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Golder Associates Inc.
CONSULTING ENGINEERS

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PRE-DESIGN INVESTIGATION
TASK GW-2
HYDROGEOLOGIC CHARACTERIZATION
FOR THE
EXTRACTION/RECHARGE SYSTEM
INTERIM FINAL REPORT

INDUSTRI-PLEX SITE
WOBURN, MASSACHUSETTS

Prepared for:

Industri-Plex Site Remedial Trust
800 North Lindbergh Boulevard
St. Louis, Missouri 63167

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December 1990

Project No.: 893-6255

Golder Associates Inc.
CONSULTING ENGINEERS

December 13, 1990 Project No. 893-6255

United States Environmental Protection Agency, Region 1
J.F.K. Federal Building HRS-CAN-3
Boston, Massachusetts 02203-2211

Attn: Joseph DeCola
Remedial Project Manager

RE: INDUSTRI-PLEX SITE PRE-DESIGN INVESTIGATION
TASK GW-2 HYDROGEOLOGIC CHARACTERIZATION FOR
EXTRACTION/RECHARGE SYSTEM - INTERIM FINAL REPORT

Gentlemen:

On behalf of the Industri-Plex Site Remedial Trust, we are submitting the attached Hydrogeologic Characterization For Extraction/Recharge System Interim Final Report for the Industri-Plex Site in Woburn, Massachusetts. This report is being submitted in accordance with the Pre-Design Investigation Work Plan (PDI) Task GW-2 reporting requirements (PDI Sections 3.3.4.4, p.81 and 3.8.1.2.2, p. 128).

Please contact us if you have any questions.

Very truly yours,

GOLDER ASSOCIATES INC.

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1.0 INTRODUCTION

In accordance with the reporting requirements of the Pre-Design Investigation (PDI) Work Plan (Section 3.3.4.4, p. 81 and Section 3.8.1.2.2, p.128), an Interim Final Report for the Industri-Plex Site (Site) must be prepared and submitted to the United States Environmental Protection Agency (USEPA) and the Massachusetts Department of Environmental Protection (MDEP) for review and approval. This Interim Final Report fulfills this reporting requirement for Task GW-2 and presents the interpretation of the data developed from the performance of Task GW-2 Subtask 1, Subtask 2, and Subtask 3.

This report presents the data necessary to support the design of the extraction wells and recharge basin. Aquifer testing results (Section 6.0) have provided the hydraulic coefficients needed to determine the optimal pumping rate for the extraction system. The absence of an unsaturated zone, as evidenced from soil borings conducted in the areas for the recharge basin, precluded the implementation of a percolation test. Thus, a recharge test (Section 7.0) was best suited to determine the rate that ground water can be recharged on-site. This work has provided enough data to design the extraction and recharge system.

1.1 Location

The location for the aquifer test was presented to the USEPA and the MDEP in the Work Plan titled "Aquifer Test Work Plan, Task GW-2/Subtask 1, August 21, 1990." In addition, the location of the test was discussed with the USEPA and the MDEP during a meeting on October 4, 1990. At that time the details of the proposed aquifer test, such as analytical methods and well locations, were discussed.

The location of the testing site was selected primarily based upon the results of the Plume Delineation Task (Task GW-1 of the Work Plan), and supplemented with hydrogeological data developed during the Pre-Design Investigation (PDI). Because the aquifer testing site is not located within an area of identified organic impacted ground water, treatment of the discharged ground water is not anticipated to be required. The rationale for performing the aquifer tests in an unimpacted versus an organic impacted area was presented in Section 3.3.4.3 of the PDI Work Plan.

The location and design of the recharge basin test were also discussed with the USEPA and the MDEP during the October 4, 1990 meeting. The scope of work and the rationale for the selection of the location for the recharge test was provided in the Work Plan titled "Recharge Test Work Plan, Task GW-2/Subtask 3, August 14, 1990."

2.0 BACKGROUND

The aquifer test and the recharge test were performed to develop data during the PDI to support the design of the ground-water extraction and recharge system. The Consent Decree specifies that the remedy for ground water in the Remedial Design Action Plan consists of an interim remedy of pumping and treating "hot spot" areas of ground-water contamination. The interim ground-water remedy will consist of several interceptor wells/recovery wells, and the treated effluent from these wells which is to be discharged to a subsurface leaching pit to be located on-site, in an upgradient portion of the aquifer. The aquifer and recharge tests developed data to support the design of this interim ground-water remedy.

3.0 METHODOLOGY

The constant-rate (pumping) test was designed to employ the Stallman Method (1965) for conducting a pumping test in, and analyzing pumping test data from an unconfined (water-table) aquifer. A detailed description of the analytical approach is discussed in Section 6.1.1, titled "Stallman Method."

The Stallman Method requires that the test (pumping) well and the observation wells used to monitor ground-water levels during the pumping test be designed to screen distinct sections of the water-table aquifer. The depths of penetration of the well screens is directly related to the geometry of the water-table aquifer (i.e., the initial saturated thickness of the unconfined aquifer). Thus, the methodology involves the drilling and installation of observation wells, and the running of the pumping test.

3.1 Observation Well Drilling and Installation

Between October 1, 1990 and October 11, 1990, Roux Associates, Inc. (Roux Associates) directed the drilling and installation of eight temporary observation wells at four separate cluster locations in the Industri-Plex pumping test study area (study area) south of the Industri-Plex Site (Plate 1). These temporary wells included TW-1S, TW-1D, TW-2S, TW-2D, TW-3S, TW-3D, TW-4S, and TW-4D. In addition, a temporary well (TW-5) was hand driven by Roux Associates into Hall's Brook and screened the ground water immediately below the stream bed. This work was done in accordance with the "Aquifer Test Work Plan, Task GW-2/Subtask 1, August 21, 1990" and the agreed to changes to that work plan (DeCillis, pers. comm. 1990a) as finalized to the USEPA by Golder Associates Inc. (Golder) on October 9, 1990. (Note that the original designations of the temporary piezometers as P-[number and letter] in the Work Plan, were changed in the field to TW-[number and letter], for temporary well.) Temporary well locations are depicted in Figure 1.

Temporary well sites were chosen to obtain a sufficient distribution of data points for accurate determination of the hydraulic coefficients of the water-table aquifer (i.e., transmissivity, storage coefficient, horizontal hydraulic conductivity, and vertical hydraulic conductivity) in the vicinity of the pumping test site. A temporary well cluster, consisting of one shallow well and one deep well, is present at each location. Temporary Wells TW-1S/TW-1D through TW-4S/TW-4D were installed using the hollow-stem auger drilling method. Drilling equipment was decontaminated between each well installation using a high-pressure, hot-water wash.

At the TW-1 well cluster, formation samples were collected in the borehole for Temporary Well TW-1D using a 2-inch diameter, 2-foot long, split-barrel core (split-spoon) sampler at 5-foot intervals from ground surface to the bottom of the boring. In addition, formation cuttings from the auger flights were examined to supplement and to verify the geological records compiled from the split-spoon samples. A record of the sample location, depth, grain size, and color was maintained throughout the drilling operations by the Roux Associates' field hydrogeologist. The geologic log for Temporary Well TW-1D is presented in Appendix A. All subsequent boreholes for the temporary wells were not sampled with a split-barrel core sampler; however, formation cuttings from the auger flights were inspected to determine if subsurface lithologic conditions varied from those encountered at Temporary Well TW-1D.

The purpose of collecting split-spoon samples from the borehole for Temporary Well TW-1D was twofold. First, it was necessary to determine the lithologic composition of the unconsolidated sediments (i.e., types, variability, gradation, etc.). Second, it was necessary to determine the saturated thickness of the water-table aquifer. An accurate measurement of the saturated thickness of the water-table aquifer is imperative because the Stallman Method (1965) dictates specific penetration depths (well screen intervals) for the design of the observation wells and the pumping well. These specific penetration depths correspond to the type curve analysis option used to analyze the time versus drawdown data. Collecting these data was a key to the design of the pumping test, and was facilitated by collecting split-spoon samples from the borehole of one deep temporary well (TW-1D) close to the pumping well.

As illustrated in Figure 1, Temporary Well Clusters TW-1S and TW-1D, TW-2S and TW-2D, and TW-3S and TW-3D were located approximately 24 feet to 26 feet from Pumping Well PW-1. The temporary well clusters were installed relatively close to the pumping well in the event that the water-table aquifer being stressed may have been low-yielding (e.g., yielding less than 100 gallons per minute [gpm]). Thus, to ensure the collection of drawdown data of sufficient magnitude, the temporary wells were situated approximately 25 feet from the pumping well. Moreover, the presence of a recharge boundary (barrier) in the study area supported the distance of Temporary Wells TW-1S and TW-1D through TW-3S and TW-3D because this close well spacing could provide early drawdown data before the cone of depression has the time to potentially extend to, and intercept, the recharge boundary, and potentially distort the cone of depression (i.e., affect the time versus drawdown relationship). Additional discussions related to this topic are in subsequent paragraphs.

Temporary Well Cluster TW-4S and TW-4D were situated approximately 150 feet from Pumping Well PW-1. The rationale for locating this temporary well cluster further from the pumping well was to collect drawdown data at a greater distance from the pumping well in the event that the water-table aquifer was more prolific (e.g., yielding low 100s of gpm).

The orientation of the temporary wells was based upon the presence of a recharge boundary (i.e., Hall's Brook to the west) and a barrier boundary (i.e., the subsurface bedrock "wall" that rises to the west, resulting in a reduction in the saturated thickness of the water-table aquifer). Because the potential impacts of the boundaries were unknown, one of the three Temporary Well Clusters (TW-3S and TW-3D) was oriented perpendicular to the two boundaries, while two of the four Temporary Well Clusters (TW-2S and TW-2D, and TW-4S and TW-4D) were oriented parallel to the two boundaries.

Temporary Well Cluster TW-3S and TW-3D were oriented perpendicular to the coincident boundaries, at distances of 25.10 feet and 26.40 feet, respectively, from Pumping Well PW-1 (Figure 1). The purpose for this orientation and these distances for Well Cluster TW-3S and TW-3D is to evaluate the time versus drawdown data resulting from impacts on either boundary or both boundaries, and to allow for the analysis of early time versus drawdown data before the data is affected by the boundary condition(s) (Walton 1962).

Temporary Well Cluster TW-2S and TW-2D were oriented parallel to the coincident boundaries, at distances of 23.80 feet and 25.10 feet, respectively, from Pumping Well PW-1.

The purpose for these distances and this orientation is to monitor water levels close to the pumping well (in the event that the well yield is low) and to monitor the hydraulic gradient of the cone of depression in the parallel direction where it would not be disturbed to any great degree by boundary effects (Walton 1962).

This same logic was applied to the orientation of Temporary Well Cluster TW-4S and TW-4D (i.e., parallel to the boundary conditions). However, these temporary wells were situated at a greater distance (i.e., 146.0 feet and 151.7 feet, respectively) from the pumping well to monitor drawdowns further away from the pumping well in the event that the water-table aquifer could produce water at high rates (i.e., in the low 100s gpm).

Temporary Well Cluster TW-1S and TW-1D were oriented at an oblique angle away from the hydraulic barriers, at distances of 25.20 feet and 26.15 feet, respectively. The rationale for situating this temporary well cluster away from the hydraulic barriers was to collect drawdown data that was also anticipated to be unaffected by barrier conditions.

The shallow temporary wells were either screened in the midpoint of the water-table aquifer (TW-1S, TW-2S, and TW-4S) (z = 0.506, Stallman 1965) or in the upper 25 percent of the aquifer (TW-3S) (z = 0.75b, Stallman 1965). All four shallow temporary wells were equipped with 5-foot long screens, as illustrated in the Monitoring Well Construction Logs (Appendix B).

The pumping well (PW-1) was installed using the dual-rotary drilling technique with water as the drilling fluid. Pumping Well PW-1 screened the bottom three-tenths of the water-table aquifer (Stallman 1965). As illustrated on the Monitoring Well Construction Log (Appendix B), Pumping Well PW-1 was equipped with a 19-foot long screen.

With the exception of Temporary Well TW-5, the temporary observation wells were constructed with 2-inch diameter, polyvinyl chloride (PVC) screen and casing. The temporary cluster wells were equipped with 5-foot long, 0.010-inch openings (10 slot) screen, and sufficient casing to extend from the top of the well screen to approximately 2.5 feet above land surface (i.e., the stick-up).

With the exception of Temporary Wells TW-1D and TW-3D (which will be discussed below), the remaining temporary wells were not gravel packed and sealed with bentonite, except at the surface. Instead, the auger flights were removed from the borehole and the formation was allowed to collapse around the well. A bentonite seal was installed at the surface to prevent the infiltration of any surface runoff through the annulus.

Temporary Wells TW-1D and TW-3D were gravel packed, with the gravel extending from a couple of feet below the bottom of the screen to several feet above the top of the screen. A bentonite slurry seal was placed on top of the gravel pack, and the remainder of the annular space was filled with bentonite grout.

The purpose for constructing Temporary Wells TW-1D and TW-3D in this manner is because they were to also serve as monitoring wells for the collection of ground-water quality samples. The sampling of Temporary Wells TW-1D and TW-3D prior, and subsequent, to the pumping test was part of the agreement negotiated between the Industri-Plex Site Remedial Trust (ISRT) and Digital Equipment Corporation, on whose property the pumping test was to be conducted.

Temporary Well TW-5, which was a 1.5-inch diameter stainless steel piezometer, was hand driven through the stream bed of Hall's Brook. The screen was 3 feet in length, with a 14-slot opening. The top of the screen was approximately 2 feet to 3 feet below the stream bed, and the casing extended from the top of the screen to approximately 2.5 feet to 3.0 feet above the surface of the water in Hall's Brook.

Pumping Well PW-1 was constructed with 8-inch diameter, stainless steel screen and steel casing. The pumping well was equipped with a 19-foot long, 100-slot screen, and sufficient casing to extend from the top of the well screen to a couple of feet above land surface. (Stick-up of the steel casing was cut and new sections were welded onto the steel casing to accommodate the two different pumps used during the aquifer test [i.e., the suction pump used during the step-drawdown test and the turbine pump used during the constant-rate test].)

Temporary Wells TW-1S and TW-1D through TW-4 and TW-4D, and Pumping Well PW-1 were developed with a centrifugal pump; Temporary Well TW-5 was developed with a peristaltic pump. All ground water removed during well development was pumped into a 250-gallon capacity tank that was mounted on a pickup truck, transported to the decontamination pad, and discharged to the on-site storage tanks.

3.1.1 Surveying

On October 11, 1990, the water-level measurement point (MP) elevation of each temporary well was surveyed by SAIC Engineering, Inc., Lakeville, Massachusetts. The surveyor's report is included in Appendix C.

3.2 Description of Aquifer Tests

In accordance with Task GW-2, Subtask 1 (Aquifer Testing) and Subtask 3 (Recharge Test) of the "Pre-Design Investigation Work Plan, Industri-Plex Site, Woburn, Massachusetts" aquifer testing consisting of a step-drawdown (step) test and a constant-rate (pumping) test was implemented on Digital Equipment Corporation property (study area), and a recharge test was conducted on the Industri-Plex Site (Site). All three aquifer tests were run by Roux Associates. The step test and pumping test are discussed below and in Section 6.0 (Hydraulic Coefficient Determination), and the recharge test is discussed in Section 7.0 (Results of Recharge Test). (Additionally, slug tests were performed by Golder on 30 wells both on and off of the Site.)

3.2.1 Step Test and Pumping Test

A pumping test was conducted in the study area to obtain data from which aquifer (hydraulic) parameters, including the vertical hydraulic conductivity and horizontal hydraulic conductivity (permeability), the transmissivity, the storage coefficient (elastic and/or water table), and the degree of anisotropy could be calculated.

Prior to the pumping test, a step test was conducted to assess the performance characteristics of the pumping well. The step test consisted of pumping the pumping well (PW-1) at successively greater discharge rates for relatively short periods of time (e.g., 1 hour to 2 hours). Data from the step test were used for selecting an optimum pumping rate for the pumping test.

The pumping test consisted of pumping the pumping well at a constant and continuous rate for 48 hours while recording drawdown (i.e., the difference between static water levels and pumping water levels) in the pumping well and in the observation wells at times that were as close as possible to those specified in the Roux Associates' Standard Operating Procedure (SOP) for conducting a constant-rate (pumping) test (Appendix D). Measurements required for the pumping test included the pumping rate, the static water levels just before the test was started, the time since the pump started, the pumping or dynamic water levels at designated intervals during the pumping period (time versus drawdown data), and the time the pump stopped. The distances between the pumping well, the temporary well clusters and the observation well cluster (closest to the pumping well) were also measured and recorded. All time versus drawdown data from the pumping test is presented in Appendix E.

Prior to the start of the pumping test, static water levels were determined with either a steel tape and chalk or an electric sounding device (m-scope). In addition, several synoptic rounds of water levels were measured the day before the pumping test. Although specific wells had specific water-level measuring devices dedicated to them, all water-level measuring devices used during the pumping test (i.e., a steel tape and chalk and/or a m-scope) were compared to ensure they were measuring water-levels similarly.

The pumping (discharge) rate for the test was measured using a circular orifice weir and manometer tube. This arrangement allows the discharge rate to be accurate and instantaneously determined by measuring the height of water in the manometer tube, and then comparing the measurement to a reference table to find the corresponding discharge rate (as discussed in Anderson [1977]). Discharged water from the pumping well was piped into Hall's Brook, approximately 300 feet southeast of the pumping well to preclude the discharged water from artificially recharging the aquifer and thereby adversely influencing the pumping test. Sampling and analysis of discharged water is discussed in Section 5.0 (Monitoring Pumping Test Discharge Water).

Drawdown in the pumping well, the temporary wells, and the observation wells was measured using several methods including: 1) calibrated steel tapes; 2) m-scopes; and 3) a pressure transducer combined with the Instrumentation Northwest, Inc. data logger or the

Telog, Inc. data logger. The latter method was used to collect a continuing record of drawdown measurements. Regular synoptic rounds of water levels were measured in all the wells being monitored during the pumping test with the steel tape or the m-scope, as well as being used to check the water levels being monitored by the pressure transducers and the data loggers. The manual measurements also served as a "back-up" in the event of a transducer and/or data logger failure, and/or the inability of the data logger software to convert water-level measurements into a usable form for plotting and/or input to analytical aquifer test software packages (programs).

The data provided by the pumping tests required interpretation by various analytical techniques to determine aquifer parameters. The pumping test and its results are discussed in Section 6.0 (Hydraulic Coefficient Determination).

3.2.1.1 Step Test

The step test was conducted on Friday, October 26, 1990 on Pumping Well PW-1. Five pumping rates were used to evaluate the optimum pumping rate for the pumping test. The step test pumping rates included 145 gallons per minute (gpm) to 172 gpm, 250 gpm, 350 gpm, 400 gpm, and 450 gpm (Figure 2). Water levels during the first step (145 gpm to 172 gpm) fluctuated and could not be maintained at a constant rate because the pumping rate was too low to fill the discharge line and to create sufficient back pressure. The following three steps (250 gpm, 350 gpm, and 400 gpm) were each maintained at their respective constant rate until water levels reached near stabilization (i.e., approximately 1 hour to 2 hours). The last step (450 gpm) could not be maintained for more than approximately 10 minutes to 15 minutes before breaking suction (i.e., reducing the water level to a point below the intake capacity of the pump).

The pumping rate for the 48-hour test was determined based upon the following considerations: 1) the pumping rate chosen could not dewater the water table substantially (i.e., leave sufficient water above the screen to provide a margin of safety relative to the amount of usable drawdown in the pumping well) and would leave sufficient head in the pumping well in the event that the cone of drawdown intercepted the barrier boundary (i.e., the barrier boundary would limit the growth of the cone of depression and result in additional drawdown by as much as 50 percent by not making ground water available to the pumping well); 2) the projected drawdown for the 48 hour pumping test would not dewater the pumping well and cause the pump to break suction; 3) the saturated thickness of the water-table aquifer in the study area is approximately 60 feet; 4) the length of screen of the pumping well was 19 feet (extending from 41 feet to 60 feet into the water table; and 5) the height of the column of standing water in the pumping well that is above the screen is 41 feet.

Based upon the information discussed above, a pumping rate of approximately 350 gpm was chosen for the 48-hour pumping test (Figure 2).

4.0 HYDROGEOLOGY

The unconfined aquifer, underlying the Industri-Plex Study Area, is comprised of mainly unconsolidated stratified glacial drift deposited during and subsequent to glaciation of the area. The advance and retreat of ice sheets, along with their associated environments of deposition, have resulted in heterogeneity of strata (i.e., porous media) which influences horizontal and vertical ground-water flow through the aquifer. Consequently, the aquifer has been subdivided based on lithology into five hydrogeologic units interpreted to be representative of Pleistocene glacial cycles and their associated facies and Holocene fluvial sequences. Each unit has unique hydraulic characteristics resulting in a complex anisotropic flow system within the study area.

4.1 Geology

The Industri-Plex Site is located within a regional buried glacial valley which is incised into igneous bedrock. This feature, designated the Fresh Pond Buried Valley, is discussed in more detail in a report titled "Hydrogeologic Characterization For Extraction/Recharge System Interim Report for the Industri-Plex Site in Woburn, Massachusetts" dated November 30, 1990 (Roux Associates, Inc. 1990a) which was submitted in accordance with PDI Task GW-2. This remnant valley, which measures approximately 2 miles across and up to 170 feet deep in places, is now filled with unconsolidated coarse-clastic sediments. It trends south-southeast, and begins just to the north of the Industri-Plex Site. Five hydrogeologic units which include lacustrine, alluvial fan and fluvial deposits are recognized from subsurface data. Each unit has individual sedimentary characteristics such as grain size and sorting which influence hydraulic conductivity. The unconfined aquifer thins to less than 10 feet in the northern portion of the study area. It thickens to greater than 100 feet in the south-central portion, where coarse-clastic sands and gravels were deposited in an ancient distributary channel that is coincident with the present day Aberjona River (Roux Associates, Inc. 1990a).

Another remnant tributary has been recognized in the subsurface along the west side of the study area coincident with Hall's Brook. These ancient river systems appear to coalesce in the vicinity of the pumping test wells (i.e., Pumping Well PW-1), where thick beds of well-sorted, graded sand comprise the lower two-thirds of the aquifer.

4.2 Ground-Water Flow

Ground-water occurrence and movement within the Industri-Plex study area is influenced by near-surface bedrock distribution, and the variable nature of the stratified glacial drift and fluvial deposits which comprises the unconfined aquifer. The recognition of the five previously mentioned hydrogeologic units has led to a better understanding of the anisotropy of the flow system. Horizontal southward ground-water flow is restricted by the low-permeability of till deposits of clay, sand, and gravel which fringe the buried glacial valley. Flow is enhanced through the permeable well-sorted, clean fluvial sands deposited in the central portion of the study area. The areal extent of these channelized sands most likely confine the greatest amount of ground-water movement to within these depositional troughs.

Contaminant plumes are mapped within and coincident to these channelized areas (Roux Associates, Inc., 1990a and 1990b). Vertical lithologic variability of layered geologic strata associated with each depositional sequence introduce additional anisotropic complexity to the aquifer. In general, the lower two-thirds of the aquifer mainly contains permeable sands and gravels while the upper one-third contains less permeable silts and clays.

5.0 MONITORING PUMPING TEST DISCHARGE WATER

One concern in discharging large volumes of ground water to a stream during the step test and pumping test was that the ground water might contain contaminants at concentrations that could have an effect on stream biota. The four potential contaminants were benzene, toluene, trichloroethylene (TCE), and arsenic. Therefore, the pumping test discharge stream was monitored for each of these analytes on a real-time basis, so that the pumping test could be terminated if allowable concentrations of either of the above four contaminants were being exceeded.

Sampling and analysis of the discharge water from the step test and the pumping test was performed according to the Sampling and Analysis Plan (SAP) of October 23, 1990 (Appendix F). In the course of the pumping test, some alterations were made based upon field conditions. These alterations are described below.

5.1 Sampling Locations and Frequency

Forty-nine samples were collected at approximately hourly intervals for arsenic and volatile organic compound (VOC) analysis. Ground water was sampled from a port on the turbine pump prior to water entering the discharge line.

In addition, nine samples were collected from the end of the discharge pipe and two were collected from the Hall's Brook receiving channel. Table 1 lists the time and location of each sample.

5.2 Sample Designation

Each sample was given a unique identification number based upon a system developed for all Pre-Design tasks. The designation was as follows:

IP/GW2/PW1/000/2/1 to 60/01 (arsenic bottles) or 02 (VOC vials) where

- the first two characters (IP) stand for the Industri-Plex Site;
- the third through fifth characters stand for the Pre-Design task number (GW2);
- the sixth through eighth characters stand for the sample location within that task (i.e., Pumping Well PW-1);
- the ninth through eleventh characters stand for the depth of the bottom of the sampled interval, which was not applicable for the samples;

- the twelfth character stands for the matrix type (1=solid, 2=liquid, 3=gas);
- the thirteenth character stands for the sampling round number; and
- the fourteenth and fifteenth characters stand for the analyte.

Note that the sampling rounds were numbered consecutively over the 48-hour period, necessitating the use of a two-digit code instead of the proposed single digit.

The applicable analyte types are:

1 - arsenic; and

2 - benzene, toluene, and TCE.

5.3 Sampling Equipment and Procedures

All samples were obtained from a sampling port (valve) located on the turbine pump which was pumping the well. This valve directly sampled a representative stream of the well water. Before collecting samples, the valve was run for 15 seconds to flush any stagnant water from valve surfaces.

Samples for arsenic analysis were collected in plastic 250-milliliter (ml) screw-cap bottles containing nitric acid as a preservative. Samples for analysis of benzene, toluene, and TCE were collected in triplicate in 40-ml glass septum vials, allowing zero headspace gas. The VOC vials were preserved with 1:1 hydrochloric acid (HCl) to achieve a pH of 2.

5.4 Sample Handling and Analyses

Because the samples were analyzed immediately on-site, it was not necessary to fill out a Chain-of-Custody form. Samples were transported in a cooler to the on-site mobile laboratory and field trailer immediately following collection.

Analyses were performed by Goldberg-Zoino and Associates, Inc. (GZA). Volatile organic analyses were performed using a mobile laboratory mini-van located at the field office area of the Site. Arsenic analyses were performed in laboratory space set up in a field trailer at the same location. The distance from the pumping well to the analytical facilities is approximately three-quarters of a mile.

5.4.1 Arsenic Analysis

Water samples were analyzed for arsenic [oxidation states +5 and +3, which include arsenate ($AsO_4^{\equiv}$) and arsenite (AsO_2^{-}), respectively]. The method used was the silver diethyldithiocarbamate spectrophotometric method for arsine (also described in the analytical report [Appendix F]). Thirty-five milliliters(ml) of sample water were transferred to the reaction vessel. Reagents were added which convert dissolved arsenic (III and V) compounds to hydrogen arsenide (arsine), AsH_3. The arsine was detected by trapping in a solution of silver diethyldithiocarbamate to form a colored complex. The absorbance of the color was measured spectrophotometrically at 535 nanometers (nm), and arsenic concentration was determined from a standard curve. This method is capable of detecting 30 parts per billion (ppb) arsenic, which is less than the allowable in-stream concentration of 190 ppb (approval letter of October 10, 1990 from USEPA Region 1 to ISRT [Appendix F]). The method required approximately 1 hour to analyze each sample.

In addition to performing the analysis on ground water, the following samples were run to demonstrate the validity of the results:

- standard arsenic solutions in the range 16 ppb to 64 ppb; and
- arsenic-free distilled water.

The arsine gas generated was contained within a closed reaction tube and was not released to the laboratory atmosphere. In addition, the field laboratory was equipped with a fume hood to remove any traces of the gas present. The small quantities of spent chemicals were temporarily retained for subsequent testing and disposal.

5.4.2 Volatile Organics

Samples were analyzed for benzene, toluene, and TCE using the static headspace method (a modified Method 3810) for collecting purgeable organics, followed by gas chromatograph (GC) analysis. The analytical report (Appendix F) describes the instrumentation and methods. This system is capable of detecting the VOCs of interest at the required detection limits of 0.5 ppb for benzene, 200 ppb for toluene, and 0.5 ppb for TCE. The ability of the headspace method to perform at these detection limits was documented by GZA before the samples were analyzed. Results were reported back to the field location by messenger.

5.5 Analytical Results

Table 1 gives the results of real-time analyses during the pumping test. No samples exceeded the action levels (see below) for benzene, toluene, TCE, or arsenic.

Appendix G is the laboratory's analytical report, which includes quality assurance/quality control (QA/QC) data.

5.6 Action Levels for Pumping Test Analytes

The Action Levels for the three volatile organic analytes of interest in the pumping test discharge stream were derived by considering the dilution of the discharge in the receiving surface-water body (Hall's Brook). This method was discussed with and approved by the NUS representative for USEPA as a Field Change after the pumping test had begun (DeCillis, pers. comm. 1990b). This change was based upon a newly-available estimate of stream discharge and the fact that dilution by the receiving stream had been omitted from the previous Action Level calculation. The dilution factor applicable at the discharge point was calculated from the estimated stream flow through a culvert downstream from the pumping test outfall, as described in Appendix H. The dilution factor, 4.37, was multiplied by the previous Action Levels proposed in the Work Plan. The Action Levels derived from these calculations were: benzene, 22 ppb; toluene, 8740 ppb; and TCE, 22 ppb. (Dilution had previously been taken into account in arriving at the Action Level for total arsenic at 1,900 ppb.)

6.0 HYDRAULIC COEFFICIENT DETERMINATION

The three methods used to determine the hydraulic coefficients for the Industri-Plex study area were a pumping test, mechanical sieving, and slug tests. The pumping test was conducted in the study area to determine the hydraulic coefficients of transmissivity (T), horizontal hydraulic conductivity (K_r) and vertical hydraulic conductivity (K_z) and the ratio between them (i.e., the anisotropy) and storage coefficient. Mechanical sieving, which was undertaken as part of the PDI, was carried out on ten soil samples collected from boreholes at the Site to determine the hydraulic conductivity of the unconsolidated deposits. Slug tests were performed on 30 wells by Golder to determine the horizontal hydraulic conductivity of the zone of the aquifer screened by each well.

For the purpose of this report, emphasis is placed on the implementation of the pumping test and the analyses of pumping test data.

6.1 Pumping Test

A pumping test was conducted on the Digital Equipment Corporation property beginning on Wednesday, October 31, 1990 and ended on Friday, November 2, 1990, lasting approximately 48 hours (i.e., 2 days). Temporary Pumping Well (Pumping Well) PW-1 served as the pumping well. Temporary Wells TW-1S, TW-1D, TW-2S, TW-2D, TW-3S, TW-3D, TW-4S, TW-4D, and TW-5, and Observation Wells OW-19, OW-19A, OW-24A, OW-24B, OW-33A, and OW-33B served as the water-level monitoring wells. Water-level measurements were monitored in both the pumping well, and the temporary wells and the observation wells throughout the duration of the pumping test.

The optimal pumping rate for the pumping test, 350 gpm, was determined from a step test run on Friday, October 26, 1990, prior to the pumping test. Details of the step test were previously discussed in Sections 3.2.1.1 (Step Test). (The actual rate for the pumping test was 351 gpm.

For the analysis of the pumping test, the drawdown (decline in ground-water level) observed in the pumping well, and in the temporary wells and the observation wells was plotted against time. Where pumping test site conditions and drawdown were conducive to the analysis of the time versus drawdown data, pumping test analyses were performed. These criteria were met for only the temporary wells, and Observation Wells OW-19 and OW-19A. The data from the remaining observation wells (OW-24A, OW-24B, OW-33A, and OW-33B) could not be analyzed for a variety of reasons (which will be presented in detail below).

The pumping test analytical methodology included a combination of two or more of the following procedures: 1) the Stallman type curve techniques showing nondimensional response to pumping a well penetrating the bottom three-tenths of the thickness of an unconfined aquifer; 2) the Neuman analysis of pumping test data from anisotropic unconfined aquifers considering delayed gravity response and partially penetrating wells (facilitated by the use of AQTESOLV™ [Duffield and Rumbaugh 1989], an aquifer test solving software package); and 3) the Hantush partial penetration type curve analysis.

A description of each analytical technique is provided below.

6.1.1 Stallman Method

Stallman (1965), with the aid of a digital computer and the design of an electric analogue model, computed various values of the type curve parameters for different penetrations of both a pumping well and observation wells in a anisotropic unconfined water-table aquifer. (Anisotropy is the condition under which one or more of the hydraulic parameters of an aquifer vary according to the direction of flow [Fetter, Jr., 1980].)

Stallman's work was an extension of that of N. S. Boulton. Boulton derived an integral equation for the drawdown of the water table near a pumping well prior to the flow system's reaching steady-state conditions. This equation is founded partly on a consideration of the vertical flow components that exist near a well during the early portion of a pumping test in a water-table aquifer (Stallman 1961). Detailed explanations of Boulton's work are documented in a series of his papers (1954a, 1954b, 1963, and 1964). Additional information regarding pumping tests in unconfined aquifers with partially penetrating wells can be found in Prickett (1965), Neuman (1975), and Walton (1987). A simplified presentation of the Stallman type curve matching technique, as related by Lohman (1972), is described below.

When the Stallman type curve matching technique is used, water-level drawdown data collected from an observation well is plotted versus time on full logarithmic graph paper of the same scale as the type curves for analysis and determination of the hydraulic coefficients of transmissivity and storativity, and the anisotropy ratio (i.e., K_z to K_r). However, before the time versus drawdown data is plotted and analyzed, drawdown measured (observed) during the pumping test must be corrected to account for the partial dewatering of the aquifer. As the water level declines, gravity drainage of the pore spaces between the sediments of the aquifer decreases the saturated thickness of the water-table zone and, therefore, the coefficient of transmissivity also decreases as it is a function of the saturated thickness. The coefficient of transmissivity is defined by the relationship: transmissivity (T) equals the product of the horizontal hydraulic conductivity (K_r) multiplied by the aquifer saturated thickness (b), or $T = K_r b$. Methods (including the Stallman technique) available for analysis of aquifer pumping test data assume a constant saturated thickness; thus, for the water-table conditions at the Site, the observed values of drawdown were adjusted for the decrease in saturated thickness, and then the data were plotted and used to determine the hydraulic properties of the aquifer.

The dewatering correction, as described by Walton (1962), is given by the equation

$$s' = s - (s^2/2m)$$

where:

s'	=	drawdown that would occur in an equivalent nonleaky artesian aquifer [L]
s	=	observed drawdown under water-table conditions [L]
m	=	initial saturated thickness of aquifer [L]

The corrected data plotted on the appropriate logarithmic paper is then matched (overlayed) to the Stallman type curves (Lohman 1972) until the best fit between the plotted drawdown data and a type curve is found. As previously discussed, the type curves for a pumping well penetrating the bottom three-tenths of the thickness of the unconfined aquifer (Lohman 1972, Plate 7) were used.

The transmissivity and storage coefficient of the water-table aquifer at the pumping test site are then calculated by using the match point data values from the type curve (sT/Q and Tt/r_2S) and the time versus drawdown plot (t [time] and s [drawdown]) in the following equations from Lohman (1972):

$$T = (sT/Q)\,Q/s$$
$$S = Tt/(Tt/r^2\,S)r^2$$

where:

T	=	transmissivity of the aquifer $[L^2T^{-1}]$
(sT/Q)	=	dimensionless match point value from the Stallman type curves
Q	=	discharge rate of the pumping well $[L^3T^{-1}]$
s	=	drawdown match point value from the time versus drawdown plot [L]
S	=	storage coefficient of the aquifer, [dimensionless]
t	=	time match point from the time versus drawdown plot [T]
(Tt/r^2S)	=	dimensionless match point value from the Stallman type curves
r	=	radial distance from the observation well to the pumping well [L].

The anisotropy of the water-table aquifer ratio (i.e., the ratio between K_z and K_r) at the pumping test site is calculated based on the psi (ψ) value of the matched type curve. Using the value for psi, the anisotropy ratio (and the corresponding K_r and K_z) is then calculated using the following equations from Lohman (1972):

$$K_z/K_r = (\psi b/r)^2$$

where:

K_z	=	vertical hydraulic conductivity of the aquifer $[LT^{-1}]$
K_r	=	horizontal hydraulic conductivity of the aquifer $[LT^{-1}]$
ψ	=	the value of psi corresponding to the type curve [dimensionless]
b	=	saturated thickness of the aquifer [L]
r	=	distance between the pumping well and the observation well [L]

and

$$K_r = T/b$$

therefore,

$$K_z = (K_z/K_r)K_r$$

6.1.2 Neuman Delayed Gravity Response and Partial Penetration Method

Neuman developed an analytical model for the delayed response process characterizing flow to a pumping well in an unconfined aquifer. This technique is used to develop methods for determining the hydraulic properties of an anisotropic water-table aquifer from time versus drawdown data collected during a pumping test (Neuman 1975).

The method employed for the analysis of the pumping test data from the Industri-Plex study area employed the type curve matching technique whereby time versus drawdown data collected during the pumping test is matched to theoretical type curves. However, for this particular pumping test, partially penetrating wells (test and observation) were used, which necessitated the use of a special set of theoretical curves to be developed for each pumping well and observation well configuration.

To facilitate the Neuman analysis of the time versus drawdown data from partially penetrating wells, the aquifer test analysis software package (computer program) AQTESOLV™ (Duffield and Rumbaugh 1989) was employed. AQTESOLV™ is an interactive menu-driven program that provides the user complete control over the analysis of aquifer test data. AQTESOLV™ provides the analyst with the option to interactively match type curves to aquifer test data directly on the screen while providing instantaneous quantification of the transmissivity and the storage coefficients (i.e., the elastic storage coefficient [S] and the specific yield/water-table storage [S_y]) as well as the value of beta (β) corresponding to the type curve.

Prior to performing the type curve matching on the computer screen, AQTESOLV™ calculates the well-specific partial penetration type curves for $\beta = 0.001$ to $\beta = 7.0$ (see Neuman 1975, Figure 1 as examples of the type curves) using the equations accounting for partially penetrating wells (see Neuman 1975, Equations 26, 27, and 28). Additionally, the program automatically estimates aquifer parameters using the Marquardt nonlinear least-squares technique to provide the best match between observed and calculated water levels (using the Gauss-Newton procedure [Draper and Smith 1981] with the Marquardt modifications [Marquardt 1963]).

When the type curve option of AQTESOLV™ is used, water-level drawdown data collected from an observation well is plotted versus time on a logarithmic scale on the computer screen. However, prior to plotting the drawdown data, the dewatering correction (i.e., $s' = s - (s^2/m)$), as described by Walton (1962) and in Section 6.1.1 (Stallman Method), was used to correct the measured drawdown values.

Time versus drawdown data is first matched to the Type B curves (see Neuman 1975, Figure 1 as examples of Type B curves), and the value of β corresponding to this type curve is displayed along with the calculated values for the transmissivity and the water-table storage coefficient. For the same value of β, the time versus drawdown data is then matched to the Type A curves (see Neuman 1975, Figure 1 as examples of type A Curves), and the calculated values for the transmissivity and the water-table storage coefficient are displayed. The transmissivity initially obtained from the data fit to the Type B curve is "fine tuned" (refined) when matched to the Type A curve to be representative of the entire type curve.

The values for the transmissivity and the water-table storage coefficient (specific yield) are calculated using the following equations from Neuman (1975).

$$T = Qs_D^*/s^*$$

and

$$S_y = Tt^*/r^2t_y^*$$

where:

- T = transmissivity of the aquifer $[L^2T^{-1}]$
- Q = discharge rate of the pumping well $[L^3T^{-1}]$
- s_D^* = dimensionless drawdown match point value from the type B Neuman type curves, equal to $4\pi Ts/Q$
- S^* = drawdown match point value from the time versus drawdown plot corresponding to the type B Neuman type curves [L]
- S_y = specific yield/water-table storage coefficient [dimensionless]
- t^* = time match point value from the time versus drawdown plot corresponding to the type B Neuman type curves [T]
- r = radial distance from the observation well to the pumping well [L]

t_y^* = dimensionless time match point value from the type B Neuman type curves with respect to S_y, equal to $Tt/S_y r^2$.

The value for the storage coefficient (elastic) is calculated using the following equation from Neuman (1975):

$$S = Tt^*/r^2 t_s^*$$

where:

T = transmissivity of the aquifer $[L^2T^{-1}]$

t^* = time match point value from the time versus drawdown plot corresponding to the Type A Neuman type curves [T]

r = radial distance from the observation well to the pumping well [L]

t_s^* = dimensionless time match point value from the type B Neuman type curves with respect to S, equal to Tt/Sr^2.

The horizontal hydraulic conductivity is calculated from the relationship that the horizontal hydraulic conductivity (K_r) is equal to the transmissivity (T) divided by the saturated thickness of the aquifer (b), i.e., $K_r = T/b$.

Finally, the degree of anisotropy and the vertical hydraulic conductivity are calculated using the following equations from Neuman (1975):

$$K_D = \beta b^2/r^2$$

and

$$K_z = K_D K_r$$

where:

K_D = degree of anisotropy, equal to K_z/K_r [dimensionless]

β = the value of beta corresponding to the type curve [dimensionless]

b = saturated thickness of the aquifer [L]

r = radial distance from the observation well to the pumping well [L]

K_z = vertical hydraulic conductivity of the aquifer $[LT^{-1}]$

K_r = horizontal hydraulic conductivity of the aquifer $[LT^{-1}]$

6.1.3 Hantush Partial Penetration Method

Partially penetrating wells are those in which the water-entry section (well screen) is less than the thickness of the aquifer they penetrate. Ground-water flow towards partially penetrating wells is three-dimensional (unlike the flow toward completely penetrating wells which is two-dimensional and effectively occurs parallel to the bedding planes). As a result, the drawdown observed in partially penetrating wells depends on the length and location of the screens of the observation and pumping wells and the degree of anisotropy of the flow system.

Detailed discussions pertaining to the solution for the drawdown around a partially penetrating well are given by Hantush (1961, 1962, 1964). Supplementary information concerning the analysis of aquifer test data for determining in-situ horizontal hydraulic conductivity values and vertical hydraulic conductivity (aquifer anisotropy) is given by Weeks (1964, 1969) and Witherspoon (1967). A fundamental presentation of the Weeks' method, supplemental with information from Hantush describing the type curve matching technique is outlined by Javandel (1984) and is explained below.

When the type curve matching technique is used, site-specific (pumping test location) well configuration and hydrogeologic conditions are used to create a series of dimensionless time versus dimensionless drawdown partial penetration type curves on logarithmic graph paper for varying anisotropic conditions. Time versus drawdown pumping test data are plotted on logarithmic graph paper of the same scale as the type curves. However, prior to plotting the drawdown data, the dewatering correction (i.e., $s' = s - (s^2/m)$), as described by Walton (1962) and in Section 6.1.1 (Stallman Method), was used to correct the measured drawdown values.

The drawdown data is matched (overlayed) to the type curves and a match point is selected. Match point values are then used to calculate the horizontal hydraulic conductivity and the vertical hydraulic conductivity values, and the storage coefficient. The equations used to develop the dimensionless partial penetration type curves are given by Javandel (1984) as follows:

$$s = Q/4\pi K_r b \{W(u) + f\}$$

where:

$$f=2b/\pi(l-d)\sum_{n=1}^{\infty} 1/n\ (\sin(n\pi l/b) - \sin(n\pi d/b))\ \cos(n\pi z/b)$$

$$W[u_f\ \sqrt{(K_z/K_r)\ (n\pi r/b)^2}]$$

and

s_D = $4\pi K_r bs/Q$
t_D = tT/r^2s.

The definitions of the variables presented in the four equations listed above are given below, where:

- s = drawdown [L]
- Q = discharge rate of the pumping well [L^3T^{-1}]
- K_r = horizontal hydraulic conductivity of the aquifer [LT^{-1}]
- b = saturated thickness of the aquifer [L]
- W(u) = well function for nonleaky artesian aquifers [dimensionless]
- l = distance from the top of the aquifer to the bottom of the screen of the pumping well [L]
- d = distance from the top of the aquifer to the top of the screen of the pumping well [L]
- z = distance from the top of the aquifer to the piezometer screen [L]
- K_z = vertical hydraulic conductivity of the aquifer [LT^{-1}]
- s_D = dimensionless drawdown match point value from the partial penetration type curve
- s = drawdown match point value from the time versus drawdown plot [L]
- t_D = dimensionless time match point value from the partial penetration type curve
- t = time match point from the time versus drawdown plot [T]
- T = transmissivity of the aquifer [L^2T^{-1}]

r = radial distance from the observation well to the pumping well [L]

S = storage coefficient of the aquifer [dimensionless]

6.2 Pumping Test Results

The pumping test was conducted on Pumping Well PW-1 beginning on October 31, 1990 and ending on November 2, 1990 (i.e., total of approximately 2,880 minutes). The pumping rate was maintained at a constant rate of 351 gpm. Water levels were measured in all the temporary wells and in the two select observation clusters in the study area.

No precipitation occurred during the 48-hour pumping test. Because the pumping test was conducted in a water-table aquifer, there is no concern regarding barometric efficiency. Regardless, the barometer remained constant throughout the pumping test (Figure 3).

Pumping test analyses were conducted using the water-level measurements recorded by hand. The automated water-level recording device used, Instrumentation Northwest, Inc. data loggers, either failed during the test, or the hexadecimal formatted data stored in the data logger could not be converted to a useable form (i.e., while using the data logger software to convert the data into a form that can be imported into a data base spreadsheet, error messages occurred and "file may be corrupt" appeared). Thus, the data logger data for Temporary Wells TW-1S/TW-1D through TW-4S/TW-4D and Observation Wells OW-19 and OW-19A were questionable, and the "back-up" hand measurements were used.

6.2.1 Pumping Well PW-1

A semi-logarithmic plot of time versus drawdown for the pumping well (PW-1), which is provided on Figure 4, shows that the water level in the well declined rapidly and erratically during the first 6 minutes of the pumping test. This initial portion of the drawdown data precluded it from being analyzed for the transmissivity using the modified nonleaky artesian (Jacob) formula as described by Walton (1962) because of the fluctuating water levels. (A detailed description of the method is given by Cooper and Jacob [1946].) Moreover, a straight line fitted to the early drawdown data (i.e., the first few minutes) for a Jacob analysis would have a steep slope resulting in the calculation of an unrealistically low transmissivity.

Data beyond the 6-minute interval was lost as a result of data logger malfunction (as previously discussed), and the drawdown data was supplemented by manual measurements from the 370-minute interval through the end of the test. The latter data continued to show a drawdown trend, as water levels did not reach equilibrium.

A Jacob analysis was performed on the latter drawdown data as discussed in Walton (1962), as follows:

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

where:

- T = coefficient of transmissivity, in gpd/ft
- Q = discharge, in gpm
- Δs = drawdown difference per log cycle, in ft.

Substituting Δs of 1.6 feet (Figure 4) into the equation and a discharge rate of 351 gpm, a transmissivity of 57,915 gallons per day per foot (gpd/ft) is calculated.

This transmissivity value is too low, and is not believed to be representative of aquifer hydraulic conditions (when compared to the other analytical results discussed below).

6.2.2 Temporary Well TW-1S

The time versus drawdown data for Temporary Wells TW-1S, TW-2S, and TW-3S were analyzed using the Stallman Method (as described in Lohman 1972) and the Neuman Method (1975) for partially penetrating wells. The Hantush partial penetration analysis could not be applied to the time versus drawdown data for these wells because no unique fit between the early portion of the data curve and the type curves was found.

A logarithmic plot of time versus drawdown for Temporary Well TW-1S was constructed at the same scale as the Stallman type curves because the data are suitable for a Stallman analysis. For Temporary Well TW-1S, Stallman type curve matching indicated that the best fit of the field data to the type curve was when psi (ψ) equals 0.0730. This resulted in a match point value for sT/Q and Tt/r^2S of 1.0 each, and for drawdown (s) and time (t) of 13.6 feet and 25 minutes, respectively (Figure 5). When these data are substituted into the appropriate equations to calculate hydraulic coefficients, values for the transmissivity (T), the storage coefficient (S), and the degree of anisotropy are calculated to be 37,165 gpd/ft, 0.14, and 0.03, respectively. Substituting the 37,165 gpd/ft and the saturated thickness (b) of 60.13 feet into the equation to calculate the horizontal hydraulic conductivity (K_r) (i.e., $K_r = T/b$), a value of 618 gallons per day per square foot (gpd/ft^2) is calculated. With an anisotropy ratio of 1 to 33 (0.03) (i.e., vertical hydraulic conductivity [K_z] to horizontal hydraulic conductivity (K_r) ratio) for K_z to K_r, a K_z value of 19 gpd/ft^2 is calculated (Table 2).

An independent confirmation of the Stallman evaluation employed AQTESOLV™ to calculate the Neuman (1975) partial penetration type curves to perform the Neuman analysis. The time and drawdown data for Temporary Well TW-1S were entered into the AQTESOLV™ program, and the option to calculate the Neuman partial penetration type curves for the type curve matching procedure was invoked. Once the type curves were calculated, a logarithmic plot of the time versus drawdown data was plotted on a personal computer (PC) monitor.

For Temporary Well TW-1S, Neuman partial penetration type curve matching indicated that the best fit of the late portion of the field data to the Type B type curve occurred when beta (β) equals 0.004 (Figure 6). Using the identical β value (0.004), the Type A type curve was then fit to the early portion of the field data. The order of type curving the later data to the Type B curve first, followed by the early data to the Type A curve, is discussed by Neuman (1975).

Once the type curve has been chosen, AQTESOLV™ calculated and plotted the matched curve (Figure 6). At the same time, AQTESOLV™ calculated and displayed the hydraulic coefficients of T, the elastic storage coefficient (S), and the water-table storage coefficient/specific yield (Sy). For Temporary Well TW-1S, this resulted in a transmissivity of 2.772 square feet per min (ft^2/min) (29,858 gpd/ft^2), a S of 0.0018 (approximately 0.002), and a Sy of 0.18. When these data are substituted into the appropriate equations to solve for K_r, the degree of anisotropy, and for K_z, values of 497 gpd/ft^2, 0.022 (i.e., 45:1 ratio for $K_r : K_z$), and 11 gpd/ft^2 are calculated (Table 3).

The hydraulic coefficients corroborate those calculated using the Stallman Method.

6.2.3 Temporary Well TW-2S

The time versus drawdown data for Temporary Well TW-2S were analyzed using the Stallman Method (as described in Lohman 1972) and the Neuman Method (1975) for partially penetrating wells. The Hantush partial penetration analysis could not be applied to the time versus drawdown data because no unique fit between the early portion of the data curve and the type curves was found.

A logarithmic plot of time versus drawdown for Temporary Well TW-2S was constructed at the same scale as the Stallman type curves because the data are suitable for a Stallman analysis. For Temporary Well TW-2S, Stallman type curve matching indicated that the best fit of the field data to the type curve was when ψ equals 0.0730. This resulted in match point values for sT/Q and Tt/r^2S of 1.0 each, and for s and t of 14 feet and 29 minutes, respectively (Figure 7). When these data are substituted into the appropriate equations to calculate hydraulic coefficients, values for T, S, and the degree of anisotropy are calculated to be 36,103 gpd/ft, 0.17, and 0.03, respectively. Substituting the T of 36,103 gpd/ft and the b of 60.13 feet into the equation to calculate the K_r (i.e., K_r = T/b), a value of 600 gpd/ft^2 is calculated. With an anisotropy ratio of 1 to 33 (0.03) for the ratio of K_z to K_r, a K_z value of 18 gpd/ft^2 is calculated (Table 2).

An independent confirmation of the Stallman evaluation employed AQTESOLV™ to calculate the Neuman (1975) partial penetration type curves to perform the Neuman analysis. The time and drawdown data for Temporary Well TW-2S were entered into the AQTESOLV™ program, and the option to calculate the Neuman partial penetration type curves for the type curve matching procedure was invoked. Once the type curves were calculated, a logarithmic plot of the time versus drawdown data was plotted on a PC monitor.

For Temporary Well TW-2S, Neuman partial penetration type curve matching indicated that the best fit of the late portion of the field data to the Type B type curve occurred when β equals 0.004 (Figure 8). Using the identical β value (0.004), the Type A type curve was then fit to the early portion of the field data. The order of type curving the later data to the Type B curve first, followed by the early data to the Type A curve, is discussed by Neuman (1975).

Once the type curve had been chosen, AQTESOLV™ calculated and plotted the matched curve (Figure 8). At the same time, AQTESOLV™ calculated and displayed the hydraulic coefficients of T, S, and Sy. For Temporary Well TW-2S, this resulted in a transmissivity of 2.288 ft^2/min (24,645 gpd/ft^2), a S of 0.0020, and a Sy of 0.21. When these data are substituted into the appropriate equations to solve for K_r, the degree of anisotropy, and for K_z, values of 410 gpd/ft^2, 0.027 (i.e., 37:1 ratio for K_r : K_z) and 11 gpd/ft^2 are calculated (Table 3).

The hydraulic coefficients corroborate those calculated using the Stallman Method.

6.2.4 Temporary Well TW-3S

The time versus drawdown data for Temporary Well TW-3S was analyzed using the Stallman Method (as described in Lohman 1972) and the Neuman Method (1975) for partially penetrating wells. The Hantush partial penetration analysis could not be applied to the time versus drawdown data because no unique fit between the early portion of the data curve and the type curves was found.

A logarithmic plot of time versus drawdown for Temporary Well TW-3S was constructed at the same scale as the Stallman type curves because the data are suitable for a Stallman analysis. For Temporary Well TW-3S, Stallman type curve matching indicated that the best fit of the field data to the type curve was when ψ equals 0.0730. This resulted in match point values for sT/Q and Tt/r^2S of 1.0 each, and for s and t of 30 feet and 100 minutes, respectively (Figure 9). When these data are substituted into the appropriate equations to calculate hydraulic coefficients, values for T, S, and the degree of anisotropy are calculated to be 16,848 gpd/ft, 0.25, and 0.029, respectively. Substituting the T of 16,848 gpd/ft and the b of 60.13 feet into the equation to calculate the K_r (i.e., K_r = T/b), a value of 280 gpd/ft^2 is calculated. With an anisotropy ratio of 1 to 35 (0.029) for the ratio of K_z to K_r, a K_z value of 8 gpd/ft^2 is calculated (Table 2).

An independent confirmation of the Stallman evaluation employed AQTESOLV™ to calculate the Neuman (1975) partial penetration type curves to perform the Neuman analysis. The time and drawdown data for Temporary Well TW-3S were entered into the AQTESOLV™ program, and the option to calculate the Neuman partial penetration type curves for the type curve matching procedure was invoked. Once the type curves were calculated, a logarithmic plot of the time versus drawdown data was plotted on a PC monitor.

For Temporary Well TW-3S, Neuman partial penetration type curve matching indicated that the best fit of the late portion of the field data to the Type B type curve occurred when β equals 0.004 (Figure 10). Using the identical β value (0.004), the Type A type curve was then fit to the early portion of the field data. The order of type curving the later data to the Type B curve first, followed by the early data to the Type A curve, is discussed by Neuman (1975).

Once the type curve had been chosen, AQTESOLV™ calculated and plotted the matched curve (Figure 10). At the same time, AQTESOLV™ calculated and displayed the hydraulic coefficients of T, S, and Sy. For Temporary Well TW-3S, this resulted in a transmissivity of 1.543 ft^2/min (16,620 gpd/ft^2), a S of 0.001, and a Sy of 0.19. When these data are substituted into the appropriate equations to solve for K_r, the degree of anisotropy, and for K_z, values of 276 gpd/ft^2, 0.022 (i.e., 46:1 ratio for $K_r : K_z$) and 6 gpd/ft^2 are calculated (Table 3).

The hydraulic coefficients corroborate those calculated using the Stallman Method.

6.2.5 Temporary Well TW-4S

The time versus drawdown data for Temporary Well TW-4S was analyzed using the Stallman Method (as described in Lohman 1972) and the Neuman Method (1975) for partially penetrating wells. The Hantush partial penetration analysis could not be applied to the time versus drawdown data because no unique fit between the early portion of the data curve and the type curves was found.

A logarithmic plot of time versus drawdown for Temporary Well TW-4S was constructed at the same scale as the Stallman type curves because the data are suitable for a Stallman analysis. For Temporary Well TW-4S, Stallman type curve matching indicated that the best fit of the field data to the type curve was when ψ equals 0.0730. This resulted in match point values for sT/Q and Tt/r^2S of 1.0 each, and for s and t of 7.8 feet and 11 minutes, respectively (Figure 11). When these data are substituted into the appropriate equations to calculate hydraulic coefficients, values for T, S, and the degree of anisotropy are calculated to be 64,800 gpd/ft, 0.003, and 0.001 respectively. Substituting the T of 64,800 gpd/ft and the b of 60.13 feet into the equation to calculate the K_r (i.e., $K_r = T/b$), a value of 1,078 gpd/ft^2 is calculated. With an anisotropy ratio of 1 to 1000 (0.001) for the ratio of K_z to K_r, a K_z value of 1 gpd/ft^2 is calculated (Table 2).

An independent confirmation of the Stallman evaluation employed AQTESOLV™ to calculate the Neuman (1975) partial penetration type curves to perform the Neuman analysis. The time and drawdown data for Temporary Well TW-4S were entered into the AQTESOLV™ program, and the option to calculate the Neuman partial penetration type curves for the type curve matching procedure was invoked. Once the type curves were calculated, a logarithmic plot of the time versus drawdown data was plotted on a PC monitor.

For Temporary Well TW-4S, Neuman partial penetration type curve matching indicated that the best fit of the late portion of the field data to the Type B type curve occurred when β equals 0.01 (Figure 12). Using the identical β value (0.01), the Type A type curve was then fit to the early portion of the field data. The order of type curving the later data to the Type B curve first, followed by the early data to the Type A curve, is discussed by Neuman (1975).

Once the type curve had been chosen, AQTESOLV™ calculated and plotted the matched curve (Figure 12). At the same time, AQTESOLV™ calculated and displayed the hydraulic coefficients of T, S, and Sy. For Temporary Well TW-4S, this resulted in a transmissivity of 4.997 ft^2/min (53,824 gpd/ft^2), a S of 0.00032 (approximately 0.0003), and a Sy of 0.01.

When these data are substituted into the appropriate equations to solve for K_r, the degree of anisotropy, and for K_z, values of 895 gpd/ft^2, 0.002 (i.e., 448:1 ratio for $K_r : K_z$) and 2 gpd/ft^2 are calculated (Table 3).

The hydraulic coefficients are similar to those calculated using the Stallman Method.

6.2.6 Temporary Well TW-1D

The time versus drawdown data for Temporary Well TW-1D was analyzed using the Stallman Method, the Neuman Method for partially penetrating wells, and the Hantush Partial Penetration Method.

A logarithmic plot of time versus drawdown for Temporary Well TW-1D was constructed at the same scale as the Stallman type curves because the data are suitable for a Stallman analysis. For Temporary Well TW-1D, Stallman type curve matching indicated that the best fit of the field data to the type curve was when ψ equals 0.0730. This resulted in match point values for sT/Q and Tt/r^{2}S of 1.0 each, and for s and t of 3.7 feet and 3 minutes, respectively (Figure 13). When these data are substituted into the appropriate equations to calculate hydraulic coefficients, values for T, S, and the degree of anisotropy are calculated to be 136,605 gpd/ft, 0.060, and 0.028, respectively. Substituting the T of 136,605 gpd/ft and the b of 60.13 feet into the equation to calculate the K_r (i.e., K_r = T/b), a value of 2,272 gpd/ft^2 is calculated. With an anisotropy ratio of 1 to 36 (0.028) for the ratio of K_z to K_r, a K_z value of 64 gpd/ft^2 is calculated (Table 2).

An independent confirmation of the Stallman evaluation employed AQTESOLV™ to calculate the Neuman (1975) partial penetration type curves to perform the Neuman analysis. The time and drawdown data for Temporary Well TW-1D were entered into the AQTESOLV™ program, and the option to calculate the Neuman partial penetration type curves for the type curve matching procedure was invoked. Once the type curves were calculated, a logarithmic plot of the time versus drawdown data was plotted on a PC monitor.

For Temporary Well TW-1D, Neuman partial penetration type curve matching indicated that the best fit of the late portion of the field data to the Type B type curve occurred when β equals 0.01 (Figure 14). Using the identical β value (0.01), the Type A type curve was then fit to the early portion of the field data. The order of type curving the later data to the Type B curve first, followed by the early data to the Type A curve, is discussed by Neuman (1975).

Once the type curve had been chosen, AQTESOLV™ calculated and plotted the matched curve (Figure 14). At the same time, AQTESOLV™ calculated and displayed the hydraulic coefficients of T, S, and Sy. For Temporary Well TW-1D, this resulted in a transmissivity of 8.902 ft^2/min (95,885 gpd/ft^2), a S of 0.040, and a Sy of 0.22. When these data are substituted into the appropriate equations to solve for K_r, the degree of anisotropy, and for K_z, values of 1,595 gpd/ft^2, 0.053 (i.e., 19:1 ratio for $K_r : K_z$) and 85 gpd/ft^2 respectively, are calculated (Table 3).

AQTESOLV™ was also used for a Neuman partial penetration type curve analysis using the parameter estimation option. This option uses the Marquardt (1963) nonlinear least-squares technique to provide the best match between observed and calculated water levels. However, for this option to yield representative results, the time versus drawdown data must reveal an initial, well defined drawdown trend, followed by a distinct flattening of the data plot (due to gravity response), with a return to a final, well defined increase in drawdown (i.e., a drawdown trend). Because the time versus drawdown data do not fit this ideal form, the estimation option was perceived to yield less field representative results than the type curve option. Regardless, the parameter estimation option was attempted.

The results from the parameter estimation option for Temporary Well TW-1D are illustrated on Figure 15 and tabulated in Table 3. A T, S, S_y, and β of 11.71 ft^2/min (126,130 gpd/ft), 0.019 (approximately 0.02), 0.06 and 0.003, respectively, were estimated. The estimated T of 126,130 gpd/ft is higher than the type curved T of 95,885 gpd/ft. At the same time, the estimated S of 0.019 and S_y of 0.06 are lower than the type curve S of 0.04 (approximately 0.034) and S_y of 0.22, respectively. The estimated β of 0.003 is lower than the type curve β of 0.0100; consequently, the degree of anisotropy from the estimated parameters is less than the degree of anisotropy from the type curve parameters.

When these data are substituted into the appropriate equations to solve for K_r and K_z, values of 2,098 gpd/ft^2 and 38 gpd/ft^2, (i.e., 55:1 ratio for K_r:K_z) respectively, are calculated. Because the estimated T is higher than the type curve T, the calculated K_r of 2,098 gpd/ft^2 from the estimation option is higher than the calculated K_r of 1,595 gpd/ft^2 from the type curve option. Furthermore, because the estimated β is lower than the type curve β, the calculated K_z of 38 gpd/ft^2 from the estimation option is lower than the calculated K_z of 85 gpd/ft^2 from the type curve option.

For the reasons discussed above, the values for the hydraulic coefficients obtained from the estimation option are not believed to be as representative of the aquifer as hydraulic coefficients obtained from the type curve, and the values for the hydraulic coefficients obtained from the type curve option are a better characterization of the aquifer.

Finally, a Hantush partial penetration analysis (as described by Javandel [1984]) was used as a third independent check on both the Stallman Method and the Neuman Method.

A series of partial penetration type curves were generated on a logarithmic scale for the site-specific geologic conditions using data from Temporary Well TW-1D and the Pumping Well PW-1 (as described in the Hantush partial penetration type curve section above). The Hantush partial penetration type curve for this condition is illustrated on Figure 16. The time versus drawdown data for Temporary Well TW-1D were replotted to the scale of the partial penetration type curves (Figure 17). Type curve matching indicated that the best fit between the time versus drawdown data (see Figure 17) and the type curve (see Figure 16) occurred when the ratio between K_r and K_z was 40 to 1 (i.e., a degree of anisotropy of 0.025).

The match point data values for Temporary Well TW-1D (Figure 17) for dimensionless drawdown (s_D) and dimensionless time (t_D) were both 1.0 (obtained from the Hantush curve), and for s and t of 0.34 feet and 1.70 minutes, respectively, (obtained from the drawdown graph) were substituted into the appropriate equations to calculate the hydraulic coefficients. The calculated values for K_r and K_z are 1,967 gpd/ft^2 and 49 gpd/ft^2, respectively, and the calculated value for the storage coefficient is 0.03 (Figure 17 and Table 4). Because the K_r is defined as the T divided by the b, or K_r = T/b, it follows that

$T = K_r \times b$. Using a saturated thickness of 60.13 feet and a K_r of 1,967 gpd/ft^2, a T value of 118,276 gpd/ft was calculated. The horizontal to vertical anisotropy ratio is 40 to 1 (i.e., the ratio of K_r to K_z).

The hydraulic coefficients obtained from the Stallman Method, the Neuman Method (type curve option), and the Hantush Method are similar.

6.2.7 Temporary Well TW-2D

The time versus drawdown data for Temporary Well TW-2D were analyzed using the Stallman Method, the Neuman Method for partially penetrating wells, and the Hantush Partial Penetration Method.

A logarithmic-plot of time versus drawdown for Temporary Well TW-2D was made at the same scale as the Stallman type curves because the data are suitable for a Stallman analysis. For Temporary Well TW-2D, Stallman type curve matching indicated that the best fit of the field data to the type curve was when ψ equaled 0.0730. This resulted in a match point value for sT/Q and Tt/r^{2}S of 1.0 each, and for s and t of 3.6 feet and 3.3 minutes, respectively (Figure 18). When these data are substituted into the appropriate equations to calculate hydraulic coefficients, values for the T, S, and the degree of anisotropy are 140,400 gpd/ft, 0.07, and 0.031 substituting the T of 140,400 gpd/ft and the b of 60.13 feet into the equation to calculate the K_r (i.e., $K_r = T/b$), a value of 2,335 is calculated. With an anisotropy ratio of 1 to 32 (0.031) gpd/ft^2 for K_z to K_r, a K_z value of 72 gpd/ft^2 is calculated (Table 2).

An independent confirmation of the Stallman evaluation employed AQTESOLV™ to calculate the Neuman (1975) partial penetration type curves to perform the Neuman analysis. The time and drawdown data for Temporary Well TW-2D were entered into the AQTESOLV™ program, and the option to calculate the Neuman partial penetration type curve for the type curve matching procedure was invoked. Once the type curves were calculated, a logarithmic plot of the time versus drawdown data was plotted on the PC monitor.

For Temporary Well TW-2D, Neuman partial penetration type curve matching indicated that the best fit of the late portion of the field data to the Type B type curve was when β equals 0.01. Using the identical β value (0.01), the Type A type curve was then fit to the early portion of the field data. The order of type curving the late data to the Type B curve first, followed by the early data to the Type A curve second is discussed by Neuman (1975).

Once the type curve had been chosen, AQTESOLV™ calculated and plotted the matched curve (Figure 19). At the same time, AQTESOLV™ calculated and displayed the hydraulic coefficients of T, S, and S_y. For Temporary Well TW-2D, this resulted in a transmissivity of 9.772 ft/min (105,256 gpd/ft^2), a S of 0.034 and, a S_y of 0.19. When these data are substituted into the appropriate equations to solve for K_r and K_z, values of 1,750 gpd/ft^2 and 100 gpd/ft^2, respectively, are calculated (Table 3).

AQTESOLV™ was also used for a Neuman partial penetration type curve analysis using the parameter estimation option. This option uses the Marquardt (1963) nonlinear least-squares technique to provide the best match between observed and calculated water levels. For this option to yield characteristic results, the time versus drawdown data must reveal an initial, well defined drawdown trend, followed by a distinct flattening of the data plot (due to gravity response), with a return to a final, well defined increase in drawdown (i.e., a drawdown trend). Because the time versus drawdown data do not fit this ideal form, the estimation option and the type curve option did not yield identical values; however, the results between the two options did yield similar values. Thus, the parameter estimation option was also employed.

The results from the parameter estimation option for Temporary Well TW-2D are illustrated in Figure 20 and tabulated in Table 3. Estimated values for the parameters defining T, S, S_y, and β were 12.5 ft^2/min (134,640) gpd/ft), 0.022, 0.05, and 0.004. The estimated T of 134,640 gpd/ft is slightly higher than the type curved T of 105,256 gpd/ft. At the same time, the estimated S of 0.022 and the estimated S_y of 0.05 are slightly lower than the type curved S of 0.034 and the type curved S_y of 0.19, respectively. The estimated β of 0.004 is lower than the type curved β of 0.01; consequently, the degree of anisotropy from the estimated parameters is slightly greater than the degree of anisotropy from the type curved parameters.

When these data are substituted into the appropriate equations to solve for K_r and K_z, values of 2,239 gpd/ft^2 and 47 gpd/ft^2 (i.e., 48:1 ratio for K_r to K_z), respectively, are calculated. Because the estimated T is higher than the type curved T, the calculated K_r of 2,239 gpd/ft^2 from the estimation options is slightly higher than the calculated K_r of 1,750 gpd/ft^2 from the type curve option. Furthermore, because the estimated β is lower than the type curved β, the calculated K_z of 47 gpd/ft^2 from the estimation option is lower than the calculated K_z of 100 gpd/ft^2 from the type curve option. Although some variability exists between the two options, the values for the hydraulic coefficients obtained from the estimation option are believed to be representative values for the aquifer, and the values for the hydraulic coefficients obtained from the type curve option and from the estimation option will be used to characterize the aquifer.

Finally, a Hantush partial penetration analysis (as described by Javandel [1984]) was used as a third, independent check on both the Stallman method and the Neuman method.

A series of partial penetration type curves were generated on a logarithmic scale for the site-specific geologic conditions using data from Temporary Well TW-2D and Pumping Well PW-1 (as described in the Hantush partial penetration type curve section above). The Hantush partial penetration type curve for this condition is illustrated on Figure 21. The time versus drawdown data for Temporary Well TW-2D were replotted to the scale of the partial penetration type curves (Figure 22). Type curve matching indicated that the best fit between the time versus drawdown data (see Figure 22) and the type curve (see Figure 21 occurred when the ratio between K_r and K_z was 40 to 1 (i.e., of anisotropy of 0.025).

The match point data values for Temporary Well TW-2D (Figure 22) for s_D and for t_D were both 1.0 (obtained from the Hantush curve), and for s and t of 0.33 feet and 1.04 minutes, respectively, (obtained from the drawdown graph) were substituted into the appropriate equations to calculate the hydraulic coefficients. The calculated values for K_r and K_z are 2,027 gpd/ft^2 and 51 gpd/ft^2, respectively, and the calculated value for the storage coefficient is 0.02 (Figure 22 and Table 4). Because the K_r is defined as the T divided by b, or K_r = T/b, it follows that T = K_r x b. Using a saturated thickness of 60.13 feet and a K_r of 2,027 gpd/ft^2, a T value of 121,884 gpd/ft was calculated. The horizontal to vertical anisotropy ratio is 40 to 1 (i.e., the ratio of K_r to K_z).

The hydraulic coefficients obtained from the Stallman Method, the Neuman Method (type curve option), and the Hantush Method are similar.

6.2.8 Temporary Well TW-3D

The drawdown versus time data for Temporary Well TW-3D was analyzed using the Stallman Method, the Neuman Method for partially penetrating wells, and the Hantush Partial Penetration Method.

A logarithmic plot of time versus drawdown for Temporary Well TW-3D was made at the same scale as the Stallman type curves because the data are suitable for a Stallman analysis. For Temporary Well TW-3D, Stallman type curve matching indicated that the best fit of the field data to the type curve was when ψ equaled 0.0730. This resulted in match point values for sT/Q and Tt/r^2S of 1.0 each , and for s and t of 4.6 feet and 2.8 minutes, respectively (Figure 23). When these data are substituted into the appropriate equations to calculate hydraulic coefficients, values for the T, S, and the degree of anisotropy on 109,878 gpd/ft, 0.04 and 0.028. Substituting the T of 109,878 gpd/ft and the b of 60.13 feet into the equation to calculate the K_r (i.e., $K_r = T/b$), a value of 1,827 gpd/ft^2 is calculated. With an anisotropy ratio of 1 to 36 (0.028) for K_z to K_r, a K_z value of 51 gpd/ft^2 is calculated (Table 2).

An independent confirmation of the Stallman evaluation employed AQTESOLV™ to calculate the Neuman (1975) partial penetration type curves to perform the Neuman analysis. The time and drawdown data for Temporary Well TW-3D were entered into the AQTESOLV™ program, and the option to calculate the Neuman partial penetration type curves for the type curve matching procedure was invoked. Once the type curves were calculated, a logarithmic plot of the time versus drawdown data was plotted on the PC monitor. For Temporary Well TW-3D, Neuman partial penetration type curve matching indicated that the best fit for the late portion of the field data to the Type B type curve was when β equals 0.01. The Type A type curve was then fit to the early portion of the field data. The order of type curving the late data to the Type B curve first, followed by the early data to the Type A curve second is discussed by Neuman (1975).

Once the type curve had been chosen, AQTESOLV™ calculated and plotted the matched curve (Figure 24). At the same time, AQTESOLV™ calculated and displayed the hydraulic coefficients of T, S, and Sy. For Temporary Well TW-3D, this resulted in a transmissivity of 7.773 ft^2/min (83,725 gpd/ft^2), a S 0.017 (approximately 0.02) and, a Sy of 0.21. When these data are substituted into the appropriate equations to solve for K_r, the degree of anisotropy, and for K_z, values of 1,392 gpd/ft^2, 0.052 (i.e., 19:1 ratio for K_r : K_z), and 72 gpd/ft^2, respectively, are calculated (Table 3).

AQTESOLV™ was also used for a Neuman partial penetration type curve analysis using the parameter estimation option. This option uses the Marquardt (1963) nonlinear least-squares technique to provide the best match between observed and calculated water levels. However, for this option to yield characteristic results, the time versus drawdown data must reveal an initial, well defined drawdown trend, followed by a distinct flattening of the data plot (due to gravity response), with a return to a final, well defined increase in drawdown (i.e., a drawdown trend). Because the time versus drawdown data do not fit this ideal form as well as the other three temporary deep well (TW-1D, TW-2D, and TW-4D) (i.e., these data seemed to yield the least characteristic ideal curves), the estimation option was perceived to yield the most questionable field representative results between the two options. Regardless, the parameter estimation option was attempted. The results from the parameter estimation option for Temporary Well TW-3D are illustrated on Figure 25 and tabulated in Table 3. Estimated values for the parameters T, S, S_y, and defining were 15.18 ft^2/min (163,507 gpd/ft), 0.0034 (approximately 0.003), 0.0042 (approximately 0.004) and 0.0003, respectively. The estimated T of 163,507 gpd/ft is almost twice as high as the type curved T of 83,725 gpd/ft. At the same time, the estimated S of 0.003 and Sy of 0.004 are one and two orders of magnitude lower, respectively, than the estimated type curved S of 0.02 and Sy of 0.21, respectively. The estimated β of 0.0003 is two orders of magnitude lower than the type curved β of 0.01; consequently, the degree of anisotropy from the estimated parameters is an order of magnitude less than the degree of anisotropy from the type curved parameters.

When these data are substituted into the appropriate equations to solve for K_r and K_z, values of 2,719 gpd/ft^2 and 5 gpd/ft^2 (i.e., 544:1 ratio for K_r to K_z), respectively, are calculated. Because the estimated T is almost twice as high as the type curve T, the calculated K_r of 2,719 gpd/ft^2 from the estimation option is also almost twice as high as the calculated K_r of 1,392 gpd/ft^2 from the type curve option. Furthermore, because the estimated β is an order of magnitude lower than the type curved β, the calculated K_z of 5 gpd/ft^2 from the estimation option is also an order of magnitude lower than the calculated K_z of 72 gpd/ft^2 from the type curve option. For the reasons discussed above (combined with a comparison between the hydraulic coefficients obtained from the Stallman Method and the Hantush Method), the values for the hydraulic coefficients obtained from the estimation option are not believed to be representative of the aquifer, and the values for the hydraulic coefficients obtained from the type curve option will be used to characterize the aquifer.

Finally, a Hantush partial penetration analysis (as described by Javandel [1984]) was used as a third, independent check on both the Stallman Method and the Neuman Method.

A series of partial penetration type curves were generated on a logarithmic scale for the site-specific geologic conditions using data from Temporary Well TW-3D and Pumping Well PW-1 (as described in the Hantush partial penetration type curve section above). The Hantush partial penetration type curve for this condition is illustrated on Figure 26. The time versus drawdown data for Temporary Well TW-3D were replotted to the scale of the partial penetration type curves (Figure 27). Type curve matching indicated that the best fit between the time versus drawdown data (see Figure 27) and the type curves (see Figure 26) occurred when the ratio between K_r and K_z was 40 to 1 (i.e., of anisotropy of 0.025).

The match point data values for the Temporary Well TW-3D (Figure 27) for s_D and for t_D, were both 1.0 (obtained from the Hantush curve) and for s and t of 0.37 feet and 0.50 minutes, respectively, (obtained from the drawdown graph) were substituted into the appropriate equations to calculate the hydraulic coefficients. The calculated values for K_r and K_z are 1,808 gpd/ft^2 and 45 gpd/ft^2, respectively, and the calculated value for the storage coefficient is 0.01 (Figure 27 and Table 4). Because the K_r is defined as the T divided by the b, or K_r = T/b, it follows that T = K_r x b. Using a saturated thickness of 60.13 feet K_r of 1,808 gpd/ft^2, a T value of 108,715 gpd/ft was calculated. The horizontal to vertical anisotropy ratio is 40 to 1 (i.e., the ratio of K_r to K_z).

The hydraulic coefficients obtain from the Stallman Method, the Neuman Method (type curve option), and the Hantush Method are similar.

6.2.9 Temporary Well TW-4D

The time versus drawdown data for Temporary Well TW-4D were analyzed using the Stallman Method, Neuman Method for partially penetrating wells, and the Hantush Partial Penetration Method.

A logarithmic plot of time versus drawdown for Temporary Well TW-4D was made at the same scale as the Stallman type curves because the data are suitable for a Stallman analysis. For Temporary Well TW-4D, Stallman type curve matching indicated that the best fit of the field data to the type curve was when ψ equaled 0.154. This resulted in a match point values for sT/Q and Tt/r^2S of 1.0 each, and for s and t of 2.8 feet and 2.5 minutes, respectively (Figure 28). When these data are substituted into the appropriate equations to calculate hydraulic coefficients, values for the T, S, and the degree of anisotropy 180,514 gpd/ft, 0.002 and 0.004. Substituting the T of 180,514 gpd/ft and the b of 60.13 feet into the equation to calculate K_r (i.e., K_r = T/b), a value of 3,002 gpd/ft^2 is calculated. With an anisotropy ratio of 1 to 250 (0.004) for K_z to K_r, a K_z value of 12 gpd/ft^2 is calculated (Table 2).

An independent confirmation of the Stallman evaluation employed AQTESOLV™ to calculate the Neuman (1975) partial penetration type curves to perform the Neuman analysis. The time and drawdown data for Temporary Well TD-4D were entered into the AQTESOLV™ program, and the option to calculate the Neuman partial penetration type curves for the type curve matching procedure was invoked. Once the type curves were calculated, a logarithmic plot of the time versus drawdown data was plotted in the PC monitor. For Temporary Well TW-4D, Neuman partial penetration type curve matching indicated that the best fit for the late portion of the field data to the Type B type curve was when β equals 0.03. The Type A type curve was then fit to the early portion of the field data. The order of type curving the late data to the Type B curve first, followed by the early data to the Type A curve second is discussed by Neuman (1975).

Once the type curve had been chosen, AQTESOLV™ calculated and plotted the matched curve (Figure 29). At the same time, AQTESOLV™ calculated and displayed the hydraulic coefficients of T, S, and Sy. For Temporary Well TW-4D, this resulted in a transmissivity of 11.79 ft^2/min (126,992 gpd/ft^2), a S of 0.0042 (approximately 0.004) and, a Sy of 0.02. When these data are substituted into the appropriate equations to solve for K_r, the degree of anisotropy, and for K_z, values of 2,112 gpd/ft^2, 0.005 (i.e., 192:1 ratio for $K_r : K_z$), and 11 gpd/ft^2, respectively, are calculated (Table 3).

AQTESOLV™ was also used for a Neuman partial penetration type curve analysis using the parameter estimation option. This option uses the Marquardt (1963) nonlinear least-squares technique to provide the best match between observed and calculated water levels. For this option to yield characteristic results, the time versus drawdown data must reveal an initial, well defined drawdown trend, followed by a distinct flattening of the data plot (due to gravity response), with a return to a final, well defined increase in drawdown (i.e., a drawdown trend). Because the time versus drawdown data do not fit this ideal form, the estimation option and the type curve option did not yield identical values; however, the results between the two options did yield similar values. Thus, the parameter estimation option was also completed. The results from the parameter estimation option for Temporary Well TW-4D are illustrated on Figure 30 and tabulated in Table 3. Estimated value for the parameters defining T, S, Sy, and β were 17.33 ft^2/min (186,665 gpd/ft), 0.0024, 0.0013 and 0.0083, respectively. The estimated T of 186,665 gpd/ft is slightly higher than the type curved T of 126,992 gpd/ft. At the same time, the estimated S of 0.002 and Sy of 0.001 are slightly lower than the type curved S of 0.004 and Sy of 0.02, respectively. The estimated β of 0.0083 (approximately 0.008) is slightly lower than the type curved β of 0.03; consequently, the degree of anisotropy from the estimated parameters is slightly less than the degree of anisotropy from the type curved parameters.

When these data are substituted into the appropriate equations to solve for K_r and K_z, values of 3,104 gpd/ft^2 and 3 gpd/ft^2 (i.e., 1,035:1 ratio for K_r to K_z), respectively, are calculated. Because the estimated T is slightly higher than the type curve T, the calculated K_r of 3,104 gpd/ft^2 from the estimation option is slightly higher than the calculated K_r of 2,112 gpd/ft^2 from the type curve option. Furthermore, because the estimated β is slightly lower than the type curved β, the calculated K_z of 3 gpd/ft^2 from the estimation option is slightly lower than the calculated K_z of 11 gpd/ft^2 from the type curve option. Although some variability exists between the two options, the hydraulic coefficients obtained from the estimation option are believed to be representative values for the aquifer, and the values for the hydraulic coefficients obtained from the type curve option and from the estimation option will be used to characterize the aquifer.

Finally, a Hantush partial penetration analysis (as described by Javandel [1984]) was used as a third, independent check on both the Stallman Method and the Neuman Method.

A series of partial penetration type curves were generated on a logarithmic scale for the site-specific geologic conditions using data from Temporary Well TW-4D and Pumping Well PW-1 (as described in the Hantush partial penetration type curve section above). The Hantush partial penetration type curve for this condition is illustrated on Figure 31. The time versus drawdown data for Temporary Well TW-4D were replotted to the scale of the partial penetration type curves (Figure 32). Type curve matching indicated that the best fit between the time versus drawdown data (see Figure 32) and the type curves (see Figure 31) occurred when the ratio between K_r and K_z was 40 to 1 (i.e., an anisotropy of 0.025).

The match point data values for the Temporary Well TW-4D (Figure 32) for s_D and for t_D, were both 1.0 (obtained from the Hantush curve) and for s and t of 0.40 feet and 4.50 minutes, respectively, (obtained from the drawdown graph) were substituted into the appropriate equations to calculate the hydraulic coefficients. The calculated values for K_r and K_z are 1,672 gpd/ft^2 and 42 gpd/ft^2, respectively, and the calculated value for the storage coefficient is 0.002 (Figure 32 and Table 4). Because the K_r is defined as the T divided by b, or K_r = T/b, it follows that T = K_r x b. Using a saturated thickness of 60.13 feet and a K_r of 1,672 gpd/ft^2, a T value of 100,537 gpd/ft was calculated. The horizontal to vertical anisotropy ratio is 40 to 1 (i.e., the ratio of K_r to K_z).

The hydraulic coefficients obtained from the Stallman Method, the Neuman Method (type curve option), and the Hantush Method are similar.

6.2.10 Observation Well OW-19A

The time versus drawdown data for Observation Well OW-19A could not be analyzed using the Stallman Method because it is an existing observation well whose construction design is not applicable to the Stallman Method (i.e., the saturated thickness of the aquifer being tapped by the well screen does not adhere to any of those stipulated for the Stallman Method). Furthermore, the time versus drawdown data for Observation Well OW-9A could not be analyzed using the Hantush Partial Penetration Method because no unique fit of the data and the type curves could be found. Thus, the pumping test data collected for Observation Well OW-19A were analyzed using AQTESOLV™ to perform the Neuman analysis.

The time versus drawdown data for Observation Well OW-19A were entered into the AQTESOLV™ program, and the option to calculate the Neuman partial penetration type curves for the type curve matching procedure was invoked. Once the type curves were calculated, a logarithmic plot of the time versus drawdown data was plotted on the PC monitor. For Observation Well OW-19A, Neuman partial penetration type curve matching indicated that the best fit of the late portion of the field data to the Type B type curve was when β equals 0.0043 (approximately 0.004). Using the identical β (0.004), the Type A type curve was then fit to the early portion of the field data. The order of type curving the late data to the Type B curve first, followed by the early data to the Type A curve is discussed by Neuman (1975).

Once the type curve had been chosen, AQTESOLV™ calculated and plotted the matched curve (Figure 33). At the same time, AQTESOLV™ calculated and displayed the hydraulic coefficients of T, S, and Sy. For Observation Well OW-19A, this resulted in a transmissivity of 3.169 ft^2/min (34,134 gpd/ft), a S of 0.0001, and a S_y of 0.005. Substituting the T of 34,134 gpd and the b of 64.5 feet (b at Observation Well OW-19A) into the equation to calculate the K_r (i.e., $K_r = T/b$), a value of 529 gpd/ft^2 is calculated. When these values are substituted into the appropriate equations to solve for the degree of anisotropy and for K_z, values of 0.001 (i.e., 1,058:1 ratio for K_r to K_z) and approximately 0.5 gpd/ft^2, respectively, are calculated (Table 3).

AQTESOLV™ was also used for a Neuman partial penetration type curve analysis using the parameter estimation option. This option uses the Marquardt (1963) nonlinear least-squares technique to provide the best match between observed and calculated water levels. For this option to yield representative results, the time versus drawdown data must reveal an initial, well defined drawdown trend, followed by a distinct flattening of the data plot (due to gravity response), with a return to a final, well defined increase in drawdown (i.e., a drawdown trend). Because the time versus drawdown data do not fit this ideal form, the estimation option and the type curve option did not yield identical values; however, the results between the two options did yield similar values. Thus, the parameter estimation option was also employed.

The results from the parameter estimation option for Observation Well OW-19A are illustrated on Figure 34 and tabulated in Table 3. Estimated values for the parameters defining T, S, S_y, and β were 3.284 ft^2/min (35,373 gpd/ft), 0.00001, and 0.001, and 0.001. The estimated T of 35,374 gpd/ft is slightly higher than the type curved T of 34,134 gpd/ft. At the same time, the estimated S of 0.00001 is one order of magnitude lower than the type curved S of 0.0001, while the estimated S_y of 0.001 is slightly lower than the type curved S_y of 0.005. The estimated β of 0.001 is lower than the type curve β of 0.004; consequently, the degree of anisotropy from the estimated parameters is an order of magnitude lower than the degree of anisotropy from the type curve parameters.

When these data are substituted into the appropriate equations to solve for K_r and K_z, values of 548 gpd/ft^2 and approximately 0.1 gpd/ft^2 (i.e., 5,480:1 ratio for K_r to K_z), respectively, are calculated. Because the estimated T is slightly higher than the type curve T, the calculated K_r of 529 gpd/ft^2 from the estimation option is similarly equal to the calculated K_r of 548 gpd/ft^2 from the type curve option. Furthermore, because the estimated β is lower than the type curve β, the calculated K_z of approximately 0.1 gpd/ft^2 from the estimation option is slightly lower than the calculated K_z of 0.5 gpd/ft^2 from the type curve option.

For the reasons discussed above, the values for the hydraulic coefficients obtained from the estimation option are believed to be representative of the aquifer, and the values for the hydraulic coefficients obtained from the type curve option will be used to characterize the aquifer.

Moreover, because Observation Well OW-19A has a screen that taps approximately the upper 50 percent of the aquifer, the hydraulic coefficients for T and K_r are similar to Temporary Wells TW-1S, TW-2S, and TW-4S (all of which are screened 50 percent into the aquifer). In lieu of other analytic techniques to compare the analytical results for Observation Well OW-19A, the comparison to the three temporary wells correlates with the Neuman Method results characterizing flow conditions.

6.2.11 Observation Well OW-19

The time versus drawdown data for Observation Well OW-19 could not be analyzed using the Stallman Method because it is an existing observation well whose construction design is not applicable to the Stallman Method (i.e., the saturated thickness of the aquifer being tapped by the well screen does not adhere to any of those stipulated for the Stallman Method). However, the time versus drawdown data for Observation Well OW-19 is suitable for analyses using the Neuman Method for partially penetrating wells and the Hantush Partial Penetration Method.

The time and drawdown data for Observation Well OW-19 were entered into the AQTESOLV™ program, and the option to calculate the Neuman partial penetration type curves for the type curve matching procedure was invoked. Once the type curves were calculated, a logarithmic plot of the time versus drawdown data was plotted on a PC monitor.

For Observation Well OW-19, Neuman partial penetration type curve matching indicated that the best fit of the late portion of the field data to the Type B type curve occurred when β equals 0.03. Using the identical β value (0.03), the Type A type curve was then fit to the early portion of the field data. The order of type curving the later data to the Type B curve first, followed by the early data to the Type A curve second is discussed by Neuman (1975).

Once the type curve has been chosen, AQTESOLV™ calculated and plotted the matched curve (Figure 35). At the same time, AQTESOLV™ calculated and displayed the hydraulic coefficients of T, S, and Sy. For Observation Well OW-19, this resulted in a transmissivity of 8.597 ft^2/min (92,600 gpd/ft^2), a S of 0.002, and a Sy of 0.01. Substituting the T of 92,600 gpd/ft^2 and the b of 64.5 feet (the saturated thickness at Well OW-19) into the equation to calculate K_r (i.e., K_r=T/b), a value of 1,436 gpd/ft^2 is calculated. When these data are substituted into the appropriate equations to solve for the degree of anisotropy and for K_z, values of 0.004 (i.e., 239:1 ratio for K_r : K_z) and 6 gpd/ft^2 respectively are calculated (Table 3).

AQTESOLV™ was also used for a Neuman partial penetration type curve analysis using the parameter estimation option. This option uses the Marquardt (1963) nonlinear least-squares technique to provide the best match between observed and calculated water levels. For this option to yield representative results, the time versus drawdown data must reveal an initial, well defined drawdown trend, followed by a distinct flattening of the data plot (due to gravity response), with a return to a final, well defined increase in drawdown (i.e., a drawdown trend). Because the time versus drawdown data do not fit this ideal form, the estimation option and the type curve option did not yield identical values; however, the results between the two options did yield similar values. Thus, the parameter estimation option was also employed.

The results from the parameter estimation option for Observation Well OW-19 are illustrated in Figure 36 and tabulated in Table 3. Estimated values for the parameters defining T, S, S_y, and β were 10.33 ft^2/min (111,267 gpd/ft), 0.002, 0.01 and 0.02. The estimated T of 111,267 gpd/ft is slightly higher than the type curved T of 92,600 gpd/ft. At the same time, the estimated S of 0.002 and Sy of 0.01 are equal to the estimated type curved S (0.002) and S_y (0.01), respectively. The estimated β of 0.02 is slightly lower than the type curved β of 0.03; consequently, the degree of anisotropy from the estimated parameters is slightly less than the degree of anisotropy from the type curved parameters.

When these data are substituted into the appropriate equations to solve for K_r and K_z, values of 1,725 gpd/ft^2 and 3 gpd/ft^2 (i.e., 575:1 ratio for K_r to K_z, respectively, are calculated. Because the estimated T is slightly higher than the type curved T, the calculated

K_r of 1,725 gpd/ft^2 from the estimation options is slightly higher than the calculated K_r of 1,436 gpd/ft^2 from the type curve option. Furthermore, because the estimated β of 0.02 is slightly lower than the type curved β of 0.03, the calculated K_z of 3 gpd/ft^2 from the estimation option is slightly lower than the calculated K_z of 6 gpd/ft^2 from the type curve option.

For the reasons discussed above, the values for the hydraulic coefficients obtained from the estimation option are believed to be representative values for the aquifer, and the values for the hydraulic coefficients obtained from the type curve option and from the estimation option will be used to characterize the aquifer.

Finally, a Hantush partial penetration analysis (as described by Javandel [1984]) was used as an independent check on the Neuman method.

A series of partial penetration type curves were generated on a logarithmic scale for the site-specific geologic conditions using data from Observation Well OW-19 and Pumping Well PW-1 (as described in the Hantush partial penetration type curve section above). The Hantush partial penetration type curve for this condition is illustrated on Figure 37. The time versus drawdown data for Observation Well OW-19 were replotted (Figure 38) to the scale of the partial penetration type curves (Figure 38). Type curve matching indicated that the best fit between the time versus drawdown data (Figure 38) and the type curve (Figure 37) occurred when the ratio between K_r and K_z was 40 to 1 (i.e., an anisotropy of 0.025).

The match point data values for Observation Well OW-19 (Figure 38) for s_D and for t_D were both 1.0 (obtained from the Hantush curve), and for s and t of 0.59 feet and 6.3 minutes, respectively, (obtained from the drawdown graph) were substituted into the appropriate equations to calculate the hydraulic coefficients. The calculated values for K_r and K_z are 1,057 gpd/ft^2 and 26 gpd/ft^2, respectively, and the calculated value for the storage coefficient is 0.001 (Figure 38 and Table 4). Because the K_r is defined as the T divided by b, or K_r = T/b, it follows that T = K_r x b. Using a b of 64.5 feet and a K_r of 1,057 gpd/ft^2, a T value of 68,177 gpd/ft was calculated. The horizontal to vertical anisotropy ratio is 40 to 1 (i.e., the ratio of K_r to K_z).

The hydraulic coefficients obtained from the Neuman Method (type curve option) and the Hantush Method are similar.

6.2.12 Temporary Well TW-5

The graph of time versus drawdown for Temporary Well TW-5 is illustrated on Figure 39. Although the data were not analyzed to quantify hydraulic coefficients because of insufficient hydrogeologic data (e.g., the saturated thickness of the aquifer at Temporary Well TW-5, the aquifer geometry), the data were used to obtain qualitative information.

The time versus drawdown plot clearly indicates that there is an initial drawdown trend that lasts approximately 900 minutes into the pumping test, at which time the rate of drawdown in Temporary Well TW-5 decreases as surface water is induced through Hall's Brook stream bed to infiltrate into the cone of drawdown created by Pumping Well PW-1. The result of this induced infiltration is evidenced in the flattening of the time versus drawdown plot (Figure 39) and the fact that the drawdown only slightly deviates from this flat trend (whereas the data in the time versus drawdown graphs of Temporary Wells TW-1S, TW-1D, TW-2S, TW-2D, TW-3S, TW-3D, TW-4S, and TW-4D, and Observation Wells OW-19 and OW-19A show a more pronounced deviation). Thus, under the influence of pumping conditions within communication with Hall's Brook, the brook is a recharge (induced infiltration) boundary to the aquifer close to the brook. However, Hall's Brook is not a constant-head boundary to the aquifer as the brook penetrates only a few feet of the saturated thickness of the aquifer.

During the pumping test, the elevation of the water in Hall's Brook did not change by more than 0.05 foot (Table E17, in Appendix E, and Figure 40).

6.2.13 Observation Wells OW-24A, OW-24B, OW-33A, and OW-33B

Graphs of time versus drawdown for Observation Wells OW-24A, OW-24B, OW-33A, and OW-33B are illustrated of Figures 41, 42, 43, and 44, respectively. The data preclude the use of the Neuman Method for partially penetrating wells and the Hantush Partial Penetration Method for pumping test analyses because the plots do not define the characteristic shapes required for either method. In addition to the data precluding the use of the Stallman Method for pumping test analysis (i.e., the characteristic shape required for the method is lacking), the existing observation wells construction designs are not applicable because the saturated thicknesses of the aquifer being tapped by the well screens do not adhere to any of the configurations stipulated by the Stallman Method. Thus, the data collected from Observation Wells OW-24A, OW-24B, OW-33A, and OW-33B were not able to be analyzed to quantify hydraulic coefficients.

6.3 Summary of Pumping Test Results

A representative value for each of the hydraulic coefficients (i.e., the K_r, S_y, and degree of anisotropy) characterizing the flow conditions of the water-table aquifer is obtained from the analyses of the pumping test data which used one or more of the analytical techniques (i.e., the Stallman Method, the Neuman Method for partially penetrating wells, and the Hantush Partial Penetration Method). Variations exhibited in the hydraulic coefficients calculated for a well using the different analytical techniques is normal when analyzing field data because of the inherent assumptions of each analytical technique and because the field condition always varies from the ideal conditions upon which the analytical procedure is based (e.g., the aquifer has infinite areal extent; the aquifer is homogeneous and has uniform thickness; the aquifer potentiometric surface is initially horizontal).

6.3.1 Temporary Wells TW-1S and TW-2S

Temporary Wells TW-1S and TW-2S were both screened halfway into the saturated thickness of the aquifer (i.e., at z = 0.50b [Stallman 1965]), and are both approximately 25 feet from Pumping Well PW-1. Horizontal hydraulic conductivities for these two wells ranged from 600 gpd/ft^2 to 618 gpd/ft^2 for the Stallman Method, and ranged from 410 gpd/ft^2 to 497 gpd/ft^2 for the Neuman Method (AQTESOLV™ using the type curve option). From this close range of values, an average K_r of 531 gpd/ft^2 (approximately 530 gpd/ft^2) is calculated for the middle section of the aquifer.

Water-table storage coefficients for these two wells ranged from 0.14 to 0.17 for the Stallman Method, and ranged from 0.18 to 0.21 for the Neuman Method (AQTESOLV™ using the type curve option). From this close range of values, an average S_y of 0.175 (approximately 0.18) is calculated for the middle section of the aquifer.

The anisotropy ratio (i.e, the ratio of K_z to K_r) for these two wells were both 0.030 for the Stallman Method, and ranged from 0.022 to 0.027 for the Neuman Method (AQTESOLV™ using the type curve option). From this close range of values, an average anisotropy of 0.027, which is equivalent to values of K_r to K_z of 37 to 1, respectively, is calculated for the middle section of the aquifer.

The average hydraulic coefficients are tabulated in Table 5.

6.3.2 Temporary Well TW-3S

Temporary Well TW-3S is the only well screened one-quarter into the saturated thickness of the aquifer (i.e., at z = 0.75b [Stallman 1965]), and the well is also approximately 25 feet from Pumping Well PW-1 (similar to Temporary Wells TW-1S and TW-2S). Horizontal hydraulic conductivities for this well ranged from 280 gpd/ft^2 for the Stallman Method to 276 gpd/ft^2 for the Neuman Method (AQTESOLV™ using the type curve option). From these practical range of equal values, an average K_r of 278 gpd/ft^2 (approximately 280 gpd/ft^2) is calculated for the upper section of the aquifer. The fact that this K_r (280 gpd/ft^2), relative to the average K_r of 530 gpd/ft^2 for Temporary Wells TW-1S and TW-2S, is lower corroborates subsurface geologic information that shows that the aquifer is finer grained at the top and grades into coarser sediments with depth (see the Geologic Log for Temporary Well TW-1D, in Appendix A).

Water-table storage coefficients for this well ranged from 0.25 for the Stallman Method to 0.19 for the Neuman Method (AQTESOLV™ using the type curve option). From this close range of values, an average S_y of 0.22 is calculated for the upper section of the aquifer.

The anisotropy ratio (i.e, the ratio of K_z to K_r) for this well ranged from 0.029 for the Stallman Method to 0.022 for the Neuman Method (AQTESOLV™ using the type curve option). From this close range of values, an average anisotropy of 0.026, which is equivalent to values of K_r to K_z of 38 to 1, respectively, is calculated for the upper section of the aquifer.

The average hydraulic coefficients are tabulated in Table 5.

6.3.3 Temporary Well TW-4S

Temporary Well TW-4S was screened halfway into the saturated thickness of the aquifer (i.e., at z = 0.50b [Stallman 1965]), and is 146 feet from Pumping Well PW-1. Horizontal hydraulic conductivities for this well ranged from 1,078 gpd/ft^2 for the Stallman Method to 895 gpd/ft^2 for the Neuman Method (AQTESOLV™ using the type curve option). From this close range of values, an average K_r of 987 gpd/ft^2 (approximately 990 gpd/ft^2) is calculated for the middle section of the aquifer. A possible explanation for this higher K_r is that the well is screened within a zone in which there is a higher amount of coarser grained material, thus yielding a correspondingly higher T (from which the K_r value is calculated).

Water-table storage coefficients for this well ranged from 0.003 for the Stallman Method to 0.01 for the Neuman Method (AQTESOLV™ using the type curve option). From this order of magnitude difference in the range of values, an average S_y of 0.0065 (approximately 0.01) is calculated for the middle section of the aquifer. This relatively low value for S_y is the result of the following: 1) the greater distance from the impact of the pumping well (PW-1); and 2) the greater time that may be needed for the drawdown curve to return to the Type B (later portion) curve, from which the S_y is calculated.

The anisotropy ratio (i.e, the ratio of K_z to K_r) for this well ranged from 0.001 for the Stallman Method to 0.002 for the Neuman Method (AQTESOLV™ using the type curve option). From this close range of values, an average anisotropy of 0.0015 (approximately 0.002), which is equivalent to values of K_r to K_z of 500 to 1, is calculated for the middle section of the aquifer. The reasons for this uncharacteristically low degree of anisotropy are identical to those discussed above (i.e., the distance and the time needed to impact the aquifer fully).

The average hydraulic coefficients are tabulated in Table 5.

6.3.4 Temporary Wells TW-1D, TW-2D, and TW-3D

Temporary Wells TW-1D, TW-2D, and TW-3D are all screened at the bottom of the aquifer (i.e., at z = 0b [Stallman 1965]), and are all approximately 25 feet from Pumping Well PW-1. Horizontal hydraulic conductivities calculated for these three wells from the three analytical methods are as follows:

1. The Stallman Method values were 2,272 gpd/ft^2, 2,335 gpd/ft^2, and 1,827 gpd/ft^2, respectively;

2. The Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option, respectively) values were 1,595 gpd/ft^2 and 2,098 gpd/ft^2, 1,750 gpd/ft^2 and 2,239 gpd/ft^2, and 1,392 gpd/ft^2 and 2,719 gpd/ft^2, respectively; and

3. The Hantush Partial Penetration Method values were 1,967 gpd/ft^2, 2,027 gpd/ft^2, and 1,808 gpd/ft^2, respectively.

With the exception of the estimated K_r value of 2,719 gpd/ft^2, as discussed in Section 6.2.8 (from the Neuman Method using AQTESOLV™) for Temporary Well TW-3D, the K_r values range from a low of 1,392 gpd/ft^2 to a high of 2,335 gpd/ft^2. Using all of the K_r values, with the exception of the 2,719 gpd/ft^2, an average K_r of 1,937 gpd/ft^2 (approximately 1,900 gpd/ft^2) is calculated for the deeper section of the aquifer. If the estimated K_r value for Temporary Well TW-3D is included, then an average K_r of 2,002 gpd/ft^2 (approximately 2,000 gpd/ft^2) is calculated for the deeper section of the aquifer. Thus, the inclusion of a K_r value of 2,719 gpd/ft^2 only changes the average K_r value by 100 gpd/ft^2. The fact that this average K_r is higher than K_r values calculated for the shallow wells corroborates subsurface geologic information that shows that the aquifer is finer grained at the top and grades into coarser sediments with depths (see the Geologic Log for Temporary Well TW-1D, Appendix A).

Storage coefficients calculated for Temporary Wells TW-1D, TW-2D, and TW-3D from the three analytical methods follow accordingly:

1. The Stallman Method S values were 0.06, 0.07, and 0.04, respectively;

2. The Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option, respectively) S_y values were 0.22 and 0.06, 0.19 and 0.05, and 0.21 and 0.004, respectively; and

3. The Hantush Partial Penetration Method values for S were 0.03, 0.02, and 0.01, respectively. However, this method, which was adapted from a confined aquifer analysis, does not provide S_y values, but instead, calculates S.

With the exception of the estimated S_y value of 0.004 for Temporary Well TW-3D (from the Neuman Method using AQTESOLV™), as discussed in Section 6.2.8, water-table storage coefficients for these three wells, using a combination of S_y and S values, ranged from a low of 0.01 to a high of 0.22, and averaged 0.09 (approximately 0.1). If the S values from the Hantush Partial Penetration Method are eliminated, then the range becomes 0.04 to a high of 0.22, and the average value is 0.11.

Because greater time (on the order of days) would be needed to determine if the drawdown curve would return to the Type B (later portion) curve from which the S_y is calculated, the majority of the values for S_y are less than typical values for a water-table aquifer (e.g., the 0.18 average value obtained from Temporary Wells TW-1S and TW-2S, and the 0.22 value obtained from Temporary Well TW-3S). Regardless, the S_y data from Temporary Wells TW-1D, TW-2D, and TW-3D are useful as the data are comparable to the representative values of 0.21, 0.19, and 0.22 that are evidenced through other pumping test analyses based upon these and previous data discussions, and are believed to be characteristic of the lower portion of the water-table aquifer.

The anisotropy ratio (i.e, the ratio of K_z to K_r) calculated for Temporary Wells TW-1D, TW-2D, and TW-3D from the three analytical methods follow:

1. The Stallman Method values were 0.028, 0.031, and 0.028, respectively;

2. The Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option, respectively) values were 0.053 and 0.018, 0.057 and 0.021, and 0.052 and 0.002, respectively; and

3. The Hantush Partial Penetration Method values were all 0.025.

With the exception of the anisotropy ratio of 0.002 for Temporary Well TW-3D for the Neuman Method (AQTESOLV™ using the parameter estimation option), as discussed in Section 6.2.8, the remaining values ranged from a low of approximately 0.02 (i.e., a K_r to K_z ratio of 50 to 1) to a high of approximately 0.06 (i.e., a K_r to K_z ratio of approximately 20 to 1). From this relatively close range of values, an average anisotropy of 0.033 (approximately 0.03), which is equivalent to values of K_r to K_z of 33 to 1, respectively, is calculated for the lower section of the water-table aquifer.

The average hydraulic coefficients are tabulated in Table 5.

6.3.5 Temporary Well TW-4D

Temporary Well TW-4D is screened at the bottom of the aquifer (i.e., at z = Ob [Stallman 1965]), and the well is approximately 152 from Pumping Well PW-1. Horizontal hydraulic conductivities for this well ranged from 3,002 gpd/ft^2 for the Stallman Method to 2,112 gpd/ft^2 and 3,104 gpd/ft^2 for the Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option, respectively), to 1,672 gpd/ft^2 for the Hantush partial penetration method.

The K_r values range from a low of 1,672 gpd/ft^2 to a high of 3,104 gpd/ft^2. Using all of the K_r values, an average K_r of 2,473 gpd/ft^2 (approximately 2,500 gpd/ft^2) is calculated for the deeper section of the aquifer. If the K_r value of 1,672 gpd/ft^2 is eliminated, an average K_r of 2,739 gpd/ft^2 (approximately 2,700 gpd/ft^2) is calculated for the deeper section of the aquifer. Thus, regardless of the inclusion of the value that varies the most (i.e., 1,672 gpd/ft^2), the average K_r values differ by only 200 gpd/ft^2.

Storage coefficients calculated for this well from the three analytical methods follow:

1. The Stallman Method S value was 0.002;

2. The Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option, respectively) S_y values were 0.02 and 0.001; and

3. The Hantush Partial Penetration Method value for S was 0.002. However, this method, which was adapted from a confined aquifer analysis, does not provide S_y values but instead calculates S.

With the exception of the estimated S_y value of 0.001 (from the Neuman Method using AQTESOLV™), as discussed in Section 6.2.9, storage coefficients for this well, using a combination of S_y and S values, ranged from a low of 0.002 to a high of 0.02, and averaged 0.008 (approximately 0.01). If the S value from the Hantush Partial Penetration Method is also eliminated, then the range remains the same (i.e., a low of 0.001 to a high of 0.02) and the average value is 0.011 (approximately 0.01).

The values for S_y are less than typical values for a water-table aquifer (e.g., the 0.18 average value obtained from Temporary Wells TW-1S and TW-2S, and the 0.22 value obtained from Temporary Well TW-3S) because greater time (on the order of days) may be needed for the drawdown curve to return to the Type B (later portion) curve, from which the S_y is calculated. A value of 0.02 is representative of the lower end of a S_y value. However, as discussed previously, data from other temporary wells are indicative of more typical S_y values.

The anisotropy ratio (i.e., the ratio of K_z to K_r) calculated for Temporary Well TW-4D from the three analytical methods follow:

1. The Stallman Method value was 0.004;

2. The Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option, respectively) values were 0.005 and 0.001; and

3. The Hantush Partial Penetration Method value was 0.025.

With the exception of the anisotropy ratio of 0.025 from the Hantush Partial Penetration Method, the remaining values are too low and are not considered representative of aquifer conditions at Temporary Well TW-4D for the lower section of the water-table aquifer. The reasons for these uncharacteristically low degrees of anisotropy are the same as those previously discussed (i.e., the distance and the time needed to impact the aquifer fully). Thus, the value of 0.025 is used as the "average" value.

The average hydraulic coefficients are tabulated in Table 5.

6.3.6 Observation Well OW-19A

Observation Well OW-19A is the only well screened throughout the approximate upper half of the saturated thickness of the water-table aquifer.

Horizontal hydraulic conductivities calculated for this well from the Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option) are, for all practical purposes, equal (i.e., 529 gpd/ft^2 and 548 gpd/ft^2, respectively). From this practical range of values, an average K_r of 539 gpd/ft^2 (approximately 540 gpd/ft^2) is calculated for the "upper half" of the water-table aquifer. The fact that this K_r (gpd/ft^2) is similar to the average K_r of 530 gpd/ft^2 for Temporary Wells TW-1S and TW-2S corroborates subsurface geologic information that shows that the aquifer is finer grained at the top and grades into coarser sediments with depth (see the Geologic Log for Temporary Well TW-1D, Appendix A).

Water-table storage coefficients for this well ranged from 0.005 to 0.001 for the Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option, respectively). From this close range of values, an average S_y of 0.003 is calculated for the upper section of the aquifer; however, this value is too low to be considered representative of aquifer conditions.

This low value for S_y is the result of the following: 1) the higher T as a result of the increase in b; 2) the greater distance from the impact of the pumping well (PW-1); and 3) the greater time that may be needed for the drawdown curve to return to the Type B curve, from which the S_y is calculated.

The anisotropy ratio (i.e., the ratio of K_z to K_r) for Observation Well OW-19A ranged from 0.001 to 0.0002 for the Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option, respectively). These anisotropy ratios are equivalent to values of K_r to K_z of 1,058 to 1 and K_r to K_z of 5,480 to 1, respectively. These values are too low to be considered representative of aquifer conditions. The reasons for this uncharacteristically low degree of anisotropy are identical to those discussed above (i.e., the distance and the time that may be needed to impact the aquifer fully).

The average hydraulic coefficients are tabulated in Table 5.

6.3.7 Observation Well OW-19

Observation Well OW-19 is the only well screened throughout the approximate lower half of the saturated thickness of the water-table aquifer.

Horizontal hydraulic conductivities calculated for this well from the Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option) are 1,436 gpd/ft^2 and 1,725 gpd/ft^2, respectively. The K_r for this well calculated from the Hantush Partial Penetration Method is 1,057 gpd/ft^2.

From this range of values, an average K_r of 1,406 gpd/ft^2 (approximately 1,400 gpd/ft^2) is calculated for the "lower half" of the water-table aquifer. The fact that this K_r is similar to the average K_r of 1,900 gpd/ft^2 for Temporary Wells TW-1D, TW-2D, and TW-3D corroborates subsurface geologic information that shows that the aquifer is finer grained at the top and grades into coarser sediments with depth (see the Geologic Log for Temporary Well TW-1D, Appendix A.

Water-table storage coefficients for this well were equal (0.01) for the Neuman Method (AQTESOLV™ using the type curve option and the parameter estimation option). This relatively low value for S_y is the result of the following: 1) the higher T as a result of the increase in b; 2) the greater distance from the impact of the pumping well (PW-1); and 3) the greater time that may be needed for the drawdown curve to return to the Type B curve, from which the S_y is calculated.

The Hantush Partial Penetration Method value for S was 0.001. However, this method, which was adapted from a confined aquifer analysis, does not provide a value for S_y, but instead, it calculates S. If the S value of 0.001 is omitted, then the average S_y equals 0.01. If the S value is included, then the average "S_y" is 0.007 (approximately 0.01). The S value for this well from the Hantush Partial Penetration Method, which by itself is deemed to be nonrepresentative, has a minimal effect on the average S_y. Thus, the average S_y is 0.01.

The anisotropy ratio (i.e., the ratio of K_z to K_r) for Observation Well OW-19 ranged from 0.004 to 0.002 for the Neuman Method (AQTESOLV™ using the type curve and the parameter estimation option, respectively). These anisotropy ratios are equivalent to values of K_r to K_z of 250 to 1, and of K_r to K_z of 500 to 1, respectively. These values are too low to be considered representative of aquifer conditions. The reasons for this uncharacteristically low degree of anisotropy are identical to those discussed above (i.e., the distance and the time that may be needed to impact the aquifer fully).

The average hydraulic coefficients are tabulated in Table 5.

6.4 Comparison of Study-Area Specific Data to Available Information

Pumping test results were compared to the two available sources of information characterizing the hydraulic coefficients of the flow system in Woburn, Massachusetts. The sources of information include the following:

1. The grain size analyses performed on ten soil samples from the Site; and

2. The pumping tests conducted at Superfund-Site Wells G and H, Woburn, Massachusetts.

6.4.1 Grain-Size Analyses

Ten soil samples were submitted to Golder for sieve analyses for effective grain-size determination. Hydraulic conductivities were determined by Roux Associates using a graphical method developed by Rose and Smith (1957) and modified by Sheahan (1965).

The minimum K that can be determined using this method is 100 gpd/ft^2. None of the sieved samples were coarse enough to indicate a K of at least 100 gpd/ft^2 (Roux Associates, Inc. 1990a).

Because the soil samples are sieved, the K value determined from the effective grain-size analysis would be a "combination" of the geologic conditions affecting the K_r and the K_z (i.e., not representative of either). Thus, the K results obtained from the effective grain-size analyses would be expected to be less than the K_r and greater than the K_z. Representative K_r values from the pumping test are greater than 100 gpd/ft^2, which corroborates the results of the K from the grain-size analysis. Although the grain-size analysis does not provide for quantifying a K that is less than 100 gpd/ft^2, representative K_z values from the pumping test are less than 100 gpd/ft^2, and apparently corroborate the results of the K from the grain-size analysis also.

6.4.2 Superfund-Site Wells G and H, Woburn, Massachusetts

Pumping tests were conducted in Superfund-Site Wells G and H, which are located south of the pumping test study area. Values for the hydraulic coefficients of K_r and S obtained from the Wells G and H pumping test ranged from 935 gpd/ft^2 to 2,618 gpd/ft^2 and from 0.16 to 0.20, respectively (Myette, et. al. 1987).

The K_r values are similar to, or within the range of the K_r values obtained from the pumping test on Pumping Well PW-1. Although some of the values for S_y from the pumping test on Pumping Well PW-1 were lower than those from Wells G and H, several values were within the same range. The S_y values from the pumping test on Pumping Well PW-1 show that they are within the range of those that are considered to be the most representative of the water-table aquifer (i.e., 0.05 to 0.25, Tables 2, 3, and 5). Thus, the hydraulic coefficients obtained from the Pumping Well PW-1 pumping test quantitatively characterize the flow conditions for the water-table aquifer.

6.4.3 Interpretation of Pumping Test Results

Based on an evaluation of the results obtained from the analyses of the pumping test data, the following interpretation of the hydrogeologic system can be made:

1. The aquifer exists under unconfined conditions;

2. The K_r of the water-table aquifer varies with depth, and is relatively constant within similar screened zones with depth within the area of the pumping test (i.e., Temporary Wells TW-1S, TW-1D, TW-2S, TW-2D, TW-3S, TW-3D, TW-4S, and TW-4D, and Observation Wells OW-19 and OW-19A);

3. The K_r of the water-table aquifer increases with depth;

4. The anisotropy of the water-table aquifer is relatively constant within the area of the pumping test;

5. The S_y of the water-table aquifer is relatively constant within the area of the pumping test; and

6. Under the influence of a pumping well within hydraulic connection with Hall's Brook, the brook is a recharge (induced infiltration) boundary to the aquifer.

6.4.4 Data Quality Objectives

The hydraulic coefficients, as summarized in Table 5, are considered to be representative of the flow-system parameters for the water-table aquifer. Thus, the hydrogeologic data fulfill the data quality objectives, that is, sufficient quantitative data characterizing flow-system parameters have been collected to design a ground-water extraction system.

7.0 RESULTS OF RECHARGE TEST

As stipulated in the Remedial Design Action Plan (RDAP), "The treated effluent shall be discharged via a subsurface leaching pit to be located on-site in an upgradient portion of the aquifer." Therefore, in accordance with the PDI August 14, 1990 Recharge Test Work Plan (Task GW-2/Subtask 3), and the supplemental data (DeCillis, pers. comm. 1990c) which was submitted to the USEPA by Golder on October 11, 1990, the recharge test was conducted at the Industri-Plex Site, Woburn, Massachusetts to evaluate the feasibility of recharging treated ground-water effluent into a subsurface leaching pit on-site.

The purpose of conducting the recharge test was to: 1) develop data to determine the percolation rate of the unsaturated (vadose) zone beneath the proposed recharge area; and 2) evaluate the local subsurface hydrogeological conditions. These data will be used to determine the rate at which treated effluent can be recharged to the ground-water system, and whether or not a recharge basin can be designed to contain and to recharge the capacity of treated effluent discharged on-site as part of the Remedial Design.

7.1 Methods of Investigation

Five areas at the Site were selected as potential locations for recharge basins based upon geologic mapping and the drilling of soil borings (Task GW-2/Subtask 2). Four to five soil borings were drilled at each location until auger refusal. Refusal was reached when crystalline bedrock, dense till, or boulder was encountered. The geologic logs for the soil borings are provided in Appendix I and the locations are shown in Plate 2.

The five potential recharge basin locations were evaluated based upon the following: 1) hydrogeologic conditions; 2) absence of residual hide material; 3) accessibility; and 4) proximity to a potable water supply. As stated in the Recharge Test Work Plan (Roux Associates, Inc. August 14, 1990c), Area 4 was selected as the most suitable area to construct the recharge basin.

7.1.1 Construction of the Recharge Basin

Cornerstone Construction of Saugus, Massachusetts was subcontracted to construct the recharge basin according to the Recharge Test Work Plan, Task GW-2/Subtask 3, Industri-Plex Site, Woburn, Massachusetts (Roux Associates, Inc. 1990c), and supplements to the

Recharge Test Work Plan (DeCillis, pers. comm. 1990b) as submitted to the USEPA by Golder. The recharge basin was constructed on October 24, 1990 in the area designated as Area 4 (Roux Associates, Inc. 1990c). The original location for the recharge basin construction was to be as close as possible to, but no closer than 10 feet from, Observation Well OW-22 because this well is located near swampland and a partially buried concrete obstruction (possibly a building foundation) which could affect the test by restricting the rate of inflow to the water table. The basin was excavated to the water table, approximately 3.0 feet below land surface. The bottom of the basin was horizontal and covered an area of 105 square feet (i.e., an area approximately 7 feet wide and 15 feet long). As shown on the test pit log (Appendix I), the soils consist of poorly sorted fine to medium sand, some silt, cobbles, and fill material.

A piezometer (P-3) consisting of 2.5-foot long, 2-inch diameter, 0.010-inch opening (10-slot) PVC screen and 5 feet of blank PVC was installed through the bottom of the basin to measure the levels of ground water beneath the basin during the recharge test. After the piezometer was installed, the basin was backfilled with crushed stone around the PVC casing. Two additional piezometers (P-2 and P-5) were installed at the bottom of the basin to measure the mounding of recharge water. A 4-inch diameter, 0.040-inch (40 slot) screen was installed approximately in the center of the basin to provide recharge water to the basin (Figure 45). The depths of the recharge basin and piezometers are provided below.

Piezometer	Depth (feet below land surface)	Screen Zone (feet below land surface)
Recharge Basin	3.0	Not Applicable
P-1	6.0	1.0 to 6.0
P-2	3.0	0.0 to 3.0
P-3	6.0	3.5 to 6.0
P-4	6.0	1.0 to 6.0
P-5	3.0	0.0 to 3.0

Following the excavation and installation of the piezometers and the 4-inch diameter infiltration well, the basin was backfilled with clean, uniform 2-inch diameter crushed stone. The crushed stone was placed in the basin to prevent the basin from collapsing during the test. Because the permeability of the crushed stone is orders of magnitude greater than the natural formation into which it was excavated, the percolation rate through the native soils will not be affected (Freeze and Cherry 1979).

7.1.2 Installation of Background Piezometers

To measure the effect of ground-water mounding during the test, two additional piezometers were installed approximately 2 feet (P-1) and 10 feet (P-4) south of the basin (Figure 45). A hollow-stem auger drilling rig was used to install a 5-foot long, 2-inch diameter PVC screen and blank casing at each location. The screen intervals were set to intersect (straddle) the water table. The remaining annular space was backfilled to 0.5 foot below land surface and a bentonite seal was installed on top of the gravel pack to prevent infiltration of surface runoff into the annulus. The piezometers were developed with a Teflon™ bailer upon completion of the well to ensure a good hydraulic connection between each piezometer and the aquifer. The geologic well logs and well construction diagrams for the piezometers are provided in Appendix I.

7.1.3 Installation of Data Loggers

After the recharge basin and background piezometers were completed, pressure transducers were installed in each piezometer and connected to data loggers (Telog Instruments, Inc., Rochester, New York), with the exception of the infiltration well and Piezometer P-5, which were used to collect manual water-level measurements in the basin. Transducer probes were set at the bottom of each piezometer. The water level in the basin and the ground-water level were monitored for approximately 3 days at 15-minute intervals. These data were stored on the data loggers and were monitored in the field to determine the status of water levels in the piezometers (i.e., an increasing trend or a "leveling off" trend). The water-level recording data are provided in Appendix J.

The pressure transducer and/or the data logger in Piezometer P-1 began to function erratically after 48 hours into the test, and resulted in unrealistic water-level fluctuations over time. Recorded changes in water levels ranged from 0 feet to 10 feet relative to the bottom of the well. Because the thickness of the unconsolidated material above the transducer was no greater than 6 feet, a water level of 10 feet is not realistic, therefore, the data were judged to be erroneous. Thus, these water-level data were not used in the evaluation of the recharge test.

7.1.4 Potable Water Supply

The source of potable water for the recharge test was a fire hydrant located on Atlantic Avenue, approximately 600 feet south of the recharge basin. A backflow prevention device was installed to prevent backsiphoning of water from the recharge basin into the hydrant. Approximately 600 feet of 2-inch diameter, black vinyl hose was used to transport the water from the hydrant to the basin. In addition, flow valves and a digital flow meter were attached to the discharge line so that the flow rate could be regulated and monitored, respectively.

7.2 Implementation of Recharge Test

The purpose of the recharge test was to determine the rate of percolation of water through the vadose zone beneath the test (recharge) basin, and to evaluate the hydrogeologic conditions in the area of the basin. Because there was no vadose zone beneath the basin (i.e., the bottom of the basin was approximately coincident with the water table), it was not possible to evaluate the rate of percolation through the vadose zone. However, this eliminated the time needed to saturate the vadose zone and to evaluate the infiltration rate through the saturated zone, which would represent the actual recharge rate that would occur under field conditions of long-term recharge.

The recharge test ran from November 6, 1990 through November 9, 1990, lasting 69 hours. The test was conducted until water levels within the basin and in the piezometers outside of the basin had ceased to vary, or varied minimally, with time (Figures 46 through 49).

The evaluation of the recharge test is based on the hydrogeologic principle that the inflow (Q_{in}) is equal to the outflow (Q_{out}) plus or minus the change in storage (ΔS) (i.e., $Q_{in} = Q_{out} \pm \Delta S$) (Fetter, Jr. 1980). However, because by the end of the recharge test, water levels in Piezometer P-2 and P-4 (Figures 47 and 49, respectively) were not changing with time, and because water levels in Piezometer P-3 were only rising at a rate of 0.03 foot per hour (Figure 48), water levels were basically constant with time and storage was not changing.

Thus, the storage coefficient is not included in the solution as it is only significant when evaluating the change in water-level elevations with time (Fetter, Jr. 1980), and the solution is reduced to $Q_{in} = Q_{out}$. The $Q_{in} = Q_{out} \pm \Delta S$ option for analysis of recharge test data was provided by Virginia DeLima (1990).

7.2.1 Rate of Inflow to the Basin

The rate of inflow was monitored and adjusted so that the water levels in the basin did not overflow the basin. The initial inflow rate was approximately 5 gpm; however, as shown in Piezometer P-2 (Figure 47), the water level in the basin rose rapidly and after 3 hours the water level in the basin was almost to land surface and continuing to rise. Therefore, the flow rate was decreased to approximately 1.0 gpm for 15 hours and 50 minutes. The water levels within the basin decreased. Consequently, ground-water mounding decreased in response to the decreased inflow, and also as a result of the presence of unsaturated soils in the side walls releasing trapped air as the moisture content increased (Prill and Aronson 1978).

The water levels decreased approximately 1 foot below grade in the basin when inflow was decreased to 1.0 gpm (Figure 47). In response to this change, the inflow was increased to approximately 2.0 gpm in order to determine the maximum inflow that the basin could accommodate without flooding, while water levels in the aquifer are no longer changing with time. Over the next 48-hour period, the water levels in the basin and in the ground water adjacent to the basin approached the point where they were no longer changing with time at the inflow rate of 2.0 gpm (Figures 46 through 49).

As previously stated, the only piezometer with water levels still increasing with time was Piezometer P-3. However, as also stated, water levels in Piezometer P-3 were only rising at a rate of 0.03 foot per hour. The piezometer responded in a similar manner to the other piezometers in the early portion of the test. However, after 48 hours the water level below the basin declined approximately 1.0 foot for 3 hours, indicating that more water could be introduced into the aquifer. After 3 hours of water-level decline, the level increased steadily until near the end of the test, when levels were again beginning to decline. These changes in water levels in Piezometer P-3 are apparently attributed to a malfunction in the data logger because water levels beneath the basin (in the water table) should respond directly to the increase or decrease in the rate of inflow into the basin, and not decrease when the inflow rate remains constant.

7.2.2 Hydrologic Effect of the Recharge Basin

Depth to ground water in the area of the test recharge basin is very shallow, approximately 2.5 feet below land surface. The base of the recharge basin was in contact with the aquifer (approximately 3.0 feet below land surface), hence providing direct recharge to the aquifer from the infiltration well.

The recharge to the aquifer at 2.0 gpm produced a ground-water mound of 2.0 feet above the original static water level (Figure 47) in the basin. The water level in Piezometer P-1 rose 1.0 foot, and in Piezometer P-4 the water level increased approximately 0.5 foot (Figures 46 and 49). As shown in the graphs, increasing the inflow rate or recharge rate increases the water level (head) in the basin.

7.3 Data Quality Objectives

The recharge (infiltration) rates tested during the recharge test are considered to be representative of the recharge rate for treated effluent into the flow system in an upgradient area of the Site.

Moreover, the information obtained during the excavation of the test recharge basin, the drilling and installation of the monitoring wells, and the implementation of the pumping test provided a means to evaluate subsurface hydrogeologic conditions (as previously discussed). Thus, the hydrogeologic and recharge data fulfill the data quality objectives, that is, to obtain sufficient data to design an effluent recharge system.

Respectfully Submitted,

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TABLES

Table 1. Times, Locations, and Results of Pumping Test Discharge Sampling, October 31, 1990 through November 2, 1990 Pumping Test, Industri-Plex Study Area, Woburn, Massachusetts.

Sample Number	Date	Time	Location*	TCE (ppb)	Benzene (ppb)	Toluene (ppb)	Arsenic (ppb)
GW-31-01	10/31/90	7:44 AM	GW	2.74	ND	ND	11
GW-31-02	10/31/90	8:44 AM	GW	3.67	ND	ND	ND
GW-31-03	10/31/90	9:44 AM	GW	6.52	ND	0.58	ND
GW-31-04	10/31/90	10:44 AM	GW	8.69	ND	0.85	ND
GW-31-05	10/31/90	10:48 AM	OF	9.69	ND	0.72	**
GW-31-06	10/31/90	11:38 AM	GW	8.21	ND	0.60	ND
GW-31-07	10/31/90	12:44 PM	GW	13.0	ND	ND	ND
GW-31-08	10/31/90	2:03 PM	GW	11.1	ND	ND	ND
GW-31-09	10/31/90	2:48 PM	OF	4.99	ND	ND	**
GW-31-10	10/31/90	2:46 PM	GW	5.88	ND	ND	10
GW-31-11	10/31/90	3:45 PM	GW	7.76	ND	ND	14
GW-31-12	10/31/90	3:59 PM	OF	3.40	ND	ND	**
GW-31-13	10/31/90	4:02 PM	SW	6.30	ND	ND	**
GW-31-14	10/31/90	4:50 PM	GW	6.93	ND	1.63	13
GW-31-15	10/31/90	5:49 PM	GW	17.7	ND	ND	16
GW-31-16	10/31/90	6:05 PM	OF	7.27	ND	ND	**
GW-31-17	10/31/90	6:45 PM	SW	ND	ND	ND	**
GW-31-18	10/31/90	6:52 PM	GW	ND	ND	ND	11
GW-31-19	10/31/90	7:44 PM	GW	3.98	ND	ND	ND
GW-31-20	10/31/90	8:44 PM	GW	ND	ND	ND	ND
GW-31-21	10/31/90	8:55 PM	OF	0.90	ND	ND	**
GW-31-22	10/31/90	9:50 PM	GW	ND	ND	ND	ND
GW-31-23	10/31/90	10:54 PM	GW	---- LOST	DATA ----		11
GW-31-24	10/31/90	11:55 PM	GW	3.61	ND	ND	10
GW-01-25	11/1/90	12:46 AM	GW	7.34	ND	ND	ND
GW-01-26	11/1/90	12:46 AM	OF	ND	ND	1.05	**
GW-01-27	11/1/90	1:49 AM	GW	ND	ND	1.26	ND
GW-01-28	11/1/90	2:45 AM	GW	0.87	ND	ND	ND
GW-01-29	11/1/90	3:54 AM	GW	18.7	ND	ND	ND
GW-01-30	11/1/90	3:54 AM	OF	4.91	ND	ND	**

* - GW, ground water at pump; OF, outfall to Hall's Brook; SW, surface water from Hall's Brook near outfall.
** - Sample not analyzed for arsenic.
ND - Not detected

Table 1. Times, Locations, and Results of Pumping Test Discharge Sampling, October 31, 1990 through November 2, 1990 Pumping Test, Industri-Plex Study Area, Woburn, Massachusetts.

Sample Number	Date	Time	Location*	TCE (ppb)	Benzene (ppb)	Toluene (ppb)	Arsenic (ppb)
GW-01-31	11/1/90	4:55 AM	GW	0.29	ND	3.03	ND
GW-01-32	11/1/90	5:50 AM	GW	0.19	ND	2.93	ND
GW-01-33	11/1/90	6:50 AM	GW	1.09	ND	1.21	ND
GW-01-34	11/1/90	6:50 AM	OF	9.57	ND	ND	**
GW-01-35	11/1/90	7:50 AM	GW	15.2	ND	ND	ND
GW-01-36	11/1/90	8:50 AM	GW	8.99	ND	0.59	ND
GW-01-37	11/1/90	9:50 AM	GW	8.16	ND	ND	ND
GW-01-38	11/1/90	10:00 AM	OF	4.99	ND	ND	**
GW-01-39	11/1/90	10:47 AM	GW	15.8	ND	ND	ND
GW-01-40	11/1/90	11:44 AM	GW	10.9	ND	ND	ND
GW-01-41	11/1/90	12:55 PM	GW	2.43	ND	ND	ND
GW-01-42	11/1/90	1:55 PM	GW	1.87	ND	ND	ND
GW-01-43	11/1/90	2:45 PM	GW	1.00	ND	ND	ND
GW-01-44	11/1/90	3:50 PM	GW	4.40	ND	ND	ND
GW-01-45	11/1/90	4:55 PM	GW	0.91	ND	ND	ND
GW-01-46	11/1/90	6:00 PM	GW	3.31	ND	ND	ND
GW-01-47	11/1/90	7:00 PM	GW	0.92	ND	ND	ND
GW-01-48	11/1/90	8:00 PM	GW	1.60	ND	ND	ND
GW-01-49	11/1/90	9:00 PM	GW	4.02	ND	ND	ND
GW-01-50	11/1/90	10:00 PM	GW	5.97	ND	ND	ND
GW-01-51	11/1/90	11:00 PM	GW	5.69	ND	ND	ND
GW-02-52	11/2/90	12:00 AM	GW	2.25	ND	ND	ND
GW-02-53	11/2/90	1:00 AM	GW	3.18	ND	ND	ND
GW-02-54	11/2/90	2:00 AM	GW	3.32	ND	ND	ND
GW-02-55	11/2/90	3:00 AM	GW	2.06	ND	ND	ND
GW-02-56	11/2/90	4:00 AM	GW	5.03	ND	ND	ND
GW-02-57	11/2/90	5:00 AM	GW	4.79	ND	ND	ND
GW-02-58	11/2/90	6:00 AM	GW	3.34	ND	ND	ND
GW-02-59	11/2/90	7:00 AM	GW	2.86	ND	ND	ND
GW-02-60	11/2/90	8:00 AM	GW	7.19	ND	ND	ND

* - GW, ground water at pump; OF, outfall to Hall's Brook; SW, surface water from Hall's Brook near outfall.
** - Sample not analyzed for arsenic.
ND - Not detected

Table 2. Summary of Hydraulic Coefficients from the Stallman Method for the October 31, 1990 through November 2, 1990 Pumping Test at the Industri-Plex Study Area, Woburn, Massachusetts.

STALLMAN METHOD							
WELL NUMBER	T gpd/ft	S	ψ	K_z / K_r	K_r gpd/ft^2	K_z gpd/ft^2	$K_r : K_z$
TW-1S	37,165	0.14	0.0730	0.030	618	19	33 : 1
TW-2S	36,103	0.17	0.0730	0.030	600	18	33 : 1
TW-3S	16,848	0.25	0.0730	0.029	280	8	35 : 1
TW-4S	64,800	0.003	0.0730	0.001	1,078	1	1,000 : 1
TW-1D	136,605	0.060	0.0730	0.028	2,272	64	36 : 1
TW-2D	140,400	0.070	0.0730	0.031	2,335	72	32 : 1
TW-3D	109,878	0.040	0.0730	0.028	1,827	51	36 : 1
TW-4D	180,514	0.002	0.154	0.004	3,002	12	250 : 1
OW-19	(a)	(a)	(a)	(a)	(a)	(a)	(a)
OW-19A	(a)	(a)	(a)	(a)	(a)	(a)	(a)

T = Transmissivity

S = Water-table storage coefficient

ψ = Psi value for the type curve

K_z = Vertical hydraulic conductivity

K_r = Horizontal hydraulic conductivity

(a) Existing well construction design is not applicable to the Stallman Method.

Table 3. Summary of Hydraulic Coefficients from the Neuman Method for Partial Penetration for the October 31, 1990 through November 2, 1990 Pumping Test at the Industri-Plex Study Area, Woburn, Massachusetts.

NEUMAN METHOD FOR PARTIAL PENETRATION								
WELL NUMBER	T gpd/ft	S	S_y	β	K_D K_z / K_r	K_r gpd/ft^2	K_z gpd/ft^2	$K_r : K_z$
TW-1S	29,858	0.002	0.18	0.004	0.022	497	11	45 : 1
TW-2S	24,645	0.002	0.21	0.004	0.027	410	11	37 : 1
TW-3S	16,620	0.001	0.19	0.004	0.022	276	6	46 : 1
TW-4S	53,824	0.0003	0.01	0.01	0.002	895	2	448 : 1
TW-1D	95,885	0.04	0.22	0.01	0.053	1,595	85	19 : 1
TW-1D[(a)]	126,130	0.02	0.06	0.003	0.018	2,098	38	55 : 1
TW-2D	105,256	0.034	0.19	0.01	0.057	1,750	100	18 : 1
TW-2D[(a)]	134,640	0.022	0.05	0.004	0.021	2,239	47	48 : 1
TW-3D	83,725	0.02	0.21	0.01	0.052	1,392	72	19 : 1
TW-3D[(a)]	163,507	0.003	0.004	0.0003	0.002	2,719	5	544 : 1
TW-4D	126,992	0.004	0.02	0.03	0.005	2,112	11	192 : 1
TW-4D[(a)]	186,665	0.002	0.001	0.008	0.001	3,104	3	1,035 : 1
OW-19A	34,134	0.0001	0.005	0.004	0.001	529	0.5	1,058 : 1
OW-19A[(a)]	35,374	0.00001	0.001	0.001	0.0002	548	0.1	5,480 : 1
OW-19	92,600	0.002	0.01	0.03	0.004	1,436	6	239 : 1
OW-19[(a)]	111,267	0.002	0.01	0.02	0.002	1,725	3	575 : 1

T = Transmissivity

S = Elastic storage coefficient

S_y = Water-table storage coefficient/specific yield

β = Beta value for the type curve

K_D = Degree of anisotropy

K_z = Vertical hydraulic conductivity

K_r = Horizontal hydraulic conductivity

(a) Values obtained from AQTESOLV™ using parameter estimation option.

Table 4. Summary of Hydraulic Coefficients from the Hantush Method for Partial Penetration for the October 31, 1990 through November 2, 1990 Pumping Test at the Industri-Plex Study Area, Woburn, Massachusetts.

HANTUSH METHOD FOR PARTIAL PENETRATION					
WELL NUMBER	K_r gpd/ft^2	S	K_z gpd/ft^2	$K_r : K_z$	T gpd/ft
TW-1S	(a)	(a)	(a)	(a)	(a)
TW-2S	(a)	(a)	(a)	(a)	(a)
TW-3S	(a)	(a)	(a)	(a)	(a)
TW-4S	(a)	(a)	(a)	(a)	(a)
TW-1D	1,967	0.03	49	40 : 1	118,276
TW-2D	2,027	0.02	51	40 : 1	121,884
TW-3D	1,808	0.01	45	40 : 1	108,715
TW-4D	1,672	0.002	42	40 : 1	100,537
OW-19	1,057	0.001	26	40 : 1	68,177

T = Transmissivity

S = Elastic storage coefficient

K_z = Vertical hydraulic conductivity

K_r = Horizontal hydraulic conductivity

(a) No unique fit of time versus drawdown data for this particular temporary well configuration.

Table 5. Summary of Average Hydraulic Coefficients from October 31, 1990 through November 2, 1990 Pumping Test, Industri-Plex Study Area, Woburn, Massachusetts.

Well	Horizontal Hydraulic Conductivity in gpd/ft^2	S_y	Degree of Anisotropy (K_z / K_r)
TW-1S/TW-2S	530	0.18	0.027
TW-3S	280	0.22	0.026
TW-4S	990	0.01	0.002
TW-1D/TW-2D/TW-3D	1,900	0.1	0.03
TW-4D	2,600	0.01	0.025[a]
OW-19A	540	NA	NA
OW-19	1,400	0.01[a]	NA

gpd/ft^2 = Gallons per day per square foot

S_y = Water-table storage coefficient/specific yield

K_v = Vertical hydraulic conductivity

K_r = Horizontal hydraulic conductivity

NA = Not applicable, value too low and nonrepresentative

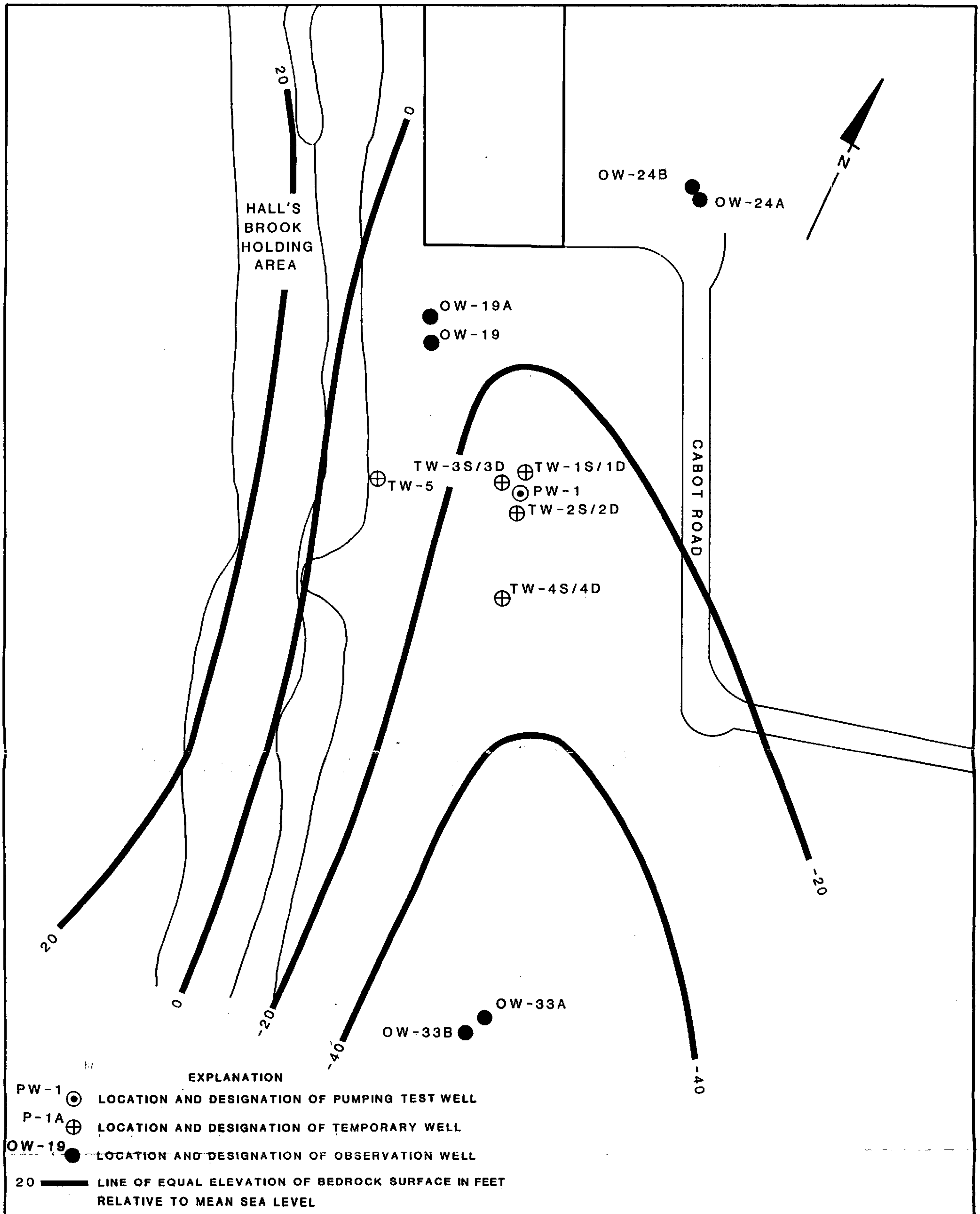
(a) = Does not include all values because they are too low and nonrepresentative

Table 6. Comparison of Horizontal Hydraulic Conductivity Values from Slug Tests Performed by Golder Associates Inc. November 5, 1990 through November 9, 1990, and Horizontal Hydraulic Conductivity Values from Constant-Rate (Pumping) Test Performed by Roux Associates, Inc., October 31, 1990 through November 2, 1990, Industri-Plex Study Area, Woburn, Massachusetts.

	Slug Tests				Pumping Tests		
	Bouwer and Rice Analysis		Hvorslev Analysis		Stallman Method	Neumann Method	Hantash Method
Well Number	Hydraulic Conductivity in gpd/square ft Falling Head Test	Hydraulic Conductivity in gpd/square ft Rising Head Test	Hydraulic Conductivity in gpd/square ft Falling Head Test	Hydraulic Conductivity in gpd/square ft Rising Head Test	Hydraulic Conductivity in gpd/square ft	Hydraulic Conductivity in gpd/square ft	Hydraulic Conductivity in gpd/square ft
OW-19	8.18E+01	1.08E+02	8.52E+01	8.12E+01	NAp	1.58E+03	1.08E+03
OW-19A	4.75E+02	3.20E+02	9.86E+02	6.02E+02	NAp	5.39E+02	NAp
TW-1S	NA	NA	2.54E+02	5.13E+02	6.00E+02	4.10E+02	NAp
TW-1D	3.22E+01	3.63E+01	6.79E+01	5.85E+01	2.27E+03	1.85E+03	1.97E+03
TW-2S	NA	NA	1.01E+03	1.38E+02	6.18E+02	4.97E+02	NAp
TW-2D	1.59E+01	1.41E+01	1.54E+01	2.27E+01	2.34E+03	1.99E+03	2.03E+03
TW-3S	3.27E+02	2.10E+02	4.81E+02	3.54E+02	2.80E+02	2.76E+02	NAp
TW-3D	1.52E+02	1.63E+02	2.31E+02	2.16E+02	1.83E+03	2.06E+03	1.81E+03
TW-4S	8.88E+02	NA	9.33E+02	NA	1.08E+03	8.95E+02	NAp
TW-4D	7.59E+02	1.25E+03	1.09E+03	1.52E+03	3.00E+03	2.61E+03	1.67E+04

NA = Test data was invalid due to either no displacement or fast recovery (within 3 seconds)
NAp = Not applicable because no unique fit between data and type curves
gpd/square ft = gallons per day per square foot

FIGURES



0 125 300 FT.

Title:
LOCATIONS AND DESIGNATIONS OF PUMPING WELL, TEMPORARY WELLS, AND OBSERVATION WELLS FOR THE OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

Prepared for:
INDUSTRI-PLEX SITE REMEDIAL TRUST

ROUX ASSOCIATES INC Consulting Ground-Water Geologists & Engineers	Compiled by: M.D.	Date: 11/90	Figure
	Prepared by: V.M.	Scale: SHOWN	1
	Project Mgr: M.D.	Revision: 0	
	File No:		

SEMI-LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR PUMPING WELL PW-1
OCTOBER 26, 1990 STEP-DRAWDOWN TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

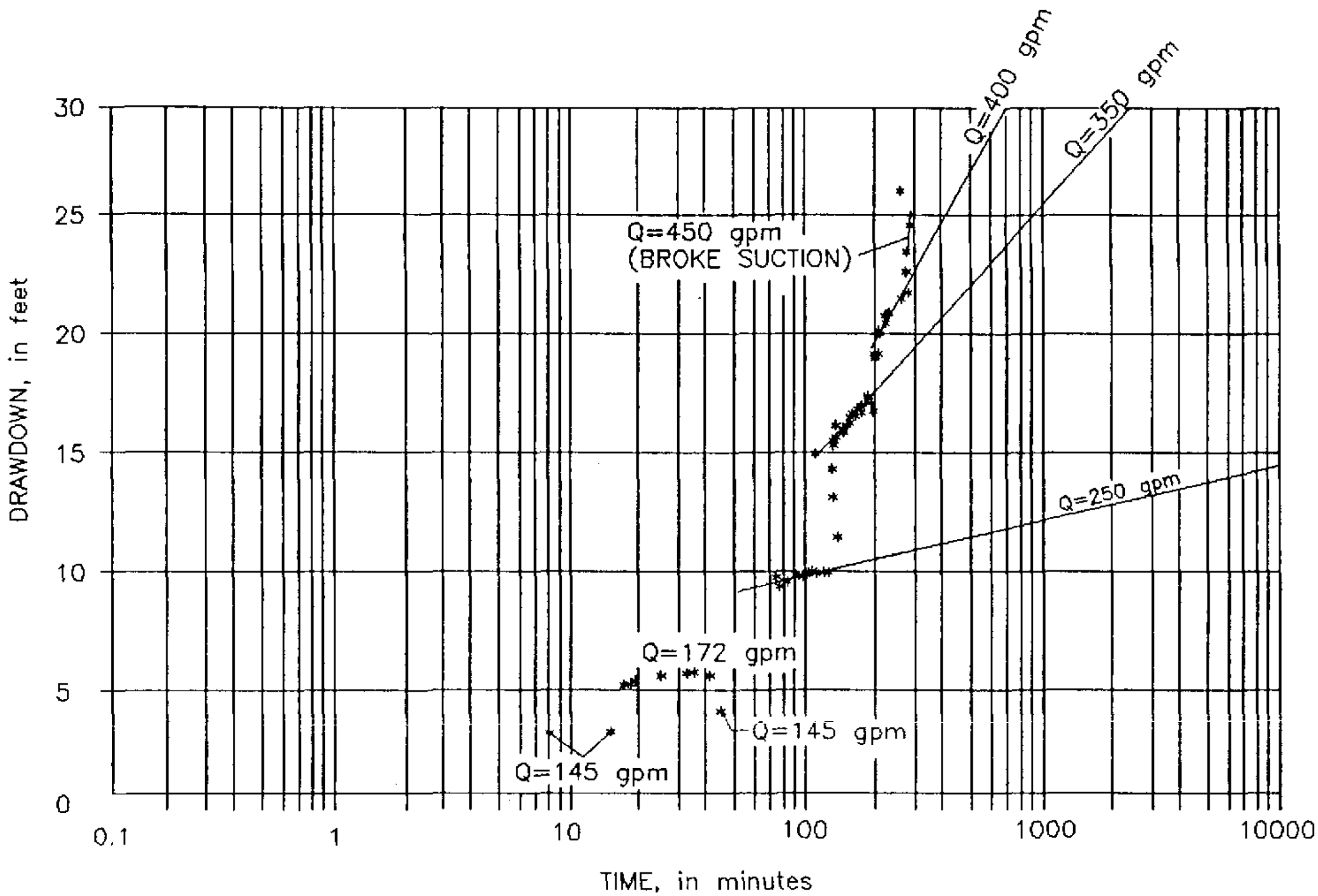


FIGURE 2

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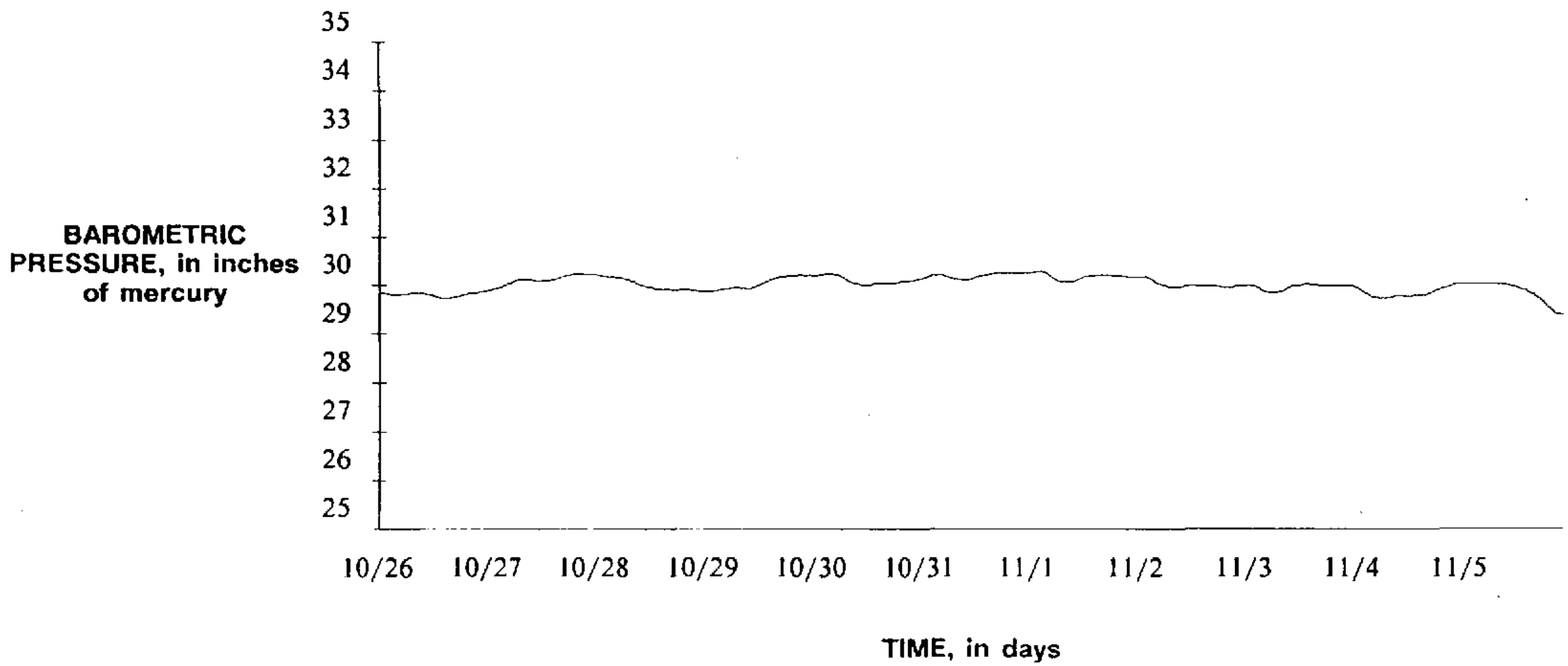
FIGURE 3. BAROMETRIC PRESSURE FROM OCTOBER 26, 1990 THROUGH NOVEMBER 6, 1990 AT THE INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS.



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SEMI-LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR PUMPING WELL PW-1,
OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST,
INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

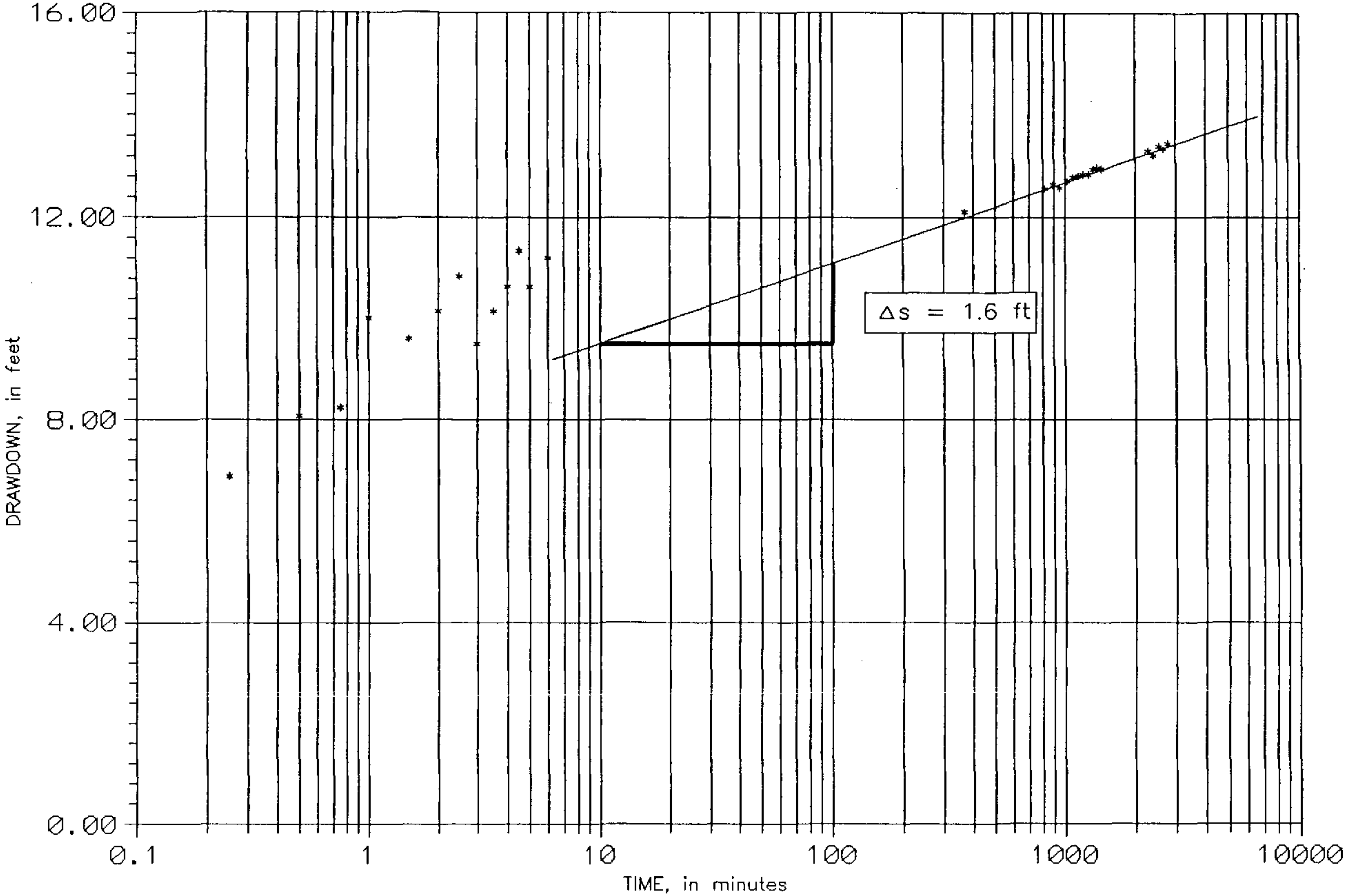

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FIGURE 4

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR STALLMAN ANALYSIS FOR TEMPORARY WELL TW-1S, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

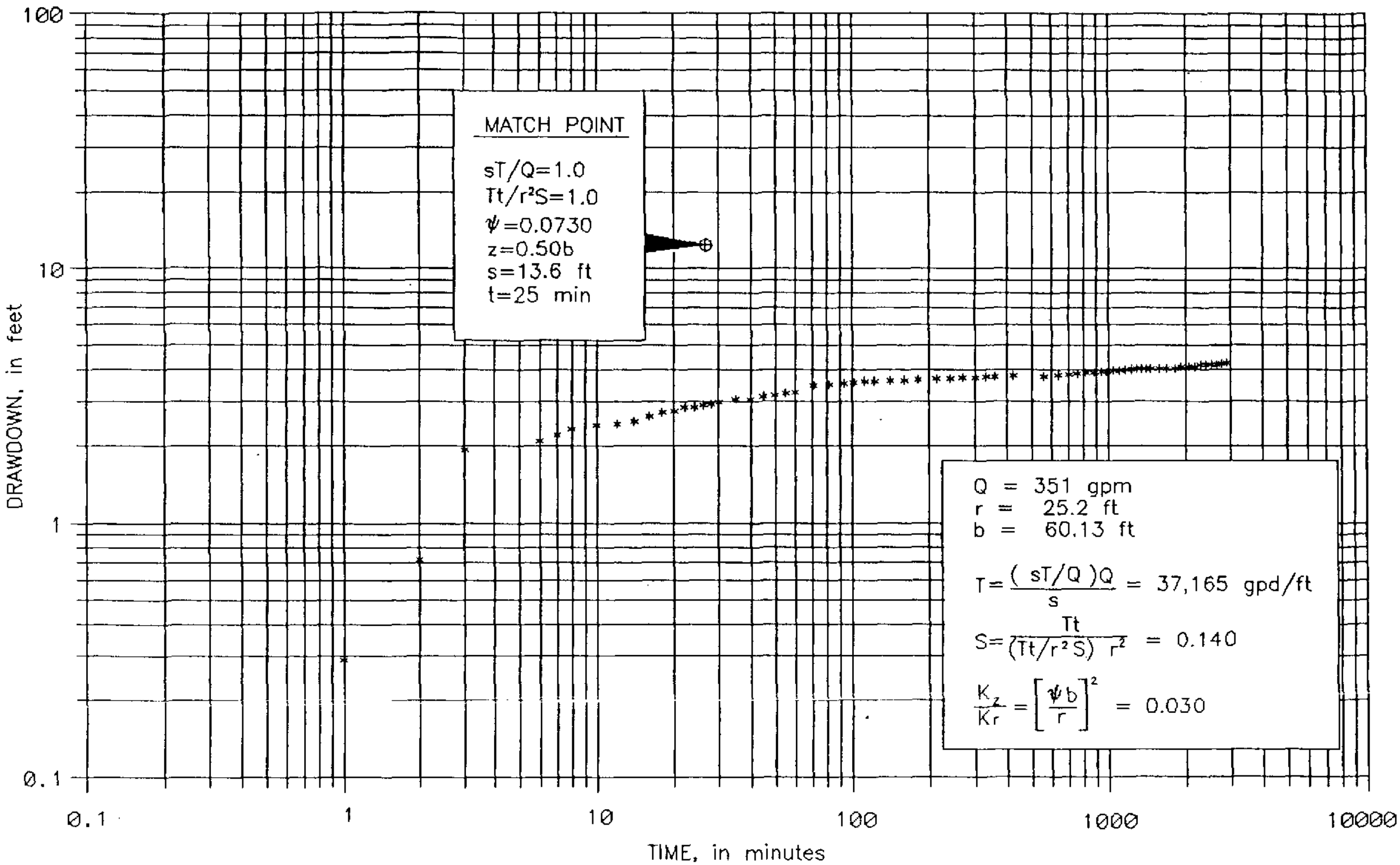

FIGURE 5

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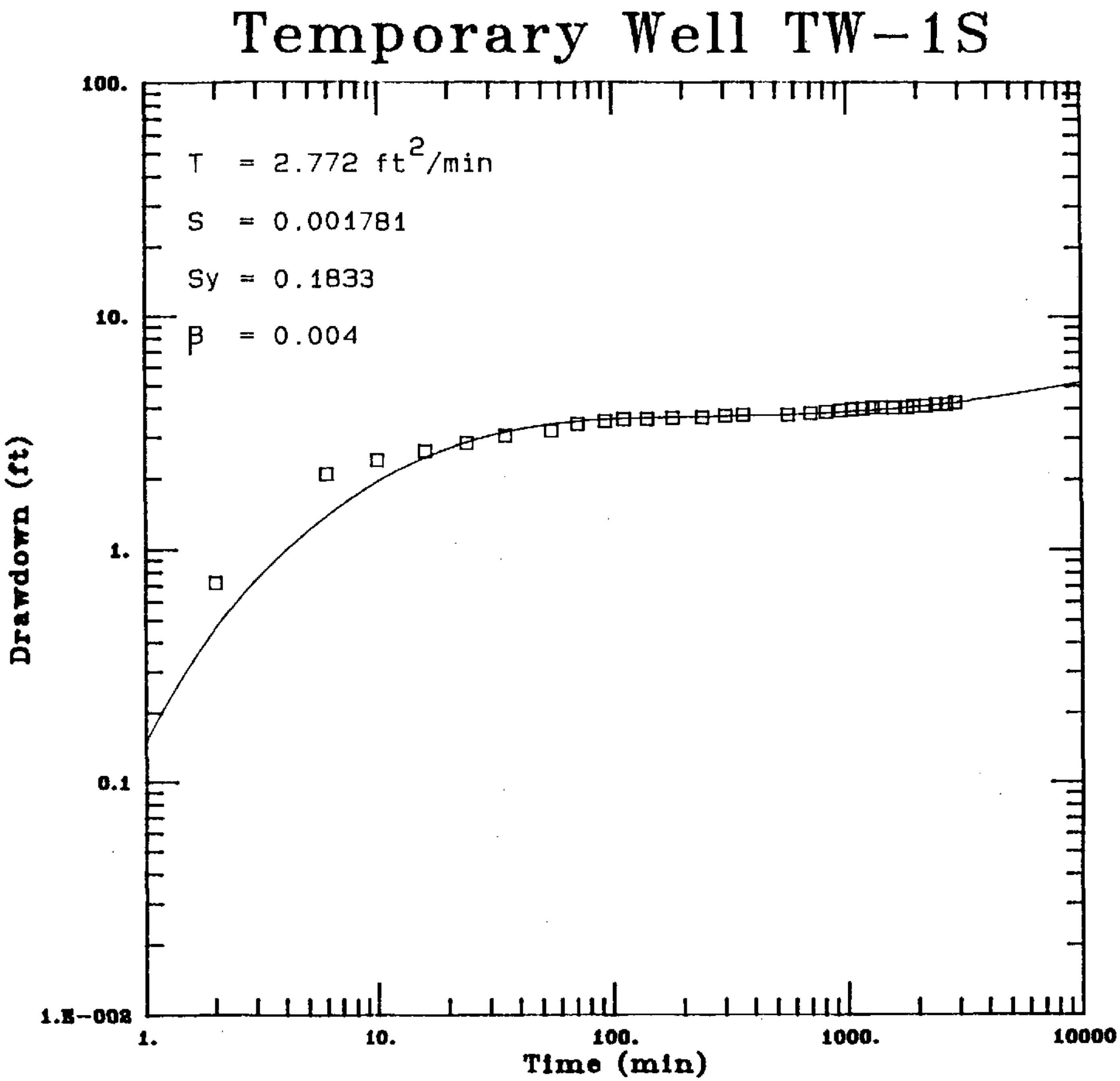

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV TYPE CURVE OPTION, FOR TEMPORARY WELL TW-1S, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 6

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR STALLMAN ANALYSIS FOR TEMPORARY WELL TW-2S, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

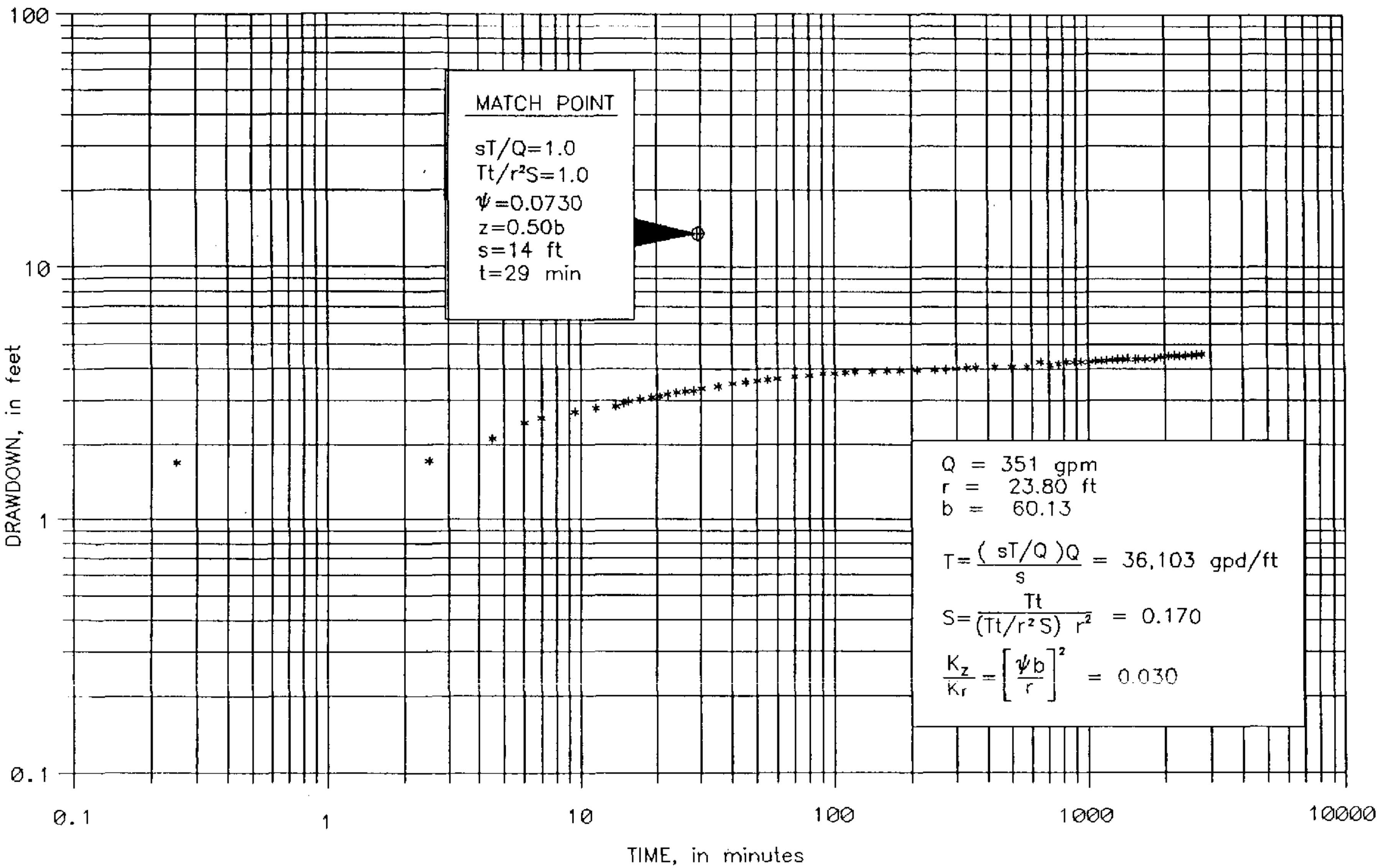

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FIGURE 7

Temporary Well TW-2S

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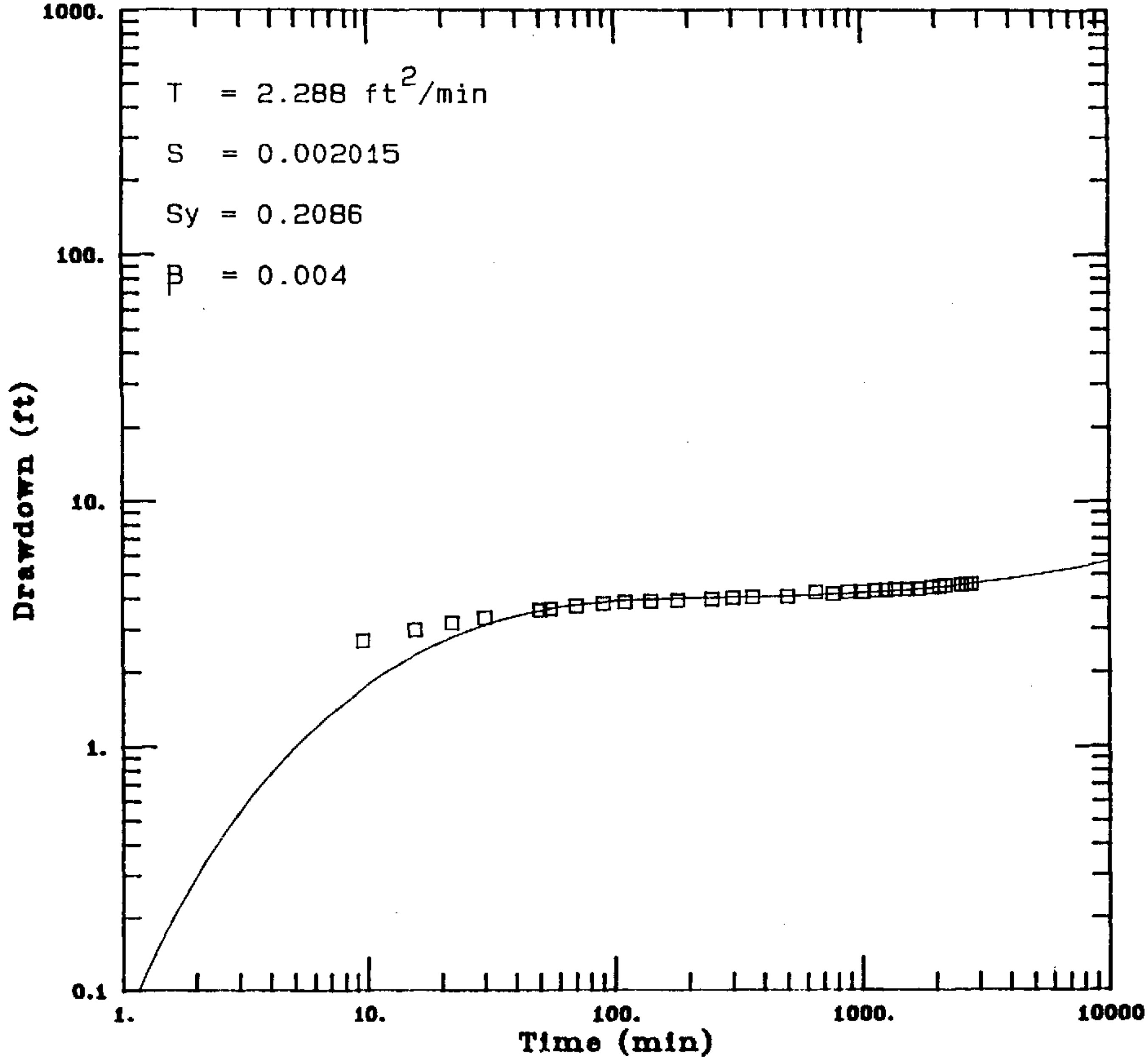
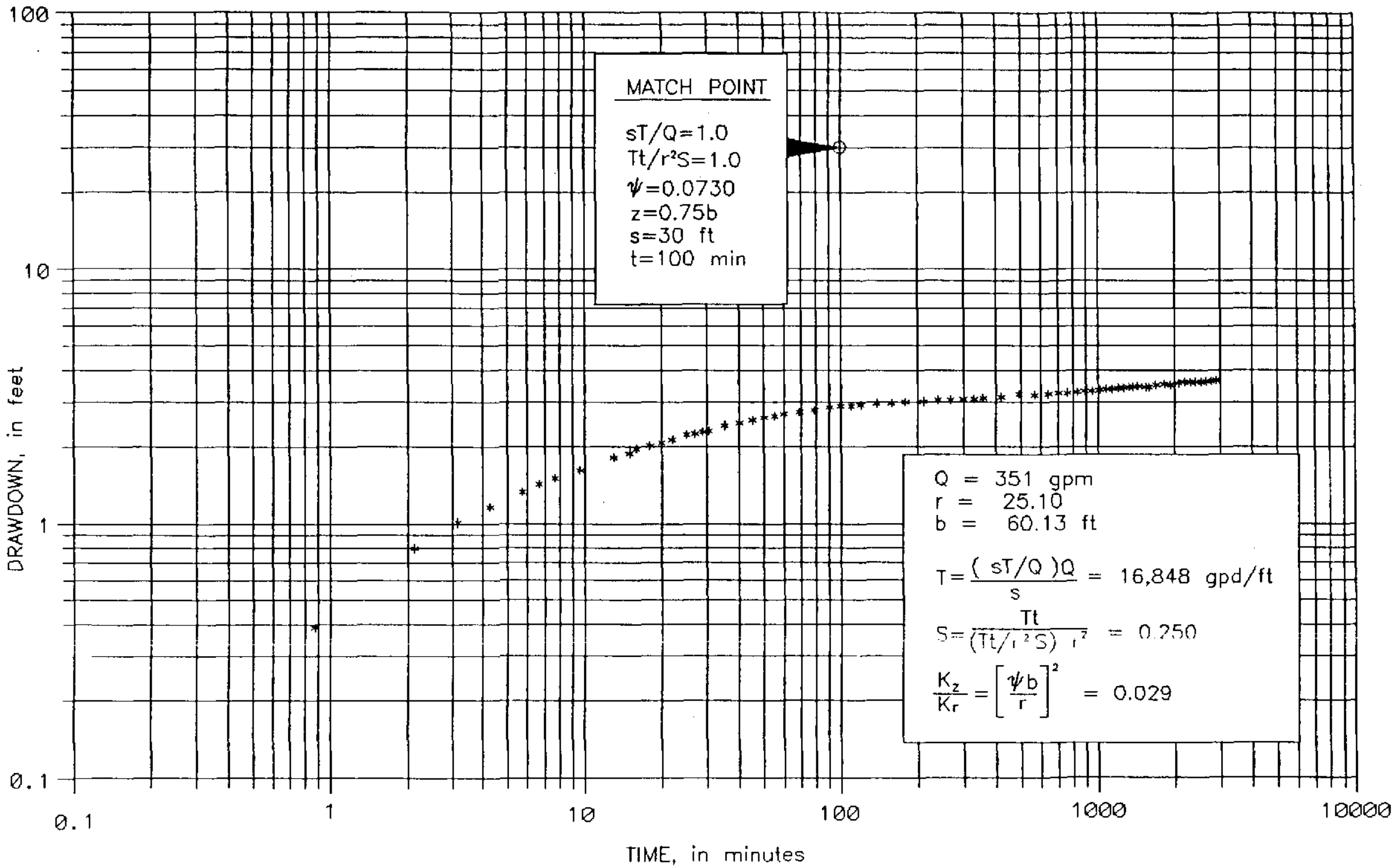


LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV TYPE CURVE OPTION, FOR TEMPORARY WELL TW-2S, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

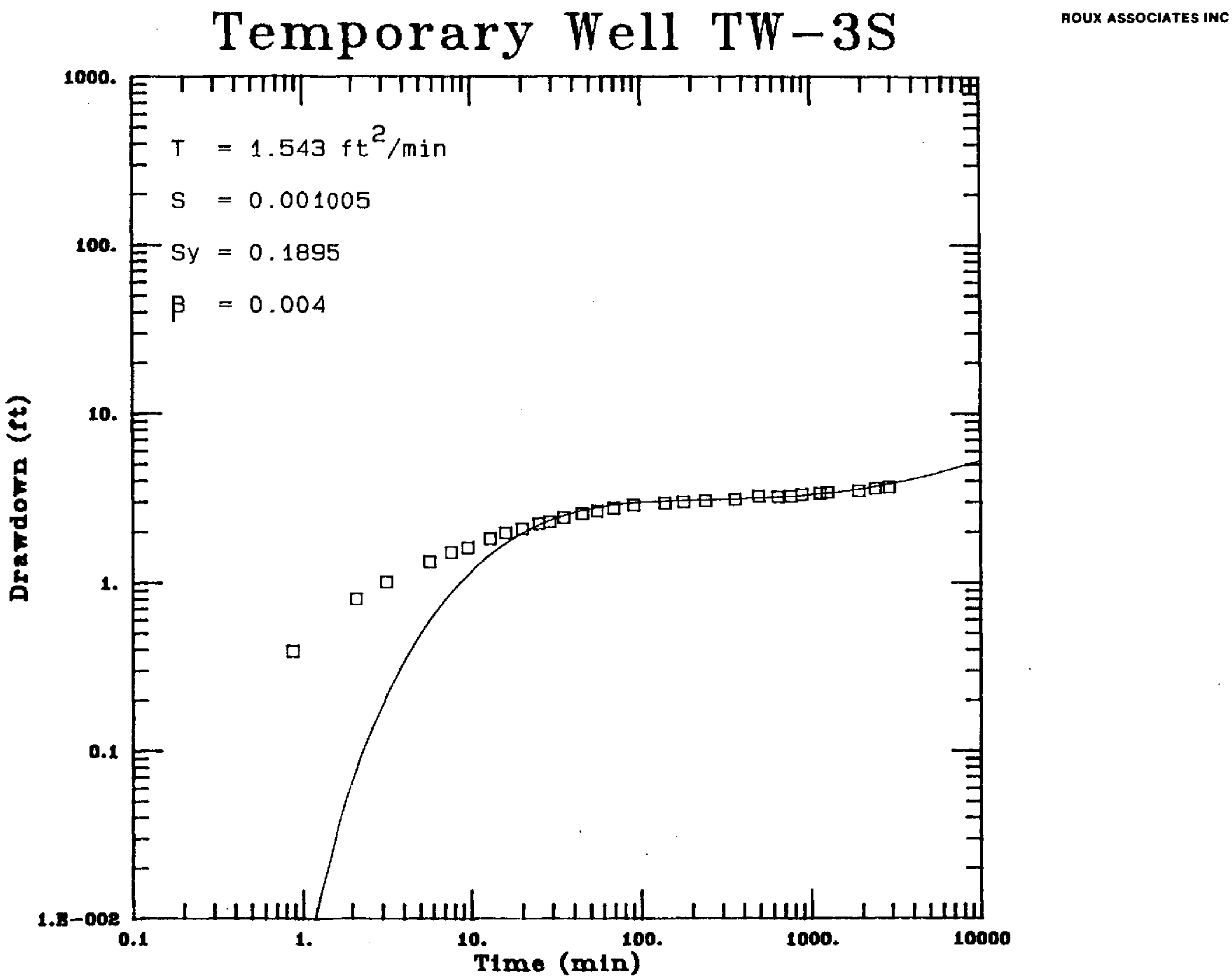
FIGURE 8

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR STALLMAN ANALYSIS FOR TEMPORARY WELL TW-3S, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS



ROUX ASSOCIATES INC

FIGURE 9



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV TYPE CURVE OPTION, FOR TEMPORARY WELL TW-3S, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 10

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR STALLMAN ANALYSIS FOR TEMPORARY WELL TW-4S, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

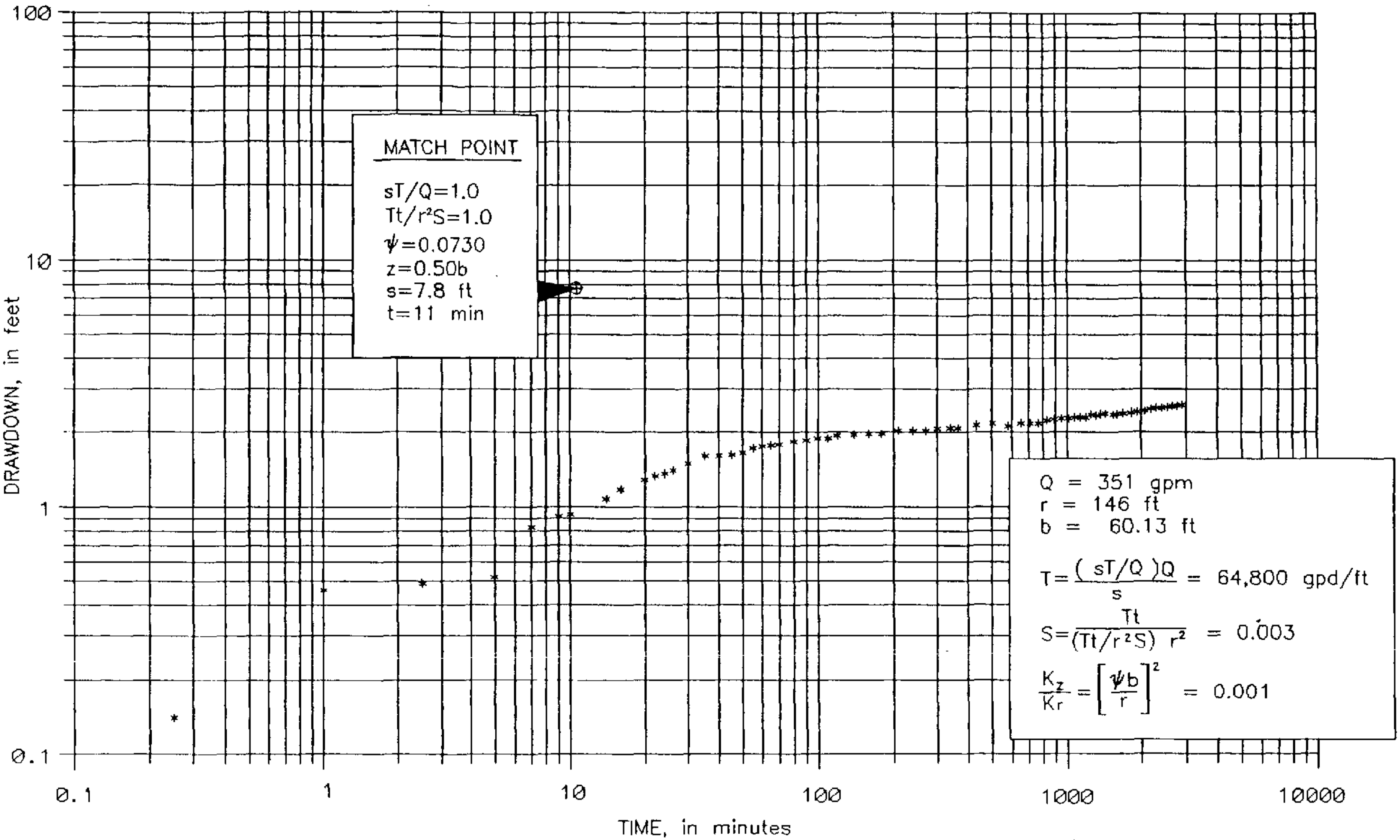
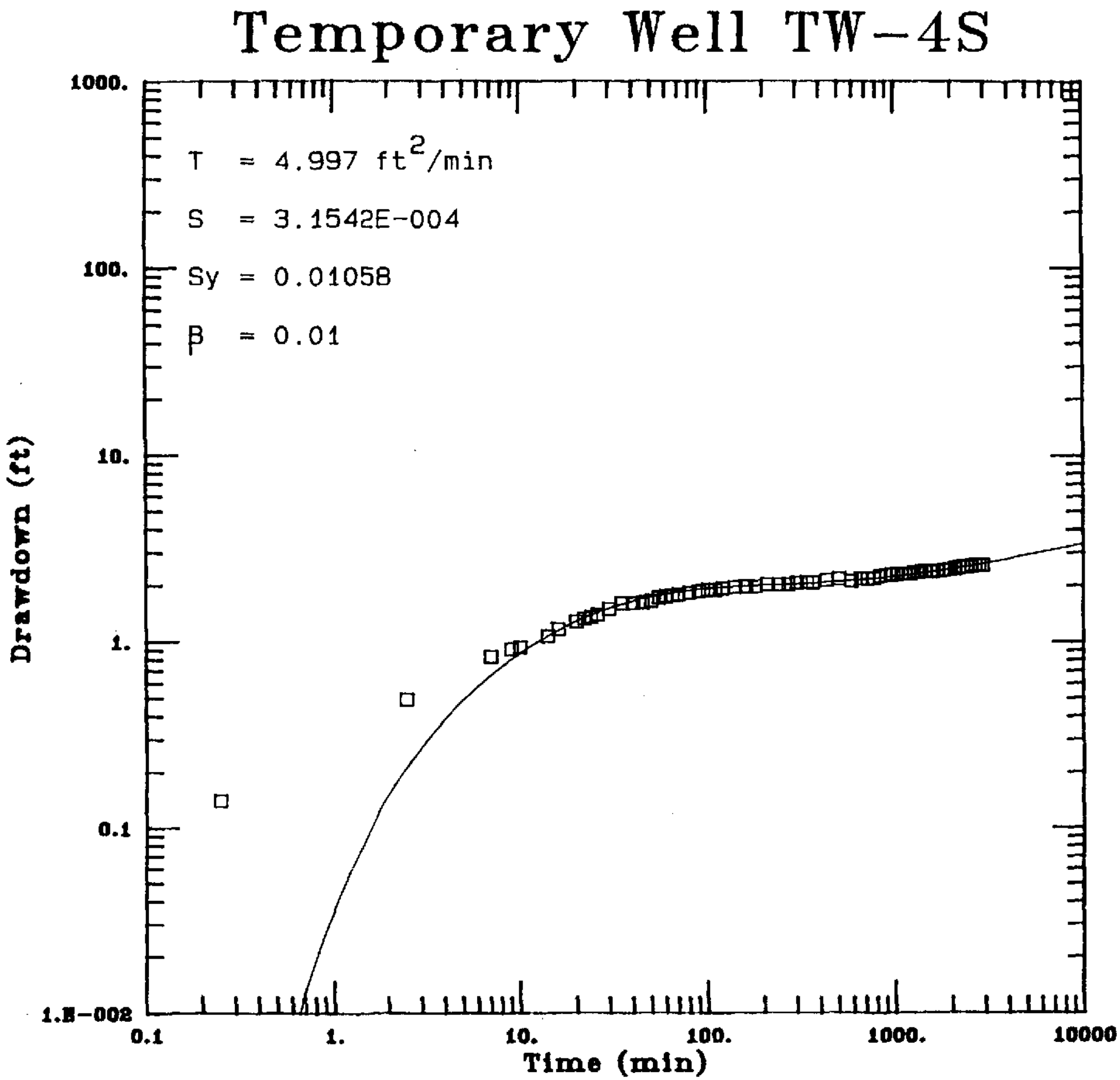


FIGURE 11

ROUX ASSOCIATES INC



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV TYPE CURVE OPTION, FOR TEMPORARY WELL TW-4S, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 12

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR STALLMAN ANALYSIS FOR TEMPORARY WELL TW-1D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

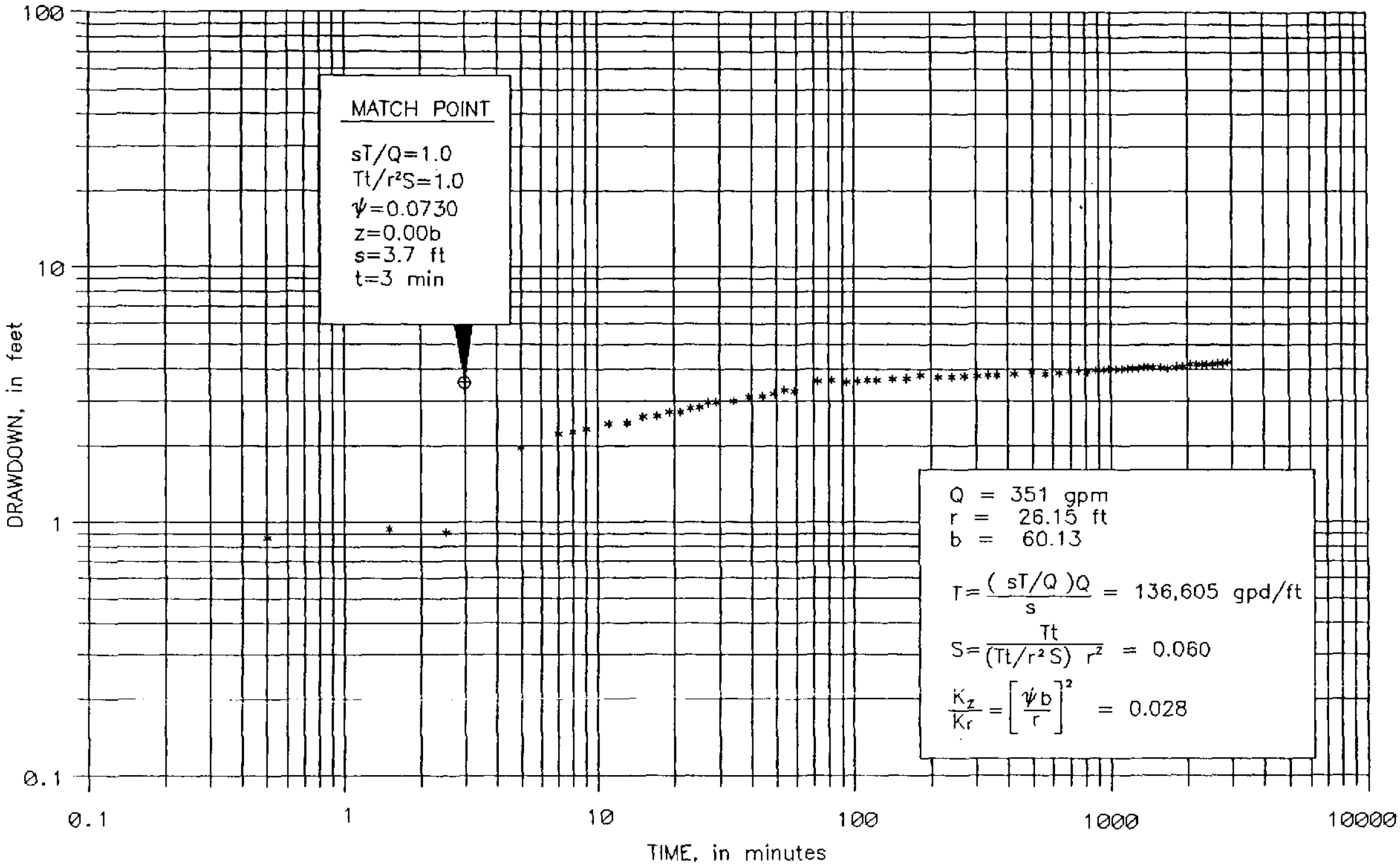


FIGURE 13

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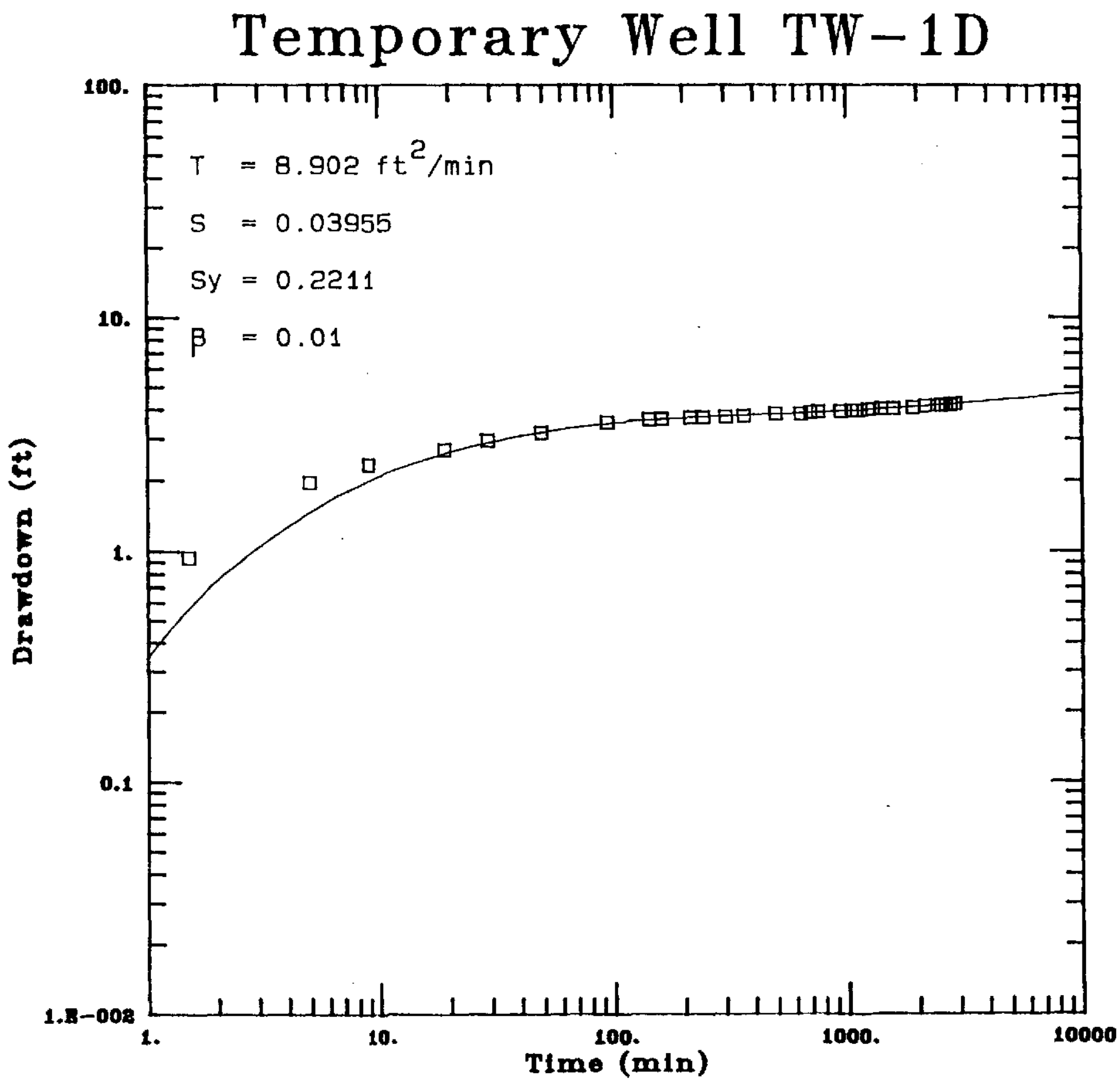
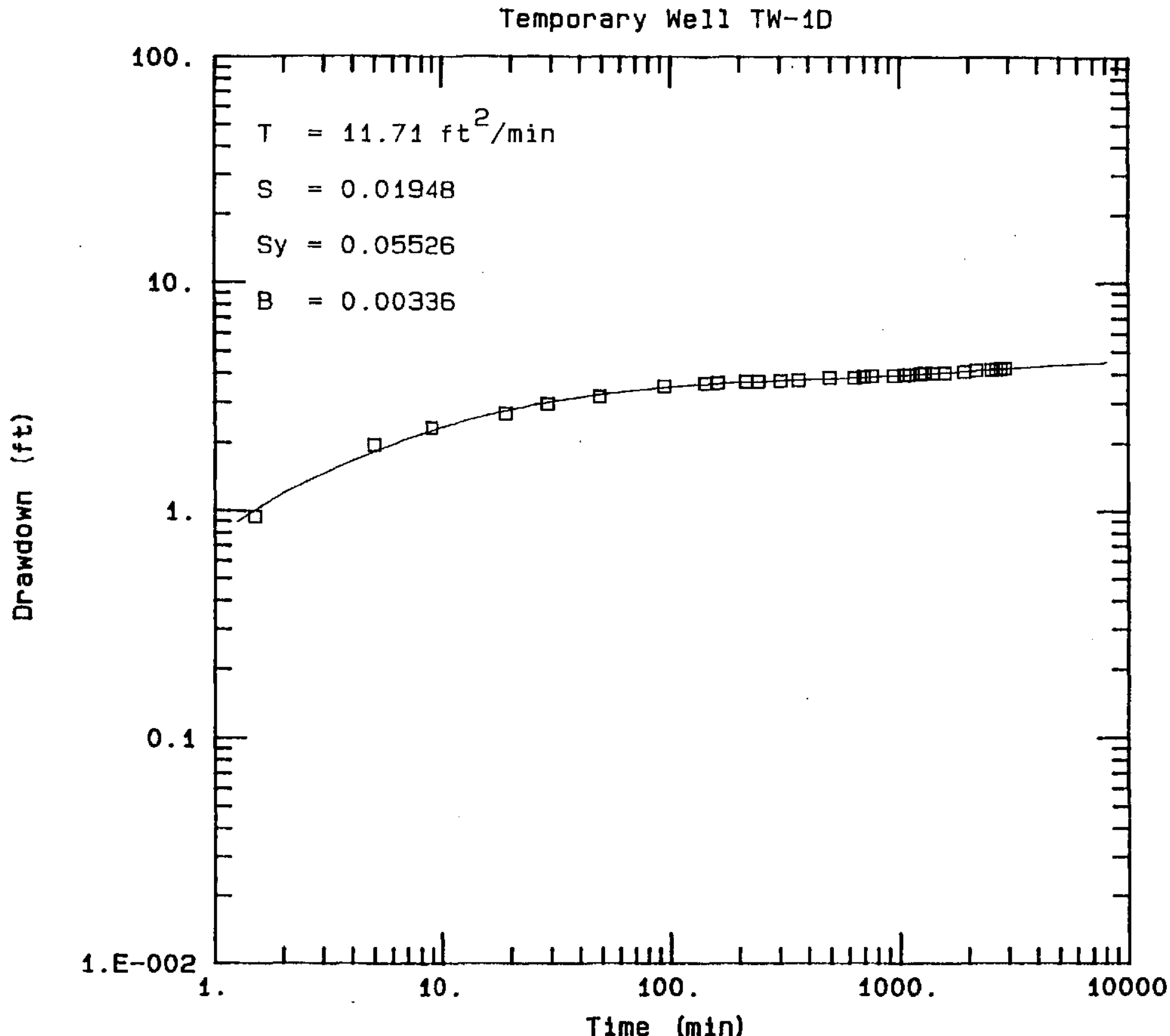


LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV TYPE CURVE OPTION, FOR TEMPORARY WELL TW-1D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 1 4



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV PARAMETER ESTIMATION OPTION, FOR TEMPORARY WELL TW-1D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 15

HANTUSH PARTIAL PENETRATION TYPE CURVE FOR TEMPORARY WELL TW-1D
FOR K_r TO K_z RATIO OF 40 TO 1, OCTOBER 30, 1990 THROUGH NOVEMBER 2,1990
PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

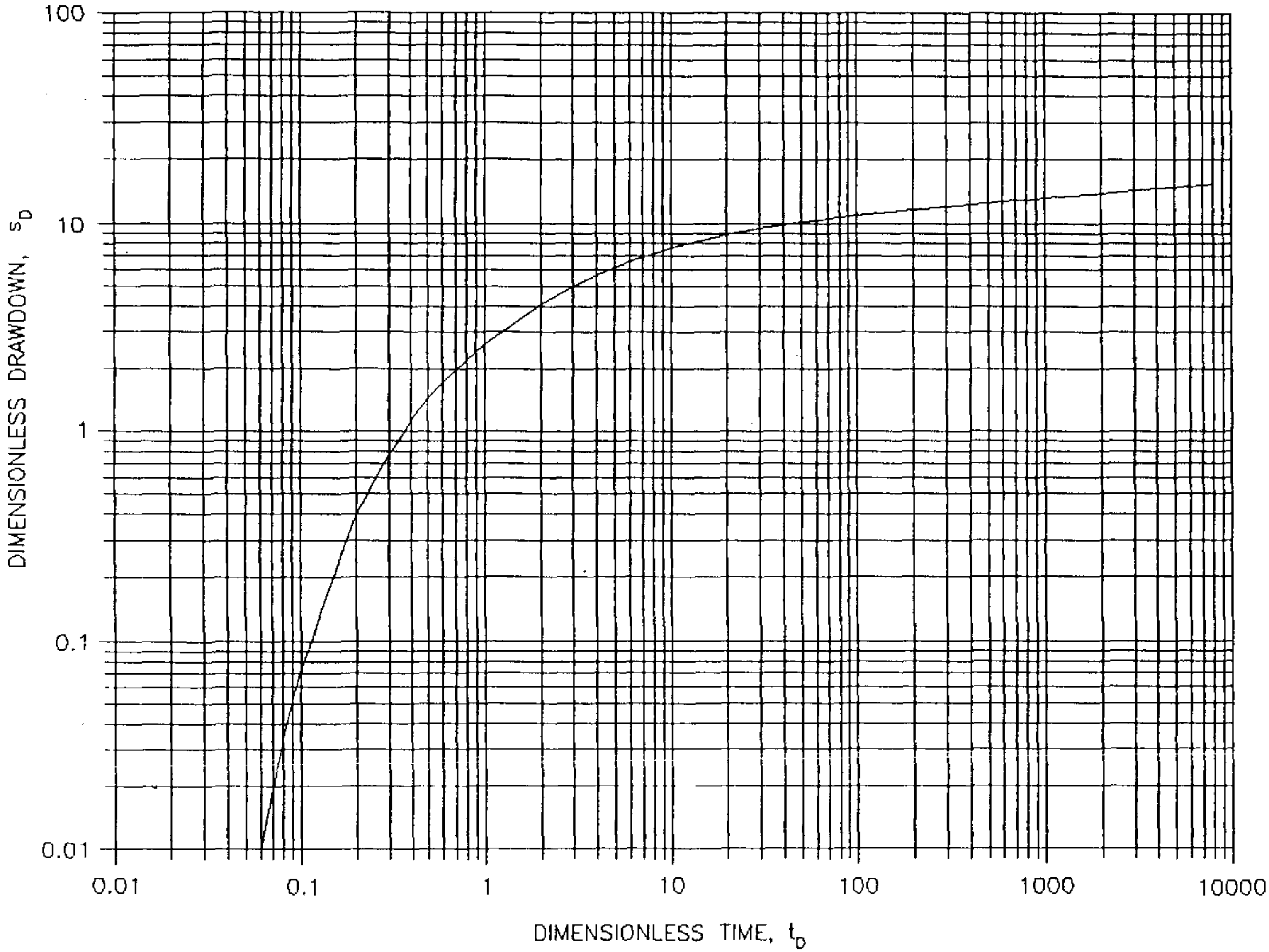


FIGURE 16

ROUX ASSOCIATES INC

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR HANTUSH PARTIAL PENETRATION ANALYSIS, FOR TEMPORARY WELL TW-1D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

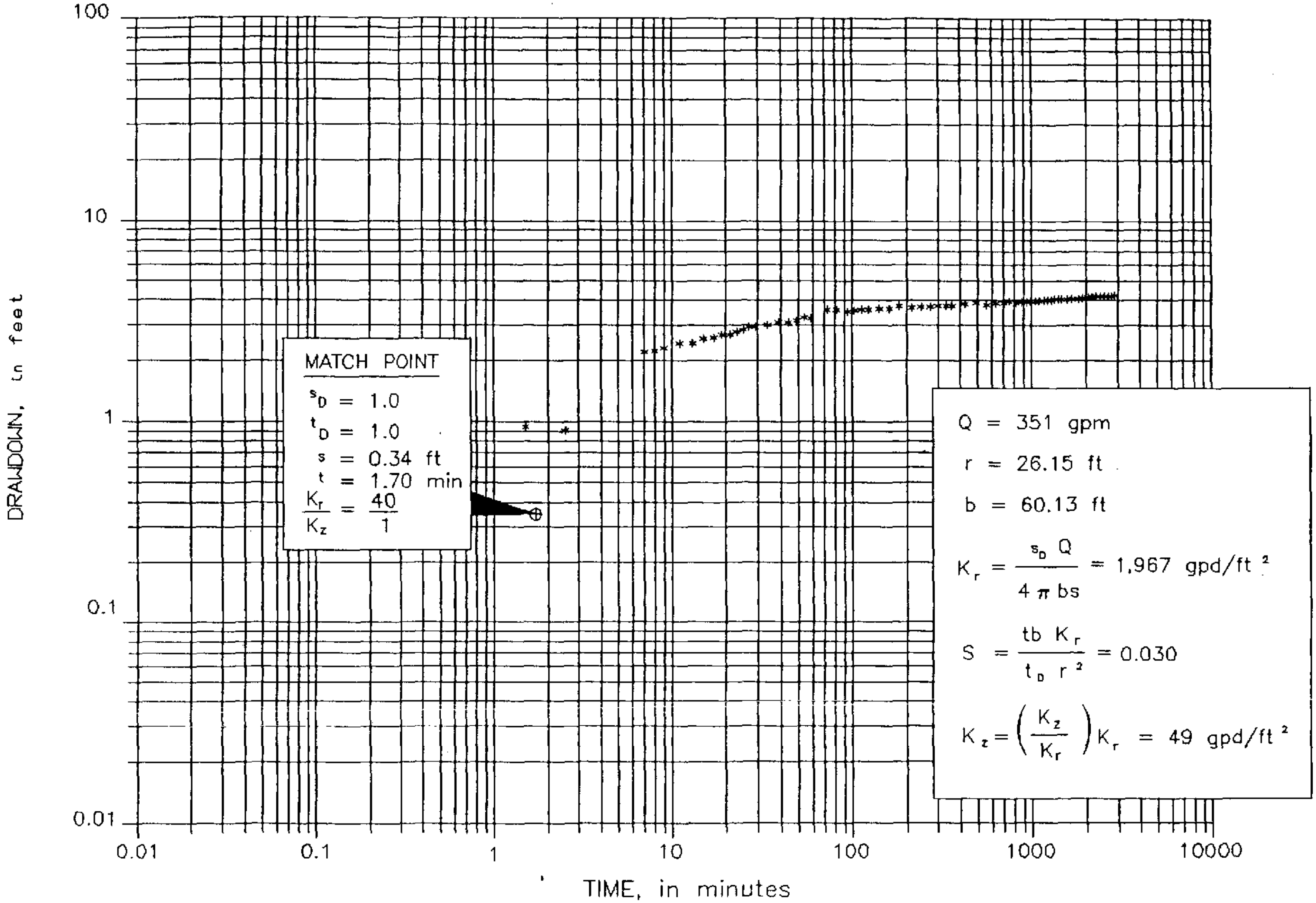


FIGURE 17

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LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR STALLMAN ANALYSIS FOR TEMPORARY WELL TW-2D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

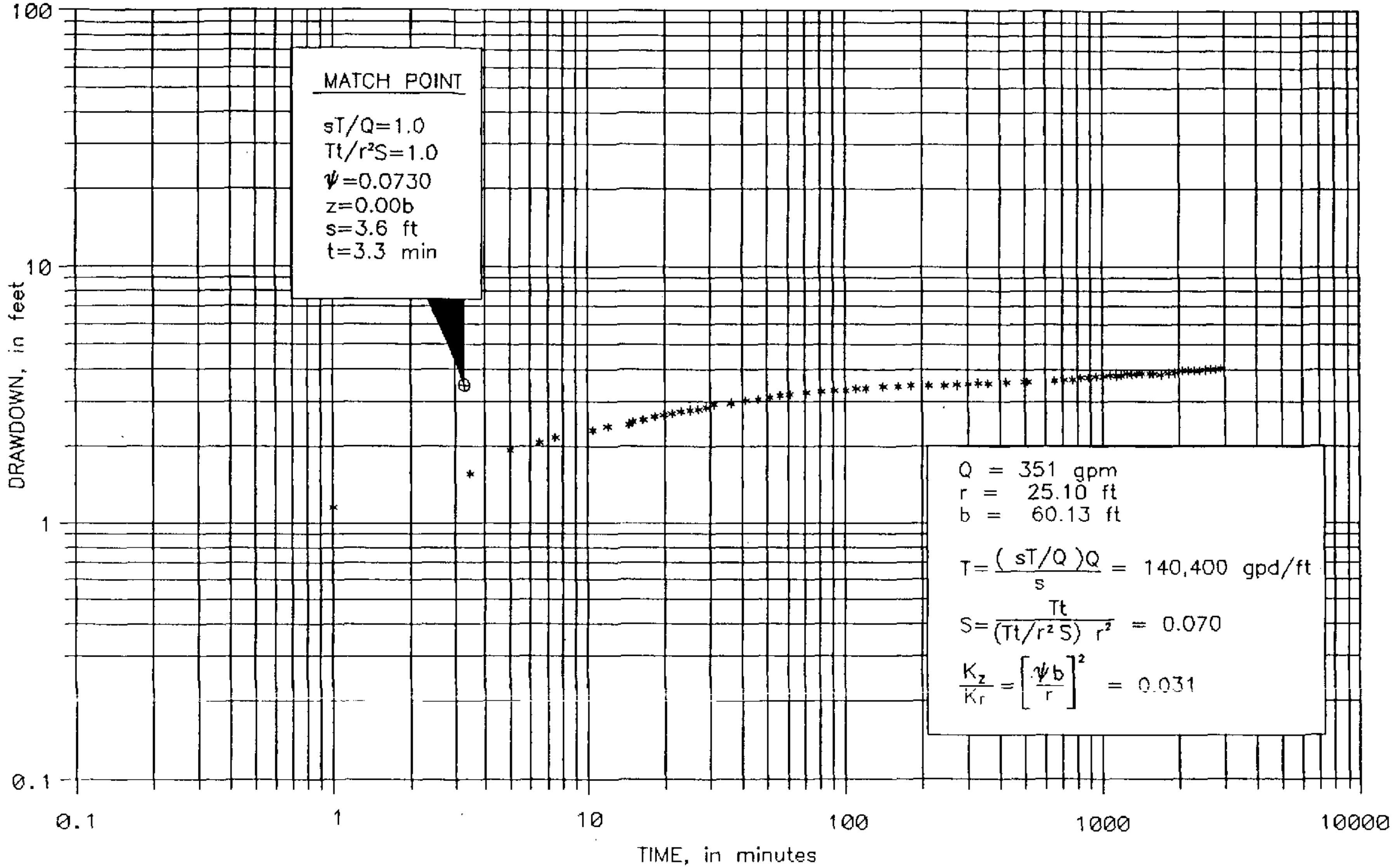

FIGURE 18

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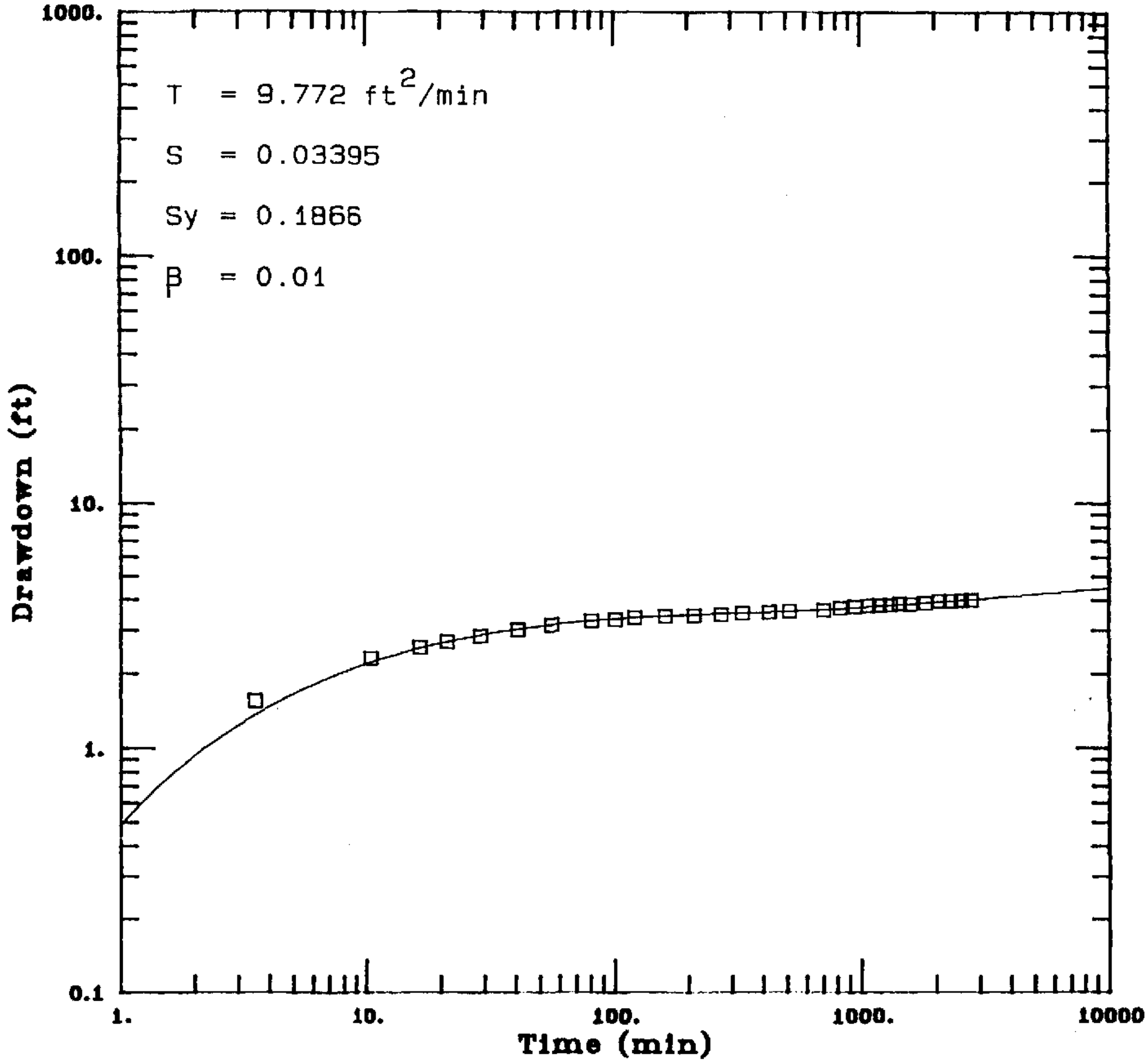
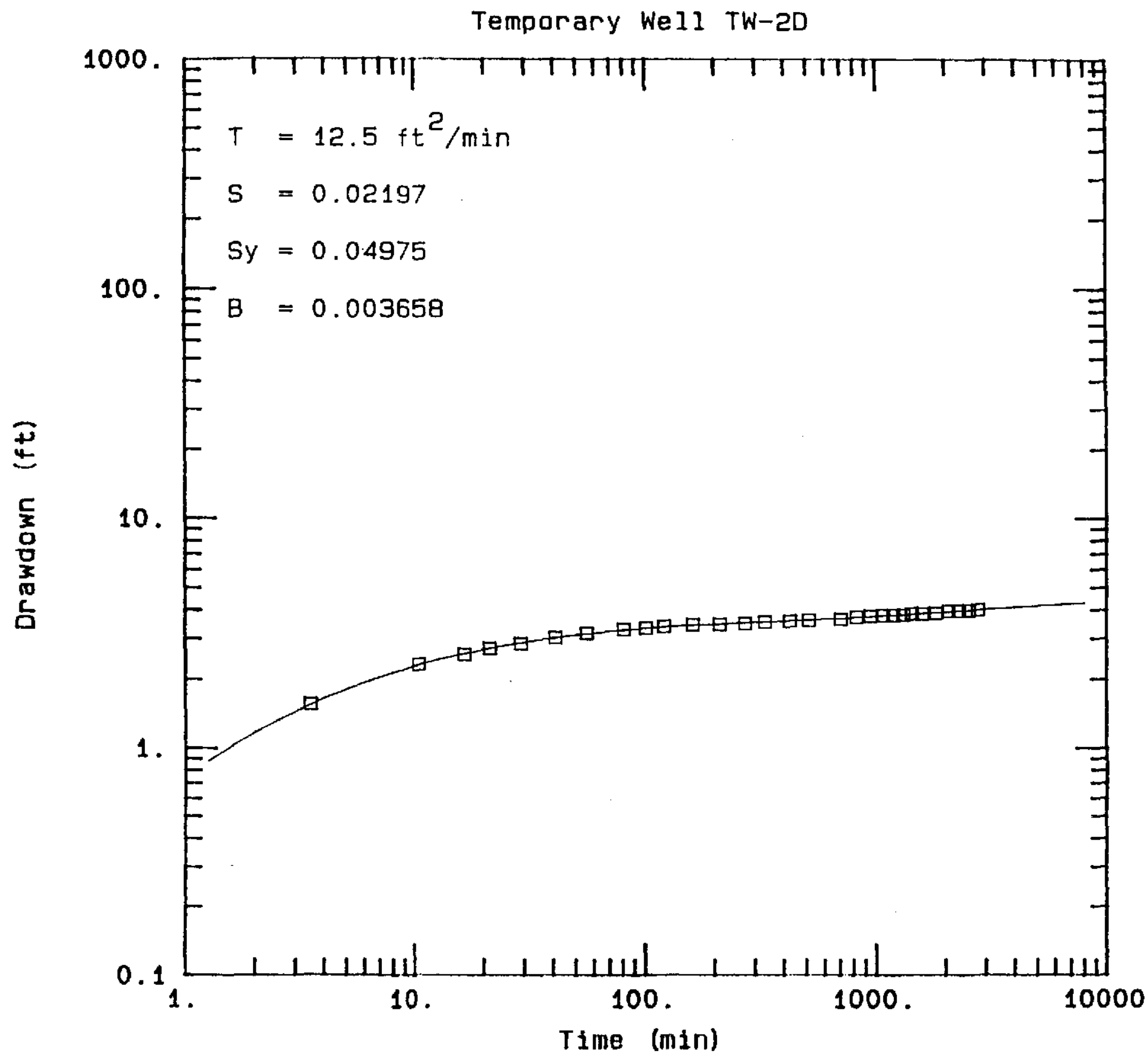
Temporary Well TW-2D



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV TYPE CURVE OPTION, FOR TEMPORARY WELL TW-2D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 19



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV PARAMETER ESTIMATION OPTION, FOR TEMPORARY WELL TW-2D OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 20

HANTUSH PARTIAL PENETRATION TYPE CURVE FOR TEMPORARY WELL TW-2D
FOR K_r TO K_z RATIO OF 40 TO 1, OCTOBER 30, 1990 THROUGH NOVEMBER 2, 1990
PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

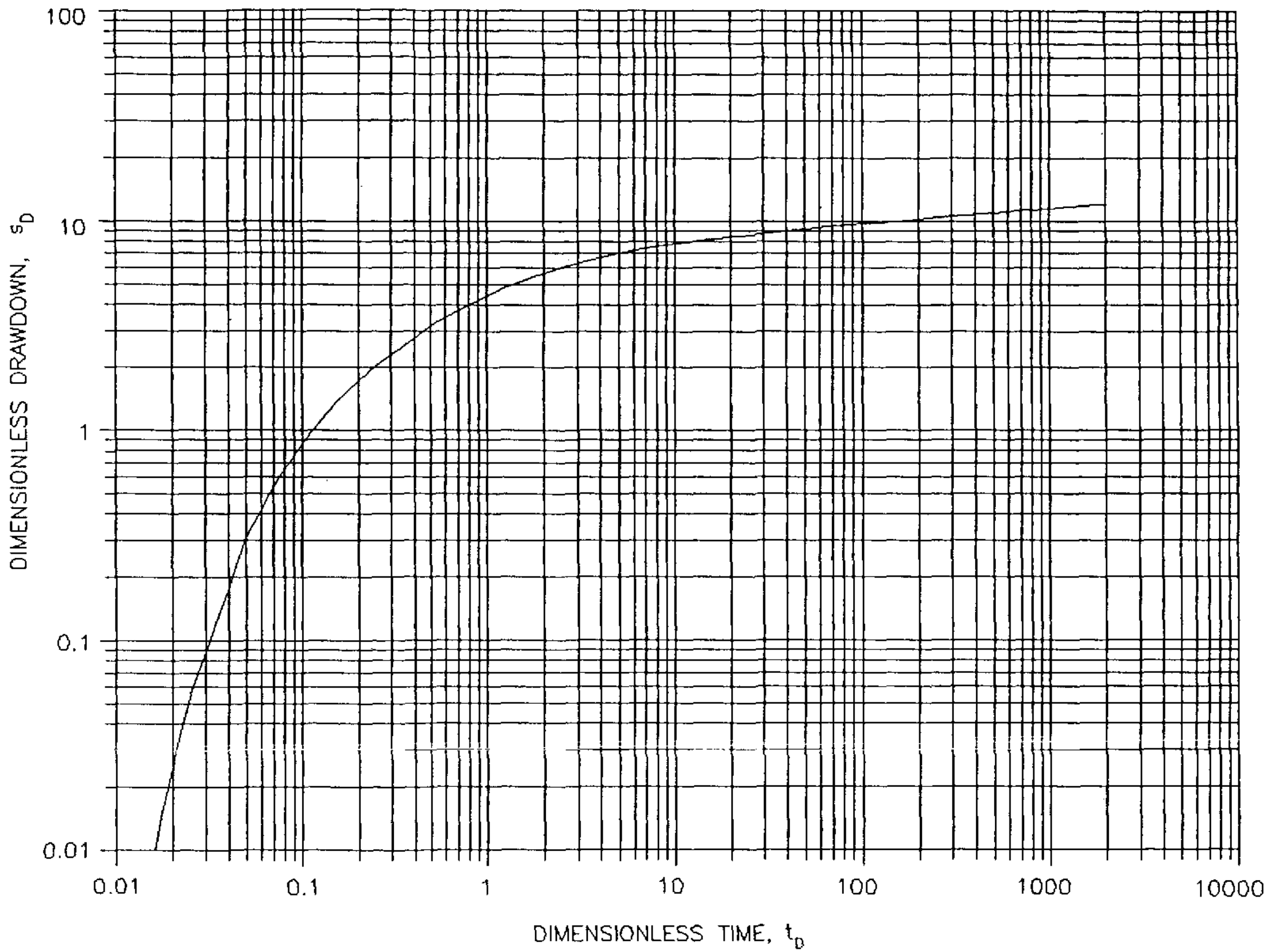


FIGURE 21

ROUX ASSOCIATES INC

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR HANTUSH PARTIAL PENETRATION ANALYSIS, FOR TEMPORARY WELL TW-2D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

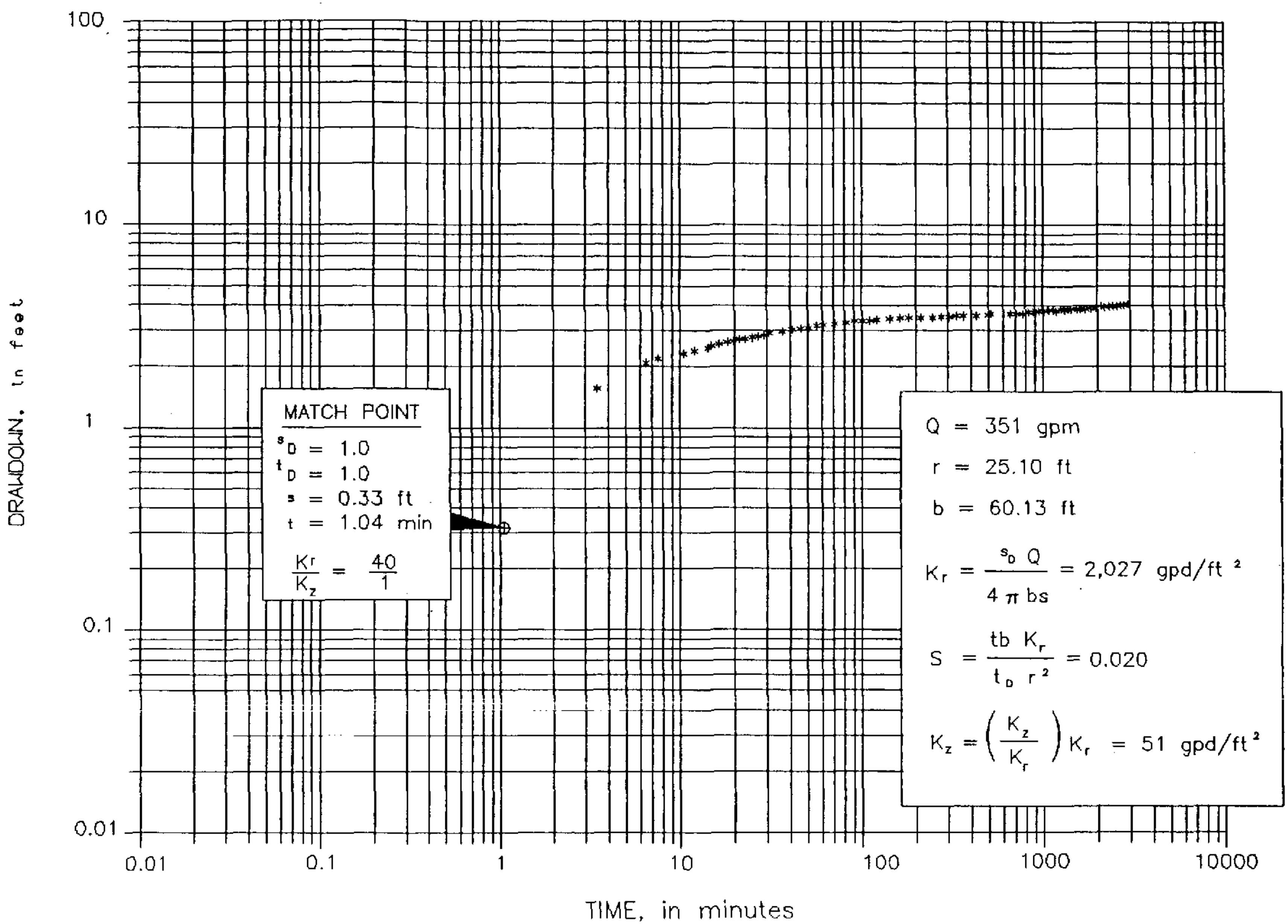


FIGURE 22

ROUX ASSOCIATES INC

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR STALLMAN ANALYSIS FOR TEMPORARY WELL TW-3D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

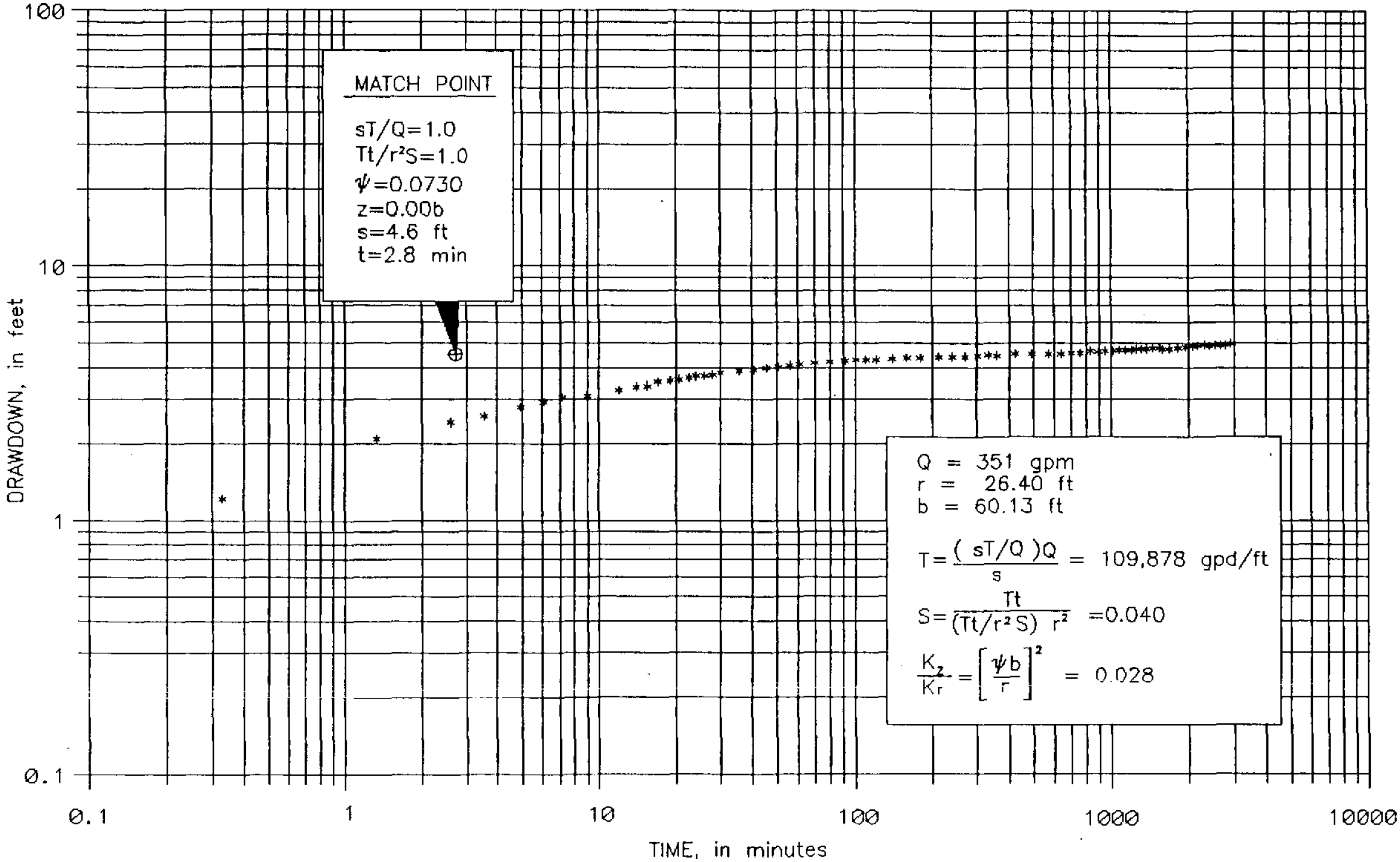
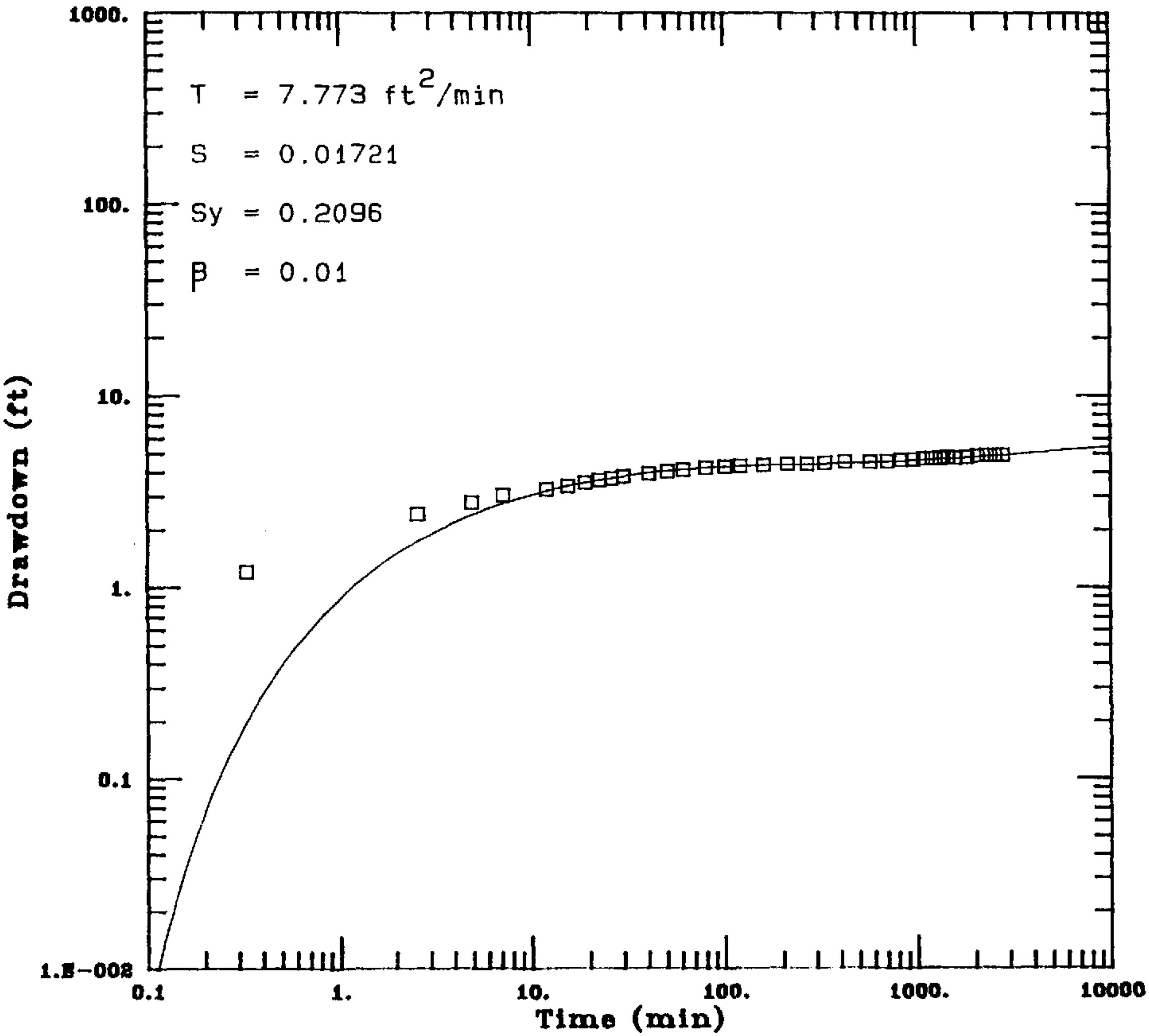


FIGURE 23

ROUX ASSOCIATES INC

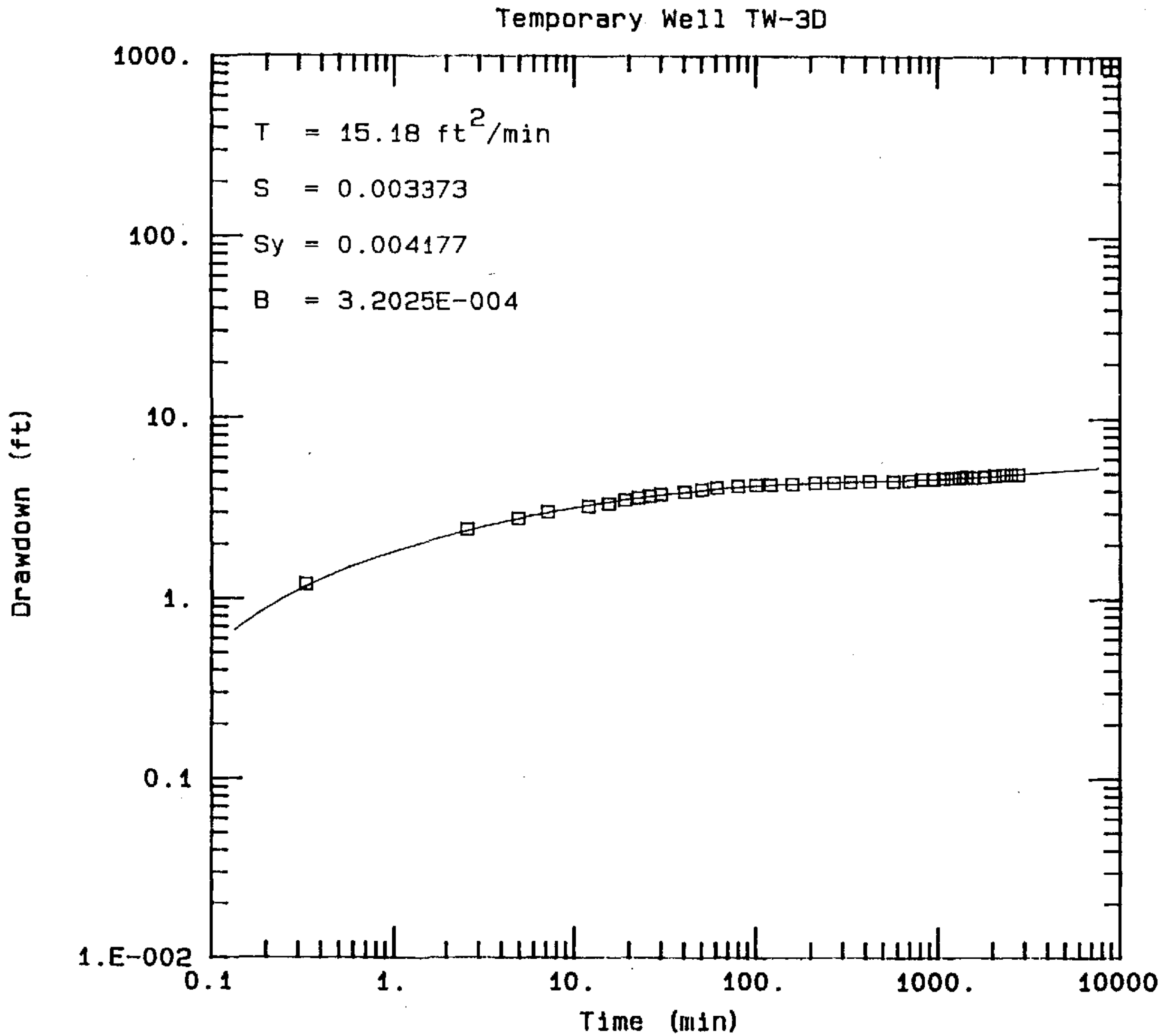
Temporary Well TW-3D

ROUX ASSOCIATES INC



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV TYPE CURVE OPTION, FOR TEMPORARY WELL TW-3D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

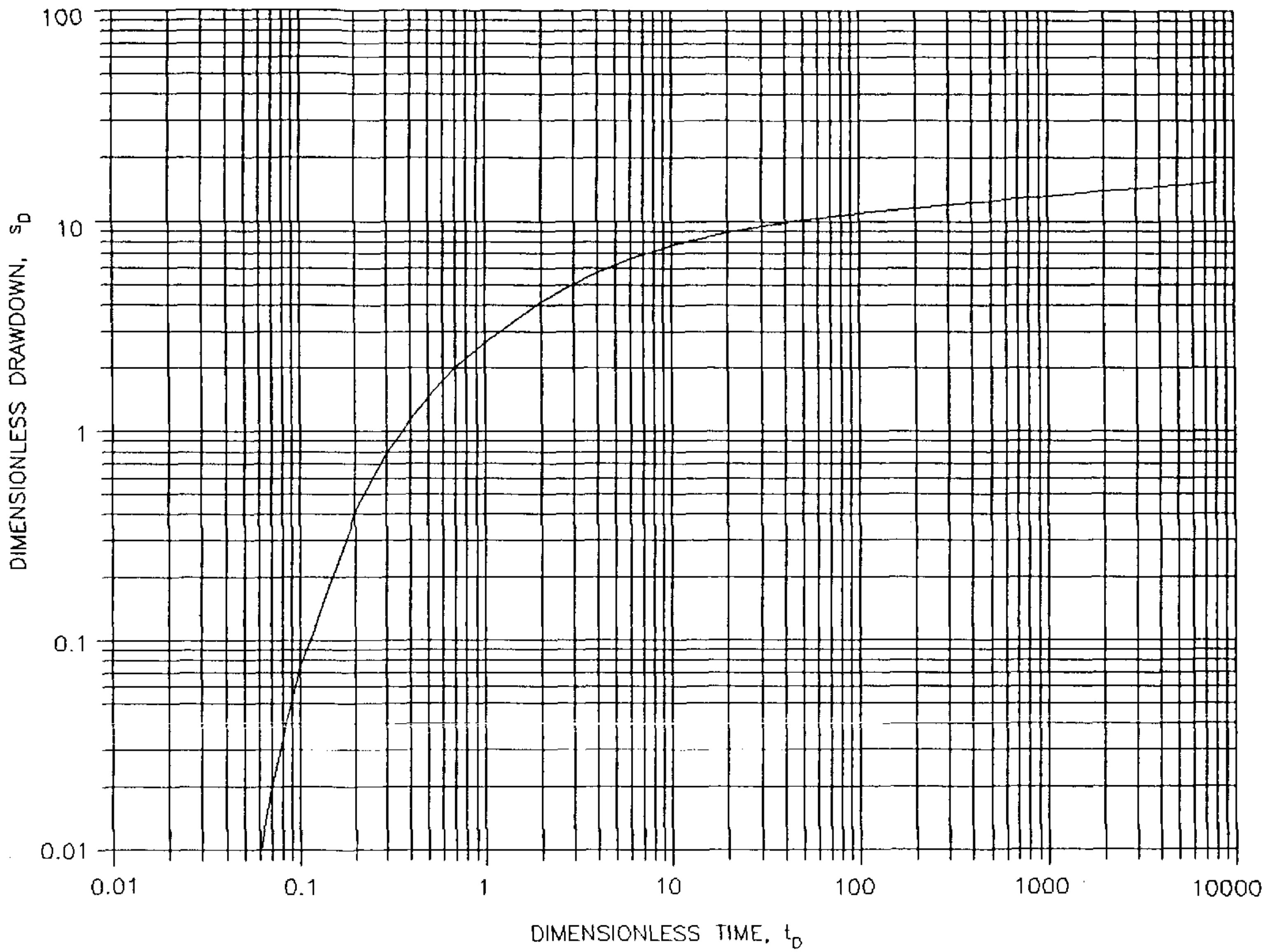
FIGURE 24



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV PARAMETER ESTIMATION OPTION, FOR TEMPORARY WELL TW-3D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 25

HANTUSH PARTIAL PENETRATION TYPE CURVE FOR TEMPORARY WELL TW-3D
FOR Kr TO Kz RATIO OF 40 TO 1, OCTOBER 30, 1990 THROUGH NOVEMBER 2, 1990
PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS



ROUX ASSOCIATES INC

FIGURE 26

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR HANTUSH PARTIAL PENETRATION ANALYSIS, FOR TEMPORARY WELL TW-3D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

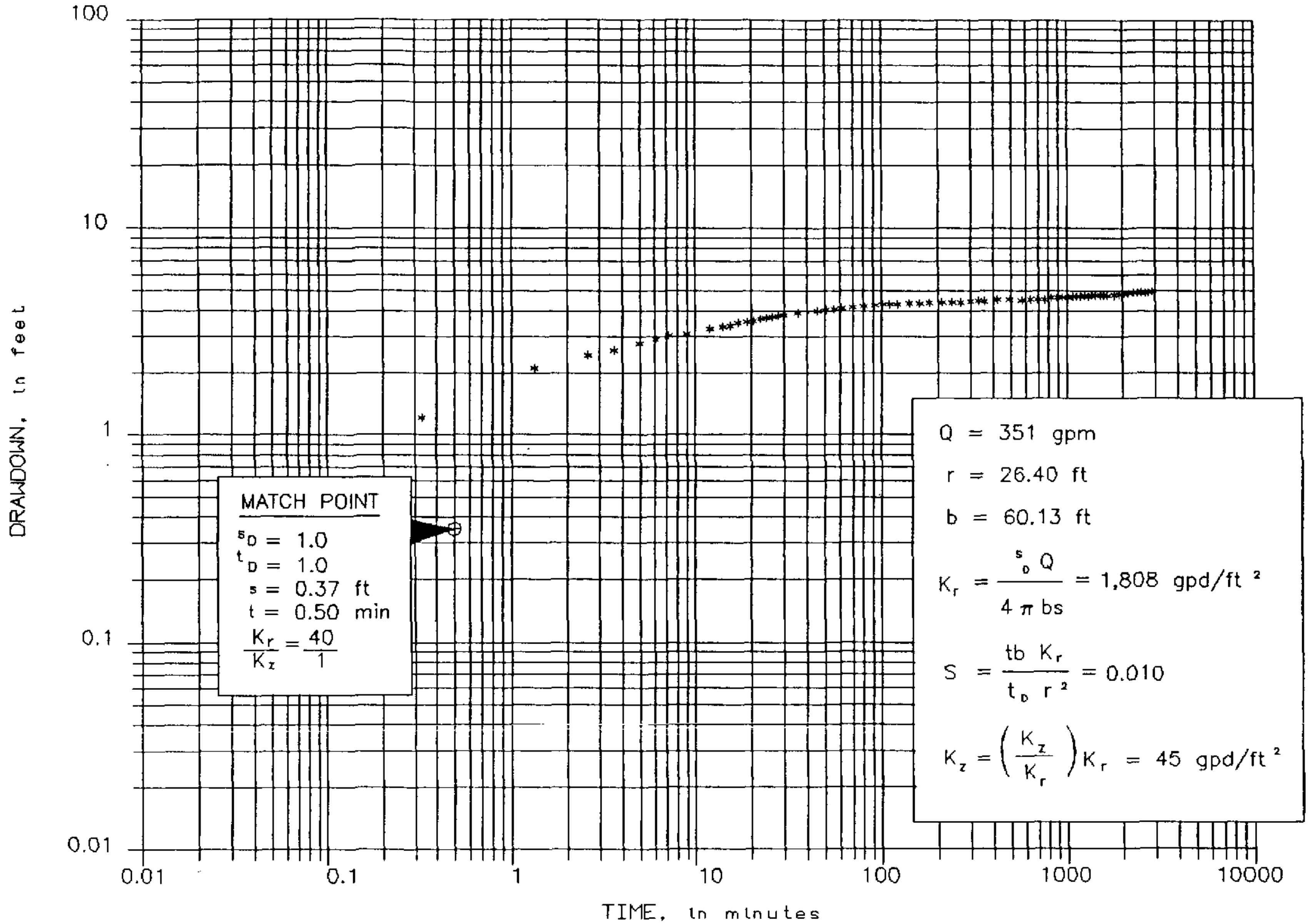


FIGURE 27

ROUX ASSOCIATES INC

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR STALLMAN ANALYSIS FOR TEMPORARY WELL TW-4D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

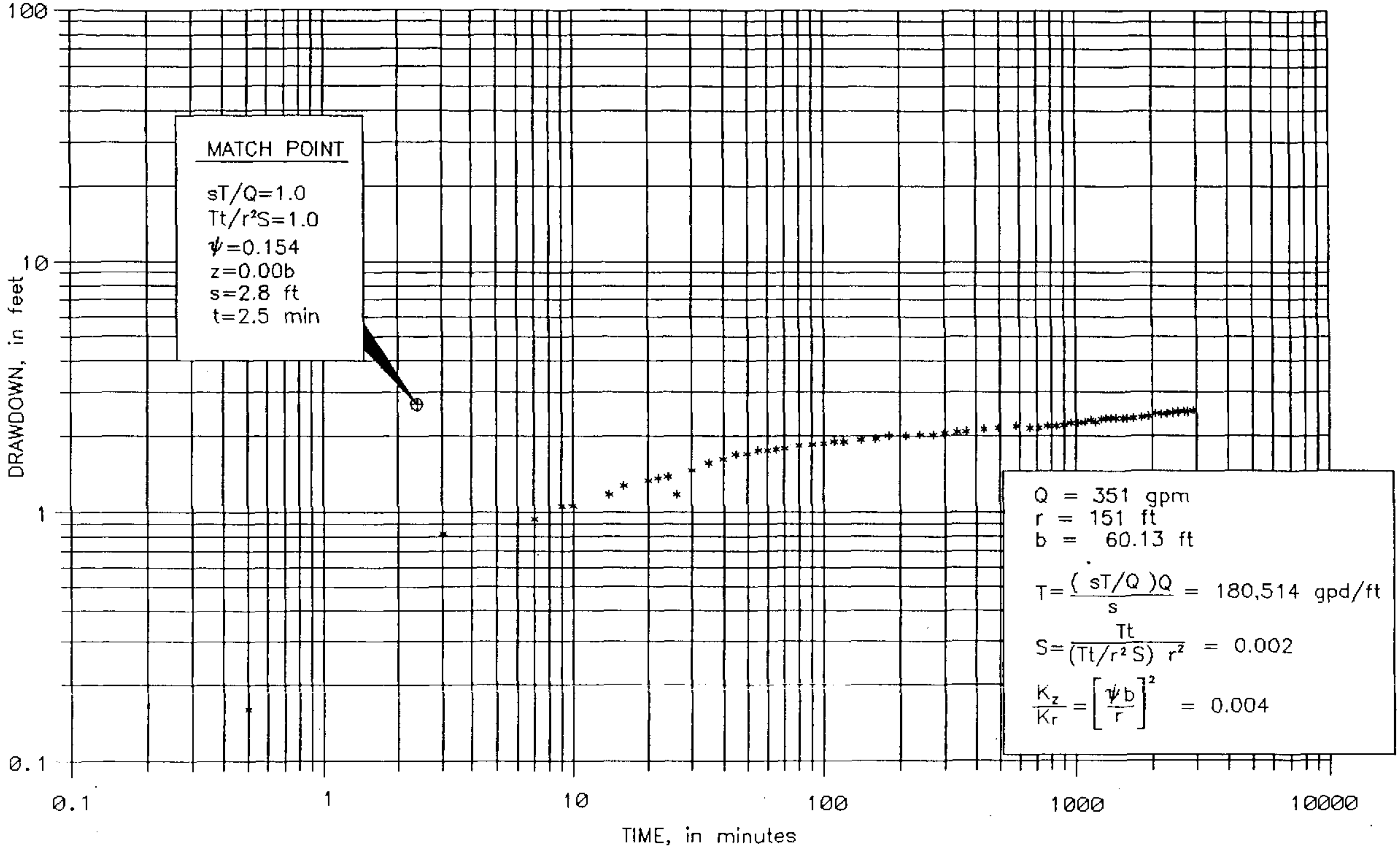
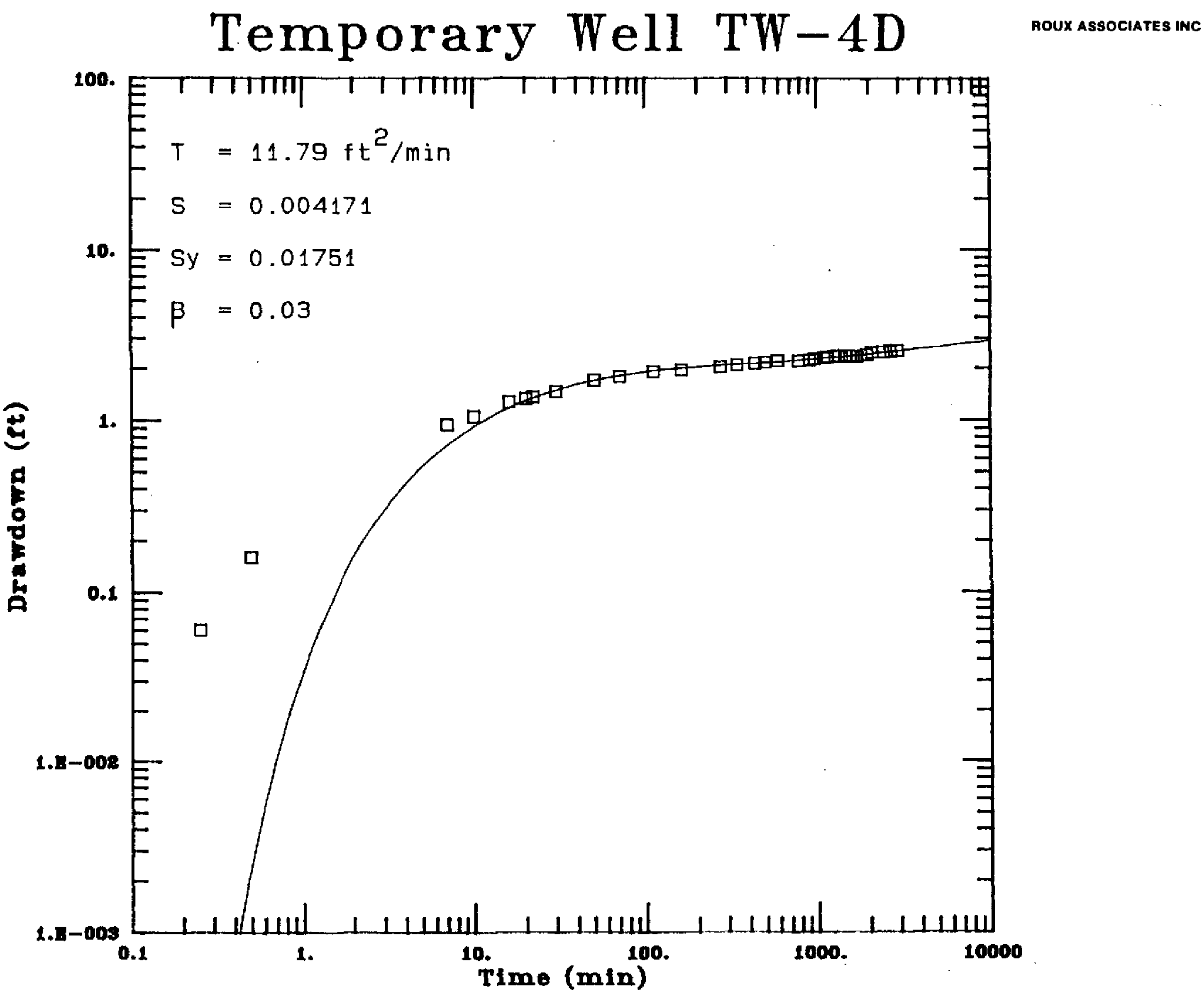


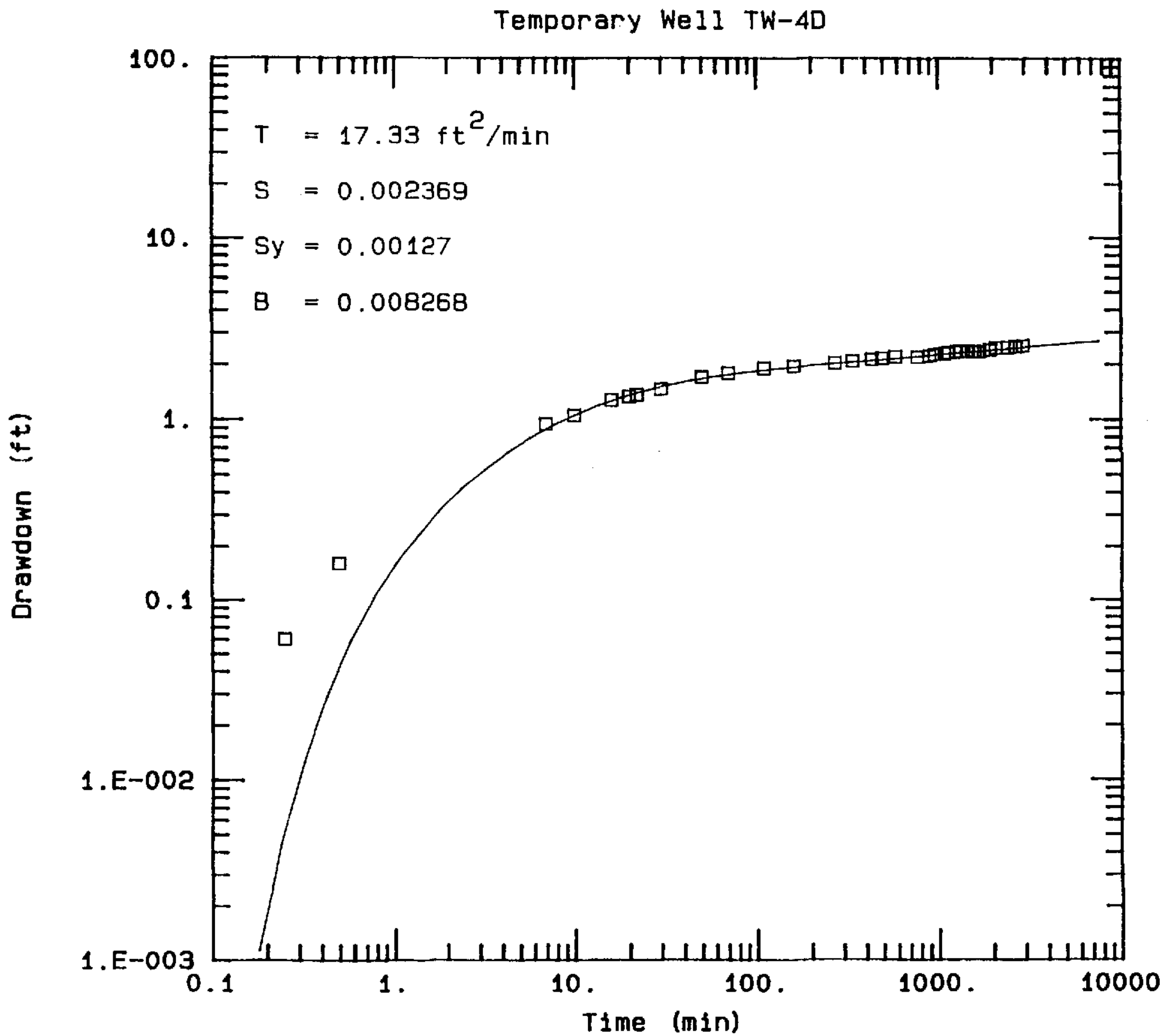
FIGURE 28

ROUX ASSOCIATES INC



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV TYPE CURVE OPTION, FOR TEMPORARY WELL TW-4D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 29



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV PARAMETER ESTIMATION OPTION, FOR TEMPORARY WELL TW-4D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 30

HANTUSH PARTIAL PENETRATION TYPE CURVE FOR TEMPORARY WELL TW-4D
FOR K_r TO K_z RATIO OF 40 TO 1, OCTOBER 30, 1990 THROUGH NOVEMBER 2, 1990
PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

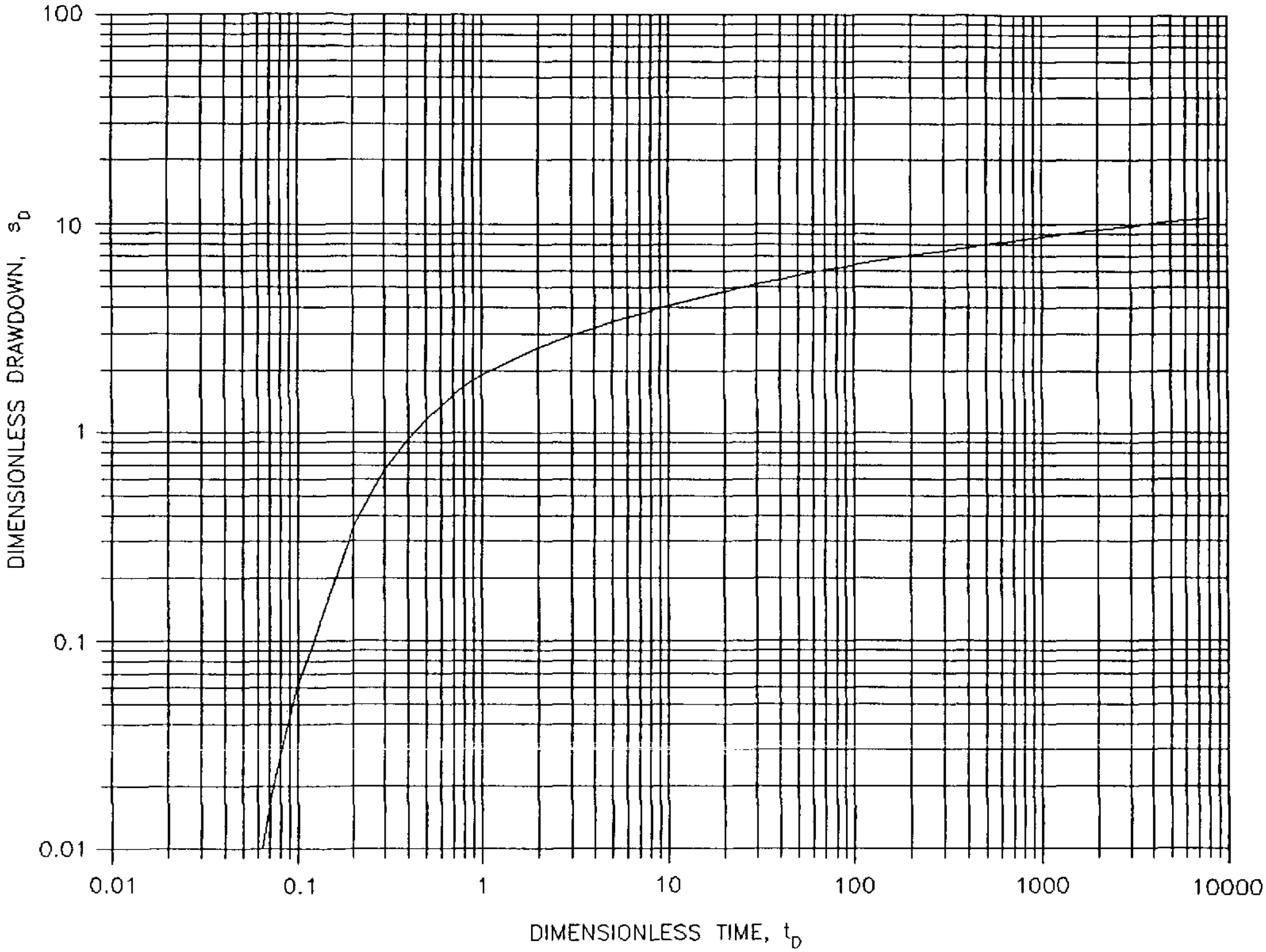


FIGURE 31

ROUX ASSOCIATES INC

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR HANTUSH PARTIAL PENETRATION ANALYSIS, FOR TEMPORARY WELL TW-4D, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

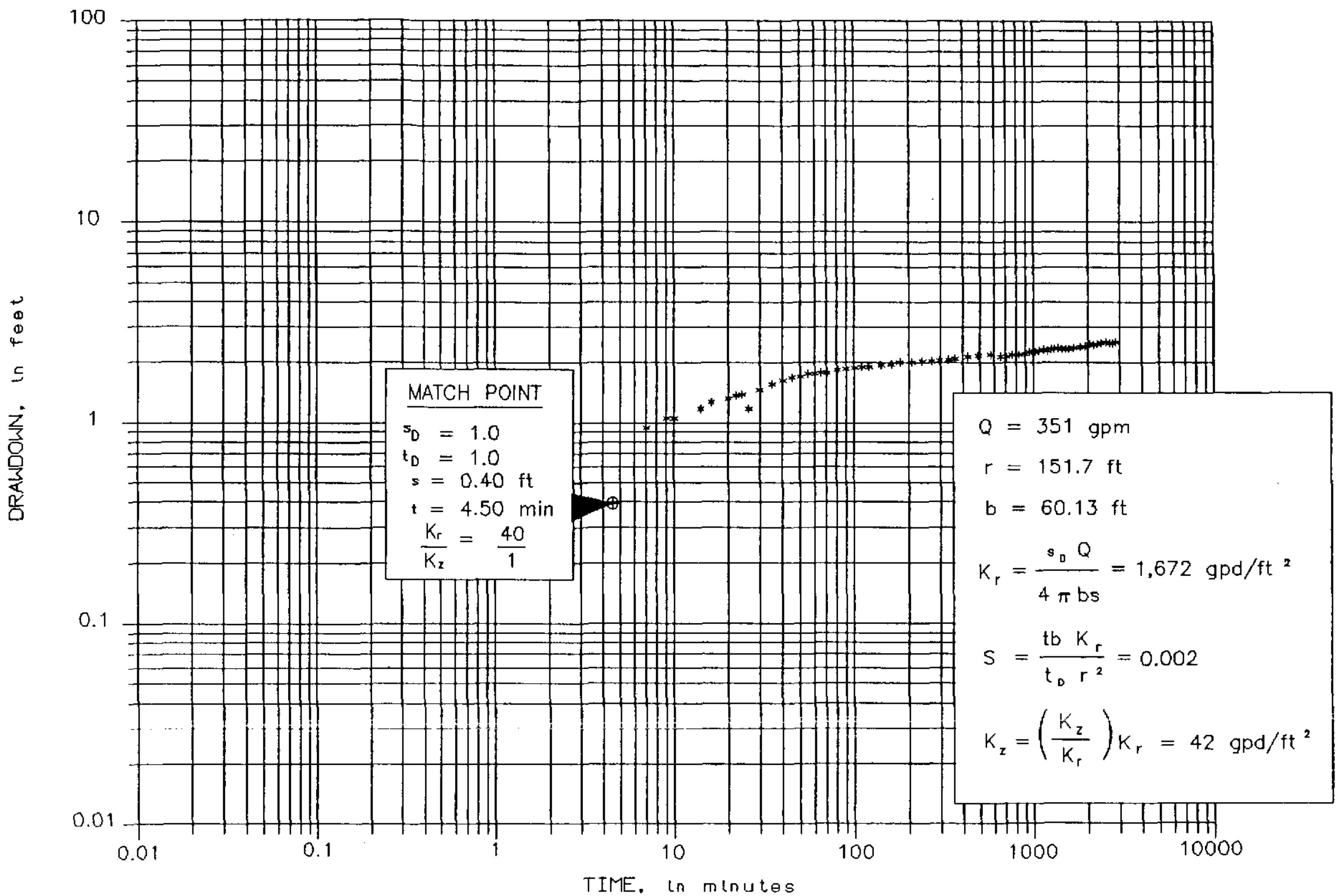
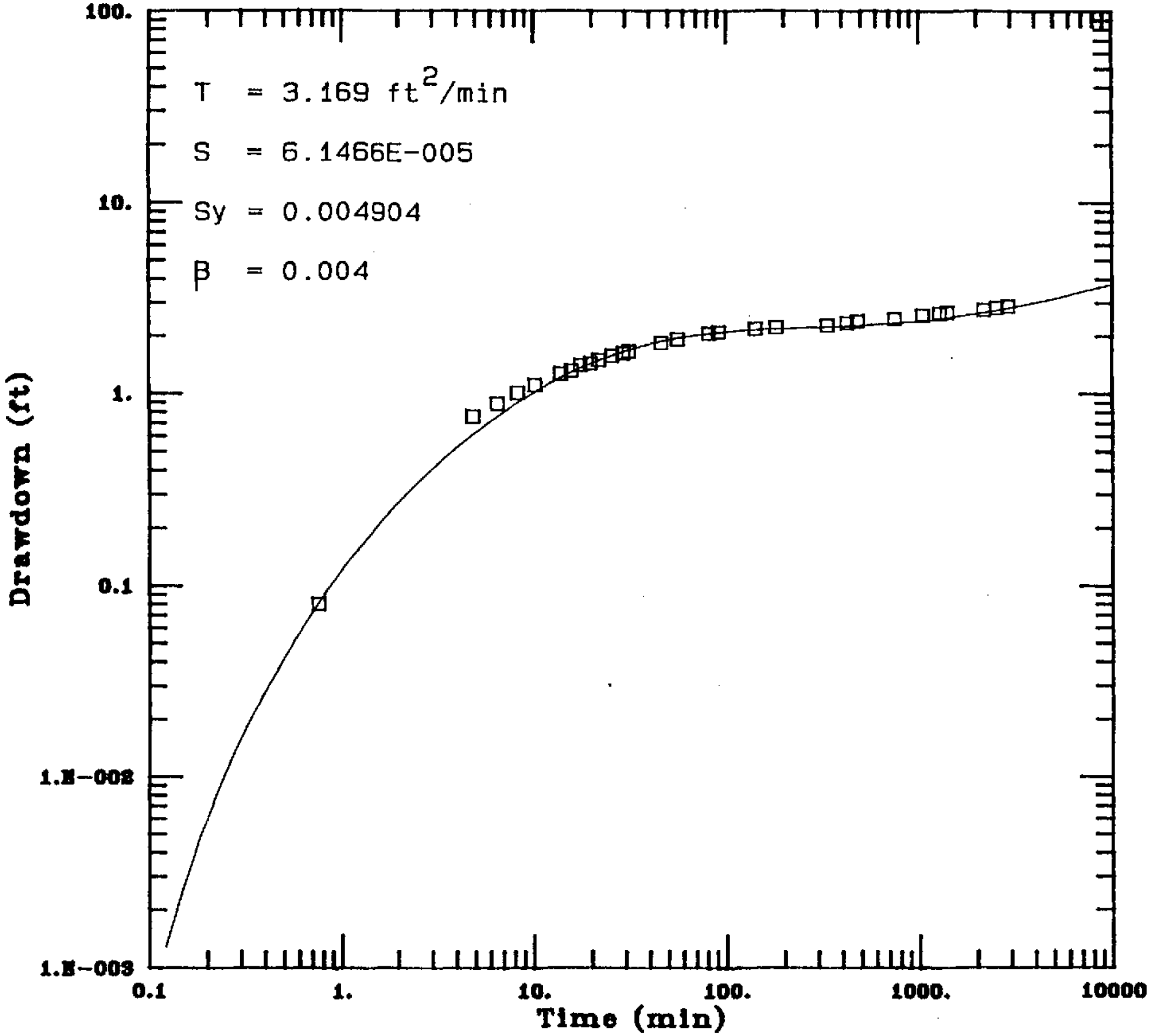


FIGURE 32

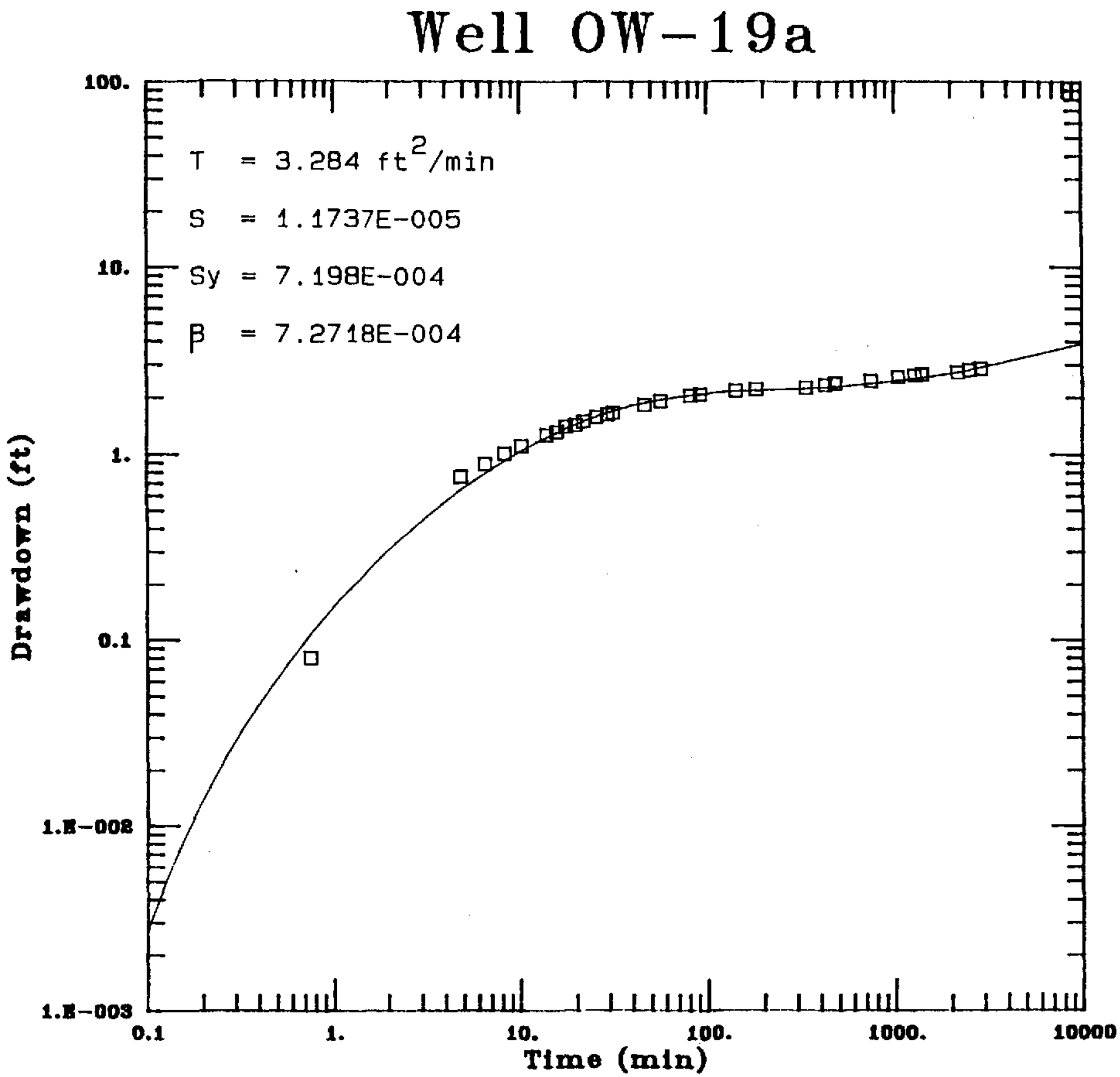
ROUX ASSOCIATES INC

WELL OW-19A



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV TYPE CURVE OPTION, FOR OBSERVATION WELL OW-19A, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 33

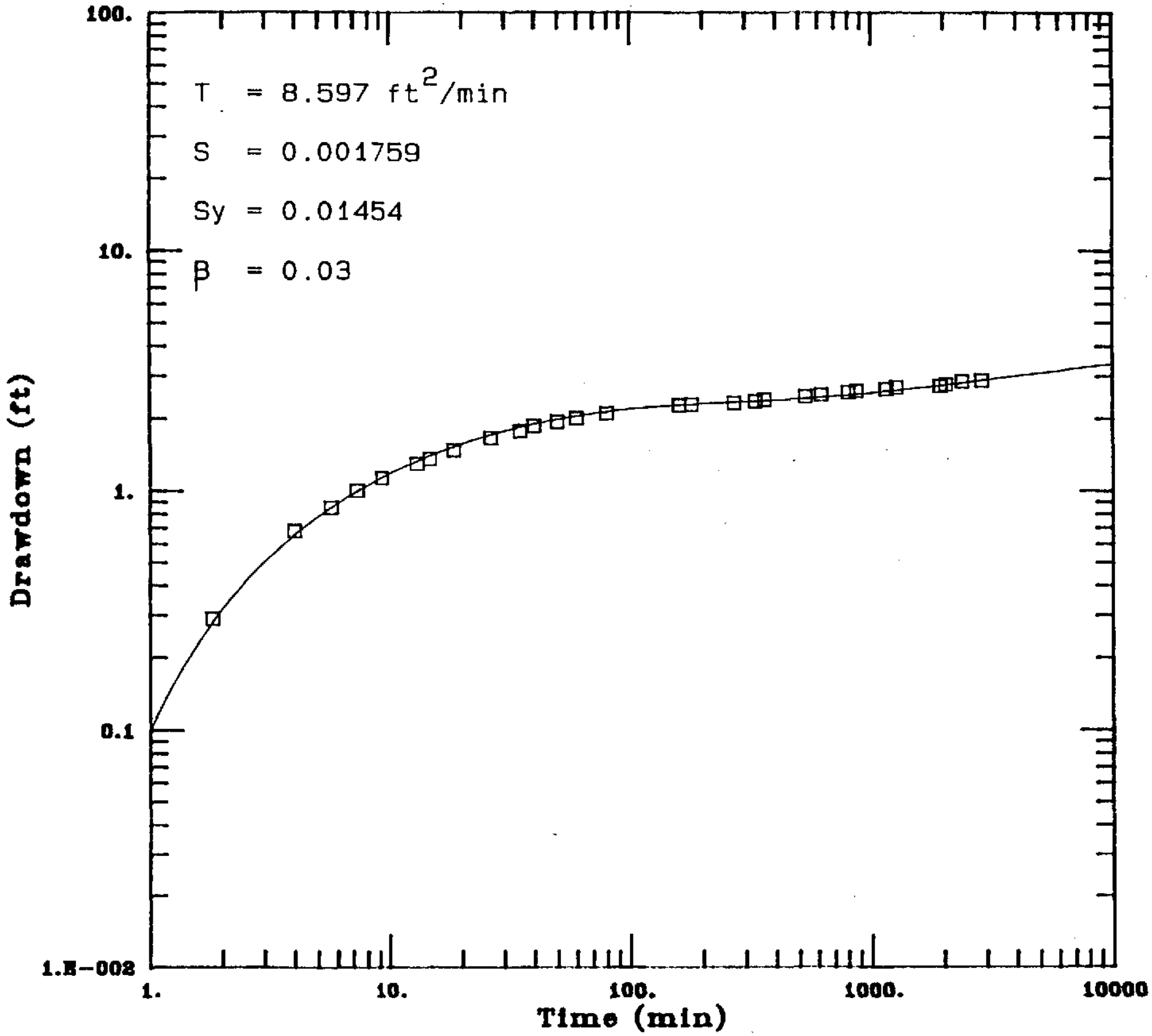


LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV PARAMETER ESTIMATION OPTION, FOR OBSERVATION WELL OW-19A, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 34

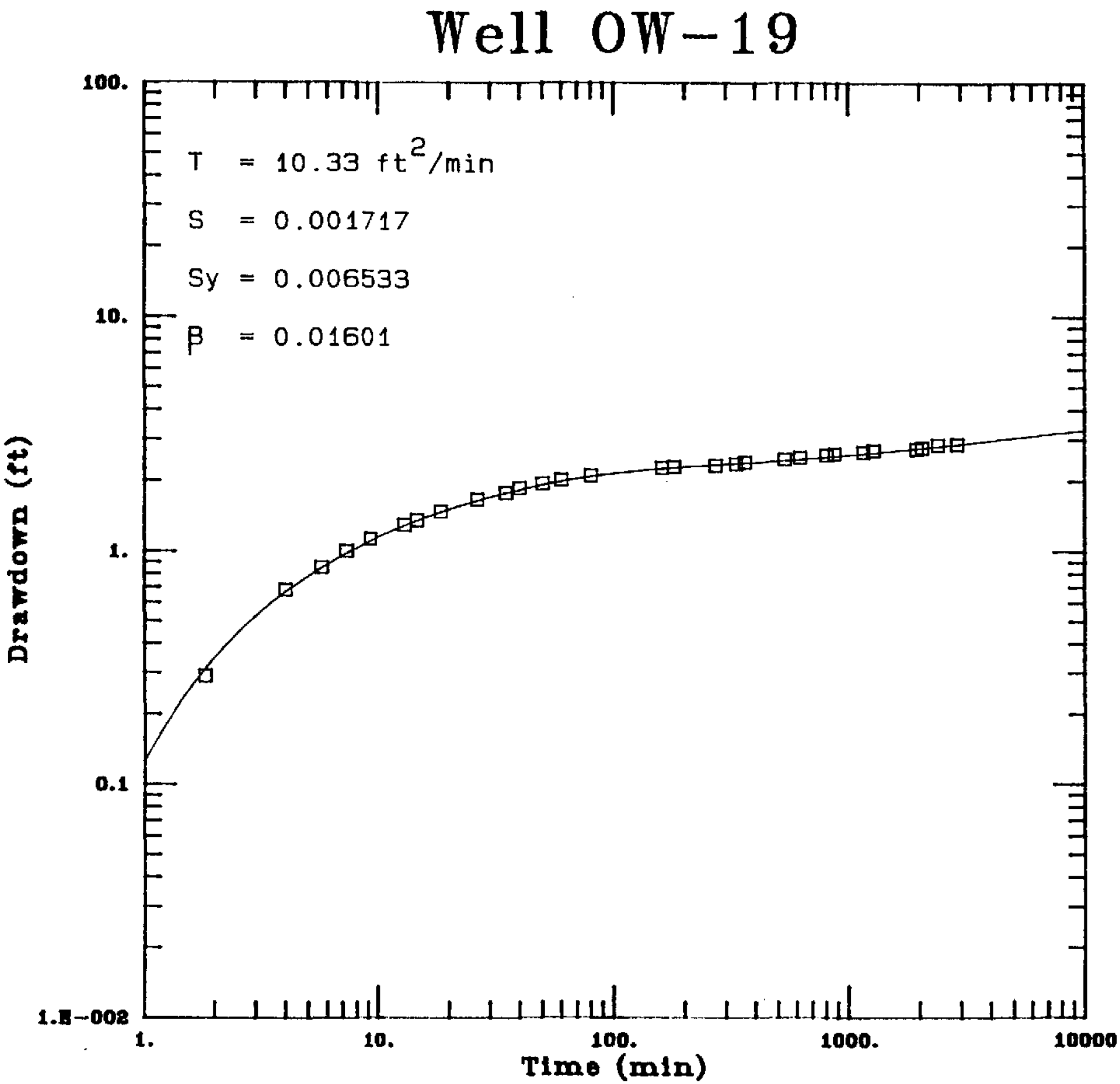
Well OW-19

ROUX ASSOCIATES INC



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV TYPE CURVE OPTION, FOR OBSERVATION WELL OW-19, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN MASSACHUSETTS

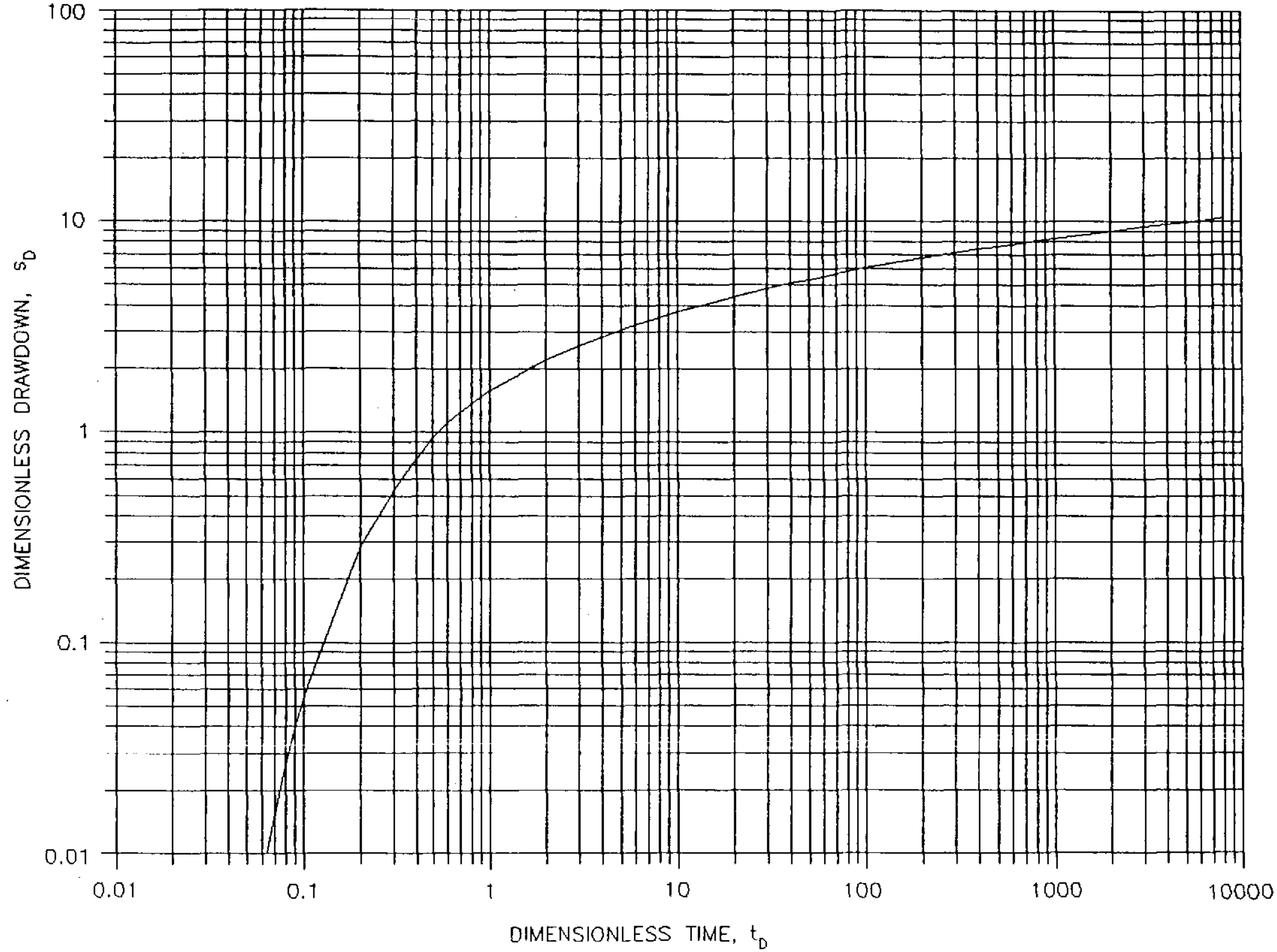
FIGURE 35



LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR NEUMAN PARTIAL PENETRATION ANALYSIS USING AQTESOLV PARAMETER ESTIMATION OPTION, FOR OBSERVATION WELL OW-19, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

FIGURE 36

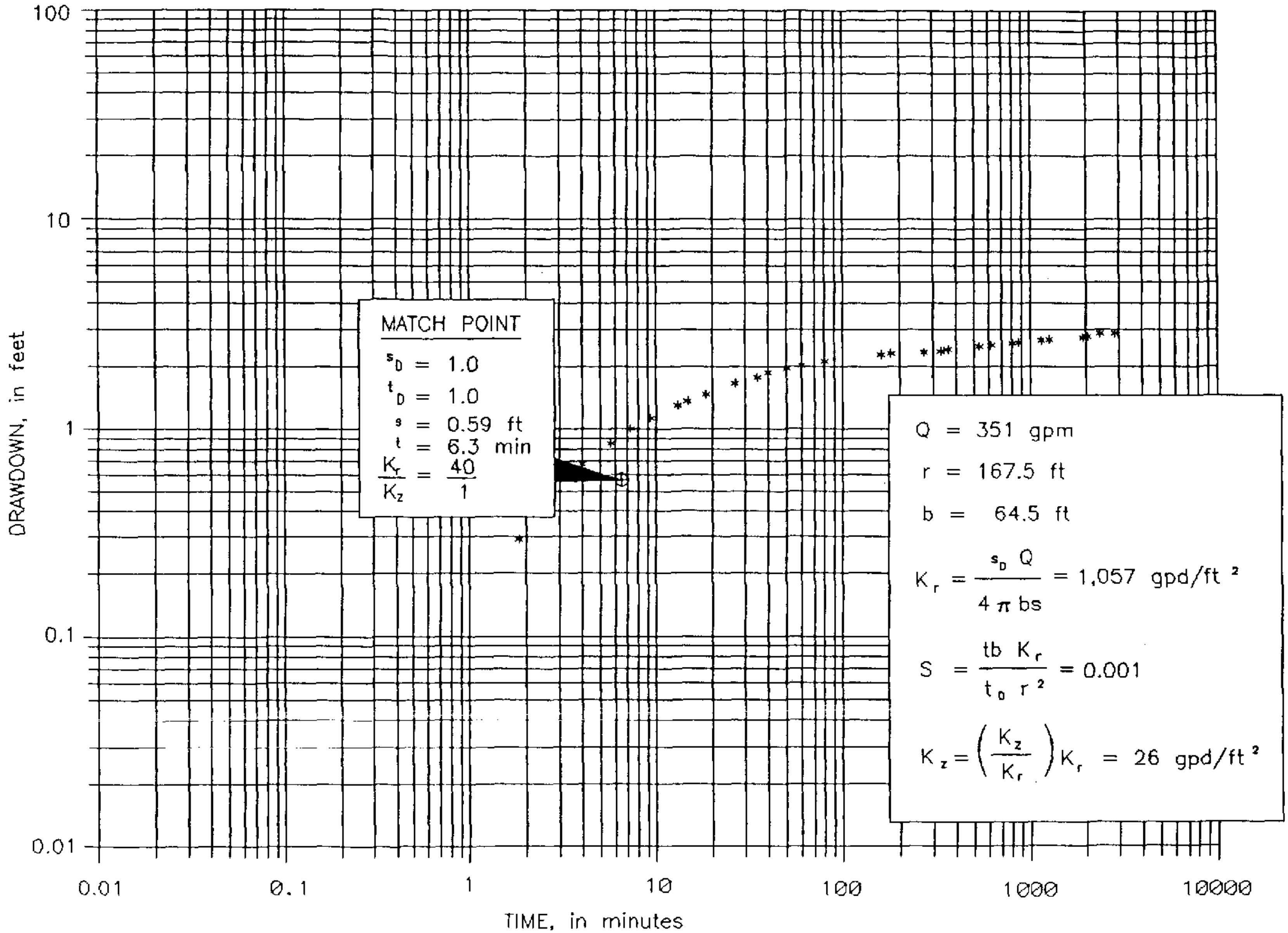
HANTUSH PARTIAL PENETRATION TYPE CURVE FOR OBSERVATION WELL OW-19
FOR K_r TO K_z RATIO OF 40 TO 1, OCTOBER 30, 1990 THROUGH NOVEMBER 2, 1990
PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS



ROUX ASSOCIATES INC

FIGURE 37

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR HANTUSH PARTIAL PENETRATION ANALYSIS FOR OBSERVATION WELL OW-19, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS



ROUX ASSOCIATES INC

FIGURE 38

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR TEMPORARY WELL TW-5,
OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST,
INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

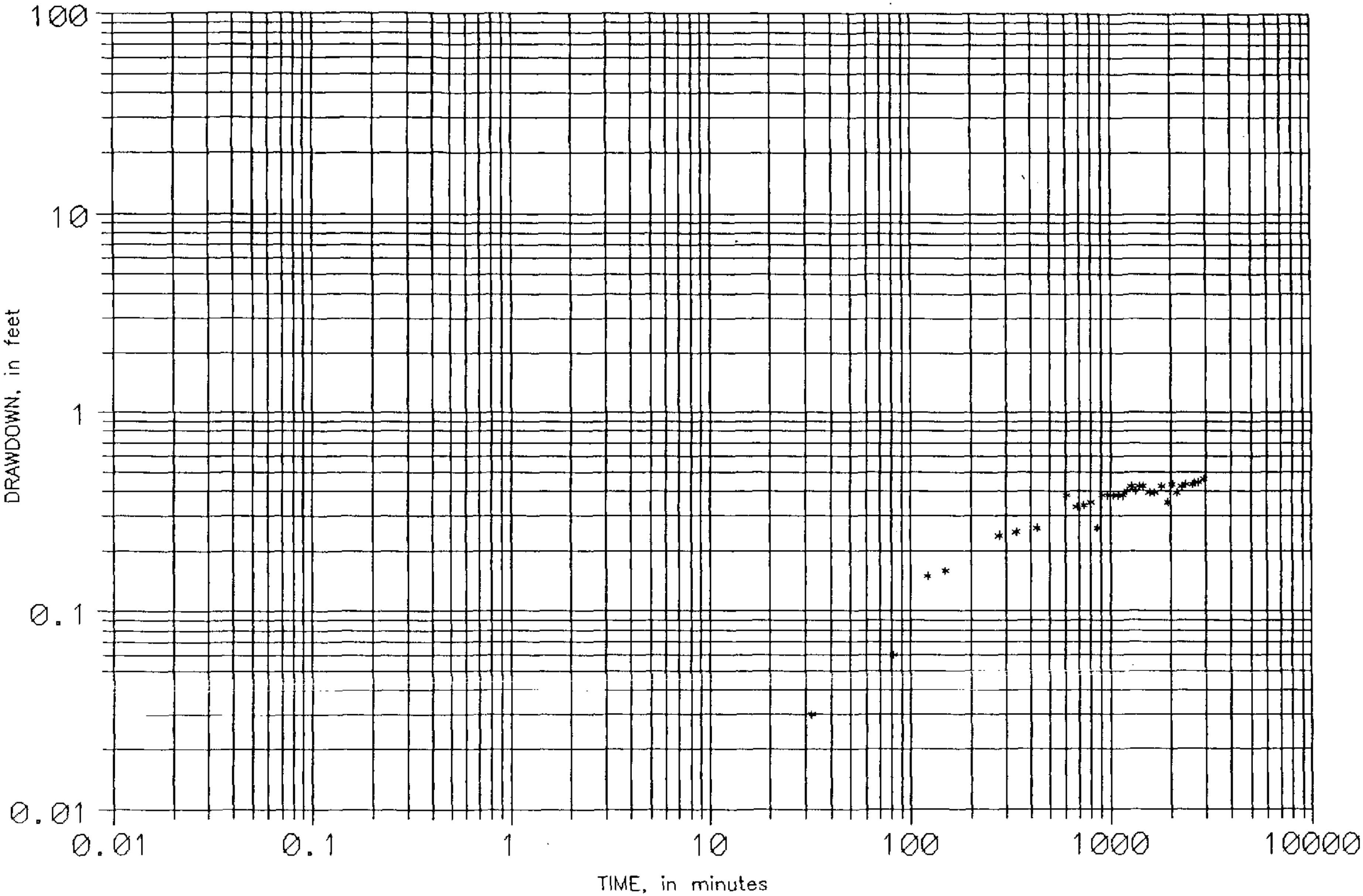


FIGURE 39

ROUX ASSOCIATES INC

PLOT OF TIME VERSUS WATER-LEVEL ELEVATIONS IN HALL'S BROOK,
OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST,
INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

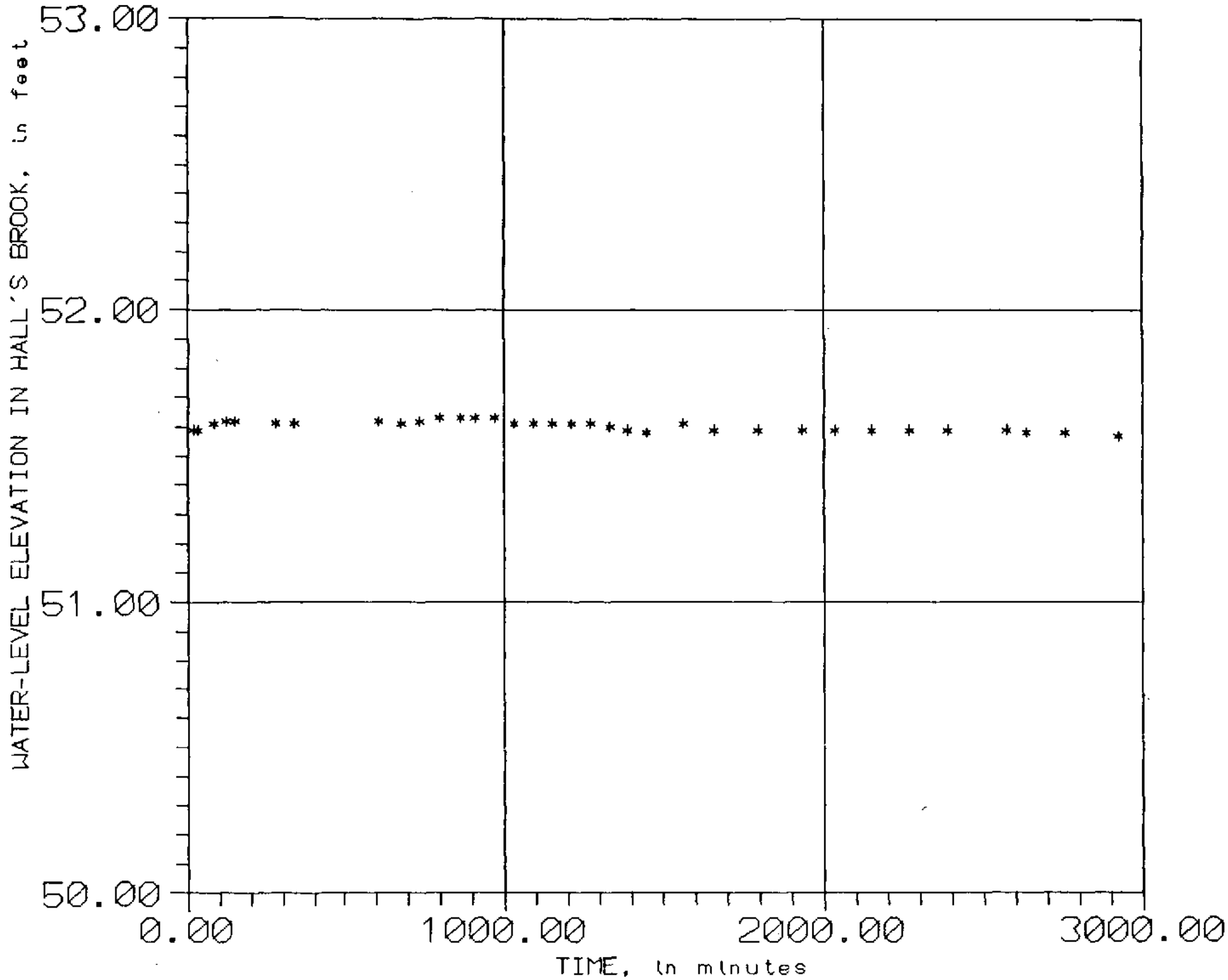
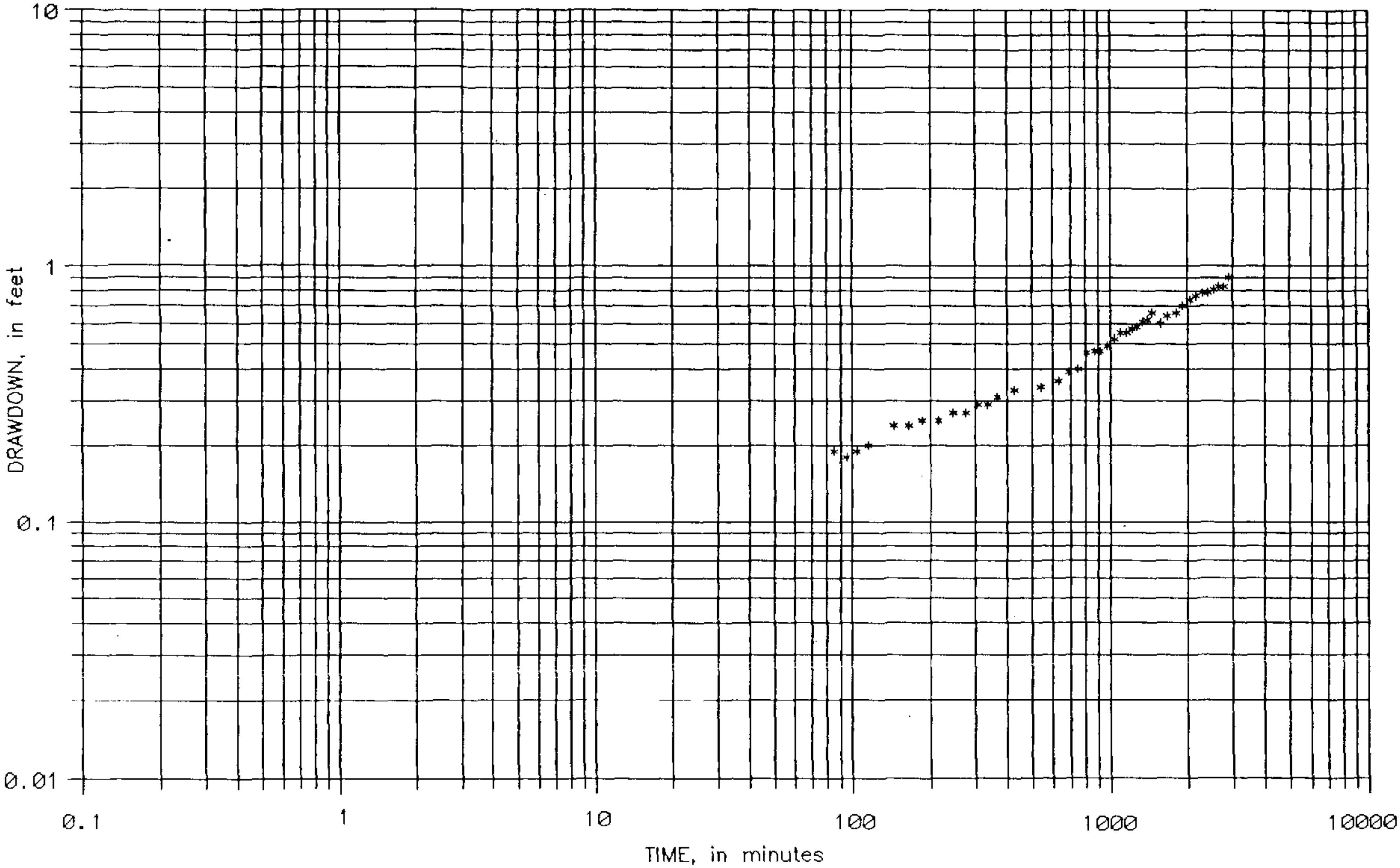


FIGURE 40

ROUX ASSOCIATES INC

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR OBSERVATION WELL OW-24A, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS



ROUX ASSOCIATES INC

FIGURE 41

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR OBSERVATION WELL OW-24B, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST, INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

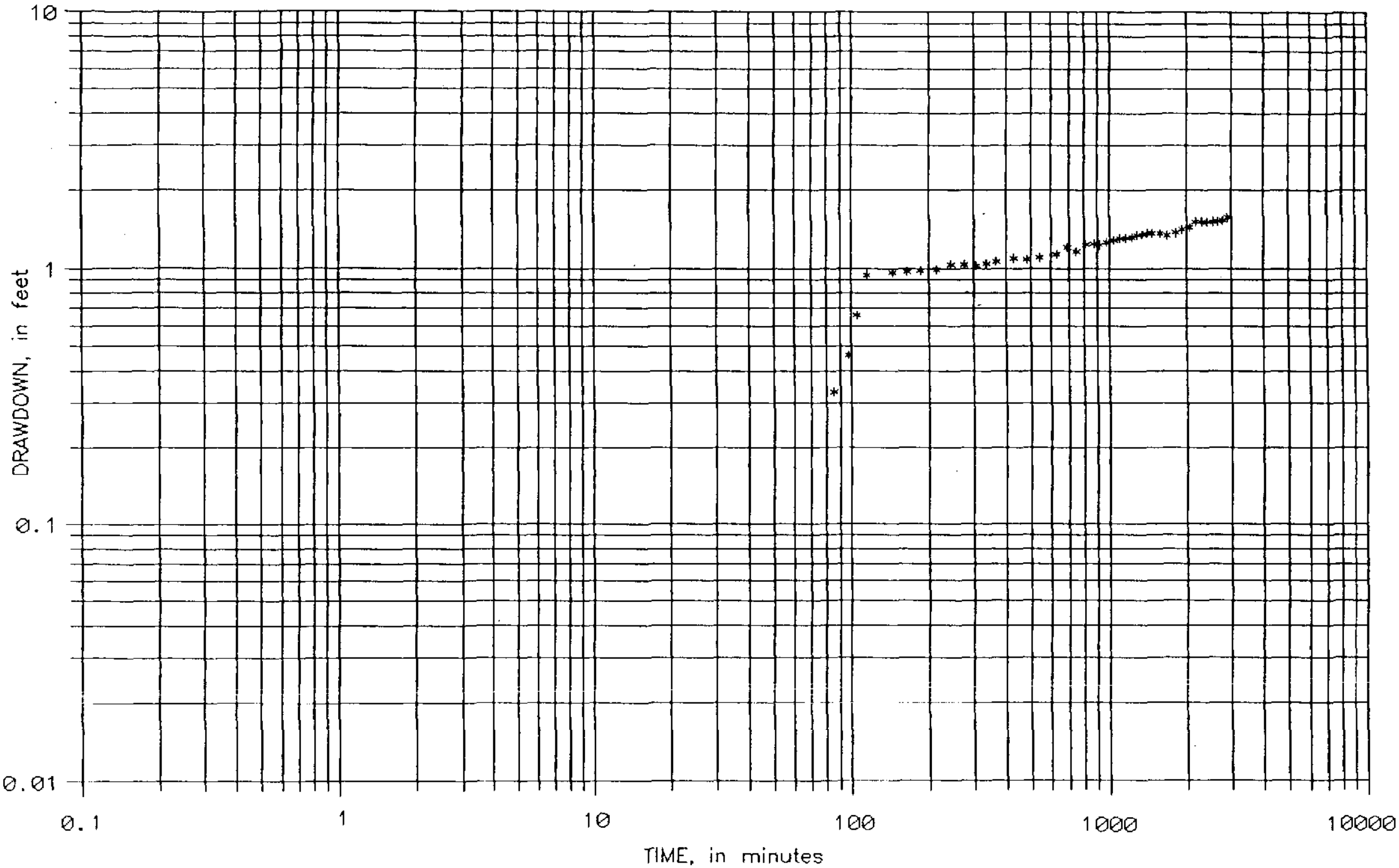


FIGURE 42

ROUX ASSOCIATES INC

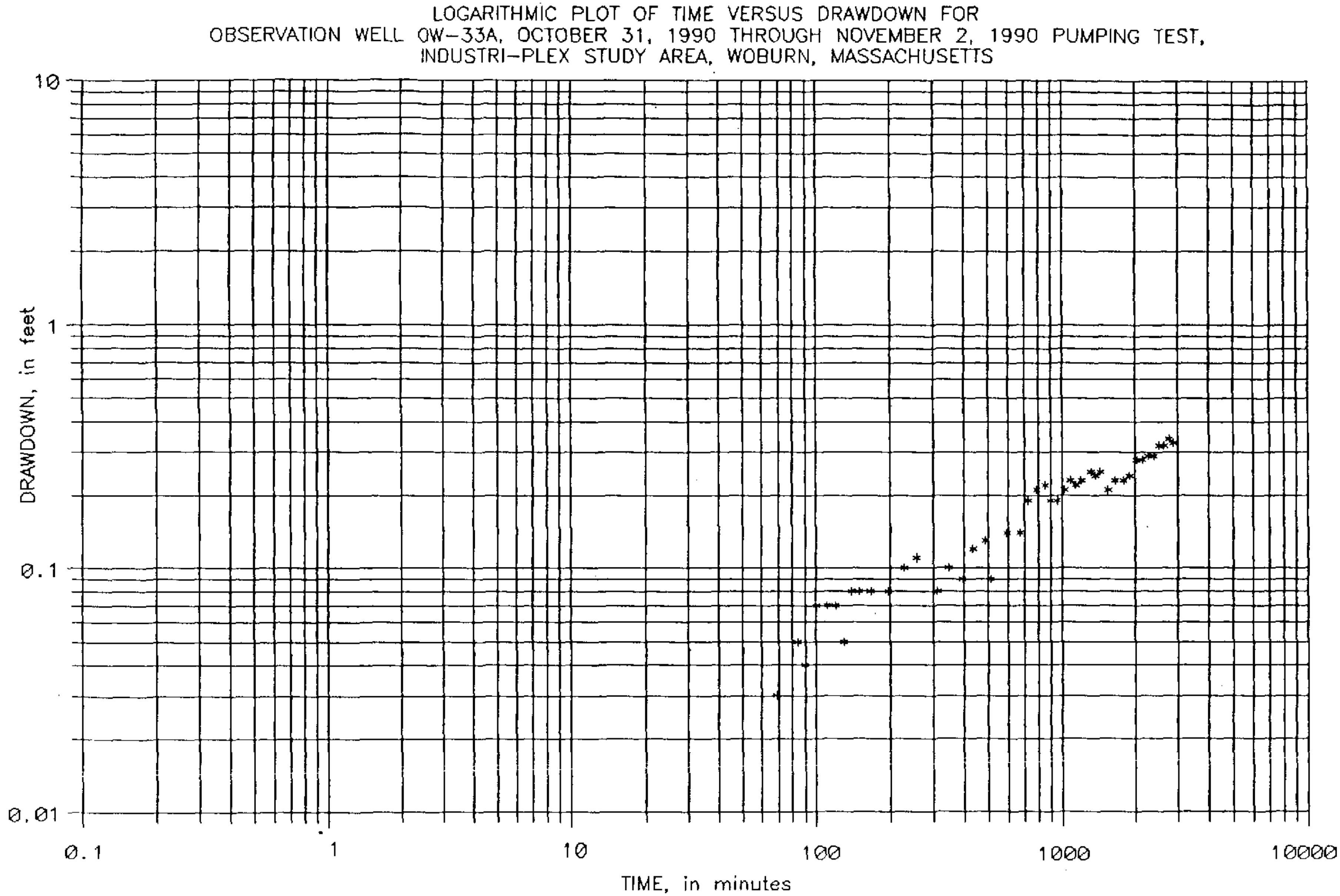


FIGURE 43

ROUX ASSOCIATES INC

LOGARITHMIC PLOT OF TIME VERSUS DRAWDOWN FOR
OBSERVATION WELL OW-33B, OCTOBER 31, 1990 THROUGH NOVEMBER 2, 1990 PUMPING TEST,
INDUSTRI-PLEX STUDY AREA, WOBURN, MASSACHUSETTS

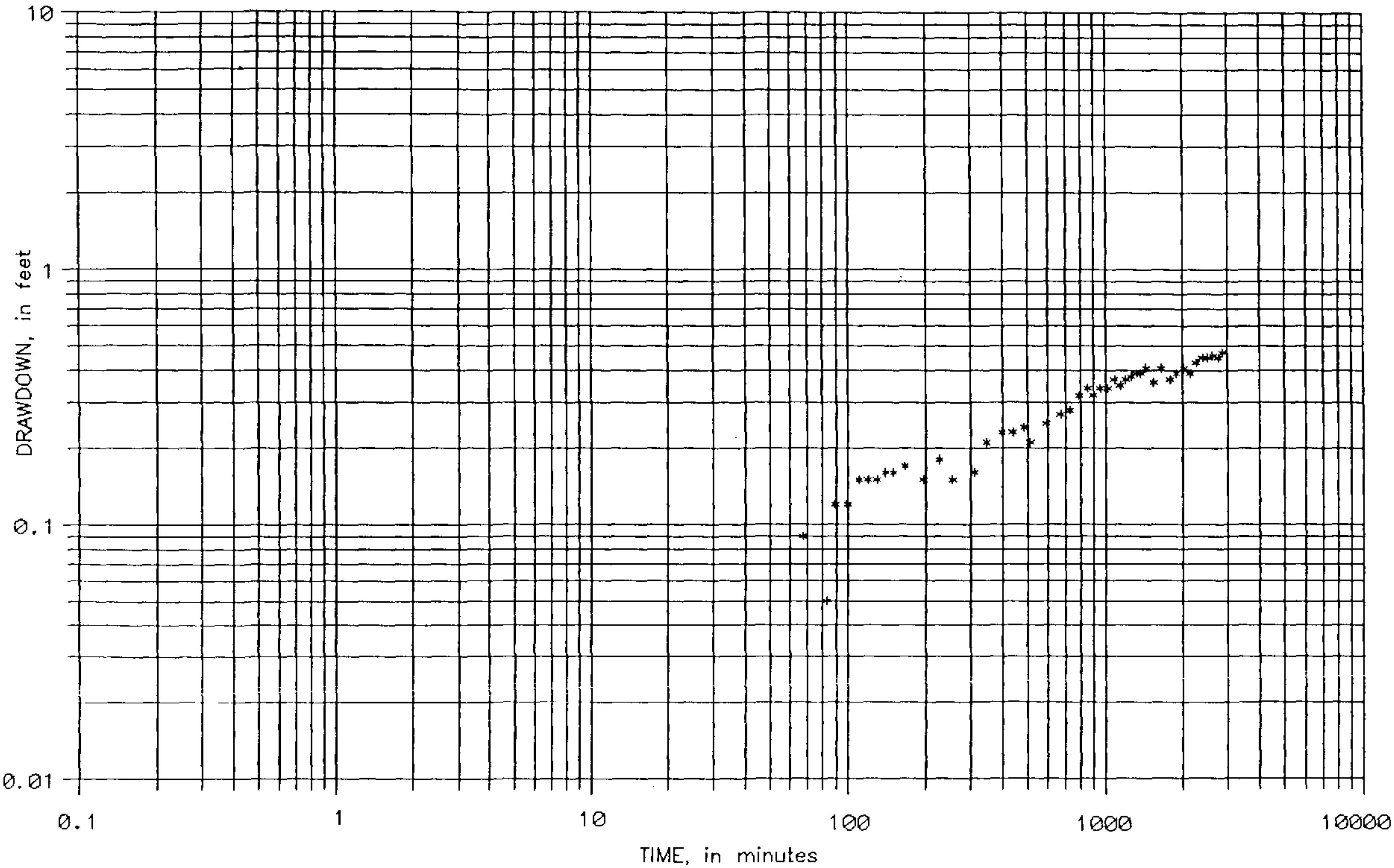
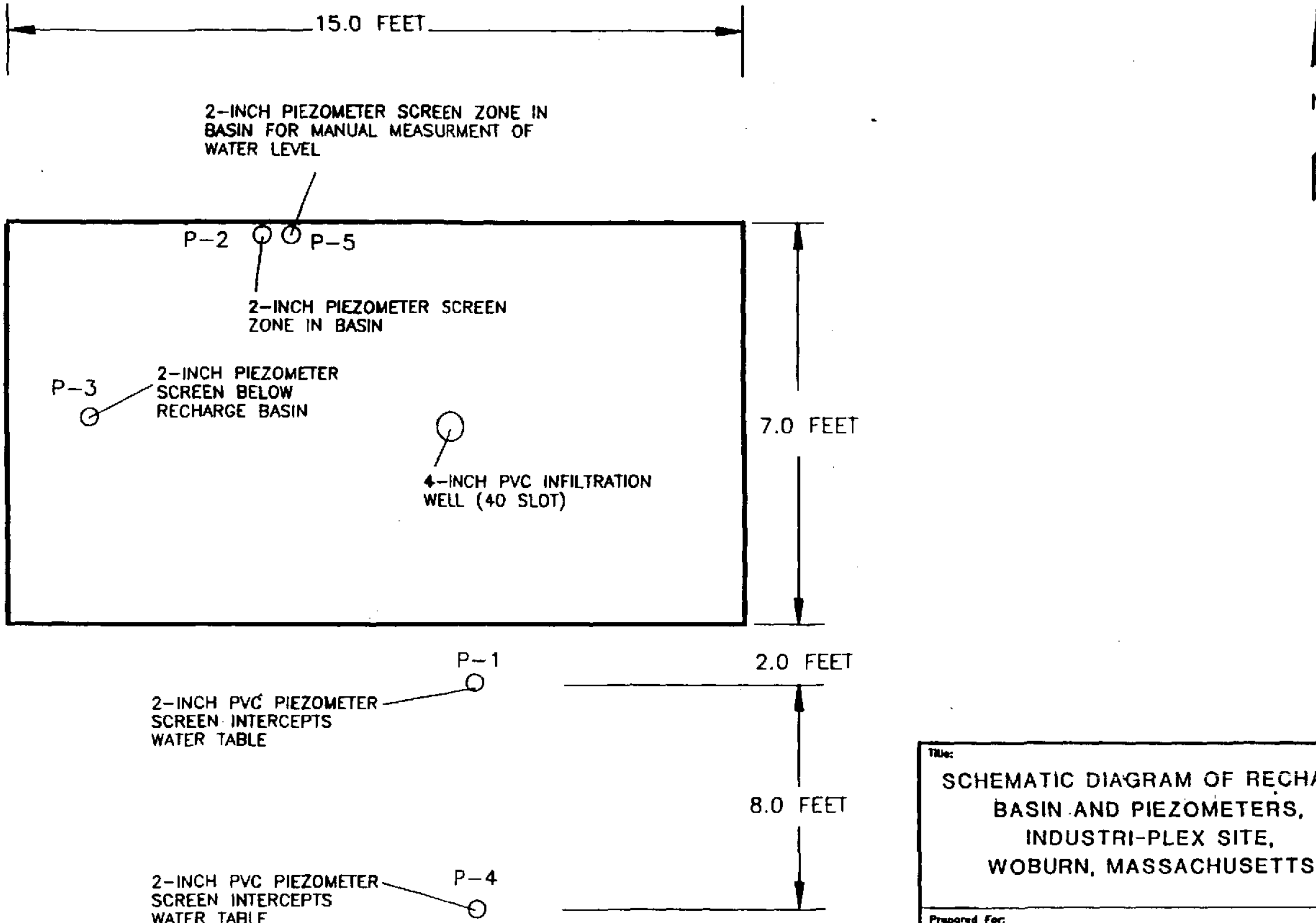


FIGURE 44

ROUX ASSOCIATES INC



Title:

SCHEMATIC DIAGRAM OF RECHARGE BASIN AND PIEZOMETERS, INDUSTRI-PLEX SITE, WOBURN, MASSACHUSETTS

Prepared For:
INDUSTRI-PLEX SITE REMEDIAL TRUST

ROUX
ROUX ASSOCIATES INC
Consulting Ground-Water Geologists & Engineers

Compiled by: B.T.	Date: 11/90	FIGURE
Prepared by: C.L.	Scale: SHOWN	45
Project Mgr: W.S.	Revision:	
File No: 16101RBP		

FIGURE 46 - PLOT OF TIME VERSUS GROUND-WATER ELEVATION AND PUMPING RATE FOR PIEZOMETER P-1, NOVEMBER 6, 1990 THROUGH NOVEMBER 9, 1990 RECHARGE TEST, INDUSTRI-PLEX SITE, WOBURN, MASSACHUSETTS

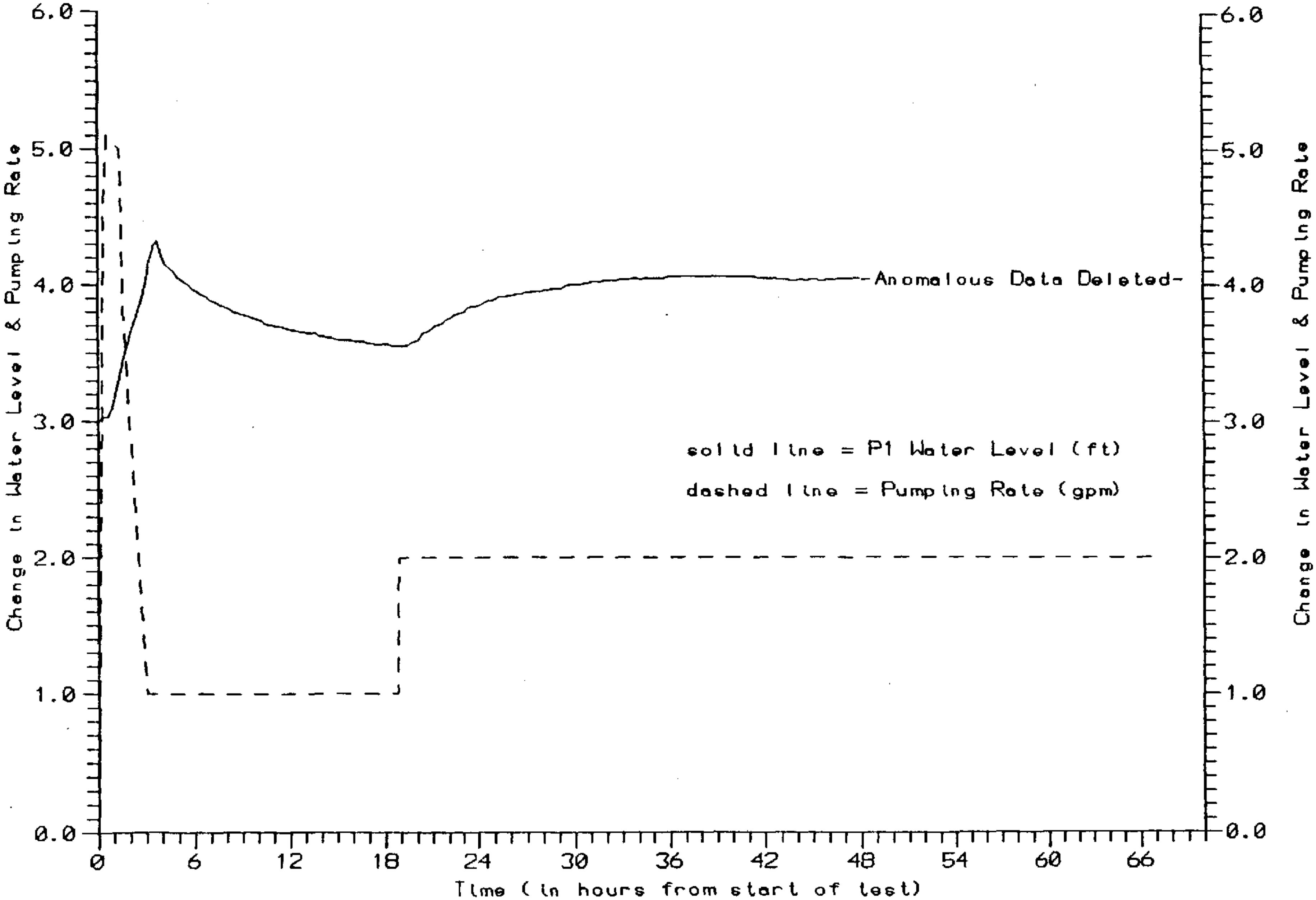


FIGURE 47 - PLOT OF TIME VERSUS GROUND-WATER ELEVATION AND PUMPING RATE FOR PIEZOMETER P-2, NOVEMBER 6, 1990 THROUGH NOVEMBER 9, 1990 RECHARGE TEST, INDUSTRI-PLEX SITE, WOBURN, MASSACHUSETTS

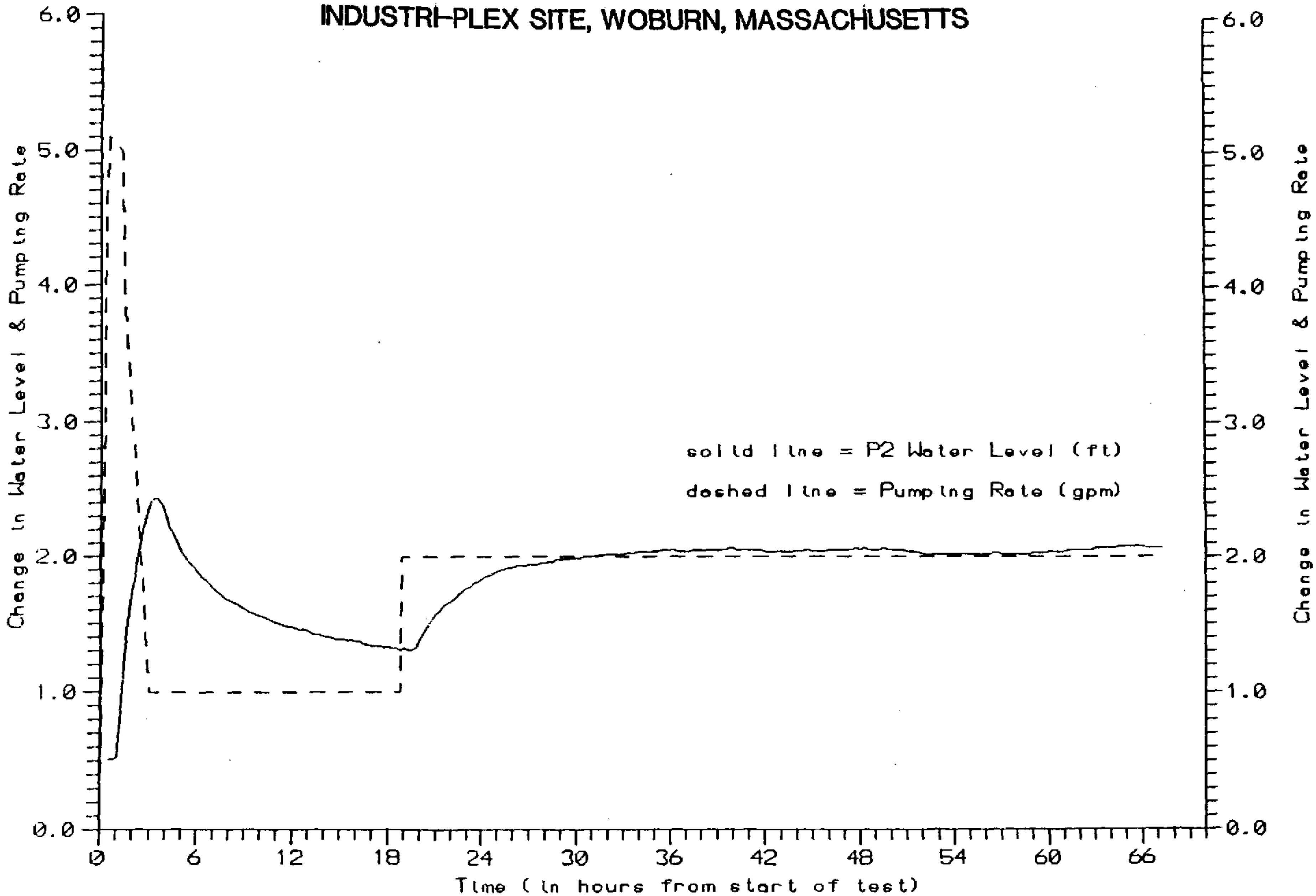


FIGURE 48 – PLOT OF TIME VERSUS GROUND-WATER ELEVATION AND PUMPING RATE FOR PIEZOMETER P-3, NOVEMBER 6, 1990 THROUGH NOVEMBER 9, 1990 RECHARGE TEST, INDUSTRI-PLEX SITE, WOBURN, MASSACHUSETTS

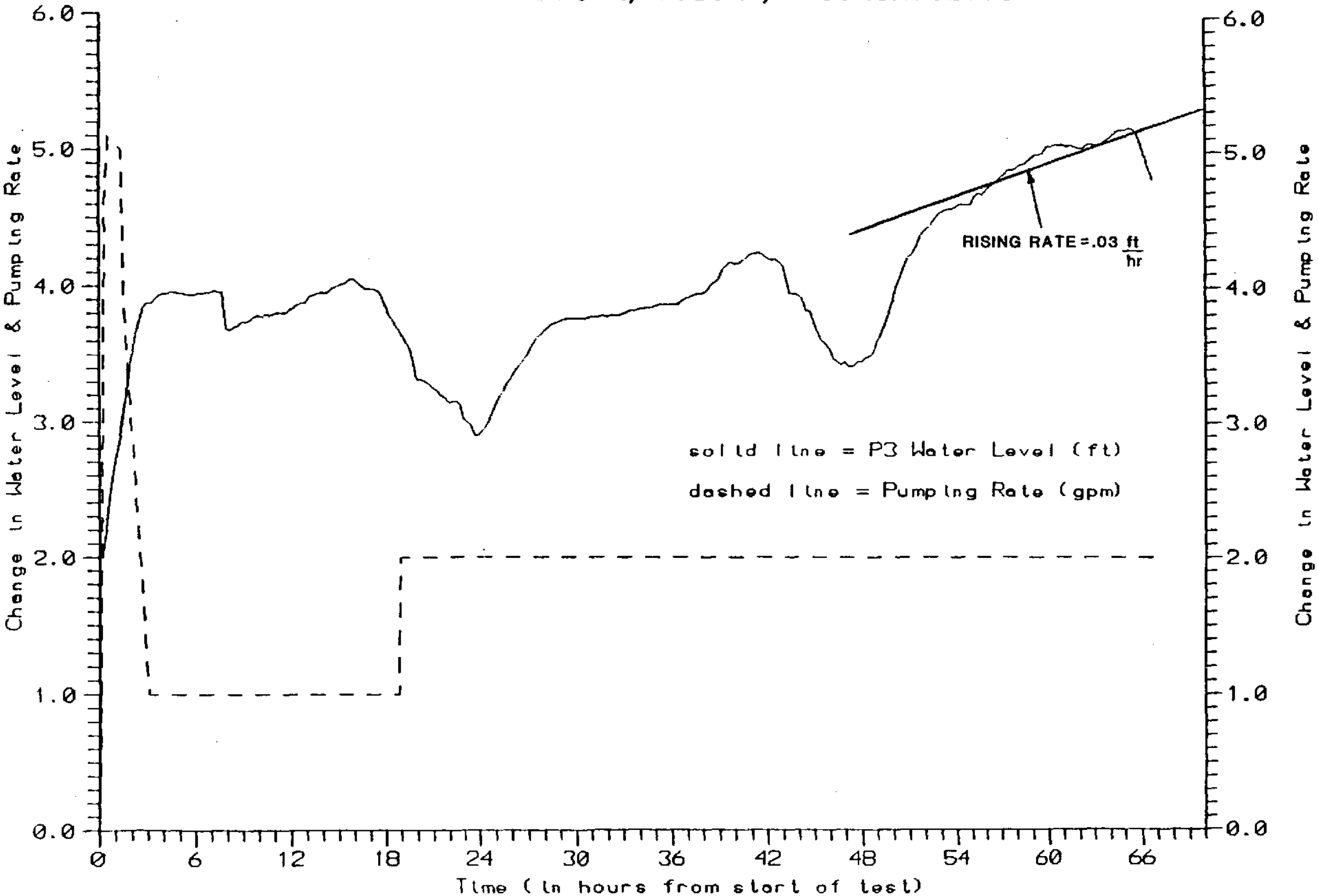
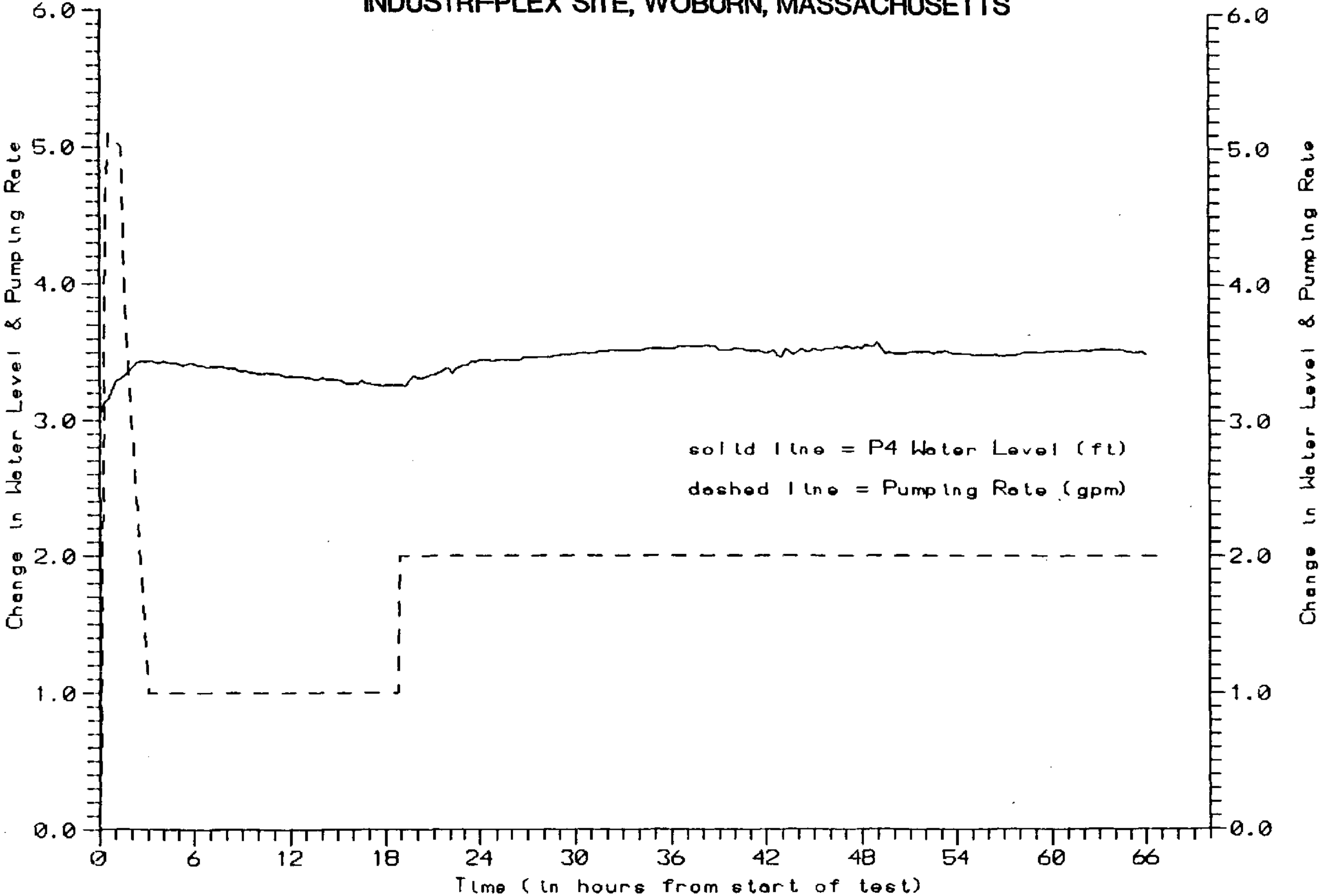


FIGURE 49 - PLOT OF TIME VERSUS GROUND-WATER ELEVATION AND PUMPING RATE FOR PIEZOMETER P-4, NOVEMBER 6, 1990 THROUGH NOVEMBER 9, 1990 RECHARGE TEST, INDUSTRI-PLEX SITE, WOBURN, MASSACHUSETTS



APPENDICES

APPENDIX A

Geologic Log of Temporary Well TW-1D

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No.	16101Y
Date	
Project	IndustriPlex Site PDI
Client	Golder Associates, Inc.
Page	1 Of 1
Logged By	B. Thomas
Well No.	TW-1S
Loc.	Woburn, MA
M.P. Elevation	(3) 56.59'
Drilling Started	10/5/90
Ended	10/5/90
Driller	D.L. Maher
Type Of Rig	Hollow Stem Auger

WELL DATA

Hole Diam. (in.)	6"
Final Depth (ft.)	32
Casing Diam. (in.)	2"
Casing Length (ft.)	28.75
Screen Setting (ft.)	26.31-31.31
Screen Slot & Type	10 slot PVC
Well Status	

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T

SAMPLER

Type	Not Applicable
Hammer	N/A lb.
Fall	N/A in.

DEVELOPMENT

HNU	SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
							See log of TW-1D

REMARKS: (1) in feet relative to a common datum (3) in feet above mean sea level
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No. 16101Y   Date 11/5/90
Project IndustriPlex Site PDI
Client Golder Associates, Inc.
Page 1 Of 3
Logged By B. Thomas
Well No. TW-1D
Loc. Woburn, MA
M.P. Elevation (3) 56.44'
Drilling Started 10/1/90   Ended 10/2/90
Driller D.L. Maher
Type Of Rig Hollow Stem Auger

WELL DATA

Hole Diam. (in.) 6"
Final Depth (ft.) 60
Casing Diam. (in.) 2"
Casing Length (ft.) 57.5
Screen Setting (ft.) 55-60
Screen Slot & Type 10 slot PVC
Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T.

SAMPLER

Type Splitspoon
Hammer 140 lb.
Fall 30 in.

DEVELOPMENT

HNU	SAMPLE No.	Rec.	Depth (ft.)	Blows / 6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
0		1.6	0-2'	2,4,8,10	SW	0	Brown medium SAND, well sorted.
0		1.4	5-7'	14,19,20,21	SP	5	Top 1.1': Grey fine(+) to medium SAND, some coarse gravel. poorly sorted. Bottom 0.3': Brown medium sand and gravel; wet.
0		0.8	10-12'	12,12,12,20	GP	10	Brown fine to coarse GRAVEL and fine to medium sand poorly sorted.
0		0.5	15-17'	8,62,41,35	SP	15	Brown medium to coarse SAND, little coarse gravel; pushed a cobble.
1.8		1.0	20-22'	5,4,8,9	SP	20	Brown medium to coarse(+) SAND some (-) fine to coarse gravel.
1.0		0.8	25-27'	5,17,4,9	SP	25	Brown medium sand and coarse gravel, little fine sand; poorly sorted.
0		1.2	30-32'	50,40,19,7	GW	30	Fine-coarse(+) GRAVEL, little coarse Sand.

REMARKS: (1) in feet relative to a common datum (3) in feet above mean sea level
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No. 16101Y Date 11/5/90
Project IndustriPlex Site PDI
Client Golder Associates, Inc
Page 2 Of 3
Logged By B. Thomas
Well No. TW-1D
Loc. Woburn, MA
M.P. Elevation (3) 56.44'
Drilling Started 10/1/90 Ended 10/2/90
Driller D.L. Maher
Type Of Rig Hollow Stem Auger

WELL DATA

Hole Diam. (in.) 6"
Final Depth (ft.) 60.0
Casing Diam. (in.) 2"
Casing Length (ft.) 57.5
Screen Setting (ft.) 55-60
Screen Slot & Type 10 slot PVC
Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T

SAMPLER

Type Splitspoon
Hammer 140 lb.
Fall 30 in.

DEVELOPMENT

HNU	SAMPLE No.	Rec.	Depth (ft.)	Blows / 6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
0		0.7	35-37'	30,35,20,9	SP	35	Brown coarse Sand and coarse gravel; subangular gravel.
0		0.8	40-42'	30,35,20,9	SP	40	Brown fine(+) to medium SAND and fine gravel, trace silt poorly sorted; tight.
0		0.9	45-47'	4,7,10,10	GW	45	Brown fine(+) to coarse GRAVEL, some fine to coarse Sand; coarsening downward.
0		1.4	50-52'	7,5,13,38	GP SW	50	Fine to coarse GRAVEL, some fine to medium Sand; fining downward to fine to meduium SAND.
0		2.0	55-57'	21,20,15,35	GW SP	55	Top 0.5':fine GRAVEL, little coarse Sand. Middle 0.9':fine to coarse SAND,some fine to coarse gravel, little silt. Bottom 0.6':Orange to brown to grey fine to medium SAND, some coarse gravel.
0		1.0	60-62'	7,15,19,85	SP SMd SMu	60	Brown fine to meduium SAND, some fine gravel. Bottom 0.7': Brown fine sand and coarse gravel, some silt; tight.

REMARKS: (1) in feet relative to a common datum (3) in feet above mean sea level
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No. 16101Y Date 11/5/90
Project IndustriPlex Site PDI
Client Golder Associates, Inc.
Page 3 Of 3
Logged By B. Thomas
Well No. TW-1D
Loc. Woburn, MA
M.P. Elevation (3) 56.44'
Drilling Started 10/1/90 Ended 10/2/90
Driller D.L. Maher
Type Of Rig Hollow Stem Auger

WELL DATA

Hole Diam. (in.) 6"
Final Depth (ft.) 60
Casing Diam. (in.) 2"
Casing Length (ft.) 57.5
Screen Setting (ft.) 55-60
Screen Slot & Type 10 slot PVC
Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T.

SAMPLER

Type Splitspoon
Hammer 140 lb.
Fall 30 in.

DEVELOPMENT

HNU	SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
0		1.0	65-67'	4,32,27,50	SM_u^d	65	Brown fine(+) to medium Sand and coarse gravel, some silt, tight, poorly sorted.
0		0.9	70-72'	12,25,50,50	SM_u^d	70	Grey-brown fine Sand and coarse gravel, Some(+) silt; tight; gravel consists of weathered bedrock.
0		0.5	75-76.5'	2,8,100/5"	SM_u^d	75	Grey fine sand and silt, some coarse gravel; very tight, poorly sorted. Auger refusal @ 76.5'.

REMARKS: (1) in feet relative to a common datum (3) in feet above mean sea level
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No. 16101Y Date

Project IndustriPlex Site PDI

Client Golder Associates, Inc.

Page 1 Of 1

Logged By B. Thomas

Well No. TW-2S

Loc. Woburn, MA

M.P. Elevation (3) 56.71'

Drilling Started 10/05/90 Ended 10/05/90

Driller D.L. Maher

Type Of Rig Hollow Stem Auger

WELL DATA

Hole Diam. (in.) 6"

Final Depth (ft.) 30.19

Casing Diam. (in.) 2"

Casing Length (ft.) 27.5

Screen Setting (ft.) 25.19-30.19

Screen Slot & Type 10 slot PVC

Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T

SAMPLER

Type Not Applicable

Hammer N/A lb.

Fall N/A in.

DEVELOPMENT

SAMPLE No.	Rec.	Depth (ft.)	Blows / 6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION

REMARKS: (1) in feet relative to a common datum (3) in feet above mean sea level
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No.	16101Y
Date	11/5/90
Project	IndustriPlex Site PDI
Client	Golder Associates, Inc.
Page	1 Of 1
Logged By	B. Thomas
Well No.	TW-2D
Loc.	Woburn, MA
M.P. Elevation	(3) 56.85'
Drilling Started	10/04/90
Ended	10/04/90
Driller	D.L. Maher
Type Of Rig	Hollow Stem Auger

WELL DATA

Hole Diam. (in.)	6"
Final Depth (ft.)	60.08
Casing Diam. (in.)	2"
Casing Length (ft.)	57.62
Screen Setting (ft.)	55.08-60.08
Screen Slot & Type	10 slot PVC
Well Status	

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T.

SAMPLER

Type	Not Applicable
Hammer	N/A lb.
Fall	N/A in.

DEVELOPMENT

SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
					0	Cuttings: Brown medium SAND, little coarse gravel
					5	Cuttings 5-10': Brown medium SAND little cobble, little coarse gravel
					10	
					20	
					30	
					40	
					50	
					60	

REMARKS: (1) in feet relative to a common datum (3) in feet above mean sea level
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No.	16101Y
Date	
Project	IndustriPlex Site PDI
Client	Golder Associates, Inc.
Page	1 Of 1
Logged By	R. Crowell
Well No.	TW-3S
Loc.	Woburn, MA
M.P. Elevation	(3) 56.34'
Drilling Started	10/10/90
Ended	10/10/90
Driller	D.L. Maher
Type Of Rig	Hollow Stem Auger

WELL DATA

Hole Diam. (in.)	6"
Final Depth (ft.)	21
Casing Diam. (in.)	2"
Casing Length (ft.)	20.39
Screen Setting (ft.)	15.39-20.39
Screen Slot & Type	10 slot PVC
Well Status	

G W READINGS(1)

Date	DTW MP(2)	Elev. W.T

SAMPLER

Type	Not Applicable
Hammer	N/A lb.
Fall	N/A in.

DEVELOPMENT

HNU	SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
							See geologic log for TW-3D

REMARKS: (1) in feet relative to a common datum
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No. 16101Y Date

Project IndustriPlex Site PDI

Client Golder Associates, Inc.

Page 1 Of 1

Logged By R. Crowell

Well No. TW-3D

Loc. Woburn, MA

M.P. Elevation (3) 56.50'

Drilling Started 10/11/90 Ended 10/11/90

Driller D.L. Maher

Type Of Rig Hollow Stem Auger

WELL DATA

Hole Diam. (in.) 6"

Final Depth (ft.) 60

Casing Diam. (in.) 2"

Casing Length (ft.) 57.52

Screen Setting (ft.) 54.79-59.79

Screen Slot & Type 10 slot PVC

Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev. W.T.

SAMPLER

Type Not Applicable

Hammer N/A lb.

Fall N/A in.

DEVELOPMENT

	SAMPLE No.	Rec.	Depth (ft.)	Blows / 6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
							Cuttings 0-5': Black SILT
						5	Cuttings 5-10': Light grey fine to medium SAND.
						10	Cuttings 10-15': Dark gray SAND, some silt.
						15	Cuttings 15-20': Grey fine to medium SAND.
						20	Cuttings 20-60': Grey fine to medium SAND, some coarse gravel.

REMARKS: (1) in feet relative to a common datum
(2) from top of PVC casing
(3) in feet above mean sea level

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No. 16101Y Date
Project IndustriPlex Site PDI
Client Golder Associates, Inc.
Page 1 Of 1
Logged By R. Crowell
Well No. TW-4S
Loc. Woburn, MA
M.P. Elevation (3) 56.26
Drilling Started 10/09/90 Ended 10/09/90
Driller D.L. Maher
Type Of Rig Hollow Stem Auger

WELL DATA

Hole Diam. (in.) 6"
Final Depth (ft.) 31.39
Casing Diam. (in.) 2"
Casing Length (ft.) 23.9
Screen Setting (ft.) 26.39-31.39
Screen Slot & Type 10 slot PVC
Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev. W.T

SAMPLER

Type Not Applicable
Hammer N/A lb.
Fall N/A in.

DEVELOPMENT

SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
						Cuttings show coarse Sand and coarse gravel.

REMARKS: (1) in feet relative to a common datum (3) in feet above mean sea level
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No. 16101Y Date
Project IndustriPlex Site PDI
Client Golder Associates, Inc.
Page 1 Of 2
Logged By R. Crowell
Well No. TW-4D
Loc. Woburn, MA
M.P. Elevation (3) 56.38'
Drilling Started 10/10/90 Ended
Driller D.L. Maher
Type Of Rig Hollow Stem Auger

WELL DATA

Hole Diam. (in.) 6"
Final Depth (ft.) 61.1
Casing Diam. (in.) 2"
Casing Length (ft.) 58.5
Screen Setting (ft.) 56.1-61.1
Screen Slot & Type 10 slot PVC
Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T.

SAMPLER

Type Not Applicable
Hammer N/A lb.
Fall N/A in.

DEVELOPMENT

SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
					0	Cuttings 0-5': Brown medium SAND
					5	Cuttings 5-10': Grey-grey black SAND
					10	Cuttings 10-15': Grey SAND.
					15	Cuttings 15-20': Coarse Sand and coarse gravel.
					20	Cuttings 20-30': Same as above
					25	
					30	Cuttings 30-40': Same as above

REMARKS: (1) in feet relative to a common datum (3) in feet above mean sea level
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No. 16101Y Date
Project IndustriPlex Site PDI
Client Golder Associates, Inc.
Page 2 Of 2
Logged By R. Crowell
Well No. TW-4D
Loc. Woburn, MA
M.P. Elevation (3) 56.38'
Drilling Started 10/10/90 Ended
Driller D.L. Maher
Type Of Rig Hollow Stem Auger

WELL DATA

Hole Diam. (in.) 6"
Final Depth (ft.) 61.1
Casing Diam. (in.) 2"
Casing Length (ft.) 58.5
Screen Setting (ft.) 56.1-61.1
Screen Slot & Type 10 slot PVC
Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T

SAMPLER

Type Not Applicable
Hammer N/A lb.
Fall N/A in.

DEVELOPMENT

	SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
						35	Cuttings 35-40': Coarse SAND and coarse gravel.
						40	Cuttings 40-50': Brown Sand and silt, some gravel.
						45	Same as above.
						50	Cuttings 50-60': Same as above
						55	Same as above.

REMARKS: (1) in feet relative to a common datum (3) in feet above mean sea level
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No. 16101Y Date
Project IndustriPlex Site PDI
Client Golder Associates, Inc.
Page 1 Of 1
Logged By B. Thomas
Well No. TW-5
Loc. Woburn, MA
M.P. Elevation (3) 53.50'
Drilling Started 10/11/90 Ended 10/11/90
Driller B. Thomas
Type Of Rig Driven Well Point

WELL DATA

Hole Diam. (in.) 1.5"
Final Depth (ft.) 5.3
Casing Diam. (in.) 1.5"
Casing Length (ft.) 5.0
Screen Setting (ft.) 2.3-5.3
Screen Slot & Type SS 14 slot
Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev. W.T.

SAMPLER

Type ~~Not Applicable~~
Hammer N/A lb.
Fall N/A in.

DEVELOPMENT

	SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION

REMARKS: (1) in feet relative to a common datum (3) in feet above mean sea level
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES INC

GEOLOGIC LOG

Study No. 16101Y Date
Project IndustriPlex Site PDI
Client Golder Associates, Inc.
Page 1 of 1
Logged By B. Thomas
Well No. Pump Well
Loc. Woburn, MA
M.P. Elevation
Drilling Started 10/10/90 Ended 10/11/90
Driller D.L. Maher
Type Of Rig Dual Rotary Rig

WELL DATA

Hole Diam. (in.) 12"
Final Depth (ft.) 60
Casing Diam. (in.) 8"
Casing Length (ft.) 42
Screen Setting (ft.) 41-60
Screen Slot & Type 100 slot SS
Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T

SAMPLER

Type Not Applicable
Hammer N/A lb.
Fall N/A in.

DEVELOPMENT

HNU	SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
						0	Cuttings 0-15': Fine-medium SAND, some(+) coarse gravel.
						15	Cuttings 15-36': Coarse GRAVEL, little(+) fine Sand, little Silt.
						30	
							Cuttings 36-55': Coarse GRAVEL, some coarse to fine Sand, little silt fining downward.

REMARKS: (1) in feet relative to a common datum
(2) from top of PVC casing

APPENDIX B

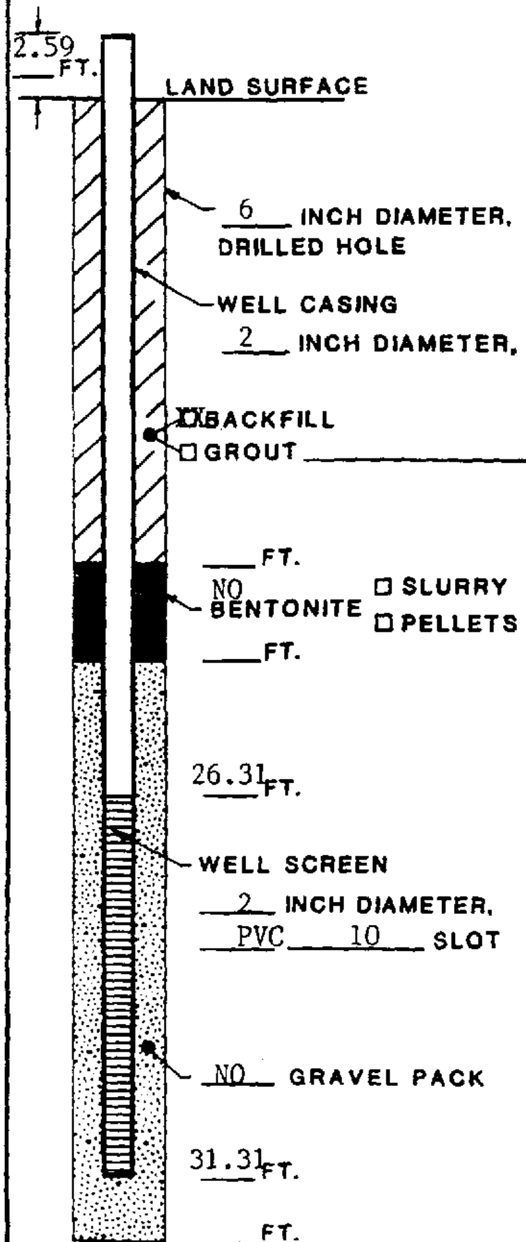
Temporary Well Construction Logs

ROUX

Consulting Ground-Water Geologists

ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET BELOW LAND SURFACE

PROJECT NAME IndustriPlex Site NUMBER 16101Y

WELL NO. TW-1S PERMIT NO. ____

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM 54.0 FEET above mean sea level

XX SURVEYED

☐ ESTIMATED

INSTALLATION DATE(S) 10/5/90

DRILLING METHOD Hollow Stem Auger

DRILLING CONTRACTOR D.L. Maher

DRILLING FLUID ____

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Centrifugal Pump

FLUID LOSS DURING DRILLING ____ GALLONS

WATER REMOVED DURING DEVELOPMENT ____ GALLONS

STATIC DEPTH TO WATER ____ FEET BELOW M.P.

PUMPING DEPTH TO WATER ____ FEET BELOW M.P.

PUMPING DURATION ____ HOURS

YIELD ____ GPM ____ DATE ____

SPECIFIC CAPACITY ____ GPM/FT.

WELL PURPOSE Observation Well (Piezometer)

REMARKS Temporary Observation Well

HYDROGEOLOGIST Brian Thomas

ROUX
Consulting Ground-Water Geologists
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG

2.54 FT.

LAND SURFACE

6 INCH DIAMETER, DRILLED HOLE

WELL CASING
2 INCH DIAMETER,

☐ BACKFILL
☒ GROUT Bentonite

2 FT.

BENTONITE ☒ SLURRY ☐ PELLETS

20 FT.

55 FT.

WELL SCREEN
2 INCH DIAMETER,
PVC 10 SLOT

#20 GRAVEL PACK

60 FT.

___ FT.

NOTE:
ALL DEPTHS IN FEET BELOW LAND SURFACE

PROJECT NAME IndustriPlex Site NUMBER 16101Y
WELL NO. TW-1D PERMIT NO. ________
TOWN/CITY Woburn
COUNTY Middlesex STATE MA
LAND-SURFACE ELEVATION AND DATUM 53.9 FEET ☒ SURVEYED
above mean sea level ☐ ESTIMATED
INSTALLATION DATE(S) 10/1/90 - 10/2/90
DRILLING METHOD Hollow Stem Auger
DRILLING CONTRACTOR D.L. Maher
DRILLING FLUID Water

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Centrifugal Pump 10/18/90

FLUID LOSS DURING DRILLING ________ GALLONS
WATER REMOVED DURING DEVELOPMENT ________ GALLONS
STATIC DEPTH TO WATER ________ FEET BELOW M.P.
PUMPING DEPTH TO WATER ________ FEET BELOW M.P.
PUMPING DURATION ________ HOURS
YIELD ________ GPM ________ DATE ________
SPECIFIC CAPACITY ________ GPM/FT.
WELL PURPOSE Monitoring Well / Observation Wells

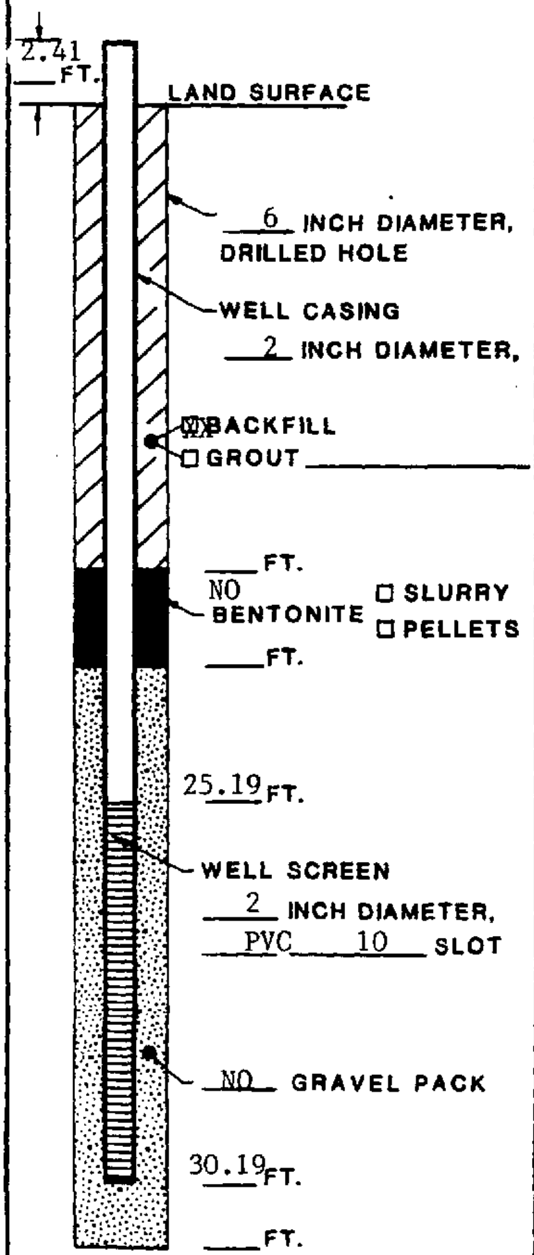
REMARKS Temporary Well

HYDROGEOLOGIST Brian Thomas

ROUX

Consulting Ground-Water Geologists
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET BELOW LAND SURFACE

PROJECT NAME IndustriPlex Site NUMBER 16101Y

WELL NO. TW-2S PERMIT NO. ______

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM 54.3 FEET above mean sea level ☒ SURVEYED ☐ ESTIMATED

INSTALLATION DATE(S) 10/5/90

DRILLING METHOD Hollow Stem Auger

DRILLING CONTRACTOR D.L. Maher

DRILLING FLUID ______

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Centrifugal Pump 10/19/90

FLUID LOSS DURING DRILLING ______ GALLONS

WATER REMOVED DURING DEVELOPMENT 200 GALLONS

STATIC DEPTH TO WATER ______ FEET BELOW M.P.

PUMPING DEPTH TO WATER ______ FEET BELOW M.P.

PUMPING DURATION ______ HOURS

YIELD ______ GPM ______ DATE ______

SPECIFIC CAPACITY ______ GPM/FT.

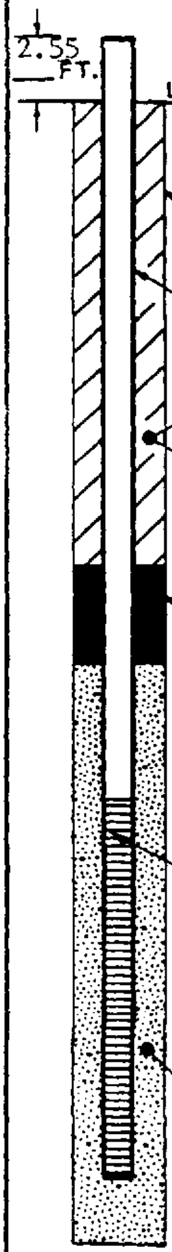
WELL PURPOSE Observation Well (Piezometer)

REMARKS Temporary Well

HYDROGEOLOGIST Brian Thomas

ROUX
Consulting Ground-Water Geologists
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



2.55 FT.

LAND SURFACE

6 INCH DIAMETER, DRILLED HOLE

WELL CASING
2 INCH DIAMETER,

☒ BACKFILL
☐ GROUT

___ FT.

NO BENTONITE ☐ SLURRY ☐ PELLETS

___ FT.

55.08 FT.

WELL SCREEN
2 INCH DIAMETER,
PVC 10 SLOT

NO GRAVEL PACK

60.08 FT.

___ FT.

NOTE:
ALL DEPTHS IN FEET BELOW LAND SURFACE

PROJECT NAME IndustriPlex Site NUMBER 16101Y

WELL NO. TW-2D PERMIT NO. ___

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM 54.3 FEET ☒ SURVEYED
above mean sea level ☐ ESTIMATED

INSTALLATION DATE(S) 10/4/90

DRILLING METHOD Hollow Stem Auger

DRILLING CONTRACTOR D.L. Maher

DRILLING FLUID Water

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Centrifugal Pump 10/19/90

FLUID LOSS DURING DRILLING ___ GALLONS

WATER REMOVED DURING DEVELOPMENT 50-60 GALLONS

STATIC DEPTH TO WATER ___ FEET BELOW M.P.

PUMPING DEPTH TO WATER ___ FEET BELOW M.P.

PUMPING DURATION ___ HOURS

YIELD ___ GPM ___ DATE ___

SPECIFIC CAPACITY ___ GPM/FT.

WELL PURPOSE Observation Well (Piezometer)

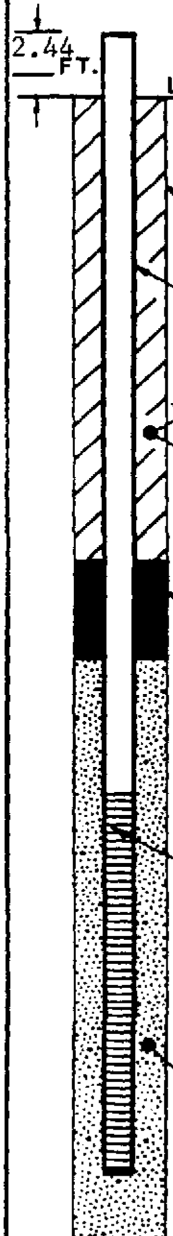
REMARKS Temporary Well

HYDROGEOLOGIST Brian Thomas

ROUX

Consulting Ground-Water Geologists
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



2.44 FT.

LAND SURFACE

6 INCH DIAMETER, DRILLED HOLE

WELL CASING
2 INCH DIAMETER,

XX BACKFILL
☐ GROUT ______

____ FT.

NO BENTONITE ☐ SLURRY ☐ PELLETS

____ FT.

15.39 FT.

WELL SCREEN
2 INCH DIAMETER,
PVC 10 SLOT

NO GRAVEL PACK

20.39 FT.

____ FT.

NOTE:
ALL DEPTHS IN FEET BELOW LAND SURFACE

PROJECT NAME IndustriPlex Site NUMBER 16101Y

WELL NO. TW-3S PERMIT NO. ______

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM 53.9 FEET above mean sea level

XX SURVEYED
☐ ESTIMATED

INSTALLATION DATE(S) 10/10/90

DRILLING METHOD Hollow Stem Auger

DRILLING CONTRACTOR D.L. Maher

DRILLING FLUID ______

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Centrifugal Pump 10/18/90

FLUID LOSS DURING DRILLING ______ GALLONS

WATER REMOVED DURING DEVELOPMENT 50 GALLONS

STATIC DEPTH TO WATER ______ FEET BELOW M.P.

PUMPING DEPTH TO WATER ______ FEET BELOW M.P.

PUMPING DURATION ______ HOURS

YIELD ______ GPM ______ DATE ______

SPECIFIC CAPACITY ______ GPM/FT.

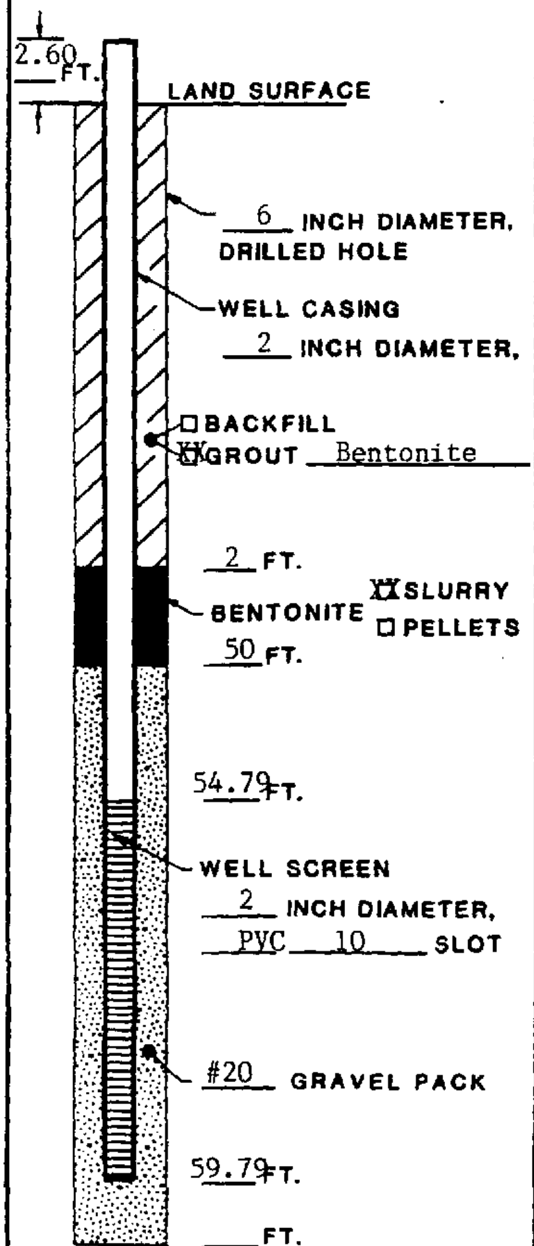
WELL PURPOSE Observation Well (Piezometer)

REMARKS Temporary Well

HYDROGEOLOGIST Rob Crowell

ROUX
Consulting Ground-Water Geologists
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET
BELOW LAND SURFACE

PROJECT NAME IndustriPlex Site NUMBER 16101Y

WELL NO. TW-3D PERMIT NO. ______

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM 53.9 FEET ☒ SURVEYED
above mean sea level ☐ ESTIMATED

INSTALLATION DATE(S) 10/11/90

DRILLING METHOD Hollow Stem Auger

DRILLING CONTRACTOR D.L. Maher

DRILLING FLUID Water

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Centrifugal Pump 10/18/90

FLUID LOSS DURING DRILLING ______ GALLONS

WATER REMOVED DURING DEVELOPMENT 40 GALLONS

STATIC DEPTH TO WATER ______ FEET BELOW M.P.

PUMPING DEPTH TO WATER ______ FEET BELOW M.P.

PUMPING DURATION ______ HOURS

YIELD ______ GPM ______ DATE ______

SPECIFIC CAPACITY ______ GPM/FT.

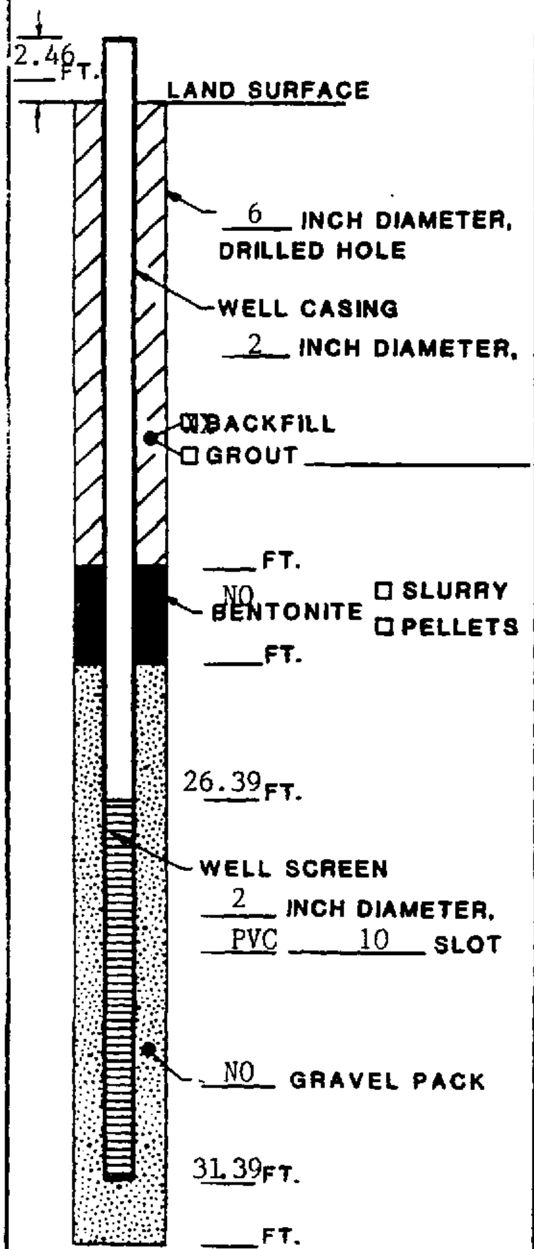
WELL PURPOSE Observation Well (Piezometer)

REMARKS Temporary Well

HYDROGEOLOGIST Rob Crowell

ROUX
Consulting Ground-Water Geologists
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET BELOW LAND SURFACE

PROJECT NAME IndustriPlex Site NUMBER 16101Y

WELL NO. TW-4S PERMIT NO.

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM 53.8 FEET above mean sea level

☒ SURVEYED
☐ ESTIMATED

INSTALLATION DATE(S) 10/9/90

DRILLING METHOD Hollow Stem Auger

DRILLING CONTRACTOR D.L. Maher

DRILLING FLUID

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Centrifugal Pump 10/12/90

FLUID LOSS DURING DRILLING ______ GALLONS

WATER REMOVED DURING DEVELOPMENT 40 GALLONS

STATIC DEPTH TO WATER ______ FEET BELOW M.P.

PUMPING DEPTH TO WATER ______ FEET BELOW M.P.

PUMPING DURATION ______ HOURS

YIELD ______ GPM ______ DATE ______

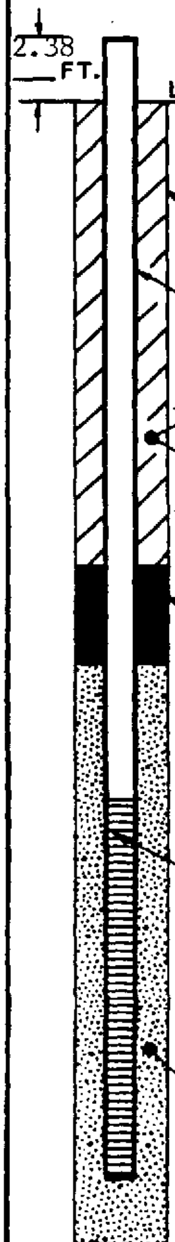
SPECIFIC CAPACITY ______ GPM/FT.

WELL PURPOSE Observation Well (Piezometer)

REMARKS Temporary Well

HYDROGEOLOGIST Rob Crowell

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET
BELOW LAND SURFACE

PROJECT NAME IndustriPlex Site NUMBER 16101Y

WELL NO. TW-4D PERMIT NO. ___

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM 54.0 FEET above mean sea level ☒ SURVEYED ☐ ESTIMATED

INSTALLATION DATE(S) 10/10/90 - 10/11/90

DRILLING METHOD Hollow Stem Auger

DRILLING CONTRACTOR D.L. Maher

DRILLING FLUID Water

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Centrifugal Pump 10/12/90

FLUID LOSS DURING DRILLING ___ GALLONS

WATER REMOVED DURING DEVELOPMENT 50 GALLONS

STATIC DEPTH TO WATER ___ FEET BELOW M.P.

PUMPING DEPTH TO WATER ___ FEET BELOW M.P.

PUMPING DURATION ___ HOURS

YIELD ___ GPM ___ DATE ___

SPECIFIC CAPACITY ___ GPM/FT.

WELL PURPOSE Observation Well (Piezometer)

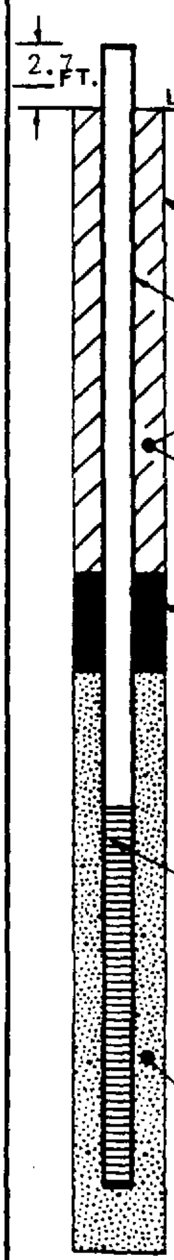
REMARKS Temporary Well

HYDROGEOLOGIST Rob Crowell

ROUX

Consulting Ground-Water Geologists
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET BELOW LAND SURFACE

PROJECT NAME IndustriPlex Site NUMBER 16101Y

WELL NO. TW-5 PERMIT NO. ___

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM ___ FEET ☒ SURVEYED ☐ ESTIMATED

INSTALLATION DATE(S) 10/11/90

DRILLING METHOD Hand Driven

DRILLING CONTRACTOR Not Applicable (N/A)

DRILLING FLUID N/A

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Peristaltic Pump 10/11/90

FLUID LOSS DURING DRILLING N/A GALLONS

WATER REMOVED DURING DEVELOPMENT 10 GALLONS

STATIC DEPTH TO WATER ___ FEET BELOW M.P.

PUMPING DEPTH TO WATER ___ FEET BELOW M.P.

PUMPING DURATION ___ HOURS

YIELD ___ GPM ___ DATE ___

SPECIFIC CAPACITY ___ GPM/FT.

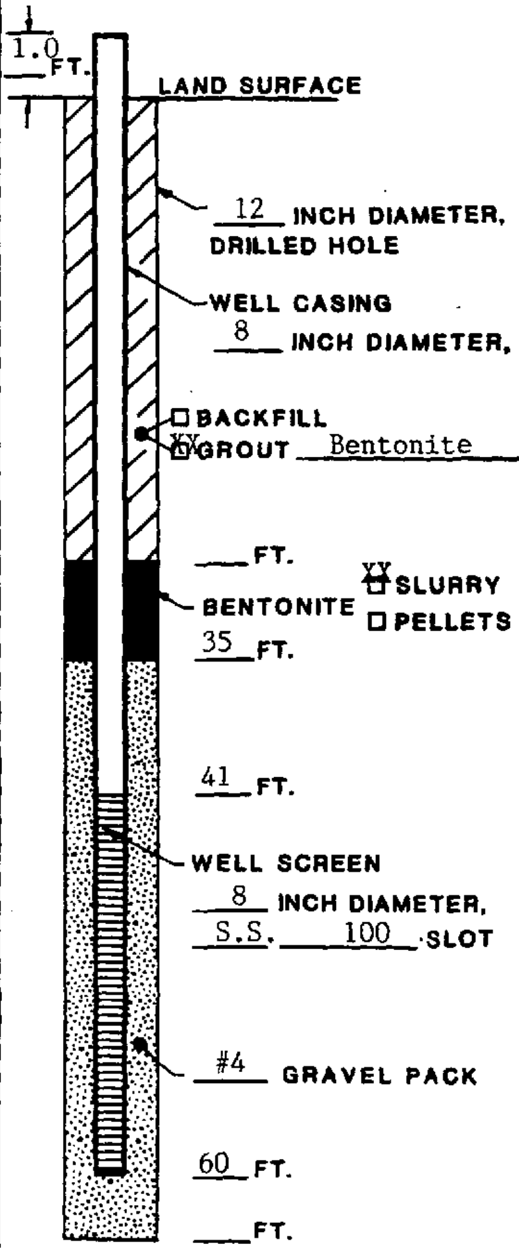
WELL PURPOSE Observation Well (Piezometer)

REMARKS Located in Halls Brook Holding Area

HYDROGEOLOGIST Brian Thomas

ROUX
Consulting Ground-Water Geologists
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET BELOW LAND SURFACE

PROJECT NAME IndustriPlex Site NUMBER 16101Y

WELL NO. Pump Well PERMIT NO. ______

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM 54.0 FEET above mean sea level ☒ SURVEYED ☐ ESTIMATED

INSTALLATION DATE(S) 10/9/90 - 10/10/90

DRILLING METHOD Dual Rotary Rig

DRILLING CONTRACTOR D.L. Maher

DRILLING FLUID Water

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Centrifugal Pump 10/11/90

FLUID LOSS DURING DRILLING ______ GALLONS

WATER REMOVED DURING DEVELOPMENT 5800 GALLONS

STATIC DEPTH TO WATER ~2 FEET BELOW ground surface

PUMPING DEPTH TO WATER ~23 FEET BELOW ground surface

PUMPING DURATION 50 HOURS

YIELD 351 GPM ______ DATE 10/31/90-11/2/90

SPECIFIC CAPACITY ______ GPM/FT.

WELL PURPOSE Test Well

REMARKS Temporary Well
Stick-up of measuring point changed as steel casing was cut and new sections welded on to accomodate two different pumps.

HYDROGEOLOGIST Brian Thomas

APPENDIX C

Surveyor's Report

An Employee-Owned Company
SAIC Engineering, Inc.

November 1, 1990

805-0184
19-805-05-024-00

Golder Associates
20000 Horizon Way Suite 500
Mt. Laurel, NJ 08054

Attn: Mr. Ken Moser

Ref: Task III Sub-Tasks GW-2 and GW-1, Phase II
Industriplex Site, Woburn, MA

Dear Mr. Moser:

Below are elevations of locations specified in Golder Purchase Order #2527, dated October 11, 1990:

Location	Elevation	Location	Elevation
OW-36(ground)	72.7	OW-42(ground)	67.0
OW-36(casing)	75.42	OW-42(casing)	69.96
OW-36(pvc)	74.86	OW-42(pvc)	69.80
OW-37(ground)	69.3	Pumping well(ground)	54.0
OW-37(casing)	72.87	Pumping well(casing)	55.00
OW-37(pvc)	72.60	Note: This is the 8" inner casing	
OW-38(ground)	69.8		
OW-38(casing)	71.90	Staff gauge at 3.33 mark	53.50
OW-38(pvc)	71.40		
OW-39(ground)	71.8		
OW-39(casing)	74.59	TW-1S(ground)	54.0
OW-39(pvc)	74.14	TW-1S(casing)	56.70
OW-40(ground)	68.7	TW-1S(pvc)	56.59
OW-40(casing)	71.74	TW-1D(ground)	53.9
OW-40(pvc)	71.64	TW-1D(casing)	56.54
OW-41(ground)	67.5	TW-1D(pvc)	56.44
OW-41(casing)	67.48	TW-2S(ground)	54.3
OW-41(pvc)	66.95	TW-2S(casing)	56.92
TW-2D(ground)	54.3	TW-2S(pvc)	56.71
TW-2D(casing)	57.00	TW-3S(ground)	53.9
TW-2D(pvc)	56.85	TW-3S(casing)	56.54
		TW-3S(pvc)	56.34

Location	Elevation
TW-3D(ground)	53.9
TW-3D(casing)	56.68
TW-3D(pvc)	56.50
TW-4S(ground)	53.8
TW-4S(casing)	56.44
TW-4S(pvc)	56.26
TW-4D(ground)	54.0
TW-4D(casing)	56.52
TW-4D(pvc)	56.38

Sincerely,

SAIC ENGINEERING, INC.

Michael R. Keegan

Michael R. Keegan, P.L.S.

MRK/saf

cc: James R. Larson

ISRT SITE WOBURN MASSACHUSETTS
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LIST COORDINATES

PT#	NORTH	EAST	ELE
934	554108.711713	695680.893962	74.855
OW-36 PVC 74.855, TC 74.415, GRD 72.7			
933	553886.797829	695878.215096	72.595
OW-37 PVC 72.595, TC 72.87, GRD 69.3			
935	553193.961174	695222.156392	71.400
OW-38 PVC 71.40, TC 71.90, GRD 69.8			
929	553211.557473	697034.510124	74.135
OW-39 PVC 74.135, TC 74.59, GRD 71.8			
930	552759.891374	696441.384396	71.645
OW-40 PVC 71.645, TC 71.735, GRD 68.7			
932	552685.368753	696947.983496	66.950
OW-41 PVC 66.95, CURB BOX 67.48, GRD 67.5			
931	551691.323272	697008.808350	69.805
OW-42 PVC 69.805, TC 69.965, GRD 67.0			
909	550271.882241	697503.718342	54.995
PUMPING WELL RIM, 54.995 (*Pw-1*)			
908	550297.153070	697501.557788	56.585
TW-1S PPVC 56.585, TC 56.695, GRD 54.0			
907	550299.732395	697506.370150	56.440
TW-1D PVC 56.44, TC 56.545, GRD 53.9			
910	550250.934073	697515.249467	56.710
TW-2S PVC 56.71, TC 56.915, GRD 54.3			
923	550249.651188	697514.238296	56.850
TW-2D PVC 56.85, TC 57.00, GRD 54.3			
925	550258.958351	697482.152540	56.340
TW-3S PVC 56.34, TC 56.535, GRD 53.9			
924	550261.759104	697478.930757	56.495
TW-3D PVC 56.495, TC 56.675, GRD 53.9			
927	550131.927017	697553.308589	56.260
TW-4S PVC 56.26, TC 56.445, GRD 53.8			
926	550126.746954	697552.832524	56.380
TW-4D PVC 56.38, TC 56.525, GRD 54.0			
928	550198.785058	697324.923994	53.810
TW-5 TOP 2" PIPE, 53.81			
936	550198.785058	697324.923994	53.505
STAFF GUAGE @ TW-5, 3.33 MARK, 53.505			

APPENDIX D

Standard Operating Procedure
for Conducting a Constant-Rate
(Pumping) Test and Recovery Test

STANDARD OPERATING PROCEDURE FOR CONDUCTING A CONSTANT-RATE (PUMPING) TEST AND RECOVERY TEST

Date: December 21, 1989 Revision Number: 0

Corporate QA/QC Manager: Michael A. DeCillis

1.0 PURPOSE

The purpose for this standard operating procedure (SOP) is to describe the methods to be used for conducting constant-rate (pumping) tests and recovery tests. Constant-rate tests are designed to measure the response of an aquifer to stress imposed on it (i.e., pumping or injection of water). In the constant-rate test, the well is pumped or recharged at a constant rate for a significant period of time, usually 24 hours or longer. Pumping tests are conducted to quantify hydraulic coefficients and characterize boundary conditions. Pumping tests can also be used to qualitatively or quantitatively evaluate the degree of hydraulic connection between and within flow systems which is particularly applicable to bedrock ground-water systems where hydraulic parameter determination may not be possible.

Drawdown is measured throughout the test at preselected time intervals to provide the data necessary to quantitatively characterize the aquifer. Automatic water-level records may be used which provide a detailed, continuous drawdown record and are periodically checked by manually measuring the water level with a steel tape and chalk or an electronic sounding device (m-scope).

Pumping tests are generally the easiest aquifer tests to interpret, and can provide the most accurate, quantitative information; thus pumping tests are favored when conditions are suitable (i.e., when hydrogeologic conditions are such that the system can sustain a properly designed constant-rate pumping test).

Measurements of water-level recovery after the pump is shutdown may be used to confirm the results of the drawdown test. Additionally, problems such as those created by a fluctuating pumping rate and corresponding drawdown measurements during the drawdown phase can be eliminated during the recovery phase (which is not effected by pumpage). Therefore, data loggers and/or the automatic recorders should remain in operation to measure the extended recovery period of the water levels to provide a suitable database in the event that recovery data analysis is undertaken.

2.0 EQUIPMENT AND MATERIALS

2.1 The following items may be needed for aquifer testing:

a. Electronic sounding device (m-scope).

b. Steel tape (in 0.01-foot increments) and chalk (e.g., blue carpenter's).

c. Data loggers and pressure transducers.

d. Field forms (i.e., Daily Log, Pumping Test, and Well Inspection Checklist) and study notebook.

e. Rain gauge.

f. Barometer.

g. Stop watch or watch with second display/hand.

h. Pump.

i. Extension cord(s) or generator and fuel/power supply.

j. Water-level recorders (e.g., Stevens type).

k. Flashlights/illumination.

l. Stream gauge and/or tide gauge.

m. Shelter.

n. In-line flow meter and/or orifice and manometer.

o. Valve(s).

p. On-site holding tanks or tank trucks, or treatment capability.

q. Discharge line (leak free).

r. Water-quality meters (pH, conductivity, temperature).

s. Extra batteries (flashlight, meters).

t. Non-absorbent cord (e.g., polypropylene).

u. Portable personal computer (PC), appropriate cables, software, and floppy disks.

v. Five-gallon bucket.

w. Clean cloth or paper towel.

x. Non-phosphate, laboratory-grade detergent solution.

y. Distilled or deionized water and potable water.

3.0 DECONTAMINATION

3.1 Make sure all equipment that enters the well(s) is(are) decontaminated and cleaned before use. Use new, clean materials when decontamination is not appropriate (e.g., non-absorbent cord, disposable gloves). Document, and initial and date the decontamination procedures on the appropriate field form (e.g., Daily Log) and in the field notebook.

a. Decontaminate a pump by: 1) wearing disposable gloves, 2) flushing it and the discharge hose (if not disposable) with non-phosphate, laboratory-grade detergent and distilled/deionized or potable water solution, 3) rinsing with potable water, and 4) rinsing or wiping pump-related equipment (electrical lines, cables, discharge hose) with a clean cloth and potable water. If a turbine pump is used, then ensure that all materials that are set in the well or above it (well head) are steam cleaned for decontamination purposes.

b. Decontaminate a transducer and cable by: 1) wearing disposable gloves, 2) wiping transducer-related equipment (e.g., probe, cables) with a clean cloth and non-phosphate, laboratory-grade detergent solution, and 3) rinsing or wiping equipment with a clean cloth and distilled/deionized water or potable water.

c. Decontaminate a float/probe and cable (water-level recorder) by: 1) wearing disposable gloves, 2) wiping equipment with a clean cloth and non-phosphate, laboratory-grade detergent solution, and 3) rinsing or wiping equipment with a clean cloth and distilled/deionized water or potable water.

d. Decontaminate a steel measuring tape or electronic sounding device (m-scope) by: 1) wearing disposable gloves, 2) wiping water-level measurement equipment with a clean cloth and non-phosphate, laboratory-grade detergent solution, and 3) rinsing or wiping equipment with a clean cloth and distilled/deionized water or potable water.

4.0 PROCEDURE

4.1 Inspect the protective casings of the wells and the well casings, and note any items of concern such as a missing lock, or bent or damaged casing(s). Complete a Well Inspection Checklist for each well, and initial and date upon completion.

4.2 Enter all pertinent data concerning the pumping well, piezometers and/or observation wells, to be measured on the Pumping Test form, appropriate field forms (e.g. Daily Log form) and the study notebook.

4.3 Measure water levels (depth to water below a predetermined measuring point [MP]) in the pumping well and all piezometers and/or observation wells (synoptic round of water-level measurements) to an accuracy of 0.01 foot at least one day prior to the pumping test. Document the water levels, and initial and date data entries. The synoptic round of water-level measurements will include wells and piezometers inside and outside of the influence (impact) of the area tested.

4.4 Sound (measure the total depth) the test well and each well and/or piezometer measured in the synoptic round to an accuracy of 0.01 foot. Document the sounded depth, and initial and date data entries. Compare the sounded depth to the as-built total well/piezometer depth to ensure no appreciable sanding or silting (clogging) has occurred. If appreciable clogging has taken place, then the well or piezometer must be redeveloped to re-establish good hydraulic connection between the well or piezometer and the aquifer. Wells and piezometers must respond quickly to changes in water levels.

4.5 Establish background wells and/or piezometers to measure water-level trends outside the influence of the pumping well.

4.6 Install precleaned transducers and program data loggers, and/or install precleaned floats/probes and set up recorders on several, select wells and/or piezometers for an extended period of time (e.g., one week) prior to the test to monitor water-level trends throughout the test area. At least two hours of readings at quarter-hour to half-hour intervals should be collected immediately prior to start-up of the test. If water levels in the aquifer are fluctuating, then more readings will be necessary. Water-level fluctuation data may be needed to correct aquifer test data.

4.7 Obtain as many pretest (nonpumping), synoptic water-level readings as possible to provide a sound background water-level data base. If available, dedicate an individual to collect continuous, synoptic water-level measurements on the day of the test, from the time of arrival onsite to the start of the test.

4.8 Set up a rain gauge onsite to measure precipitation before, during, and after the test. Monitor the rain gauge on a regular basis, particularly if the tested aquifer is shallow. If precipitation is occurring at the beginning of the test, then the test should be postponed until optimum meteorological conditions prevail and water levels, if changing, return to static conditions. If needed, precipitation data collected during the test (after start-up) will be used to correct aquifer test data affected by recharge.

4.9 Set up a continuous recording barometer onsite to measure barometric pressure before, during, and after the test. If needed, data from this instrument will be used to correct aquifer test data for changes in barometric pressure during the pumping test.

4.10 Install a stream or tide gauge to measure changes in stream stage or tidal fluctuations before, during, and after the test if the pumping test site is located near a surface-water body. If needed, this data will be used to correct aquifer test data for changes in surface-water body elevations.

4.11 Ensure that the pumping system selected for the test is properly installed including the power supply and leak-free discharge line complete with a valve(s), flow meter, or manometer and orifice.

4.12 Make arrangements to dispose of the pumped water in an appropriate manner. If the pumped water is contaminated, then disposal may be via treatment and discharge, trucking offsite, etc. Water that is discharged onsite must be a substantial distance from the test site to preclude adversely affecting the test (e.g., recharging the aquifer during testing and influencing water levels).

4.13 Make sure that the proper transducers (data loggers) and gear ratios (water-level recorders) are used to measure the full anticipated range of drawdown in the wells and/or piezometers.

4.14 Install a precleaned transducer (which is preferred over manual measurement devices, e.g., steel tape and chalk or m-scope) in the test well, connect it to the data logger, and verify that the equipment is working. Program the data logger accordingly, using the PC and appropriate software.

4.15 Install precleaned transducers and program data loggers, and/or install precleaned floats/probes and set up recorders in select piezometers and/or observation wells to be monitored during the test (e.g., those impacted by the test, those serving as background). Verify that the equipment is working.

4.16 Conduct a step-drawdown (step) test several days before the scheduled constant-rate pumping test to check the performance of the pumping well and establish the pumping rate to be used for the final test. (Refer to the SOP for conducting a step-drawn test.) Use both automatic and manual water-level measuring devices to measure water levels in the wells and record appropriate measurements on the Pumping Test form and in the field notebook. The rate chosen for the pumping test will be the maximum rate the well can produce and sustain in order to stress the aquifer as much as possible.

4.17 Set the discharge line valve(s) so they will be preset and marked for the desired pumping rate (obtained from the step test).

4.18 Check that the in-line flow meter and/or manometer is indicating that the pumping rate is the same as that selected from the step test. It is preferred to use both devices to measure and monitor discharge to provide a check and a back up.

4.19 Begin the pumping test only after the water level in the aquifer has returned to the nonpumping (static) conditions observed prior to the step test.

4.20 Check that all equipment is functioning properly before starting the test (e.g., transducers and data loggers, automated water-level recorders, m-scopes, valves in proper position, generator running properly and sufficient fuel [if needed], power supply, etc.)

4.21 Synchronize all watches prior to the test.

4.22 Begin the pumping test on the hour or half-hour and pump at a constant rate until sufficient data is collected to analyze the test (at least 24 hours or longer if needed). Some pumping tests may require several days (sometimes up to and exceeding 1 week) to collect the data needed to analyze the test.

4.23 Measure water levels (drawdown) on a specified schedule. An example of the frequency of measurements to produce a uniform plot of water-level data on a logarithmic scale follows:

Elapsed Time (minutes)	Frequency of Measurement
0 - 1	Every 15 seconds
1 - 5	Every 30 seconds
5 - 10	Every minute
10 - 30	Every 2 minutes
30 - 60	Every 5 minutes
60 - 120	Every 10 minutes
120 - 180	Every 20 minutes
180 - 360	Every 30 minutes
360 - 1,440	Every hour
1,440 - 2,880	Every 2 hours
2,880 - end of test	Every 4 hours

4.24 Check the drawdown measurements obtained with the automated water-level measuring devices (on a regular basis) manually using a m-scope and/or a steel tape and chalk to an accuracy of 0.01 foot. If a recorder is used, then "tick" recorders and document the time next to each "tick" in the chart. Manual measurements should be made as close to the established schedule as possible. However, if a reading is missed, then take a measurement as soon as possible after the scheduled reading and record the actual time. This will maintain the time versus drawdown relationship needed to analyze the test data. Record water-level data on the Pumping Test form, and initial and date data entry.

4.25 Check the discharge rate using the in-line flow meter and/or manometer on a regular basis. If adjustments have to be made to maintain the constant pumping rate, then adjust the valve. Record readings and adjustments (if made) on the Pumping Test form and the field notebook, and initial and date data entry.

4.26 Measure temperature, pH, and conductivity of discharged water on a periodic, regular basis. Record data on the Pumping Test form and in the field notebook, and initial and date data entry.

4.27 Note any changes, throughout the pumping test, that are pertinent to the test such as changes in water color or turbidity, time and length of any temporary pump shut down, effects of any nearby pumping wells, precipitation events, etc. Document these notes on the Pumping Test form and in the field notebook, and initial and date data entry.

4.28 Measure water levels in the pumping well and as many piezometers and/or wells as practical (to an accuracy of 0.01 foot) following recovery procedures if there is a shutdown, no matter how brief.

4.29 Measure water levels together during a change in personnel for at least one period of measurement to ensure consistency. Note the personnel change and time on the Pumping Test form and in the field notebook, and initial and date data entry.

4.30 Begin plotting the drawdown verses time data, when time allows, on the appropriate graph paper (semi-logarithmic and/or full logarithmic) to perform a preliminary analysis of the data for hydraulic coefficients and determine if the pumping test can be terminated or has to be extended. Correct drawdown data as needed before plotting (e.g., for dewatering, barometric efficiency, tidal fluctuations, regional trends, etc.)

4.31 Shut down the pumping test at the specified time or when sufficient data has been collected to analyze the pumping test data. Shut down should occur on the hour or half-hour so that recovery starts on the hour or half-hour.

4.32 Close the valve (closest to the pump) as quickly as possible to prevent back flow of water into the pumping well.

4.33 Measure recovery (rise in water levels) to an accuracy of 0.01 foot until water levels return as close as possible to pretest levels. The identical measurement schedule followed for the drawdown phase should be followed during the recovery phase. Automated water-level recorders should be left in select wells and/or piezometers (same ones monitored during pretest) to monitor water levels for an extended period of time (one or more days).

4.34 Collect at least one round of synoptic water-level measurements after water levels have recovered following the test.

4.35 Secure all wells and/or piezometers after the collection of water-level data is completed (i.e., replace cap and/or cover, and lock).

4.36 Clean (decontaminate) all test equipment that came in contact with the ground water according to the appropriate protocol given in Section 3.0. Dispose of all materials that cannot be decontaminated in an appropriate manner (e.g., discharge hose, etc.).

APPENDIX E

Pumping Test Data

Table E1. Constant-Rate (Pumping) Test Data for Temporary Well PW-1 October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
PW-1	10/31/90	7:29:41	NA	0.00		
		7:29:56	NA	0.25	7.33	6.88
		7:30:11	NA	0.50	8.70	8.07
		7:30:26	NA	0.75	8.90	8.24
		7:30:41	NA	1.00	11.03	10.02
		7:31:11	NA	1.50	10.53	9.61
		7:31:41	NA	2.00	11.18	10.14
		7:32:11	NA	2.50	12.05	10.84
		7:32:41	NA	3.00	10.41	9.51
		7:33:11	NA	3.50	11.19	10.15
		7:33:41	NA	4.00	11.80	10.64
		7:34:11	NA	4.50	12.68	11.34
		7:34:41	NA	5.00	11.79	10.63
		7:35:41	NA	6.00	12.51	11.21
		13:40:00	21.45	370.00	13.65	12.10
		21:08:00	22.03	818.00	14.23	12.55
		22:14:00	22.14	884.00	14.34	12.63
		23:15:00	22.06	945.00	14.26	12.57
	11/1/90	0:25:00	22.23	1015.00	14.43	12.70
		1:23:00	22.32	1073.00	14.52	12.77
		12:24:00	22.36	1134.00	14.56	12.80
		3:18:00	22.40	1188.00	14.60	12.83
		4:24:00	22.40	1254.00	14.60	12.83
		5:23:00	22.53	1313.00	14.73	12.93
		6:19:00	22.57	1369.00	14.77	12.96
		7:20:00	22.55	1430.00	14.75	12.95
		21:36:00	23.02	2286.00	15.22	13.29
		23:33:00	22.90	2403.00	15.10	13.20
	11/2/90	1:39:00	23.13	2529.00	15.33	13.38
		3:40:00	23.07	2650.00	15.27	13.33
		5:41:00	23.22	2771.00	15.42	13.44

NA - Not applicable because data was collected by pressure transducer/data logger.

Table E2. Constant-Rate (Pumping) Test Data for Temporary Well TW-1S, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-1S	10/31/90	7:30:00	5.06			
		7:31:00	5.35	1.00	0.29	0.29
		7:32:00	5.78	2.00	0.72	0.72
		7:33:00	7.02	3.00	1.96	1.93
		7:36:00	7.20	6.00	2.14	2.10
		7:37:00	7.32	7.00	2.26	2.22
		7:38:00	7.45	8.00	2.39	2.34
		7:40:00	7.52	10.00	2.46	2.41
		7:42:00	7.55	12.00	2.49	2.44
		7:44:00	7.62	14.00	2.56	2.51
		7:46:00	7.75	16.00	2.69	2.63
		7:48:00	7.84	18.00	2.78	2.72
		7:50:00	7.87	20.00	2.81	2.74
		7:52:00	7.98	22.00	2.92	2.85
		7:54:00	7.98	24.00	2.92	2.85
		7:56:00	8.03	26.00	2.97	2.90
		7:58:00	8.05	28.00	2.99	2.92
		8:00:00	8.12	30.00	3.06	2.98
		8:05:00	8.20	35.00	3.14	3.06
		8:10:00	8.19	40.00	3.13	3.05
		8:15:00	8.28	45.00	3.22	3.13
		8:20:00	8.30	50.00	3.24	3.15
		8:25:00	8.37	55.00	3.31	3.22
		8:30:00	8.40	60.00	3.34	3.25
		8:41:00	8.62	71.00	3.56	3.45
		8:51:30	8.66	81.50	3.60	3.49
		9:03:00	8.70	93.00	3.64	3.53
		9:11:30	8.73	101.50	3.67	3.56
		9:21:30	8.77	111.50	3.71	3.60
		9:32:00	8.77	122.00	3.71	3.60
		9:50:30	8.79	140.50	3.73	3.61
		10:10:00	8.81	160.00	3.75	3.63
		10:30:30	8.83	180.50	3.77	3.65
		11:03:30	8.85	213.50	3.79	3.67
		11:31:30	8.85	241.50	3.79	3.67
		11:59:30	8.89	269.50	3.83	3.71
		12:32:30	8.89	302.50	3.83	3.71
		13:02:30	8.92	332.50	3.86	3.74
		13:30:00	8.94	360.00	3.88	3.75
		14:33:00	8.97	423.00	3.91	3.78
		16:49:00	8.95	559.00	3.89	3.76
		18:06:00	8.99	636.00	3.93	3.80
		19:08:00	9.01	698.00	3.95	3.82
		20:05:00	9.05	755.00	3.99	3.86
		21:04:00	9.06	814.00	4.00	3.87
		22:06:00	9.09	876.00	4.03	3.89
		23:10:00	9.12	940.00	4.06	3.92
		23:54:00	9.12	984.00	4.06	3.92

Table E2. Constant-Rate (Pumping) Test Data for Temporary Well TW-1S, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-1S	11/1/90	0:57:00	9.15	1047.00	4.09	3.95
		1:53:00	9.16	1103.00	4.10	3.96
		2:54:00	9.18	1164.00	4.12	3.98
		3:55:00	9.21	1225.00	4.15	4.01
		4:54:00	9.22	1284.00	4.16	4.02
		5:54:00	9.24	1344.00	4.18	4.03
		6:48:00	9.24	1398.00	4.18	4.03
		7:48:00	9.24	1458.00	4.18	4.03
		9:47:00	9.22	1577.00	4.16	4.02
		11:27:00	9.24	1677.00	4.18	4.03
		13:40:00	9.25	1810.00	4.19	4.04
		15:30:00	9.30	1920.00	4.24	4.09
		17:47:00	9.31	2057.00	4.25	4.10
		19:38:00	9.32	2168.00	4.26	4.11
		21:33:00	9.37	2283.00	4.31	4.16
		23:29:00	9.39	2399.00	4.33	4.17
	11/2/90	1:36:00	9.40	2526.00	4.34	4.18
		3:37:00	9.40	2647.00	4.34	4.18
		5:38:00	9.43	2768.00	4.37	4.21
		7:41:00	9.47	2891.00	4.41	4.25

Table E3. Constant-Rate (Pumping) Test Data for Temporary Well TW-1D, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-1D	10/31/90	6:57:00	4.47			
		7:30:30	5.35	0.50	0.88	0.87
		7:31;30	5.42	1.50	0.95	0.94
		7:32:30	5.39	2.50	0.92	0.91
		7:35:00	6.46	5.00	1.99	1.96
		7:37:00	6.73	7.00	2.26	2.22
		7:38:00	6.77	8.00	2.30	2.26
		7:39:00	6.85	9.00	2.38	2.33
		7:41:00	6.96	11.00	2.49	2.44
		7:43:00	6.98	13.00	2.51	2.46
		7:45:00	7.12	15.00	2.65	2.59
		7:47:00	7.15	17.00	2.68	2.62
		7:49:00	7.23	19.00	2.76	2.70
		7:51:00	7.24	21.00	2.77	2.71
		7:53:00	7.34	23.00	2.87	2.80
		7:55:00	7.38	25.00	2.91	2.84
		7:57:00	7.50	27.00	3.03	2.95
		7:59:00	7.51	29.00	3.04	2.96
		8:04:00	7.55	34.00	3.08	3.00
		8:09:00	7.65	39.00	3.18	3.10
		8:14:00	7.68	44.00	3.21	3.12
		8:19:00	7.76	49.00	3.29	3.20
		8:24:00	7.85	54.00	3.38	3.29
		8:29:00	7.82	59.00	3.35	3.26
		8:42:30	8.16	72.50	3.69	3.58
		8:52:00	8.19	82.00	3.72	3.60
		9:04:00	8.12	94.00	3.65	3.54
		9:13:00	8.15	103.00	3.68	3.57
		9:23:00	8.18	113.00	3.71	3.60
		9:33:00	8.20	123.00	3.73	3.61
		9:52:00	8.23	142.00	3.76	3.64
		10:11:00	8.25	161.00	3.78	3.66
		10:32:00	8.38	182.00	3.91	3.78
		11:04:00	8.30	214.00	3.83	3.71
		11:32:00	8.31	242.00	3.84	3.72
		12:01:00	8.32	271.00	3.85	3.73
		12:33:00	8.33	303.00	3.86	3.74
		13:04:00	8.36	334.00	3.89	3.76
		13:32:00	8.37	362.00	3.90	3.77
		14:34:00	8.40	424.00	3.93	3.80
		15:45:00	8.46	495.00	3.99	3.86
		16:51:00	8.40	561.00	3.93	3.80
		18:04:00	8.45	634.00	3.98	3.85
		19:06:00	8.51	696.00	4.04	3.90
		20:04:00	8.54	754.00	4.07	3.93
		21:06:00	8.50	816.00	4.03	3.89
		22:07:00	8.56	877.00	4.09	3.95
		23:11:00	8.55	941.00	4.08	3.94
		23:56:00	8.58	986.00	4.11	3.97

Table E3. Constant-Rate (Pumping) Test Data for Temporary Well TW-1D, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-1D	11/1/90	0:58:00	8.58	1048.00	4.11	3.97
		1:54:00	8.59	1104.00	4.12	3.98
		2:55:00	8.62	1165.00	4.15	4.01
		3:56:00	8.62	1226.00	4.15	4.01
		4:55:00	8.65	1285.00	4.18	4.03
		5:55:00	8.66	1345.00	4.19	4.04
		6:49:00	8.66	1399.00	4.19	4.04
		7:49:00	8.67	1459.00	4.20	4.05
		9:46:00	8.67	1576.00	4.20	4.05
		11:26:00	8.64	1676.00	4.17	4.03
		13:39:00	8.69	1809.00	4.22	4.07
		15:28:00	8.72	1918.00	4.25	4.10
		17:45:00	8.78	2055.00	4.31	4.16
		19:36:00	8.79	2166.00	4.32	4.16
		21:34:00	8.81	2284.00	4.34	4.18
		23:30:00	8.80	2400.00	4.33	4.17
	11/2/90	1:37:00	8.81	2527.00	4.34	4.18
		3:38:00	8.83	2648.00	4.36	4.20
		5:39:00	8.84	2769.00	4.37	4.21
		7:42:00	8.87	2892.00	4.40	4.24

Table E4. Constant-Rate (Pumping) Test Data for Temporary Well TW-2S, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-2S	10/31/90	7:20:00	4.74			
		7:30:15	6.43	0.25	1.69	1.67
		7:32:30	6.46	2.50	1.72	1.70
		7:34:30	6.85	4.50	2.11	2.07
		7:36:00	7.17	6.00	2.43	2.38
		7:37:00	7.29	7.00	2.55	2.50
		7:39:30	7.42	9.50	2.68	2.62
		7:41:30	7.52	11.50	2.78	2.72
		7:43:45	7.58	13.75	2.84	2.77
		7:44:45	7.66	14.75	2.92	2.85
		7:45:30	7.70	15.50	2.96	2.89
		7:47:15	7.76	17.25	3.02	2.94
		7:49:00	7.81	19.00	3.07	2.99
		7:50:30	7.85	20.50	3.11	3.03
		7:52:00	7.91	22.00	3.17	3.09
		7:54:00	7.95	24.00	3.21	3.12
		7:56:00	7.98	26.00	3.24	3.15
		7:58:00	8.00	28.00	3.26	3.17
		8:00:00	8.07	30.00	3.33	3.24
		8:05:00	8.14	35.00	3.40	3.30
		8:10:00	8.23	40.00	3.49	3.39
		8:15:00	8.27	45.00	3.53	3.43
		8:20:00	8.32	50.00	3.58	3.47
		8:25:00	8.35	55.00	3.61	3.50
		8:30:00	8.40	60.00	3.66	3.55
		8:40:00	8.46	70.00	3.72	3.60
		8:50:00	8.49	80.00	3.75	3.63
		9:00:00	8.54	90.00	3.80	3.68
		9:10:00	8.55	100.00	3.81	3.69
		9:20:00	8.59	110.00	3.85	3.73
		9:30:00	8.61	120.00	3.87	3.75
		9:50:00	8.63	140.00	3.89	3.76
		10:10:00	8.66	160.00	3.92	3.79
		10:30:00	8.66	180.00	3.92	3.79
		11:00:00	8.70	210.00	3.96	3.83
		11:37:00	8.70	247.00	3.96	3.83
		12:03:00	8.71	273.00	3.97	3.84
		12:30:00	8.74	300.00	4.00	3.87
		13:00:00	8.75	330.00	4.01	3.88
		13:30:00	8.78	360.00	4.04	3.90
		14:37:00	8.80	427.00	4.06	3.92
		15:49:00	8.81	499.00	4.07	3.93
		17:04:00	8.81	574.00	4.07	3.93
		18:19:00	8.97	649.00	4.23	4.08
		19:15:00	8.89	705.00	4.15	4.01
		20:13:00	8.90	763.00	4.16	4.02
		21:11:00	8.97	821.00	4.23	4.08
		22:09:00	8.98	879.00	4.24	4.09
		23:12:00	9.00	942.00	4.26	4.11

Table E4. Constant-Rate (Pumping) Test Data for Temporary Well TW-2S, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-2S	11/1/90	0:22:00	8.97	1012.00	4.23	4.08
		1:20:00	9.02	1070.00	4.28	4.13
		2:21:00	9.03	1131.00	4.29	4.14
		3:15:00	9.04	1185.00	4.30	4.15
		4:22:00	9.05	1252.00	4.31	4.16
		5:19:00	9.08	1309.00	4.34	4.18
		6:16:00	9.08	1366.00	4.34	4.18
		7:17:00	9.12	1427.00	4.38	4.22
		9:04:00	9.08	1534.00	4.34	4.18
		9:53:00	9.11	1583.00	4.37	4.21
		11:36:00	9.10	1686.00	4.36	4.20
		13:45:00	9.12	1815.00	4.38	4.22
		15:35:00	9.16	1925.00	4.42	4.26
		17:53:00	9.21	2063.00	4.47	4.30
		19:44:00	9.24	2174.00	4.50	4.33
		21:38:00	9.23	2288.00	4.49	4.32
		23:34:00	9.24	2404.00	4.50	4.33
	11/2/90	1:41:00	9.27	2531.00	4.53	4.36
		3:42:00	9.28	2652.00	4.54	4.37
		5:43:00	9.30	2773.00	4.56	4.39

Table E5. Constant-Rate (Pumping) Test Data for Temporary Well TW-2D, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-2D	10/31/90	7:19:00	4.90			
		7:31:00	6.06	1.00	1.16	1.15
		7:33:30	6.48	3.50	1.58	1.56
		7:35:00	6.87	5.00	1.97	1.94
		7:36:30	7.02	6.50	2.12	2.08
		7:37:30	7.12	7.50	2.22	2.18
		7:40:30	7.26	10.50	2.36	2.31
		7:42:00	7.34	12.00	2.44	2.39
		7:44:30	7.40	14.50	2.50	2.45
		7:45:00	7.46	15.00	2.56	2.51
		7:46:30	7.51	16.50	2.61	2.55
		7:48:15	7.58	18.25	2.68	2.62
		7:49:45	7.62	19.75	2.72	2.66
		7:51:15	7.66	21.25	2.76	2.70
		7:53:00	7.71	23.00	2.81	2.74
		7:55:00	7.75	25.00	2.85	2.78
		7:57:00	7.77	27.00	2.87	2.80
		7:59:00	7.81	29.00	2.91	2.84
		8:01:00	7.88	31.00	2.98	2.91
		8:06:00	7.94	36.00	3.04	2.96
		8:11:00	8.00	41.00	3.10	3.02
		8:16:00	8.04	46.00	3.14	3.06
		8:21:00	8.10	51.00	3.20	3.11
		8:26:00	8.15	56.00	3.25	3.16
		8:31:00	8.19	61.00	3.29	3.20
		8:41:00	8.23	71.00	3.33	3.24
		8:51:00	8.27	81.00	3.37	3.28
		9:01:00	8.32	91.00	3.42	3.32
		9:11:00	8.32	101.00	3.42	3.32
		9:21:00	8.36	111.00	3.46	3.36
		9:31:00	8.38	121.00	3.48	3.38
		9:51:00	8.43	141.00	3.53	3.43
		10:11:00	8.44	161.00	3.54	3.44
		10:31:00	8.47	181.00	3.57	3.46
		11:01:00	8.47	211.00	3.57	3.46
		11:34:00	8.48	244.00	3.58	3.47
		12:02:00	8.49	272.00	3.59	3.48
		12:31:00	8.52	301.00	3.62	3.51
		13:06:00	8.55	331.00	3.65	3.54
		13:31:00	8.54	361.00	3.64	3.53
		14:35:00	8.58	425.00	3.68	3.57
		15:48:00	8.60	498.00	3.70	3.59
		16:02:00	8.62	512.00	3.72	3.60
		18:20:00	8.65	650.00	3.75	3.63
		19:16:00	8.66	706.00	3.76	3.64
		20:14:00	8.67	764.00	3.77	3.65
		21:13:00	8.73	823.00	3.83	3.71
		22:11:00	8.73	881.00	3.83	3.71
		23:15:00	8.78	945.00	3.88	3.75

Table E5. Constant-Rate (Pumping) Test Data for Temporary Well TW-2D, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-2D	11/1/90	0:23:00	8.77	1013.00	3.87	3.75
		1:22:00	8.81	1072.00	3.91	3.78
		2:22:00	8.80	1132.00	3.90	3.77
		3:16:00	8.82	1186.00	3.92	3.79
		4:23:00	8.87	1253.00	3.97	3.84
		5:21:00	8.84	1311.00	3.94	3.81
		6:18:00	8.88	1368.00	3.98	3.85
		7:18:00	8.89	1428.00	3.99	3.86
		9:06:00	8.88	1536.00	3.98	3.85
		9:52:00	8.87	1582.00	3.97	3.84
		11:38:00	8.85	1688.00	3.95	3.82
		13:46:00	8.90	1816.00	4.00	3.87
		15:36:00	8.90	1926.00	4.00	3.87
		17:54:00	8.99	2064.00	4.09	3.95
		19:45:00	8.99	2175.00	4.09	3.95
		21:39:00	9.00	2289.00	4.10	3.96
		23:35:00	9.00	2405.00	4.10	3.96
	11/2/90	1:42:00	9.02	2532.00	4.12	3.98
		3:43:00	9.04	2653.00	4.14	4.00
		5:44:00	9.04	2774.00	4.14	4.00
		7:49:00	9.08	2899.00	4.18	4.03

Table E6. Constant-Rate (Pumping) Test Data for Temporary Well TW-3S, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-3S	10/31/90	7:19:00	4.40			
		7:30:52	4.79	0.87	0.39	0.39
		7:32:07	5.21	2.12	0.81	0.80
		7:33:11	5.42	3.18	1.02	1.01
		7:34:16	5.57	4.27	1.17	1.16
		7:35:43	5.75	5.72	1.35	1.33
		7:36:39	5.85	6.65	1.45	1.43
		7:37:41	5.93	7.68	1.53	1.51
		7:39:37	6.03	9.62	1.63	1.61
		7:43:00	6.25	13.00	1.85	1.82
		7:45:00	6.32	15.00	1.92	1.89
		7:46:00	6.40	16.00	2.00	1.97
		7:48:00	6.45	18.00	2.05	2.02
		7:50:00	6.52	20.00	2.12	2.08
		7:52:00	6.58	22.00	2.18	2.14
		7:55:00	6.67	25.00	2.27	2.23
		7:57:00	6.69	27.00	2.29	2.25
		7:59:00	6.74	29.00	2.34	2.29
		8:00:30	6.77	30.50	2.37	2.32
		8:05:00	6.88	35.00	2.48	2.43
		8:10:00	6.94	40.00	2.54	2.49
		8:15:00	7.02	45.00	2.62	2.56
		8:20:00	7.07	50.00	2.67	2.61
		8:25:00	7.11	55.00	2.71	2.65
		8:30:00	7.15	60.00	2.75	2.69
		8:39:00	7.22	69.00	2.82	2.75
		8:49:00	7.27	79.00	2.87	2.80
		9:00:30	7.34	90.50	2.94	2.87
		9:09:30	7.35	99.50	2.95	2.88
		9:19:30	7.37	109.50	2.97	2.90
		9:29:30	7.40	119.50	3.00	2.93
		9:48:00	7.44	138.00	3.04	2.96
		10:07:30	7.46	157.50	3.06	2.98
		10:28:00	7.48	178.00	3.08	3.00
		11:00:00	7.49	210.00	3.09	3.01
		11:29:00	7.52	239.00	3.12	3.04
		11:58:00	7.54	268.00	3.14	3.06
		12:30:00	7.56	300.00	3.16	3.08
		13:00:00	7.57	330.00	3.17	3.09
		13:27:30	7.58	357.50	3.18	3.10
		14:31:00	7.63	421.00	3.23	3.14
		15:43:00	7.72	493.00	3.32	3.23
		16:57:00	7.69	567.00	3.29	3.20
		18:10:00	7.70	640.00	3.30	3.21
		19:12:00	7.74	702.00	3.34	3.25
		20:10:00	7.73	760.00	3.33	3.24
		21:16:00	7.79	826.00	3.39	3.29
		22:16:00	7.81	886.00	3.41	3.31
		23:16:00	7.82	946.00	3.42	3.32

Table E6. Constant-Rate (Pumping) Test Data for Temporary Well TW-3S, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-3S	11/1/90	0:26:00	7.83	1016.00	3.43	3.33
		1:25:00	7.88	1075.00	3.48	3.38
		2:25:00	7.87	1135.00	3.47	3.37
		3:22:00	7.89	1192.00	3.49	3.39
		4:25:00	7.91	1255.00	3.51	3.41
		5:24:00	7.92	1314.00	3.52	3.42
		6:21:00	7.94	1371.00	3.54	3.44
		7:22:00	7.98	1432.00	3.58	3.47
		9:01:00	7.92	1531.00	3.52	3.42
		9:50:00	7.92	1580.00	3.52	3.42
		11:34:00	8.00	1684.00	3.60	3.49
		13:43:00	8.04	1813.00	3.64	3.53
		15:34:00	8.00	1924.00	3.60	3.49
		17:50:00	8.07	2060.00	3.67	3.56
		19:42:00	8.09	2172.00	3.69	3.58
		21:41:00	8.09	2291.00	3.69	3.58
		23:37:00	8.11	2407.00	3.71	3.60
	11/2/90	1:44:00	8.12	2534.00	3.72	3.60
		3:45:00	8.13	2655.00	3.73	3.61
		5:45:00	8.15	2775.00	3.75	3.63
		7:51:00	8.18	2901.00	3.78	3.66

Table E7. Constant-Rate (Pumping) Test Data for Temporary Well TW-3D, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-3D	10/31/90	7:20:00	4.51			
		7:30:20	5.73	0.33	1.22	1.21
		7:31:20	6.65	1.33	2.14	2.10
		7:32:36	6.99	2.60	2.48	2.43
		7:33:35	7.15	3.58	2.64	2.58
		7:34:56	7.37	4.93	2.86	2.79
		7:36:05	7.49	6.08	2.98	2.91
		7:37:10	7.63	7.17	3.12	3.04
		7:38:59	7.68	8.98	3.17	3.09
		7:42:00	7.86	12.00	3.35	3.26
		7:44:00	7.96	14.00	3.45	3.35
		7:45:30	7.99	15.50	3.48	3.38
		7:47:00	8.13	17.00	3.62	3.51
		7:49:00	8.16	19.00	3.65	3.54
		7:50:00	8.23	20.50	3.72	3.60
		7:52:30	8.28	22.50	3.77	3.65
		7:54:00	8.33	24.00	3.82	3.70
		7:56:00	8.36	26.00	3.85	3.73
		7:58:00	8.40	28.00	3.89	3.76
		8:00:00	8.45	30.00	3.94	3.81
		8:05:00	8.53	35.50	4.02	3.89
		8:10:30	8.58	40.50	4.07	3.93
		8:15:30	8.64	45.50	4.13	3.99
		8:20:30	8.70	50.50	4.19	4.04
		8:26:00	8.74	56.00	4.23	4.08
		8:37:00	8.79	61.00	4.28	4.13
		8:40:00	8.84	70.00	4.33	4.17
		8:50:00	8.88	80.00	4.37	4.21
		9:01:30	8.92	91.50	4.41	4.25
		9:10:30	8.95	100.50	4.44	4.28
		9:20:00	8.97	110.00	4.46	4.29
		9:30:30	8.98	120.50	4.47	4.30
		9:49:30	9.01	139.50	4.50	4.33
		10:09:00	9.03	159.00	4.52	4.35
		10:29:00	9.06	179.00	4.55	4.38
		11:01:30	9.09	211.50	4.58	4.41
		11:29:30	9.08	239.50	4.57	4.40
		11:58:30	9.11	268.50	4.60	4.42
		12:31:30	9.12	301.50	4.61	4.43
		13:02:00	9.16	332.00	4.65	4.47
		13:28:30	9.15	358.50	4.64	4.46
		14:32:00	9.21	422.00	4.70	4.52
		15:40:00	9.24	490.00	4.73	4.54
		17:00:00	9.20	570.00	4.69	4.51
		18:09:00	9.22	639.00	4.71	4.53
		19:10:00	9.25	700.00	4.74	4.55
		20:08:00	9.25	758.00	4.74	4.55
		21:18:00	9.33	828.00	4.82	4.63
		22:18:00	9.32	888.00	4.81	4.62
		23:17:00	9.34	947.00	4.83	4.64

Table E7. Constant-Rate (Pumping) Test Data for Temporary Well TW-3D, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-3D	11/1/90	0:29:00	9.36	1019.00	4.85	4.65
		1:26:00	9.40	1076.00	4.89	4.69
		2:25:00	9.40	1135.00	4.89	4.69
		3:23:00	9.41	1193.00	4.90	4.70
		4:26:00	9.45	1256.00	4.94	4.74
		5:25:00	9.43	1315.00	4.92	4.72
		6:21:00	9.46	1371.00	4.95	4.75
		7:23:00	9.48	1443.00	4.97	4.76
		9:02:00	9.48	1532.00	4.97	4.76
		9:49:00	9.45	1579.00	4.94	4.74
		11:29:00	9.45	1679.00	4.94	4.74
		13:42:00	9.50	1812.00	4.99	4.78
		15:53:00	9.52	1943.00	5.01	4.80
		17:49:00	9.58	2059.00	5.07	4.86
		19:40:00	9.60	2170.00	5.09	4.87
		21:42:00	9.62	2292.00	5.11	4.89
		23:38:00	9.61	2408.00	5.10	4.88
	11/2/90	1:45:00	9.63	2535.00	5.12	4.90
		3:46:00	9.64	2656.00	5.13	4.91
		5:46:00	9.65	2776.00	5.14	4.92
		7:52:00	9.70	2902.00	5.19	4.97

Table E8. Constant-Rate (Pumping) Test Data for Temporary Well TW-4S, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-4S	10/31/90	7:30:00	4.38			
		7:30:15	4.52	0.25	0.14	0.14
		7:31:00	4.84	1.00	0.46	0.46
		7:32:30	4.87	2.50	0.49	0.49
		7:35:00	4.90	5.00	0.52	0.52
		7:37:00	5.22	7.00	0.84	0.83
		7:39:00	5.30	9.00	0.92	0.91
		7:40:00	5.32	10.00	0.94	0.93
		7:44:00	5.46	14.00	1.08	1.07
		7:46:00	5.56	16.00	1.18	1.17
		7:50:00	5.67	20.00	1.29	1.28
		7:52:00	5.72	22.00	1.34	1.33
		7:54:00	5.76	24.00	1.38	1.36
		7:56:00	5.80	26.00	1.42	1.40
		8:00:00	5.90	30.00	1.52	1.50
		8:05:00	6.01	35.00	1.63	1.61
		8:10:00	6.01	40.00	1.63	1.61
		8:15:00	6.02	45.00	1.64	1.62
		8:20:00	6.05	50.00	1.67	1.65
		8:25:00	6.13	55.00	1.75	1.72
		8:30:00	6.16	60.00	1.78	1.75
		8:35:00	6.18	65.00	1.80	1.77
		8:40:00	6.20	70.00	1.82	1.79
		8:50:00	6.24	80.00	1.86	1.83
		9:00:00	6.27	90.00	1.89	1.86
		9:10:00	6.30	100.00	1.92	1.89
		9:20:00	6.30	110.00	1.92	1.89
		9:30:00	6.34	120.00	1.96	1.93
		9:50:00	6.37	140.00	1.99	1.96
		10:10:00	6.38	160.00	2.00	1.97
		10:30:00	6.38	180.00	2.00	1.97
		10:59:00	6.43	209.00	2.05	2.02
		11:30:00	6.44	240.00	2.06	2.02
		12:00:00	6.45	270.00	2.07	2.03
		12:30:00	6.49	300.00	2.11	2.07
		13:08:00	6.50	338.00	2.12	2.08
		13:34:00	6.50	364.00	2.12	2.08
		14:42:00	6.55	432.00	2.17	2.13
		15:53:00	6.59	503.00	2.21	2.17
		17:13:00	6.53	583.00	2.15	2.11
		18:26:00	6.59	656.00	2.21	2.17
		19:23:00	6.59	713.00	2.21	2.17
		20:19:00	6.60	769.00	2.22	2.18
		21:21:00	6.65	831.00	2.27	2.23
		22:20:00	6.68	890.00	2.30	2.26
		23:20:00	6.69	950.00	2.31	2.27

Table E8. Constant-Rate (Pumping) Test Data for Temporary Well TW-4S, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-4S	11/1/90	0:28:00	6.70	1018.00	2.32	2.28
		1:28:00	6.73	1078.00	2.35	2.30
		2:28:00	6.72	1138.00	2.34	2.29
		3:25:00	6.73	1195.00	2.35	2.30
		4:28:00	6.78	1258.00	2.40	2.35
		5:26:00	6.77	1316.00	2.39	2.34
		6:23:00	6.80	1373.00	2.42	2.37
		7:24:00	6.81	1434.00	2.43	2.38
		9:10:00	6.79	1540.00	2.41	2.36
		10:04:00	6.80	1594.00	2.42	2.37
		11:41:00	6.82	1691.00	2.44	2.39
		13:49:00	6.84	1819.00	2.46	2.41
		15:39:00	6.85	1929.00	2.47	2.42
		17:58:00	6.88	2068.00	2.50	2.45
		19:48:00	6.92	2178.00	2.54	2.49
		21:43:00	6.94	2293.00	2.56	2.51
		23:40:00	6.94	2410.00	2.56	2.51
	11/2/90	1:47:00	6.98	2537.00	2.60	2.54
		3:48:00	7.00	2658.00	2.62	2.56
		5:48:00	7.00	2778.00	2.62	2.56
		7:54:00	7.01	2904.00	2.63	2.57

Table E9. Constant-Rate (Pumping) Test Data for Temporary Well TW-4D, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-4D	10/31/90	7:00:00	4.52			
		7:30:15	4.58	0.25	0.06	0.06
		7:30:30	4.68	0.50	0.16	0.16
		7:33:00	5.35	3.00	0.83	0.82
		7:37:00	5.47	7.00	0.95	0.94
		7:39:00	5.58	9.00	1.06	1.05
		7:40:00	5.58	10.00	1.06	1.05
		7:44:00	5.70	14.00	1.18	1.17
		7:46:00	5.80	16.00	1.28	1.27
		7:50:00	5.86	20.00	1.34	1.33
		7:52:00	5.90	22.00	1.38	1.36
		7:54:00	5.92	24.00	1.40	1.38
		7:56:00	5.70	26.00	1.18	1.17
		8:00:00	6.00	30.00	1.48	1.46
		8:05:00	6.10	35.00	1.58	1.56
		8:10:00	6.16	40.00	1.64	1.62
		8:15:00	6.23	45.00	1.71	1.69
		8:20:00	6.24	50.00	1.72	1.70
		8:25:00	6.30	55.00	1.78	1.75
		8:30:00	6.30	60.00	1.78	1.75
		8:35:00	6.32	65.00	1.80	1.77
		8:40:00	6.34	70.00	1.82	1.79
		8:50:00	6.38	80.00	1.86	1.83
		9:00:00	6.41	90.00	1.89	1.86
		9:10:00	6.42	100.00	1.90	1.87
		9:20:00	6.45	110.00	1.93	1.90
		9:30:00	6.45	120.00	1.93	1.90
		9:50:00	6.48	140.00	1.96	1.93
		10:10:00	6.50	160.00	1.98	1.95
		10:30:00	6.55	180.00	2.03	2.00
		11:00:00	6.55	210.00	2.03	2.00
		11:29:00	6.59	239.00	2.07	2.03
		11:59:00	6.59	269.00	2.07	2.03
		12:29:00	6.62	299.00	2.10	2.06
		13:06:00	6.64	336.00	2.12	2.08
		13:35:00	6.65	365.00	2.13	2.09
		14:40:00	6.69	430.00	2.17	2.13
		15:42:00	6.72	492.00	2.20	2.16
		17:10:00	6.76	580.00	2.24	2.20
		18:25:00	6.71	655.00	2.19	2.15
		19:21:00	6.71	711.00	2.19	2.15
		20:18:00	6.75	768.00	2.23	2.19
		21:22:00	6.76	832.00	2.24	2.20
		22:21:00	6.78	891.00	2.26	2.22
		23:21:00	6.82	951.00	2.30	2.26

Table E9. Constant-Rate (Pumping) Test Data for Temporary Well TW-4D, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-4D	11/1/90	0:29:00	6.82	1019.00	2.30	2.26
		1:30:00	6.85	1080.00	2.33	2.28
		2:28:00	6.88	1138.00	2.36	2.31
		3:26:00	6.85	1196.00	2.33	2.28
		4:29:00	6.91	1259.00	2.39	2.34
		5:26:00	6.92	1316.00	2.40	2.35
		6:24:00	6.93	1374.00	2.41	2.36
		7:25:00	6.93	1435.00	2.41	2.36
		9:08:00	6.92	1538.00	2.40	2.35
		10:02:00	6.92	1592.00	2.40	2.35
		11:40:00	6.92	1690.00	2.40	2.35
		13:48:00	6.95	1818.00	2.43	2.38
		15:38:00	6.97	1928.00	2.45	2.40
		17:57:00	7.04	2067.00	2.52	2.47
		19:47:00	7.01	2177.00	2.49	2.44
		21:44:00	7.03	2294.00	2.51	2.46
		23:41:00	7.05	2411.00	2.53	2.48
	11/2/90	1:48:00	7.07	2538.00	2.55	2.50
		3:49:00	7.07	2659.00	2.55	2.50
		5:49:00	7.07	2779.00	2.55	2.50
		7:57:00	7.11	2907.00	2.59	2.53

Table E10. Constant-Rate (Pumping) Test Data for Temporary Well TW-5, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
TW-5	10/31/90	6:48:00	2.12			
		7:48:00	2.09	18.00	-0.03	-0.03
		8:02:00	2.15	32.00	0.03	0.03
		8:52:00	2.18	82.00	0.06	0.06
		9:31:00	2.27	121.00	0.15	0.15
		9:58:00	2.28	148.00	0.16	0.16
		12:08:00	2.36	278.00	0.24	0.24
		13:08:00	2.37	338.00	0.25	0.25
		14:39:00	2.38	429.00	0.26	0.26
		17:38:00	2.50	608.00	0.38	0.38
		18:50:00	2.45	680.00	0.33	0.33
		19:47:00	2.46	737.00	0.34	0.34
		20:49:00	2.47	799.00	0.35	0.35
		21:54:00	2.38	864.00	0.26	0.26
		22:39:00	2.50	909.00	0.38	0.38
		23:40:00	2.50	970.00	0.38	0.38
	11/1/90	0:41:00	2.50	1031.00	0.38	0.38
		1:42:00	2.50	1092.00	0.38	0.38
		2:40:00	2.50	1150.00	0.38	0.38
		3:41:00	2.52	1211.00	0.40	0.40
		4:41:00	2.54	1271.00	0.42	0.42
		5:42:00	2.52	1332.00	0.40	0.40
		6:37:00	2.54	1387.00	0.42	0.42
		7:38:00	2.54	1448.00	0.42	0.42
		9:34:00	2.51	1564.00	0.39	0.39
		11:11:00	2.51	1661.00	0.39	0.39
		13:27:00	2.54	1797.00	0.42	0.42
		15:44:00	2.47	1934.00	0.35	0.35
		17:26:00	2.55	2036.00	0.43	0.43
		19:21:00	2.51	2151.00	0.39	0.39
		21:20:00	2.54	2270.00	0.42	0.42
		23:18:00	2.55	2388.00	0.43	0.43
	11/2/90	1:24:00	2.55	2574.00	0.43	0.43
		3:25:00	2.56	2635.00	0.44	0.44
		5:26:00	2.56	2756.00	0.44	0.44
		8:13:00	2.58	2923.00	0.46	0.46

Table E11. Constant-Rate (Pumping) Test Data for Temporary Well OW-19, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
OW-19	10/31/90	7:30:00	4.07			
		7:31:50	4.36	1.83	0.29	0.29
		7:34:00	4.75	4.00	0.68	0.68
		7:35:40	4.93	5.67	0.86	0.85
		7:37:15	5.08	7.25	1.01	1.00
		7:39:15	5.21	9.25	1.14	1.13
		7:41:00	5.29	11.00	1.22	1.21
		7:43:00	5.38	13.00	1.31	1.30
		7:44:40	5.45	14.67	1.38	1.36
		7:46:30	5.51	16.50	1.44	1.42
		7:48:30	5.57	18.50	1.50	1.48
		7:50:35	5.63	20.58	1.56	1.54
		7:52:55	5.69	22.92	1.62	1.60
		7:54:45	5.70	24.75	1.63	1.61
		7:56:30	5.76	26.50	1.69	1.67
		7:58:25	5.80	28.42	1.73	1.71
		8:00:15	5.82	30.25	1.75	1.72
		8:05:00	5.88	35.00	1.81	1.78
		8:10:00	5.97	40.00	1.90	1.87
		8:15:00	6.01	45.00	1.94	1.91
		8:20:00	6.05	50.00	1.98	1.95
		8:25:00	6.09	55.00	2.02	1.99
		8:30:00	6.13	60.00	2.06	2.02
		8:40:00	6.20	70.00	2.13	2.09
		8:50:00	6.22	80.00	2.15	2.11
		9:00:00	6.26	90.00	2.19	2.15
		9:10:00	6.28	100.00	2.21	2.17
		9:20:00	6.31	110.00	2.24	2.20
		9:30:00	6.33	120.00	2.26	2.22
		9:50:00	6.38	140.00	2.31	2.27
		10:10:00	6.39	160.00	2.32	2.28
		10:30:00	6.42	180.00	2.35	2.30
		11:00:00	6.48	210.00	2.41	2.36
		11:30:00	6.44	240.00	2.37	2.32
		12:00:00	6.45	270.00	2.38	2.33
		12:01:00	6.46	271.00	2.39	2.34
		12:30:00	6.47	300.00	2.40	2.35
		13:00:00	6.49	330.00	2.42	2.37
		13:30:00	6.53	360.00	2.46	2.41
		14:30:00	6.59	420.00	2.52	2.47
		15:25:00	6.57	475.00	2.50	2.45
		16:22:00	6.60	532.00	2.53	2.48
		17:48:00	6.65	618.00	2.58	2.52
		18:53:00	6.63	683.00	2.56	2.51
		19:51:00	6.67	741.00	2.60	2.54
		20:52:00	6.71	802.00	2.64	2.58
		21:58:00	6.74	868.00	2.67	2.61
		22:41:00	6.74	911.00	2.67	2.61
		23:41:00	6.75	971.00	2.68	2.62

Table E11. Constant-Rate (Pumping) Test Data for Temporary Well OW-19, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
OW-19	11/1/90	0:46:00	6.76	1036.00	2.69	2.63
		1:44:00	6.77	1094.00	2.70	2.64
		2:43:00	6.78	1153.00	2.71	2.65
		3:49:00	6.80	1219.00	2.73	2.67
		4:42:00	6.83	1272.00	2.76	2.70
		5:44:00	6.82	1334.00	2.75	2.69
		6:38:00	6.85	1388.00	2.78	2.72
		7:40:00	6.88	1450.00	2.81	2.74
		9:36:00	6.83	1566.00	2.76	2.70
		11:14:00	6.85	1664.00	2.78	2.72
		13:29:00	6.85	1799.00	2.78	2.72
		15:47:00	6.88	1937.00	2.81	2.74
		17:31:00	6.92	2041.00	2.85	2.78
		19:24:00	7.00	2154.00	2.93	2.86
		21:23:00	7.00	2273.00	2.93	2.86
		23:20:00	7.00	2390.00	2.93	2.86
	11/2/90	1:25:00	7.00	2515.00	2.93	2.86
		3:27:00	7.01	2637.00	2.94	2.87
		5:38:00	7.01	2758.00	2.94	2.87
		7:28:00	7.02	2878.00	2.95	2.88

Table E12. Constant-Rate (Pumping) Test Data for Temporary Well OW-19A, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
OW-19A	10/31/90	7:22:00	3.99			
		7:30:45	4.07	0.75	0.08	0.08
		7:33:50	4.50	3.83	0.51	0.51
		7:34:50	4.75	4.83	0.76	0.76
		7:36:30	4.89	6.50	0.90	0.89
		7:38:15	5.01	8.25	1.02	1.01
		7:40:10	5.11	10.17	1.12	1.11
		7:41:55	5.19	11.92	1.20	1.19
		7:43:50	5.27	13.83	1.28	1.27
		7:45:40	5.32	15.67	1.33	1.32
		7:47:30	5.42	17.50	1.43	1.41
		7:49:40	5.45	19.67	1.46	1.44
		7:51:45	5.51	21.75	1.52	1.50
		7:53:55	5.55	23.92	1.56	1.54
		7:55:30	5.59	25.50	1.60	1.58
		7:57:20	5.61	27.33	1.62	1.60
		7:59:15	5.64	29.25	1.65	1.63
		8:01:15	5.68	31.25	1.69	1.67
		8:05:45	5.78	35.75	1.79	1.76
		8:10:50	5.83	40.83	1.84	1.81
		8:15:50	5.86	45.83	1.87	1.84
		8:20:55	5.92	50.92	1.93	1.90
		8:25:45	5.95	55.75	1.96	1.93
		8:30:45	5.97	60.75	1.98	1.95
		8:40:50	6.01	70.83	2.02	1.99
		8:50:55	6.10	80.92	2.11	2.07
		9:00:50	6.13	90.83	2.14	2.10
		9:10:50	6.15	100.83	2.16	2.12
		9:20:45	6.18	110.75	2.19	2.15
		9:30:45	6.18	120.75	2.19	2.15
		9:50:45	6.22	140.75	2.23	2.19
		10:11:00	6.24	161.00	2.25	2.21
		10:30:50	6.26	180.83	2.27	2.23
		11:00:45	6.29	210.75	2.30	2.26
		11:30:50	6.31	240.83	2.32	2.28
		12:02:00	6.29	272.00	2.30	2.26
		12:32:30	6.29	302.50	2.30	2.26
		13:01:45	6.31	331.75	2.32	2.28
		13:31:00	6.36	361.00	2.37	2.32
		14:31:00	6.39	421.00	2.40	2.35
		15:26:00	6.44	476.00	2.45	2.40
		16:24:00	6.41	534.00	2.42	2.37
		17:50:00	6.47	620.00	2.48	2.43
		18:55:00	6.48	685.00	2.49	2.44
		19:51:00	6.50	741.00	2.51	2.46
		20:54:00	6.57	804.00	2.58	2.52
		22:00:00	6.57	870.00	2.58	2.52
		22:43:00	6.57	913.00	2.58	2.52
		23:48:00	6.59	978.00	2.60	2.54

Table E12. Constant-Rate (Pumping) Test Data for Temporary Well OW-19A, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
OW-19A	11/1/90	0:48:00	6.63	1038.00	2.64	2.58
		1:45:00	6.63	1095.00	2.64	2.58
		2:44:00	6.67	1154.00	2.68	2.62
		3:46:00	6.68	1216.00	2.69	2.63
		4:44:00	6.68	1274.00	2.69	2.63
		5:45:00	6.69	1335.00	2.70	2.64
		6:40:00	6.72	1390.00	2.73	2.67
		7:41:00	6.72	1451.00	2.73	2.67
		9:37:00	6.70	1567.00	2.71	2.65
		11:15:00	6.72	1665.00	2.73	2.67
		13:31:00	6.76	1801.00	2.77	2.71
		15:49:00	6.74	1939.00	2.75	2.69
		17:32:00	6.79	2042.00	2.80	2.73
		19:26:00	6.81	2156.00	2.82	2.75
		21:25:00	6.85	2275.00	2.86	2.79
		23:21:00	6.88	2391.00	2.89	2.82
	11/2/90	1:27:00	6.88	2517.00	2.89	2.82
		3:29:00	6.90	2639.00	2.91	2.84
		5:30:00	6.98	2760.00	2.99	2.92
		7:30:00	6.93	2880.00	2.94	2.87

Table E13. Constant-Rate (Pumping) Test Data for Temporary Well OW-24A, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
OW-24A	10/31/90	6:55:00	4.61			
		8:55:00	4.80	85.00	0.19	0.19
		9:05:00	4.79	95.00	0.18	0.18
		9:14:00	4.80	104.00	0.19	0.19
		9:25:00	4.81	115.00	0.20	0.20
		9:55:00	4.85	145.00	0.24	0.24
		10:15:00	4.85	165.00	0.24	0.24
		10:36:00	4.86	186.00	0.25	0.25
		11:05:00	4.86	215.00	0.25	0.25
		11:35:00	4.88	245.00	0.27	0.27
		12:05:00	4.88	275.00	0.27	0.27
		12:36:00	4.90	306.00	0.29	0.29
		13:05:00	4.90	335.00	0.29	0.29
		13:35:00	4.92	365.00	0.31	0.31
		14:36:00	4.94	426.00	0.33	0.33
		16:29:00	4.95	539.00	0.34	0.34
		17:58:00	4.97	628.00	0.36	0.36
		19:00:00	5.00	690.00	0.39	0.39
		19:58:00	5.01	748.00	0.40	0.40
		20:59:00	5.07	809.00	0.46	0.46
		22:03:00	5.08	873.00	0.47	0.47
		22:46:00	5.08	916.00	0.47	0.47
		23:49:00	5.10	979.00	0.49	0.49
	11/1/90	0:52:00	5.13	1042.00	0.52	0.52
		1:49:00	5.16	1099.00	0.55	0.55
		2:49:00	5.16	1159.00	0.55	0.55
		3:50:00	5.18	1220.00	0.57	0.57
		4:49:00	5.19	1279.00	0.58	0.58
		5:50:00	5.22	1340.00	0.61	0.61
		6:44:00	5.23	1394.00	0.62	0.62
		7:44:00	5.27	1454.00	0.66	0.66
		9:41:00	5.21	1571.00	0.60	0.60
		11:20:00	5.25	1670.00	0.64	0.64
		13:35:00	5.27	1805.00	0.66	0.66
		15:22:00	5.31	1912.00	0.70	0.70
		17:29:00	5.35	2049.00	0.74	0.74
		19:30:00	5.38	2160.00	0.77	0.77
		21:28:00	5.40	2278.00	0.79	0.78
		23:25:00	5.40	2395.00	0.79	0.78
	11/2/90	1:32:00	5.42	2522.00	0.81	0.80
		3:32:00	5.44	2642.00	0.83	0.82
		5:34:00	5.44	2764.00	0.83	0.82
		7:34:00	5.51	2884.00	0.90	0.89

Table E14. Constant-Rate (Pumping) Test Data for Temporary Well OW-24B, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
OW-24B	10/31/90	6:55:00	4.49			
		8:55:00	4.82	85.00	0.33	0.33
		9:07:00	4.95	97.00	0.46	0.46
		9:15:00	5.15	105.00	0.66	0.66
		9:25:00	5.43	115.00	0.94	0.93
		9:55:00	5.45	145.00	0.96	0.95
		10:15:00	5.46	165.00	0.97	0.96
		10:36:00	5.47	186.00	0.98	0.97
		11:05:00	5.48	215.00	0.99	0.98
		11:35:00	5.52	245.00	1.03	1.02
		12:06:00	5.52	276.00	1.03	1.02
		12:36:00	5.51	306.00	1.02	1.01
		13:05:00	5.53	335.00	1.04	1.03
		13:36:00	5.55	366.00	1.06	1.05
		14:36:00	5.58	426.00	1.09	1.08
		15:31:00	5.57	481.00	1.08	1.07
		16:30:00	5.59	540.00	1.10	1.09
		17:59:00	5.62	629.00	1.13	1.12
		19:02:00	5.69	692.00	1.20	1.19
		19:59:00	5.65	749.00	1.16	1.15
		21:01:00	5.72	811.00	1.23	1.22
		22:04:00	5.73	874.00	1.24	1.23
		22:48:00	5.72	918.00	1.23	1.22
		23:05:00	5.75	980.00	1.26	1.25
	11/1/90	0:53:00	5.77	1043.00	1.28	1.27
		1:50:00	5.79	1100.00	1.30	1.29
		2:50:00	5.79	1160.00	1.30	1.29
		3:51:00	5.80	1221.00	1.31	1.30
		4:51:00	5.83	1281.00	1.34	1.33
		5:51:00	5.84	1341.00	1.35	1.33
		6:45:00	5.85	1395.00	1.36	1.34
		7:45:00	5.85	1455.00	1.36	1.34
		9:42:00	5.85	1572.00	1.36	1.34
		11:21:00	5.83	1671.00	1.34	1.33
		13:36:00	5.86	1806.00	1.37	1.35
		15:23:00	5.90	1913.00	1.41	1.39
		17:41:00	5.93	2051.00	1.44	1.42
		19:32:00	6.00	2162.00	1.51	1.49
		21:29:00	6.00	2279.00	1.51	1.49
		23:27:00	5.99	2397.00	1.50	1.48
	11/2/90	1:33:00	6.00	2523.00	1.51	1.49
		3:33:00	6.01	2643.00	1.52	1.50
		5:35:00	6.02	2765.00	1.53	1.51
		7:35:00	6.06	2885.00	1.57	1.55

Table E15. Constant-Rate (Pumping) Test Data for Temporary Well OW-33A, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
OW-33A	10/31/90	6:45:00	5.32			
		8:39:00	5.35	69.00	0.03	0.03
		8:54:00	5.37	84.00	0.05	0.05
		9:00:00	5.36	90.00	0.04	0.04
		9:10:00	5.39	100.00	0.07	0.07
		9:21:00	5.39	111.00	0.07	0.07
		9:30:00	5.39	120.00	0.07	0.07
		9:40:00	5.37	130.00	0.05	0.05
		9:50:00	5.40	140.00	0.08	0.08
		10:00:00	5.40	150.00	0.08	0.08
		10:37:00	5.40	167.00	0.08	0.08
		11:07:00	5.40	197.00	0.08	0.08
		11:38:00	5.42	228.00	0.10	0.10
		12:07:00	5.43	257.00	0.11	0.11
		12:41:00	5.40	311.00	0.08	0.08
		13:15:00	5.42	345.00	0.10	0.10
		14:05:00	5.41	395.00	0.09	0.09
		14:44:00	5.44	434.00	0.12	0.12
		15:36:00	5.45	486.00	0.13	0.13
		16:01:00	5.41	511.00	0.09	0.09
		17:23:00	5.46	593.00	0.14	0.14
		18:41:00	5.46	671.00	0.14	0.14
		19:39:00	5.51	729.00	0.19	0.19
		20:39:00	5.53	789.00	0.21	0.21
		21:44:00	5.54	854.00	0.22	0.22
		22:28:00	5.51	898.00	0.19	0.19
		23:26:00	5.51	956.00	0.19	0.19
	11/1/90	0:33:00	5.53	1023.00	0.21	0.21
		1:33:00	5.55	1083.00	0.23	0.23
		2:03:00	5.54	1143.00	0.22	0.22
		3:32:00	5.55	1202.00	0.23	0.23
		4:33:00	5.58	1263.00	0.26	0.26
		5:30:00	5.57	1320.00	0.25	0.25
		6:28:00	5.56	1378.00	0.24	0.24
		7:29:00	5.57	1439.00	0.25	0.25
		9:18:00	5.53	1548.00	0.21	0.21
		11:05:00	5.55	1655.00	0.23	0.23
		13:19:00	5.55	1789.00	0.23	0.23
		15:08:00	5.56	1898.00	0.24	0.24
		17:17:00	5.60	2027.00	0.28	0.28
		19:13:00	5.60	2143.00	0.28	0.28
		21:12:00	5.61	2262.00	0.29	0.29
		23:10:00	5.61	2380.00	0.29	0.29
	11/2/90	1:14:00	5.64	2504.00	0.32	0.32
		3:15:00	5.64	2625.00	0.32	0.32
		5:18:00	5.66	2748.00	0.34	0.34
		7:18:00	5.65	2868.00	0.33	0.33

Table E16. Constant-Rate (Pumping) Test Data for Temporary Well OW-33B, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Well Number	Date	Time	Depth to Water	Time, in minutes from start of test	Measured Drawdown, in feet	Corrected Drawdown, in feet
OW-33B	10/31/90	6:43:00	5.13			
		8:37:00	5.22	67.00	0.09	0.09
		8:53:00	5.18	83.00	0.05	0.05
		8:59:00	5.25	89.00	0.12	0.12
		9:09:00	5.25	99.00	0.12	0.12
		9:20:00	5.28	110.00	0.15	0.15
		9:29:00	5.28	119.00	0.15	0.15
		9:39:00	5.28	129.00	0.15	0.15
		9:49:00	5.29	139.00	0.16	0.16
		9:59:00	5.29	149.00	0.16	0.16
		10:36:00	5.30	166.00	0.17	0.17
		11:06:00	5.28	196.00	0.15	0.15
		11:37:00	5.31	227.00	0.18	0.18
		12:06:00	5.28	256.00	0.15	0.15
		12:40:00	5.29	310.00	0.16	0.16
		13:16:00	5.34	346.00	0.21	0.21
		14:06:00	5.36	396.00	0.23	0.23
		14:45:00	5.36	435.00	0.23	0.23
		16:00:00	5.34	510.00	0.21	0.21
		16:32:00	5.37	482.00	0.24	0.24
		17:21:00	5.38	591.00	0.25	0.25
		18:38:00	5.40	668.00	0.27	0.27
		19:37:00	5.41	727.00	0.28	0.28
		20:40:00	5.45	790.00	0.32	0.32
		21:46:00	5.47	856.00	0.34	0.34
		22:30:00	5.45	900.00	0.32	0.32
		23:27:00	5.47	957.00	0.34	0.34
	11/1/90	0:34:00	5.47	1024.00	0.34	0.34
		1:35:00	5.50	1085.00	0.37	0.37
		2:35:00	5.48	1145.00	0.35	0.35
		3:32:00	5.50	1202.00	0.37	0.37
		4:33:00	5.51	1263.00	0.38	0.38
		5:30:00	5.52	1320.00	0.39	0.39
		6:29:00	5.52	1379.00	0.39	0.39
		7:30:00	5.54	1440.00	0.41	0.41
		9:17:00	5.49	1547.00	0.36	0.36
		11:04:00	5.54	1654.00	0.41	0.41
		13:18:00	5.50	1788.00	0.37	0.37
		15:07:00	5.52	1897.00	0.39	0.39
		17:16:00	5.54	2026.00	0.41	0.41
		19:10:00	5.52	2140.00	0.39	0.39
		21:13:00	5.56	2263.00	0.43	0.43
		23:12:00	5.58	2382.00	0.45	0.45
	11/2/90	1:17:00	5.58	2507.00	0.45	0.45
		3:17:00	5.59	2627.00	0.46	0.46
		5:19:00	5.58	2749.00	0.45	0.45
		7:20:00	5.60	2870.00	0.47	0.47

Table E17. Water-Level Elevation Data for Hall's Brook during Constant-Rate (Pumping) Test, October 31, 1990 through November 2, 1990, Pre-Design Investigation, Industri-Plex Study Area, Woburn, Massachusetts.

Staff Gauge	Date	Time	Time, in minutes from start of test	Stream Elevation, in feet
SG-1	10/31/90	6:48:00		
		7:48:00	18.00	51.59
		8:02:00	32.00	51.59
		8:52:00	82.00	51.61
		9:31:00	121.00	51.62
		9:58:00	148.00	51.62
		12:08:00	278.00	51.61
		13:08:00	338.00	51.61
		14:39:00	429.00	
		17:38:00	608.00	51.62
		18:50:00	680.00	51.61
		19:47:00	737.00	51.62
		20:49:00	799.00	51.63
		21:54:00	864.00	51.63
		22:39:00	909.00	51.63
		23:40:00	970.00	51.63
	11/1/90	0:41:00	1031.00	51.61
		1:42:00	1092.00	51.61
		2:40:00	1150.00	51.61
		3:41:00	1211.00	51.61
		4:41:00	1271.00	51.61
		5:42:00	1332.00	51.60
		6:37:00	1387.00	51.59
		7:38:00	1448.00	51.58
		9:34:00	1564.00	51.61
		11:11:00	1661.00	51.59
		13:27:00	1797.00	51.59
		15:44:00	1934.00	51.59
		17:26:00	2036.00	51.59
		19:21:00	2151.00	51.59
		21:20:00	2270.00	51.59
		23:18:00	2388.00	51.59
	11/2/90	1:24:00	2574.00	51.59
		3:25:00	2635.00	51.58
		5:26:00	2756.00	51.58
		8:13:00	2923.00	51.57

APPENDIX F

Addendum to Aquifer Test Work Plan
(August 21, 1990) Task GW-2, Subtask 1,
Sampling and Analysis of Ground Water During Aquifer Tests

ADDENDUM TO AQUIFER TEST WORK PLAN (AUGUST 21, 1990) TASK GW-2, SUBTASK 1

Sampling and Analysis of Ground Water During Aquifer Tests

October 23, 1990

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GA16101Y.4.3

INTRODUCTION

This Sampling and Analysis Plan outlines the procedures which will be followed for the field analysis of volatile organic compounds (VOCs) and arsenic during the Aquifer Test performed as part of the Pre-Design Investigation (PDI) at the Industri-Plex Site, Woburn, Massachusetts. It was prepared in response to United States Environmental Protection Agency (USEPA) and Massachusetts Department of Environmental Protection (MDEP) comments on the August 21, 1990 "Aquifer Test Work Plan, Task GW-2/Subtask 1", and in response to the approval letter from USEPA to the Industri-Plex Site Remedial Trust of October 10, 1990.

As described in the Aquifer Test Work Plan, the tests will produce approximately 100 gpm or more of water, which will be discharged to the Hall's Brook Holding Area. During the tests, pumped ground water will be analyzed for benzene, toluene, trichloroethylene (TCE), and arsenic on a real-time basis. If the concentration of any parameter exceeds the action level for three consecutive tests, aquifer testing will be discontinued. This addendum describes methods for carrying out this real-time sampling and analysis.

1.0 SAMPLING LOCATION AND FREQUENCY

Samples will be collected from a valve on the discharge line of the test well (PW-1) at 1-hr intervals.

2.0 SAMPLING DESIGNATION

Each sample will be given a unique identification number based upon a system developed for all pre-design tasks. The designation will be as follows:

IP/000/000/000/0/0/00

where the first two characters (IP) stand for the Industri-Plex Site;

The third through fifth characters stand for the pre-design task number;

The sixth through eighth characters stand for the sample location within that task;

The ninth through eleventh characters stand for the depth of the bottom of the sample interval, where applicable;

The twelfth character stands for the matrix type (1=solid, 2=liquid, 3=gas);

The thirteenth character stands for the sampling round number; and

The fourteenth and fifteenth characters stand for the analysis type.

The applicable analysis types are:

1 - Arsenic; and

2 - Benzene, toluene, and TCE.

3.0 SAMPLING EQUIPMENT AND PROCEDURES

All samples will be obtained from a valve located in the discharge line from the test well pump. This valve will directly sample a representative stream of the well water. Before collecting samples, the valve will be run for 15 seconds to flush any stagnant water from valve surfaces.

One set of samples will be collected for analysis by gas chromatography (GC) using the static headspace technique for purgeable organics, and a second will be collected in a glass bottle (without acid preservative) for arsenic analysis.

4.0 SAMPLE HANDLING AND ANALYSES

Because the samples will be analyzed immediately on-site, it will not be necessary to fill out a Chain-of-Custody form. Samples will be transported to the on-site trailer in a cooler.

Analyses will be performed by Goldberg-Zoino and Associates, Inc. (GZA). Volatile organic analysis will be performed using a mobile laboratory mini-van to be located at the field office area of the site. Arsenic analysis will be performed in laboratory space set up on a field trailer at the same location. The distance from PW-1 to the analytical facilities is approximately three-quarters of a mile.

4.1 Volatile Organics

Samples will be collected in three 40-ml VOA vials and analyzed for benzene, toluene, and TCE using the static headspace method (a modified Method 3810) for collecting purgeable organics, followed by GC analysis. The gas chromatograph will be a Tracor GC with a capillary column and dual (PID and ECD) detectors. This system is capable of detecting the VOCs of interest at the required detection limits of 0.5 ppb for benzene, 200 ppb for toluene, and 0.5 ppb for TCE. Results will be reported back to the field site by telephone.

The ability of the headspace method to perform at these detection limits will be documented before samples are analyzed.

If the analytical results indicate that ground water containing benzene, toluene, or TCE above the respective action levels is being discharged to the Halls Brook Holding Area, then additional samples will be collected and analyzed as frequently as possible to confirm the presence and concentration of benzene, toluene, or TCE in the discharged ground water. Thus, the pumping test will not be terminated at the first evidence of benzene, toluene, or TCE in the discharged ground water, but after three consecutive and frequent (as possible) confirmatory sampling and analytical events.

Action levels of 5 ppb for benzene and TCE, and 2,000 ppb for toluene will be used. If the three subsequent samples confirm the presence of benzene, toluene or TCE in the discharged water above these action levels, then the pumping test will be terminated. If subsequent samples do not show a consistent presence of benzene, toluene, or TCE, then the pumping test will continue.

In addition to performing the analysis on ground water, the following samples will be run to validate the results:

- standard benzene, toluene, and TCE solutions;
- VOC-free distilled water;
- duplicates of samples following an initial detection of VOC above the action level; and
- a matrix spike of field water at 5 ppb benzene, 2,000 ppb toluene, and 5 ppb TCE.

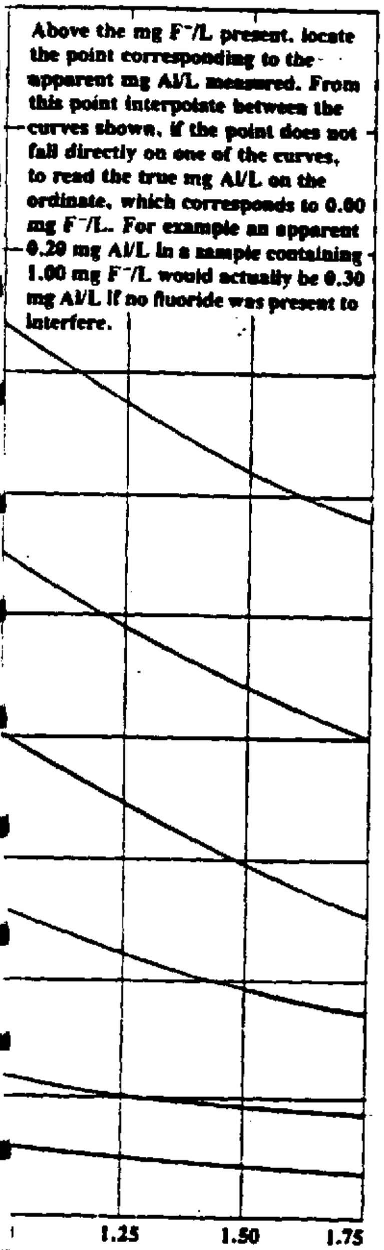
4.2 Arsenic Analysis

Water samples will be collected in glass screw-cap bottles and analyzed for arsenic [oxidation states +5 and +3, which include arsenate ($AsO_4^{\equiv}$) and arsenite (AsO_2^{-}), respectively]. The method used will be the silver diethyldithiocarbamate spectrophotometric method for arsine. The method is described in Standard Methods for the Examination of Water and Waste Water, Method 307.B (attached). Thirty-five milliliters (ml) of sample water are transferred to the reaction vessel. Reagents are added which convert dissolved arsenic (III and V) compounds to hydrogen arsenide (arsine), AsH_3. The arsine is detected by trapping in a solution of silver diethyldithiocarbamate to form a colored complex. The absorbance of the color is measured spectrophotometrically at 535 nm, and arsenic concentration is determined from a standard curve. This method is capable of detecting 30 ppb arsenic, which is less than the allowable in-stream concentration of 190 ppb (refer to the October 10 approval letter cited above). The method requires approximately one hour per sample.

In addition to performing the analysis on ground water, the following samples will be run to validate the results:

- standard arsenic solutions;
- arsenic-free distilled water;
- duplicates of samples following an initial detection of arsenic above 1,900 ppb; and
- a matrix spike field of water at 190, 500, 800, and 1,900 ppb.

The arsine gas generated will be contained within a closed reaction tube and will not be released to the laboratory atmosphere. However, the field laboratory will be equipped with a fume hood to remove any traces of the gas present. The small quantities of spent chemicals will be temporarily retained for subsequent testing and disposal.



n in the presence of fluoride.

µg Al/L and 750 µg F/L in distilled water was analyzed in 16 laboratories that relied on the curve to correct for the fluoride content. Relative standard deviation was 25.5% and relative error 2.3%. The 17 laboratories that added fluoride to the aluminum standards showed a relative standard deviation of 22.5% and a relative error of 7.1%.

7. Bibliography

SHULL, K.E. & G.R. GUTHAN. 1967. Rapid modified Eriochrome cyanine R method for determination of aluminum in water. *J. Amer. Water Works Ass.* 59:1456.

307 ARSENIC*

Severe poisoning can arise from the ingestion of as little as 100 mg arsenic; chronic effects can appear from its accumulation in the body at low intake levels. Carcinogenic properties also have been imputed to arsenic. The arsenic concentration of most potable waters seldom exceeds 10 µg/L, although values as high as 100 µg/L have been reported. Arsenic may occur in water as a result of mineral dissolution, industrial discharges, or the application of insecticides.

*Approved by Standard Methods Committee, 1981.

Selection of method: The atomic absorption spectrometric method (A), which converts arsenic to its hydride and uses an argon-hydrogen flame, is the method of choice, although the direct electrothermal method is simpler in the demonstrated absence of interference. The silver diethyldithiocarbamate method (B) is applicable when interferences are absent. The mercuric bromide stain method (C) requires care and experience and is suitable only for qualitative or semiquantitative determinations (±5 µg As).

307 A. Atomic Absorption Spectrometric Method

See Sections 303E and 304.

307 B. Silver Diethyldithiocarbamate Method

1. General Discussion

a. Principle: Inorganic arsenic is reduced to arsine, AsH_3, by zinc in acid solution in a Gutzeit generator. The arsine is then passed through a scrubber containing glass wool impregnated with lead acetate solution and into an absorber tube containing silver diethyldithiocarbamate dissolved in pyridine or chloroform. In the absorber, arsenic reacts with the silver salt, forming a soluble red complex suitable for photometric measurement.

b. Interference: Although certain metals—chromium, cobalt, copper, mercury, molybdenum, nickel, platinum, and silver—interfere in the generation of arsine, the concentrations of these metals normally present in water do not interfere significantly. Antimony salts in the sample form stibine, which interferes with color development by yielding a red color with maximum absorbance at 510 nm.

c. Minimum detectable quantity: 1 µg As.

2. Apparatus

a. Arsine generator and absorption tube: See Figure 307:1.*

b. Photometric equipment:

1) *Spectrophotometer,* for use at 535 nm with 1-cm cells.

2) *Filter photometer,* with green filter having a maximum transmittance in the range 530 to 540 nm, with 1-cm cells.

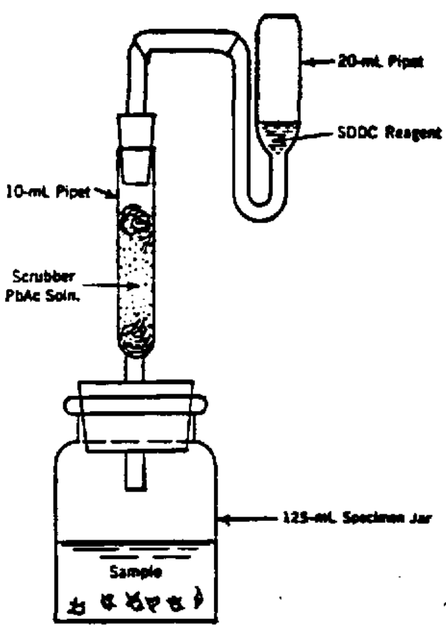


Figure 307:1. Arsine generator and absorber assembly.

*Fisher Scientific Co., No. 1-405 or equivalent apparatus.

3. Reagents

a. Hydrochloric acid, HCl, conc.

b. Potassium iodide solution: Dissolve 15 g KI in 100 mL distilled water. Store in a brown bottle.

c. Stannous chloride reagent: Dissolve 40 g arsenic-free $SnCl_2 \cdot 2H_2O$ in 100 mL conc HCl.

d. Lead acetate solution: Dissolve 10 g $Pb(C_2H_3O_2)_2 \cdot 3H_2O$ in 100 mL distilled water.

e. Silver diethyldithiocarbamate reagent: Prepare this reagent as described in either 1) or 2):

1) Dissolve 410 mg 1-ephedrine in 200 mL chloroform ($CHCl_3$), add 625 mg $AgSCSN(C_2H_5)_2$, and adjust volume to 250 mL with additional $CHCl_3$. Filter and store in brown bottle.

2) Dissolve 1 g $AgSCSN(C_2H_5)_2$ in 200 mL pyridine. Store in brown bottle.

f. Zinc, 20 to 30 mesh, arsenic-free.

g. Stock arsenic solution: Dissolve 1.320 g arsenic trioxide, As_2O_3, in 10 mL distilled water containing 4 g NaOH, and dilute to 1000 mL with distilled water; 1.00 mL = 1.00 mg As. (CAUTION: *Toxic—take care to avoid ingestion of arsenic solutions.*)

h. Intermediate arsenic solution: Dilute 5.00 mL stock solution to 500 mL with distilled water; 1.00 mL = 10.0 µg As.

i. Standard arsenic solution: Dilute 10.00 mL intermediate solution to 100 mL with distilled water; 1.00 mL = 1.00 µg As.

4. Procedure

For total arsenic digest sample by the procedure in 307C.4*a*. Report if sample has been digested or not.

a. Treatment of sample: Pipet 35.0 mL sample into a clean generator bottle. Add successively, with thorough mixing after each addition, 5 mL conc HCl, 2 mL KI solution, and 8 drops (0.40 mL) $SnCl_2$ reagent. Allow 15 min for reduction of arsenic to the trivalent state.

b. Preparation of scrubber and absorber:

its

xchloric acid. HCl, conc.

ium iodide solution: Dissolve 15 0 mL distilled water. Store in a tle.

ous chloride reagent: Dissolve 40 ree $SnCl_2 \cdot 2H_2O$ in 100 mL conc

acetate solution: Dissolve 10 g $)_2 \cdot 3H_2O$ in 100 mL distilled

diethyldithiocarbamate reagent: is reagent as described in either

ılve 410 mg 1-ephedrine in 200 oform ($CHCl_3$), add 625 mg $C_2H_5)_2$, and adjust volume to 250 dditional $CHCl_3$. Filter and store bottle.

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d arsenic digest sample by the n 307C.4*a*. Report if sample has ed or not.

ment of sample: Pipet 35.0 mL o a clean generator bottle. Add , with thorough mixing after on, 5 mL conc HCl, 2 mL KI nd 8 drops (0.40 mL) $SnCl_2$ re- w 15 min for reduction of ar- trivalent state.

ation of scrubber and absorber:

Impregnate glass wool in the scrubber with lead acetate solution. Do not make too wet because water will be carried over into the reagent solution. Pipet 4.00 mL silver diethyldithiocarbamate reagent into absorber tube.

c. Arsine generation and measurement: Add 3 g zinc to generator and connect scrubber-absorber assembly immediately. Make certain that all connections are fitted tightly.

Allow 30 min for complete evolution of arsine. Warm the generator slightly to insure that all arsine is released. Pour solution from absorber directly into a 1-cm cell and measure absorbance at 535 nm, using the reagent blank as the reference.

d. Preparation of standard curve: Treat portions of standard solution containing 0, 1.0, 2.0, 5.0, and 10.0 μg As described in ¶s 4*a* through *c* above. Plot absorbance versus concentration of arsenic in the standard.

5. Calculation

$$\text{mg As/L} = \frac{\mu\text{g As (in 4.00 mL final volume)}}{\text{mL sample}}$$

6. Precision and Accuracy

A synthetic sample containing 40 μg As/L, 250 μg Be/L, 240 μg B/L, 20 μg Se/L, and 6 μg V/L in distilled water was analyzed in 46 laboratories by the silver diethyldithiocarbamate method, with a relative standard deviation of 13.8% and a relative error of 0%.

307 C. Mercuric Bromide Stain Method

1. General Discussion

a. Principle: After sample concentration arsenic is liberated as arsine, AsH_3, by zinc in acid solution in a Gutzeit generator. The generated arsine is passed through a column containing a roll of cotton moistened with lead acetate solution. The generated arsine produces a yellow-brown stain on test paper strips impregnated with mercuric bromide. The length of the stain is roughly proportional to the amount of arsenic present.

b. Interference: Antimony (>0.10 mg) interferes by giving a similar stain.

c. Minimum detectable quantity: 1 μg As.

2. Apparatus

Arsine generator: See Figure 307:2.

3. Reagents

a. Sulfuric acid, H_2SO_4, 1 + 1.

b. Nitric acid, HNO_3, conc.

c. Roll cotton: Cut a roll of dentist's cotton into 25-mm lengths.

d. Lead acetate solution: Prepare as directed in Method B, ¶ 3*d*.

e. Mercuric bromide paper: Use commercial arsenic papers cut uniformly into strips about 12 cm long and 2.5 mm wide (papers can be obtained already cut and sensitized). Soak strips for at least 1 h in filtered solution prepared by dissolving 3 to 6 g $HgBr_2$ in 100 mL 95% ethyl or isopropyl alcohol; dry by waving in air. Store in dry, dark place. For best results, make up papers just before use.

f. Potassium iodide solution: Prepare as directed in Method B, ¶ 3*b*.

g. Stannous chloride reagent: Prepare as directed in Method B, ¶ 3*c*.

h. Zinc, 20 to 30 mesh, arsenic-free.

i. Standard arsenic solution: Prepare as directed in Method B, ¶ 3*i*.

KAM

314 694-6262

October 10, 1990

Post-it™ brand fax transmittal memo 7671	# of pages ▸ 1
To MICHAEL DECILLIS	From KEN MOSER
Co. ROUX ASSOC.	Co. GOLDER ASSOC.
Dept.	Phone # 609-273-1110
Fax # 516-678-7216	Fax # 609-273-0778

Warren L. Smull, Coordinator
Industri-Plex Remedial Trust
Monsanto Chemical Company
800 N. Lindbergh Blvd. G4WM
St. Louis, Missouri 63167

RE: Pump Test Approval

Dear Mr. Smull:

In accordance with the IP Consent Decree and after consultation with the Commonwealth of Massachusetts, EPA approves the Pump Test to delineate aquifer characteristics. This pump test will incur a discharge rate of about 100 gal/hr for 48 hours and will be discharged into Hall's Brook.

The aquifer test discharge water will be monitored for volatile organics, including toluene, benzene, TCE, and arsenic every hour over the test period. A gas chromatograph will be employed for the organic analysis and a wet method , such as spectrophotometry, will be employed for the inorganic analysis.

Arsenic levels in Hall's Brook shall not exceed 190 ppb based upon a discharge rate of 100gal/min or 600 gal/hr. Under these conditions the arsenic level in the discharge shall not exceed 1,900 ppb. Any increase in the discharge rate would have to reflect a lower discharge concentration of arsenic such that the water quality of Hall's Brook is not violated.

Although not specifically defined in this approval letter, all other conditions of water quality in the Hall's Brook shall be maintained during the pump test. Any discharge constituent that results in violation of water quality criteria shall result in the immediate cessation of the pump test and and associated discharge into Hall's Brook.

Should you have any questions on this please give me a call at 617-573-5733.

Sincerely yours,

Joseph N. DeCola
Environmental Engineer

APPENDIX G

Water-Quality Analytical Report

GOLDBERG·ZOINO & ASSOCIATES, INC.
320 Needham Street Newton Upper Falls, MA 02164
(617) 969-0050 FAX (617) 965-7769

November 26, 1990
File No. L-12268

Mr. Robert L. Hall, Ph.D.
Senior Geochemist
Roux Associates, Inc.
The Huntington Atrium
775 Park Avenue, Suite 255
Huntington, NY 11743

Re: On-Site Analytical Services
Industri-Plex Superfund Site
Woburn, Massachusetts

Dear Mr. Hall:

This letter presents the results of on-site volatile organic compound (VOC) and arsenic analyses of discharge samples from aquifer pumping tests at the Industri-Plex Superfund Site, Woburn, Massachusetts. These analyses were performed using Goldberg-Zoino & Associates, Inc. (Goldberg-Zoino) Mobile Environmental Laboratory (MEL). This work was completed at your request and in accordance with our proposal for services dated October 19, 1990.

This report has been prepared in accordance with the Limitations set forth in Appendix A.

ON-SITE ANALYTICAL SERVICES PROGRAM

On October 25 and 26, 1990, a total of five water samples in both 500 ml plastic jars and in three 40 ml glass vials were submitted to Goldberg-Zoino's MEL for the analysis of VOCs by the static headspace method described in Appendix B and for the analysis of arsenic by the silver diethyldithiocarbamate spectrophotometric method described in Appendix C. During the period of 7:00 a.m. on October 31, 1990 through 9:00 a.m. on November 2, 1990, an additional 60 water samples were submitted for VOC analysis and 49 water samples were submitted for arsenic analysis by the same techniques. Goldberg-Zoino's MEL analyzed all of the 54 water samples for arsenic and 65 water samples for VOCs.

GOLDBERG-ZOINO MEL ANALYSES OF ARSENIC AND VOCS

Arsenic samples were analyzed using a HACH, Inc. Model DR/2000 spectrophotometer and associated glassware, reagents and methodology provided by HACH, Inc. Quality control measures included the analysis of check standards at the beginning and end of each day to verify the calibration of the instrument and to corroborate the attainment of method detection limits. A method detection limit of 10 ppb was extrapolated from the analysis of calibration standards ranging in concentration from 16 to 64 ppb. A summary of Goldberg-Zoino's arsenic analysis is presented in Table 1.

The VOC samples were analyzed by a static headspace technique for trichloroethene (TCE), benzene and toluene using a Tracor Model 9000 gas chromatograph equipped with an electron capture detector (ECD) and a photoionization detector (PID) in a serial configuration. The ability of the static headspace technique to attain and exceed the method detection limit performance criteria was formally confirmed using recognized statistical methods. Quality control measures included method blanks, duplicate analysis, calibration check standards and confirmatory analysis by EPA Method 524.2 on the order of every 10 samples. The final results presented herein may differ somewhat from the "real time" results issued during field testing in that corrections were made upon office review of the final QA/QC data. Of the three compounds analyzed for, only TCE and toluene were detected (at low ppb levels). Frequently, an additional unknown compound, which can be tentatively identified as tetrachloroethene, was also detected in the samples. Particular emphasis has been placed on TCE as toluene results never exceeded two percent of the discharge criterion of 200 ppb. A summary of Goldberg-Zoino's VOC analysis is presented in Table 2.

Goldberg-Zoino's eight duplicate VOC analyses exhibited results similar to those of the original sample analyses with the exception of sample GW-31-19. The variation in concentrations for this sample may be due, in part, to non-homogeneity of duplicate samples. However, based on the general trend of the analytical data, the duplicate result of 18.9 ppb (versus the original result of 3.98 ppb) of trichloroethene in sample GW-31-19 appears to be anomalous data. A summary of analytical results of Goldberg-Zoino's original and duplicate samples are presented in Table 3.

EPA METHOD 524.2 CONFIRMATORY ANALYSIS

As a further QA/QC check on our field VOC analytical procedure and for QA/QC purposes, we randomly selected six water samples for analysis by EPA Method 524.2. These analyses were performed in our Environmental Chemistry Laboratory (ECL) located at the corporate headquarters in Newton Upper Falls, Massachusetts. EPA Method 524.2, the method for the determination of volatile organics in drinking water by GC/MS, was selected as the appropriate method for confirmatory purposes as it targets the compounds of interest at the requisite method detection limits of 0.50 ppb for trichloroethene and benzene. Goldberg-Zoino's ECL participates in the EPA's Performance Evaluation program and is certified by the Department of Environmental Protection of the Commonwealth of Massachusetts to perform volatile organic analysis of drinking water samples (Massachusetts Laboratory I.D. No. MA092).

Goldberg-Zoino's on-site screening results generally compare well with results obtained in the laboratory. (For sample GW-31-23, review of the field data originally reported as "ND", were considered invalid due to the absence of an injection peak in the chromatogram for this sample. Therefore, a comparison for this sample and 524.2 was not possible.) Variations in concentrations may be due to the performance limitations of the two methods in combination with non-homogeneity in individual samples. With one exception, these comparative results agree to well within an order of magnitude of each other; a level of confirmation not unusual for split sample analyses by two different methods. (The comparison for sample GW-01-32 appears to exceed the error bars for both methods). Analyzed in the early morning, it is possible that field conditions, particularly low ambient temperatures, may have imposed additional limitations on the on-site performance of this GC analytical program. This additional environmental limitation appears to have been documented by the low spike recovery for TCE that occurred at the time when sample GW-01-32 was analyzed. A summary of screening and 524.2 results are presented in Table 4. In all cases, field screening data should be subordinated to data acquired by EPA methodology under laboratory conditions.

We trust that this report satisfies your current requirements. We have appreciated the opportunity to assist you with this project and we look forward to working with you in the future. Should you have any questions, please do not hesitate to call one of the undersigned.

Very truly yours,

GOLDBERG-ZOINO & ASSOCIATES, INC.

Janine Bartels
Environmental Chemist

Edward W. Pickering
Environmental Chemistry
Laboratory Manager

Donald A. Schulze
Associate-in Charge

EWP/DAS:idm
Attachment: Tables
Appendices

TABLES

GOLDBERG-ZOINO & ASSOCIATES, INC.
320 NEEDHAM STREET
NEWTON UPPER FALLS, MA 02164
(617) 969-0050

TABLE 1
ARSENIC ANALYSIS

STEP TEST

JOB DESCRIPTION: INDUSTRIPLEX - WOBURN, MA
JOB #: 12268
DATE TESTED: 10/25-26/90

SAMPLE ID#	DATE	TIME	CONCENTRATION mg/l
GW-1	10/25	3:55 PM	ND
STD 034	10/26	8:30 AM	0.036
STD 065	10/26	8:35 AM	0.065
GW-2	10/26	11:00 AM	ND
GW-3	10/26	12:14 PM	ND
GW-4	10/26	1:14 PM	ND
GW-5	10/26	2:11 PM	ND
STD 034	10/26	3:00 PM	0.036
STD 064	10/26	3:05 PM	0.065

ANALYST: [signature]

DATA REVIEWER: [signature]

PROJECT REVIEWER: CW Pickering

GOLDBERG-ZOINO & ASSOCIATES, INC.
320 NEEDHAM STREET
NEWTON UPPER FALLS, MA 02164
(617) 969-0050

TABLE 1
ARSENIC ANALYSIS

48 HOUR PUMP TEST

JOB DESCRIPTION: INDUSTRIPLEX - WOBURN, MA
JOB #: 12268

SAMPLE ID#	DATE	TIME	CONC. mg/l	SAMPLE ID#	DATE	TIME	CONC. mg/l
GW-31-01	10/31	7:44 AM	0.011	GW-01-27	11/1	9:50 AM	ND
GW-31-02	10/31	8:44 AM	ND	GW-01-28	11/1	10:47 AM	ND
GW-31-03	10/31	9:44 AM	ND	GW-01-29	11/1	11:44 AM	ND
GW-31-04	10/31	10:44 AM	ND	GW-01-30	11/1	12:55 PM	ND
GW-31-05	10/31	11:38 AM	ND	GW-01-31	11/1	1:55 PM	ND
GW-31-06	10/31	12:44 PM	ND	GW-01-32	11/1	2:45 PM	ND
GW-31-07	10/31	2:03 PM	ND	GW-01-33	11/1	3:50 PM	ND
GW-31-08	10/31	2:48 PM	0.010	STD. 0.016	11/1	4:00 PM	0.014
GW-31-09	10/31	3:45 PM	0.014	STD. 0.064	11/1	4:05 PM	0.054
GW-31-10	10/31	4:50 PM	0.013	GW-01-34	11/1	4:55 PM	ND
GW-31-11	10/31	5:49 PM	0.016	GW-01-35	11/1	6:00 PM	ND
GW-31-12	10/31	6:45 PM	0.011	GW-01-36	11/1	7:00 PM	ND
GW-31-13	10/31	7:44 PM	ND	GW-01-37	11/1	8:00 PM	ND
GW-31-14	10/31	8:44 PM	ND	GW-01-38	11/1	9:00 PM	ND
GW-31-15	10/31	9:50 PM	ND	STD. 0.034	11/1	9:15 PM	0.025
GW-31-16	10/31	10:54 PM	0.011	STD. 0.064	11/1	9:20 PM	0.050
GW-31-17	10/31	11:55 PM	0.010	GW-01-39	11/1	10:00 PM	ND
GW-31-18	11/1	12:46 AM	ND	GW-01-40	11/1	11:00 PM	ND
STD. 0.034	11/1	1:00 AM	0.027	GW-01-41	11/2	12:00 AM	ND
STD. 0.064	11/1	1:05 AM	0.051	GW-01-42	11/2	1:00 AM	ND
GW-31-19	11/1	1:49 AM	ND	GW-01-43	11/2	2:00 AM	ND
GW-01-20	11/1	2:45 AM	ND	GW-01-44	11/2	3:00 AM	ND
GW-01-21	11/1	3:54 AM	ND	GW-01-45	11/2	4:00 AM	ND
GW-01-22	11/1	4:55 AM	ND	GW-01-46	11/2	5:00 AM	ND
GW-01-23	11/1	5:50 AM	ND	GW-01-47	11/2	6:00 AM	ND
GW-01-24	11/1	6:50 AM	ND	GW-01-48	11/2	7:00 AM	ND
GW-01-25	11/1	7:50 AM	ND	GW-01-49	11/2	8:00 AM	ND
GW-01-26	11/1	8:50 AM	ND				

ANALYST: [signature] DATA REVIEWER: [signature]

PROJECT REVIEWER: CW Pickering

GOLDBERG-ZOINO & ASSOCIATES
320 NEEDHAM STREET
NEWTON UPPER FALLS, MA 02164
(617)969-0050
MASS ID#. MA092

JOB DESCRIPTION: INDUSTRIPLEX - WOBURN, MA
JOB #: 12268
DATE TESTED: 10/25/90-10/26/90

TABLE 2
AQUEOUS ANALYTICAL RESULTS

STEP TEST

GW SAMPLE	DATE	TIME	TCE	BENZENE	TOLUENE	TOTAL (ug/l)
BLK	10/25	3:00 PM	ND	ND	ND	ND
GW-1	10/25	3:55 PM	2.89	ND	ND	2.89
GW-2	10/26	11:12 AM	2.17	ND	ND	2.17
GW-2 DUP	10/26	11:12 AM	2.44	ND	ND	2.44
BLK	10/26	11:30 AM	ND	ND	ND	ND
GW-3	10/26	12:14 PM	3.37	ND	ND	3.37
GW-4	10/26	1:11 PM	3.18	ND	ND	3.18
GW-5	10/26	2:11 PM	5.20	ND	ND	5.20
GW-5 DUP	10/26	2:11 PM	7.75	ND	ND	7.75

ANALYST: [signature]

DATA REVIEWER: [signature]

PROJECT REVIEWER: CW Pickering

GOLDBERG-ZOINO & ASSOCIATES, INC.
320 NEEDHAM STREET
NEWTON UPPER FALLS, MA 02164
(617) 969-0050

AQUEOUS ANALYTICAL RESULTS

STEP TEST

JOB DESCRIPTION: INDUSTRIPLEX – WOBURN, MA
JOB #: 12268
DATE TESTED: 10/25/90

QUALITY ASSURANCE/QUALITY CONTROL

COMPOUND	STANDARD CONCENTRATIONS (ppb) ug/l				REGRESSION COEFFICIENT
TCE	1	5	10	50	0.9968
BENZENE	1	5	10	50	0.9972
TOLUENE	1	5	10	50	0.9935

SPIKE RECOVERIES OF DAILY STANDARDS

COMPOUND	SPIKE CONC. MORNING	% REC MORNING	SPIKE CONC. AFTERNOON	% REC AFTERNOON
TCE	1	50	5	127
BENZENE	1	92	5	68
TOLUENE	1	62	5	79

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(617)969-0050
MASS ID#. MA092

JOB DESCRIPTION: INDUSTRIPLEX – WOBURN, MA
JOB #: 12268
DATE TESTED: 10/31/90

AQUEOUS ANALYTICAL RESULTS

48 HOUR PUMP TEST

GW SAMPLE	DATE	TIME	TCE	BENZENE	TOLUENE	TOTAL ug/l
GW-31-01	10/31	7:44 AM	2.74	ND	ND	2.74
GW-31-02	10/31	8:44 AM	3.67	ND	ND	3.67
GW-31-03	10/31	9:44 AM	6.52	ND	0.58	7.10
GW-31-03 DUP	10/31	9:44 AM	8.14	ND	0.83	8.97
GW-31-04	10/31	10:44 AM	8.69	ND	0.85	9.54
BLK	10/31	10:45 AM	ND	ND	ND	ND
GW-31-04 DUP	10/31	10:50 AM	8.16	ND	ND	8.16
GW-31-05	10/31	10:48 AM	9.69	ND	0.72	10.4
GW-31-06	10/31	11:38 AM	8.21	ND	0.60	8.81
GW-31-07	10/31	12:44 PM	13.0	ND	ND	13.0
GW-31-08	10/31	2:03 PM	11.1	ND	ND	11.1
BLK	10/31	2:30 PM	ND	ND	ND	ND
GW-31-09	10/31	2:48 PM	4.99	ND	ND	4.99
GW-31-10	10/31	2:46 PM	5.88	ND	ND	5.88

ANALYST: [signature]

DATA REVIEWER: [signature]

PROJECT REVIEWER: CW Pickering

GOLDBERG-ZOINO & ASSOCIATES, INC.
320 NEEDHAM STREET
NEWTON UPPER FALLS, MA 02164
(617) 969-0050

AQUEOUS ANALYTICAL RESULTS

48 HOUR PUMP TEST

JOB DESCRIPTION: INDUSTRIPLEX – WOBURN, MA
JOB #: 12268
DATE TESTED: 10/31/90

QUALITY ASSURANCE/QUALITY CONTROL

COMPOUND	STANDARD CONCENTRATIONS (ppb) ug/l				REGRESSION COEFFICIENT
TCE	1	5	10	50	0.9973
BENZENE	1	5	10	50	0.9972
TOLUENE	1	5	10	50	0.9935

SPIKE RECOVERIES OF DAILY STANDARDS

COMPOUND	SPIKE CONC. MORNING	% REC MORNING	SPIKE CONC. AFTERNOON	% REC AFTERNOON
TCE	10	70	5	62
BENZENE	10	75	5	98
TOLUENE	10	73	5	110

GOLDBERG-ZOINO & ASSOCIATES
320 NEEDHAM STREET
NEWTON UPPER FALLS, MA 02164
(617)969-0050
MASS ID#. MA092

JOB DESCRIPTION: INDUSTRIPLEX - WOBURN, MA
JOB #: 12268
DATE TESTED: 10/31/90-11/1/90

AQUEOUS ANALYTICAL RESULTS

48 HOUR PUMP TEST

GW SAMPLE	DATE	TIME	TCE	BENZENE	TOLUENE	TOTAL ug/l
GW-31-11	10/31	3:45 PM	7.76	ND	ND	7.76
GW-31-12	10/31	3:59 PM	3.40	ND	ND	3.40
GW-31-13	10/31	4:02 PM	6.30	ND	ND	6.30
GW-31-14	10/31	4:50 PM	6.93	ND	1.63	8.56
GW-31-15	10/31	5:49 PM	17.7	ND	ND	17.7
GW-31-16	10/31	6:05 PM	7.27	ND	ND	7.27
BLK	10/31	6:30 PM	ND	ND	ND	ND
GW-31-17	10/31	6:45 PM	ND	ND	ND	ND
GW-31-18	10/31	6:52 PM	ND	ND	ND	ND
GW-31-19	10/31	7:44 PM	3.98	ND	ND	3.98
GW-31-19 DUP	10/31	7:44 PM	18.9	ND	ND	18.9
BLK	10/31	8:00 PM	ND	ND	ND	ND
GW-31-20	10/31	8:44 PM	ND	ND	ND	ND
GW-31-21	10/31	8:55 PM	0.90	ND	ND	0.90
GW-31-22	10/31	9:50 PM	ND	ND	ND	ND
GW-31-23	10/31	10:54 PM	LOST DATA			
GW-31-24	10/31	11:55 PM	3.61	ND	ND	3.61
GW-31-25	11/1	12:46 AM	7.34	ND	ND	7.34
BLK	11/1	12:46 AM	ND	ND	ND	ND
GW-31-26	11/1	12:46 AM	ND	ND	1.05	1.05
GW-31-27	11/1	1:49 AM	ND	ND	1.26	1.26
GW-31-28	11/1	2:45 AM	0.87	ND	ND	0.87
GW-31-29	11/1	3:54 AM	18.7	ND	ND	18.7

ANALYST: [signature]

DATA REVIEWER: [signature]

PROJECT REVIEWER: CW Pickering

GOLDBERG-ZOINO & ASSOCIATES
320 NEEDHAM STREET
NEWTON UPPER FALLS, MA 02164
(617)969-0050
MASS ID#. MA092

JOB DESCRIPTION: INDUSTRIPLEX - WOBURN, MA
JOB #: 12268
DATE TESTED: 11/1/90

AQUEOUS ANALYTICAL RESULTS

48 HOUR PUMP TEST

GW SAMPLE	DATE	TIME	TCE	BENZENE	TOLUENE	TOTAL ug/l
GW-01-30	11/1	3:54 AM	4.91	ND	ND	4.91
GW-01-31	11/1	4:55 AM	0.29	ND	3.03	3.32
GW-01-32	11/1	5:50 AM	0.19	ND	2.93	3.12
GW-01-33	11/1	6:50 AM	1.09	ND	1.21	2.30
BLK	11/1	6:50 AM	ND	ND	0.50	0.50
GW-01-34	11/1	6:50 AM	9.57	ND	ND	9.57
GW-01-35	11/1	7:50 AM	15.2	ND	ND	15.2
GW-01-36	11/1	8:50 AM	8.99	ND	0.59	8.99
GW-01-37	11/1	9:50 AM	8.16	ND	ND	8.16
GW-01-38	11/1	10:00 AM	4.99	ND	ND	4.99
GW-01-39	11/1	10:47 AM	15.8	ND	ND	15.8
BLK	11/1	11:00 AM	ND	ND	0.60	0.60
GW-01-40	11/1	11:44 AM	10.9	ND	ND	10.9
GW-01-41	11/1	12:55 PM	2.43	ND	ND	2.43
GW-01-42	11/1	1:55 PM	1.87	ND	ND	1.87
GW-01-43	11/1	2:45 PM	1.00	ND	ND	1.00
GW-01-44	11/1	3:50 PM	4.40	ND	ND	4.40
BLK	11/1	4:00 PM	ND	ND	0.50	0.50
GW-01-45	11/1	4:55 PM	0.91	ND	ND	0.91
GW-01-46	11/1	5:00 PM	3.31	ND	ND	3.31
GW-01-46 DUP	11/1	6:00 PM	2.80	ND	0.85	3.65
GW-01-47	11/1	7:00 PM	0.92	ND	ND	0.92
GW-01-48	11/1	8:00 PM	1.60	ND	ND	1.60
GW-01-48 DUP	11/1	8:00 PM	3.07	ND	ND	3.07

ANALYST: [signature]

DATA REVIEWER: [signature]

PROJECT REVIEWER: CW Pickering

GOLDBERG-ZOINO & ASSOCIATES, INC.
320 NEEDHAM STREET
NEWTON UPPER FALLS, MA 02164
(617) 969-0050

AQUEOUS ANALYTICAL RESULTS

48 HOUR PUMP TEST

JOB DESCRIPTION: INDUSTRIPLEX – WOBURN, MA
JOB #: 12268
DATE TESTED: 11/1/90

QUALITY ASSURANCE/QUALITY CONTROL

COMPOUND	STANDARD CONCENTRATIONS (ppb) ug/l				REGRESSION COEFFICIENT
TCE	1	5	10	----	0.9976
BENZENE	1	5	10	50	0.9972
TOLUENE	1	5	10	50	0.9935

SPIKE RECOVERIES OF DAILY STANDARDS

COMPOUND	SPIKE CONC. MORNING	% REC MORNING	SPIKE CONC. AFTERNOON	% REC AFTERNOON
TCE	5	51	10	70
BENZENE	5	68	10	75
TOLUENE	5	72	10	73

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NEWTON UPPER FALLS, MA 02164
(617)969-0050
MASS ID#. MA092

JOB DESCRIPTION: INDUSTRIPLEX - WOBURN, MA
JOB #: 12268
DATE TESTED: 11/1/90-11/2/90

AQUEOUS ANALYTICAL RESULTS

48 HOUR PUMP TEST

GW SAMPLE	DATE	TIME	TCE	BENZENE	TOLUENE	TOTAL ug/l
GW-01-49	11/1	9:00 PM	4.02	ND	ND	4.02
GW-01-50	11/1	10:00 PM	5.97	ND	ND	5.97
BLK	11/1	10:00 PM	ND	ND	ND	ND
GW-01-51	11/1	11:00 PM	5.69	ND	ND	5.69
GW-01-51 DUP	11/1	11:00 PM	2.26	ND	ND	2.26
GW-01-52	11/2	12:00 AM	2.25	ND	ND	2.25
GW-01-53	11/2	1:00 PM	3.18	ND	ND	3.18
GW-01-54	11/2	2:00 AM	3.32	ND	ND	3.32
GW-01-55	11/2	3:00 AM	2.06	ND	ND	2.06
GW-01-56	11/2	4:00 AM	5.03	ND	ND	5.03
GW-01-57	11/2	5:00 AM	4.79	ND	ND	4.79
GW-01-58	11/2	6:00 AM	3.34	ND	ND	3.34
GW-01-59	11/2	7:00 AM	2.86	ND	ND	2.86
BLK	11/2	7:30 AM	ND	ND	0.50	0.50
GW-01-60	11/2	8:00 AM	7.19	ND	ND	7.19
BLK	11/2	8:00 AM	ND	ND	ND	ND

ANALYST: [signature]

DATA REVIEWER: [signature]

PROJECT REVIEWER: CW Pickering

GOLDBERG-ZOINO & ASSOCIATES
320 NEEDHAM STREET
NEWTON UPPER FALLS, MA 02164
(617)969-0050
MASS ID#. MA092

JOB DESCRIPTION: INDUSTRIPLEX - WOBURN, MA
JOB #: 12268

TABLE 3

SUMMARY OF DUPLICATE ANALYSIS OF RAPID VOC SCREENING

SAMPLE	VOC (PPB) (ug/l)		DUP (PPB) (ug/l)	
GW-2	TCE:	2.17	TCE:	2.44
GW-5	TCE:	5.20	TCE:	7.75
GW-31-03	TCE:	6.52	TCE:	8.14
GW-31-04	TCE:	8.69	TCE:	8.16
GW-31-19	TCE:	3.98	TCE:	18.9
GW-01-46	TCE:	3.31	TCE:	2.80
GW-01-48	TCE:	1.60	TCE:	3.07
GW-01-51	TCE:	5.69	TCE:	2.26

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NEWTON UPPER FALLS, MA 02164
(617)969-0050
MASS ID#. MA092

JOB DESCRIPTION: INDUSTRIPLEX – WOBURN, MA
JOB #: 12268
DATE TESTED: 11/1/90 & 11/7/90-11/8/90

TABLE 4

AQUEOUS ANALYTICAL RESULTS

RAPID VOC SCREENING vs. EPA METHOD 524.2

SAMPLE	SCREENING TCE (ug/l)	EPA METHOD 524.2 TCE (ug/l)
GW2 PW1 5	5.20	4.2
GW2 PW1 14	6.93	6.2
GW2 PW1 23	LOST DATA	5.7
GW2 PW1 32	0.19	7.2
GW2 PW1 44	4.40	7.4
GW2 PW1 55	2.06	7.8

ANALYST: [signature]

DATA REVIEWER: [signature]

PROJECT REVIEWER: CW Pickering

APPENDIX A

LIMITATIONS

APPENDIX A

LIMITATIONS

1. The conclusions and recommendations contained in this report are based in part upon various types of chemical data and are contingent upon their validity. These data have been reviewed and interpretations made in the Report. As indicated within the Report, some of these data are preliminary "screening" level data, and should be confirmed with quantitative analyses if more specific information is necessary. Should additional chemical data become available in the future, these data should be reviewed by GZA, and the conclusions and recommendations presented therein modified accordingly.

2. Chemical analyses have been performed for specific parameters during the course of this study, as detailed in the text. It must be noted that additional constituents not searched for during the current study may be present in soil and groundwater at the site.

APPENDIX B

APPENDIX B

GOLDBERG-ZOINO & ASSOCIATES, INC.
MOBIL ENVIRONMENTAL LABORATORY
RAPID VOLATILE ORGANIC SCREENING OF WATER SAMPLES
BY THE STATIC HEADSPACE TECHNIQUE

SAMPLE PREPARATION AND ANALYTICAL METHODOLOGY

OVERVIEW

The GZA Mobile Environmental Laboratory (MEL) rapid screening technique for volatile organics in water estimates aqueous concentrations of these compounds from gaseous concentrations measuring air over the sample. Dissolved volatile organics are driven from the water phase by equilibrating at an elevated temperature in a hermetic system containing the sample and clean air. An 1 ml aliquot of the equilibrated headspace gas is injected into the chromatograph to provide an evaluation of the quality of the water sample. This method has been developed by the GZA Environmental Chemistry Laboratory (ECL) as a rapid, reasonably accurate and reliable, and cost effective screening of water samples for volatile organics. However, this technique is not definitive and is not an EPA approved analytical method.

METHODOLOGY

Water samples taken in the field are placed in 40 ml glass septum vials filled to capacity and capped to exclude air bubbles. In preparing the sample for analysis, a volume ratio of 3:1 sample to headspace (air) is created by discarding 10 ml of sample (replaced by air). The vial is resealed and heated to approximately 40 degrees Celsius in a warm water bath. A 1 ml aliquot of headspace gas is withdrawn manually with a syringe. The headspace sample is injected in to the sample port of a Tracor 9000 gas chromatograph fitted with a 30 meter by 530 micro meter fused silica capillary column. Concentrations of eluting volatile organics are measured with dual detectors configured in series, a photoionization detector (PID) and an Electron Capture Detector (ECD) and response data were acquired by a Nelson Analytical 760 Series intelligent interface. The chromatographic data are transmitted to a CompuAdd personal computer and analyzed using the Nelson Analytical 9000 Series Chromatography software.

CALIBRATION

The response of the gas chromatograph is calibrated with external standards prepared for concentrations of 1.0, 5.0 10.0 and 50.0 ug/l (ppb) and introduced into the chromatograph as headspace samples in the same manner as unknown water samples. Sample peaks are identified by comparing their retention times from both detectors to retention times of calibration standards for both detectors. Qualitative comparisons are made between the two sets of test data for each sample. Sample peaks identified as known compounds are quantified according to response factors determined from calibration standards.

REPORT FORMAT

The method quantitation limit (MQL) for each compound is stated for every report with 90 percent certainty in an average chromatographic run. Concentrations less than the MQL may be identified as beneath the method quantitation limit (BMQL) in instances where the compound's presence is 90 percent certain in that particular chromatogram.

DISCLAIMER

Identities and concentrations of volatile organic compounds reported by this headspace technique are subject to limitations inherent to this method. If confirmation is desired, duplicate samples should be submitted to a State certified laboratory for analysis by the appropriate EPA protocol methods.

MOBILE VAN CONTACT PERSONS

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Janine Bartels, Field Chemist
Environmental Chemistry Laboratory
Newton Upper Falls, Massachusetts
Phone No.: (617) 969-0050, x169 and x371

REFERENCES

Commonwealth of Massachussetts DEP, "Minimum Standards for Analytical Data for Remedial Response Actions Under M.G.L. c. 21E", Policy No. WSC-89004 (1990).

Ettre, L.S., B. Kolb, and S.G. Hurt, "Techniques of Headspace Gas Chromatography," Am. Lab. 15(10), 76-83, (1983).

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McNally, M.E., and R.L. Grob, "A Review: Current Applications of Static and Dynamic Headspace Analysis: Part One: Environmental Applications," Am. Lab. 17(1) 20-33, 1985.

Spittler, T.M., R. Siscanaw, M. Lataille, and P.A. Parks, "Correlation Between Field GC measurement of Volatile Organics and Laboratory Confirmation of Collected Field Samples Using GC/MS," Paper presented at 11/82 Washington, D.C. Hazardous Materials Control Research Institute Conference.

U.S. EPA, "Test methods for Evaluation Solid Waste, Physical/Chemical Methods", SW–846, Third Edition, Volume 1B, Method 3810: Headspace (1986).

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APPENDIX C

APPENDIX C

GOLDBERG-ZOINO & ASSOCIATES, INC.
MOBIL ENVIRONMENTAL LABORATORY

ARSENIC ANALYSIS
SILVER DIETHYLDITHIOCARBAMATE METHOD

OVERVIEW

Total Arsenic Analysis was performed by the silver diethyldithiocarbamate spectrophotometric method which is described in Standard Methods, Part 307B. In this method Arsenic is reduced to Arsine gas by a mixture of zinc stannous chloride, potassium iodide and hydrochloric acid in a specially equipped distillation apparatus. The arsine is passed through a scrubber containing cotton saturated with lead acetate and then into an absorber tube containing silverdiethyldithiocarbonate in pyridine. The arsenic forms a red complex which is read colormetrically.

METHODOLOGY

Refer to standards methods 307B. Absorbance data are acquired by a Hach Model DR2000 spectrophotometer. The method quantitation limit is 10 ppb ug/L as confirmed by the performance of the system with calibration and chec standards. Results of less than 10 ppb are reported as "ND", none detected.

QUALITY CONTROL

The Hach Model DR/2000 spectrophotometer is calibrated in house with arsenic standards of 16, 32 and 64 ppb. The calibration is checked at the beginning and end of each field day. The calibration curve is stored in the spectrophotometer and used to read direct concentration readings from the field samples.

DISCLAIMER

Concentrations of Arsenic determined in the field by the spectrophotometric technique are subject to the limitations inherent to this method.

LABORATORY CONTACT PERSON

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Environmental Chemistry Laboratory
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REFERENCES

American Public Health Association, American Water Works Association and Water Pollution Control Federation, "Standard Methods for the Examination of Water and Wastewater", Sixteenth Edition, Part 307B, Silver Diethyldithiocarbamate Method, pp. 187–189 (1985).

Hach, Incorporated, "DR/2000 Spectrophotometer Procedures Manual", Arsenic Procedure, pp. 52–56, (1990).

APPENDIX H

Calculation of Dilution Factor

Stream Flow Rate

Hall's Brook flows through a cylindrical culvert approximately 2,400 feet downstream from the pump test outfall point, and upstream from the convergence with the Aberjona River. The culvert has a measured diameter of 4.7 feet. On October 31, 1990, the depth of water in the culvert was 1.2 feet. Therefore, the freeboard was (4.7 feet - 1.2 feet), or 3.5 feet. The flow rate through the culvert was measured to be approximately 1 foot per second (ft/sec).

The discharge rate of Hall's Brook through the culvert was estimated as follows, using the method described in Anderson, Water Well Handbook, 1984 edition, page 156.

1. The ratio of freeboard (F) to inside diameter (D) was calculated for the culvert: F/D = 3.5 ft/4.7 ft = 74%

2. The correction factor was obtained from the table in the reference citation for an F/D -value of 75% (the closest to the actual value). Correction factor = 0.195.

3. The hypothetical flow rate if the culvert were full was calculated:
   Hypothetical flow rate = (Cross-sectional area) x (flow rate)
   = $(\pi)\ (4.7\ \text{ft}/2)^2\ (1\ \text{ft/sec})$
   = $17.5\ \text{ft}^3/\text{sec}$

4. The actual flow rate = (hypothetical flow rate) x (correction factor)
   = $(17.5\ \text{ft}^3/\text{sec})\ (0.195)$
   = $3.41\ \text{ft}^3/\text{sec}$
   = $(3.41\ \text{ft}^3/\text{sec})\ (7.48\ \text{gal/ft}^3)$
   = 25.5 gal/sec
   = (25.5 gal/sec) (3600 sec/hr)
   = 91,800 gal/hr

<u>Dilution Factor</u>

The dilution factor is the ratio of the final volume to the initial volume. In this case, the dilution is by flow rather than by static dilution, so the dilution factor is calculated as:

Dilution factor = (final flow rate)/(initial flow rate)

The final flow rate was calculated above. The initial flow rate is the pump discharge rate, 350/gal min (or 21,000 gal/hr).

Dilution factor = (91,800 gal/min)/(21,000 gal/hr)
= 4.37

APPENDIX I

Recharge Test Geologic Logs and Well Construction Diagrams

CONSULTING GROUND - WATER GEOLOGISTS

ROUX ASSOCIATES INC

TEST PIT LOGS

Recharge Basin

CLIENT: Golder Associates, Inc.
PROJECT: IndustriPlex Site PDI
DATE: 10/24/90

Depth (Ft.)	Code	Description
0–2	SW	Tan medium SAND, little coarse gravel.
2–3	SM_u^d	Brown fine-medium SAND, some silt, occasional rock and brick fragments.
3–3.5		Black cinder and gravel, wet.
3.5–6	SP	Brown fine-medium SAND, some silt, little cobbles. Poorly sorted.
6		Bedrock encountered @ 6.0'
7–10		

TP No. ____

Depth (Ft.)	Code	Description
0–9		

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES

GEOLOGIC LOG

Study No. 16101Y Date
Project IndustriPlex Site PDI
Client Golder Associates
Page 1 Of 1
Logged By M. Smith
Well No. P-1
Loc. Woburn, MA
M.P. Elevation
Drilling Started 10/29/90 Ended 10/29/90
Driller D.L.Maher
Type Of Rig Hollow Stem Auger

WELL DATA

Hole Diam. (in.) 6"
Final Depth (ft.) 6.0
Casing Diam. (in.) 2"
Casing Length (ft.) 3.0'
Screen Setting (ft.) 1.0-6.0
Screen Slot & Type 10 slotPVC
Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev. W.T.

SAMPLER

Type
Hammer lb.
Fall in.

DEVELOPMENT

	SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
							Cuttings were logged 0-5.0': Dark brown SAND and gravel
						5	Large cobbles encountered at 5.0' B.O.B. 6.5'

REMARKS: (1) in feet relative to a common datum
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES

GEOLOGIC LOG

Study No.	16101Y
Date	
Project	IndustriPlex Site PDI
Client	Golder Associates
Page	1 Of 1
Logged By	M. Smith
Well No.	P-2
Loc.	Woburn, MA
M.P. Elevation	
Drilling Started	10/24/90
Ended	10/24/90
Driller	Corner Stone Construction
Type Of Rig	Dug Well

WELL DATA

Hole Diam. (in.)	
Final Depth (ft.)	3.0
Casing Diam. (in.)	2"
Casing Length (ft.)	
Screen Setting (ft.)	0.0-3.0
Screen Slot & Type	10 slotPVC
Well Status	

G W READINGS (1)

Date	DTW MP (2)	Elev. W.T.

SAMPLER

Type ______
Hammer ______ lb.
Fall ______ in.

DEVELOPMENT

	SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
							See log of recharge basin

REMARKS: (1) in feet relative to a common datum
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES

GEOLOGIC LOG

Study No. 16101Y Date

Project IndustriPlex Site PDI

Client Golder Associates

Page 1 Of 1

Logged By M. Smith

Well No. P-3

Loc. Woburn, MA

M.P. Elevation

Drilling Started 10/24/90 Ended 10/24/90

Driller Corner Stone Construction

Type Of Rig Dug Well

WELL DATA

Hole Diam. (in.)

Final Depth (ft.) 6.0

Casing Diam. (in.) 2"

Casing Length (ft.) 5.0

Screen Setting (ft.) 3.0-6.0'

Screen Slot & Type 10 slotPVC

Well Status

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T.

SAMPLER

Type

Hammer lb.

Fall in.

DEVELOPMENT

SAMPLE No.	Rec.	Depth (ft.)	Blows /6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
						See log of recharge basin

REMARKS: (1) in feet relative to a common datum
(2) from top of PVC casing

CONSULTING GROUND WATER GEOLOGISTS
ROUX ASSOCIATES

GEOLOGIC LOG

Study No.	16101Y
Date	
Project	IndustriPlex Site PDI
Client	Golder Associates
Page	1 Of 1
Logged By	M. Smith
Well No.	P-4
Loc.	Woburn, MA
M.P. Elevation	
Drilling Started	10/29/90
Ended	10/29/90
Driller	D.L. Maher
Type Of Rig	Hollow Stem Auger

WELL DATA

Hole Diam. (in.)	6"
Final Depth (ft.)	6.0
Casing Diam. (in.)	2"
Casing Length (ft.)	3.0
Screen Setting (ft.)	1.0-6.0
Screen Slot & Type	10 slotPVC
Well Status	

G W READINGS(1)

Date	DTW MP(2)	Elev.W.T.

SAMPLER

Type ______
Hammer ______ lb.
Fall ______ in.

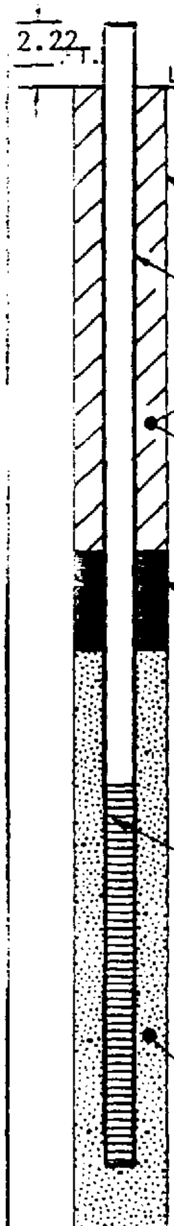
DEVELOPMENT

SAMPLE No.	Rec.	Depth (ft.)	Blows/6"	Strata Change & Gen. Desc.	Depth (ft.)	SAMPLE DESCRIPTION
					0	Cuttings were logged. 0-3': Dark brown SAND and gravel
					3	3-4': Purple SAND and gravel 4-6': Tan SAND
					6	B.O.B. 6.0'

REMARKS: (1) in feet relative to a common datum
(2) from top of PVC casing

ROUX
Consulting Ground-Water Geologists
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET BELOW LAND SURFACE

PROJECT NAME IndustriPlex NUMBER 16101Y
WELL NO. P-1 PERMIT NO.
TOWN/CITY Woburn
COUNTY Middlesex STATE MA
LAND-SURFACE ELEVATION AND DATUM ______ FEET ☐ SURVEYED ☐ ESTIMATED
INSTALLATION DATE(S) 10/29/90
DRILLING METHOD Hollow Stem Auger
DRILLING CONTRACTOR D.L. Maher
DRILLING FLUID

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Teflon Bailer 11/5/90

FLUID LOSS DURING DRILLING ______ GALLONS
WATER REMOVED DURING DEVELOPMENT 5 GALLONS
STATIC DEPTH TO WATER ______ FEET BELOW M.P.
PUMPING DEPTH TO WATER ______ FEET BELOW M.P.
PUMPING DURATION ______ HOURS
YIELD ______ GPM ______ DATE ______
SPECIFIC CAPACITY ______ GPM/FT.
WELL PURPOSE Piezometer

REMARKS Temporary piezometer installed adjacent to Recharge Test Basin.

HYDROGEOLOGIST Brian Thomas

ROUX
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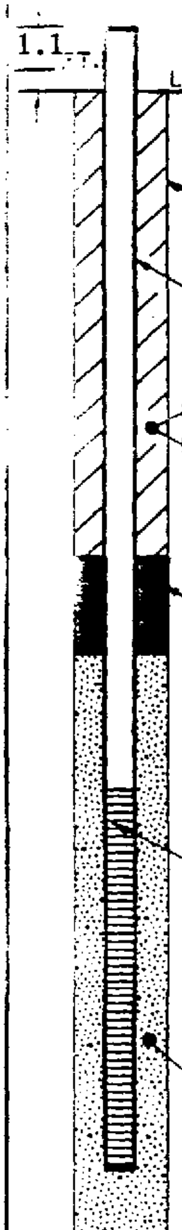
MONITORING WELL CONSTRUCTION LOG



1.1 FT.

LAND SURFACE

____ INCH DIAMETER, DRILLED HOLE

WELL CASING
2 INCH DIAMETER,

☒ BACKFILL
☐ GROUT 2" stone

____ FT.

BENTONITE ☐ SLURRY ☐ PELLETS

____ FT.

0 FT.

WELL SCREEN
2 INCH DIAMETER,
PVC 10 SLOT

____ GRAVEL PACK

3.0 FT.

____ FT.

NOTE:
ALL DEPTHS IN FEET BELOW LAND SURFACE

PROJECT NAME IndustriPlex NUMBER 16101Y

WELL NO. P-2 PERMIT NO. ____

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM ____ FEET ☐ SURVEYED ☐ ESTIMATED

INSTALLATION DATE(S) 10/24/90

DRILLING METHOD Well Point

DRILLING CONTRACTOR Corner Stone Construction

DRILLING FLUID Not Applicable

DEVELOPMENT TECHNIQUE(S) AND DATE(S) ____

FLUID LOSS DURING DRILLING ____ GALLONS

WATER REMOVED DURING DEVELOPMENT ____ GALLONS

STATIC DEPTH TO WATER ____ FEET BELOW M.P.

PUMPING DEPTH TO WATER ____ FEET BELOW M.P.

PUMPING DURATION ____ HOURS

YIELD ____ GPM ____ DATE ____

SPECIFIC CAPACITY ____ GPM/FT.

WELL PURPOSE ____

REMARKS Screened to land surface
Temporary piezometer installed and screened in Recharge Test Basin.

HYDROGEOLOGIST Brian Thomas

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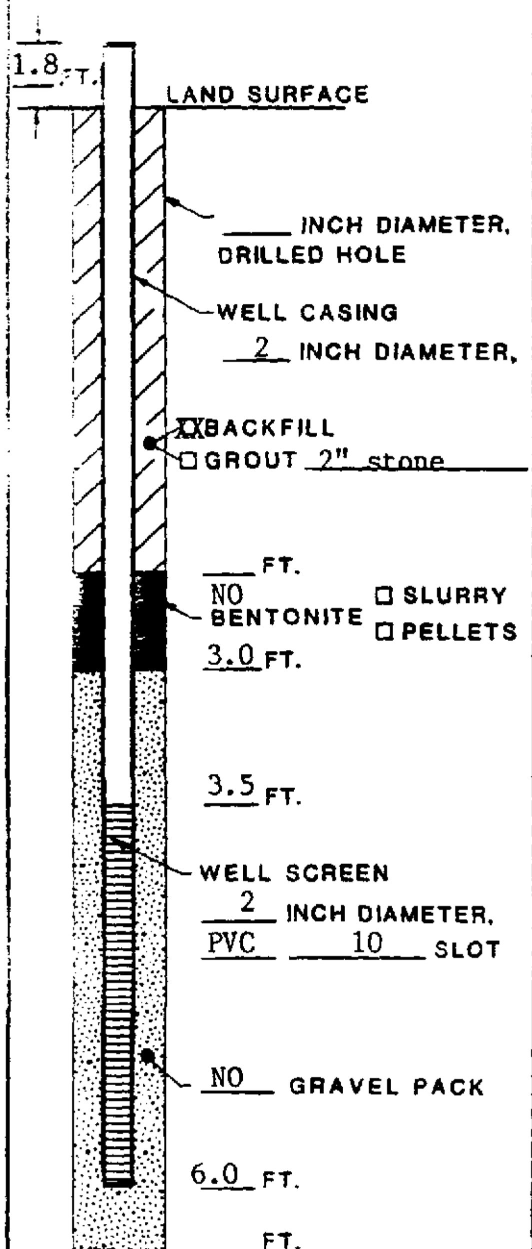
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET
BELOW LAND SURFACE

PROJECT NAME IndustriPlex NUMBER 16101Y

WELL NO. P-3 PERMIT NO. ____

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM ____ FEET ☐ SURVEYED ☐ ESTIMATED

INSTALLATION DATE(S) 10/24/90

DRILLING METHOD Well Point

DRILLING CONTRACTOR ____

DRILLING FLUID Not Applicable

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Teflon Bailer 11/5/90

FLUID LOSS DURING DRILLING ____ GALLONS

WATER REMOVED DURING DEVELOPMENT ____ GALLONS

STATIC DEPTH TO WATER ____ FEET BELOW M.P.

PUMPING DEPTH TO WATER ____ FEET BELOW M.P.

PUMPING DURATION ____ HOURS

YIELD ____ GPM ____ DATE ____

SPECIFIC CAPACITY ____ GPM/FT.

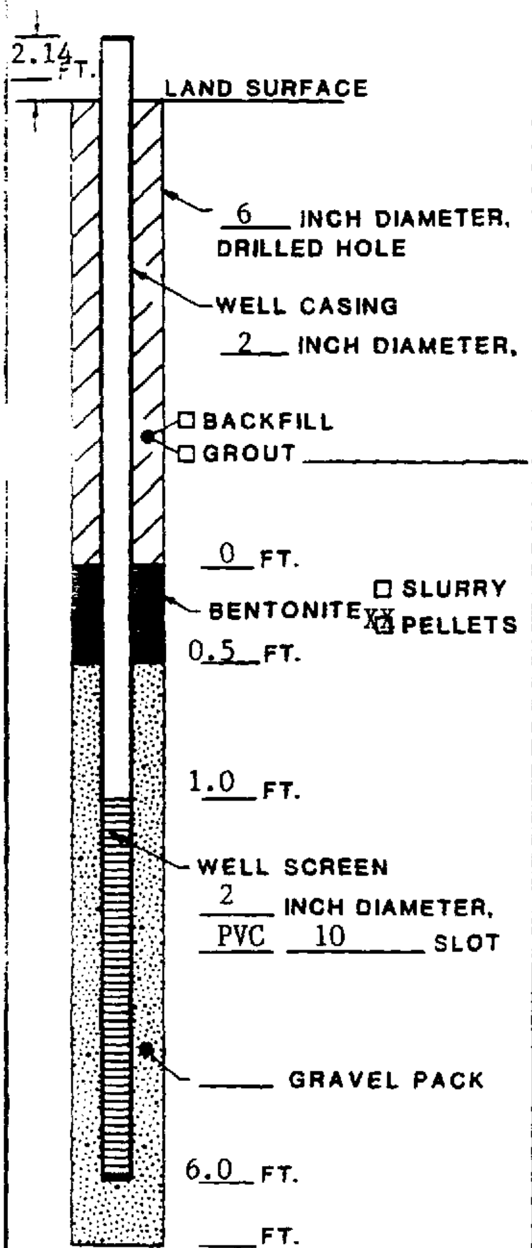
WELL PURPOSE ____

REMARKS Temporary piezometer installed in and screened below Recharge Test Basin.

HYDROGEOLOGIST Brian Thomas

ROUX
Consulting Ground-Water Geologists
ROUX ASSOCIATES INC

MONITORING WELL CONSTRUCTION LOG



NOTE:
ALL DEPTHS IN FEET
BELOW LAND SURFACE

PROJECT NAME IndustriPlex NUMBER 16101Y

WELL NO. P-4 PERMIT NO. ______

TOWN/CITY Woburn

COUNTY Middlesex STATE MA

LAND-SURFACE ELEVATION AND DATUM ______ FEET ☐ SURVEYED ☐ ESTIMATED

INSTALLATION DATE(S) 10/29/90

DRILLING METHOD Hollow Stem Auger

DRILLING CONTRACTOR D.L. Maher

DRILLING FLUID ______

DEVELOPMENT TECHNIQUE(S) AND DATE(S)
Teflon Bailer 11/5/90

FLUID LOSS DURING DRILLING ______ GALLONS

WATER REMOVED DURING DEVELOPMENT 5 GALLONS

STATIC DEPTH TO WATER ______ FEET BELOW M.P.

PUMPING DEPTH TO WATER ______ FEET BELOW M.P.

PUMPING DURATION ______ HOURS

YIELD ______ GPM ______ DATE ______

SPECIFIC CAPACITY ______ GPM/FT.

WELL PURPOSE Piezometer

REMARKS Tempoary piezometer installed 10 ft. from Recharge Test Basin.

HYDROGEOLOGIST Brian Thomas

1/89

APPENDIX J

Water-Level Measurements in Piezometers P-1 through P-4

RECHARGE BASIN RAW DATA-PIEZOMETER 1

Saved Recorder Status

Type: 2109-5 Range: 0.00 - 11.55 feet Recorder ID: 38]

Time at Recorder: 11/09/90 09:09:33 Last Update: 05/25/89 15:34:59

Signal process: Not Available

Values being saved: averages

Alarm status: Low alarm @ 0.05 is OFF Upper alarm @ 11.52 is OFF

Current averaging period: 00:15:00

Amount of time history data recorded: 2 days 19:00:00

Storage Capacity: 6515 values records: 22 days 14:45:00

Output compressed by a factor of 1

Date	Time	Avg
11/06/90	13:57:07	3.01
11/06/90	14:12:07	3.03
11/06/90	14:27:07	3.03
11/06/90	14:42:07	3.12
11/06/90	14:57:07	3.26
11/06/90	15:12:07	3.4
11/06/90	15:27:07	3.51
11/06/90	15:42:07	3.6
11/06/90	15:57:07	3.7
11/06/90	16:12:07	3.79
11/06/90	16:27:07	3.88
11/06/90	16:42:07	4.01
11/06/90	16:57:07	4.17
11/06/90	17:12:07	4.28
11/06/90	17:27:07	4.32
11/06/90	17:42:07	4.22
11/06/90	17:57:07	4.15
11/06/90	18:12:07	4.11
11/06/90	18:27:07	4.09
11/06/90	18:42:07	4.05
11/06/90	18:57:07	4.03
11/06/90	19:12:07	4.01
11/06/90	19:27:07	3.99
11/06/90	19:42:07	3.96
11/06/90	19:57:07	3.94
11/06/90	20:12:07	3.92
11/06/90	20:27:07	3.91
11/06/90	20:42:07	3.88
11/06/90	20:57:07	3.87
11/06/90	21:12:07	3.86
11/06/90	21:27:07	3.84
11/06/90	21:42:07	3.83
11/06/90	21:57:07	3.82
11/06/90	22:12:07	3.8
11/06/90	22:27:07	3.79
11/06/90	22:42:07	3.78
11/06/90	22:57:07	3.77
11/06/90	23:12:07	3.76
11/06/90	23:27:07	3.75
11/06/90	23:42:07	3.74
11/06/90	23:57:07	3.73
11/07/90	00:12:07	3.71
11/07/90	00:27:07	3.7
11/07/90	00:42:07	3.7

RECHARGE BASIN RAW DATA-PIEZOMETER 1

11/07/90	00:57:07	3.69
11/07/90	01:12:07	3.69
11/07/90	01:27:07	3.68
11/07/90	01:42:07	3.67
11/07/90	01:57:07	3.66
11/07/90	02:12:07	3.66
11/07/90	02:27:07	3.65
11/07/90	02:42:07	3.65
11/07/90	02:57:07	3.64
11/07/90	03:12:07	3.64
11/07/90	03:27:07	3.64
11/07/90	03:42:07	3.62
11/07/90	03:57:07	3.62
11/07/90	04:12:07	3.61
11/07/90	04:27:07	3.61
11/07/90	04:42:07	3.6
11/07/90	04:57:07	3.59
11/07/90	05:12:07	3.59
11/07/90	05:27:07	3.59
11/07/90	05:42:07	3.59
11/07/90	05:57:07	3.58
11/07/90	06:12:07	3.58
11/07/90	06:27:07	3.58
11/07/90	06:42:07	3.57
11/07/90	06:57:07	3.57
11/07/90	07:12:07	3.56
11/07/90	07:27:07	3.56
11/07/90	07:42:07	3.56
11/07/90	07:57:07	3.56
11/07/90	08:12:07	3.55
11/07/90	08:27:07	3.55
11/07/90	08:42:07	3.55
11/07/90	08:57:07	3.55
11/07/90	09:12:07	3.55
11/07/90	09:27:07	3.57
11/07/90	09:42:07	3.58
11/07/90	09:57:07	3.59
11/07/90	10:12:07	3.64
11/07/90	10:27:07	3.65
11/07/90	10:42:07	3.66
11/07/90	10:57:07	3.69
11/07/90	11:12:07	3.7
11/07/90	11:27:07	3.71
11/07/90	11:42:07	3.74
11/07/90	11:57:07	3.75
11/07/90	12:12:07	3.77
11/07/90	12:27:07	3.78
11/07/90	12:42:07	3.79
11/07/90	12:57:07	3.8
11/07/90	13:12:07	3.83
11/07/90	13:27:07	3.84
11/07/90	13:42:07	3.84
11/07/90	13:57:07	3.85
11/07/90	14:12:07	3.87
11/07/90	14:27:07	3.88
11/07/90	14:42:07	3.88

RECHARGE BASIN RAW DATA-PIEZOMETER 1

11/07/90	14:57:07	3.9
11/07/90	15:12:07	3.91
11/07/90	15:27:07	3.91
11/07/90	15:42:07	3.92
11/07/90	15:57:07	3.92
11/07/90	16:12:07	3.93
11/07/90	16:27:07	3.93
11/07/90	16:42:07	3.94
11/07/90	16:57:07	3.94
11/07/90	17:12:07	3.95
11/07/90	17:27:07	3.95
11/07/90	17:42:07	3.95
11/07/90	17:57:07	3.96
11/07/90	18:12:07	3.96
11/07/90	18:27:07	3.97
11/07/90	18:42:07	3.97
11/07/90	18:57:07	3.97
11/07/90	19:12:07	3.99
11/07/90	19:27:07	4
11/07/90	19:42:07	4
11/07/90	19:57:07	4
11/07/90	20:12:07	4
11/07/90	20:27:07	4.01
11/07/90	20:42:07	4.01
11/07/90	20:57:07	4.02
11/07/90	21:12:07	4.02
11/07/90	21:27:07	4.02
11/07/90	21:42:07	4.03
11/07/90	21:57:07	4.03
11/07/90	22:12:07	4.03
11/07/90	22:27:07	4.03
11/07/90	22:42:07	4.04
11/07/90	22:57:07	4.04
11/07/90	23:12:07	4.04
11/07/90	23:27:07	4.05
11/07/90	23:42:07	4.05
11/07/90	23:57:07	4.04
11/08/90	00:12:07	4.05
11/08/90	00:27:07	4.05
11/08/90	00:42:07	4.05
11/08/90	00:57:07	4.05
11/08/90	01:12:07	4.05
11/08/90	01:27:07	4.05
11/08/90	01:42:07	4.06
11/08/90	01:57:07	4.06
11/08/90	02:12:07	4.06
11/08/90	02:27:07	4.06
11/08/90	02:42:07	4.06
11/08/90	02:57:07	4.06
11/08/90	03:12:07	4.06
11/08/90	03:27:07	4.06
11/08/90	03:42:07	4.06
11/08/90	03:57:07	4.06
11/08/90	04:12:07	4.06
11/08/90	04:27:07	4.06
11/08/90	04:42:07	4.06

RECHARGE BASIN RAW DATA-PIEZOMETER 1

11/08/90	04:57:07	4.06
11/08/90	05:12:07	4.06
11/08/90	05:27:07	4.06
11/08/90	05:42:07	4.06
11/08/90	05:57:07	4.06
11/08/90	06:12:07	4.06
11/08/90	06:27:07	4.06
11/08/90	06:42:07	4.06
11/08/90	06:57:07	4.06
11/08/90	07:12:07	4.06
11/08/90	07:27:07	4.05
11/08/90	07:42:07	4.05
11/08/90	07:57:07	4.05
11/08/90	08:12:07	4.05
11/08/90	08:27:07	4.05
11/08/90	08:42:07	4.04
11/08/90	08:57:07	4.04
11/08/90	09:12:07	4.04
11/08/90	09:27:07	4.03
11/08/90	09:42:07	4.03
11/08/90	09:57:07	4.04
11/08/90	10:12:07	4.04
11/08/90	10:27:07	4.03
11/08/90	10:42:07	4.04
11/08/90	10:57:07	4.04
11/08/90	11:12:07	4.03
11/08/90	11:27:07	4.03
11/08/90	11:42:07	4.04
11/08/90	11:57:07	4.04
11/08/90	12:12:07	4.04
11/08/90	12:27:07	4.05
11/08/90	12:42:07	4.05
11/08/90	12:57:07	4.05
11/08/90	13:12:07	4.05
11/08/90	13:27:07	4.05
11/08/90	13:42:07	4.05
11/08/90	13:57:07	5.92
11/08/90	14:12:07	1.45
11/08/90	14:27:07	11.14
11/08/90	14:42:07	4.18
11/08/90	14:57:07	9.91
11/08/90	15:12:07	0.36
11/08/90	15:27:07	0
11/08/90	15:42:07	0
11/08/90	15:57:07	0
11/08/90	16:12:07	0
11/08/90	16:27:07	0
11/08/90	16:42:07	0
11/08/90	16:57:07	10.12
11/08/90	17:12:07	0.55
11/08/90	17:27:07	4.61
11/08/90	17:42:07	0.18
11/08/90	17:57:07	6.35
11/08/90	18:12:07	6.8
11/08/90	18:27:07	5.06
11/08/90	18:42:07	2.98

RECHARGE BASIN RAW DATA-PIEZOMETER 1

11/08/90	18:57:07	7.28
11/08/90	19:12:07	7.28
11/08/90	19:27:07	7.1
11/08/90	19:42:07	7.1
11/08/90	19:57:07	7.1
11/08/90	20:12:07	7.1
11/08/90	20:27:07	7.1
11/08/90	20:42:07	7.1
11/08/90	20:57:07	7.1
11/08/90	21:12:07	7.1
11/08/90	21:27:07	7.1
11/08/90	21:42:07	6.92
11/08/90	21:57:07	7.1
11/08/90	22:12:07	7.1
11/08/90	22:27:07	7.1
11/08/90	22:42:07	6.92
11/08/90	22:57:07	6.92
11/08/90	23:12:07	6.92
11/08/90	23:27:07	6.92
11/08/90	23:42:07	6.92
11/08/90	23:57:07	6.92
11/09/90	00:12:07	6.92
11/09/90	00:27:07	7.1
11/09/90	00:42:07	6.92
11/09/90	00:57:07	6.92
11/09/90	01:12:07	7.1
11/09/90	01:27:07	7.1
11/09/90	01:42:07	7.28
11/09/90	01:57:07	7.28
11/09/90	02:12:07	7.28
11/09/90	02:27:07	7.28
11/09/90	02:42:07	7.28
11/09/90	02:57:07	7.28
11/09/90	03:12:07	7.46
11/09/90	03:27:07	7.46
11/09/90	03:42:07	7.46
11/09/90	03:57:07	7.46
11/09/90	04:12:07	7.46
11/09/90	04:27:07	7.46
11/09/90	04:42:07	7.64
11/09/90	04:57:07	7.64
11/09/90	05:12:07	7.64
11/09/90	05:27:07	7.64
11/09/90	05:42:07	7.64
11/09/90	05:57:07	7.64
11/09/90	06:12:07	7.64
11/09/90	06:27:07	7.82
11/09/90	06:42:07	7.64
11/09/90	06:57:07	7.64
11/09/90	07:12:07	7.64
11/09/90	07:27:07	7.46
11/09/90	07:42:07	7.46
11/09/90	07:57:07	7.46
11/09/90	08:12:07	7.28
11/09/90	08:27:07	7.46
11/09/90	08:42:07	7.46

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 2

Saved Recorder Status

Type: 2109-5 Range: 0.00 - 11.55 feet Recorder ID: 37

Time at Recorder: 11/09/90 09:25:15 Last Update: 07/27/90 14:28:50

Signal process: Not Available

Values being saved: averages

Alarm status: Low alarm @ 0.05 is OFF Upper alarm @ 11.47 is OFI

Current averaging period: 00:15:00

Amount of time history data recorded: 2 days 19:00:00

Storage Capacity: 6515 values records: 67 days 20:45:00

Output compressed by a factor of 1

Date	Time	Avg
11/06/90	14:19:37	0.51
11/06/90	14:34:37	0.51
11/06/90	14:49:37	0.53
11/06/90	15:04:37	0.87
11/06/90	15:19:37	1.26
11/06/90	15:34:37	1.58
11/06/90	15:49:37	1.83
11/06/90	16:04:37	2.02
11/06/90	16:19:37	2.17
11/06/90	16:34:37	2.28
11/06/90	16:49:37	2.39
11/06/90	17:04:37	2.44
11/06/90	17:19:37	2.44
11/06/90	17:34:37	2.39
11/06/90	17:49:37	2.3
11/06/90	18:04:37	2.22
11/06/90	18:19:37	2.17
11/06/90	18:34:37	2.11
11/06/90	18:49:37	2.05
11/06/90	19:04:37	2.01
11/06/90	19:19:37	1.96
11/06/90	19:34:37	1.93
11/06/90	19:49:37	1.89
11/06/90	20:04:37	1.85
11/06/90	20:19:37	1.83
11/06/90	20:34:37	1.8
11/06/90	20:49:37	1.77
11/06/90	21:04:37	1.74
11/06/90	21:19:37	1.72
11/06/90	21:34:37	1.69
11/06/90	21:49:37	1.68
11/06/90	22:04:37	1.66
11/06/90	22:19:37	1.65
11/06/90	22:34:37	1.63
11/06/90	22:49:37	1.61
11/06/90	23:04:37	1.59
11/06/90	23:19:37	1.58
11/06/90	23:34:37	1.57
11/06/90	23:49:37	1.56
11/07/90	00:04:37	1.55
11/07/90	00:19:37	1.54
11/07/90	00:34:37	1.52
11/07/90	00:49:37	1.51
11/07/90	01:04:37	1.5

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 2

11/07/90	01:19:37	1.49
11/07/90	01:34:37	1.48
11/07/90	01:49:37	1.48
11/07/90	02:04:37	1.47
11/07/90	02:19:37	1.46
11/07/90	02:34:37	1.46
11/07/90	02:49:37	1.45
11/07/90	03:04:37	1.43
11/07/90	03:19:37	1.42
11/07/90	03:34:37	1.42
11/07/90	03:49:37	1.41
11/07/90	04:04:37	1.41
11/07/90	04:19:37	1.4
11/07/90	04:34:37	1.39
11/07/90	04:49:37	1.39
11/07/90	05:04:37	1.39
11/07/90	05:19:37	1.38
11/07/90	05:34:37	1.38
11/07/90	05:49:37	1.37
11/07/90	06:04:37	1.37
11/07/90	06:19:37	1.35
11/07/90	06:34:37	1.35
11/07/90	06:49:37	1.34
11/07/90	07:04:37	1.34
11/07/90	07:19:37	1.34
11/07/90	07:34:37	1.33
11/07/90	07:49:37	1.33
11/07/90	08:04:37	1.32
11/07/90	08:19:37	1.32
11/07/90	08:34:37	1.31
11/07/90	08:49:37	1.32
11/07/90	09:04:37	1.31
11/07/90	09:19:37	1.31
11/07/90	09:34:37	1.33
11/07/90	09:49:37	1.39
11/07/90	10:04:37	1.43
11/07/90	10:19:37	1.48
11/07/90	10:34:37	1.52
11/07/90	10:49:37	1.57
11/07/90	11:04:37	1.59
11/07/90	11:19:37	1.63
11/07/90	11:34:37	1.65
11/07/90	11:49:37	1.67
11/07/90	12:04:37	1.69
11/07/90	12:19:37	1.72
11/07/90	12:34:37	1.74
11/07/90	12:49:37	1.76
11/07/90	13:04:37	1.77
11/07/90	13:19:37	1.8
11/07/90	13:34:37	1.81
11/07/90	13:49:37	1.83
11/07/90	14:04:37	1.85
11/07/90	14:19:37	1.86
11/07/90	14:34:37	1.87
11/07/90	14:49:37	1.89
11/07/90	15:04:37	1.9

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 2

11/07/90	15:19:37	1.91
11/07/90	15:34:37	1.92
11/07/90	15:49:37	1.92
11/07/90	16:04:37	1.93
11/07/90	16:19:37	1.93
11/07/90	16:34:37	1.93
11/07/90	16:49:37	1.94
11/07/90	17:04:37	1.94
11/07/90	17:19:37	1.94
11/07/90	17:34:37	1.95
11/07/90	17:49:37	1.95
11/07/90	18:04:37	1.96
11/07/90	18:19:37	1.96
11/07/90	18:34:37	1.98
11/07/90	18:49:37	1.98
11/07/90	19:04:37	1.98
11/07/90	19:19:37	1.98
11/07/90	19:34:37	1.99
11/07/90	19:49:37	1.99
11/07/90	20:04:37	1.99
11/07/90	20:19:37	2
11/07/90	20:34:37	2
11/07/90	20:49:37	2
11/07/90	21:04:37	2.01
11/07/90	21:19:37	2.01
11/07/90	21:34:37	2.01
11/07/90	21:49:37	2.02
11/07/90	22:04:37	2.02
11/07/90	22:19:37	2.02
11/07/90	22:34:37	2.02
11/07/90	22:49:37	2.02
11/07/90	23:04:37	2.03
11/07/90	23:19:37	2.03
11/07/90	23:34:37	2.03
11/07/90	23:49:37	2.04
11/08/90	00:04:37	2.04
11/08/90	00:19:37	2.04
11/08/90	00:34:37	2.04
11/08/90	00:49:37	2.04
11/08/90	01:04:37	2.04
11/08/90	01:19:37	2.05
11/08/90	01:34:37	2.05
11/08/90	01:49:37	2.05
11/08/90	02:04:37	2.05
11/08/90	02:19:37	2.04
11/08/90	02:34:37	2.04
11/08/90	02:49:37	2.04
11/08/90	03:04:37	2.04
11/08/90	03:19:37	2.05
11/08/90	03:34:37	2.05
11/08/90	03:49:37	2.05
11/08/90	04:04:37	2.05
11/08/90	04:19:37	2.05
11/08/90	04:34:37	2.05
11/08/90	04:49:37	2.05
11/08/90	05:04:37	2.05

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 2

11/08/90	05:19:37	2.05
11/08/90	05:34:37	2.07
11/08/90	05:49:37	2.07
11/08/90	06:04:37	2.05
11/08/90	06:19:37	2.05
11/08/90	06:34:37	2.05
11/08/90	06:49:37	2.05
11/08/90	07:04:37	2.05
11/08/90	07:19:37	2.05
11/08/90	07:34:37	2.05
11/08/90	07:49:37	2.04
11/08/90	08:04:37	2.04
11/08/90	08:19:37	2.04
11/08/90	08:34:37	2.04
11/08/90	08:49:37	2.04
11/08/90	09:04:37	2.04
11/08/90	09:19:37	2.04
11/08/90	09:34:37	2.04
11/08/90	09:49:37	2.04
11/08/90	10:04:37	2.04
11/08/90	10:19:37	2.05
11/08/90	10:34:37	2.05
11/08/90	10:49:37	2.04
11/08/90	11:04:37	2.04
11/08/90	11:19:37	2.04
11/08/90	11:34:37	2.04
11/08/90	11:49:37	2.05
11/08/90	12:04:37	2.05
11/08/90	12:19:37	2.05
11/08/90	12:34:37	2.05
11/08/90	12:49:37	2.05
11/08/90	13:04:37	2.05
11/08/90	13:19:37	2.05
11/08/90	13:34:37	2.07
11/08/90	13:49:37	2.05
11/08/90	14:04:37	2.07
11/08/90	14:19:37	2.05
11/08/90	14:34:37	2.05
11/08/90	14:49:37	2.05
11/08/90	15:04:37	2.05
11/08/90	15:19:37	2.07
11/08/90	15:34:37	2.05
11/08/90	15:49:37	2.05
11/08/90	16:04:37	2.05
11/08/90	16:19:37	2.05
11/08/90	16:34:37	2.05
11/08/90	16:49:37	2.04
11/08/90	17:04:37	2.04
11/08/90	17:19:37	2.04
11/08/90	17:34:37	2.03
11/08/90	17:49:37	2.02
11/08/90	18:04:37	2.02
11/08/90	18:19:37	2.02
11/08/90	18:34:37	2.02
11/08/90	18:49:37	2.02
11/08/90	19:04:37	2.02

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 2

11/08/90	19:19:37	2.02
11/08/90	19:34:37	2.02
11/08/90	19:49:37	2.02
11/08/90	20:04:37	2.02
11/08/90	20:19:37	2.02
11/08/90	20:34:37	2.02
11/08/90	20:49:37	2.02
11/08/90	21:04:37	2.02
11/08/90	21:19:37	2.02
11/08/90	21:34:37	2.02
11/08/90	21:49:37	2.02
11/08/90	22:04:37	2.02
11/08/90	22:19:37	2.03
11/08/90	22:34:37	2.03
11/08/90	22:49:37	2.02
11/08/90	23:04:37	2.02
11/08/90	23:19:37	2.02
11/08/90	23:34:37	2.02
11/08/90	23:49:37	2.02
11/09/90	00:04:37	2.02
11/09/90	00:19:37	2.02
11/09/90	00:34:37	2.02
11/09/90	00:49:37	2.03
11/09/90	01:04:37	2.03
11/09/90	01:19:37	2.03
11/09/90	01:34:37	2.03
11/09/90	01:49:37	2.04
11/09/90	02:04:37	2.04
11/09/90	02:19:37	2.04
11/09/90	02:34:37	2.04
11/09/90	02:49:37	2.04
11/09/90	03:04:37	2.05
11/09/90	03:19:37	2.05
11/09/90	03:34:37	2.05
11/09/90	03:49:37	2.05
11/09/90	04:04:37	2.05
11/09/90	04:19:37	2.05
11/09/90	04:34:37	2.05
11/09/90	04:49:37	2.07
11/09/90	05:04:37	2.07
11/09/90	05:19:37	2.07
11/09/90	05:34:37	2.07
11/09/90	05:49:37	2.07
11/09/90	06:04:37	2.07
11/09/90	06:19:37	2.08
11/09/90	06:34:37	2.08
11/09/90	06:49:37	2.08
11/09/90	07:04:37	2.08
11/09/90	07:19:37	2.08
11/09/90	07:34:37	2.08
11/09/90	07:49:37	2.08
11/09/90	08:04:37	2.07
11/09/90	08:19:37	2.07
11/09/90	08:34:37	2.07
11/09/90	08:49:37	2.07
11/09/90	09:04:37	2.07

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 3

Date Tuesday November 20, 1990 10:50 AM
PlotFile A:\PIEZ301.PRN
DataFile A:\PIEZ3

Time of First Log in Specified Window
33183.55 0.552026

Date	Time	Analog#01 20psi...... FT H2O.....
11/06/90	13:14:55	1.9288
11/06/90	13:29:56	2.0097
11/06/90	13:44:56	1.9981
11/06/90	13:59:55	1.9981
11/06/90	14:14:56	2.2176
11/06/90	14:29:56	2.4486
11/06/90	14:44:55	2.668
11/06/90	14:59:56	2.8528
11/06/90	15:14:56	3.0954
11/06/90	15:29:55	3.2802
11/06/90	15:44:56	3.465
11/06/90	15:59:56	3.6267
11/06/90	16:14:56	3.7422
11/06/90	16:29:56	3.8346
11/06/90	16:44:56	3.8692
11/06/90	16:59:56	3.8692
11/06/90	17:14:56	3.9039
11/06/90	17:29:56	3.927
11/06/90	17:44:56	3.9385
11/06/90	17:59:56	3.9385
11/06/90	18:14:56	3.9501
11/06/90	18:29:56	3.9501
11/06/90	18:44:56	3.9385
11/06/90	18:59:56	3.9385
11/06/90	19:14:56	3.927
11/06/90	19:29:56	3.927
11/06/90	19:44:56	3.927
11/06/90	19:59:56	3.9385
11/06/90	20:14:56	3.9385
11/06/90	20:29:56	3.9501
11/06/90	20:44:56	3.9501
11/06/90	20:59:56	3.9616
11/06/90	21:14:56	3.9501
11/06/90	21:29:56	3.9501
11/06/90	21:44:56	3.6844
11/06/90	21:59:56	3.6729
11/06/90	22:14:56	3.696
11/06/90	22:29:56	3.7075
11/06/90	22:44:56	3.7306
11/06/90	22:59:56	3.7306
11/06/90	23:14:56	3.7422
11/06/90	23:29:56	3.7653
11/06/90	23:44:56	3.7768
11/06/90	23:59:56	3.7653
11/07/90	00:14:56	3.7884

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 3

11/07/90	00:29:56	3.7768
11/07/90	00:44:56	3.7884
11/07/90	00:59:56	3.7999
11/07/90	01:14:56	3.7999
11/07/90	01:29:56	3.7999
11/07/90	01:44:56	3.823
11/07/90	01:59:56	3.8346
11/07/90	02:14:56	3.8577
11/07/90	02:29:56	3.8692
11/07/90	02:44:56	3.8692
11/07/90	02:59:56	3.9154
11/07/90	03:14:56	3.927
11/07/90	03:29:56	3.9385
11/07/90	03:44:56	3.9501
11/07/90	03:59:56	3.9385
11/07/90	04:14:56	3.9616
11/07/90	04:29:56	3.9847
11/07/90	04:44:56	3.9963
11/07/90	04:59:56	4.0078
11/07/90	05:14:56	4.0194
11/07/90	05:29:56	4.0425
11/07/90	05:44:56	4.0425
11/07/90	05:59:56	4.0194
11/07/90	06:14:56	3.9963
11/07/90	06:29:56	3.9732
11/07/90	06:44:56	3.9732
11/07/90	06:59:56	3.9732
11/07/90	07:14:56	3.9616
11/07/90	07:29:56	3.927
11/07/90	07:44:56	3.8577
11/07/90	07:59:56	3.7768
11/07/90	08:14:56	3.7422
11/07/90	08:29:56	3.696
11/07/90	08:44:56	3.6498
11/07/90	08:59:56	3.6036
11/07/90	09:14:56	3.5574
11/07/90	09:29:56	3.4534
11/07/90	09:44:56	3.3148
11/07/90	09:59:56	3.3148
11/07/90	10:14:56	3.3033
11/07/90	10:29:56	3.2802
11/07/90	10:44:56	3.2571
11/07/90	10:59:56	3.234
11/07/90	11:14:56	3.1993
11/07/90	11:29:56	3.1762
11/07/90	11:44:56	3.1416
11/07/90	11:59:56	3.1531
11/07/90	12:14:56	3.1531
11/07/90	12:29:56	3.13
11/07/90	12:44:56	3.0261
11/07/90	12:59:56	3.003
11/07/90	13:14:55	2.9799
11/07/90	13:29:56	2.899
11/07/90	13:44:56	2.9106
11/07/90	13:59:55	2.9452
11/07/90	14:14:56	2.9914

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 3

11/07/90	14:29:56	3.0607
11/07/90	14:44:56	3.13
11/07/90	14:59:56	3.1878
11/07/90	15:14:56	3.234
11/07/90	15:29:56	3.2917
11/07/90	15:44:56	3.3264
11/07/90	15:59:56	3.3841
11/07/90	16:14:56	3.4188
11/07/90	16:29:56	3.465
11/07/90	16:44:56	3.4996
11/07/90	16:59:56	3.5574
11/07/90	17:14:56	3.592
11/07/90	17:29:56	3.6382
11/07/90	17:44:56	3.6613
11/07/90	17:59:56	3.696
11/07/90	18:14:56	3.7191
11/07/90	18:29:56	3.7306
11/07/90	18:44:56	3.7422
11/07/90	18:59:56	3.7537
11/07/90	19:14:56	3.7653
11/07/90	19:29:56	3.7653
11/07/90	19:44:56	3.7653
11/07/90	19:59:56	3.7653
11/07/90	20:14:56	3.7653
11/07/90	20:29:56	3.7653
11/07/90	20:44:56	3.7768
11/07/90	20:59:56	3.7768
11/07/90	21:14:56	3.7768
11/07/90	21:29:56	3.7884
11/07/90	21:44:56	3.7768
11/07/90	21:59:56	3.7884
11/07/90	22:14:56	3.7884
11/07/90	22:29:56	3.7884
11/07/90	22:44:56	3.7999
11/07/90	22:59:56	3.8115
11/07/90	23:14:56	3.823
11/07/90	23:29:56	3.823
11/07/90	23:44:56	3.8346
11/07/90	23:59:56	3.8346
11/08/90	00:14:56	3.8461
11/08/90	00:29:56	3.8461
11/08/90	00:44:56	3.8577
11/08/90	00:59:56	3.8692
11/08/90	01:14:56	3.8692
11/08/90	01:29:56	3.8692
11/08/90	01:44:56	3.8692
11/08/90	01:59:56	3.8692
11/08/90	02:14:56	3.8692
11/08/90	02:29:56	3.8923
11/08/90	02:44:56	3.9154
11/08/90	02:59:56	3.927
11/08/90	03:14:56	3.9385
11/08/90	03:29:56	3.9501
11/08/90	03:44:56	3.9501
11/08/90	03:59:56	3.9616
11/08/90	04:14:56	4.0078

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 3

11/08/90	04:29:56	4.0309
11/08/90	04:44:56	4.054
11/08/90	04:59:56	4.1233
11/08/90	05:14:56	4.158
11/08/90	05:29:56	4.1811
11/08/90	05:44:56	4.1695
11/08/90	05:59:56	4.1695
11/08/90	06:14:56	4.1926
11/08/90	06:29:56	4.2157
11/08/90	06:44:56	4.2388
11/08/90	06:59:56	4.2388
11/08/90	07:14:56	4.2504
11/08/90	07:29:56	4.2388
11/08/90	07:44:56	4.2157
11/08/90	07:59:56	4.1926
11/08/90	08:14:56	4.2042
11/08/90	08:29:56	4.1811
11/08/90	08:44:56	4.158
11/08/90	08:59:56	4.054
11/08/90	09:14:56	3.9501
11/08/90	09:29:56	3.9501
11/08/90	09:44:56	3.9385
11/08/90	09:59:56	3.9154
11/08/90	10:14:56	3.823
11/08/90	10:29:56	3.823
11/08/90	10:44:56	3.7422
11/08/90	10:59:56	3.6729
11/08/90	11:14:56	3.6151
11/08/90	11:29:56	3.5805
11/08/90	11:44:56	3.5458
11/08/90	11:59:56	3.4765
11/08/90	12:14:56	3.4534
11/08/90	12:29:55	3.4303
11/08/90	12:44:56	3.4534
11/08/90	12:59:56	3.4188
11/08/90	13:14:55	3.4188
11/08/90	13:29:56	3.4534
11/08/90	13:44:56	3.4534
11/08/90	13:59:55	3.4765
11/08/90	14:14:56	3.4881
11/08/90	14:29:56	3.5112
11/08/90	14:44:55	3.592
11/08/90	14:59:56	3.6382
11/08/90	15:14:56	3.7191
11/08/90	15:29:56	3.7999
11/08/90	15:44:56	3.9039
11/08/90	15:59:56	4.0078
11/08/90	16:14:56	4.0771
11/08/90	16:29:56	4.158
11/08/90	16:44:56	4.2157
11/08/90	16:59:56	4.2504
11/08/90	17:14:56	4.3081
11/08/90	17:29:56	4.3774
11/08/90	17:44:56	4.4121
11/08/90	17:59:56	4.4352
11/08/90	18:14:56	4.4698

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 3

11/08/90	18:29:56	4.516
11/08/90	18:44:56	4.5391
11/08/90	18:59:56	4.5622
11/08/90	19:14:56	4.5738
11/08/90	19:29:56	4.5738
11/08/90	19:44:56	4.5853
11/08/90	19:59:56	4.6084
11/08/90	20:14:56	4.6084
11/08/90	20:29:56	4.6084
11/08/90	20:44:56	4.6084
11/08/90	20:59:56	4.6662
11/08/90	21:14:56	4.6893
11/08/90	21:29:56	4.6777
11/08/90	21:44:56	4.7008
11/08/90	21:59:56	4.7355
11/08/90	22:14:56	4.7586
11/08/90	22:29:56	4.7817
11/08/90	22:44:56	4.8163
11/08/90	22:59:56	4.8279
11/08/90	23:14:56	4.8625
11/08/90	23:29:56	4.8625
11/08/90	23:44:56	4.8741
11/08/90	23:59:56	4.8972
11/09/90	00:14:56	4.9087
11/09/90	00:29:56	4.9318
11/09/90	00:44:56	4.9549
11/09/90	00:59:56	4.978
11/09/90	01:14:56	4.978
11/09/90	01:29:56	4.9896
11/09/90	01:44:56	5.0358
11/09/90	01:59:56	5.0358
11/09/90	02:14:56	5.0473
11/09/90	02:29:56	5.0473
11/09/90	02:44:56	5.0473
11/09/90	02:59:56	5.0358
11/09/90	03:14:56	5.0473
11/09/90	03:29:56	5.0358
11/09/90	03:44:56	5.0242
11/09/90	03:59:56	5.0242
11/09/90	04:14:56	5.0473
11/09/90	04:29:56	5.0589
11/09/90	04:44:56	5.0473
11/09/90	04:59:56	5.0473
11/09/90	05:14:56	5.0589
11/09/90	05:29:56	5.082
11/09/90	05:44:56	5.1051
11/09/90	05:59:56	5.1282
11/09/90	06:14:56	5.1513
11/09/90	06:29:56	5.1628
11/09/90	06:44:56	5.1628
11/09/90	06:59:56	5.1744
11/09/90	07:14:56	5.1628
11/09/90	07:29:56	5.1166
11/09/90	07:44:56	5.0473
11/09/90	07:59:56	4.9665
11/09/90	08:14:56	4.8741

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 3

11/09/90 08:29:56 4.7932

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 4

Saved Recorder Status

Type: 2109-5 Range: 0.00 - 11.55 feet Recorder ID: 3_1

Time at Recorder: 11/09/90 08:13:59 Last Update: 03/15/90 09:48:13

Signal process: Not Available

Values being saved: averages

Alarm status: Low alarm @ 0.05 is OFF Upper alarm @ 11.52 is OFF

Current averaging period: 00:15:00

Amount of time history data recorded: 2 days 19:00:00

Storage Capacity: 6515 values records: 67 days 20:45:00

Output compressed by a factor of 1

Date	Time	Avg
11/06/90	13:02:15	3.06
11/06/90	13:17:15	3.03
11/06/90	13:32:15	3.06
11/06/90	13:47:15	3.05
11/06/90	14:02:15	3.13
11/06/90	14:17:15	3.15
11/06/90	14:32:15	3.22
11/06/90	14:47:15	3.29
11/06/90	15:02:15	3.31
11/06/90	15:17:15	3.33
11/06/90	15:32:15	3.36
11/06/90	15:47:15	3.39
11/06/90	16:02:15	3.42
11/06/90	16:17:15	3.43
11/06/90	16:32:15	3.43
11/06/90	16:47:15	3.43
11/06/90	17:02:15	3.43
11/06/90	17:17:15	3.42
11/06/90	17:32:15	3.42
11/06/90	17:47:15	3.43
11/06/90	18:02:15	3.42
11/06/90	18:17:15	3.42
11/06/90	18:32:15	3.42
11/06/90	18:47:15	3.41
11/06/90	19:02:15	3.4
11/06/90	19:17:15	3.41
11/06/90	19:32:15	3.42
11/06/90	19:47:15	3.41
11/06/90	20:02:15	3.4
11/06/90	20:17:15	3.4
11/06/90	20:32:15	3.39
11/06/90	20:47:15	3.39
11/06/90	21:02:15	3.39
11/06/90	21:17:15	3.39
11/06/90	21:32:15	3.39
11/06/90	21:47:15	3.38
11/06/90	22:02:15	3.38
11/06/90	22:17:15	3.38
11/06/90	22:32:15	3.36
11/06/90	22:47:15	3.36
11/06/90	23:02:15	3.36
11/06/90	23:17:15	3.35
11/06/90	23:32:15	3.35
11/06/90	23:47:15	3.34

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 4

11/07/90	00:02:15	3.34
11/07/90	00:17:15	3.35
11/07/90	00:32:15	3.34
11/07/90	00:47:15	3.34
11/07/90	01:02:15	3.34
11/07/90	01:17:15	3.33
11/07/90	01:32:15	3.32
11/07/90	01:47:15	3.32
11/07/90	02:02:15	3.32
11/07/90	02:17:15	3.32
11/07/90	02:32:15	3.32
11/07/90	02:47:15	3.31
11/07/90	03:02:15	3.31
11/07/90	03:17:15	3.3
11/07/90	03:32:15	3.3
11/07/90	03:47:15	3.31
11/07/90	04:02:15	3.3
11/07/90	04:17:15	3.3
11/07/90	04:32:15	3.3
11/07/90	04:47:15	3.3
11/07/90	05:02:15	3.29
11/07/90	05:17:15	3.27
11/07/90	05:32:15	3.27
11/07/90	05:47:15	3.27
11/07/90	06:02:15	3.27
11/07/90	06:17:15	3.29
11/07/90	06:32:15	3.27
11/07/90	06:47:15	3.27
11/07/90	07:02:15	3.26
11/07/90	07:17:15	3.26
11/07/90	07:32:15	3.25
11/07/90	07:47:15	3.26
11/07/90	08:02:15	3.26
11/07/90	08:17:15	3.26
11/07/90	08:32:15	3.26
11/07/90	08:47:15	3.26
11/07/90	09:02:15	3.25
11/07/90	09:17:15	3.3
11/07/90	09:32:15	3.33
11/07/90	09:47:15	3.31
11/07/90	10:02:15	3.31
11/07/90	10:17:15	3.32
11/07/90	10:32:15	3.33
11/07/90	10:47:15	3.33
11/07/90	11:02:15	3.35
11/07/90	11:17:15	3.36
11/07/90	11:32:15	3.38
11/07/90	11:47:15	3.38
11/07/90	12:02:15	3.35
11/07/90	12:17:15	3.38
11/07/90	12:32:15	3.4
11/07/90	12:47:15	3.41
11/07/90	13:02:15	3.41
11/07/90	13:17:15	3.44
11/07/90	13:32:15	3.43
11/07/90	13:47:15	3.45

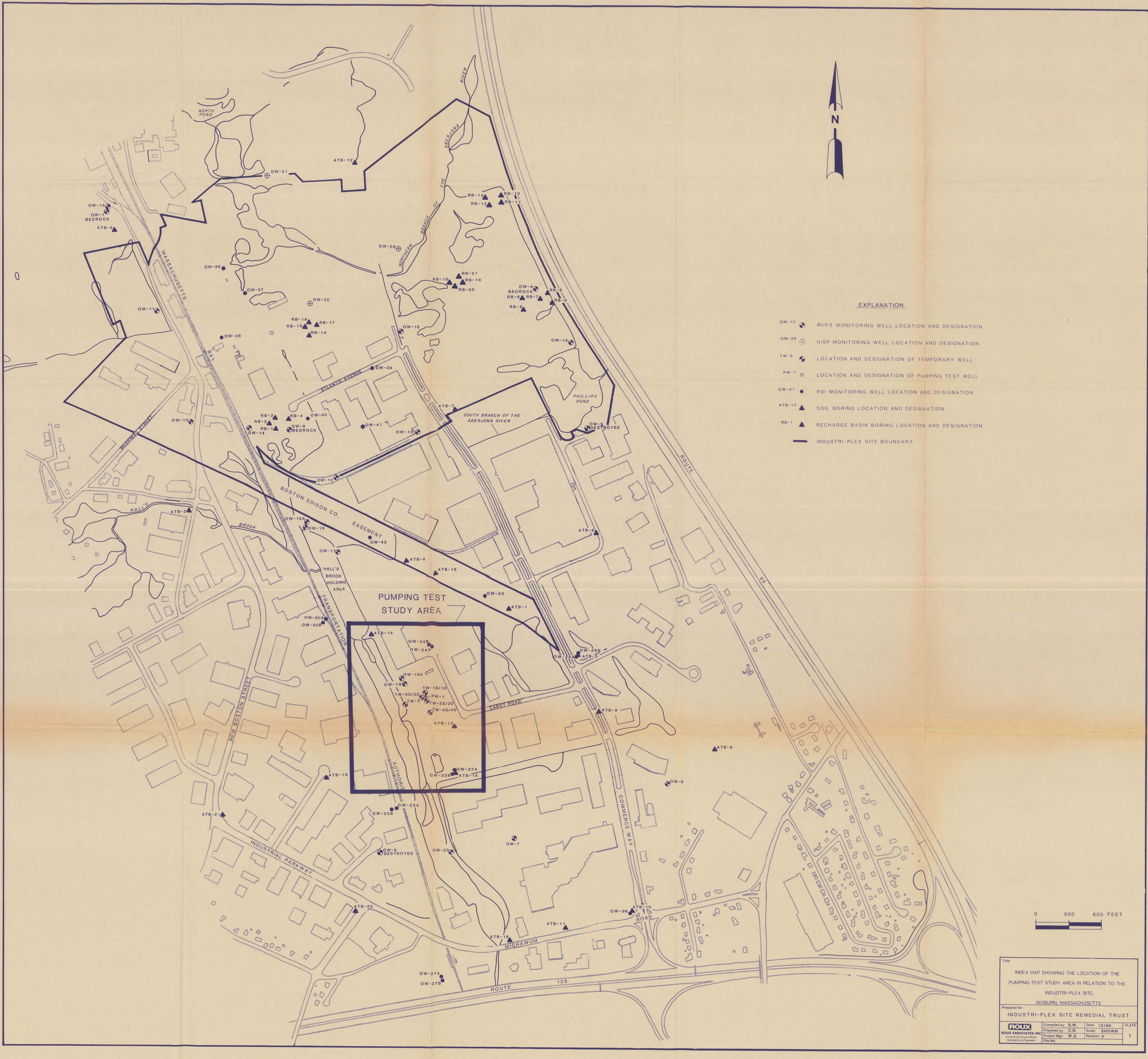
RECHARGE BASIN TEST RAW DATA-PIEZOMETER 4

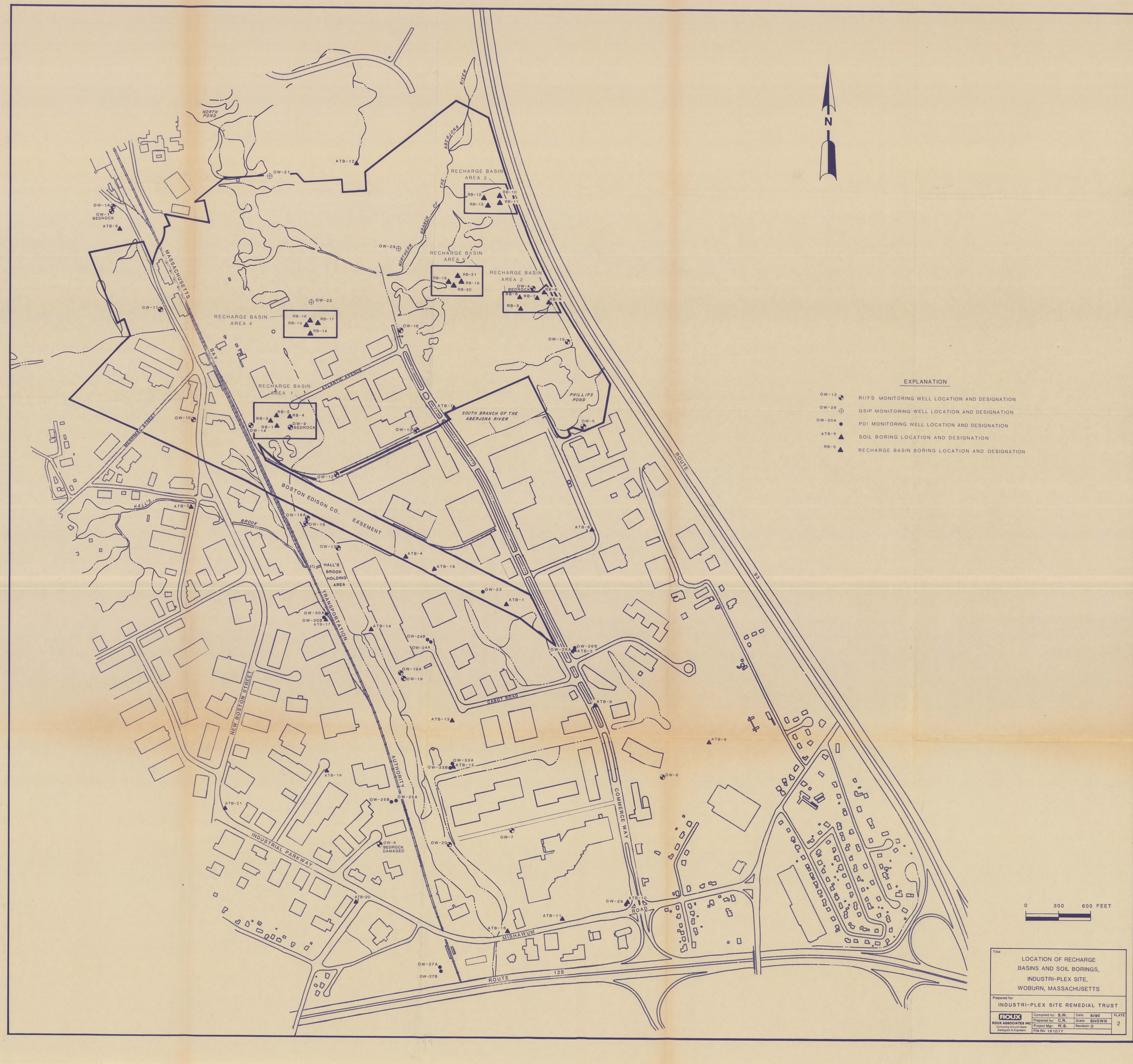
11/07/90	14:02:15	3.45
11/07/90	14:17:15	3.45
11/07/90	14:32:15	3.44
11/07/90	14:47:15	3.45
11/07/90	15:02:15	3.45
11/07/90	15:17:15	3.45
11/07/90	15:32:15	3.45
11/07/90	15:47:15	3.45
11/07/90	16:02:15	3.45
11/07/90	16:17:15	3.45
11/07/90	16:32:15	3.47
11/07/90	16:47:15	3.47
11/07/90	17:02:15	3.47
11/07/90	17:17:15	3.47
11/07/90	17:32:15	3.47
11/07/90	17:47:15	3.47
11/07/90	18:02:15	3.47
11/07/90	18:17:15	3.47
11/07/90	18:32:15	3.48
11/07/90	18:47:15	3.48
11/07/90	19:02:15	3.49
11/07/90	19:17:15	3.49
11/07/90	19:32:15	3.49
11/07/90	19:47:15	3.49
11/07/90	20:02:15	3.5
11/07/90	20:17:15	3.5
11/07/90	20:32:15	3.5
11/07/90	20:47:15	3.5
11/07/90	21:02:15	3.5
11/07/90	21:17:15	3.51
11/07/90	21:32:15	3.51
11/07/90	21:47:15	3.51
11/07/90	22:02:15	3.52
11/07/90	22:17:15	3.52
11/07/90	22:32:15	3.52
11/07/90	22:47:15	3.52
11/07/90	23:02:15	3.52
11/07/90	23:17:15	3.52
11/07/90	23:32:15	3.52
11/07/90	23:47:15	3.52
11/08/90	00:02:15	3.52
11/08/90	00:17:15	3.53
11/08/90	00:32:15	3.53
11/08/90	00:47:15	3.53
11/08/90	01:02:15	3.53
11/08/90	01:17:15	3.53
11/08/90	01:32:15	3.53
11/08/90	01:47:15	3.53
11/08/90	02:02:15	3.53
11/08/90	02:17:15	3.55
11/08/90	02:32:15	3.55
11/08/90	02:47:15	3.55
11/08/90	03:02:15	3.55
11/08/90	03:17:15	3.55
11/08/90	03:32:15	3.55
11/08/90	03:47:15	3.55

RECHARGE BASIN TEST RAW DATA-PIEZOMETER 4

11/08/90	04:02:15	3.56
11/08/90	04:17:15	3.55
11/08/90	04:32:15	3.55
11/08/90	04:47:15	3.52
11/08/90	05:02:15	3.52
11/08/90	05:17:15	3.52
11/08/90	05:32:15	3.52
11/08/90	05:47:15	3.53
11/08/90	06:02:15	3.53
11/08/90	06:17:15	3.53
11/08/90	06:32:15	3.52
11/08/90	06:47:15	3.52
11/08/90	07:02:15	3.52
11/08/90	07:17:15	3.52
11/08/90	07:32:15	3.51
11/08/90	07:47:15	3.5
11/08/90	08:02:15	3.51
11/08/90	08:17:15	3.52
11/08/90	08:32:15	3.48
11/08/90	08:47:15	3.47
11/08/90	09:02:15	3.53
11/08/90	09:17:15	3.51
11/08/90	09:32:15	3.49
11/08/90	09:47:15	3.51
11/08/90	10:02:15	3.53
11/08/90	10:17:15	3.51
11/08/90	10:32:15	3.51
11/08/90	10:47:15	3.53
11/08/90	11:02:15	3.52
11/08/90	11:17:15	3.52
11/08/90	11:32:15	3.53
11/08/90	11:47:15	3.53
11/08/90	12:02:15	3.53
11/08/90	12:17:15	3.55
11/08/90	12:32:15	3.53
11/08/90	12:47:15	3.55
11/08/90	13:02:15	3.55
11/08/90	13:17:15	3.53
11/08/90	13:32:15	3.55
11/08/90	13:47:15	3.53
11/08/90	14:02:15	3.56
11/08/90	14:17:15	3.55
11/08/90	14:32:15	3.55
11/08/90	14:47:15	3.58
11/08/90	15:02:15	3.53
11/08/90	15:17:15	3.5
11/08/90	15:32:15	3.51
11/08/90	15:47:15	3.5
11/08/90	16:02:15	3.5
11/08/90	16:17:15	3.5
11/08/90	16:32:15	3.5
11/08/90	16:47:15	3.51
11/08/90	17:02:15	3.51
11/08/90	17:17:15	3.51
11/08/90	17:32:15	3.51
11/08/90	17:47:15	3.51

PLATES


N
NORTH POND
ABERJONA RIVER
NORTHERN BRANCH OF THE ABERJONA RIVER
PHILLIPS POND
SOUTH BRANCH OF THE ABERJONA RIVER
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
BOSTON EDISON CO. EASEMENT
HALL'S BROOK
HALL'S BROOK HOLDING AREA
MERRIMAC STREET
ATLANTIC AVENUE
NEW BOSTON STREET
INDUSTRIAL PARKWAY
CABOT ROAD
COMMERCE WAY
MISHAWUM ROAD
ROUTE 93
ROUTE 128
PUMPING TEST STUDY AREA
EXPLANATION
OW-13 RI/FS MONITORING WELL LOCATION AND DESIGNATION
OW-28 GISP MONITORING WELL LOCATION AND DESIGNATION
TW-5 LOCATION AND DESIGNATION OF TEMPORARY WELL
PW-1 LOCATION AND DESIGNATION OF PUMPING TEST WELL
OW-41 PDI MONITORING WELL LOCATION AND DESIGNATION
ATB-13 SOIL BORING LOCATION AND DESIGNATION
RB-1 RECHARGE BASIN BORING LOCATION AND DESIGNATION
INDUSTRI-PLEX SITE BOUNDARY
0 300 600 FEET
Title:
INDEX MAP SHOWING THE LOCATION OF THE PUMPING TEST STUDY AREA IN RELATION TO THE INDUSTRI-PLEX SITE, WOBURN, MASSACHUSETTS
Prepared for:
INDUSTRI-PLEX SITE REMEDIAL TRUST
ROUX
ROUX ASSOCIATES INC
Consulting Ground-Water Geologists & Engineers
Compiled by: S.W.
Prepared by: C.R.
Project Mgr: W.S.
File No:
Date: 12/90
Scale: SHOWN
Revision 0
PLATE 1


N
EXPLANATION
OW-13 RI/FS MONITORING WELL LOCATION AND DESIGNATION
OW-28 GSIP MONITORING WELL LOCATION AND DESIGNATION
OW-30A PDI MONITORING WELL LOCATION AND DESIGNATION
ATB-9 SOIL BORING LOCATION AND DESIGNATION
RB-5 RECHARGE BASIN BORING LOCATION AND DESIGNATION
0 300 600 FEET
NORTH POND
NORTHERN BRANCH OF THE ABERJONA RIVER
SOUTH BRANCH OF THE ABERJONA RIVER
PHILLIPS POND
RECHARGE BASIN AREA 1
RECHARGE BASIN AREA 2
RECHARGE BASIN AREA 3
RECHARGE BASIN AREA 4
RECHARGE BASIN AREA 5
HALL'S BROOK HOLDING AREA
HALL'S BROOK
BOSTON EDISON CO. EASEMENT
MASSACHUSETTS BAY TRANSPORTATION AUTHORITY
ATLANTIC AVENUE
MERRIMAC STREET
NEW BOSTON STREET
INDUSTRIAL PARKWAY
CABOT ROAD
COMMERCE WAY
MISHAWUM ROAD
ROUTE 93
ROUTE 128
OW-1A
OW-1 BEDROCK
OW-4 BEDROCK
OW-8 BEDROCK DAMAGED
OW-9 BEDROCK
Title:
LOCATION OF RECHARGE BASINS AND SOIL BORINGS, INDUSTRI-PLEX SITE, WOBURN, MASSACHUSETTS
Prepared for:
INDUSTRI-PLEX SITE REMEDIAL TRUST
ROUX
ROUX ASSOCIATES INC
Consulting Ground-Water Geologists & Engineers
Compiled by: S.W.
Prepared by: C.R.
Project Mgr: W.S.
File No: 16101Y
Date: 8/90
Scale: SHOWN
Revision: 0
PLATE 2