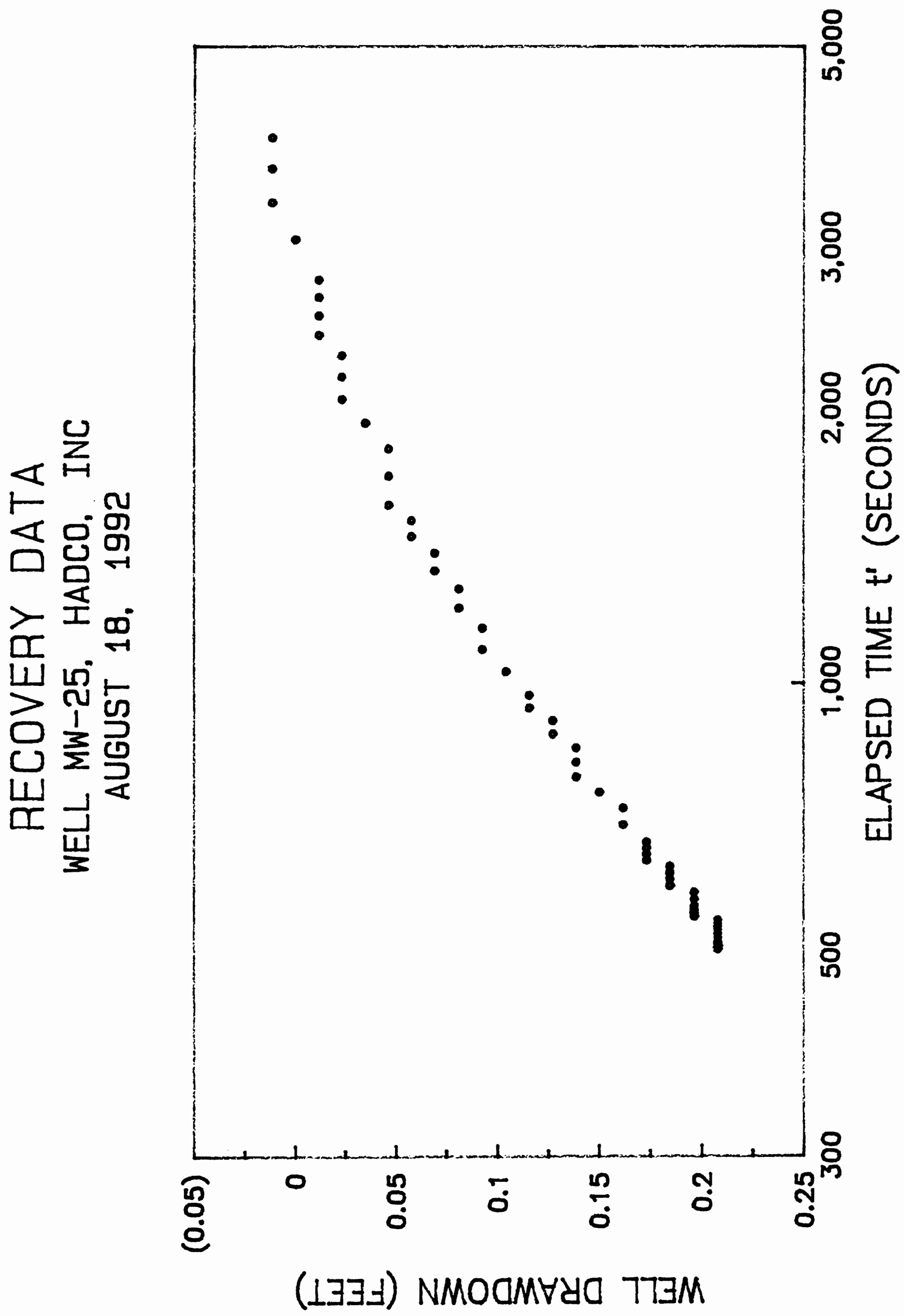


Figure C-6



RECOVERY DATA
WELL MW-25, HADCO, INC
AUGUST 18, 1992
WELL DRAWDOWN (FEET)
(0.05)
0
0.05
0.1
0.15
0.2
0.25
ELAPSED TIME t' (SECONDS)
300
500
1,000
2,000
3,000
5,000

RECOVERY DATA
WELL MW-26, HADCO, INC.
AUGUST 18, 1992

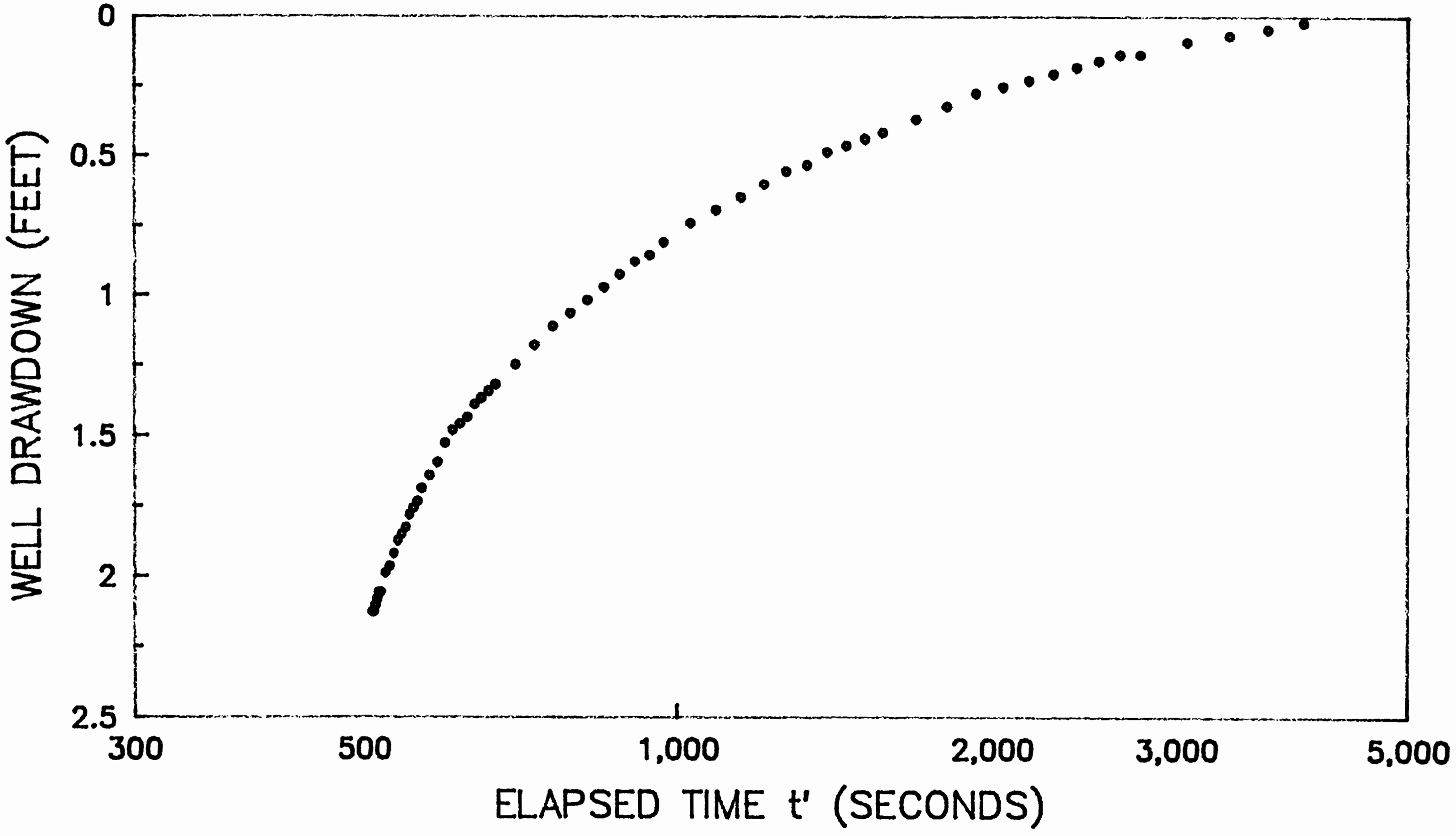


Figure C-7

TABLE C–3

DRAWDOWN PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: PW–3

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING:	21.04
DRAWDOWN PHASE START TIME:	12:19:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:17:45	21.04	−75	0.00
12:18:39	21.02	−21	0.02
12:18:41	21.04	−19	0.00
12:18:43	21.04	−17	0.00
12:18:45	21.04	−15	0.00
12:18:46	21.02	−14	0.02
12:18:47	20.72	−13	0.32
12:18:48	20.74	−12	0.30
12:18:49	20.44	−11	0.60
12:18:50	20.28	−10	0.76
12:18:55	19.54	−5	1.50
12:19:00	19.08	−0	1.96
12:19:05	18.80	5	2.24
12:19:10	18.69	10	2.36
12:19:15	18.50	15	2.54
12:19:20	18.46	20	2.59
12:19:25	18.36	25	2.68
12:19:30	18.25	30	2.79
12:19:35	18.18	35	2.86
12:19:40	18.16	40	2.89
12:19:50	18.02	50	3.03
12:20:00	17.93	60	3.12
12:20:10	17.83	70	3.21
12:20:20	17.72	80	3.33
12:20:30	17.70	90	3.35
12:20:40	17.65	100	3.40
12:20:50	17.53	110	3.51
12:21:00	17.46	120	3.58
12:21:10	17.39	130	3.65
12:21:20	17.39	140	3.65
12:21:50	17.23	170	3.81
12:22:20	17.14	200	3.90
12:22:50	17.03	230	4.02
12:23:20	17.05	260	4.00
12:23:50	16.93	290	4.11
12:24:20	16.89	320	4.16
12:24:50	16.75	350	4.30
12:25:20	16.72	380	4.32
12:25:50	16.61	410	4.43
12:26:20	16.59	440	4.46
12:27:20	16.59	500	4.46
12:28:20	16.45	560	4.60
12:29:20	16.42	620	4.62
12:30:20	16.40	680	4.64
12:31:20	16.29	740	4.76
12:32:20	16.22	800	4.83
12:33:20	16.24	860	4.80

TABLE C–3

DRAWDOWN PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: PW–3

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING:	21.04
DRAWDOWN PHASE START TIME:	12:19:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:34:20	16.15	920	4.90
12:35:20	16.19	980	4.85
12:36:20	16.15	1040	4.90
12:38:20	16.05	1160	4.99
12:40:20	16.01	1280	5.04
12:42:20	15.96	1400	5.08
12:44:20	15.94	1520	5.10
12:46:20	15.87	1640	5.17
12:48:20	15.87	1760	5.17
12:50:20	15.87	1880	5.17
12:52:20	15.78	2000	5.27
12:54:20	15.71	2120	5.34
12:56:20	15.69	2240	5.36
13:01:20	15.64	2540	5.40
13:06:20	15.62	2840	5.43
13:11:20	15.59	3140	5.45
13:16:20	15.57	3440	5.48
13:21:20	15.55	3740	5.50
13:26:20	15.57	4040	5.48
13:31:20	15.55	4340	5.50
13:36:20	15.59	4640	5.45
13:41:20	15.59	4940	5.45
13:46:20	15.57	5240	5.48
13:56:20	15.62	5840	5.43
14:06:20	15.57	6440	5.48
14:16:20	15.50	7040	5.54
14:26:20	15.52	7640	5.52
14:36:20	15.62	8240	5.43
14:46:20	15.57	8840	5.48
14:56:20	15.59	9440	5.45
15:06:20	15.57	10040	5.48
15:16:20	15.64	10640	5.40
15:26:20	15.62	11240	5.43
15:46:20	15.57	12440	5.48
16:06:20	15.55	13640	5.50
16:26:20	15.57	14840	5.48
16:46:20	15.50	16040	5.54
17:06:20	15.50	17240	5.54
17:26:20	15.55	18440	5.50
17:46:20	15.50	19640	5.54
18:06:20	15.62	20840	5.43
18:26:20	15.62	22040	5.43
18:46:20	15.69	23240	5.36
19:26:20	15.71	25640	5.34
20:06:20	15.69	28040	5.36
20:46:20	15.69	30440	5.36
21:26:20	15.57	32840	5.48
22:06:20	15.57	35240	5.48

TABLE C−4

RECOVERY PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: PW−3

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING:	21.04
RECOVERY PHASE START TIME:	22:14:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME(Sec)	APPARENT DRAWDOWN(Ft)
22:14:49	18.94	49	2.10
22:14:51	18.97	51	2.08
22:14:52	18.97	52	2.08
22:14:53	18.99	53	2.06
22:14:53	18.99	53	2.06
22:14:55	19.01	55	2.03
22:14:55	19.01	55	2.03
22:14:57	19.03	57	2.01
22:14:58	19.03	58	2.01
22:14:59	19.03	59	2.01
22:14:59	19.06	59	1.99
22:15:05	19.10	65	1.94
22:15:10	19.15	70	1.89
22:15:15	19.17	75	1.87
22:15:20	19.22	80	1.83
22:15:25	19.24	85	1.80
22:15:30	19.29	90	1.76
22:15:35	19.31	95	1.73
22:15:40	19.36	100	1.69
22:15:45	19.40	105	1.64
22:15:50	19.43	110	1.62
22:16:00	19.52	120	1.53
22:16:10	19.66	130	1.39
22:16:20	19.73	140	1.32
22:16:30	19.64	150	1.41
22:16:40	19.64	160	1.41
22:16:50	19.66	170	1.39
22:17:00	19.66	180	1.39
22:17:10	19.70	190	1.34
22:17:20	19.73	200	1.32
22:17:30	19.75	210	1.29
22:18:00	19.82	240	1.22
22:18:30	19.89	270	1.16
22:19:00	19.96	300	1.09
22:19:30	20.01	330	1.04
22:20:00	20.05	360	0.99
22:20:30	20.10	390	0.95
22:21:00	20.14	420	0.90
22:21:30	20.19	450	0.86
22:22:00	20.21	480	0.83

TABLE C–4

RECOVERY PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: PW–3

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING:	21.04
RECOVERY PHASE START TIME:	22:14:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME(Sec)	APPARENT DRAWDOWN(Ft)
22:22:30	20.26	510	0.79
22:23:30	20.33	570	0.72
22:24:30	20.37	630	0.67
22:25:30	20.42	690	0.62
22:26:30	20.47	750	0.58
22:27:30	20.51	810	0.53
22:28:30	20.56	870	0.49
22:29:30	20.58	930	0.46
22:30:30	20.61	990	0.44
22:31:30	20.63	1050	0.42
22:32:30	20.67	1110	0.37
22:34:30	20.72	1230	0.32
22:36:30	20.77	1350	0.28
22:38:30	20.79	1470	0.25
22:40:30	20.84	1590	0.21
22:42:30	20.86	1710	0.19
22:44:30	20.88	1830	0.16
22:46:30	20.91	1950	0.14
22:48:30	20.93	2070	0.12
22:50:30	20.95	2190	0.09
22:52:30	20.95	2310	0.09
22:57:30	21.00	2610	0.05
23:02:30	21.02	2910	0.02
23:07:30	21.02	3210	0.02
23:12:30	21.04	3510	0.00

TABLE C−5

DRAWDOWN PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: MW−25

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING: 4.14
DRAWDOWN PHASE START TIME: 12:19:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:17:45	4.12	−75	0.01
12:18:39	4.13	−21	0.00
12:18:41	4.13	−19	0.00
12:18:43	4.13	−17	0.00
12:18:45	4.13	−15	0.00
12:18:46	4.13	−14	0.00
12:18:47	4.13	−13	0.00
12:18:48	4.13	−12	0.00
12:18:49	4.13	−11	0.00
12:18:50	4.13	−10	0.00
12:18:55	4.13	−5	0.00
12:19:00	4.13	−0	0.00
12:19:05	4.12	5	0.01
12:19:10	4.12	10	0.01
12:19:15	4.12	15	0.01
12:19:20	4.12	20	0.01
12:19:25	4.12	25	0.01
12:19:30	4.11	30	0.02
12:19:35	4.11	35	0.02
12:19:40	4.10	40	0.03
12:19:50	4.10	50	0.03
12:20:00	4.10	60	0.03
12:20:10	4.10	70	0.03
12:20:20	4.10	80	0.03
12:20:30	4.11	90	0.02
12:20:40	4.11	100	0.02
12:20:50	4.11	110	0.02
12:21:00	4.11	120	0.02
12:21:10	4.10	130	0.03
12:21:20	4.10	140	0.03
12:21:50	4.09	170	0.05
12:22:20	4.10	200	0.03
12:22:50	4.11	230	0.02
12:23:20	4.11	260	0.02
12:23:50	4.12	290	0.01
12:24:20	4.15	320	−0.01
12:24:50	4.17	350	−0.03
12:25:20	4.17	380	−0.03
12:25:50	4.16	410	−0.02
12:26:20	4.12	440	0.01
12:27:20	4.08	500	0.06
12:28:20	4.07	560	0.07
12:29:20	4.04	620	0.09
12:30:20	4.02	680	0.12
12:31:20	3.98	740	0.15
12:32:20	3.97	800	0.16

TABLE C–5

DRAWDOWN PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: MW–25

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING:	4.14
DRAWDOWN PHASE START TIME:	12:19:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:33:20	3.96	860	0.17
12:34:20	3.95	920	0.18
12:35:20	3.95	980	0.18
12:36:20	3.96	1040	0.17
12:38:20	3.97	1160	0.16
12:40:20	3.94	1280	0.20
12:42:20	3.94	1400	0.20
12:44:20	3.94	1520	0.20
12:46:20	3.92	1640	0.22
12:48:20	3.93	1760	0.21
12:50:20	3.92	1880	0.22
12:52:20	3.94	2000	0.20
12:54:20	3.94	2120	0.20
12:56:20	3.93	2240	0.21
13:01:20	3.94	2540	0.20
13:06:20	3.90	2840	0.23
13:11:20	3.94	3140	0.20
13:16:20	4.00	3440	0.14
13:21:20	3.94	3740	0.20
13:26:20	4.01	4040	0.13
13:31:20	3.90	4340	0.23
13:36:20	4.00	4640	0.14
13:41:20	3.94	4940	0.20
13:46:20	3.96	5240	0.17
13:56:20	3.90	5840	0.23
14:06:20	3.97	6440	0.16
14:16:20	3.97	7040	0.16
14:26:20	3.97	7640	0.16
14:36:20	3.97	8240	0.16
14:46:20	3.98	8840	0.15
14:56:20	3.95	9440	0.18
15:06:20	3.86	10040	0.28
15:16:20	3.85	10640	0.29
15:26:20	3.88	11240	0.25
15:46:20	3.86	12440	0.28
16:06:20	3.96	13640	0.17
16:26:20	3.97	14840	0.16
16:46:20	3.90	16040	0.23
17:06:20	3.87	17240	0.27
17:26:20	3.98	18440	0.15
17:46:20	3.95	19640	0.18
18:06:20	3.96	20840	0.17
18:26:20	3.89	22040	0.24
18:46:20	3.95	23240	0.18
19:26:20	3.95	25640	0.18
20:06:20	3.94	28040	0.20
20:46:20	3.94	30440	0.20
21:26:20	3.94	32840	0.20
22:06:20	3.94	35240	0.20

TABLE C-6

RECOVERY PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: MW-25

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING:	4.14
RECOVERY PHASE START TIME:	22:14:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME(Sec)	APPARENT DRAWDOWN(Ft)
22:14:49	3.93	49	0.21
22:14:51	3.93	51	0.21
22:14:52	3.93	52	0.21
22:14:53	3.93	53	0.21
22:14:53	3.93	53	0.21
22:14:55	3.93	55	0.21
22:14:55	3.93	55	0.21
22:14:57	3.93	57	0.21
22:14:58	3.93	58	0.21
22:14:59	3.93	59	0.21
22:14:59	3.93	59	0.21
22:15:05	3.93	65	0.21
22:15:10	3.93	70	0.21
22:15:15	3.93	75	0.21
22:15:20	3.93	80	0.21
22:15:25	3.93	85	0.21
22:15:30	3.93	90	0.21
22:15:35	3.94	95	0.20
22:15:40	3.94	100	0.20
22:15:45	3.94	105	0.20
22:15:50	3.94	110	0.20
22:16:00	3.94	120	0.20
22:16:10	3.94	130	0.20
22:16:20	3.95	140	0.18
22:16:30	3.95	150	0.18
22:16:40	3.95	160	0.18
22:16:50	3.95	170	0.18
22:17:00	3.96	180	0.17
22:17:10	3.96	190	0.17
22:17:20	3.96	200	0.17
22:17:30	3.96	210	0.17
22:18:00	3.97	240	0.16
22:18:30	3.97	270	0.16
22:19:00	3.98	300	0.15
22:19:30	4.00	330	0.14
22:20:00	4.00	360	0.14
22:20:30	4.00	390	0.14
22:21:00	4.01	420	0.13
22:21:30	4.01	450	0.13
22:22:00	4.02	480	0.12

TABLE C-6

RECOVERY PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: MW-25

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING:	4.14
RECOVERY PHASE START TIME:	22:14:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME(Sec)	APPARENT DRAWDOWN(Ft)
22:22:30	4.02	510	0.12
22:23:30	4.03	570	0.10
22:24:30	4.04	630	0.09
22:25:30	4.04	690	0.09
22:26:30	4.05	750	0.08
22:27:30	4.05	810	0.08
22:28:30	4.07	870	0.07
22:29:30	4.07	930	0.07
22:30:30	4.08	990	0.06
22:31:30	4.08	1050	0.06
22:32:30	4.09	1110	0.05
22:34:30	4.09	1230	0.05
22:36:30	4.09	1350	0.05
22:38:30	4.10	1470	0.03
22:40:30	4.11	1590	0.02
22:42:30	4.11	1710	0.02
22:44:30	4.11	1830	0.02
22:46:30	4.12	1950	0.01
22:48:30	4.12	2070	0.01
22:50:30	4.12	2190	0.01
22:52:30	4.12	2310	0.01
22:57:30	4.13	2610	0.00
23:02:30	4.15	2910	−0.01
23:07:30	4.15	3210	−0.01
23:12:30	4.15	3510	−0.01

TABLE C–7

DRAWDOWN PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: MW–26

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING: 7.79
DRAWDOWN PHASE START TIME: 12:19:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:17:45	7.78	–75	0.00
12:18:39	7.78	–21	0.00
12:18:41	7.78	–19	0.00
12:18:43	7.78	–17	0.00
12:18:45	7.78	–15	0.00
12:18:46	7.78	–14	0.00
12:18:47	7.76	–13	0.02
12:18:48	7.78	–12	0.00
12:18:49	7.76	–11	0.02
12:18:50	7.76	–10	0.02
12:18:55	7.69	–5	0.09
12:19:00	7.62	–0	0.16
12:19:05	7.53	5	0.25
12:19:10	7.44	10	0.35
12:19:15	7.37	15	0.42
12:19:20	7.30	20	0.49
12:19:25	7.25	25	0.53
12:19:30	7.21	30	0.58
12:19:35	7.14	35	0.65
12:19:40	7.11	40	0.67
12:19:50	7.02	50	0.76
12:20:00	6.95	60	0.83
12:20:10	6.88	70	0.90
12:20:20	6.81	80	0.97
12:20:30	6.77	90	1.02
12:20:40	6.70	100	1.09
12:20:50	6.65	110	1.13
12:21:00	6.61	120	1.18
12:21:10	6.56	130	1.22
12:21:20	6.51	140	1.27
12:21:50	6.40	170	1.39
12:22:20	6.31	200	1.48
12:22:50	6.24	230	1.55
12:23:20	6.17	260	1.62
12:23:50	6.10	290	1.69
12:24:20	6.03	320	1.76
12:24:50	5.98	350	1.80
12:25:20	5.91	380	1.87
12:25:50	5.87	410	1.92
12:26:20	5.82	440	1.96
12:27:20	5.75	500	2.03
12:28:20	5.68	560	2.10
12:29:20	5.64	620	2.15
12:30:20	5.57	680	2.22
12:31:20	5.52	740	2.26
12:32:20	5.47	800	2.31

TABLE C-7

DRAWDOWN PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: MW-26

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING:
DRAWDOWN PHASE START TIME: 7.79
12:19:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:33:20	5.45	860	2.33
12:34:20	5.41	920	2.38
12:35:20	5.36	980	2.43
12:36:20	5.34	1040	2.45
12:38:20	5.29	1160	2.49
12:40:20	5.22	1280	2.56
12:42:20	5.20	1400	2.59
12:44:20	5.15	1520	2.63
12:46:20	5.13	1640	2.66
12:48:20	5.08	1760	2.70
12:50:20	5.06	1880	2.73
12:52:20	5.04	2000	2.75
12:54:20	5.01	2120	2.77
12:56:20	4.99	2240	2.80
13:01:20	4.94	2540	2.84
13:06:20	4.92	2840	2.86
13:11:20	4.90	3140	2.89
13:16:20	4.87	3440	2.91
13:21:20	4.87	3740	2.91
13:26:20	4.85	4040	2.93
13:31:20	4.85	4340	2.93
13:36:20	4.85	4640	2.93
13:41:20	4.83	4940	2.96
13:46:20	4.83	5240	2.96
13:56:20	4.83	5840	2.96
14:06:20	4.80	6440	2.98
14:16:20	4.80	7040	2.98
14:26:20	4.83	7640	2.96
14:36:20	4.83	8240	2.96
14:46:20	4.83	8840	2.96
14:56:20	4.80	9440	2.98
15:06:20	4.83	10040	2.96
15:16:20	4.83	10640	2.96
15:26:20	4.83	11240	2.96
15:46:20	4.80	12440	2.98
16:06:20	4.80	13640	2.98
16:26:20	4.80	14840	2.98
16:46:20	4.80	16040	2.98
17:06:20	4.80	17240	2.98
17:26:20	4.80	18440	2.98
17:46:20	4.80	19640	2.98
18:06:20	4.85	20840	2.93
18:26:20	4.87	22040	2.91
18:46:20	4.90	23240	2.89
19:26:20	4.92	25640	2.86
20:06:20	4.90	28040	2.89
20:46:20	4.90	30440	2.89
21:26:20	4.90	32840	2.89
22:06:20	4.90	35240	2.89

TABLE C-8

RECOVERY PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: MW-26

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING:	7.79
RECOVERY PHASE START TIME:	22:14:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME(Sec)	APPARENT DRAWDOWN(Ft)
22:14:49	5.66	49	2.13
22:14:51	5.66	51	2.13
22:14:52	5.66	52	2.13
22:14:53	5.68	53	2.10
22:14:53	5.68	53	2.10
22:14:55	5.71	55	2.08
22:14:55	5.71	55	2.08
22:14:57	5.73	57	2.06
22:14:58	5.73	58	2.06
22:14:59	5.73	59	2.06
22:14:59	5.73	59	2.06
22:15:05	5.80	65	1.99
22:15:10	5.82	70	1.96
22:15:15	5.87	75	1.92
22:15:20	5.91	80	1.87
22:15:25	5.94	85	1.85
22:15:30	5.96	90	1.82
22:15:35	6.01	95	1.78
22:15:40	6.03	100	1.76
22:15:45	6.05	105	1.73
22:15:50	6.10	110	1.69
22:16:00	6.14	120	1.64
22:16:10	6.19	130	1.59
22:16:20	6.26	140	1.52
22:16:30	6.31	150	1.48
22:16:40	6.33	160	1.46
22:16:50	6.35	170	1.43
22:17:00	6.40	180	1.39
22:17:10	6.42	190	1.36
22:17:20	6.44	200	1.34
22:17:30	6.47	210	1.32
22:18:00	6.54	240	1.25
22:18:30	6.61	270	1.18
22:19:00	6.68	300	1.11
22:19:30	6.72	330	1.06
22:20:00	6.77	360	1.02
22:20:30	6.81	390	0.97
22:21:00	6.86	420	0.92
22:21:30	6.91	450	0.88
22:22:00	6.93	480	0.85

TABLE C-8

RECOVERY PHASE TRANSDUCER DATA REDUCTION
WELL NUMBER: MW-26

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC TRANSDUCER READING:	7.79
RECOVERY PHASE START TIME:	22:14:00

CLOCK TIME	TRANSDUCER READING (Ft)	RUNNING TIME(Sec)	APPARENT DRAWDOWN(Ft)
22:22:30	6.98	510	0.81
22:23:30	7.05	570	0.74
22:24:30	7.09	630	0.69
22:25:30	7.14	690	0.65
22:26:30	7.18	750	0.60
22:27:30	7.23	810	0.55
22:28:30	7.25	870	0.53
22:29:30	7.30	930	0.49
22:30:30	7.32	990	0.46
22:31:30	7.35	1050	0.44
22:32:30	7.37	1110	0.42
22:34:30	7.42	1230	0.37
22:36:30	7.46	1350	0.32
22:38:30	7.51	1470	0.28
22:40:30	7.53	1590	0.25
22:42:30	7.55	1710	0.23
22:44:30	7.58	1830	0.21
22:46:30	7.60	1950	0.18
22:48:30	7.62	2070	0.16
22:50:30	7.65	2190	0.14
22:52:30	7.65	2310	0.14
22:57:30	7.69	2610	0.09
23:02:30	7.72	2910	0.07
23:07:30	7.74	3210	0.05
23:12:30	7.76	3510	0.02

TABLE C−9

DRAWDOWN AND RECOVERY PHASE MANUAL DATA REDUCTION
WELL NUMBER: MW−17

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC WATER LEVEL: 8.65
TEST START TIME: 12:19:00

CLOCK TIME	DEPTH TO WATER (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:19:00		PUMP ON	
12:38:00	8.72	1140	0.07
13:01:00	8.72	2520	0.07
13:38:00	8.70	4740	0.05
15:05:00	8.64	9960	−0.01
16:03:00	8.72	13440	0.07
16:59:00	8.73	16800	0.08
17:56:00	8.73	20220	0.08
19:04:00	8.74	24300	0.09
20:00:00	8.73	27660	0.08
20:55:00	8.74	30960	0.09
21:53:00	8.75	34440	0.10
22:14:00		PUMP OFF	
22:20:00	8.78	36060	0.13
22:26:00	8.75	36420	0.10
22:36:00	8.74	37020	0.09
22:43:00	8.73	37440	0.08
22:51:00	8.74	37920	0.09
22:57:00	8.73	38280	0.08
23:08:00	8.73	38940	0.08
23:39:00	8.73	40800	0.08

TABLE C−10

DRAWDOWN AND RECOVERY PHASE MANUAL DATA REDUCTION
WELL NUMBER: MW−19

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC WATER LEVEL:	6.72
TEST START TIME:	12:19:00

CLOCK TIME	DEPTH TO WATER (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:19:00		PUMP ON	
12:41:00	6.69	1320	−0.03
13:04:00	6.69	2700	−0.03
13:30:00	6.69	4260	−0.03
14:40:00	6.69	8460	−0.03
16:07:00	6.70	13680	−0.02
17:02:00	6.70	16980	−0.02
17:58:00	6.71	20340	−0.01
19:07:00	6.72	24480	0.00
20:00:00	6.73	27660	0.01
20:57:00	6.75	31080	0.03
21:56:00	6.73	34620	0.01
22:14:00		PUMP OFF	
22:24:00	6.76	36300	0.04
22:30:00	6.75	36660	0.03
22:39:00	6.74	37200	0.02
22:47:00	6.73	37680	0.01
22:54:00	6.74	38100	0.02
23:05:00	6.74	38760	0.02
23:12:00	6.74	39180	0.02
23:42:00	6.75	40980	0.03

TABLE C-11

DRAWDOWN AND RECOVERY PHASE MANUAL DATA REDUCTION
WELL NUMBER: MW-23

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC WATER LEVEL: 7.23
TEST START TIME: 12:19:00

CLOCK TIME	DEPTH TO WATER (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:19:00		PUMP ON	
12:42:00	7.17	1380	−0.06
13:04:00	7.19	2700	−0.04
13:30:00	7.21	4260	−0.02
14:41:00	7.23	8520	0.00
16:08:00	7.19	13740	−0.04
17:02:00	7.17	16980	−0.06
17:59:00	7.20	20400	−0.03
19:08:00	7.20	24540	−0.03
20:03:00	7.21	27840	−0.02
20:37:00	7.22	29880	−0.01
21:57:00	7.22	34680	−0.01
22:14:00		PUMP OFF	
22:25:00	7.23	36360	0.00
22:31:00	7.22	36720	−0.01
22:40:00	7.22	37260	−0.01
22:48:00	7.22	37740	−0.01
22:55:00	7.22	38160	−0.01
23:06:00	7.22	38820	−0.01
23:13:00	7.22	39240	−0.01
23:43:00	7.21	41040	−0.02

TABLE C-12

DRAWDOWN AND RECOVERY PHASE MANUAL DATA REDUCTION
WELL NUMBER: MW-24

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC WATER LEVEL:	8.89
TEST START TIME:	12:19:00

CLOCK TIME	DEPTH TO WATER (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:19:00		PUMP ON	
12:20:00	8.90	60	0.01
12:20:30	8.90	90	0.01
12:21:00	8.90	120	0.01
12:50:00	8.90	1860	0.01
13:00:00	8.91	2460	0.02
13:37:00	8.93	4680	0.04
14:34:00	8.93	8100	0.04
15:02:00	8.93	9780	0.04
16:04:41	8.94	13541	0.05
16:59:36	8.95	16836	0.06
17:56:00	8.95	20220	0.06
19:03:00	8.96	24240	0.07
19:59:00	8.96	27600	0.07
20:55:00	8.97	30960	0.08
21:54:00	8.98	34500	0.09
22:14:00		PUMP OFF	
22:16:00	8.98	35820	0.09
22:17:00	8.98	35880	0.09
22:18:00	8.98	35940	0.09
22:20:00	8.98	36060	0.09
22:22:00	8.98	36180	0.09
22:24:00	8.98	36300	0.09
22:27:00	8.98	36480	0.09
22:34:00	8.98	36900	0.09
22:42:00	8.97	37380	0.08
22:49:00	8.96	37800	0.07
22:52:00	8.96	37980	0.07
22:57:00	8.96	38280	0.06
23:00:00	8.95	38460	0.06
23:07:00	8.95	38880	0.06
23:15:00	8.95	39360	0.06
23:36:00	8.94	40620	0.05
23:50:00	8.94	41460	0.05

TABLE C-13

DRAWDOWN AND RECOVERY PHASE MANUAL DATA REDUCTION
WELL NUMBER: MW-27

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

STATIC WATER LEVEL:	8.27
TEST START TIME:	12:19:00

CLOCK TIME	DEPTH TO WATER (Ft)	RUNNING TIME (Sec)	APPARENT DRAWDOWN (Ft)
12:19:00		PUMP ON	
12:40:00	8.24	1260	−0.03
13:03:00	8.26	2640	−0.01
13:31:00	8.27	4320	0.00
14:38:00	8.27	8340	0.00
16:05:29	8.27	13589	0.00
17:00:36	8.27	16896	0.00
17:57:14	8.27	20294	0.00
19:05:00	8.29	24360	0.02
20:01:00	8.29	27720	0.02
20:56:00	8.29	31020	0.02
21:55:00	8.30	34560	0.03
22:14:00		PUMP OFF	
22:20:00	8.32	36060	0.05
22:27:00	8.31	36480	0.04
22:37:00	8.30	37080	0.03
22:44:00	8.30	37500	0.03
22:53:00	8.30	38040	0.03
23:03:00	8.29	38640	0.02
23:10:00	8.29	39060	0.02
23:40:00	8.30	40860	0.03

APPENDIX D

PW-3 CAPTURE-ZONE SIMULATION

APPENDIX D

Introduction

This Appendix describes a numerical modeling effort performed to help delineate the ground-water capture zone that may be achieved during long-term pumping from recovery well PW-3. The key objectives of ground-water flow modeling were to: (1) evaluate whether pumping from PW-3 may hydraulically control and remove shallow overburden groundwater from the vicinity of PW-3, which is screened in the deep overburden; (2) illustrate in plan view and cross section the capture zone of groundwater that may be achieved by pumping from PW-3; and (3) assess the down-gradient limit of the three-dimensional capture zone.

Conceptual Model of Overburden Ground-Water Flow

The geologic data generated during monitoring well installation at the site demonstrate that the overburden is geologically heterogeneous, including zones of sand; sand and gravel; silt, sand, and gravel; clay; and till. No laterally-continuous, low-permeability, confining unit has been identified, however, within the unconsolidated overburden deposits. The numerical model described in this section, therefore, treats the overburden as a single, complex hydrogeologic unit.

Hydrogeologic data from monitoring well boreholes indicate that the overburden is grossly stratified parallel to the top-of-rock surface. In bulk, these stratified deposits may be expected to be more permeable in the horizontal than the vertical direction. The numerical model accommodates this anisotropy by allowing input of greater horizontal than vertical hydraulic conductivity for the overburden as a whole.

Model Selection

The model selected for PW-3 capture zone simulation was "MODFLOW," the USGS Modular Three-Dimensional Finite-Difference Ground-Water Flow Model (McDonald and Harbaugh, 1988). Using a three dimensional array of rectilinear finite flow units, or cells, MODFLOW offered the flexibility to represent the complex hydrogeologic flow regime, including a variable horizontal to vertical conductivity ratio and three dimensional flow.

Three Dimensional Model Grid Setup

The MODFLOW model was designed to simulate the entire overburden formation as a single hydrogeologic unit. The model grid developed to simulate the hydraulic response to pumping from PW-3 consisted of 4 layers, 19 rows, and 33 columns. The grid orientation is shown schematically in Figure D-1. To facilitate the modeling process, the model grid was designed to utilize the symmetry of the flow system during pumping. Column #1 (of 17 columns) crossed through the location of PW-3, and was oriented parallel to the south-southwestward hydraulic gradient across the site. The entire modeled zone was thus simulated using a model grid covering one half of the symmetrical flow system.

The cell representing PW-3 was in the middle of Column #1 in the bottom model layer (Layer #4). The model grid extended from PW-3 toward the north-northeast, south-southwest, and east-southeast to a distance of approximately 2000 feet, where the potentiometric responses to pumping from PW-3 were assumed to be negligible. Cells along Rows #1 and #33, and Column #17, therefore, were assigned constant head values compatible with the preexisting south-southwestward hydraulic gradient of 0.03 feet per foot, parallel to the columns in the model grid. Head values at all other cells in the grid were variable.

As shown in Figure D-2, four model layers were used to evaluate the simulated response to pumping from PW-3 in three dimensions. The layer thicknesses from top (Layer #1) to bottom (Layer #4) were 12 feet, 12 feet, 15 feet, and 18 feet, respectively, corresponding the 57- foot thick overburden zone penetrated by PW-3.

Model Calibration

Prior to simulating the affects of long-term pumping from PW-3, the model was calibrated against the actual potentiometric responses observed at observation wells MW-25 and MW-26 during the pumping test of PW-3 performed on August 18, 1992. After 10 hours of pumping from PW-3 on August 18, 1992, potentiometric drawdowns of 0.18 feet and 2.89 were observed at shallow overburden well MW-25 and deep overburden well MW-26, respectively. The objective of the calibration, therefore, was to identify parameters that, when used in the MODFLOW model, yielded computed drawdowns that match these observed drawdowns. The iterative calibration process entailed:

- running the MODFLOW model with PW-3 pumping at 11 gpm for 10 hours, as during the pumping test;
- determining the simulated drawdowns at MW-25 and MW-26;
- comparing the simulated drawdowns to the observed drawdowns of 0.18 feet MW-25 and 2.89 feet at MW-26;
- adjusting the model parameters; and
- re-running the model.

Based on the pumping test results and hydrogeologic data obtained during monitoring well installation at the site, the following hydrogeologic parameters were initially used in the calibration effort:

- horizontal and vertical hydraulic conductivity (K) = 1.8 x 10^{-3} cm/sec;
- ratio of horizontal to vertical K (Kh/Kv) = 1;
- Layer #1 storativity = 0.2, Layers #2-4 storativity = 0.001;
- hydraulic gradient = 0.03 ft/ft south-southwestward;
- PW-3 pumping rate = 11 gpm; and
- pumping time = 10 hours.

After 19 iterations of the calibration process, the simulated drawdown values of 0.18 feet and 2.69 feet were computed, providing a reasonable match with the 0.18 feet and 2.89 feet of drawdown observed at MW-25 and MW-26 after 10 hours of pumping PW-3 at 11 gpm. The parameters that were modified to provide this calibration "match" are:

- horizontal hydraulic conductivity (Kh) = 9.1 x 10^{-4} cm/sec, vertical hydraulic conductivity (Kz) = 1.8 x 10^{-4} cm/sec;
- ratio of horizontal to vertical K (Kh/Kv) = 5; and
- Layer #1 storativity = 0.05, Layers #2-4 storativity = 0.001.

The calibrated vertical hydraulic conductivity is controlled within the model by assigned values of vertical "conductance" between the model layers. Storativity values calculated from short-term pumping periods typically are low, but the effective storativity increases during pumping (Nwankwor, 1984). This affect results from delayed drainage of stored water at the top of the saturated zone. The calibrated value of 0.05 is appropriate for the relatively short 10-hour pumping test modeled during the calibration procedure. During long-term pumping, however, the effective storativity value for the top of the overburden flow system would expected to approach the specific yield of the unconfined aquifer material, approximately 0.1 to 0.3. The calibrated Layer #1 storativity value of 0.05 was thus replaced with an estimated value of 0.2 for use in long-term capture-zone modeling. Increasing the storativity slightly reduces the computed drawdown in Layer #1 and is conservative with respect to capture zone simulation.

Capture-Zone Simulation

To simulate the capture zone that may be achieved during long-term pumping from PW-3, the calibrated MODFLOW model was run using a pumping rate of 11 gpm at PW-3 and a pumping duration of 60 days. The hydraulic heads computed by the model were used to depict the simulated capture zone of PW-3. The flow system in the vicinity of PW-3 is assumed to be symmetrical. Head values computed for the modeled half of the flow system, therefore, were projected across the plane of symmetry through PW-3 to enable depiction of the entire, symmetrical capture zone.

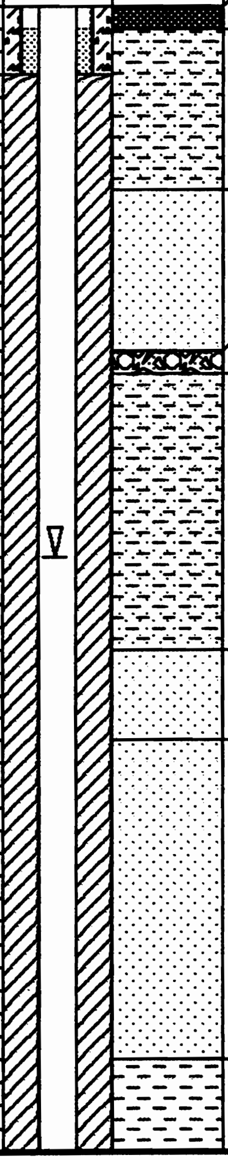
The results of the simulation are depicted on Figures D-2 and D-3. To evaluate the vertical profile of the capture zone through PW-3, head values computed along Column #1 in all four model layers are plotted and contoured on Figure D-2. Simulated flow lines also are drawn, showing the vertical capture zone through PW-3 parallel to the pre-existing hydraulic gradient. The simulated capture zone suggests that pumping 11 gpm from PW-3 for 60 days may hydraulically control shallow, intermediate, and deep overburden ground-water. The simulated capture zone is unlimited in the upgradient direction. The predicted capture zone downgradient of PW-3 extends to a distance of approximately 80 to 100 feet for shallow or deep overburden groundwater, respectively.

Figure D-3 shows a plan view of the capture zone computed for deep overburden groundwater. The computed head values from model Layer #4 are contoured, and the simulated ground-water flow lines are drawn showing the computed capture zone. The capture zone of deep overburden groundwater predicted by the model extends approximately 600 feet cross-gradient and approximately 100 feet downgradient of PW-3.

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED: 8/13/92 CLASSIFIED BY: DWL	**WELL PW-3**
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/12/92	LOCATION: Owego, NY	PAGE: 1 of 3

SUBSURFACE LOG

DEPTH (FT)	SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)
5								
0								
	1	1.3	9	0.0				
			11					
			11					
	2	1.0	7	0.0				
			9					
			14					
			12					
	3	0.5	5	0.0				
-5			6					
			9					
			5					
	4	0.5	6	0.0				
			6					
			11					
			27					
	5	0.5	3	0.0				
			7					
			10					
			17					
-10	6	1.0	4	2.0				
			8					
			8					
			10					
	7	0.5	17	1.6				
			10					
			10					
			16					
	8	1.3	6	0.0				
			6					
-15			6					
			6					
	9	1.0	6	0.0				
			10					
			13					
			22					
	10	1.0	7	0.0				
			9					
			9					
			10					
-20	11	0.5	7	0.0				
			9					
			10					
			10					
	12	1.5	8	0.0				
			6					
			10					
			11					
	13	0.4	7	0.0				
-25			9					



SOIL/ROCK CLASSIFICATION

ASPHALT

Brown fine to coarse SAND and SILT, some fine to medium Gravel, compact, moist.

Brown fine to medium SAND, little Silt, trace coarse Sand, trace Gravel, loose, moist.

Brown medium GRAVEL, little Silt, loose, moist.

Brown fine to coarse SAND and SILT, some fine to medium Gravel, loose, moist.

-Wet

Brown fine to coarse SAND, some Silt, trace Clay, loose, wet, black sheen at 15.0 feet.

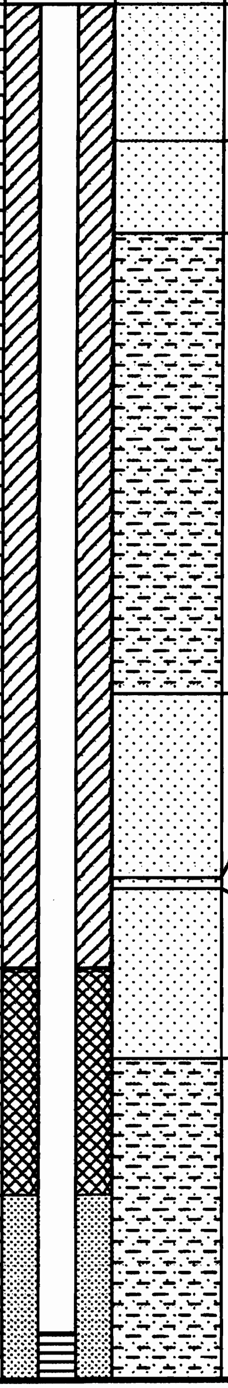
Brown fine to coarse SAND, some Silt trace fine to medium Gravel, compact, wet.

Brown SILT, some fine to coarse Sand, trace fine to medium Gravel, compact, wet.

ROCK FEATURES

BLASLAND & BOUCK ENGINEERS, P.C.	DATE COMPLETED 8/13/92 CLASSIFIED BY: DWL	# WELL PW-3
SURFACE ELEVATION:	PROJECT: HADCO CORPORATION	PROJECT NO.: 263.05
DATE STARTED: 8/12/92	LOCATION: Owego, NY	PAGE: 2 of 3

SUBSURFACE LOG



DEPTH (FT)	SAMPLES	SAMPLE/RUN NO.	SOIL DATA RECOVERY (FT)	SOIL DATA BLOWS/6 IN.	SOIL DATA PID HEADSPACE (ppm)	ROCK DATA FROM/TO	ROCK DATA % RECOVERY	ROCK DATA % RQD	ROCK DATA AVERAGE RATE (MIN./FT)	WELL COLUMN	GEOLOGIC COLUMN	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
-25				10								Brown fine to coarse SAND, little Silt, trace Gravel, compact, wet. -Grades to some angular Gravel.	
				10									
		14	1.0	5	0.0								
				13									
				14									
				14									
		15	0.5	15	0.0							Brown fine to coarse SAND, some fine to medium angular Gravel, very compact, wet.	
				16									
				16									
				12									
-30		16	1.0	11	0.0							Brown fine SAND and SILT, little fine to medium angular Gravel, compact, wet.	
				10									
				10									
				11									
		17	1.0	10	0.0								
				11									
				11									
				8									
		18	0.3	5	0.3								
				4									
-35				11									
				10									
		19	0.5	6	1.1								
				9									
				10									
				14									
		20	0.5	10	4.0								
				9									
				10									
				12									
-40		21	1.0	8	2.9							Brown fine to coarse SAND, little Silt, trace fine to medium Gravel, compact, wet.	
				9									
				10									
				12									
		22	0.4	5	6.4								
				12									
				14								Brown SILT and fine SAND, trace fine to medium Gravel, semi-compact, wet.	
				16									
		23	0.5	9	1.5								
				19								Brown fine to coarse SAND, little Silt, trace fine to medium Gravel, semi-compact, wet.	
-45				10									
				9									
		24	0.9	9	0.0								
				11									
				12									
				14									
		25	0.5	9	2.7							Brown fine SAND and SILT, trace fine to medium Gravel, semi-compact, wet.	
				6									
				4									
				3									
-50		26	1.0	WOR	3.9								
				WOH									
				2									
				5									
		27	0.2	2	0.0								
				1									
				2									
				2									
		28	0.5	WOH	7.9								
				3									
-55													

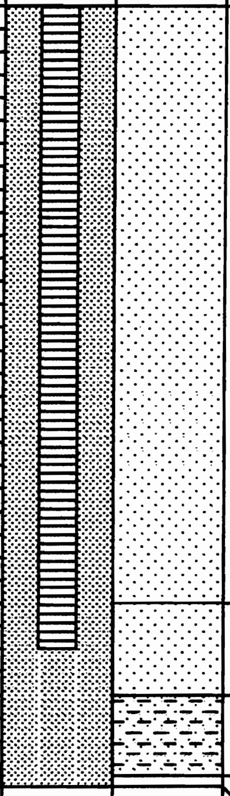
BLASLAND & BOUCK ENGINEERS, P.C.

DATE COMPLETED 8/13/92
CLASSIFIED BY: DWL

WELL PW-3

SURFACE ELEVATION:
DATE STARTED: 8/12/92
PROJECT: HADCO CORPORATION
LOCATION: Owego, NY
PROJECT NO.: 263.05
PAGE: 3 of 3

SUBSURFACE LOG



DEPTH (FT)	SAMPLES	SOIL DATA: SAMPLE/RUN NO.	SOIL DATA: RECOVERY (FT)	SOIL DATA: BLOWS/6 IN.	SOIL DATA: PID HEADSPACE (ppm)	ROCK DATA: FROM/TO	ROCK DATA: % RECOVERY	ROCK DATA: % RQD	ROCK DATA: AVERAGE RATE (MIN./FT)	SOIL/ROCK CLASSIFICATION	ROCK FEATURES
55				7						Brown fine to coarse SAND, little Silt, little rounded fine to medium Gravel, compact, wet.	
				9							
		29	1.0	14	0.0						
				10							
				10							
				13							
		30	0.3	9	0.0						
				9							
				10							
				12							
60		31	0.6	9	0.0						
				9							
				10							
				11							
		32	1.1	9	0.0						
				9							
				11							
				14							
		33	0.4	8	21.7						
				12							
65				18							
				14						-Grades with angular Siltstone fragments.	
		34	1.8	10	125.0						
				17							
				15							
				18							
		35	1.0	5	149.0					Brown fine to coarse SAND, some Silt, some angular Siltstone fragments, compact, wet.	
				15							
				22							
				21							
70		36	0.8	15	57.5					Brown fine to coarse SAND and SILT, little embedded angular Siltstone fragments, very compact, wet.	
				18							
				29							
				41							
		37	0.1	110	63.4					Weathered SILTSTONE.	
				/.5						Bottom of boring 72.0 feet. (Top of rock)	
75											
80											
85											

NOTES:

Augered through 0.5' of asphalt.

WELL CONSTRUCTION DETAILS

4-inch diameter schedule 40 PVC riser 54.0' - 0.5'
4-inch diameter, SCH 40 PVC 0.020 inch slot screen 69.0' - 54.0'
Grade 0 silica Sand pack 69.0' - 51.0'
Hydrated/bentonite seal 51.0' - 46.0'
Cement/bentonite grout 46.0' - 1.5'
Well completed with a 4-inch diameter flush mount cover set in a 2.0' deep concrete pad.

APPENDIX E

VAPOR EXTRACTION PILOT TEST DATA

TABLE E-1

FIRST PHASE VAPOR EXTRACTION PILOT TEST
VACUUM READINGS AT VAPOR POINTS

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 17, 1992

	VE-1				
TIME	VACUUM	FLOW	VP-1	VP-2	VP-3
19:35:00	--	--	0.020	0.000	0.020
19:35:05	--	--	0.020	0.050	0.040
19:35:10	34	121	0.020	0.050	0.035
19:35:15	34	124	0.020	0.050	0.035
19:35:20	--	121	0.020	0.050	0.035
19:35:25	--	--	0.020	0.050	0.035
19:35:30	--	121	0.020	0.050	0.035
19:35:35	--	--	0.020	0.050	0.035
19:35:40	--	--	0.020	0.050	0.035
19:35:45	--	121	0.020	0.050	0.035
19:35:50	--	--	0.020	0.050	0.035
19:35:55	--	--	0.020	0.050	0.035
19:36:45	34	--	0.020	0.050	0.035
19:37:00	--	--	0.020	0.050	0.035
19:37:30	34	121	0.020	0.050	0.035
19:38:00	34	121	0.020	0.050	0.035
19:38:30	34	121	0.020	0.050	0.035
19:39:00	34	121	0.020	0.050	0.035
19:39:30	--	--	0.020	0.055	0.035
19:40:00	34	121	0.020	0.055	0.035
19:40:30	--	--	0.020	0.055	0.035
19:41:00	34	121	0.020	0.055	0.035
19:41:30	--	--	0.020	0.055	0.035
19:42:00	34	121	0.020	0.055	0.035
19:42:30	--	--	0.020	0.055	0.035
19:43:30	--	--	0.020	0.055	0.035
19:44:00	34	121	0.020	0.055	0.035
19:44:30	--	--	0.020	0.055	0.035
19:45:00	34	121	0.020	0.055	0.035
19:46:00	--	--	0.020	0.055	0.035
19:47:00	34	112	0.020	0.055	0.035
19:48:00	--	--	0.020	0.055	0.035
19:49:00	34	121	0.020	0.055	0.035
19:50:00	--	--	0.020	0.055	0.035
19:51:00	34	121	0.020	0.055	0.035
19:52:00	--	--	0.020	0.055	0.035
19:53:00	34	121	0.020	0.055	0.035
19:54:00	--	--	0.020	0.055	0.035
19:55:00	34	121	0.020	0.055	0.035
19:57:00	--	--	0.020	0.055	0.035
19:59:00	--	--	0.020	0.055	0.035
20:01:00	--	--	0.020	0.055	0.035
20:03:00	--	--	0.020	0.052	0.035
20:17:00	36	--	--	--	--

TABLE E-1
(Cont'd)

FIRST PHASE VAPOR EXTRACTION PILOT TEST VACUUM READINGS AT VAPOR POINTS

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 18, 1992

TIME	VE-1		VP-1	VP-2	VP-3
	VACUUM	FLOW			
7:00:00	28	99	--	--	--
7:06:00	--	--	0.020	--	--
7:08:00	--	--	--	0.020	--
7:10:00	--	--	--	--	0.020
13:30:00	28.5	118	--	--	--
13:36:00	--	--	0.038	--	--
13:38:00	--	--	--	0.035	--
13:40:00	--	--	--	--	0.038
19:30:00	29.5	124	--	--	--
19:36:00	--	--	0.035	--	--
19:38:00	--	--	--	0.035	--
19:40:00	--	--	--	--	0.025
AUGUST 19, 1992					
7:34:00	--	--	0.025	--	--
7:35:00	--	--	--	0.035	--
7:36:00	--	--	--	--	0.025
7:39:00	31	124	--	--	--
12:07:00	31	130	--	--	--
12:11:00	--	--	0.040	--	--
12:13:00	--	--	--	0.035	--
12:14:00	--	--	--	--	0.035
16:53:00	--	--	0.035	--	--
16:55:00	--	--	--	0.038	--
16:56:00	--	--	--	--	0.025
17:00:00	30	130	--	--	--
AUGUST 20, 1992					
7:12:00	31	124	--	--	--
7:17:00	--	--	0.030	--	--
7:18:00	--	--	--	0.035	--
7:19:00	--	--	--	--	0.020
12:09:00	--	--	0.035	--	--
12:10:00	--	--	--	0.035	--
12:11:00	--	--	--	--	0.030
12:15:00	30	130	--	--	--
17:09:00	--	--	0.020	--	--
17:10:00	--	--	--	0.030	--
17:11:00	--	--	--	--	0.030
17:13:00	30	124	--	--	--
AUGUST 21, 1992					
8:00:00	--	--	0.030	--	--
8:02:00	--	--	--	0.035	--
8:03:00	--	--	--	--	0.035
8:06:00	30	130	--	--	--
10:59:00	30	130	--	--	--
11:02:00	--	--	0.035	--	--
11:03:00	--	--	--	0.035	--
11:04:00	--	--	--	--	0.035

End of pilot test.

Notes:

Vacuum measured in inches of water.
Flow measured in cubic feet per minute
-- = Measurement not taken.

TABLE E-2

SECOND PHASE VAPOR EXTRACTION PILOT TEST
VACUUM READINGS AT VAPOR POINTS

HADCO CORPORATION
OWEGO, NEW YORK

AUGUST 22, 1992

TIME	VP-3* VACUUM	FLOW	VE-1	VP-1 VACUUM	VP-2
9:19:00	--	--	--	0.010	0.000
9:19:10	40	16	0.000	0.020	--
9:19:20	--	--	--	0.020	--
9:19:30	--	--	--	--	0.050
9:19:50	--	--	--	0.035	--
9:20:00	42	16	0.000	--	0.080
9:21:00	42	16	0.000	0.035	0.080
9:22:00	42	16	0.000	0.035	0.080
9:23:00	42	16	0.000	0.035	0.080
9:24:00	42	16	0.000	0.035	0.080
9:25:00	--	--	--	0.035	0.080
9:26:00	--	--	--	0.035	0.080
9:27:00	--	--	--	0.035	0.080
9:28:00	42	16	0.000	0.035	0.080
		End of step one.			
9:29:00	67	48	0.000	0.045	0.100
9:30:00	--	--	--	0.050	0.100
9:31:00	67	48	0.000	0.050	0.100
9:32:00	--	--	--	0.050	0.100
9:33:00	--	--	--	0.050	0.100
		End of step two.			
9:34:00	74	37	0.000	0.050	0.100
9:35:00	--	--	--	0.050	0.100
9:36:00	--	--	--	0.050	0.100
9:39:00	72	37	0.010	--	--
9:49:00	--	--	--	0.050	0.100
9:51:00	--	--	--	0.050	0.100
9:53:00	--	--	--	0.050	0.100
9:55:00	--	--	--	0.050	0.100
9:59:00	70	48	0.010	--	--
10:00:00	--	--	--	0.050	0.100
10:05:00	--	--	--	0.050	0.100
10:10:00	--	--	--	0.050	0.100
10:15:00	--	--	--	0.050	0.100
10:19:00	70	48	0.015		
10:20:00	--	--	--	0.050	0.100
		End of step three.			

End of pilot test.

Notes:

Vacuum measured in inches of water.
Flow measured in cubic feet per minute.
* = VP-3 was used as the vapor extraction point in this pilot test.
-- = Measurement not taken.

APPENDIX F

ENVIRONMENTAL FATE AND TRANSPORT PROPERTIES OF THE CHEMICALS OF INTEREST

HADCO CORPORATION
RISK ASSESSMENT

APPENDIX F

ENVIRONMENTAL FATE AND TRANSPORT PROPERTIES OF THE CHEMICALS OF INTEREST

A. VOLATILES

Benzene

Benzene is highly volatile and has a moderately high water solubility (1,790 mg/l at 25°C) (CHEMFATE, 1989). In upper soil layers, volatilization is the dominant fate process. In deeper soil, the most likely transport mechanism is percolation through soil, possibly to ground water. Benzene has an adsorption coefficient (Koc) between 60 and 83, which indicates high mobility in soil (ATSDR, 1989; Swann et al., 1983). Nevertheless, transport to ground water is limited by biodegradation. Benzene is capable of completely biodegrading under both aerobic and anaerobic conditions. Possible intermediate biodegradation products include cis-dihydrodiols, 1,2-dihydroxy-1,2-dihydrazobenzene, catechols, phenol, cyclohexanone, and propanoic acid (ATSDR, 1989; Grbic-Galic and Vogel, 1987). Laboratory experiments under strictly anaerobic conditions indicated that carbon dioxide and methane were the final products of fermentation of benzene (Grbic-Galic and Vogel, 1987). Sufficient data are not available to estimate the half-life of benzene in soil. Losses due to chemical degradation in soil or water are not expected to be significant (ATSDR, 1989).

In surface waters (i.e., lakes, rivers, ponds), volatilization is the dominant removal mechanism. Volatilization rates vary depending upon a number of environmental factors including temperature, water movement and depth, and wind speed. The volatilization half-life, for example, in a rapidly flowing, shallow river on a moderately windy day has been estimated to be three hours. Biodegradation is the dominant degradation mechanism for residual benzene retained within the water body (ATSDR, 1989). Biodegradation products in water are probably the same as those identified in the soil. Benzene does not have a strong affinity for organic matter; thus, adsorption and accumulation of benzene in sediment is not a significant fate process.

Benzene is readily metabolized by animals and humans and metabolites are excreted in urine. As a result, it is not subject to bioconcentration or biomagnification in the food chain (HSDB, 1988).

In the atmosphere, benzene rapidly degrades by reaction with photochemically generated hydroxyl radicals. The average half-life of benzene in air is estimated to be 10 to 16 days (Atkinson, 1985). Information on the products of this reaction was not found. Loss through washout in precipitation is expected to be insignificant, since any benzene lost through this mechanism is likely to revolatilize to the atmosphere.

Toluene

Toluene is characterized by its high volatility, moderate water solubility (515 mg/l at 25°C), and rapid degradation in the environment (ATSDR, 1989). A Koc of 295 indicates that toluene is moderately mobile in organic soil and highly mobile in sandy or mineral soils. However, transport to ground water is limited by the rapid biodegradation of this compound. A number of microbial species are capable of biodegrading toluene, and this compound should readily degrade in the presence of a suitable microbial population (ATSDR, 1989).

In surface waters, the dominant removal processes are volatilization and biodegradation. Volatilization half-lives on the order of five to six hours in turbulent water and one to 16 days in static water have been estimated (ATSDR, 1989). The actual rate of volatilization depends on a number of different environmental factors including temperature, water movement and depth, and wind speed (Lyman et al., 1982). Adsorption to sediments is of limited importance due to the rapid biodegradation of toluene. Bioaccumulation in aquatic organisms is limited. The highest tissue levels of toluene tend to occur in species such as eels, crabs, and herring, which have low rates of toluene metabolism (ATSDR, 1989).

Toluene vapor rapidly degrades by reaction with hydroxyl radicals to yield cresol and benzaldehyde, which in turn undergo ring cleavage to yield simple hydrocarbons (ATSDR, 1989). Experimentally determined rate constants correspond to an average atmospheric half-life of about 2 to 3 days (Atkinson, 1985). Any toluene lost through washout in precipitation is expected to reenter the atmosphere through volatilization.

Chlorobenzene

Chlorobenzene is a relatively volatile compound. In soil, much of it volatilizes to the atmosphere, while the remainder either adsorbs to soil particles or percolates downward through the soil column to ground water. In sandy or mineral soils, chlorobenzene should readily leach through soil, whereas in organic soils this compound should have low mobility. If retained long enough in the soil column, chlorobenzene will biodegrade and eventually mineralize to carbon dioxide. Biodegradation in soil and water is generally a slow process, but losses via this route may be significant in situations where acclimation of the microbial population has taken place (HSDB, 1990). Sufficient data are not available to estimate the half-life of chlorobenzene in soil.

In surface waters, the primary loss mechanism is expected to be volatilization. As with most volatile organic compounds, the volatilization rate will be faster during warm weather, in turbulent, shallow water, on days with strong winds. Chlorobenzene remaining in the water column is likely to partition between the sediments and the water, where it will slowly biodegrade. A Koc value of 836 (Hansch and Leo, 1985; Lyman et al., 1982), indicates a moderately high tendency to adsorb to sediments. Sufficient data are not available to estimate the half-life of chlorobenzene in water. Limited potential for bioaccumulation in aquatic organisms exists (HSDB, 1990).

Ethylbenzene

Ethylbenzene is characterized by its high volatility and moderately low water solubility (169 mg/l at 25°C) (CHEMFATE, 1989). Volatilization, percolation, and biodegradation are the primary processes influencing the fate of ethyl benzene in soil. In upper soil layers, volatilization is the dominant fate process. At lower depths, ethylbenzene leaches readily through the soil, possibly reaching ground water. A Koc of 164 indicates that ethylbenzene has a moderately low affinity for soil organic matter and relatively high mobility in soil (HSDB, 1989; Swann et al., 1983). In aerobic soil/ground-water systems, ethylbenzene readily biodegrades if a properly acclimated microbial population is present. Under anaerobic conditions, ethylbenzene is resistant to biodegradation and should be fairly persistent. Information on the biodegradation products of ethylbenzene is not available. There is no evidence to suggest that ethylbenzene is susceptible to chemical degradation (photolysis, oxidation, hydrolysis) in soil or water (HSDB, 1989). Sufficient data were not available to predict the half-life of ethylbenzene in soil.

In surface waters, volatilization is the dominant removal mechanism. A mesocosm study using conditions simulating those of Narragansett Bay found loss of ethylbenzene to be due primarily to evaporation, with a half-life of 13 days in winter (HSDB, 1989). Environmental factors such as temperature, water movement and depth, and wind speed strongly influence the volatilization rate. Biodegradation screening studies have shown ethylbenzene to readily biodegrade under aerobic conditions. In the Narragansett Bay mesocosm study, complete biodegradation of ethyl benzene in the water column was observed after two days, following a two-week lag in the spring and a two-day lag in the summer. There is limited potential for bioconcentration in aquatic organisms and adsorption to sediments and suspended solids in the water column (HSDB, 1989).

In the atmosphere, the dominant removal mechanism is vapor-phase reaction with photochemically generated hydroxyls. The rate of this reaction is directly related to the number of daylight hours; thus, reaction rates vary with latitude and time of year. The typical atmospheric half-life of ethylbenzene is estimated to be about 6 hours in the summer and two days in the winter. Degradation in photochemical smog situations is expected to be somewhat faster. Photo-oxidation products which have been identified include ethylphenol, benzaldehyde, m- and p-ethyl nitrobenzene, and acetophenone (HSDB, 1989). Loss through washout in precipitation is also likely, but any ethylbenzene removed by this route is likely to revolatilize into the atmosphere.

<u>Xylenes (total)</u>

Xylenes (o-, m-, and p-) are characterized by their high volatility and moderately low water solubilities (161 to 178 mg/l at 25°C) (CHEMFATE, 1989). Volatilization, percolation, and biodegradation control the fate of xylenes in soil. In upper soil layers, volatilization is the dominant fate process. Koc values ranging between 129 to 260 (CHEMFATE, 1989) indicate medium to low affinity for organic soil constituents and moderate to high mobility in soil. Experimental results suggest that xylenes biodegrade readily in the presence of the proper microbial population. Biodegradation products include toluic acid isomers, dimethylpyrocatechols, mothylcatechols, and tolualdehydes (USEPA, 1986). Degradation as the result of chemical reaction (photolysis, hydrolysis, or oxidation) in soil or water is unlikely (USEPA, 1986). Sufficient data are not available to estimate the half-life of xylenes in soil.

In surface waters, volatilization is the dominant removal mechanism. Half-lives on the order of one to 6 days have been modeled for the volatilization of dilute amounts of o-, m-, or p-xylene from shallow rivers and ponds (HSDB, 1989). Volatilization rates vary depending on such factors as temperature, water movement and depth, and wind speed. There may also be some adsorption to sediments and suspended solids in the water column; however, biodegradation may limit the importance of this process. A number of biodegradation screening studies have shown xylenes readily biodegrade in various inocula including natural water samples, while others have shown xylenes poorly degrade. Therefore, depending upon the conditions, biodegradation of xylenes may occur at various rates. Limited potential for bioconcentration in aquatic organisms exists (USEPA, 1986).

In the atmosphere, xylenes will rapidly degrade by reaction with photochemically generated hydroxyl radicals. Typical half-lives for this reaction have been estimated to range between 1 to 2 hours in the summer and 1 to 2 days in the winter (Atkinson, 1985; HSDB, 1989). It has been determined that xylenes will degrade even faster in smog. Photo-oxidation products of xylenes include tolualdehyde, xylenols, glyoxal, methylglyoxal, acetaldehyde, biacetyl, and maleic anhydride (USEPA 1986). Despite their relatively short lifetime in air, there is potential for loss via washout in precipitation (USEPA, 1986). However, xylenes lost through washout are expected to reenter the atmosphere through volatilization.

Methylene Chloride

Methylene chloride is characterized by its volatility and relatively high water solubility (20,000 mg/l at 25°C) (ATSDR, 1989). When released to soil, most methylene chloride volatilizes into the atmosphere. The remainder leaches downward through the soil column to ground water. A Koc value of 9 indicates that this compound will be extremely mobile in soil and will not adsorb significantly to soil particles. In general, biodegradation of methylene chloride to methyl chloride is a very slow process, but losses via biogradation may be significant in those situations where acclimation of the microbial population has taken place. Biodegradation occurs under both aerobic and anaerobic conditions (ATSDR, 1989). Chemical degradation processes (hydrolysis, photolysis, oxidation) do not appear to be significant environmental fate processes (Clements Associates, 1985; Mabey and Mill, 1978). Sufficient data are not available to estimate the half-life of methylene chloride in soil.

In surface water, volatilization is the dominant environmental fate process. The volatilization half-life of a dilute amount of methylene chloride from a model river which is one meter deep and flows at a rate of one meter per second, with a wind speed of 3 meters per second at 25°C, has been estimated to be three hours (ATSDR, 1989; Lyman et al., 1982). However, volatilization rates are variable and influenced by such factors as temperature, water movement and depth, and wind speed. Losses via biodegradation, chemical degradation, adsorption to sediments, and bioconcentration in aquatic organisms are expected to be minor (ATSDR, 1989d; Clements Associates, 1985).

In the atmosphere, methylene chloride undergoes reaction with photochemically generated hydroxyl radicals, forming carbon dioxide, and to a lesser extent, carbon monoxide and phosgene. Phosgene further degrades to hydrochloric acid and carbon dioxide (ATSDR, 1989). The average half-life for chemical degradation of atmospheric methylene chloride is estimated to be about 110 days (Atkinson, 1985). The relatively long half-life of methylene chloride suggests that long-distance transport may occur. There is potential for removal of methylene chloride via washout in precipitation; however, any methylene chloride lost via this route is expected to reenter the atmosphere through volatilization.

Tetrachloroethene (TeCE)

Tetrachloroethene (TeCE) is characterized by its high volatility, moderate water solubility (150 mg/l at 25°C), and persistence in the environment. When released to soil, most TeCE either volatilizes or migrates through soil to ground water. TeCE exhibits moderate to high mobility in soil along with some adsorption to soil particles (ATSDR, 1987). Ultimately, TeCE will undergo anaerobic biodegradation or hydrolysis; however, neither process appears to occur rapidly in the environment. The hydrolytic half-life of TeCE in soil at room temperature is predicted to be about nine months (Dilling et al., 1975). Studies by Tabak et al. (1981) and Parsons (1984, 1985) have shown that TeCE may biodegrade in the presence of the appropriate microbial population. Biodegradation products include TCE, t-1,2-DCE, and vinyl chloride. Sufficient data are not available to estimate the half-life of TeCE in soil.

When released to surface waters, most TeCE volatilizes to the atmosphere. The rate of volatilization depends on a number of factors including temperature, water depth, flow rate of the water, and wind speed.

Estimated half-lives of seven, 1.4, and 5.6 days in ponds, rivers, and lakes, respectively, are indicative of the rapid rate at which dilute concentrations of TeCE volatilize from natural waters (ATSDR, 1987).

Experimentally measured Koc values ranging from 137 to 363 indicate moderately low potential for partitioning from the water column to sediments in natural water bodies (ATSDR, 1987). Likewise, TeCE has low potential for bioaccumulation in aquatic organisms (ATSDR, 1987).

The high vapor pressure (14 mm Hg at 20°C) of TeCE indicates that the compound exists almost entirely in the vapor phase in the atmosphere (ATSDR, 1987). TeCE undergoes slow degradation in the atmosphere via photo-oxidation by reaction with hydroxyl radicals. An average atmospheric half-life of approximately 96 days (Atkinson, 1985) suggests that long-range transport of TeCE may occur. Potential for physical removal from the atmosphere by means of washout in precipitation may also be a significant loss mechanism; however, much of the TeCE removed via this process is likely to revolatilize into air.

Acetone

Acetone is completely soluble in water and has a relatively high vapor pressure (231 mm Hg at 25°C), which indicates it is highly mobile in all environmental media (CHEMFATE, 1989). In soil, acetone is subject to aerobic and anaerobic biodegradation, leaching, and volatilization. Data regarding the rate of biodegradation in soil are not available, although laboratory studies have shown acetone to undergo 37 to 81 percent biodegradation under aerobic conditions, when incubated five to 20 days in sewage inocula. Complete biodegradation has been observed under anaerobic conditions when acetone was incubated an additional four days following a five-day acclimation lag period. These data suggest that acetone may have a biodegradation half-life of less than one month in the environment, under optimum conditions for biodegradation. A Koc value of 2 indicates that acetone is not likely to adsorb to soil and readily leaches through all soils. Contamination of ground water is likely to be limited, however, by rapid biodegradation in the soil column. There is no evidence to suggest that acetone undergoes chemical degradation (hydrolysis, photolysis, or oxidation) in soil, ground water, or surface water (HSDB, 1989).

In surface waters, the primary loss mechanisms for acetone are biodegradation and volatilization. Just as in soil, acetone is expected to rapidly biodegrade under both aerobic and anaerobic conditions. Laboratory studies have shown acetone to undergo 12 to 84 percent biodegradation under aerobic conditions when incubated five to 20 days in fresh- and saltwater media. Volatilization half-lives ranging from one to 10 days in a model river and 16 to 186 days in a model lake, under variable conditions, have been predicted. Bioconcentration in fish and adsorption onto sediments are expected to be insignificant fate processes (HSDB, 1989).

In the atmosphere, acetone is subject to both chemical and physical removal processes. Acetone degrades by direct photolysis and reactions with photochemically generated hydroxyl radicals, with an average reaction half-life of 22 days. Information on reaction products was not located. Physical removal may also result from dissolution and washout in precipitation (HSDB, 1989).

1,2-Dichloroethane (1,2-DCA)

1,2-Dichloroethane (1,2-DCA) has a moderately high vapor pressure (78.7 mm Hg at 20°C), and most 1,2-DCA released to the environment will partition into the atmosphere by volatilization. In surface water, the half-life for 1,2-DCA via evaporation is estimated at several hours to 10 days, depending upon wind and mixing conditions (HSDB, 1992). In the aquatic environment, adsorption to sediment is not significant, and chemical and biological degradation is expected to occur at a fairly slow rate (Howard, 1990).

In the terrestrial environment, 1,2-DCA will dissipate by volatilization into the atmosphere. Little adsorption to soil is expected, based upon an experimental Koc of 33 (Howard, 1990). In sandy soils, 1,2-DCA may leach to ground water. The estimated lifetime of 1,2-DCA in ground water is expected to be on the order of months to years (ATSDR, 1988). Biodegradation in soil or ground water is not considered a significant environmental fate process for 1,2-DCA, based on laboratory experiments (Howard, 1990). 1,2-DCA is also not expected to bioconcentrate in the food chain (HSDB, 1992; Howard, 1990).

Photooxidation is the primary fate process for 1,2-DCA in the atmosphere. 1,2-DCA in the atmosphere is removed by photooxidation, with a half-life of approximately one month, while direct photolysis is not a significant removal process (Howard, 1990).

1,2-Dichloroethene (1,2-DCE)

1,2-Dichloroethene (1,2-DCE) is highly volatile and has a moderately high water solubility (2,250 mg/l at 25°C). Most DCE present in surface soil would be expected to volatilize. The DCE which does not volatilize will migrate to subsurface soils. A Koc of 343 indicates that 1,2-DCE is moderately mobile in organic soil and highly mobile in sandy or mineral soils. Transport through the soil is expected to occur without significant adsorption to organic carbon. 1,2-DCE will readily migrate in ground water. Information on 1,2-DCE degradation in soil is limited. A study, discussed in ATSDR (1988), found that a methane-utilizing microbe culture isolated from lake sediments degraded DCE to non-chlorinated end products under aerobic conditions. By analogy to the fate of other chlorinated solvents, it is expected that 1,1,2-TCA would be highly persistent. As with the other chlorinated compounds, it appears that biodegradation may occur under anaerobic conditions.

Volatilization is also the major transport process of 1,2-DCE from surface waters. The propensity for 1,2-DCE to bind to organic matter in suspended solids or sediments is low. It is not expected that DCE will partition from water to aquatic organisms. Biodegradation has been observed under anaerobic conditions (such as those found in ground water), but it is not well defined for surface water (ATSDR, 1988).

1,2-DCE in the atmosphere will react rapidly with hydroxyl radicals. Photolysis of DCE in the presence of nitrogen oxides is also rapid. It is not likely that 1,2-DCE would be removed from the atmosphere via precipitation.

1,1-Dichloroethane (1,1-DCA)

1,1-Dichloroethane (1,1-DCA) has a water solubility of 5,060 mg/L at 25°C and a vapor pressure of 227 mm Hg at 25°C (Howard, 1990). In surficial soil, 1,1-dichloroethane will either volatilize or leach downward to deeper soils, possibly entering ground water. Within the subsurface environment 1,1-dichloroethane will be highly mobile. Ultimately, this compound will degrade by means of chemical hydrolysis or possibly anaerobic biodegradation in soil/ground water systems (Howard, 1990). The limited information available in the literature on the biodegradability of 1,1-dichloroethane and other aliphatic hydrocarbons suggests that these compounds are generally resistant to aerobic biodegradation (ATSDR, 1989).

In surface water, volatilization is expected to be the dominant removal process. Relative to volatilization, losses via other processes, including hydrolysis and biodegradation, are expected to be insignificant. 1,1-DCA has little tendency to adsorb to sediments or bioaccumulate in aquatic organisms (ATSDR, 1989).

In air, 1,1-DCA vapor is fairly persistent, with dispersion serving as the dominant process acting on this compound. The primary loss mechanism is expected to be reaction with photochemically-generated hydroxyl radicals. The reaction half-life for 1,1-DCA molecules is on the order of 62 days. Removal from the atmosphere via precipitation may also occur, but much of the 1,1-dichloroethane removed via by this mechanism is likely to reenter the atmosphere through volatilization (ATSDR, 1990).

1,1-Dichloroethene (1,1-DCE)

1,1-Dichloroethene (1,1-DCE) is highly volatile and has a moderately high water solubility (2250 mg/l at 25°C). Based on 1,1-DCE's Henry's Law constant (2.6×10^{-2} atm-m^3/mol), most 1,1-DCE present in surface soil would be expected to volatilize. The 1,1-DCE which does not volatilize will percolate to subsurface soils. A Koc of 343 indicates that 1,1-DCE is moderately mobile in organic soil and highly mobile in sandy or mineral soils. Transport through the soil is expected to occur without significant adsorption to organic carbon. Information on 1,1-DCE degradation in soil is limited. A study, discussed in ATSDR (1988), found a methane-utilizing culture isolated from lake sediment degraded 1,1-DCE to non-chlorinated end products under aerobic conditions.

Volatilization is also the major transport process of 1,1-DCE from surface waters. The propensity for 1,1-DCE to bind to organic or particulate matter is low. 1,1-DCE will readily solubilize and migrate relatively freely in ground water. It is not expected that DCE will partition from water to aquatic organisms. Biodegradation has been observed under anaerobic conditions (such as those found in ground water), but it is not well-defined for surface water (ATSDR, 1988).

1,1-DCE in the atmosphere will react rapidly with hydroxyl radicals. Photolysis of 1,1-DCE in the presence of nitrogen oxides is also rapid. It is not likely that 1,1-DCE would be removed from the atmosphere via precipitation.

Chloroform

When released to soil, chloroform will either volatilize rapidly or leach readily through the soil into ground water. An exception may be seen in highly organic soils where moderate retention could occur (Dilling et al., 1975). There is evidence that suggests chloroform may bioaccumulate in soil organisms under conditions of constant exposure; however, due to chloroform's transient nature in soil, this is unlikely.

Chloroform in ground water is likely to remain in solution. Tests of chloroform incubated in aquifer material for 27 weeks revealed no degradation (USEPA, 1985). Under these conditions, chloroform could be transported significant distances by ground-water flow. When ground water discharges to surface waters, chloroform would then volatilize to the atmosphere.

The dominant process of chloroform removal from solution is volatilization. Studies of half-lives in various surface waters range from 36 hours in ponds to 10 days in oligotrophic lakes (USEPA, 1985). It appears that neither oxidation nor hydrolysis reactions are important fate processes for chloroform in solution (Mabey and Mill, 1978). Chloroform will also not photolyze under normal environmental conditions (while in solution), nor will it adsorb onto suspended solids or sediments, unless the sediments are particularly rich in organic matter (USEPA, 1985). Biodegradation processes may remove some of the residue remaining in solution after volatilization. Various studies yielded conflicting results as to the degree of biodegradation possible. Some researchers have documented substantial amounts of biodegradation in relatively short periods of time under aerobic conditions; among these are a 67 percent reduction in 24 days and a 49 percent reduction after 7 days (Tabak et al., 1981). Still, other studies showed little or no biodegradation for up to 25 weeks (USEPA, 1985).

Atmospheric chloroform has an approximate half-life of two to four months. Precipitation may remove measurable quantities, but this portion will probably re-enter the atmosphere immediately. Primary destruction reactions occur in the troposphere, where chloroform is degraded by hydroxyl radicals.

Trichloroethene (TCE)

Trichloroethene (TCE) may be discharged directly into the environment or may form as a breakdown product of tetrachloroethene. It is highly volatile and relatively soluble in water (1,366 mg/l at 25°C). Consequently, most TCE released to soil either volatilizes or leaches through soil to ground water. A Koc value of 42 (ATSDR, 1989) indicates that TCE will be highly mobile in soil and have little tendency to adsorb to soil particles (Swann et al., 1983). In soil/ground-water systems, TCE may be subject to slow anaerobic biodegradation. Laboratory studies by Parsons (1984, 1985), Tabak et al., (1981), and Wilson and Wilson (1985), indicate that TCE may biodegrade in the presence of the appropriate microbial population, in which acclimation has taken place. The primary product of anaerobic degradation is dichloroethene, and occasionally small quantities of vinyl chloride are also produced (Smith and Dragun, 1984).

Studies have shown that TCE volatilizes rapidly from water (ATSDR, 1989; HSDB, 1989). Volatilization rates vary depending on a number of factors including temperature, water movement and depth, and wind speed. The following representative volatilization half-lives have been estimated for dilute amounts of TCE in various types of water bodies: one to 12 days in a river, four to 12 days in a lake, and about 11 days in a pond (USEPA, 1985). TCE has little potential to bioaccumulate in aquatic organisms or adsorb to sediments (ATSDR, 1989).

In the atmosphere, TCE is expected to degrade fairly rapidly (estimated half-life 7 days) by reaction with photochemically generated hydroxyl radicals. Degradation products of this reaction include phosgene, dichloroacetyl chloride, and formyl chloride (Atkinson, 1985; HSDB, 1989). Wet deposition of TCE in precipitation may be a significant loss mechanism in the atmosphere; nonetheless, much of the TCE removed by this route is likely to revolatilize into air.

1,1,1-Trichloroethane (1,1,1-TCA)

1,1,1-Trichloroethane (1,1,1-TCA) is highly volatile and has a moderate water solubility (1495 mg/l at 25°C). Based on 1,1,1-TCA's Henry's Law Constant (8 x 10^{-3}/mol), evaporation into the atmosphere from upper soil layers is expected to occur rapidly. 1,1,1-TCA has a Koc of 179 indicating a low affinity for soil organic matter and relatively high mobility in soil (HSDB, 1990). 1,1,1-TCA has been frequently observed in ground waters, suggesting insignificant adsorption of the chemical in soils. Biodegradation of 1,1,1-TCA in soils is expected to be slow or nonexistent. Slow degradation has been observed in loamy sands under acclimated conditions and no biodegradation has been observed in subsurface soils (HSDB, 1990).

Volatilization will also be the primary transport process of 1,1,1-TCA from surface waters. The volatilization half-life for 1,1,1-TCA from surface waters could vary from hours to a few weeks depending on wind and mixing conditions (HSDB, 1990). Biodegradation and adsorption to particulates of 1,1,1-TCA in surface waters are insignificant fate processes relative to volatilization. Biodegradation in anaerobic waters may occur but will take several weeks and acclimation is important. Field evidence of biodegradation in a confined aquifer was obtained with an observed 1,1,1-TCA half-life of 231 days (HSDB, 1990). 1,1,1-TCA has little tendency to bioconcentrate.

In the atmosphere, 1,1,1-TCA is slowly degraded by reaction with hydroxyl radicals. This degradation is increased by the presence of chlorine radicals and nitrogen oxides (HSDB, 1990). Some 1,1,1-TCA will return to the earth via precipitation.

B. INORGANICS

Arsenic

Arsenic is a naturally occurring metalloid element. In its elemental state, it is insoluble in water. Arsenic most commonly exhibits oxidation states of -3, 0, +3, and +5. There are many arsenic compounds of environmental significance, and this results in great complexity in the environmental chemistry of this element. There are both soluble and insoluble forms of arsenic, and it is common to find arsenic in both the dissolved and solid phases in environmental media (ATSDR, 1992).

Arsenic occurs in soil predominantly in an insoluble, adsorbed form. As(III) appears to be less strongly sorbed than As(V), perhaps due to complexation with Fe(III) (Bodek et al., 1988). The factors affecting arsenic sorption on soils and sediments include redox conditions, pH, the presence of certain competing anions and complexing ions, salinity, clay content, and hydrous oxide content. Clay with a high anion exchange capacity is particularly effective at adsorbing arsenate via anion exchange (ATSDR, 1987). Fuller (1977) found the mobility of arsenic in clay soils to be low to moderate, but much higher for loamy and sandy soils.

A rise in pH in high iron soil, a drop in pH in lime soil, or a change in redox potential may promote the resolubilization of fixed arsenic. Organics that complex with arsenic could also increase its mobility and decrease its sorption (Bodek et al., 1988). Leaching of arsenic is usually important only in the top 30 cm of soil (USEPA, 1982).

In aerobic waters, arsenic acid predominates. The complexation of arsenic in water by dissolved organic matter prevents sorption and co-precipitation with solid-phase organics and inorganics; essentially, it increases the mobility of arsenic in aquatic systems (Bodek et al., 1988). Wagemann (1978) studied barium, chromium, iron, and calcium at typical freshwater concentrations as possible factors controlling the amount of total dissolved arsenic in solution. He postulated that, in freshwater conditions, barium is the most likely controlling metal.

Arsenic itself and its inorganic compounds are not volatile. However, arsenic in water and soil may be reduced and methylated by fungi, yeasts, algae, and bacteria into forms which may volatilize and escape into air (Wood, 1974). This process depends on soil conditions and microbes present.

Beryllium

Beryllium is a naturally occurring element, which itself cannot be degraded by environmental fate processes. Elements such as beryllium are primarily transformed from one compound to another. The +2 oxidation state of beryllium is the only oxidation state of importance under environmental conditions.

In the natural environment, it is most likely that beryllium is present in particulate form rather than dissolved form. In most soil types, beryllium is expected to be tightly adsorbed because it displaces divalent cations which share common sorption sites (ATSDR, 1988). Based on beryllium's geochemical similarity to aluminum, USEPA (1979) expects that beryllium would adsorb onto clay surfaces at low pH and be complexed into some insoluble compounds at high pH. Little complexation with organic ligands is expected to occur in natural environments (Bodek et al., 1988). Beryllium oxide is relatively insoluble and would not be mobilized in soil at normal pH ranges of 5 to 8.

In aqueous solution, beryllium exhibits only the +2 oxidation state (Bodek et al., 1988). Hydroxo-complexes should be the dominant species in aquatic systems under typical environmental conditions where very little or no iron is present (Bodek et al., 1988). No data were available regarding either aquatic or soil biotransformation of beryllium. Beryllium will not bioaccumulate significantly and there is no evidence that it is significantly biomagnified within the food chain (ATSDR, 1988).

Cadmium

Along with zinc and mercury, cadmium is a Group IIb transition metal in the periodic table. Cadmium is most commonly found in nature in the form of its sulfide mineral in zinc, lead-zinc, and copper-lead-zinc ore.

Like zinc, cadmium occurs in the +2 valence state in almost all of its stable compounds. Cadmium is ranked 64th in crustal abundance among elements (Adriano, 1986).

In soils, physical adsorption, precipitation, and plant uptake of cadmium are key processes in the fate of this element in the environment. The mechanism for adsorption/immobilization is highly dependent on localized site characteristics. Cadmium may be found in the following forms: exchangeable phase, i.e., adsorbed to negatively charges sites on clays, organic particles, and hydrous oxides; co-precipitated with oxides, hydroxides, and hydrous oxides of iron, manganese, and possibly aluminum; precipitated carbonate or phosphate phases; organically complexed phase; insoluble phase fixed within crystalline lattices of mineral particles; insoluble sulfide phase, most commonly found in poorly aerated soils; and dissolved phase in either ionic or complexed form (Adriano, 1986). As with other elements, low pH and competition with other cations for adsorption and reaction sites will facilitate mobilization and plant uptake via dissolution into soil porewater (Bodek et al., 1988).

Compared to other heavy metals, cadmium is considered to be relatively mobile in surface water, although adsorption and precipitation are still controlling factors in the fate of this element (USEPA, 1979). The mechanism by which cadmium is adsorbed to sediments is important in determining remobilization potential. For example, cadmium adsorbed to mineral surfaces (e.g., clay) or organic materials would be more easily bioaccumulated or released in the dissolved state when disturbed, such as during flooding; whereas, cadmium found in association with carbonate minerals or precipitated as stable compounds would be less likely to be redissolved during resuspension of sediments. Mobilization of cadmium in the form of its hydrated divalent ion is most likely to occur in acidic or neutral waters (USEPA, 1979).

Cadmium is readily bioaccumulated from food and water by freshwater organisms, with bioconcentration factors of 1,000 to 3,000 reported for freshwater plants, fish, and invertebrates. Unlike mercury, which is in the same elemental group as cadmium, there is no evidence to indicate that biomethylation of cadmium occurs in the environment (USEPA, 1979).

Chromium

Chromium occurs naturally in the earth's crust, and ranks as the 21st most abundant element (Westbrook, 1985). This element may occur in oxidation states ranging from -2 to +6, although the +3 and +6 oxidation states are the most stable and significant in terms of environmental fate and transport.

In soils, chromium occurs primarily as insoluble Cr (III) oxide and Cr (III) carbonate, and therefore is relatively immobile. Lesser amounts of chromium exist in soluble Cr (III) and Cr (VI) forms, which are mobile and could potentially leach to ground water. The solubility and mobility of Cr (III) may increase due to the formation of soluble complexes with organic matter. Acidic pH may facilitate complexation. Chromium has little tendency for plant uptake and translocation to plant foliage (ATSDR, 1991).

Depending upon localized conditions Cr (III) may be converted to Cr(VI) and vice versa. Oxidation of Cr (III) to Cr (VI) is reportedly facilitated by the presence of oxygen, manganese oxide, and moisture, with soluble, organically complexed Cr (III) more readily converted to Cr (VI) than insoluble Cr (III). Under aerobic conditions, reduction of Cr (VI) to Cr (III) is reportedly facilitated by the presence of humic materials and low pH. Under anaerobic conditions, Cr (VI) is readily reduced to Cr (III) by

S^{-2} and Fe^{+2} ions present in soil, sediment, and water. Chromium speciation in ground water generally depends on redox potential and pH. Cr (VI) tends to predominate under high oxidation conditions typically found in shallow ground-water systems, and Cr (III) predominates under reducing conditions typically found in deeper ground-water systems (ATSDR, 1991).

In surface water, chromium is primarily found as Cr (III) in sediments. A very small percentage of chromium in surface waters exists as insoluble Cr (VI) and dissolved Cr (III) and Cr (VI) forms. Chromium compounds do not volatilize, and transport from water to air is likely to occur only through water droplets in the form of sea spray. As reported in the literature, the bioconcentration factor for Cr (VI) in rainbow trout is approximately 1, and the factor for Cr (VI) and Cr (III) in bottom-feeder species ranges from 86 to 192 (ATSDR, 1991). Based on this information, it appears that bioaccumulation of chromium in aquatic organisms is generally not significant.

Copper

Copper is widely distributed in nature and is present in concentrations averaging about 4 ppm in limestone, 55 ppm in igneous rocks, 50 ppm in sandstone, and 45 ppm in shales (USEPA, 1979). Copper forms salts and complexes with valences of +1, +2, and, very rarely, +3. Copper exists most commonly as Cu(II) under aerobic conditions and Cu(I) under anaerobic conditions. Those Cu(I) compounds which are stable under aerobic conditions are highly insoluble (e.g., CuCl).

Sorption is probably the most important controlling mechanism in determining the fate and transport of copper in the environment. Important mechanisms for sorption of copper onto soils are organic complexation (especially with humic materials), physical adsorption, precipitation, and ion exchange. Adsorption of copper to soils is also pH dependent. Although Lucas and Knezek (1972) found copper to be especially mobile at pH values less than 5, copper availability was drastically reduced at pH levels greater than 7. Copper has a pronounced tendency to form complexes with both organic and inorganic ligands. The formation of complexes with organic ligands modifies the solubility and precipitation behavior of copper so that complexed copper is more easily adsorbed by clay and other soil particle surfaces. Sorption of copper by precipitating hydrous iron and magnesium oxides found in soil is also an effective control on dissolved copper concentrations within the soil profile (USEPA, 1979). In organic-rich environments, however, the effective control on dissolved copper concentrations will be the competition between organic complexes in solution and sorption onto clay and particulate organic matter (USEPA, 1979).

Biological activity is a major factor in determining the distribution and occurrence of copper. Copper is accumulated by plants and animals (Chapman et al., 1968; Patrick and Loutit, 1976). Biologic activity significantly influences the seasonal availability of copper in aquatic systems (Kimball, 1973). Although copper is strongly accumulated by plants and animals, it tends not to biomagnify (ATSDR, 1989).

Lead

Lead is the most abundant of the heavy metals in the earth's crust. Possible oxidation states for lead include 0, +2, and +4. However, Pb(IV) exists only under extremely oxidizing conditions not typical of the Ph and redox conditions in the environment (Bodek et al., 1988).

Lead can be complexed by both inorganic (OH^-, CO_3^{2-}, Cl^-) and organic (humic and fulvic acids) ligands in aquatic systems (Bodek et al., 1988).

The total dissolved Pb(II) in a natural water system may include any of the low solubility compounds that lead forms with several major anions that occur in the natural environment (Bodek et al., 1988). The concentration of the compounds is dependent on the pH, redox conditions, and ions present in the system.

The sorption of lead on soils and sediments is controlled by the following mechanisms: specific adsorption or exchange adsorption at mineral matrix; precipitation of a sparingly soluble compound of which lead is a constituent; and the formation of relatively stable complex ions or chelates resulting from the interaction with organic matter (Adriano, 1986). The extent of adsorption appears to increase with increasing Ph (Bodek et al., 1988).

Manganese

Manganese is a trace element which is widely distributed in nature. One key reason for this is that manganese has the same molecular size as magnesium and calcium, which enables it to replace these elements in mineral structures. Consequently, there are over 300 minerals (e.g., sulfides, oxides, carbonates, silicates, etc.) that contain manganese. Manganese may occur in the +1, +2, +3, +4, +6, and +7 oxidation states. In general the +2 species are the most stable (Adriano, 1986).

The chemistry of manganese in the environment, particularly in soil, is very complex. Possible chemical forms of manganese in soil may be described as water-soluble, exchangeable, adsorbed, chelated or complexed, mineral, or insoluble metal oxides. Specific adsorption, ion exchange, and organic complexation all impact the mobility and retention of manganese. The mobility of manganese in soil is complicated by the large number of possible redox reactions and the various possible soluble manganese compounds. Soil microorganisms may also play a role in the chemical speciation of manganese (Adriano, 1986). In addition, manganese can be released from soil when more strongly binding metals undergo ion exchange with adsorbed manganese or when the manganese oxide structure is displaced. For example, clay minerals and hydrous iron oxides adsorb copper, zinc, and nickel more strongly than manganese (Bodek et al., 1988). Manganese is readily taken up by plants. It is an essential plant nutrient, but it can also be toxic to plants, especially in acidic soils (Adriano, 1986).

In natural waters, manganese ion (Mn^{+2}) is reportedly the dominant form of dissolved-phase manganese under neutral and acidic conditions. Other dissolved-phase chemical species, such as the chloride, sulfate, and bicarbonate, may also occur. Manganese may also complex with inorganic and organic ligands in water, but the organic complexes are not very stable. Under alkaline conditions, manganese may precipitate out of solution possibly in the form of its hydroxide ($Mn(OH)_2$) (Bodek et al., 1988).

Information on the atmospheric chemistry of manganese is not readily available. Like most other inorganic materials, removal from the atmosphere is likely to occur by wet and dry deposition.

Mercury

Mercury occurs naturally as a mineral and is ubiquitous in the environment. The chemistry of the element in the environment is complex due to its three valence states (0, +1, +2). The state and form in which mercury is found depends on such factors as redox potential and Ph of the medium. In soils and surface waters, mercury can exist in the mercuric

(Hg^{2+}) and mercurous (Hg^{+}) states as a number of complex ions with varying water solubilities.

Mercury is strongly and rapidly sorbed by soils. The primary sorbents in the soils are hydrous iron and manganese oxides, clays, and organics. It appears mercury has an affinity for sulfhydryl groups in organic matter and clays (Bodek et al., 1988). The sorption process has been found to be related to the organic matter content of the soil, and apparently is unaffected by the pH of the medium. Based on the strong adsorption and negligible desorption of mercury compounds, leaching is considered a relatively insignificant process in soils.

Mercury is very soluble in oxidized aquatic systems. However, the solubility of the mercury compounds is greatly controlled by the strong complexation behavior exhibited with common ligands. Hydrolyzed species and chloride complexes are likely to be the predominant species in water under aerobic environmental conditions. Under anaerobic conditions, in the presence of sulfur, HgS is expected to precipitate (Bodek et al., 1988). Hg(II) also forms strong complexes with organics in the water column. The factors affecting the adsorption of mercury to soil also affect the chemical's adsorption to sediments or particulates. This sorption to sediments is one of the important controlling pathways for removal of mercury from solution (Bodek et al., 1988). It is also true that inorganic mercury sorbed to particulate matter is not readily desorbed.

Inorganic mercury can be methylated by microorganisms indigenous to soils, fresh water, and salt water under anaerobic and, to a lesser extent, aerobic conditions. In sediments, this can result in remobilization of precipitated or sorbed mercury. The rate of biomethylation is dependent upon such factors as the concentration of available Hg^{2+}, the microbial population, pH, temperature, redox potential, and synergistic effects of other metabolic or chemical processes (Bodek et al., 1988). Methylation via chemical means has also been reported. Factors found to be directly proportional to the rate are temperature and Hg^{2+}, while pH (pH>5) is indirectly proportional. Degradation of methylated mercury is a slow process relative to methylation, and reportedly occurs only at elevated levels of methylmercury (Bodek et al., 1988).

Only dimethylmercury and elemental mercury are volatile under natural environmental conditions. Once dimethylmercury enters the atmosphere it photolyzes to yield elemental mercury and methyl radicals (Bodek et al., 1988). Elemental mercury vapor can be transported long distances before removal via washout in precipitation or fallout of particulate matter (ATSDR, 1990).

Nickel

Nickel is a naturally occurring metal of the earth's crust. Ni(II) is the valence state of importance in the environment.

Fuller (1977) considered nickel, as well as chromium and mercury, to be the most generally mobile of the heavy metals which he studied. Although nickel is persistent in soils, potential for leaching to ground water exists. Sorption behavior of nickel in soil has been found to correlate with pH, total iron, and surface area (ATSDR, 1988). Movement and availability of nickel have been found to be restricted by organic complexing agents present in the soil (ATSDR, 1988). Other important sorbents are believed to be iron and manganese oxides and clay minerals (Bodek et al., 1988). Other cations in the soil may reduce nickel sorption.

Aqueous nickel exists in numerous soluble and insoluble forms depending on the chemical and physical properties of the water. The mobility of nickel in aquatic systems is controlled by complexation, precipitation/dissolution, adsorption/desorption, and oxidation/reduction reactions (ATSDR, 1988). Nickel tends to complex with both inorganic and organic ligands in aquatic systems. Complexation by ligands such as chloride ion is very rapid in terms of environmental time frames (Bodek et al., 1988). Under aerobic conditions and neutral values of pH, complexation reduces the activity of aqueous nickel ion, and discourages precipitation reactions (Bodek et al., 1988).

No data exist which suggest any biological transformation processes of nickel in water or biodegradation of nickel in soil.

Silver

In nature, silver typically occurs in the +1 oxidation state or as elemental silver. Although the +2 or +3 oxidation states are known to occur, they are unstable in the natural environment. A number of silver compounds are commonly found in nature or enter the environment from various sources, including the silver halides (bromide, fluoride, chloride, iodide), cyanide, thiocyanate oxide, hydroxide, carbonate, nitrate, sulfides, ferrocyanide complexes, phosphates, and thiosulfate complexes, among others. The speciation of silver in any given situation is based upon localized conditions such as pH, mineral content, clay content, organic content, redox potential, free iron and manganese content, and particle size distribution. However, it has been reported that under oxidizing conditions the primary silver compounds are likely to be the bromides, chlorides, and iodides, while under reducing conditions the primary silver compounds are likely to be the free metal and silver sulfide. Each of these silver species are relatively insoluble (ATSDR, 1990; USEPA 1979).

In soils and water, sorption and precipitation appear to be the dominant processes controlling the fate of silver. The distribution coefficient (K_d: ratio of the concentration in soil to the concentration in water) for silver has been reported to range from 10 to 1,000 (ATSDR, 1990). Organic matter, manganese and iron oxides (common soil constituents), and clay minerals tend to form complexes with silver, resulting in immobilization of this element. However, silver may be desorbed by complexation with other constituents of soil and/or soil pore water. Biotransformation of silver is not believed to be a significant process, since silver can be toxic to soil microorganisms and may inhibit bacterial digestive enzymes (ATSDR, 1990). Studies of plant uptake studies indicate that silver may accumulate in plant roots, but it is poorly translocated to other parts of the plant (Adriano, 1986).

In surface water, sorption and precipitation processes are effective in reducing the concentration of dissolved silver, resulting in higher concentrations in the bed sediments than in the overlying waters. Sorption by manganese dioxide and precipitation with halides are probably the most common controls on the mobility of silver in the aquatic environment. Some silver may be bioaccumulated, and the remainder is found in the dissolved form. Numerous aquatic plants and primary consumer organisms reportedly accumulate silver, but the food chain is not an important route of silver accumulation for animals at the higher trophic levels (USEPA, 1979).

As part of the global geochemical cycling of silver the major forms of silver in the atmosphere are probably metallic silver, silver sulfide, silver sulfate, silver carbonate, and silver halides. Silver particles are removed from the atmosphere in dustfall and precipitation (ATSDR, 1990).

Zinc

Zinc is an essential micronutrient. In the environment, zinc occurs in the +2 oxidation state. Adsorption and fixation of zinc in soils is influenced by various factors including pH, clay minerals, cation exchange capacity, organic matter content, and soil texture (Adriano, 1986). In soils with pH>6.0, zinc availability is greatly reduced. Adsorption onto clays tends to be the dominant process affecting zinc availability. Zinc may bind in reversible form as a cation available to plants, or it may become irreversibly incorporated into the clay lattice, and thus, unavailable until liberated through weathering processes. In alkaline soils, cation exchange will control the majority of zinc in soils, and these ions will be retained in the soil matrix available for plant uptake (Kuo and Baker, 1980; Sharpless et al., 1969). As the pH rises, decreasing quantities of zinc will become available to a point where zinc will effectively become immobilized in the soil matrix.

Zinc retention has also been correlated with soil organic matter content. Highly organic soils will have a larger reservoir for zinc retention (White and Chaney, 1980). Zinc which has become complexed into humic substances may or may not be water soluble (in colloidal form), depending on soil pH and the humic constituent within which the zinc is bound. Under reducing conditions (i.e., flooded soils), zinc is relatively insoluble. Zinc is most soluble under acidic, aerobic conditions (Adriano, 1986).

Sorption of zinc is the dominant fate in aquatic systems. Zinc concentrations in sediments generally exceed concentrations in ambient waters (ATSDR, 1988). If there are large quantities of dissolved organic matter, zinc will exist in a hydrated or complexed form. If suspended solids dominate the water column, zinc will exist as an adsorbed component of these suspended solids.

In its soluble state, zinc is one of the most mobile of the heavy metals. The complexation of zinc does not preclude its adsorption onto other suspended particles or bottom sediments. In fact, in some cases this may actually increase the tendency for zinc to be adsorbed. Factors which control the adsorption of zinc in aquatic systems are pH, salinity, and the concentration of the sorbent.

Since zinc is an essential trace element, it is bioaccumulated by organisms. Biomediated removal of zinc from solution is an important process which decreases zinc mobility in aquatic systems (Adams et al., 1975). Bioconcentration of zinc by aquatic organisms may be significant on a species-by-species basis. Chapman et al. (1968) found bioconcentration factors for aquatic organisms to range from 10^2 to 10^5. While it is evident that zinc is bioconcentrated, evidence suggests that this element is not generally biomagnified.

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APPENDIX G

CHEMICAL-SPECIFIC TOXILOGICAL PROPERTIES OF THE CHEMICALS OF INTEREST

APPENDIX G

CHEMICAL-SPECIFIC TOXICOLOGICAL PROPERTIES

A. VOLATILE ORGANICS

The first general group of organic chemicals discussed are the volatile organics. This group includes: toluene, ethylbenzene, xylenes (total), methylene chloride, acetone, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, 1,1,1-trichloroethane, trichloroethene, tetrachloroethene, and chloroform.

Benzene

A major route of human exposure to benzene is inhalation of benzene vapor. The general population usually encounters benzene as a component of mixtures such as gasoline. Benzene can be absorbed into the body following ingestion and/or dermal contact, although it is rare for individuals to come into contact with pure liquid benzene. After absorption, benzene must undergo metabolic transformation (primarily in the liver) to exert its toxic effects. The main effects of brief exposures to elevated levels of benzene vapors, such as in occupational settings, are drowsiness, dizziness, and headaches. Acute exposures to very high levels of benzene may severely affect the central nervous system. Chronic exposure to low levels of benzene may cause leukemia (cancer of the white-blood-cell-forming tissue) (Sax, 1981).

Benzene is classified by USEPA as a Group A (known human) carcinogen. This classification is based on the observation that benzene causes leukemia in occupationally-exposed humans (IRIS, 1992). The SF for benzene is 0.029 $(mg/kg/day)^{-1}$ for both the oral and inhalation routes of exposure.

Chlorobenzene

Chlorobenzene is used as an industrial solvent and in the manufacture of pesticides (HSDB, 1990). Since chlorobenzene is fairly volatile, occupational exposures are most likely to occur via inhalation. The most probable routes of human exposure to chlorobenzene by the general population are via inhalation of vapors or incidental ingestion (HSDB, 1990). In cases of extreme exposure, the primary target organs are the liver and kidneys (HSDB, 1990). Chlorobenzene may be absorbed through the skin and is known to irritate the skin, eyes, and respiratory system in occupationally-exposed individuals (HSDB, 1990). Chlorobenzene also causes hemolysis and central nervous system depression (HSDB, 1990).

Acute inhalation exposures to high concentrations of chlorobenzene vapors have resulted in numbness, loss of consciousness, and eye and pharynx damage (HSDB, 1990). Histopathological changes in the lungs, liver, and kidneys were observed in animal studies after subchronic inhalation exposure (HSDB, 1990). Chronic animal exposure to chlorobenzene caused transient growth retardation and liver and kidney damage (HSDB, 1990).

USEPA has classified chlorobenzene as Group D (i.e., not classifiable as to human carcinogenity) (IRIS, 1992). The RfD for chronic oral exposure is 0.02 mg/kg/day. This value is based on studies in which liver and kidney effects were observed in dogs (USEPA, 1991d). The inhalation RfD for chronic exposure is 0.005 mg/kg/day based on similar results from experiments with dogs exposed to chlorobenzene via inhalation (USEPA, 1991d).

Toluene

Exposure to toluene occurs primarily through contact with gasoline or other mixtures. The major route of human exposure to toluene is via inhalation of vapors, often in occupational settings. Dermal absorption can occur, but is not believed to play a major role in total exposure. Dermal contact can cause physical irritation (NIOSH, 1985). Chronic exposure to high levels of toluene, such as in workplace settings, can cause anemia and leukopenia (low white blood cell count) (Casarett & Doull, 1986). The central nervous system, liver, kidneys, and skin are the primary target organs affected by toluene (ATSDR, 1988).

The primary health effects from occupational exposure to toluene are narcosis and effects on the central nervous system (CNS). The severity of these effects depends upon the dose and duration of exposure (ATSDR, 1988).

USEPA has derived an oral RfD of 0.2 mg/kg/day for chronic exposure to toluene (IRIS, 1992). This value is based on CNS effects on rats. The inhalation RfC is 0.57 mg/kg/day for chronic exposure, based on evidence of central nervous system effects and eye and nose irritation in humans exposed to toluene in air (USEPA, 1991d).

Ethylbenzene

Exposure to ethylbenzene occurs primarily via the ingestion and inhalation routes of exposure. Although dermal contact may cause skin irritation, ethylbenzene is not readily absorbed through the skin (Casarett & Doull, 1986). Narcosis and comatose conditions leading to death due to respiratory failure, have been observed in laboratory animals exposed experimentally to a 1 percent concentration of ethylbenzene vapor in air (Casarett & Doull, 1986).

Occupational exposure to high concentrations of ethylbenzene is reported to adversely effect the eyes, upper respiratory system, skin and central nervous system (NIOSH, 1985). Prolonged exposure to vapors (probably limited to occupational settings) may result in functional disorders, upper respiratory irritation, and hematological disorders (HSDB, 1989).

USEPA classifies ethylbenzene as Group D (not classifiable as to human carcinogenicity), due to a lack of animal bioassays and human studies (IRIS, 1992). The recommended oral RfD for ethylbenzene is 0.1 mg/kg/day for chronic exposures, based on liver and renal tubular effects in experimental animals (rats) (IRIS, 1992). The inhalation RfC for ethylbenzene is 0.29 mg/kg/day (IRIS, 1992).

Xylenes (total)

Xylenes (total) include the ortho, meta, and para isomers. Xylenes may be absorbed into the human body via inhalation or ingestion. Dermal absorption may occur, but little dermal toxicity has been noted (Casarett & Doull, 1986). Laboratory animal experiments involving chronic oral exposure to xylenes produced slight liver abnormalities (HSDB, 1989). Adverse effects associated with chronic human inhalation exposure were reported to include increased incidence of chronic bronchitis and a decreased volume of expired air (HSDB, 1989). Xylenes can produce lung disease as a result of chronic high level inhalation exposure (Casarett & Doull, 1986).

Target organs for xylene toxicity are the central nervous system, gastrointestinal tract, blood, liver, kidneys and skin. Symptoms related to extreme exposure include dizziness, drowsiness, nausea, abdominal pain, and eye, nose, and throat irritation (NIOSH, 1985). Xylene has not been shown to cause cancer in animal studies (HSDB, 1989).

USEPA has derived an oral RfD of 2.0 mg/kg/day for chronic exposures to mixed xylenes (IRIS, 1992). The chronic inhalation RfC for mixed xylenes is 0.09 mg/kg/day (USEPA, 1991d). The oral RfD is based on experimental data for rats exposed to high levels of mixed xylenes (USEPA, 1991d). The inhalation RfC is based on CNS effects and respiratory tract irritation in humans (USEPA, 1991d).

Methylene Chloride

The major routes of human exposure to methylene chloride are inhalation of vapor and accidental ingestion. In cases of extreme exposure, the primary targets of ingested and inhaled methylene chloride are the liver and central nervous system. Methylene chloride is also absorbed through the skin, but due to ready evaporation, the amount absorbed is usually small (ATSDR, 1987).

Studies have shown that pure vapors of methylene chloride can initiate tumor development in the liver and lungs of rodents (ATSDR, 1987). USEPA has classified methylene chloride as a Group B2 carcinogen (IRIS, 1992). The SF for the oral exposure route is 0.0075 $(mg/kg/day)^{-1}$ (IRIS, 1992). The inhalation SF for methylene chloride is 0.016 $(mg/kg/day)^{-1}$ (IRIS, 1992). RfDs have also been established for methylene chloride to protect against noncarcinogenic health effects. The oral RfD for chronic exposure is 0.06 mg/kg/day based on liver effects in rats (IRIS, 1992). The inhalation RfC is 0.86 mg/kg/day for chronic exposure (USEPA, 1991d).

Tetrachloroethene

Tetrachloroethene is used in dry cleaning, as an industrial solvent, and in chemical manufacturing. The major route of human exposure to tetrachloroethene is via inhalation in industrial settings (ATSDR, 1989). In the general population, ingestion via food and drinking water may also occur, but is far less significant (ATSDR, 1989). Tetrachloroethene does not penetrate the skin to any extent, although skin irritation may result from direct dermal contact (ATSDR, 1989). Acute exposure to high concentrations may cause central nervous system depression. Symptoms of overexposure include headache, dizziness, fatigue, staggering gait, and slowed mental processes (Sittig, 1985). Animal studies have shown that kidney and liver damage, leukemia, developmental toxicity, and liver cancer can occur following high level inhalation exposures (ATSDR, 1989).

Tetrachloroethene is classified as a Group B2 (probable human) carcinogen (USEPA, 1991d). A SF of 0.051 $(mg/kg/day)^{-1}$ has been established for the oral route of exposure on the basis of liver tumors in mice (USEPA, 1991d). The inhalation SF is 0.0018 $(mg/kg/day)^{-1}$ and is based on the occurrence of leukemia and liver tumors in rats and mice (USEPA, 1991d).

USEPA has derived a chronic oral RfD of 0.01 mg/kg/day for tetrachloroethene on the basis of liver effects in mice (IRIS, 1992). No inhalation RfC is currently available (IRIS, 1992).

Acetone

Humans may be exposed to acetone via ingestion, inhalation, and dermal contact (HSDB, 1989). Although pure acetone has comparatively low acute and chronic toxicity, it may affect the central nervous system, respiratory system, skin, and possibly the liver and kidneys in extreme cases of high-level exposure (HSDB, 1989). Dermal contact with pure acetone may produce dermatitis. The adverse health effects caused by acetone resemble those produced by ethyl alcohol. In some cases, acute exposure to very high concentrations may be followed by a latent period before symptoms occur.

Liver and kidney effects have been observed in laboratory animals exposed to high concentrations of acetone (HSDB, 1989). Animal studies also suggest that acetone may be embryotoxic, but is not mutagenic or carcinogenic (HSDB, 1989). USEPA recommends a chronic oral RfD of 0.1 mg/kg/day for acetone based on liver and kidney effects in rats (IRIS, 1992). An inhalation RfC has not been established for acetone (IRIS, 1992).

1,1-Dichloroethane (1,1-DCA)

Very little information is available on the toxic effects of 1,1-DCA in either animals or humans. Although little pharmacokinetic information is available, 1,1-DCA appears to be absorbed by all routes of exposure, although inhalation exposures are the most likely (ATSDR, 1990). There is inconclusive evidence that orally administered 1,1-DCA may be carcinogenic. Consequently, USEPA has classified 1,1-DCA as a Group C carcinogen (ATSDR, 1990). No inhalation carcinogenicity studies have been conducted. There is also limited evidence from animal studies that 1,1-DCA may be lethal at high airborne concentrations. One study in cats suggested that 1,1-DCA might be nephrotoxic, however, no kidney effects were seen in other species of animals tested, nor is nephrotoxicity a common toxic endpoint among halogenated hydrocarbons. An inhalation study in rats suggests that 1,1-DCA may retard fetal development (ATSDR, 1990).

USEPA has derived an oral RfD of 0.1 mg/kg/day (USEPA, 1991d) based on a No-Observed-Effect Level (NOEL) in rats.

1,2-Dichloroethane (1,2-DCA)

1,2-Dichloroethane (1,2-DCA) is commonly used in a variety of manufacturing processes, especially in the petroleum and plastics industries (Sittig, 1985). Human exposures to 1,2-DCA occur primarily in occupational settings (Sittig, 1985). 1,2-DCA is toxic by ingestion, inhalation and skin absorption, and is strongly irritating to the eyes and skin (Sax, 1987). 1,2-DCA is a powerful liver and kidney toxin (Casarett & Doull, 1986). Repeated skin contact with liquid 1,2,-DCA reportedly results in dermatitis. Inhalation of high concentrations of 1,2-DCA vapor may cause nausea, vomiting, mental confusion, dizziness and pulmonary edema (Sittig, 1985). Individuals subjected to chronic high-level exposures have developed neurological changes, loss of appetite and other gastrointestinal abnormalities, liver and kidney dysfunction, and in some cases, severe internal organ damage has resulted in death (Sittig, 1985). USEPA classifies 1,2-DCA as Group B2, probable human carcinogen. The oral and inhalation SFs for 1,2-DCA are both 0.091 $(mg/kg/day)^{-1}$, based on ingestion studies with experimental animals (IRIS, 1992).

1,1-Dichloroethene (1,1-DCE)

The primary means of exposure to 1,1-dichloroethene (1,1-DCE) is via air and water emissions from manufacturing facilities (ATSDR, 1989). The general population may be exposed in areas proximate to these manufacturing facilities, primarily via inhalation of air. Exposure to excess levels of 1,1-DCE is generally limited to occupational exposure (ATSDR, 1989).

Due to the high volatility of 1,1-DCE, the lungs are the primary point of entry to the human body (ATSDR, 1989). The health effects of 1,1-DCE in humans are largely unknown, but animal experiments involving high-level exposure produced liver, kidney, heart, and lung damage (ATSDR, 1989). Inhalation exposure appeared to be less damaging than oral exposure in the animal experiments (ATSDR, 1989). The available information on effects of 1,1,-DCE in humans is of limited value for predicting levels of concern with respect to human health (ATSDR, 1989). However, levels of exposure that may affect human health must be estimated from animal studies due to a lack of human data (ATSDR, 1989).

USEPA recommends an oral RfD of 0.009 mg/kg/day for chronic exposures to 1,1-DCE, based on liver effects in experimentally exposed rats (IRIS, 1992). Inhalation RfCs have not been established (IRIS, 1992). 1,1-DCE is classified by USEPA as Group C, possible human carcinogen, on the basis of limited evidence of carcinogenicity in animals (IRIS, 1992). USEPA has established a SF of 0.6 $(mg/kg/day)^{-1}$ for oral intakes and 1.2 $(mg/kg/day)^{-1}$ for inhalation exposure (IRIS, 1992). In experimental animals, kidney effects were observed as a result of inhalation exposure, and adrenal effects were observed as a result of oral exposure (IRIS, 1992).

1,2-Dichloroethene (1,2-DCE)

1,2-DCE exists in two isomeric forms: cis- and trans-. The toxicological endpoints of both isomers of 1,2-DCE are similar. Both isomers are rapidly absorbed by all routes of exposure (ATSDR, 1990). In animal studies, exposures to 1,2-DCE have resulted in lesions in the heart, liver and lungs (ATSDR, 1990). High levels of 1,2-DCE in air have been reported to cause death in humans, but the lethal concentration is unknown (ATSDR, 1990). Central nervous system effects have also been observed in animals (ATSDR, 1990). Information regarding the carcinogenic or teratogenic potential of either isomer of 1,2-DCE is not available (ATSDR, 1990). USEPA has derived an oral RfD of 0.01 mg/kg/day for cis-1,2-DCE on the basis of hematologic effects in rats (USEPA, 1991d). USEPA has derived an oral RfD of 0.02 mg/kg/day for trans-1,2-DCE on the basis of liver enzyme changes in mice (IRIS, 1992). Inhalation reference toxicity values are not available for either 1,2-DCE isomer.

1,1,1-Trichloroethane

In general, most exposure to 1,1,1-trichloroethane (1,1,1-TCA) is via inhalation of vapors, although some dermal adsorption may occur (Sittig, 1985). In cases of extreme exposure, 1,1,1-TCA acts as a narcotic, and depresses the central nervous system. Acute exposure to 1,1,1-TCA liquid and vapor are irritating to the eyes. Repeated direct dermal contact with pure 1,1,1-TCA may cause contact dermatitis. Cardiovascular and respiratory effects have been noted in both humans and animals as a result of high level inhalation exposures (Sittig, 1985). Symptoms of acute exposure to high concentrations include dizziness, lack of coordination, drowsiness, and loss of consciousness (Sittig, 1985). Bioassays have shown no evidence that 1,1,1-TCA is carcinogenic (Sittig, 1985).

USEPA recommends an oral RfD for 1,1,1-TCA of 0.09 mg/kg/day for chronic exposures (USEPA, 1991d). The inhalation RfC is set at 0.3 mg/kg/day for chronic exposures based on studies with laboratory animals (USEPA, 1991d). These studies demonstrated liver effects in guinea pigs as a result of both oral and inhalation exposures to 1,1,1-TCA (USEPA, 1991d).

Trichloroethene

Trichloroethene (TCE) is a man-made chemical which is not known to occur naturally (ATSDR, 1988). The primary human exposures to TCE occur in the environment or in occupational settings (ATSDR, 1988). Since TCE is volatile, most workplace exposure occurs via inhalation (ATSDR, 1988). TCE may also be ingested by the general population via drinking water (ATSDR 1988).

High air concentrations of TCE are associated with central nervous system effects (ATSDR, 1988). TCE is readily absorbed into the body, and dizziness, headache, eye, nose, and throat irritation may occur, with more pronounced effects associated with increased exposure durations (ATSDR, 1988). Liver and kidney damage have been noted in experiments with test animals (ATSDR, 1988). Other effects noted in animal studies include effects on the immune system, blood, and liver (ATSDR, 1988). Although long-term occupational inhalation exposures to the compound have been found to cause liver damage in humans, it is unlikely that chronic exposure to concentrations in ambient air would result in liver damage (ATSDR, 1988). TCE is classified by USEPA as a Group B2 (probable human) carcinogen (ATSDR, 1988/USEPA, 1991d). A SF of 0.011 $(mg/kg/day)^{-1}$ has been established for oral exposure based on liver tumors in mice (USEPA, 1991). USEPA has derived an inhalation SF of 0.017 $(mg/kg/day)^{-1}$ on the basis of lung tumors in mice (USEPA, 1991).

Chloroform

The general population may be exposed to chloroform via inhalation of air and ingestion of drinking water or foods contaminated with chloroform (ATSDR, 1989). Chloroform is also contained in automobile exhaust and some pesticides (ATSDR, 1989). Chloroform is found in a wide variety of occupational settings as a result of direct use in manufacturing processes and from formation during chlorination processes. Occupational exposure to chloroform accounts for the majority of chloroform exposure (ATSDR, 1989).

Chloroform can be absorbed into the body through the lungs, gastrointestinal tract, and skin. Inhalation is the primary route of exposure (ATSDR, 1989). Long-term exposure to high levels of chloroform can affect the central nervous system, liver and kidneys (ATSDR, 1989). Short-term exposure to high levels of chloroform in the air cause fatigue, dizziness, and headache (ATSDR, 1989). Drinking water supplies containing organic contaminants may contain chloroform as a by-product from chlorination of the water supply for disinfection purposes. The risks of cancer, if any, from low level exposures to chloroform in drinking water are considered to be outweighed by the benefits of chlorination (ATSDR, 1989).

USEPA has established an oral RfD of 0.01 mg/kg/day for chronic exposures to chloroform on the basis of animal studies with dogs in which chloroform exposure produced liver lesions (IRIS, 1992). Inhalation RfC have not been established (IRIS, 1992). Chloroform is classified as a Group B2, probable human carcinogen (IRIS, 1992). A SF of 0.0061 $(mg/kg/day)^{-1}$ has been established for oral exposure to chloroform on the basis of the development of kidney effects in experiments with rats (IRIS, 1992). The inhalation SF is 0.081 $(mg/kg/day)^{-1}$, since evidence of liver effects were indicated from experimental exposures of mice to chloroform (IRIS, 1992).

B. INORGANICS

There is no way to generalize the actions and influences of metals upon human health. Before presenting brief descriptions of the toxicological effects of exposure, a brief orientation regarding the complexities of metal toxicology is provided. Metals occur naturally in widely varying concentrations. Some metals are essential at certain levels for optimal health, yet many of these same metals may also exert toxic actions at higher levels if the body's internal regulatory capacity is exceeded.

The affinities of metals for specific tissues or organs varies widely. The toxic effect of a metal usually involves an interaction between the free metal ion and the target organ. Cells that are involved in the transport of metals, such as gastrointestinal, liver or renal tubular cells, are particularly susceptible to toxicity. The toxicity of metals is often related to their solubility (Casarett & Doull, 1986).

Arsenic

Information in the literature regarding effects of chronic exposure to arsenic indicates that a variety of skin abnormalities may occur, including cancerous changes. Chronic ingestion or inhalation of arsenic may cause digestive system, blood, kidney and central nervous system disturbances (Casarett & Doull, 1986). Studies have linked long-term occupational exposure of humans to inorganic arsenic compounds, with skin and lung cancer (NYSDOH, 1984).

As a result of this evidence, USEPA classifies arsenic as a Group A (known human) carcinogen (IRIS, 1992). USEPA has derived an inhalation SF of 50 $(mg/kg/day)^{-1}$ on the basis of data for occupationally-exposed humans who developed respiratory tract cancers (USEPA, 1991c). An oral SF for arsenic is currently under review by USEPA's Science Advisory Board (USEPA, 1991c). Elevated incidences of skin cancer have been observed in humans exposed to elevated concentrations of arsenic in drinking water. There is also some evidence which suggests that arsenic may be an essential nutrient (USEPA, 1982). An oral RfD of 0.0003 mg/kg/day for chronic exposures has been established (IRIS, 1992). The current RfD is based on evidence of keratosis and hyperpigmentation in orally-exposed humans (USEPA, 1991d).

Beryllium

Beryllium is primarily absorbed into the body via inhalation (Skilleter, 1985). The primary organ that beryllium affects is the lung (ATSDR, 1988). In the general population, inhalation exposure to beryllium (primarily beryllium oxide) occurs mostly in association with beryllium mining and processing activities. Inhalation of beryllium in these instances has been reported to cause inflammation of the respiratory tract. An acute chemical pneumonitis may develop, as well as hypersensitivity and a form of pulmonary disease known as berylliosis (Casarett & Doull, 1986).

Oral intake of beryllium appears to be of little importance since poorly absorbed insoluble precipitates are formed in the gut (Skilleter, 1985). Absorption through the skin is insignificant (Skilleter 1985).

Laboratory experiments indicated that inhalation of beryllium and certain beryllium compounds was associated with increased rates of lung cancer in animals (ATSDR, 1988). Therefore, USEPA classifies beryllium as a Group B2 (probable human) carcinogen (IRIS, 1992). USEPA has derived SF values of 4.3 $(mg/kg/day)^{-1}$ for oral exposure and 8.4 $(mg/kg/day)^{-1}$ for inhalation exposure (IRIS, 1992). The oral SF is based on the development of multiple-site tumors in rats (IRIS, 1992). The inhalation SF is based on occupationally-related lung cancers in humans (IRIS, 1992). The chronic oral RfD for beryllium is 0.005 mg/kg/day based on a chronic oral no-observed-effect-level (NOEL) for rats (IRIS, 1992). An inhalation RfC is not available (IRIS, 1992).

Cadmium

Human exposure to cadmium occurs via inhalation and ingestion (Sittig, 1985). The entire population is exposed to cadmium in the diet due to the occurrence of cadmium in the food chain (Sittig, 1985). Tobacco smokers are exposed to approximately 1.7 ug/cigarette of cadmium (Sittig, 1985).

Cadmium is absorbed into the body primarily via inhalation and ingestion (Sittig, 1985). Cadmium compounds are poorly absorbed from the intestinal tract, but relatively well absorbed by inhalation (Sittig, 1985). Skin absorption appears negligible (Sittig, 1985). Once absorbed, cadmium has a very long half-life and is retained in the kidneys and liver (Sittig, 1985). The soluble cadmium compounds are highly toxic, however, ingestion usually induces a strong emetic action which minimizes the risk of fatal poisoning (Sax & Lewis, 1987). In studies with experimental animals, cadmium has been shown to cause kidney damage, liver and central nervous system effects, testicular atrophy, teratogenic effects, and a decrease in red blood cells (Sittig, 1985). These effects have not been observed in occupationally-exposed humans (Sittig, 1985).

USEPA classifies cadmium as a Group B1 carcinogen for the inhalation route of exposure (IRIS, 1992). The inhalation SF is 6.1 $(mg/kg/day)^{-1}$ (IRIS, 1992). No oral SF has been established (IRIS, 1992). The oral chronic RfD for cadmium is 0.0005 mg/kg/day (IRIS, 1992).

Chromium (Trivalent and Hexavalent)

Chromium is a generally abundant element in the earth's crust and occurs in oxidation states from the divalent form to the hexavalent form, but only the trivalent and hexavalent forms are of primary biological significance (Casarett & Doull, 1986). Based on information regarding the behavior of chromium in the environment, it is assumed that both trivalent and hexavalent chromium are present at the site. USEPA guidance suggests the ratio of hexavalent to trivalent chromium in soils is 1:7 (IRIS, 1992).

The known harmful effects of chromium in humans have been attributed to the hexavalent form (Casarett & Doull, 1986). Hexavalent chromium readily crosses cell membranes and is reduced intracellularly to trivalent chromium. Hexavalent chromium is corrosive and causes ulceration and perforation of the skin; trivalent chromium compounds are neither irritating nor corrosive (Casarett & Doull, 1986).

Occupational exposure to chromium (i.e., in chrome production and chrome pigment industries) has been associated with cancer of the respiratory tract (Casarett & Doull, 1986). The major acute effect from ingestion of chromium is renal tubular necrosis (Casarett & Doull, 1986). The body stores chromium in the skin, lungs, muscle, and adipose tissue (Casarett & Doull, 1986).

The toxicity criteria for chromium which are applied in subsequent risk calculations are for both trivalent and hexavalent chromium. Trivalent chromium has an RfD of 1.0 mg/kg/day for chronic oral exposure (IRIS, 1992). Hexavalent chromium has an oral RfD of 0.005 mg/kg/day (IRIS, 1992). These criteria are based on liver effects in rats (IRIS, 1992). The inhalation RfC is 0.0000006 mg/kg/day for both trivalent and hexavalent chromium (USEPA, 1991d). Hexavalent chromium has an inhalation SF of 41 $(mg/kg/day)^{-1}$, and is considered a Group A carcinogen for the inhalation route (IRIS, 1992).

Copper

Copper is an essential nutrient and is a cofactor for several enzymes. Humans may absorb copper via oral and inhalation routes. Very little dermal absorption occurs (Casarett & Doull, 1986). The liver is the main storage organ for copper in the body (Casarett & Doull, 1986).

Copper has been reported to cause adverse effects on the liver, kidneys and blood as a result of acute and subchronic exposures (ATSDR, 1987). In general, the reported effects related to long-term occupational exposures include the development of mild anemia, contact dermatitis, and leucocytosis (ATSDR, 1987). Most inhalation exposures to copper in occupational settings result in mild, infrequent and transient effects, limited to irritation of the respiratory tract (ATSDR, 1987).

Gastrointestinal tract absorption of copper is normally regulated by body stores (Casarett & Doull 1986). This homeostatic balance severely limits episodes of toxicity from high exposures (Casarett & Doull, 1986). Individuals with Wilson's disease, a genetic condition characterized by abnormally high absorption, retention, and storage of copper by the body, are subject to chronic copper intoxication if exposed to unusually high levels (Sittig, 1985). These individuals are most sensitive and at a higher risk in cases of extreme exposure to copper.

An oral RfD of 0.037 mg/kg/day for chronic exposure has been established by USEPA (1991d). This level is based on the USEPA MCL and is related to the development of gastrointestinal irritation in humans exposed to copper after ingestion of a high-level single dose (USEPA, 1991d). An inhalation RfC is not available.

Lead

Once deposited in the lower respiratory tract, all chemical forms of lead are almost completely absorbed. Although only limited data are available, oral absorption of lead appears to be low in humans (ATSDR, 1991). In animals, absorption from the gastrointestinal tract is controlled by a saturation phenomena, and is influenced by fasting, age, and particle size. Dermal absorption of inorganic lead compounds is reported to be much less significant than absorption by inhalation or oral routes of exposure. Bone contains most of the body burden of lead. A labile compartment of the lead in bone allows for maintenance of an equilibrium of lead between bone and soft tissue or blood (ATSDR, 1991). Transfer of lead across the human placenta has been demonstrated in a number of studies, and lead has been identified in umbilical cord blood (ATSDR, 1991).

Cardiovascular effects have been noted in individuals occupationally exposed to lead. Blood pressure changes and ECG abnormalities have been observed (ATSDR, 1991). Colic is a consistent early symptom of lead poisoning in occupational exposure cases or in children (ATSDR, 1991). Lead is well known to have profound effects on heme biosynthesis by affecting the activities of several enzymes of the heme biosynthetic pathway (ATSDR, 1991). Occupational exposure to lead has often been associated with subjective signs of neurotoxicity (ATSDR, 1991). Ingestion of drinking water containing lead was found to be associated with evidence of renal insufficiency in humans. Animal studies strongly suggest that low-level lead exposure during postnatal development has a selective detrimental effect on the rods of the retina (ATSDR, 1991). In addition, studies in lab animals suggest that lead adversely affects components of the immune system (i.e., thymus) following intermediate duration dietary exposure (ATSDR, 1991).

There are no reference toxicity values for lead on IRIS (1992) or in HEAST (USEPA, 1991d).

Manganese

Manganese is a naturally-occurring element found in many types of rock, and is dissolved in low concentrations in lakes, streams, and the ocean (ATSDR, 1990). Average exposure to manganese occurs mainly through ingestion of foods and drinking water. Several investigations of adult diets have reported the average daily consumption of manganese to range between 2.0 and 8.8 mg/day (IRIS, 1992). Higher manganese intakes are associated with diets high in whole cereals, nuts, green leafy vegetables, and tea. Excess exposure to manganese is most commonly caused by inhalation of dust (ATSDR, 1990).

Inhalation exposure to high levels of manganese can lead to a disabling syndrome of neurological effects termed "manganism". Reported symptoms of manganese intoxication include lethargy, increased muscle tension, tremors, and mental disturbances. A common effect in men who are exposed to manganese is impotence (ATSDR, 1990). Inhalation of manganese dust has also been shown to irritate the lungs (ATSDR, 1990). USEPA has derived an oral RfD of 0.1 mg/kg/day and an inhalation RfC of 0.000114 mg/kg/day (IRIS, 1992).

Mercury

Mercury is a naturally-occurring element of the earth's crust. Human exposure to mercury occurs primarily via ingestion and inhalation (Casarett & Doull, 1986).

There is evidence that long-term exposure to either organic or inorganic mercury can damage the brain, kidneys and developing fetuses (Casarett & Doull, 1986). In general, the major target organs in low-level chronic exposures are the kidneys and central nervous system. At high exposure levels, respiratory, cardiovascular, and gastrointestinal effects are also seen (NAS, 1978).

Inhalation of mercury vapor in cases of high level exposure (such as in occupational settings) may produce an acute, corrosive bronchitis and interstitial pneumonitis (Casarett & Doull, 1986). Chronic exposure to mercury vapor can severely affect the central nervous system, especially the sensory, visual, and auditory areas concerned with coordination. The kidney is also implicated as a target organ, as the highest concentrations of mercury occur in the kidneys, regardless of the chemical form absorbed (Casarett & Doull, 1986).

USEPA has derived an oral RfD for mercury of 0.0003 mg/kg/day for chronic exposures (USEPA, 1991d). This value is based on the development of kidney effects in rats experimentally exposed to inorganic mercury (USEPA, 1991d). The inhalation RfC for mercury is 0.00009 mg/kg/day (USEPA, 1991d).

Nickel

Nickel is a naturally-occurring metal that is found in small quantities in the earth's crust. It can be found in all parts of the environment.

Nickel has a wide range of industrial uses, and most nickel exposures occur in workplace settings. However, exposure to nickel and its compounds can also occur via ingestion of drinking water and food, as well as through skin contact with a wide range of consumer products (ATSDR, 1988).

In general, the lung is the major target organ of nickel toxicity following inhalation exposure (ATSDR, 1988). The amount of nickel that enters the blood from the lungs depends on the size of the particles, the solubility of the nickel compounds, and the location of nickel deposited in the lungs (ATSDR, 1988). For the general population, inhalation of nickel is generally less common than intake via the diet, but inhalation of tobacco smoke may be a significant source of nickel exposure (ATSDR, 1988). The most common adverse effects of nickel exposure in the general population are skin allergies and contact dermatitis (ATSDR, 1988). On the basis of laboratory tests, nickel and inorganic nickel compounds do not appear to be carcinogenic to animals by the oral route (ATSDR, 1988).

The literature reports evidence that inhalation of nickel refinery dust (including nickel subsulfide) is associated with cancers of the lung, nasal cavity, and larynx in humans (ATSDR, 1988). Therefore, nickel subsulfide and nickel refinery dust are designated by USEPA as Group A (known human) carcinogens, via the inhalation route only (USEPA, 1991d). USEPA has derived two inhalation SFs for nickel. An inhalation SF of 1.7 $(mg/kg/day)^{-1}$ has been derived for nickel subsulfide (USEPA, 1991d). The inhalation SF for nickel refinery dust is 0.84 $(mg/kg/day)^{-1}$ (USEPA, 1991d). The inhalation SFs for these nickel compounds are based on the development of respiratory cancer in humans following occupational exposure (USEPA, 1991d). USEPA (1991d) has also established an oral RfD of 0.02 mg/kg/day (IRIS, 1992) for chronic exposures to nickel based on reduced body and organ weight in rats (USEPA, 1991d).

Silver

Studies in humans and animals indicate that silver compounds are absorbed readily by both the inhalation and oral routes, and are distributed widely throughout the body. Silver is deposited in the form of granules visible with the light microscope. With the possible exception of one report of decreased activity in mice exposed to silver nitrate, and one report of enlarged hearts in silver nitrate or silver chloride- exposed rats, there is no evidence to suggest that these silver deposits would interfere with the normal functioning of these organs in humans (ATSDR, 1989).

Silver nitrate and silver oxide have been reported to cause upper and lower respiratory tract irritation in humans when inhaled (ATSDR, 1989). Since these effects are believed to be related to the caustic properties of the compounds, and not the presence of silver, effects are not expected to persist after exposure has ceased. The same exposure conditions can also cause gastric discomfort in humans (ATSDR, 1989). This effect is also believed to be due to the caustic effects of the compounds rather than the presence and action of silver itself.

Silver is deposited in the kidney of animals, and therefore may affect kidney function. However, studies of kidney function in animals were not available, and no clear relationship between exposure to silver and these effects has been established (ATSDR, 1989).

The predominant effect of exposure to silver in humans is the development of an irreversible pigmentation of the skin. This condition involving a gray to gray-blue discoloration of the skin is called argyria. Argyria may occur in an area of repeated or abrasive dermal contact with silver or silver compounds, or more extensively over widespread areas of the skin and the eyes following long-term ingestion or inhalation exposure. USEPA (1991d) has derived a chronic oral RfD for silver of 0.005 mg/kg/day based on this effect. No inhalation reference toxicity value has been established for silver.

Zinc

Zinc is a natural element and is often associated with cadmium in the environment. The zinc-cadmium ratio influences zinc toxicity in that cadmium inhibits enzymes associated with zinc by competing with zinc and displacing it (Casarett & Doull, 1986).

Zinc is a nutritionally essential element, and the majority of zinc exposure by the general population results from normal ingestion of food and water. Zinc toxicity from excessive ingestion is uncommon among the general population, but can occur from ingestion of acidic foods and beverages stored in galvanized containers (Underwood, 1971).

USEPA has derived an oral RfD for zinc of 0.2 mg/kg/day for chronic exposures, based on evidence of anemia in humans orally exposed to dosages of zinc for therapeutic purposes (USEPA, 1990). An inhalation RfC has not been established (USEPA, 1991d).

APPENDIX G
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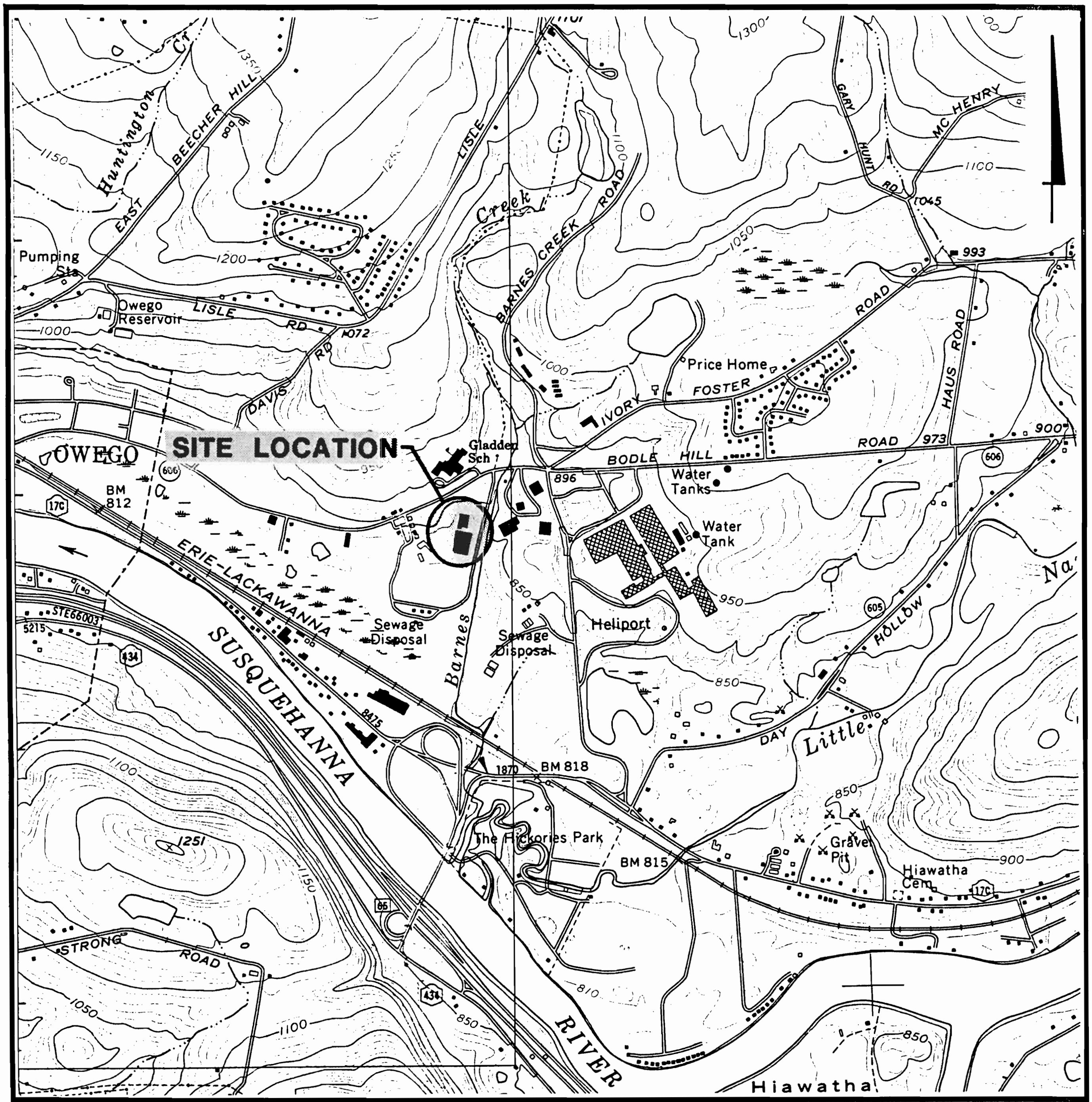
FIGURE I



HADCO CORPORATION
OWEGO, NEW YORK

CONTOUR INTERVAL = 10 FEET

SITE LOCATION MAP

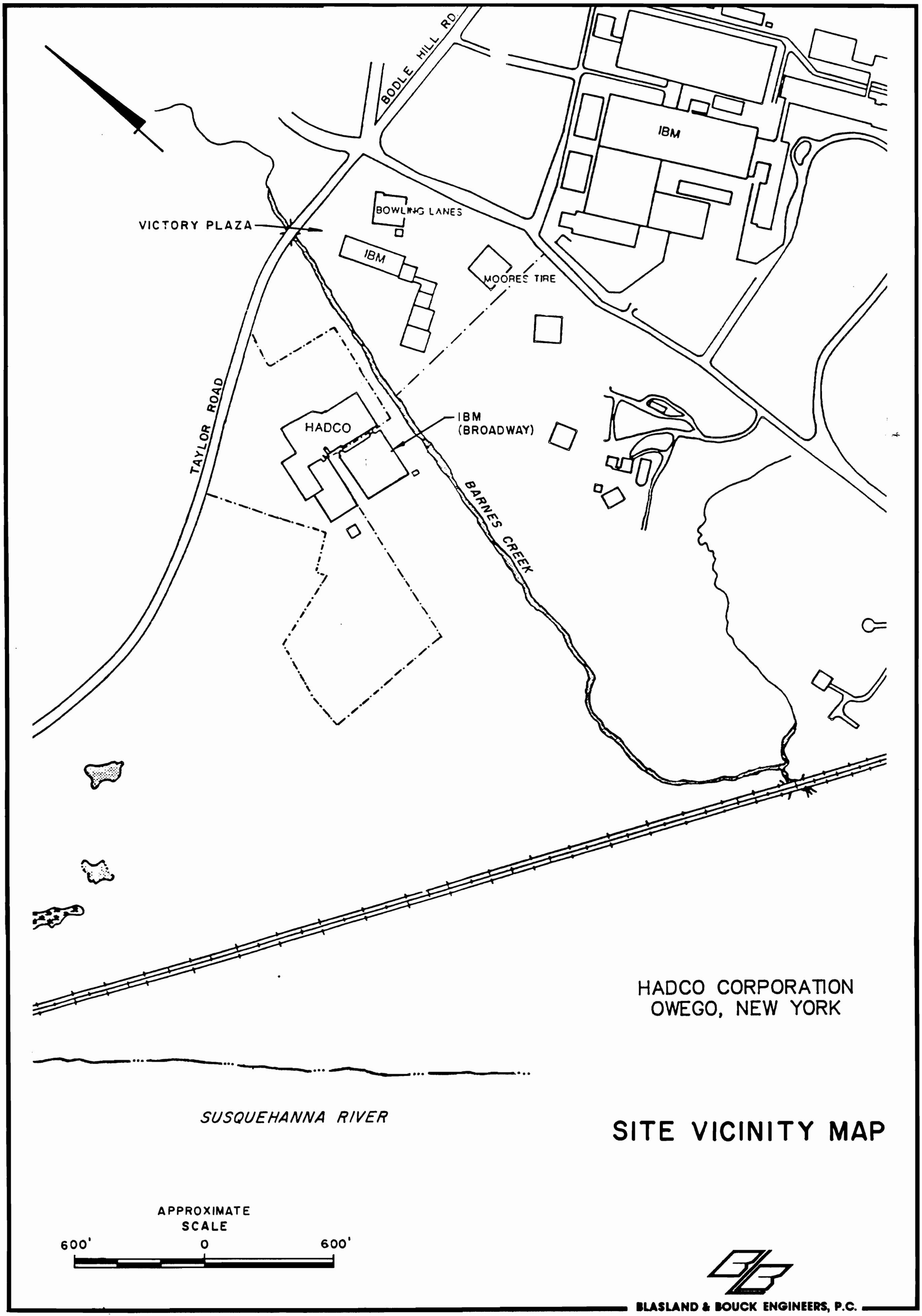
SCALE:

2000' 0 2000'

SOURCE: USGS 7 1/2 MINUTE TOPOGRAPHIC QUADRANGLE:
APALACHIN, NEW YORK, 1973

BLASLAND & BOUCK ENGINEERS, P.C.
ENGINEERS & GEOSCIENTISTS

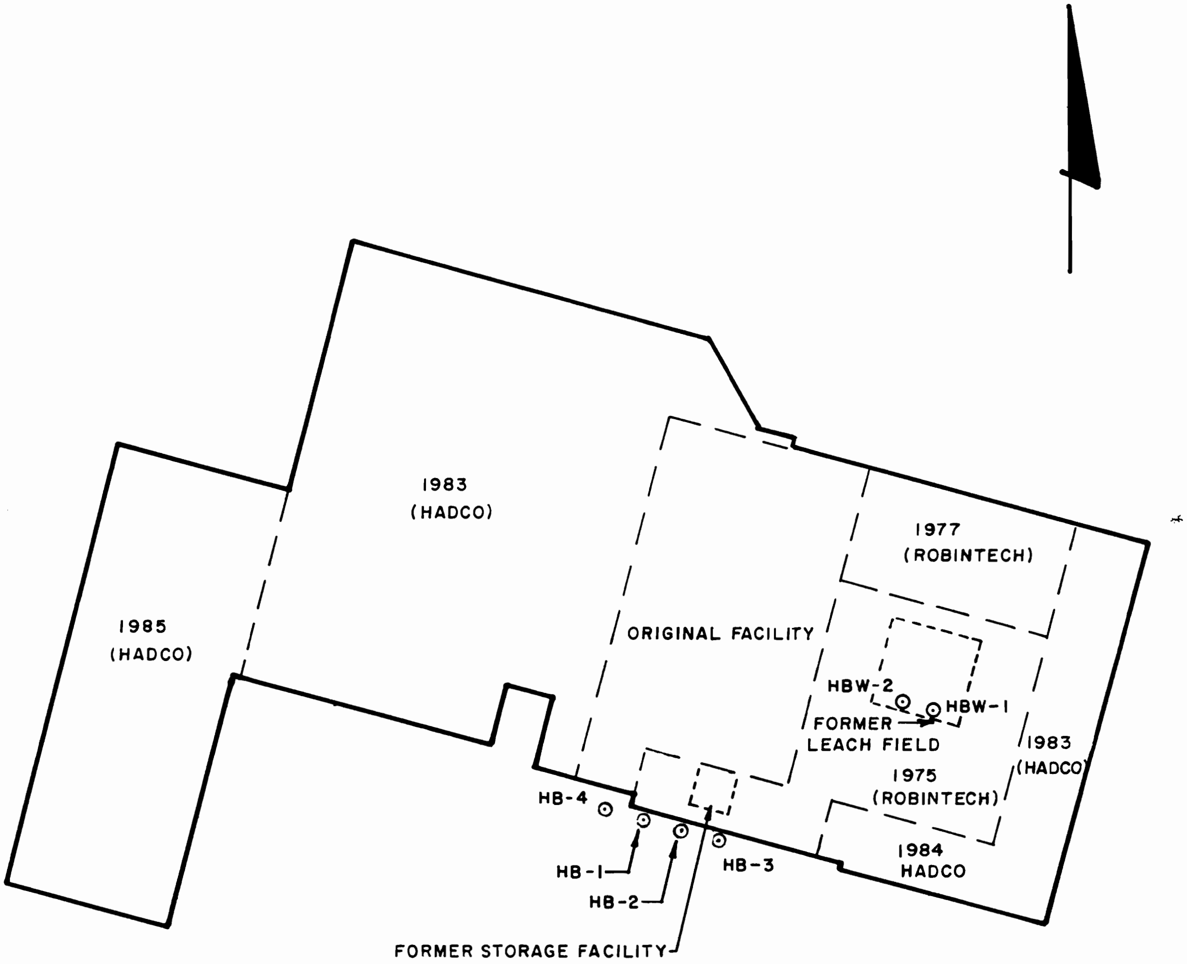
FIGURE 2



HADCO CORPORATION
OWEGO, NEW YORK

SITE VICINITY MAP

BLASLAND & BOUCK ENGINEERS, P.C.
ENGINEERS & GEOSCIENTISTS



LEGEND

⊙ SOIL BORING LOCATIONS

HADCO CORPORATION
OWEGO, NEW YORK

SOURCE INVESTIGATION LOCATION MAP

SCALE
100' 0' 100'

BLASLAND & BOUCK ENGINEERS, P.C.
ENGINEERS & GEOSCIENTISTS

HADCO CORPORATION
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