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WORK PLANS

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SITE INVESTIGATION AND REMEDIAL ACTION CONCEPTUAL DESIGN FOR THE BLOOMFIELD REFINING COMPANY

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1.0 EXECUTIVE SUMMARY

In July of 1987, Geoscience Consultants, Ltd. (GCL) was retained by the Bloomfield Refining Company (BRC) to continue a site investigation that was initiated by Engineering-Science (E-S) the previous year. The E-S investigation had identified low level hydrocarbon contamination in ground water collected from 10 monitor wells they had installed at the site. Additionally, E-S executed an electrical resistivity (ER) survey which identified several areas of low ER values that may be related to hydrocarbons in ground water. GCL installed and sampled 2 ground-water monitor wells on Bureau of Land Management (BLM) property south of the refinery. These wells were located in an area of off-site low ER values and were intended to determine whether or not hydrocarbons were present in ground water, and whether or not ground-water contamination could be correlated to the ER survey. Low concentrations of hydrocarbons were confirmed to exist in ground water south of Hammond Ditch in a gravel and sand aquifer that is perched on top of a shale aquitard.

The ultimate objective of GCL's study is to present a remedial action conceptual design that will address existing and potential environmental problems at the site. To accomplish this GCL conducted a pumping test on an existing monitor well while observing water levels in several existing and newly installed monitor wells. The data generated in this pumping test were analyzed and the hydraulic conductivity of the aquifer was estimated to be on the order of 10^{-4} ft/sec. This value, along with other observed and assumed hydraulic parameters, was applied to a computer model that simulated ground-water flow beneath the site. Three scenarios were modelled: unconfined conditions with no recovery wells being pumped; unconfined conditions with a 2-well recovery system; and unconfined conditions with a 3-well recovery system. Results of the modelling determined that a three well recovery system is optimal if the system is to be located entirely on BRC property. If a fourth recovery well becomes necessary, MW-11, located on BLM property to the south of the refinery may be utilized.

Treatment of hydrocarbon contaminated ground water should be effectively achieved with an air stripping unit. A long term pumping test and additional computer modelling will be required to determine the location of the third recovery well, the pumping rate of the recovery wells, and the size of the air stripping unit.

2.0 PREVIOUS WORK

A site investigation was conducted in 1986 by Engineering-Science, Inc., in response to an EPA administrative order issued to Gary Energy Corporation and Bloomfield Refining Company (BRC) pursuant to Section 3013 of the Resource Conservation and Recovery Act. The work included the completion of the following tasks:

- Electrical resistivity (ER) survey
- Installation of ground-water monitor wells
- Ground-water monitor well sampling
- Ground-water monitor well static water level measurements
- Ground-water monitor well slug testing
- Surface water sampling
- Final report

Results of the investigation indicated low levels of hydrocarbons in ground water which probably resulted from past leaks and spills in the western and central sections of the refinery. The ER survey identified areas of anomalously low resistivity values on refinery property, in locations where low concentrations of hydrocarbons and/or indicator parameters were identified by chemical analysis of ground water samples. There was not sufficient data available to relate off-site resistivity "lows" to hydrocarbon contamination in ground water.

3.0 MONITOR WELLS

3.1 GOALS AND OBJECTIVES

The 1986 electrical resistivity survey (ER) conducted by Engineering-Science (E-S) identified three areas of relatively low values (10 to 40 ohm-feet) at the site that may be associated with the presence of hydrocarbons in ground water. Two of these areas are located on refinery property near the evaporation ponds and near the process and refined product storage areas. The third area of anomalously low ER values occurs to the south and west of the refinery on both private and Bureau of Land Management (BLM) land. A ground-water monitoring system was designed and installed by E-S to characterize the extent and magnitude of hydrocarbons in ground water beneath the refinery. Indications of free-floating product were identified in monitor wells located in the western portion of the refinery. The off-site areas that were identified as having potential hydrocarbons in ground water were not included in the monitoring network, therefore, no correlation was established between low ER values and dissolved and/or free-floating hydrocarbons.

In July of 1987, GCL was retained by the Bloomfield Refining Company (BRC) to conduct an investigation at the site to identify potential off-site migration of hydrocarbons and provide a "conceptual" design of a remedial action for the existing and any off-site contamination. Detection of hydrocarbons in ground water was to be accomplished with the installation of 2 monitor wells in the area west and south of the refinery, on BLM property, where low ER values were observed.

3.2 LOCATION OF NEW MONITOR WELLS

Several factors were considered by the Bloomfield Refining Company in the site selection of two new monitor wells: access, potential extent of hydrocarbons in ground water, and proximity to Hammond Ditch. Access to the private land west of the refinery and north of Sullivan Road was unable to be obtained from the property owner; therefore, the off-site monitor wells constrained to locations south of Sullivan Road on BLM property (Plate 3-1).

MW-11 is located south of Sullivan Road and east of Hammond Ditch (Plate 3-1) in an area of low ER values that was previously identified by E-S in their 1986 survey. The purpose of this location is to provide ground-water quality information in an area where hydrocarbons are suspected to be present. The location is upgradient from Hammond Ditch, which may be acting as a hydraulic barrier and preventing further westward migration of hydrocarbons, and downgradient from areas on BRC property where hydrocarbon spills or leak events may have occurred.

MW-12 is located south of Sullivan Road and west of Hammond Ditch (Plate 3-1). This site is downgradient from Hammond Ditch. Analyses of water samples collected from this well should determine whether product has migrated west of the ditch, and substantiate the possibility that Hammond Ditch is acting as a hydraulic barrier to westward migration of contaminants.

3.3 DRILLING METHOD

The two new monitor wells were installed by Beeman Brothers Drilling Co. with an air-rotary casing-driver drill rig. A conventional rotary drill bit was advanced to a selected depth while cuttings were simultaneously blown upward and out of the borehole with compressed air. An in-line air filter assured that hydrocarbons were not introduced into the borehole from the compressor during drilling operations. Analytical results of air samples collected during drilling are compiled in Appendix A.

After the selected depth was reached with the rotary drill bit, steel casing (8 inch diameter) was hammered into the borehole to the same depth as the drill bit, around the drill rods, by a hydraulic casing driver that was attached to the drill rig. This process was repeated until the target depth of each borehole was reached. Samples of the drill cuttings were collected at approximately 5 foot intervals and logged by the on-site geologist. Lithologic logs of MW-11 and 12 are located in Appendix B.

3.4 INSTALLATION AND DESIGN

After the target depth of each borehole was attained, and the temporary casing advanced to within 5 feet of the total depth of the borehole, recovery of ground water was monitored until a static level could be estimated and a total depth for the well casing could be selected. A 4-inch combination stainless steel/PVC monitor well (Figure 3-1) was then installed in the borehole through the temporary steel casing. The filter pack and bentonite seal were inserted into the borehole through the annulus of the temporary casing as it was retrieved from the borehole. The borehole was grouted, above the bentonite seal, with a neat cement slurry with 5% bentonite and a concrete pad was constructed, complete with locking guard pipe. Monitor well completion diagrams and material specifications can be found in Appendix C.

After the grout in the borehole had cured, the well was developed utilizing a 2-inch stainless steel/teflon air ejector pump. The well was pumped until produced water was clear and free of sand. This pump, designed by GCL, does not permit compressed air to contact water in the aquifer. Specifications of this pump are shown in Appendix C.

3.5 SAMPLING AND ANALYSIS

Monitor wells MW-11 and MW-12 were sampled according to strict EPA protocol as outlined in the appropriate Technical Enforcement Guidance Document and in EPA Manual SW-846. All sampling materials and containers were either precleaned by the lab that supplied them, or cleaned with acetone and triple rinsed with distilled water in the field. The wells were purged of 3 casing volumes of water with a stainless steel bailer prior to sampling and all samples were collected with the same bailer that was used for purging.

All sample containers were secured with chain-of-custody seals immediately after collection and stored in an ice chest for delivery to the lab. Sample containers were provided by the lab with measured preservatives where necessary. Strict chain-of-custody procedures were followed in

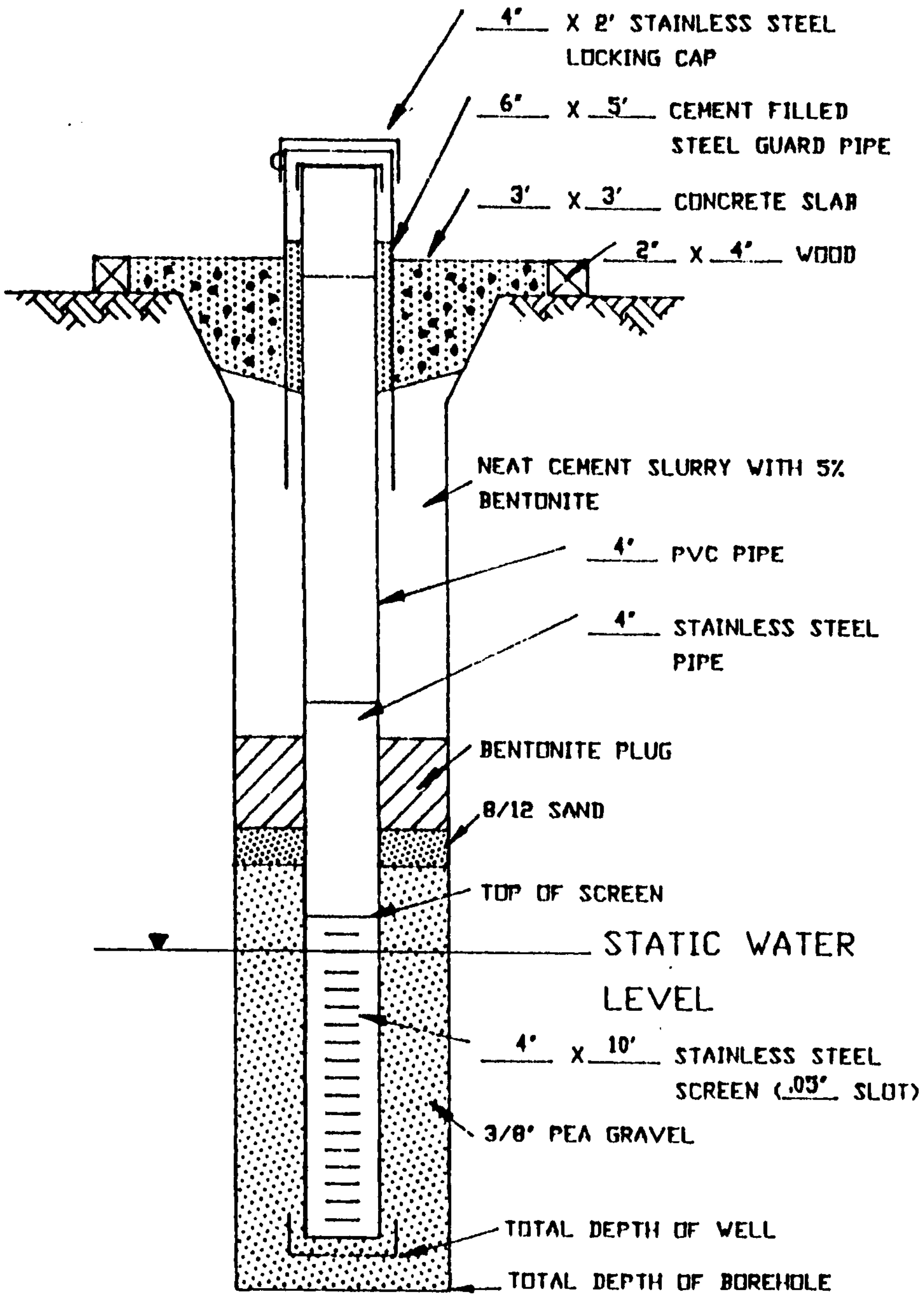


FIGURE 3-1

TYPICAL MONITOR WELL DESIGN

handling the samples and submitting them to Assaigai Analytical Laboratories for analysis.

Duplicate samples were taken from each well and were submitted to Radian Analytical Services for BTEX (benzene, toluene, ethylbenzene, and xylenes) analysis to provide quality assurance/quality control (Appendix A).

4.0 AQUIFER TEST PUMPING

4.1 GOALS AND OBJECTIVES

Although the overall objectives of the project involve the assessment of existing and potential contamination, the specific purpose of the test pumping is to characterize the hydraulic properties of the affected aquifer so that a recovery system can be designed. Determination of the transmissive properties of the sand and gravel aquifer underlying the site will help define directions and rates of ground-water flow and advective movement of dissolved hydrocarbons through the ground-water flow system. These properties can be uniquely identified through application of controlled pumping stresses within the saturated sand and gravel unit and measurement of drawdown response.

With respect to the first objective of plume definition, results of test pumping will be used to provide an adequate data base for numerical simulation of ground-water and product migration, which will eventually be used to estimate current plume geometry and determine optimal placement of future monitoring and observation wells. Results of test pumping will also permit fulfillment of the second major project goal through definition of the characteristics of the primary product migration pathway through the saturated unconsolidated aquifer and estimation of product migration rates.

4.1.1 Definition of the Extent of Contamination

The vertical and lateral extent of hydrocarbon in ground water beneath the facility has been determined through direct and indirect means. Ground water monitoring wells have been placed at strategic locations inside and outside of the estimated plume. Selection of locations of the wells were based upon three sources of data:

- The geometry of the plume as it is presently defined by existing monitoring wells.
- The distribution of low ER values as evidenced by the electrical resistivity survey, if the survey results are supported by hydrocarbon data observed at existing monitoring wells.

- The geology of the site as observed during borehole logging.

During the initial phase of the well installation program, these data sources were used in determining well locations. Numerical modeling, in concert with other sources, will be implemented during selection of additional well locations. Test pumping is required to provide an adequate data base for the numerical simulation.

4.1.2 Characterization of Product Migration Pathway

A sand and gravel unit, that was identified during drilling activities by GCL and E-S, acts as a primary pathway for product migration through the subsurface underlying the site. Aquifer test results provided data required to evaluate the hydraulic properties of this potential primary migration pathway, and will be used to judge the effectiveness of this pathway in transmitting potential hydrocarbons. Once the hydraulic characteristics of the flow system in the sand and gravel have been determined, rates of product migration can be calculated utilizing observed and predicted hydraulic head distributions.

4.2 TEST DESIGN

The design of the aquifer test was performed in accordance with the <u>GCL Standard Operating Procedure for Aquifer Test Pumping</u> presented in Appendix D.

4.2.1 Well Configuration

Selection of the pumping well and observation wells was based on the proposed recovery strategy and on expected aquifer properties. The proposed hydrocarbon recovery well MW-10 shown in Plate 3-1 was chosen as the pump well because of its large diameter and large anticipated yield. Use of the product recovery well as the aquifer test pump well also permitted the impacts of recovery and the overall efficiency of recovery operations in the process area to be assessed.

Due to the prevalence of unconfined conditions in the subsurface, slow propagation of pumping stresses over small distances was anticipated.

Moreover, the moderate average hydraulic conductivity of 2.08 X 10^{-4} ft/sec estimated from previous slug test results performed by Engineering Science suggested that pumping stresses would not be readily transmitted through the sand and gravel sediments over large distances. Preliminary calculations based on the Theis equation indicated that well MW-4, the well located closest to well MW-10 within the sand and gravel sediments and shown in Plate 3-1, would not exhibit a measurable drawdown of 0.01 feet under anticipated test conditions until more than 21 days of pumping had been conducted. A summary of these calculations, which were based on the hydraulic conductivity of 1.29 X 10^{-4} ft/sec observed during performance of a slug test at well MW-4, is presented in Appendix E. Although significant drawdown was not expected to occur at well MW-4 or any other well during the planned shorter-duration test, well MW-4 was specified as an observation well in the event that actual test conditions generated larger-than-anticipated drawdown.

Other wells at which drawdown was monitored included wells MW-11 and MW-12, which are both located farther from well MW-10 than well MW-4 (see Plate 3-1). However, as for the case with well MW-4, little or no drawdown response was anticipated at these wells, particularly in well MW-12 located on the opposite side of Hammond Ditch. For the case of well MW-12, the high stage of water flowing in Hammond Ditch during testing was expected to preclude transmittal of significant pumping stresses to the well.

4.2.2 Sustainable Well Discharge

Since well losses at well MW-10 were not known, it was not possible to estimate the rate of discharge that would induce the greatest amount of drawdown at the well without dewatering the sand and gravel. However, based on the value of conductivity determined at well MW-4 from previous slug test analysis and an estimate of the specific yield of the coarse-grained aquifer, a maximum discharge rate was identified. This sustainable rate would be equal to the rate which would completely dewater the sand and gravel where it is penetrated by the pump well. Since well losses would tend to decrease the water level in the well below that anticipated from the actual pumping rate, the sustainable rate would represent the maximum possible discharge rate that could be maintained in the sand and gravel aquifer.

The well-completion diagram presented in Figure 4-1 shows that the initial saturated thickness of the sand and gravel layer screened by the pump well MW-10 was equal to 5.7 feet. Assuming a maximum drawdown equal to the initial saturated thickness of the sand and gravel unit penetrated and screened by the pump well, a conductivity equal to that observed at well MW-4 during slug testing, a maximum specific yield of 0.20, and an effective borehole radius of 6 inches, the maximum sustainable discharge was determined using the Theis equation. Based on 1 day of pumping, the maximum sustainable discharge rate was determined to be 3.0 gpm, as indicated by calculations summarized in Appendix E. Thus, up to 3.0 gpm could theoretically be pumped from the well for a duration of 1 day without dewatering the sand and gravel layer. A larger discharge level could be sustained over a shorter period. In practice, the maximum rate of sustainable discharge would be less than 3.0 gpm due to well losses that produce greater-than-anticipated drawdown. Based on the sustainable discharge observed during development of well MW-11 of 0.8 gpm, it was predicted that between 0.8 and 3.0 gpm of pumping could be sustained at well MW-10 without causing dewatering of the sand and gravel interval.

4.2.3 Test Duration

Due to the presence of unconfined flow conditions and the large distance to the closest drawdown observation well, a long-duration test was considered desirable. Based on the hydraulic conductivity estimated at well MW-4 from slug test results, an average discharge rate of 2 gpm, and a minimum specific yield of 0.10, it was determined that at least 21 days of pumping would be required at well MW-10 in order to observe a measur-

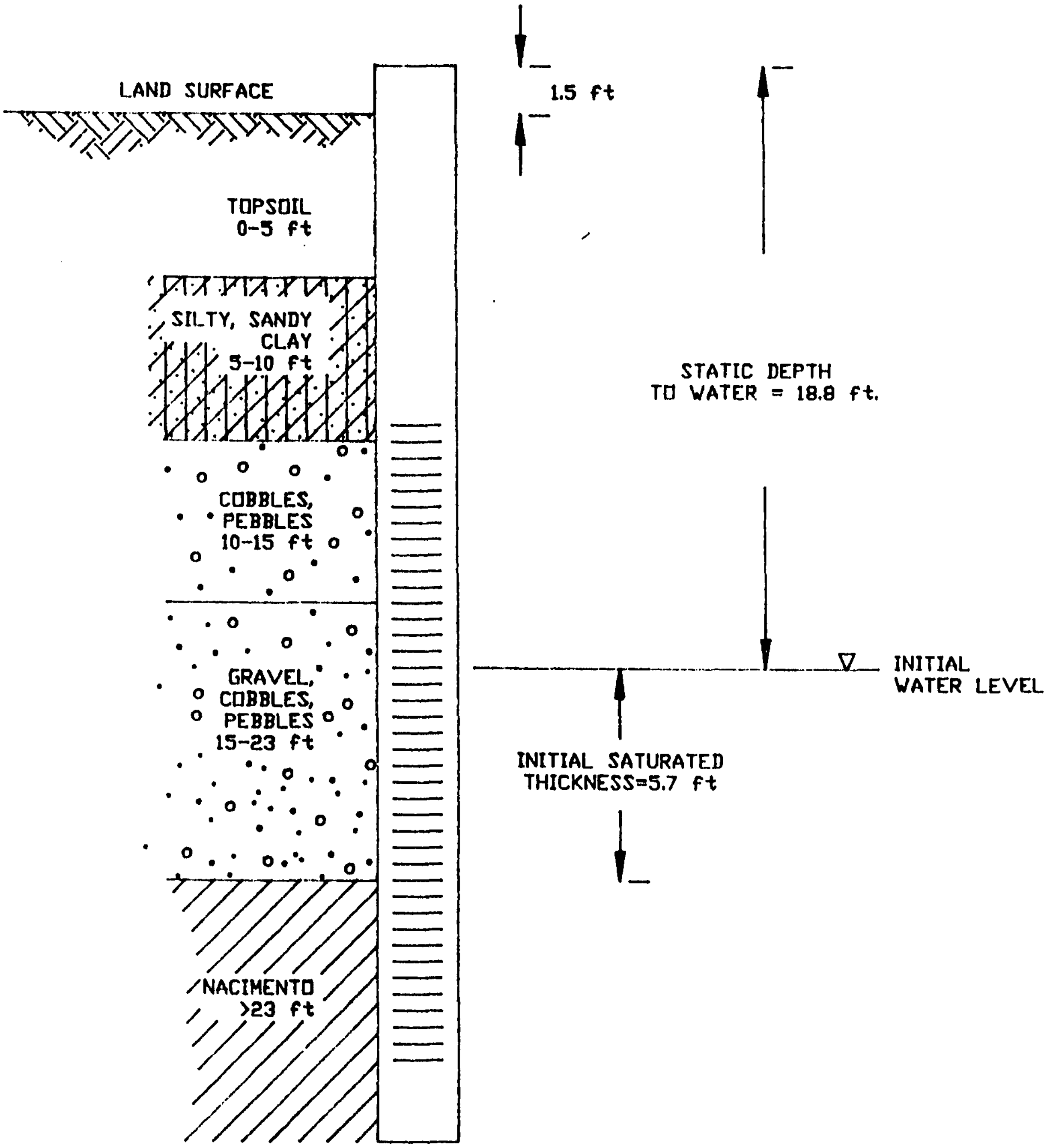


FIGURE 4-1

WELL COMPLETION DIAGRAM
WELL #MW-10

(From E-S, 1986)

able drawdown response equal to 0.01 feet in well MW-4. Calculations used in defining this minimum test duration are presented in Appendix E.

From the standpoint of discharge-water storage, such a long-duration test was considered impractical. Instead, a shorter-duration test was planned during which measurable drawdown response in only the pump well was anticipated. Although the observed drawdown at the pump well would permit analysis for aquifer transmissivity, it would not lend itself to analysis for specific yield. Test duration was specified to be equal to the time after initiation of pumpage at which the water level in the pump well dropped below the top of the Nacimiento Formation underlying the sand and gravel unit. Since the impact of well losses could not be predicted, the test duration was identified during the actual pump test.

4.2.4 Storage of Discharge Water

Assuming a maximum test duration of 1 day and a maximum discharge rate of 3.0 gpm, it was estimated that over 4,000 gallons might be generated in the course of a one-day aquifer test. A 1000-gallon stock tank was expected to provide adequate storage of discharge water if emptied at intervals of at least 5 1/2 hours, depending on the actual rate of discharge.

4.3 TEST IMPLEMENTATION

Implementation of aquifer testing was performed in accordance with the GCL Standard Operating Procedure for Aquifer Test Pumping presented in Appendix D. Due to problems associated with surging of the pump during an initial test at well MW-10, a second test was performed at this well the following day to verify results. The first pump and recovery tests at well MW-10 will be referred to as pump test #1 and recovery test #1, with the second tests referred to as pump and recovery tests #2. A previous recovery test performed at well MW-11 during development was also used to characterize the average transmissive properties of the unconsolidated unit.

4.3.1 Pump Installation

The intake of a Grundfos 4-inch submersible pump was set at a depth of 28 feet from the top of casing prior to aquifer testing, with the water level in the pump well allowed to equilibrate after the pump displaced water in the casing. The pump discharge line was connected to an Aqua Matic flow cell capable of accurately measuring discharges in the range of 2 to 11 gpm. Discharge through the flow cell was directed into a 1000-gallon stock tank placed next to the pump well where it was stored until tank capacity was attained, after which a vacuum truck was used to drain it.

4.3.2 Transducer Installation

An Enviro-Labs EL-200 Groundwater Monitoring System with a DL-120-MCP data logger was used to monitor and record the head of water in the MW-10 borehole. A transducer was connected to channel 6 of the data logger and suspended slightly above the bottom of well MW-10. As mentioned in Section 4.2.1, no changes in hydraulic head were expected in any other wells during the aquifer test. However, a transducer connected to channel 2 of the data logger was placed at the bottom of well MW-4 in the event that measurable drawdown occurred in that well. In both cases, water levels were allowed to equilibrate after water was displaced by the transducers.

4.3.3 Drawdown Monitoring Schedule

The drawdown monitoring schedule was based on the schedule outlined in the GCL Standard Operating Procedure for Aquifer Test Pumping. During early pumping or recovery times, the time between observations was specified to be very small, with time between observations progressively increased during later testing phases when the rate of change in water level decreased.

4.4 TEST RESULTS

Data collected by the transducers were extracted from the logger and stored on a hard disk drive. These data, which represented the height of water above the transducer, were input to a computer program that generated elapsed time and drawdown for each transducer reading. Time and drawdown data observed at the pump well were subsequently plotted on double-log and semi-log paper for analysis of transmissivity.

4.4.1 Pump Test Drawdown Data

Appendices F and G list the raw transducer data collected during the two pump tests performed at monitoring well MW-10. The head of water overlying the transducer installed in well MW-10 was recorded using channel 6, while water head associated with monitoring well MW-4 was recorded using channel 2. Data generated from the pump tests indicate that changes in the head of water overlying the transducer installed in well MW-4 were immeasurable.

Appendices H and I list time and drawdown data for the two pump tests calculated on the basis of the raw transducer data for well MW-10, the only well in which a hydraulic response was observed. Figures 4-2 and 4-3 show double-log plots of the data up to the time when the drawdown, uncorrected for unconfined conditions, became equal to the initial saturated thickness of the unconsolidated sediments. After this time, observed drawdown response became characteristic of the underlying Nacimiento Formation and was not incorporated into the plot. In the case of pump test #1, discharge was increased significantly at 80 minutes, resulting in an uncorrected drawdown of greater than 5.7 feet.

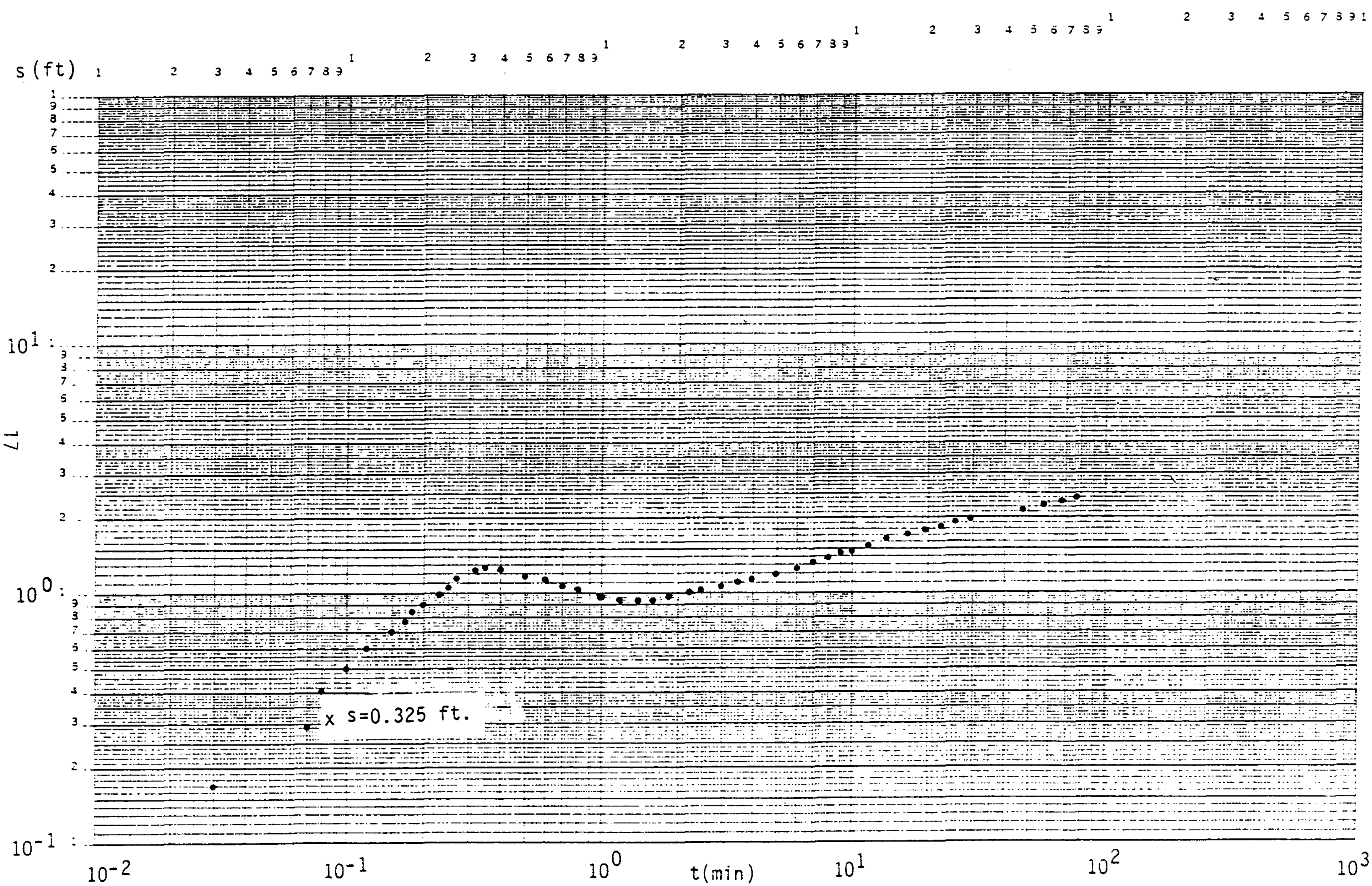


FIGURE 4-2
,DRAWDOWN VS. TIME FOR PUMP TEST #1 AT WELL MW-10

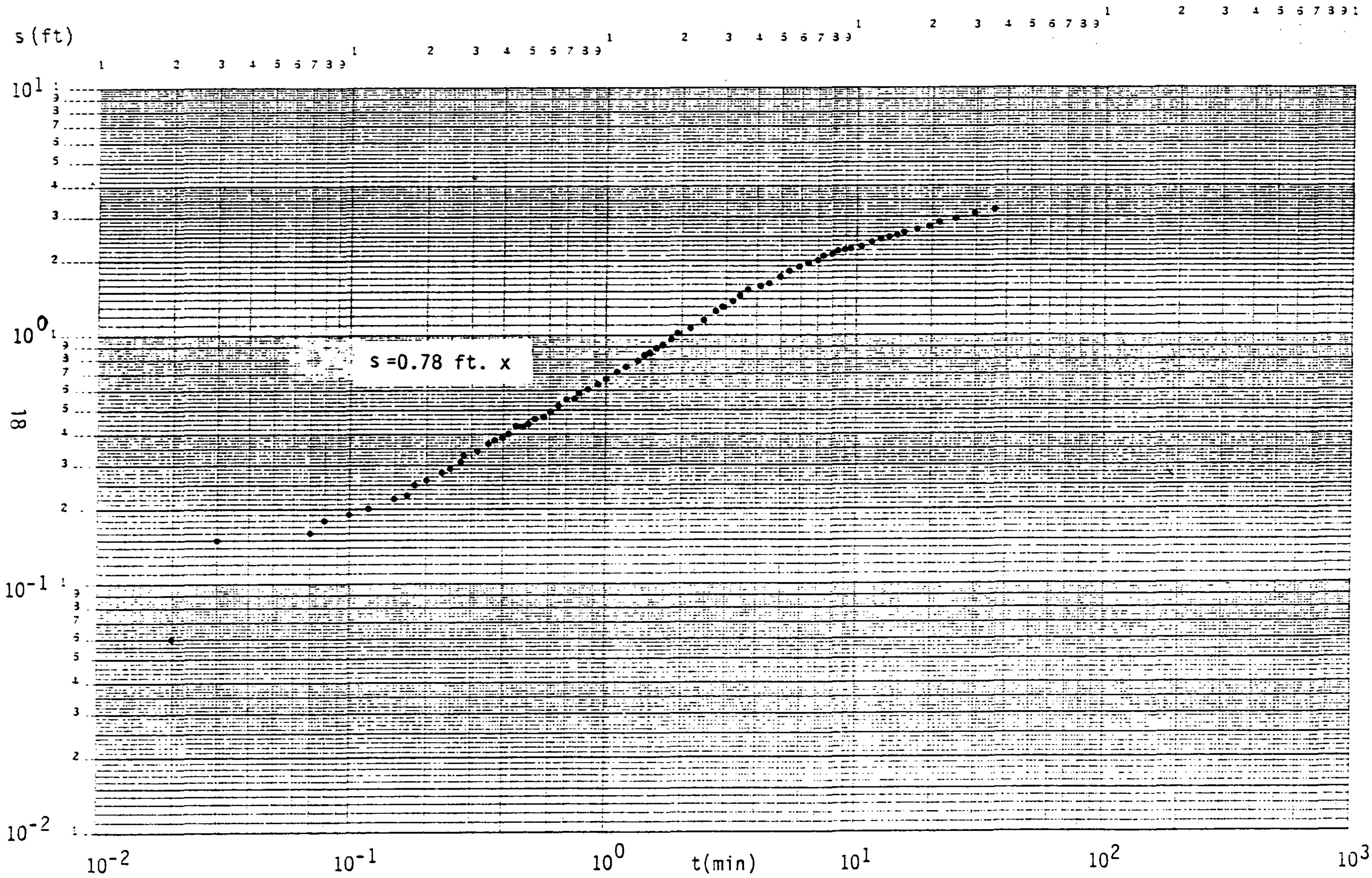


FIGURE 4-3
DRAWDOWN VS. TIME FOR PUMP TEST #2 AT WELL MW-10

Corrections for unconfined flow were performed according to the Jacob relation (1949):

$$s' = s - \frac{s^2}{2b}$$

where s' = drawdown in an equivalent confined unit under conditions of constant transmissivity (ft)

s = drawdown in the unconfined unit (ft)

b = initial saturated thickness (ft)

These corrections were automatically performed during execution of the computer program.

Figure 4-3 suggests that surging of the pump occurred during the first minute of pump test #1, after which discharge became equilibrated and was maintained at a constant rate. Data observed after 1 1/2 minutes conformed closely to the Theis type curve, indicating that the existence of recharge boundaries such as Hammond Ditch, interception of low-conductivity clay lenses, or the development of delayed yield conditions did not affect test results during the short test duration. It is likely that recharge from the downgradient ditch would reduce drawdown below that predicted by the Theis equation over long periods of pumping, during which the cone of depression would be expected to extend to the ditch.

Figure 4-3 indicates that the problem of variable discharge during early parts of the second test was not as significant as it was during the first test. Again, the drawdown vs. time data prior to the time at which uncorrected drawdown became equal to the initial saturated thickness of the unconsolidated sand and gravel deposits conformed closely to Theis behavior, indicating the absence of non-ideal influences due to the Hammond Ditch, low-conductivity clay lenses, or delayed yield effects.

4.4.2 Recovery Test Drawdown Data

Appendices J and K list the raw transducer data collected during the two recovery tests performed at monitoring well MW-10. The head of water overlying the transducers installed in wells MW-10 and MW-4 were recorded using channels 6 and 2, respectively. Since immeasurable drawdown was observed in well MW-4 during pumping, no recovery was observed at this well.

Appendices L and M list time ratio and drawdown data for the two recovery tests calculated on the basis of the raw transducer data for well MW-10, the only well in which recovery was observed. Semi-log plots of these data, observed after uncorrected drawdown increased to the initial saturated thickness of the sand and gravel unit, are shown in Figures 4-4 and 4-5.

Data observed during an additional recovery test performed at well MW-11 are shown in Appendix N, and the resulting semi-log plot is presented in Figure 4-6. Since the water level in well MW-11 did not decrease to a level below the Nacimiento Formation, all data was included in the plot for later analysis.

4.5 TEST ANALYSIS

Double-log plots of pump test drawdown vs. time data and semi-log plots of recovery test drawdown vs. time data suggested that the hydraulic response of the sand and gravel unit closely conformed to the ideal aquifer response, with no indication of boundary effects or delayed yield influences on the observed response. Due to the ideal response of the sand and gravel unit, conventional Theis analysis was used to estimate the transmissivity of this unit from pump-test results. Straight-line Jacob analysis was used to estimate transmissivity from recovery-test data. Since only drawdown data observed at the pump well were available, specific yield could not be estimated due to distorting borehole storage influences in well MW-10.

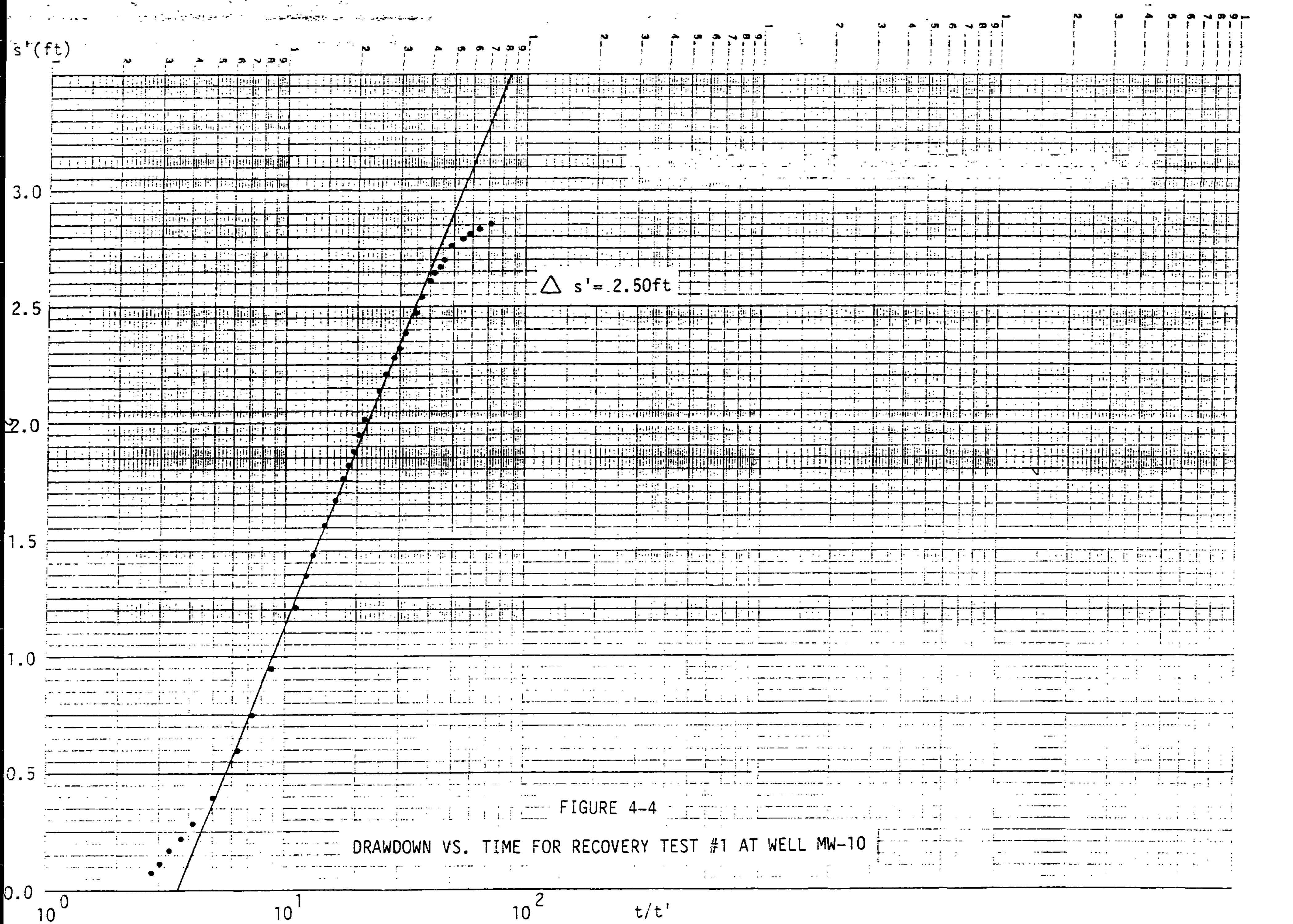


FIGURE 4-4

DRAWDOWN VS. TIME FOR RECOVERY TEST #1 AT WELL MW-10

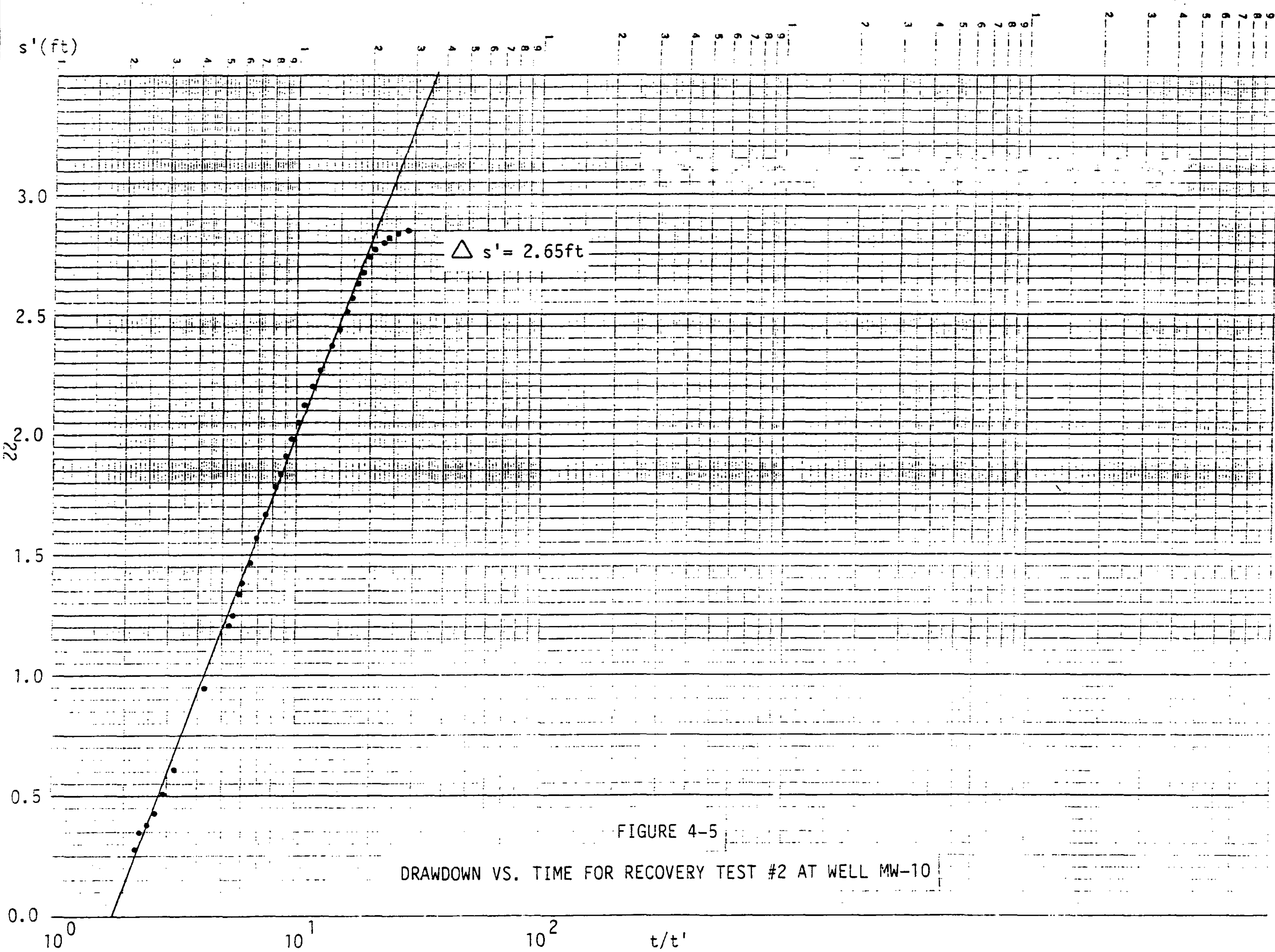


FIGURE 4-5

DRAWDOWN VS. TIME FOR RECOVERY TEST #2 AT WELL MW-10

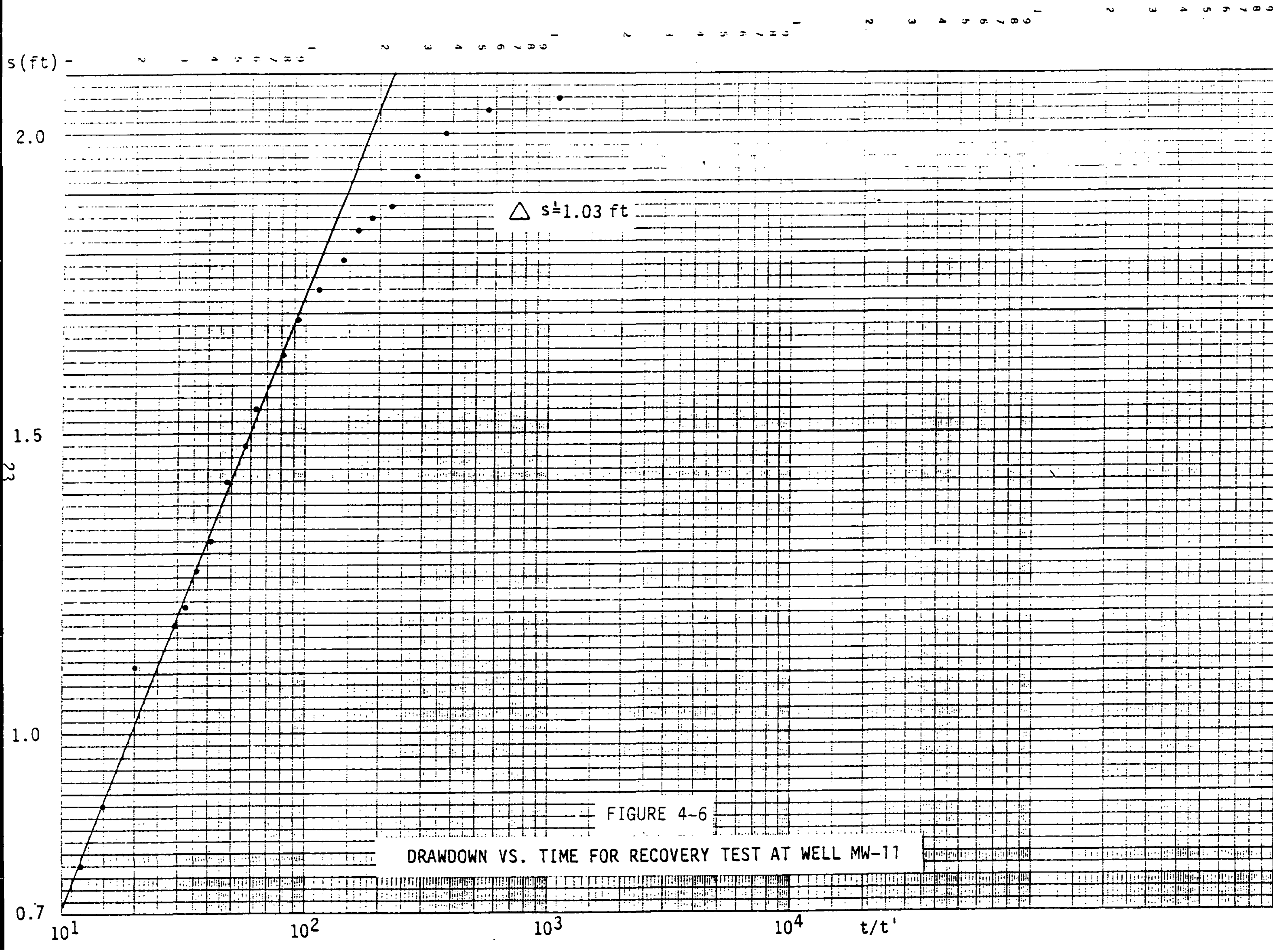


FIGURE 4-6

DRAWDOWN VS. TIME FOR RECOVERY TEST AT WELL MW-11

4.5.1 Pump Test Drawdown Data

Double-log plots of the pump-test data presented in Figures 4-2 and 4-3 were used to estimate the transmissivity and hydraulic conductivity of the sand and gravel layer. As indicated in Figure 4-2 and 4-3, data observed during the first minute of pumping reflected dewatering of the well casing and surrounding borehole, which caused excessive drawdown at early times. These data points were not included in the analysis. When match points of u=1 and W(u)=1 were selected, match-point drawdown for pump test #1 was estimated as 0.325 feet and match-point drawdown for pump test #2 was estimated as 0.78 feet. Using average discharge rates of 1.3 gpm and 2 gpm for the two tests, transmissivities of 4.16×10^{-2} and 2.73×10^{-2} ft^2/min were calculated on the basis of the two sets of data. Appendix E includes a summary of these calculations.

In order to define hydraulic conductivity from estimated transmissivity values, the average saturated thickness of the sand and gravel unit was determined. Since the saturated thickness of the sand and gravel unit decreased throughout each test, an average saturated thickness was estimated for each test by summing each drawdown observation over the time interval with which it was associated and dividing by the total time. These calculations were performed by the computer program. Only those drawdowns less than or equal to 5.7 feet, the initial saturated thickness of the sand and gravel unit, were included in the time-weighted averaging procedure. Average saturated thickness during pumping of the sand and gravel unit was determined by subtracting average drawdown from the initial saturated thickness of 5.7 feet.

Average drawdown for each test was estimated to be 2.59 and 3.36 feet for pump test #1 and #2, which involved average discharges from the sand and gravel unit of 1.3 and 2.0 gpm, respectively. Using average saturated thicknesses of 3.11 and 2.34 feet and estimated transmissivities of 4.16×10^{-2} and 2.73×10^{-2} ft^2/min, hydraulic conductivities of 2.23×10^{-4} and 1.95×10^{-4} ft/sec were calculated. The average conductivity of 2.09×10^{-4} ft/sec closely agrees with the sand and gravel conductivity of 1.29×10^{-4} ft/sec estimated on the basis of a slug test performed by Engineering Science in well MW-4 located near the pump test site. These values of hydraulic conductivity correspond to conductivities observed in silty-to-clean sands (Freeze and Cherry, 1979).

Assuming that most of the pumped water was transmitted through the saturated sand and gravel layer rather than the underlying Nacimiento Formation, the specific capacity of the well can be calculated for different flow rates and compared in order to assess the impact of well losses on drawdown response in the pump well. Specific capacity of the well during pump test #1 was estimated using average drawdown and discharge as follows:

$$(s/Q)_1 = \frac{2.59 \text{ ft}}{1.3 \text{ gpm}} = 2 \text{ ft/gpm}$$

Specific capacity of the well during pump test #2 was calculated as:

$$(s/Q)_2 = \frac{3.36 \text{ ft}}{2.0 \text{ gpm}} = 1.7 \text{ ft/gpm}$$

Maintenance of a roughly constant specific capacity at different discharge rates is an indication that well losses at the pump well were insignificant. Otherwise, increasingly turbulent flow effects would have become dominant at a higher rate of discharge, resulting in loss of usable energy and a larger specific capacity at a higher discharge rate. In general, losses at contaminant recovery wells should be minimized because they tend to cause a steep, localized cone of depression that would not efficiently capture free and dissolved hydrocarbons over a wide area and would generate a large amount of ground water requiring treatment.

4.5.2 Recovery Test Drawdown Data

Semi-log plots of the recovery-test data obtained at well MW-10 and presented in Figures 4-4 and 4-5 were used to obtain additional estimates of the transmissivity and hydraulic conductivity of the sand and gravel layer. Straight-line slopes of 2.50 ft and 2.65 feet per time log cycle were defined for the two semi-log plots of drawdown vs. time. Using discharge rates of 1.3 gpm and 2.0 gpm, respectively, transmissivities of 1.25×10^{-2} ft^2/min and 1.87×10^{-2} ft^2/min were estimated. Appendix E includes summaries of these calculations.

Based on time-weighted average drawdowns of 1.06 and 0.71 feet estimated from the two sets of recovery drawdown data, average saturated thicknesses of 4.64 and 4.99 feet were used to determine hydraulic conductivities of 4.49×10^{-5} and 6.25×10^{-5} ft/sec. The average conductivity of 5.37×10^{-5} ft/sec was almost an order of magnitude smaller than the slug-test conductivity associated with the sand and gravel unit at well MW-4 and the conductivity calculated according to pump test results. The fact that the plots of drawdown versus t/t′ intersected the t/t′ axis at values well above 1 suggested that storativity during recovery is less than during pumping. Otherwise the time required to recover all pumped water would equal the time required to pump it, with t=t′. A decrease in S during recovery occurs commonly in materials containing silt because the aquifer material does not rebound completely during recovery and because air-entrance capillary forces are large and difficult to overcome during re-saturation. These phenomena may explain why hydraulic conductivity during recovery is significantly smaller than during pumping at well MW-10. Since the efficiency of recovery operations will depend on aquifer characteristics that prevail in response to pumping, hydraulic conductivities estimated from recovery data under conditions of variable storativity near well MW-10 probably do not accurately reflect the transmissive properties that would affect product recovery at well MW-10.

Data collected during the recovery test performed at well MW-11 are shown plotted in Figure 4-6 on semi-log paper. In the absence of evidence for non-ideal behavior during the pump tests, it was assumed that ideal behavior also occurred during recovery and that use of a conventional Jacob straight-line analysis would be justified. Using a straight-line slope of 1.03 feet per time log cycle and an average discharge rate of 0.79 gpm, a transmissivity of 1.88×10^{-2} ft^2/min was estimated. On the basis of a calculated average drawdown equal to 1.34 feet, a hydraulic conductivity of 2.34 X 10^{-4} ft/sec was determined. The calculations are presented in Appendix E.

Table 4-1 lists the hydraulic conductivities associated with the two pumping and two recovery tests at well MW-10, the recovery test at well MW-11, and slug tests at wells MW-1, MW-2 and MW-4 performed within the sand and gravel interval. With the exception of conductivities estimated from recovery well data, which may be influenced by variable storativity, the calculated hydraulic conductivities were on the order of 10^{-4} ft/sec. The uniformity of hydraulic conductivity between wells suggests that the saturated sand and gravel deposits overlying the Nacimiento Formation are remarkably homogeneous over the site. Uniformity of hydraulic conductivity between slug and aquifer testing, which involve different testing scales, also implies homogeneity of the sand and gravel deposits underlying the site. Although the largest conductivities occurred in the central and southern areas of the site, point data relating to conductivity are not sufficient to justify the delineation of subsurface geologic trends. The largest conductivity was defined on the basis of slug test analysis at well MW-2, where small hydraulic gradients tend to occur in the sand and gravel unit as evidenced by water table maps.

An average hydraulic conductivity calculated on the basis of all data except the recovery data at well MW-10 was estimated to be 2.13 X 10^{-4} ft/sec. This conductivity can be used to characterize the overall transmissive properties of the sand and gravel aquifer underlying the site during recovery operations in locations where conductivity has not been specifically identified.

TABLE 4-1

HYDRAULIC CONDUCTIVITIES ESTIMATED USING PUMP-TEST AND RECOVERY-TEST DATA

Well	Type of Test	Test Number	Hydraulic Conductivity (K) (ft/sec)
MW-10	Pump	1	2.23×10^{-4}
	Pump	2	1.95×10^{-4}
	Recovery	1	4.49×10^{-5}
	Recovery	2	6.25×10^{-5}
MW-11	Recovery	-	2.34×10^{-4}
MW-1	Slug	-	1.65×10^{-4}
MW-2	Slug	-	3.30×10^{-4}
MW-4	Slug	-	1.29×10^{-4}

5.0 COMPUTER MODELING

5.1 GOALS AND OBJECTIVES

The goals of computer modelling include identification of optimal monitoring well locations in areas where current data is not adequate, as well as characterization of the transmissive properties of the unconsolidated aquifer. In response to these goals, preliminary ground water flow modeling has been performed in an effort to characterize the transport processes that control subsurface movement of dissolved hydrocarbons in the saturated sand and gravel unit beneath the Bloomfield Refinery site. Assuming that advective transport of dissolved hydrocarbons dominates dispersive and diffusive mechanisms of transport, a conceptual ground-water flow model formulated on the basis of observed aquifer characteristics and hydrogeologic conditions can provide a reliable means of predicting the long-term response of the sand and gravel aquifer to a proposed recovery strategy. The preliminary model was formulated on the basis of the average hydraulic conductivity estimated from pump, recovery, and slug tests and according to boundary conditions assumed to prevail along Hammond Ditch, the raw water ponds, and the evaporation ponds. The resulting model was used to develop a conceptual design for remedial action of the sand and gravel aquifer underlying the site and can be used to perform a sensitivity analysis for identification of locations where additional data is needed to more accurately define aquifer behavior.

5.2 SELECTION OF A GROUND-WATER FLOW ALGORITHM

Finite-difference ground-water flow algorithms currently available on the GCL IBM and Compaq network system include the two-dimensional Prickett and Lonnquist Aquifer Simulation Model (PLASM) and the modular, three-dimensional U.S. Geological Survey Ground-Water Flow Model (Prickett and Lonnquist, 1984; McDonald and Harbough, 1984).

A primary factor in model selection was suitability for simulating observed field conditions. Although vertical flow components have been observed between the sand and gravel unit and the underlying Nacimiento

Formation, the large thickness and small hydraulic conductivity associated with the Nacimiento clay would preclude the vertical movement of significant amounts of water and dissolved-phase hydrocarbons out of the overlying sand and gravel layer. Thus, the two-dimensional PLASM algorithm would appear to be more suitable for simulation of horizontal flow in the sand and gravel. Moreover, the PLASM code includes a solute-transport component that can be used, in conjunction with ground-water seepage velocities predicted by the flow component, to automatically simulate migration of dissolved hydrocarbons during recovery in response to the changing velocity field and variable hydrodynamic dispersion processes. Although beyond the scope of the current hydrogeological investigation, prediction of contaminant transport was considered to be of future interest.

5.3 DEFINITION OF FINITE-DIFFERENCE GRID

Design of a finite-difference grid accounted for characteristics of the flow field and the boundaries of the flow domain discussed previously. The finite-difference grid shown in Plate 5-1 was extended to the San Juan River escarpment for possible future simulation of ground-water flow conditions during the non-irrigation period, when Hammond Ditch is dry and ground water tends to discharge to a seepage face along the escarpment. The grid was oriented along flowlines and equipotential lines characteristic of the overall flow field during both high-stage and low-stage conditions in the ditch. Spacings between columns and rows were reduced in the vicinity of proposed recovery wells south of the process area and on the western edge of the storage area, where steep hydraulic gradients were anticipated during predictive stages of the modeling effort.

5.4 DEFINITION OF BOUNDARY CONDITIONS

Figures 5-1 and 5-2 show the distribution of hydraulic head in the unconfined sand and gravel aquifer when water stage in Hammond Ditch is at a minimum and maximum, respectively, as indicated by data collected during March 26, 1986 and September 2, 1986. As Figures 5-1 and 5-2

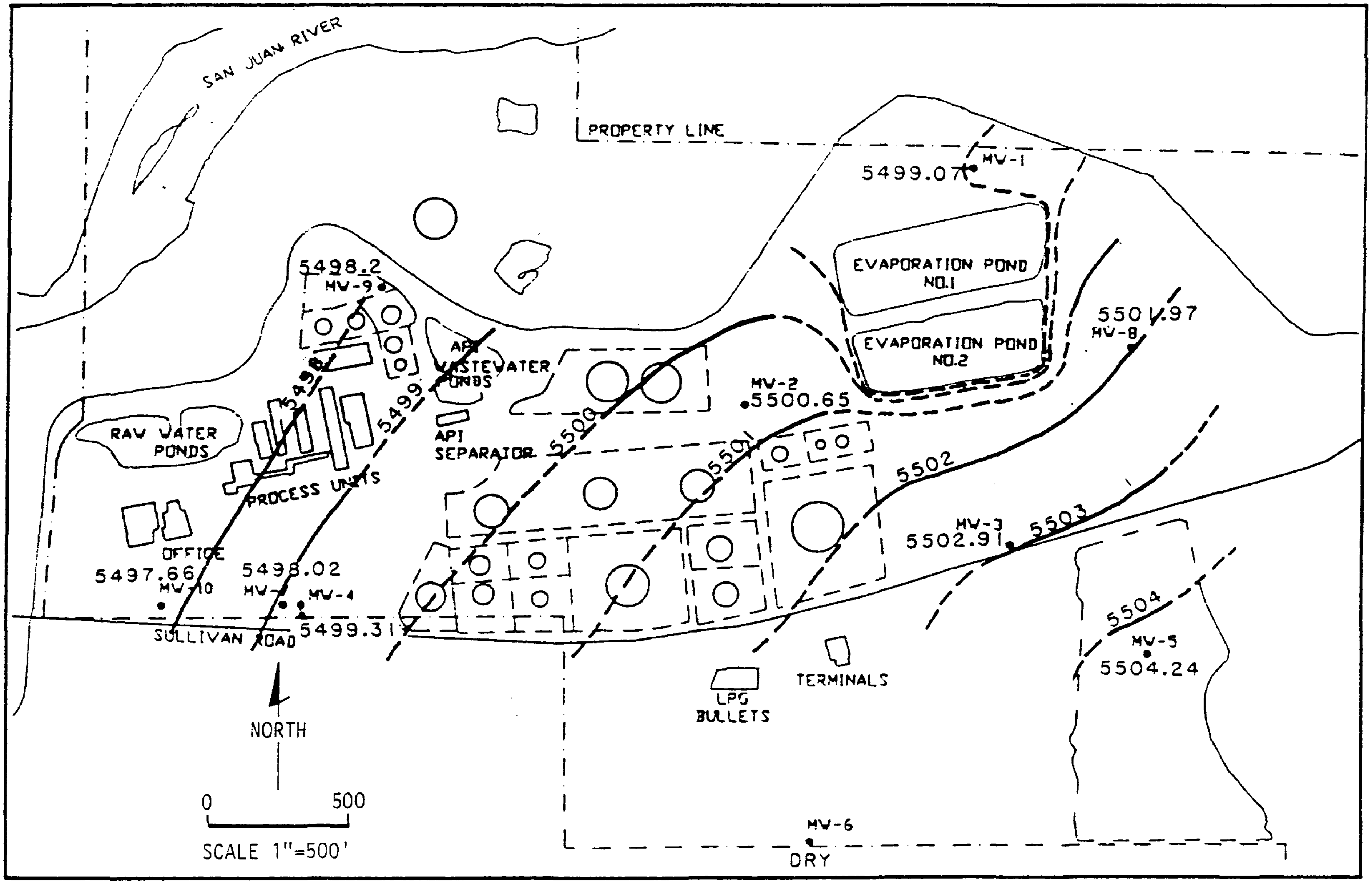


FIGURE 5-1
HYDRAULIC HEAD DISTRIBUTION IN UNCONFINED AQUIFER ON MARCH 26, 1986
(Adapted from Engineering Science, 1986)

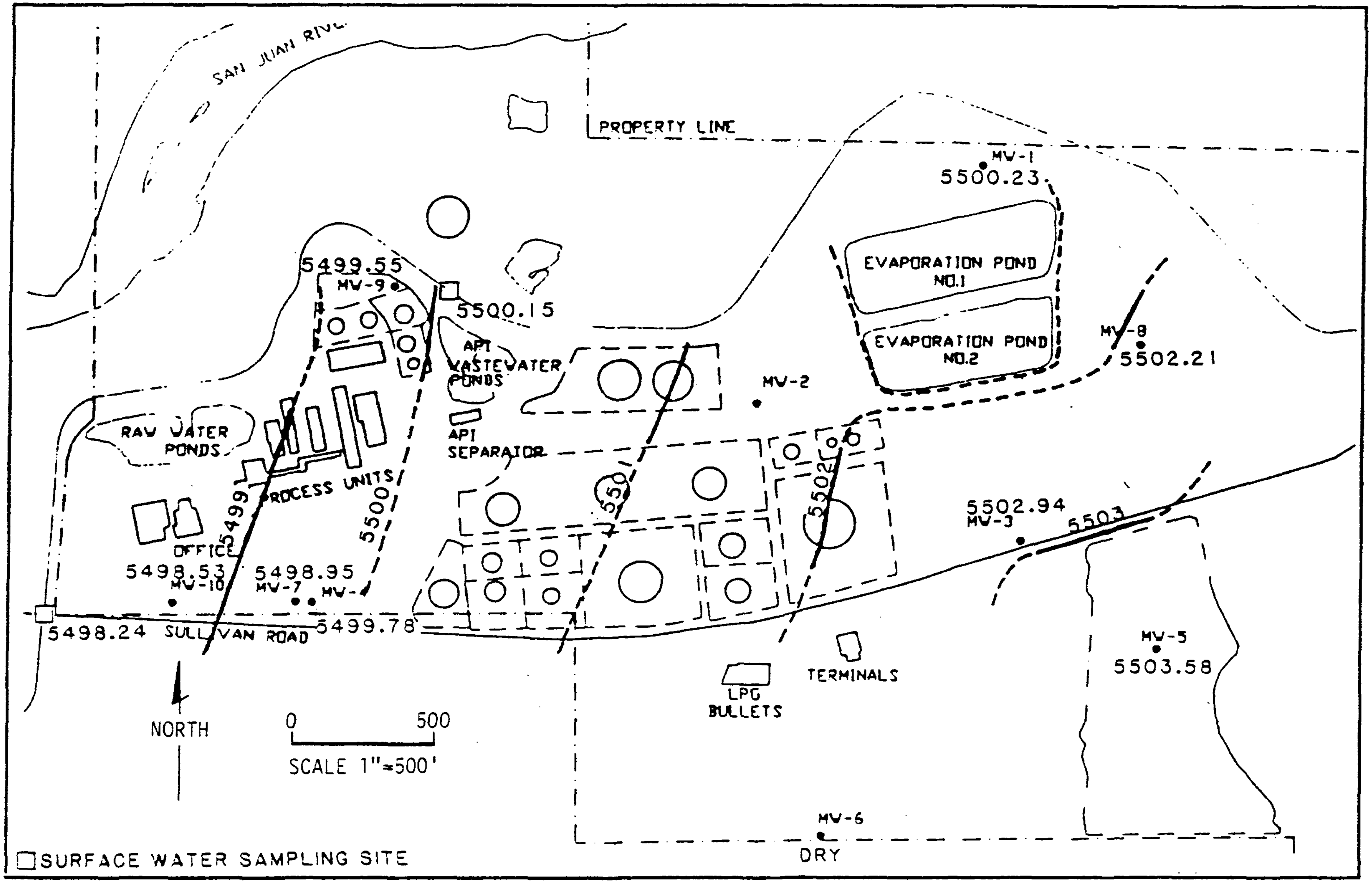


FIGURE 5-2
HYDRAULIC HEAD DISTRIBUTION IN UNCONFINED AQUIFER ON SEPTEMBER 2 , 1986
(Adapted from Engineering Science, 1986)

indicate, the direction of ground-water flow varies across the site, depending on the ditch stage.

During non-irrigation periods, Hammond Ditch is dry and ground water tends to move northwestward towards the San Juan River, where it discharges through seeps along the river escarpment. Since this water is not in hydraulic communication with water in the river, the escarpment acts as a variable-flux boundary, with flux dependent on the height of the seepage face. Under steady-state conditions, the flux can be considered constant.

During the irrigation season, Hammond Ditch is full and acts as a constant-head boundary. When the stage of water in Hammond Ditch is higher than head in the adjacent sand and gravel aquifer underlying the site, a southward flow component is imposed on northwestward-moving ground water from the eastern and central parts of the site, and ground-water flow becomes directed in a more westerly direction. Most of the ground water flowing northwestward and westward across the site eventually discharges into the ditch along its western reaches. Moreover, drawdown at recovery wells during high-stage conditions would tend to be reduced by ground-water contributions from the ditch. Since the situation involving high ditch stage represents the worst case with respect to off-site contamination and recovery drawdown, the model was formulated to account for hydrogeologic conditions that prevail during the irrigation season.

Values of constant-head along the ditch during the high-stage simulation were specified on the basis of water level elevations observed in the ditch at Sullivan Road and at the walkway north of well MW-9 on September 2, 1986. Using water level elevations of 5498.24 and 5500.15 feet at these locations, which were separated by a distance along the ditch of 1125 feet, a surface-water gradient of 0.0017 was estimated. This gradient was used to determine ditch stage at various points along Hammond Ditch when defining conditions along the eastern and southern boundaries of the flow domain. The gradient of water in the ditch is likely to be less during some periods. Measurements made on October 8, 1987 indicate a surface-water gradient of 0.0012 in the ditch.

Boundary conditions along the southern and eastern portions of the grid, where natural hydrologic boundaries are absent, were specified as constant-head boundaries by assuming that recovery stresses would not be propagated to these boundaries. Constant-head values along the eastern edge of the grid were specified on the basis of the 5503-ft piezometric contour shown in Figure 5-2. Constant-head values along the southern edge of the grid were specified according to the overall hydraulic gradient of 0.002 estimated from Figure 5-2.

Conditions within the raw water and evaporation ponds also represent boundary conditions in the model. The ponds were assumed to leak vertically into the underlying sand and gravel at a rate governed by the head of ponded water and the vertical leakance associated with the bottom of the ponds. Water level elevations of 5518.6 and 5522.3 feet were assigned to evaporation ponds #1 and #2, which were assumed to contain an average of 4 feet of ponded water (Chris Hawley, personal communication, 1987). The raw water ponds, located downgradient of the evaporation ponds, were assumed to be characterized by a hydraulic head of 5516.4 feet and 8 feet of ponded water.

5.5 DEFINITION OF AQUIFER PROPERTIES

Since only the steady-state situation was addressed during the modeling effort, the only aquifer property required as input to the flow model was hydraulic conductivity. Steady-state conditions were assumed to prevail over the site, where ground-water development has been minimal. The average conductivity of 2.13×10^{-4} ft/sec (137.7 gpd/ft^2) estimated from pumping, recovery, and slug tests was assigned to all nodes in the active flow domain. Specific yield under steady-state conditions, during which influx and outflux are equal and the aquifer does not store water, was set to 0.0 at all variable-head nodes during execution of the model. Specific yields at all constant-head nodes were assigned values of (10^{22}) to reflect infinite-storage conditions at these locations. According to standard hydrologic convention, a precipitation recharge rate equal to 10% of the 17-year annual average precipitation rate of 7.59 inches (0.00127 gpd/ft^2) was also specified. Elevations of the underlying Nacimiento contact were estimated based on a westward gradient of 0.0007.

5.6 PREDICTIVE SIMULATION OF RECOVERY IMPACTS

In an effort to duplicate observed hydrogeologic conditions underlying the site, leakance coefficients associated with the ponds, which were the most poorly-known parameters, were varied until hydraulic head at nodes representing wells 1,2,3,4,5,8,9 and 10 were approximately duplicated. Very low leakance coefficients were needed to reproduce the water levels at well nodes, suggesting that significant mounding beneath the ponds is not occurring.

Plate 5-2 shows the hydraulic head distribution simulated on the basis of the boundary conditions and aquifer properties described in Sections 5.3 and 5.4. The simulated hydraulic head distribution indicates that ground water flows predominantly northwestward throughout the central and eastern portions of the site and is directed southwestward in the western part of the site. Southwestward flow resulted from the occurrence of large heads along the Hammond Ditch, which tended to impose a strong southward gradient on the flow field and redirect water towards Sullivan Road. As stated previously, mounding under the raw water ponds was not believed to be significant on the basis of observed leakance coefficients, and did not appear likely to contribute to southwestward redirection of flow.

Judging from the simulated hydraulic head distribution, which supplied more information regarding flow direction than the observed water levels alone, an effective recovery strategy would involve capture of water south of the process area near existing wells MW-10 and MW-4. In order to assess the long-term impact of recovery at these two wells, maximum sustainable discharges of 2 gpm (2880 gpd) were imposed at the nodes representing the wells. Before contouring the resulting steady-state hydraulic head distribution, simulated drawdowns at the well nodes were corrected for radial flow conditions according to the relation:

$$\Delta s = 0.3665\ (Q/T)\ \log\ (a/4.81r_w)$$

where Δs = additional drawdown at a pump well due to radial flow (ft)
Q = discharge rate (gpd)
T = aquifer transmissivity (gpd/ft)
a = square root of well nodal element area (ft)
r_w = effective well radius (ft)

As mentioned in Section 4.0, well losses were not considered significant in the 0 to 2 gpm range of discharge and were not considered when defining drawdown at recovery wells.

The steady-state hydraulic head distribution shown in Plate 5-3 indicates that a 2-well recovery system will not be sufficient to capture all potentially-contaminated southward-moving water over the long term. Plate 5-4, which represents the long-term, steady-state hydraulic head distribution due to recovery from existing wells MW-10 and MW-4 and from a proposed 6-inch well located east of the ditch near the plant entrance, suggests that a three-well recovery strategy will be required to intercept all potentially-contaminated water moving southward between Hammond Ditch and the tank storage area. Plate 5-4 indicates that impacts of the three-well system would not propagate to the artificial constant-head boundaries along the southern and eastern portions of the grid and that the predicted impact of recovery should therefore be representative of actual recovery impact.

6.0 DISCUSSIONS AND CONCLUSIONS

6.1 SITE HYDROGEOLOGY

The Bloomfield Refinery is located in Bloomfield, New Mexico, east of State Highway 44 and north of Sullivan Road, on bluffs overlooking the San Juan River to the north. The site is situated on terrace deposits, alluvial sediments, and weathered subcrops of the Nacimiento Formation.

Most of the site is covered with a sandy unit of Quaternary Age that contains subordinate amounts of fine gravel, silt and clay and ranges in thickness from 10 to 41 feet (Engineering-Science, 1986). A sand and gravel unit (referred to in E-S 1986 report as a cobble layer) is present throughout site, beneath the sandy unit, in approximate thicknesses varying from 5 to 10 feet. Underlying the sand and gravel unit are gray to greenish clays and clayey sands that represent the weathered shale and sandstone lenses of the upper section of the Tertiary/Cretaceous Nacimiento Formation.

The uppermost saturated zone in the refinery area is an unconfined aquifer which is perched upon weathered shales of the Nacimiento Formation. Ground water occurs in both the sandy unit and the sand and gravel unit, with the underlying shale acting as an aquitard. It is possible that confined aquifers within the Nacimiento Formation may be hydraulically interconnected with the perched aquifer, but transmissivities are so low that vertical flow of ground water is insignificant (E-S, 1986). Ground water in the uppermost saturated zone flows in a general west-northwesterly direction (E-S, 1986) towards the San Juan River.

The rate of advective transport of dissolved contaminants in the sand and gravel unit can be determined by estimating the seepage velocity of ground water within the unit according to Darcy's law. Water table maps constructed by Engineering-Science during a previous investigation suggest that the hydraulic gradient characteristic of the central portion of the site is smaller than that observed in the southwestern part of the site, a condition substantiated by the slightly larger hydraulic conductivity at well MW-2 relative to that estimated for wells MW-4 and MW-10 (see Section 4.0). Separate estimates of the rate of contaminant transport were therefore made for the central and southwestern portions of the site. Table 6-1 lists the hydraulic gradients calculated on the basis of water table measurements made by Engineering Science throughout 1986.

Gradients in the southwestern portion of the site were estimated using head data observed at wells MW-4 and MW-10, which are located along a line parallel to the direction of ground-water flow south of the process area. Hydraulic gradients in the storage area of the site were estimated using head measurements collected at wells MW-2 and MW-5, which are situated along a line roughly parallel to the northwestward direction of ground water flow in the product storage area. Average gradients of 0.0036 and 0.0026 were determined in these two areas. With some exceptions, maximum hydraulic gradients were observed in the two areas during April, after which gradients decreased in response to increasing water stage in Hammond Ditch.

An average hydraulic conductivity for the process area, defined using conductivity values obtained during test pumping of well MW-10 and slug testing at well MW-4, was estimated as 1.82×10^{-4} ft/sec. The conductivity characteristic of the storage area was assumed equal to that observed at well MW-2 during slug testing, calculated to be 3.30×10^{-4} ft/sec. Assuming a minimum effective porosity of 0.10 for the silty-to-clean sand and gravel, maximum seepage velocities were identified for the two areas using Darcy's law:

$$v = (K\ \Delta h/\Delta l)/n_e$$

where v = ground water seepage velocity [L/T]
K = hydraulic conductivity [L/T]
$\Delta h/\Delta l$ = hydraulic gradient
n_e = effective porosity

TABLE 6-1

ESTIMATED HYDRAULIC GRADIENTS IN
PROCESS AND STORAGE AREAS
(1986)

Date	Process Area	Storage Area
1/24/86	--	0.0019
2/20/86	--	0.0021
3/21/86	0.0043	0.0028
3/26/86	0.0043	0.0029
4/4/86	0.0042	0.0031
4/18/86	0.0045	0.0031
5/5/86	0.0039	0.0028
5/21/86	0.0035	0.0027
6/4/86	0.0033	0.0025
7/8/86	0.0033	0.0020
8/4/86	0.0034	0.0020
9/2/86	0.0028	0.0018
10/8/86	0.0038	0.0018
11/7/86	0.0030	0.0020
12/8/86	0.0026	0.0021
12/16/86	0.0026	0.0018
Average	0.0035	0.0023

Table 6-2 presents the values of K, $\Delta h/\Delta l$, and n_e used in calculating maximum seepage velocity of ground water in the sand/gravel unit underlying the process and storage areas. Based on the 1986 data, hydrocarbons introduced into ground water in the storage area can be expected to move advectively 1.2 times faster than hydrocarbons introduced in the process area.

6.2 GROUND WATER CHEMISTRY

Samples of ground water were collected from monitor wells MW-11 and MW-12 on September 11, 1987 and sent to Assagai Analytical Laboratories for analysis. MW-11 is located south of the refinery and east (upgradient) of the Hammond Ditch. MW-12 is located southwest of the refinery and west (downgradient) of the ditch. Both wells are on BLM property.

6.2.1 Monitor Well MW-11

Ground water from MW-11 (sample number 8709111630) was found to contain concentrations of hydrocarbons and other product-associated additives. In particular, benzene, toluene, carbon tetrachloride, halogenated volatiles, and several metals were above New Mexico Water Quality Control Commission (WQCC) standards (Appendix A). No free-floating product was observed and it is believed that only dissolved-phase hydrocarbon is present in the uppermost aquifer in this area.

6.2.2 Monitor Well MW-12

Analyses of ground water collected from MW-12 (sample number 8709111600) identified <u>no</u> hydrocarbons (Appendix A). Several metals, Fe, Mn, B, Co and F were found to be above WQCC standards. It is possible that these elevated metal concentrations occur as a result of leaching of soils around Hammond Ditch and/or mixing of ground water from the upper Nacimiento, which is known to commonly exhibit a specific conductance in excess of 4000 umhos/cm (Stone and others, 1983), with water from the perched aquifer that is monitored by MW-11 and MW-12. No background water-quality data is available for the Nacimiento Formation in this specific area.

TABLE 6-2

PARAMETERS AND VARIABLES USED IN ESTIMATING
MAXIMUM SEEPAGE VELOCITY IN THE
PROCESS AND STORAGE AREAS
(1986)

Area	K (ft/sec)	$\Delta h/\Delta l$	(n_e) min	V_{max} (ft/sec)	V_{max} (ft/yr)
Process	1.82×10^{-4}	0.0035	0.10	6.37×10^{-6}	200
Storage	3.30×10^{-4}	0.0023	0.10	7.59×10^{-6}	240

7.0 REMEDIAL ACTION CONCEPTUAL DESIGN

7.1 PLUME CONTROL

The primary concern in remediation of ground water is to control the spread of contamination, that is, to prevent the plume from migrating past its present position. This can be done by pumping ground water via pumping wells to create a depression of the water table large enough to contain the plume. It is expected that three to four wells pumping at a rate of 1 to 2 gpm each will be needed to create this effect at the Bloomfield Refinery. Once the ground water is pumped to the surface, it will be treated to reduce contamination to levels required in WQCC regulations. After treatment, the water will be discharged back to aquifer.

There are several methods which can be used to reapply the treated water to the local ground-water system. These methods include infiltration via ponding of water, evaporation and infiltration via spray or drip irrigation, injection of water through wells, or infiltration of water through trenches. Ponding of the water could be feasible if a large area of open land is available on refinery property. The same large tract of land would be required for exclusive use for spray or drip irrigation to be considered feasible.

The shallow depth to ground water at the site makes infiltration trenches a highly amenable option for reapplication of treated water. Trenches positioned downgradient of the plume would create a ground water mound, aiding in the confinement of the plume boundary. Injection wells placed downgradient of the plume would also be effective, however, reintroduction of oxygenated water (from air strippers) could lead to excessive biological growth in the screened interval of the well which could cause clogging. Infiltration trenches appear to be the most viable option for the introduction of treated water back into the aquifer and are recommended for this purpose. Hammond Ditch is strategically located and would be very cost-effective for use as an infiltration trench. Also, a trench may need to be located on BLM property south of MW-11 where hydrocarbons have been identified in ground water.

7.2 GROUND WATER TREATMENT ALTERNATIVES

There are several treatment alternatives which can be considered for remediation of hydrocarbon in ground water. Most of the viable options are "pump-and-treat" technologies in which the ground water is pumped to the surface, treated, and then discharged to the surface or back to the aquifer. Based upon our experience and a review of all treatment technologies, the three primary treatment technologies evaluated for the remediation of hydrocarbon contaminated ground water at the Bloomfield Refinery are land application, carbon adsorption and air-stripping.

Land application would consist of pumping the contaminated water to the surface and discharging it to the soil surface without other treatment; contamination is then reduced or eliminated by aeration and natural soil processes. Although land application has been shown to be effective for removal of hydrocarbon contaminants, it requires a large area of land for exclusive use.

Carbon adsorption is a highly effective technology used in direct removal of organic contaminants from the water. In general, carbon adsorption can be cost competitive with other technologies (i.e., air-stripping) when treating low concentrations of hydrocarbons. However, the concentrations of hydrocarbon that could occur in ground water at the site could elevate carbon exhaustion rates to a point of cost inefficiency.

Air-stripping is another highly effective and preferred technology used for removing volatile components from hydrocarbon contaminated water. In the air-stripping process, volatiles are removed from the water and transferred to the atmosphere. The higher hydrocarbon concentrations that could be present at the site can be efficiently removed by air-stripping. Although the initial capital investment for an air-stripping unit will be approximately 60% higher than that for carbon adsorption units, regeneration or disposal of stripping media is not necessary, thus drastically reducing operation and maintenance costs. Given these considerations, air-stripping is the recommended ground water treatment technology for this site.

7.3 BACKGROUND ON SELECTED GROUND WATER REMEDIAL TECHNOLOGY

Effective removal of dissolved hydrocarbon components using air-stripping has been shown to be technically and economically feasible (Canter and Knox, 1985; IT Enviroscience, 1983). Air-stripping is an attractive alternative for ground-water remediation because of its simplicity and its ability to stand essentially alone as a treatment technology. Air-stripping is based on a mass transfer process whereby a substance such as benzene is transferred from a liquid solution to a gaseous solution. The rate at which this occurs is dependent on the driving force (concentration gradient) between the liquid and gas phases. The ability of a component to be stripped from a liquid solution can be predicted by the Henry's Law constant of that component. In general, if Henry's Law constant is greater than 1×10^{-3} atm.m^3/mole, the component can be easily stripped. Henry's Law constants for selected contaminants at the site have been calculated and are shown in Table 7-1. The constants are approximately equal to or greater than 1×10^{-3}, indicating that the compounds can be air-stripped from solution.

The basic configuration of an air-stripper consists of a packed tower and blowers (Figure 7-1). The feed solution of hydrocarbon-contaminated ground water is fed to the top of the packed tower and allowed to flow over the packing. Air is blown up through the bottom of the tower, stripping contaminants from solution. The treated water then exits the bottom portion of the tower and the contaminants are carried away into the atmosphere. In New Mexico, an air quality permit is generally required if any hazardous air pollutants are released to the atmosphere, or if the emission of total hydrocarbons is higher than ten pounds per hour.

7.4 BASIC DESIGN OF GROUND WATER AIR-STRIPPING SYSTEM

Influent (ground water) will be pumped directly from the wells to the stripper unit. This will allow for a constant influent temperature, which will increase the efficiency of the stripper unit. Effluent from the stripper will be discharged to an auxiliary storage tank before being

TABLE 7-1
HENRY'S CONSTANTS FOR
CONTAMINANTS OF CONCERN

	atm m^3/mole
Benzene	5.55×10^{-3}
Toluene	5.93×10^{-3}
Ethylbenzene	6.44×10^{-3}
Xylene	6.12×10^{-3}

Values from Treatability Manual Volume I USEPA September 1981

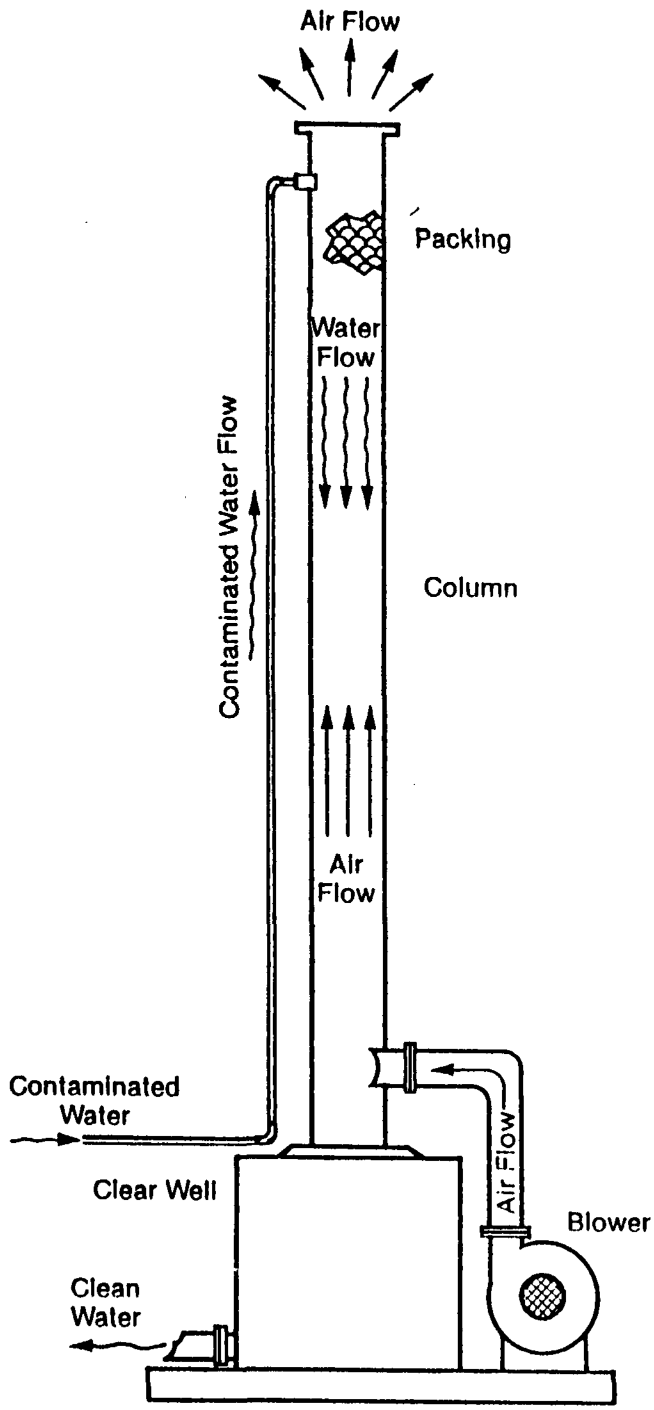


FIGURE 7-1

BASIC AIR STRIPPER CONFIGURATION

discharged to the aquifer. Location of any air-strippers will be determined in the full scale remedial action design and will be based on meteorological and land use factors.

Analyses of the treated water will be performed to assure that hydrocarbon contaminants of concern have been reduced to WQCC ground water limits. A sampling and analysis plan and QA/QC plan will be addressed in the full scale remedial action design.

8.0 RECOMMENDATIONS

The concentration of hydrocarbon identified in MW-11 indicates that hydrocarbons have migrated off the refinery property. The following measures are proposed to define the extent and magnitude of off-site contamination in order to develop an appropriate remedial action:

TASK 1. Soil Boring Program: Conduct a two to three day soil boring program utilizing a hollow-stem auger. Selected parts of the saturated and unsaturated zones will be cored and sampled for headspace analysis with a portable gas chromatograph (GC). The lithology of each borehole will be completely described. Ground water at the site is known to occur in a sand and gravel aquifer that is difficult to auger drill. Wherever the borehole can be advanced far enough into the aquifer to permit, temporary steel or PVC piezometers will be installed in the boreholes and water samples from the water-bearing zone will be collected for on-site headspace analysis. Because this program is for reconnaissance, steam-cleaning of the rig between boreholes will be limited to only the lead auger and any other tools that are used in the borehole. Well development is not proposed for the piezometers.

After the soil and/or water samples have been collected and analyzed for volatile organic compounds with a GC and for field parameters of pH and electrical conductance, the piezometers will be removed from the borehole and the borehole will be backfilled with clean native cuttings or clean surface material. Plate 8-1 shows the location of the proposed test holes. Existing monitor wells will be evaluated with the portable GC to correlate the field values with laboratory values.

Two to four piezometers will also be drilled and installed under this task to be used as observation wells during the long-term pump test. Justification of these observation wells is discussed under task 2.0.

Data from the field program conducted in this task will be evaluated and presented in tabular and map format. The data will be utilized to determine the final number and location of wells necessary to monitor the movement of observed hydrocarbons and to identify the source of the hydrocarbons.

TASK 2. Perform Long-Term Pump Test of Remedial Action System:
The purpose of this test is to refine estimates of transmissivity obtained from earlier pumping tests and to arrive at a value for aquifer storativity. Refinement of these aquifer parameters are critical to optimizing the remedial action plan. Additionally, the test will demonstrate how the water chemistry changes due to pumping with air-operated pumps and storage in open tanks. The chemistry of the produced water must be accurately determined in order for proper design of any air stripping units.

Work at other New Mexico refineries has demonstrated that pumping ground water and hydrocarbons with air-lift recovery pumps and treatment with an air stripper is an acceptable method to remove volatile organic constituents from water. Previous testing at the site demonstrates that such pumps are ideal for recovery of hydrocarbons at the Bloomfield Refinery. Air-lift recovery pumps will be installed in MW-4 and MW-10. The initial test will utilize only MW-10 as a pumping well.

The produced water will be stored in a 10,000 gallon tank. If time and storage capacity permit, MW-4 will then be pumped in concert with MW-10 so that a two well pumping test can be analyzed. The test will cease upon reaching the capacity of the tank. Water will be sampled from the storage tank in order to determine the extent to which hydrocarbons have been stripped from the water while pumping.

Based on results of a preliminary predictive numerical modeling study, existing wells MW-10 and MW-4 can be used to capture most of the northwestward-flowing water traversing the site. Long-term recovery rates of 1.5 gallons per minute at each well appear to be sufficient to capture ground water that may be migrating off site in irrigation water during high-stage conditions in Hammond Ditch. These rates of recovery would also succeed in capturing some of the contamination currently present in the vicinity of well MW-11 located south of Sullivan Road. It is expected that Hammond Ditch could be used as an infiltration trench during non-irrigation periods, but it may be necessary to install trenches in other strategic areas up or down gradient from the plume.

To ensure that the recovery network will be sufficient to capture all hydrocarbons leaving the property, a long-term test of the pumping network is required. It is necessary to know the transmissivity and storativity of the aquifer to determine optimal pumping schedules. The transmissivity of the aquifer beneath the refinery was calculated in the preliminary pumping test. However, the response to pumping was not observed at a distance from the pumping well, thus the storativity of the aquifer at the site could not be calculated.

To adequately predict the response of the aquifer to recovery pumping, two to four additional piezometers will be installed between wells MW-4 and MW-10 and used as observation wells during the pump test. This will reduce the time, and cost, of a long-term pumping test that would yield sufficient data to permit calculation of the storativity of the aquifer.

TASK 3. Final Report: Present a report on the investigations, with recommendations for a remedial action and prepare a discharge plan which meets WQCC requirements. It is presently proposed to use air-stripping in a pump-and-treat system to remediate contaminated ground water at the site. It is recommended that a 3-well recovery system be used to intercept all contaminated ground water flowing from the tank storage and process areas. Recovery wells should be located in such a way as to intercept contaminated ground water as it flows westward from the storage and the process areas during high-stage conditions in Hammond Ditch. All plans and specifications for the remedial action system , as well as all necessary aspects of the discharge plan will be provided under this task.

9.0 REFERENCES

Canter, L. W. and Knox, R. C., 1985, Ground Water Pollution Control, Lewis Publishers, Inc.

Engineering-Science, 1986, A Report on Section 3013 Administrative Order Work Elements, for Bloomfield Refinery Company.

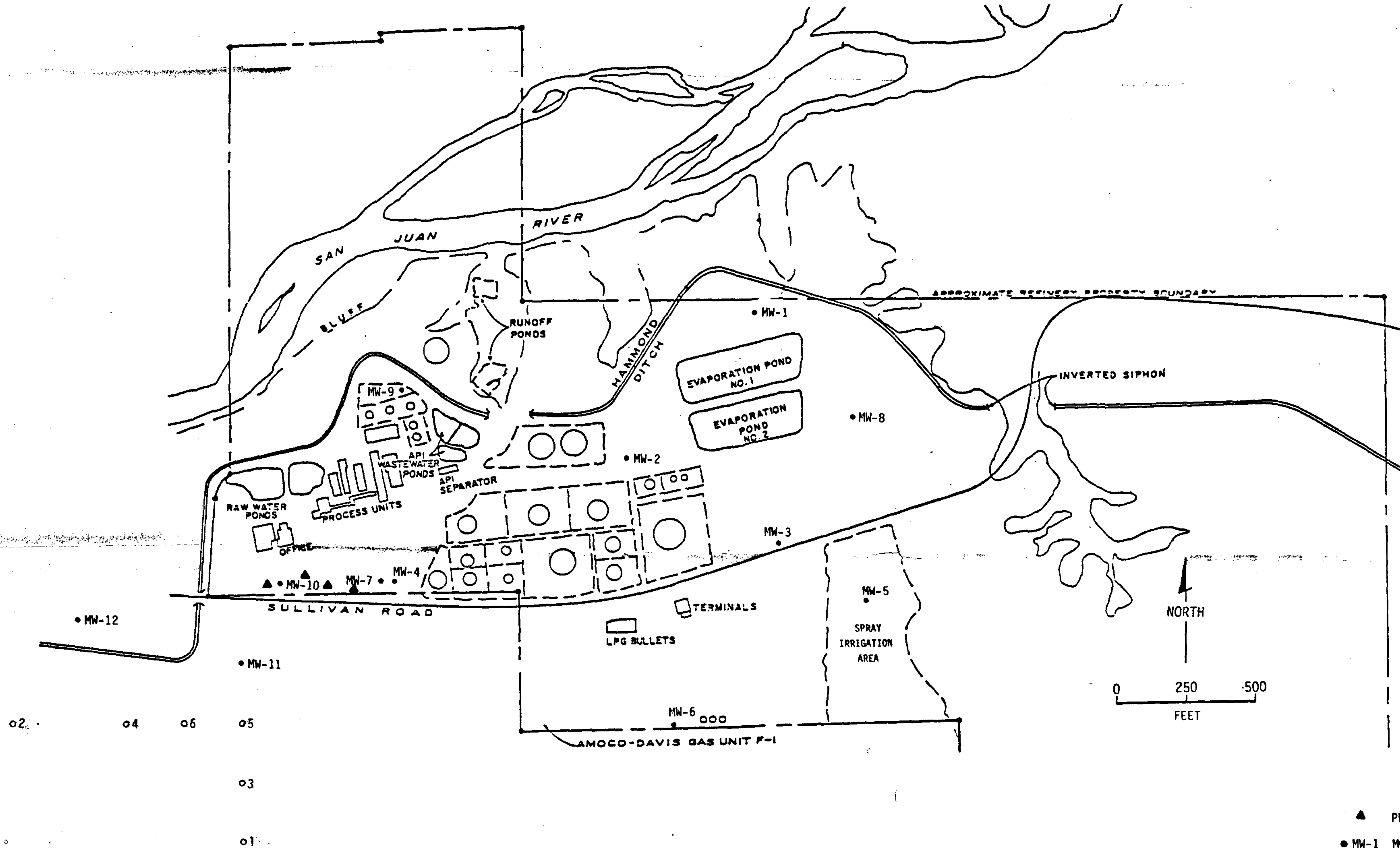
Freeze, R. A. and Cherry, J. A., 1979, Groundwater, Prentice-Hall, Inc. New Jersey.

IT Enviroscience, 1983, Treatment Technology for Removal of Dissolved Gasoline Components from Ground Water, Final Report, May 13, 1983.

McDonald, M. G. and Harbaugh, A. W., 1984, A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, U. S. Geological Survey, Reston, Virginia.

Prickett, T. A. and Lonnquist, C. G., 1971, Selected Digital Computer Techniques for Groundwater Resource Evaluation, Illinois Water Survey Division Bulletin 55, Urbana, Illinois.

Stone, W. J. and Others, 1983, Hydrogeology and Water Resources of San Juan Basin, New Mexico, New Mexico Bureau of Mines and Mineral Resources, Hydrologic Report 6.



LEGEND

▲ PROPOSED PIEZOMETERS

● MW-1 MONITOR WELL AND NUMBER.

○ 8 PROPOSED SOIL BORING

MAR 0 7 1988

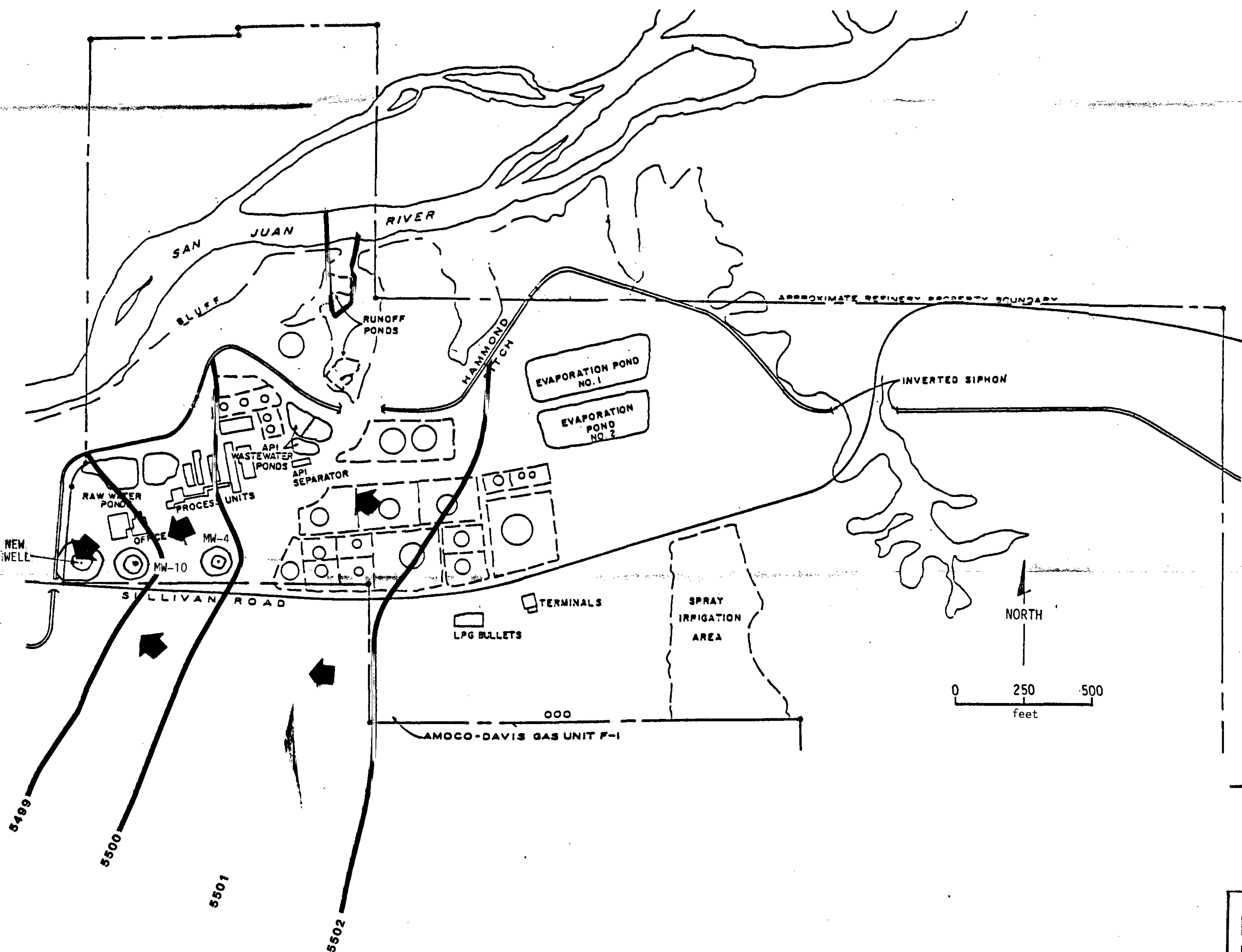
GCL

PLATE 8-1

PROPOSED SOIL BORING LOCATIONS

CLIENT: GARY REFINING.
DATE: 11-87
DRAWN BY: MK
CHECKED BY: MS
REVISED:
SCALE:

MAR 14 1988



LEGEND

—— 5500 ——	WATER TABLE CONTOURS
(arrow)	GROUND WATER FLOW DIRECTION
MW-10	MONITOR WELL

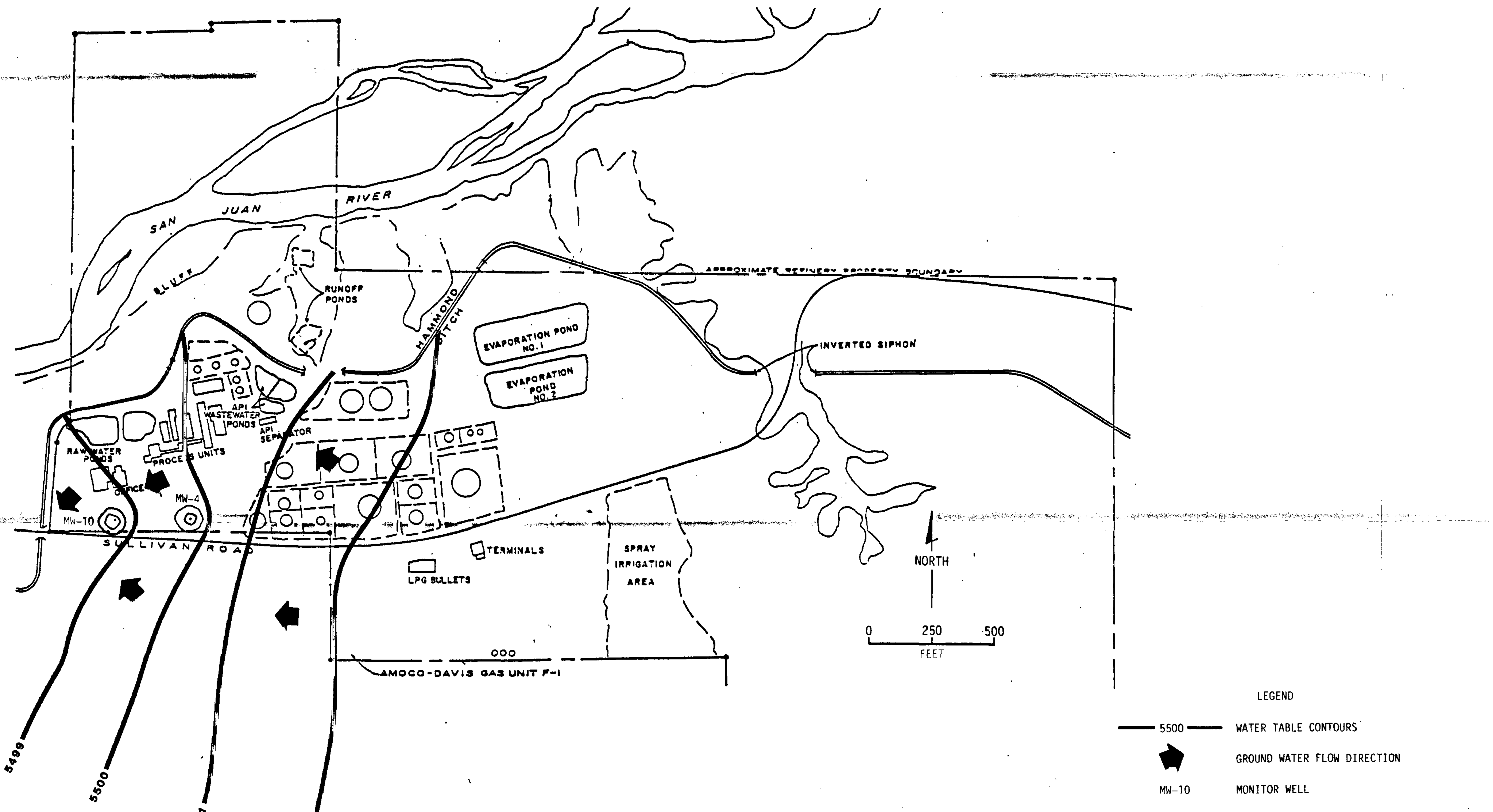
MAR 0 7 1988

GCL

PLATE 5-4
SIMULATED HYDRAULIC HEAD DISTRIBUTION IN THE UNCONFINED AQUIFER DURING 3-WELL RECOVERY

CLIENT: GARY REFINING
DATE: 11-87
DRAWN BY: MK
CHECKED BY: MS
REVISED:
SCALE:

MAR 1 4 1988
OIL CONSERV. DIVISION



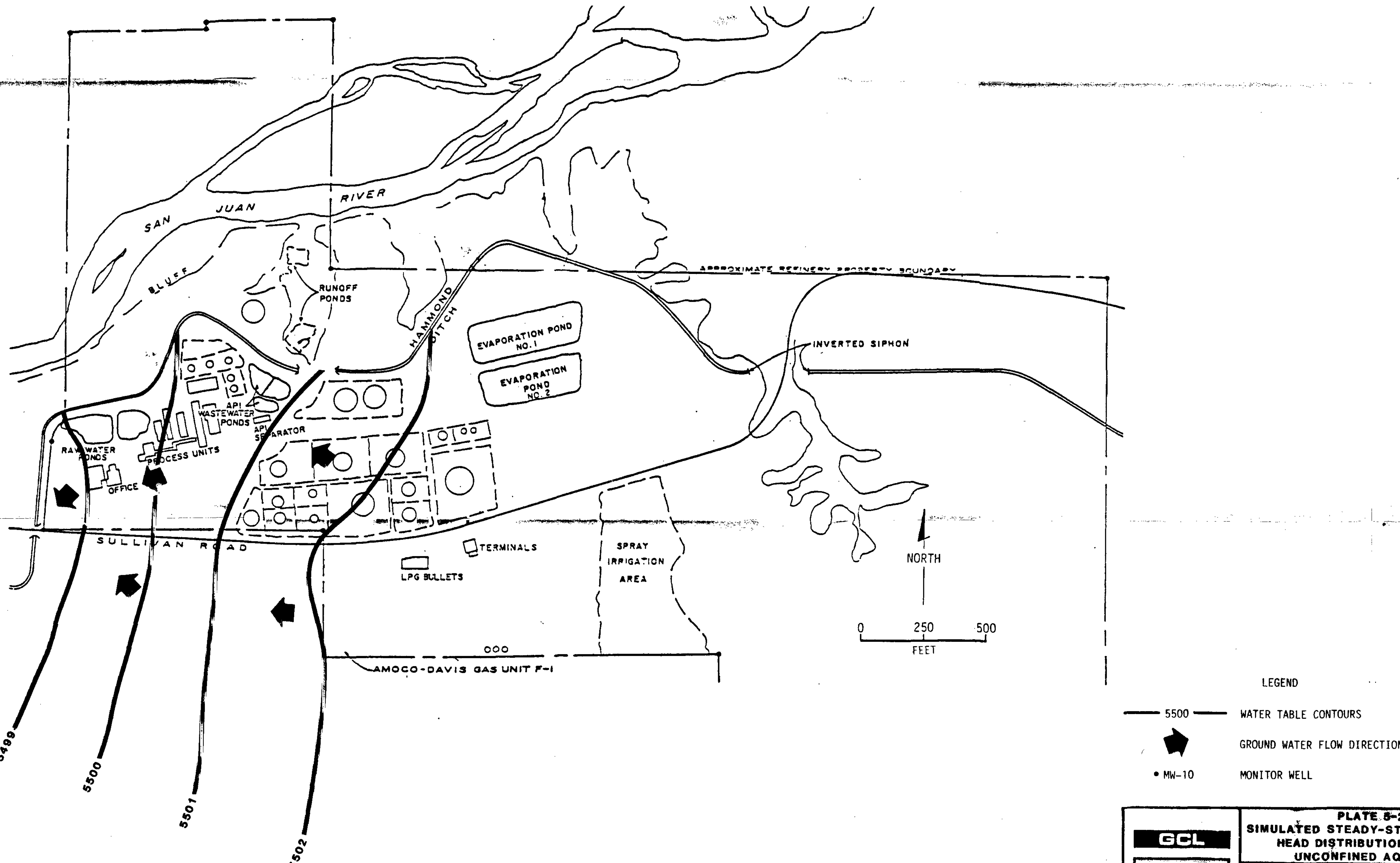
MAR 07 1988

GCL

PLATE 5-3
SIMULATED HYDRAULIC HEAD DISTRIBUTION IN THE UNCONFINED AQUIFER DURING 2-WELL RECOVERY

CLIENT: GARY REFINING
DATE: 11-87
DRAWN BY: MK
CHECKED BY: MS
REVISED:
SCALE:

MAR 14 1988
OIL CONSERVATION DIVISION
SANTA FE



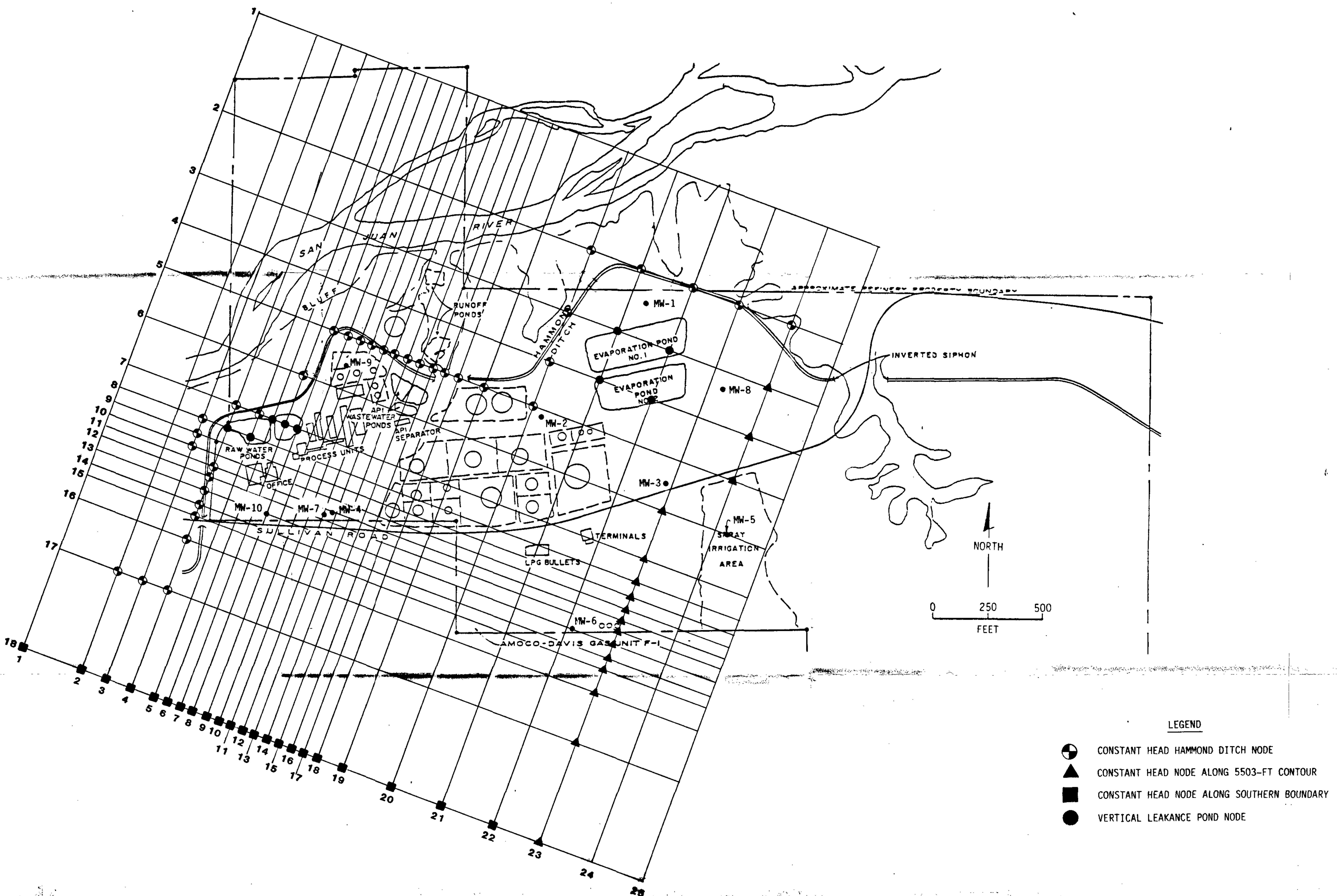
MAR 07 1988

GCL

PLATE 5-2
SIMULATED STEADY-STATE HYDRAULIC HEAD DISTRIBUTION IN THE UNCONFINED AQUIFER

CLIENT: GARY REFINING
DATE: 11-87
DRAWN BY: MK
CHECKED BY: MS
REVISED:
SCALE:

RECEIVED
MAR 14 1988
OIL CONSERVATION DIVISION
SANTA FE



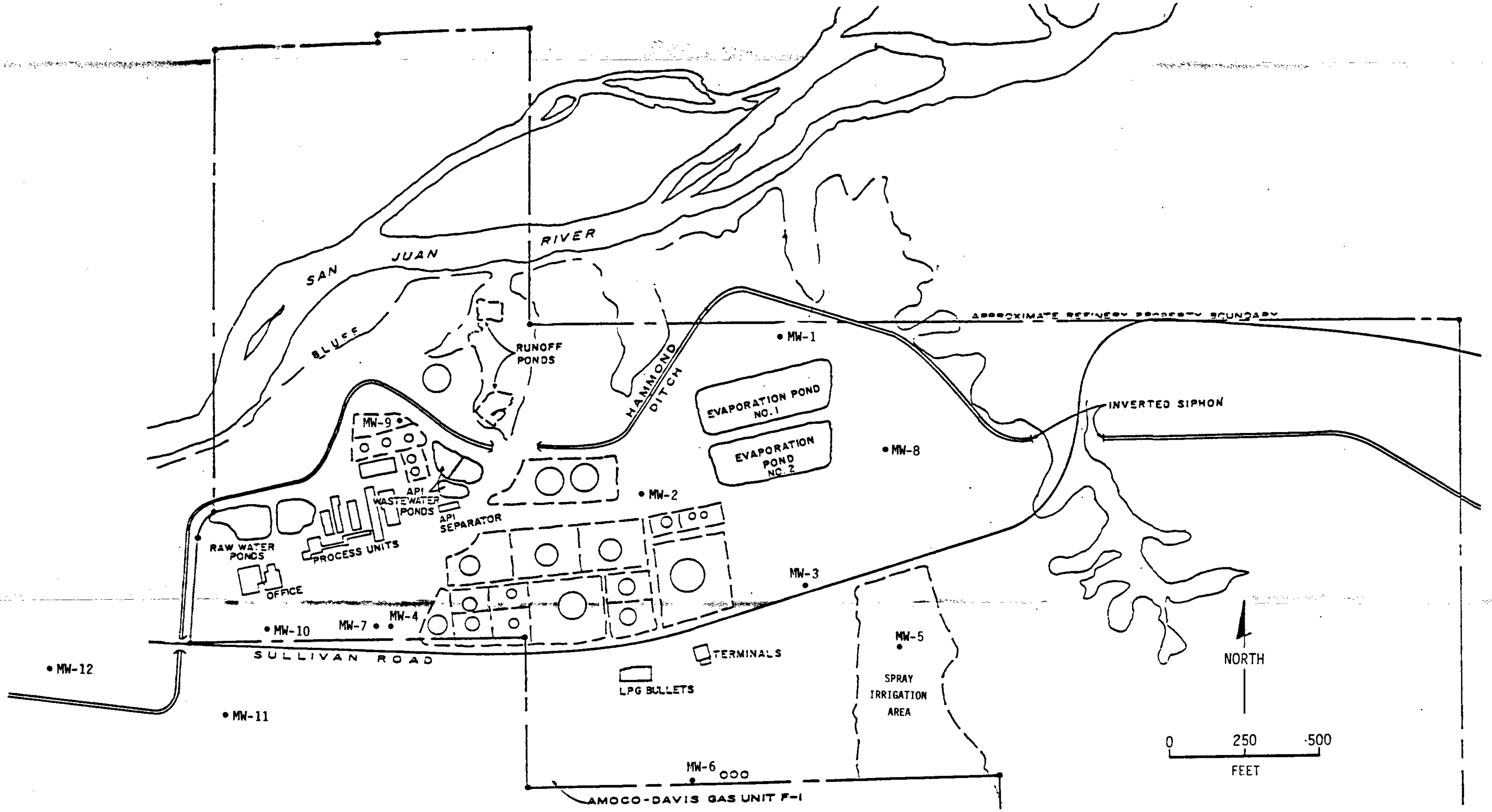
MAR 07 1988

GCL

PLATE 5-1
FINITE DIFFERENCE GRID

CLIENT: GARY REFINING
DATE: 11-87
DRAWN BY: MK
CHECKED BY: MS
REVISED:
SCALE:

RECEIVED
MAR 14 1988
OIL CONSERVATION DIVISION
SANTA FE



LEGEND

• MW-1 MONITOR WELL AND NUMBER.

MAR 07 1988

GCL

PLATE 3-1
MONITOR WELL LOCATION MAP

CLIENT: GARY REFINING
DATE: 11-87
DRAWN BY: MK
CHECKED BY: MS

MAR 14 1988

RECEIVED
MAR 14 1988
OIL CONSERVATION DIVISION
SANTA FE

SITE INVESTIGATION AND REMEDIAL ACTION CONCEPTUAL DESIGN FOR THE BLOOMFIELD REFINING COMPANY
APPENDICES A - Q

March 4, 1988

Prepared for:

CHRIS HAWLEY
ENVIRONMENTAL ENGINEER
BLOOMFIELD REFINING COMPANY
P.O. Box 159
Bloomfield, New Mexico 87413

Prepared by:

GEOSCIENCE CONSULTANTS, LTD.

HEADQUARTERS
500 Copper Avenue, NW
Suite 200
Albuquerque, New Mexico 87102
(505) 842-0001
FAX (505) 842-0595

WESTERN REGION OFFICE
5000 Birch Street
West Tower, Suite 3000
Newport Beach, CA 92660
(714) 476-3650

EASTERN REGIONAL OFFICE
1109 Spring Street
Suite 706
Silver Spring, Maryland 20910
(301) 587-2088
FAX (301) 587-2086

SITE INVESTIGATION AND REMEDIAL ACTION CONCEPTUAL DESIGN FOR THE BLOOMFIELD REFINING COMPANY APPENDICES A - Q

March 4, 1988

Prepared for:

CHRIS HAWLEY
ENVIRONMENTAL ENGINEER
BLOOMFIELD REFINING COMPANY
P.O. Box 159
Bloomfield, New Mexico 87413

Prepared by:

GEOSCIENCE CONSULTANTS, LTD.

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1109 Spring Street
Suite 706
Silver Spring, Maryland 20910
(301) 587-2088
FAX (301) 587-2086

APPENDIX A

RESULTS OF CHEMICAL ANALYSES

(8709111600)

(338)

ASSAIGAI ANALYTICAL LABORATORIES

TO: Geoscience Consultants
ATTN: Mike Selke
500 Copper NW Suite 200
Albuquerque, NM 87102

DATE: 30 September 1987
1498

ANALYTE	SAMPLE ID/ANALYTICAL RESULTS MW-12 8709111600	MW-11 8709111630	NOMINAL DETECTION LIMIT
Phenols	<0.01 mg/l	<0.01 mg/l	0.01 mg/l
Oil & Grease	0.691 mg/l	1.3 mg/l	0.01 mg/l
As	<0.05 mg/l	<0.05 mg/l	0.05 mg/l
Ba	<1.0 mg/l	6.72 mg/l	1.0 mg/l
Cd	<0.01 mg/l	0.018 mg/l	0.01 mg/l
Cr	0.064 mg/l	0.200 mg/l	0.05 mg/l
Pb	0.120 mg/l	0.320 mg/l	0.05 mg/l
Hg	<0.002 mg/l	<0.002 mg/l	0.002 mg/l
Se	0.022 mg/l	0.040 mg/l	0.002 mg/l
Ag	<0.05 mg/l	<0.05 mg/l	0.05 mg/l
Cu	0.048 mg/l	0.060 mg/l	0.02 mg/l
Fe	8.20 mg/l	32.0 mg/l	0.05 mg/l
Mn	0.380 mg/l	4.71 mg/l	0.05 mg/l
Zn	0.106 mg/l	0.728 mg/l	0.004 mg/l
Uranium	<5 mg/l	<5 mg/l	5 mg/l
Cl	7.9 mg/l	337.5 mg/l	1.0 mg/l
SO 4	248 mg/l	181 mg/l	1.0 mg/l
PCB	<0.05 ug/l	<0.05 ug/l	0.05 ug/l
CN	<0.005 mg/l	<0.005 mg/l	0.005 mg/l
NO 3 as N	0.181 mg/l	0.389 mg/l	0.01 mg/l
Al	9.50 mg/l	33.80 mg/l	0.05 mg/l
B	[illegible]	[illegible]	0.1 mg/l
Co	0.140 mg/l	0.256 mg/l	0.003 mg/l
Mo	<0.5 mg/l	<0.5 mg/l	0.5 mg/l
Ni	0.145 mg/l	0.213 mg/l	0.05 mg/l
F	9.7 mg/l	0.93 mg/l	0.001 mg/l
TDS	658 mg/l	1930 mg/l	1 mg/l
pH	7.50	7.04	0.01
Benzene	<0.001 mg/l	5.4 mg/l	0.001 mg/l
Toluene	<0.001 mg/l	<0.025 mg/l	0.002 mg/l
Carbon Tetrachloride	<0.005 mg/l	12 mg/l 13.5 mg/l duplicate	0.005 mg/l
1,2 Dichloroethane	<0.001 mg/l	0.003 mg/l	0.001 mg/l
1,1 Dichloroethylene	<0.001 mg/l	<0.001 mg/l	0.001 mg/l
1,1,2,2 Tetrachloro-ethylene	<0.001 mg/l	0.070 mg/l	0.001 mg/l
1,1,2 Trichloro-ethylene	<0.001 mg/l	0.225 mg/l	0.003 mg/l

(335) 870111635

SAMPLE ID: TRIP BLANK

ANALYTE	ANALYTICAL RESULTS
Benzene	<0.001 mg/l
Toluene	<0.001 mg/l
Carbon Tetrachloride	<0.005 mg/l
1,2-Dichloroethane	<0.001 mg/l
1,1-Dichloroethylene	<0.001 mg/l
1,1,2,2 Tetrachloroethylene	<0.001 mg/l
1,1,2 Trichloroethylene	<0.001 mg/l

REFERENCE: "Standard Methods for the Examination of Water and Wastewater", 16th Edition, APHA, N.Y., 1985.

An invoice for services is enclosed. Thank you for contacting Assaigai Laboratories.

Sincerely,

Jennifer V. Smith

Jennifer V. Smith, Ph.D.
Laboratory Director

RADIAN CORPORATION

Page 3 | RAS - Austin | REPORT | Work Order # 87-08-025

Received: 08/06/87 | Results by Sample

SAMPLE ID 8707310930 | FRACTION 01A | TEST CODE EPA602 | NAME EPA method 602

RINSATE FROM RIG & TOOLS AFTER STEAM CLEANING | Date & Time Collected 07/31/87 | Category

VERIFIED CL

ANALYST CL | FILE # | UNITS ug/L

INSTRMT I | INJECTED 08/06/87

CAS#	COMPOUND	RESULT	DET LIMIT
71-43-2	Benzene	0.5*	0.2
108-88-3	Toluene	1.3	0.2
100-41-4	Ethylbenzene	ND	0.3
108-90-7	Chlorobenzene-A	ND	0.3
106-46-7	1,4-Dichlorobenzene	ND	0.3
541-73-1	1,3-Dichlorobenzene	ND	0.4
95-50-1	1,2-Dichlorobenzene	ND	0.4

SURROGATES

98-08-8	a,a,a-Trifluorotoluene	102% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.

DET LIMIT = DETECTION LIMIT
ND = not detected at detection limit
NA = not analyzed
* = less than 5 times the detection limit
N\A = not available
Second column confirmation NOT performed unless otherwise noted.

RADIAN
CORPORATION

Received: 08/11/87

RAS - Austin REPORT
Results by Sample

Work Order # 87-08-025
Continued From Above

SAMPLE ID reagent blank

FRACTION 04A TEST CODE EPA602 NAME EPA method 602
Date & Time Collected 07/31/87 Category

A-Chlorobenzene and m-xylene co-elute.
Quantitated as chlorobenzene unless
otherwise noted.

RADIAN CORPORATION

Received: 08/05/87

RAS - Austin REPORT
Results by Sample

Work Order # 87-08-025
Continued From Above

SAMPLE ID 8707310930 FRACTION 01A TEST CODE EPA602 NAME EPA method 602
Date & Time Collected 07/31/87 Category

A-Chlorobenzene and m-xylene co-elute.
Quantitated as chlorobenzene unless
otherwise noted.

RADIAN CORPORATION

...ge 5 | RAS - Austin REPORT | Work Order # 87-08-025
...ed: 08/0?/87 | Results by Sample

...PLE ID 8707310930 FRACTION 01A TEST CODE XYLENE NAME Xylenes, EPA 602
Date & Time Collected 07/31/87 Category ________

VERIFIED CL

...ALYST CL FILE # ________
...ETRMT D INJECTD 08/06/87 UNITS ug/L

CAS #	COMPOUND	RESULT	DET LIMIT
106-42-3	p-Xylene	0.2*G	0.2
108-38-3	m-Xylene	0.3*G	0.2
95-47-6	o-Xylene	0.2*	0.1

SURROGATES

98-08-8 a,a,a-Trifluorotoluene 102% recovery

...TES AND DEFINITIONS FOR THIS REPORT.
DET LIMIT = DETECTION LIMIT
ND = not detected at detection limit
NA = not analyzed
* = less than 5 times the detection limit
N\A = not available
Second column confirmation NOT performed unless otherwise noted.
G = daily EPA standard recovery outside 95% confidence interval.

RADIAN CORPORATION

Page 2 | RAS - Austin REPORT | Work Order # 87-08-025
Received: 08/06/87 | Results by Sample

SAMPLE ID 870731000 | FRACTION 02A | TEST CODE EPA602 | NAME EPA method 602
TRIP BLANK | Date & Time Collected 07/31/87 | Category ______

VERIFIED CL

ANALYST CL | FILE # ______
INSTRMT E | INJECTED 08/06/87 | UNITS ug/L

CAS#	COMPOUND	RESULT	DET LIMIT
71-43-2	Benzene	0.9*	0.2
108-88-3	Toluene	1.5	0.2
100-41-4	Ethylbenzene	ND	0.3
108-90-7	Chlorobenzene-A	ND	0.3
106-46-7	1,4-Dichlorobenzene	ND	0.3
541-73-1	1,3-Dichlorobenzene	ND	0.4
95-50-1	1,2-Dichlorobenzene	ND	0.4

SURROGATES

98-08-8 a,a,a-Trifluorotoluene 105% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.

DET LIMIT = DETECTION LIMIT
ND = not detected at detection limit
NA = not analyzed
* = less than 5 times the detection limit
N\A = not available
Second column confirmation NOT performed unless otherwise noted.

RADIAN CORPORATION

Page 7 RAS - Austin REPORT Work Order # 87-08-025

Received: 08/01/87 Results by Sample Continued From Above

SAMPLE ID 870731100O FRACTION 02A TEST CODE EPA602 NAME EPA method 602

Date & Time Collected 07/31/87 Category

A-Chlorobenzene and m-xylene co-elute. Quantitated as chlorobenzene unless otherwise noted.

RADIAN CORPORATION

Page 3 — RAS - Austin REPORT — Work Order # 87-08-025

Results by Sample

Date Received: 08/06/87

SAMPLE ID 870731100C

FRACTION 02A TEST CODE XYLENE NAME Xylenes, EPA 602

Date & Time Collected 07/31/87 Category ______

VERIFIED CL

ANALYST CL

DIL'N AMT 2

INJECTD 08/0_/87

FILE # ______

UNITS ug/L

CAS #	COMPOUND	RESULT	DET LIMIT
106-42-3	p-Xylene	0.2*G	0.2
108-38-3	m-Xylene	0.3*G	0.2
95-47-6	o-Xylene	0.2*	0.1

SURROGATES

98-08-8 a,a,a-Trifluorotoluene 105% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.

DET LIMIT = DETECTION LIMIT
ND = not detected at detection limit
NA = not analyzed
* = less than 5 times the detection limit
N\A = not available
Second column confirmation NOT performed unless otherwise noted.
G = daily EPA standard recovery outside 95% confidence interval.

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Page 5 — RAS - Austin REPORT — Work Order # 87-08-025

Results by Sample

Received: 08/06/87

SAMPLE ID E707311200 FRACTION 03A TEST CODE EPA602 NAME EPA method 602

WATER FROM TANK -USED FOR DRILLING

Date & Time Collected 07/31/87 Category ______

VERIFIED CL

ANALYST CL

INSTRMT I

INJECTED 08/06/87

FILE # ______

UNITS ug/L

CAS#	COMPOUND	RESULT	DET LIMIT
71-43-2	Benzene	ND	0.2
108-88-3	Toluene	ND	0.2
100-41-4	Ethylbenzene	ND	0.3
108-90-7	Chlorobenzene-4	ND	0.3
106-46-7	1,4-Dichlorobenzene	ND	0.3
541-73-1	1,3-Dichlorobenzene	ND	0.4
95-50-1	1,2-Dichlorobenzene	ND	0.4

SURROGATES

98-08-8	a,a,a-Trifluorotoluene	103% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.

DET LIMIT = DETECTION LIMIT
ND = not detected at detection limit
NA = not analyzed
* = less than 5 times the detection limit
N\A = not available
Second column confirmation NOT performed unless otherwise noted.

RADIAN CORPORATION

Page 11 | RAS - Austin | REPORT | Work Order # 87-08-025
Received: 08/06/87 | Results by Sample

SAMPLE ID 870731I200 | FRACTION 03A | TEST CODE XYLENE | NAME Xylenes, EPA 602
Date & Time Collected 07/31/87 | Category

VERIFIED CL

ANALYST CL | FILE #
INSTRMT 3 | INJECTD 08/06/87 | UNITS ug/L

CAS #	COMPOUND	RESULT	DET LIMIT
106-42-3	p-Xylene	ND,Q	0.2
108-38-3	m-Xylene	ND,Q	0.2
95-47-6	o-Xylene	ND	0.1

SURROGATES

98-08-8 a,a,a-Trifluorotoluene 103% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.
- DET LIMIT = DETECTION LIMIT
- ND = not detected at detection limit
- NA = not analyzed
- * = less than 5 times the detection limit
- N\A = not available
- Second column confirmation NOT performed unless otherwise noted.
- Q = daily EPA standard recovery outside 95% confidence interval.

RADIAN CORPORATION

Lab ID [illegible]
Analyzed: 08/06/87

RAS - Austin REPORT
Results by Sample

Work Order # 87-08-025

SAMPLE ID reagent blank

FRACTION 04A TEST CODE EPA602 NAME EPA method 602
Date & Time Collected 07/21/87 Category ______

VERIFIED CL

ANALYST CL
DILUTION [illegible]

INJECTED 08/06/87

FILE # ______

UNITS ug/L

CAS#	COMPOUND	RESULT	DET LIMIT
71-43-2	Benzene	ND	0.2
108-88-3	Toluene	ND	0.2
100-41-4	Ethylbenzene	ND	0.3
108-90-7	Chlorobenzene-A	ND	0.3
106-46-7	1,4-Dichlorobenzene	ND	0.3
541-73-1	1,3-Dichlorobenzene	ND	0.4
95-50-1	1,2-Dichlorobenzene	ND	0.4

SURROGATES

98-08-8	a,a,a-Trifluorotoluene	N/A%	recovery

NOTES AND DEFINITIONS FOR THIS REPORT.
DET LIMIT = DETECTION LIMIT
ND = not detected at detection limit
NA = not analyzed
* = less than 5 times the detection limit
N\A = not available
Second column confirmation NOT performed unless otherwise noted.

RADIAN CORPORATION

Received: 08/12/87

RAS - Austin REPORT
Results by Sample

Work Order # 87-05-025
Continued From Above

FILE ID 870731120O

FRACTION 03A TEST CODE EPA602 NAME EPA method 602
Date & Time Collected 07/31/87 Category

A-Chlorobenzene and m-xylene co-elute.
Quantitated as chlorobenzene unless
otherwise noted.

RADIAN
CORPORATION

Page 14 | RAS - Austin | REPORT | Work Order # 87-08-025

Received 08/06/87 | Results by Sample

SAMPLE ID Reagent blank | FRACTION 04A | TEST CODE XYLENE | NAME Xylenes, EPA 502

Date & Time Collected 07/31/87 | Category

VERIFIED CL

ANALYST CL | FILE # | UNITS ug/L

INSTRMT D | INJECTD 08/06/87

CAS #	COMPOUND	RESULT	DET LIMIT
106-42-3	p-Xylene	ND,G	0.2
108-38-3	m-Xylene	ND,G	0.2
95-47-6	o-Xylene	ND	0.1

SURROGATES

98-08-8 a,a,a-Trifluorotoluene N/A% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.

DET LIMIT = DETECTION LIMIT
ND = not detected at detection limit
NA = not analyzed
* = less than 5 times the detection limit
N\A = not available
Second column confirmation NOT performed unless otherwise noted.
G = daily EPA standard recovery outside 95% confidence interval.

RADIAN CORPORATION

 RAS - Austin REPORT Work Order # 87-08-025

[illegible]: 08/0[illegible]/87 NonReported Work

[illegible]ION AND TEST CODES FOR WORK NOT REPORTED ELSEWHERE

[illegible]	SPR602
[illegible]	SPR602
[illegible]	SPR602

RADIAN CORPORATION

RAS - Austin REPORT 09/17/87 15:49:09

Work Order # 87-09-082

Received: 09/15/87

REPORT TO: Geoscience Consultants, Ltd.
500 Copper NW
Suite 325
Albuquerque, NM 87102

ATTEN: CAJ Schleyer

PREPARED BY: Radian Analytical Services
8501 Mo-pac Bl.
PO Box 201088
Austin, TX 78720-1088

ATTEN:

PHONE: 512-454-4797

CERTIFIED BY

CONTACT: GIBSON

CLIENT: GEOSCIENCE SAMPLES: 3

COMPANY: Geoscience Consultants, Ltd.

FACILITY:

WORK ID: Gary Refinery

TAKEN: KH

TRANS: Fed Ex

TYPE:

P.O. #: 87-0290-100

INVOICE: under separate cover

Unknown compounds present in -02.

**Possible interference.

Footnotes and Comments

---

* Indicates a value less than 5 times the detection limit. Potential error for such low values ranges between 50 and 100%.

@ Indicates that spike recovery for this analysis on the specific matrix was not within acceptable limits indicating an interferent present.

SAMPLE IDENTIFICATION

01	8709111600
02	8709111630
03	reagent blank

TEST CODES and NAMES used on this report

EPA602	EPA method 602
XYLENE	Xylenes, EPA 602

RADIAN CORPORATION

Received: 09/15/87

RAS - Austin REPORT
Results by Sample

Work Order # 87-09-082

SAMPLE ID 8709111600 MW-12 FRACTION 01A TEST CODE EPA602 NAME EPA method 602
Date & Time Collected 09/11/87 Category

VERIFIED CL

ANALYST CL
INSTRMT D

INJECTED 09/16/87 FILE # UNITS ug/L

CAS#	COMPOUND	RESULT	DET LIMIT
71-43-2	Benzene	ND	0.2
108-88-3	Toluene	ND	0.2
100-41-4	Ethylbenzene	ND	0.3
108-90-7	Chlorobenzene-A	ND	0.3
106-46-7	1,4-Dichlorobenzene	ND	0.3
541-73-1	1,3-Dichlorobenzene	ND	0.4
95-50-1	1,2-Dichlorobenzene	ND	0.4

SURROGATES

98-08-8	a,a,a-Trifluorotoluene	107% recovery	

NOTES AND DEFINITIONS FOR THIS REPORT.
DET LIMIT = DETECTION LIMIT
ND = not detected at detection limit
NA = not analyzed
* = less than 5 times the detection limit
N\A = not available
Second column confirmation NOT performed unless otherwise noted.

RADIAN CORPORATION

RAS - Austin REPORT

Results by Sample

Work Order # 87-09-082

Continued From Above

Received: 09/15/87

SAMPLE ID 8709111600 MW-12 FRACTION 01A TEST CODE EPA602 NAME EPA method 602

Date & Time Collected 09/11/87 Category

A-Chlorobenzene and m-xylene co-elute.
Quantitated as chlorobenzene unless
otherwise noted.

RADIAN CORPORATION

RAS - Austin REPORT
Results by Sample

Work Order # 87-09-082

Received: 09/15/87

SAMPLE ID 8709111600 MW-12 FRACTION 01A TEST CODE XYLENE NAME Xylenes, EPA 602
Date & Time Collected 09/11/87 Category ____

VERIFIED CL

ANALYST CL
INSTRMT D
INJECTD 09/16/87
FILE # ____
UNITS ug/L

CAS #	COMPOUND	RESULT	DET LIMIT
106-42-3	p-Xylene	ND	0.2
108-38-3	m-Xylene-A	ND	0.2
95-47-6	o-Xylene	ND	0.1

SURROGATES

98-08-8 a,a,a-Trifluorotoluene 107% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.
- DET LIMIT = DETECTION LIMIT
- ND = not detected at detection limit
- NA = not analyzed
- * = less than 5 times the detection limit
- N\A = not available
- Second column confirmation NOT performed unless otherwise noted.
- Q = daily EPA standard recovery outside 95% confidence interval.
- Chlorobenzene and m-xylene co-elute. Quantitated as chlorobenzene unless otherwise noted.

RADIAN CORPORATION

Received: 09/15/87

RAS - Austin REPORT
Results by Sample

Work Order # 87-09-062

SAMPLE ID 8709111630 mw-11 FRACTION 02A TEST CODE EPA602 NAME EPA method 602
Date & Time Collected 09/11/87 Category ______

VERIFIED CL

ANALYST CL
INSTRMT D
INJECTED 09/16/87
FILE # ______
UNITS ug/L

CAS#	COMPOUND	RESULT	DET LIMIT
71-43-2	Benzene	6200	50
108-88-3	Toluene	ND	10
100-41-4	Ethylbenzene	350	20
108-90-7	Chlorobenzene-A	ND	20
106-46-7	1,4-Dichlorobenzene	ND	20
541-73-1	1,3-Dichlorobenzene	ND	20
95-50-1	1,2-Dichlorobenzene	ND	20

SURROGATES

98-08-8	a,a,a-Trifluorotoluene	133**% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.
DET LIMIT = DETECTION LIMIT
ND = not detected at detection limit
NA = not analyzed
* = less than 5 times the detection limit
N\A = not available
Second column confirmation NOT performed unless otherwise noted.

RADIAN CORPORATION

Received: 09/15/87

RAS - Austin REPORT
Results by Sample

Work Order # 87-09-082
Continued From Above

SAMPLE ID 8709111630 mw-11 FRACTION 02A TEST CODE EPA602 NAME EPA method 602
Date & Time Collected 09/11/87 Category

A-Chlorobenzene and m-xylene co-elute.
Quantitated as chlorobenzene unless otherwise noted.

RADIAN
CORPORATION

RAS - Austin REPORT
Results by Sample

Work Order # 87-09-082

Received: 09/15/87

SAMPLE ID 8709111630 MW-11 FRACTION 02A TEST CODE XYLENE NAME Xylenes, EPA 602
Date & Time Collected 09/11/87 Category ______

VERIFIED CL

ANALYST CL FILE # ______
INSTRMT D INJECTD 09/16/87 UNITS ug/L

CAS #	COMPOUND	RESULT	DET LIMIT
106-42-3	p-Xylene	2300	50
108-38-3	m-Xylene-A	8300	50
95-47-6	o-Xylene	110	5

SURROGATES

98-08-8 a,a,a-Trifluorotoluene 133**% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.
- DET LIMIT = DETECTION LIMIT
- ND = not detected at detection limit
- NA = not analyzed
- * = less than 5 times the detection limit
- N\A = not available
- Second column confirmation NOT performed unless otherwise noted.
- G = daily EPA standard recovery outside 95% confidence interval.
- Chlorobenzene and m-xylene co-elute. Quantitated as chlorobenzene unless otherwise noted.

RADIAN CORPORATION

Received: 09/15/87

RAS - Austin REPORT
Results by Sample

Work Order # 87-09-082

SAMPLE ID reagent blank

FRACTION 03A TEST CODE EPA602 NAME EPA method 602
Date & Time Collected not specified Category

VERIFIED CL

ANALYST CL
INSTRMT D

INJECTED 09/16/87

FILE #

UNITS ug/L

CAS#	COMPOUND	RESULT	DET LIMIT
71-43-2	Benzene	ND	0.2
108-88-3	Toluene	ND	0.2
100-41-4	Ethylbenzene	ND	0.3
108-90-7	Chlorobenzene-A	ND	0.3
106-46-7	1,4-Dichlorobenzene	ND	0.3
541-73-1	1,3-Dichlorobenzene	ND	0.4
95-50-1	1,2-Dichlorobenzene	ND	0.4

SURROGATES

98-08-8 a,a,a-Trifluorotoluene N/A% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.

DET LIMIT = DETECTION LIMIT
ND = not detected at detection limit
NA = not analyzed
* = less than 5 times the detection limit
N\A = not available
Second column confirmation NOT performed unless otherwise noted.

RADIAN CORPORATION

Received: 09/15/87

RAS - Austin REPORT

Results by Sample

Work Order # 87-09-082

Continued From Above

SAMPLE ID reagent blank FRACTION 03A TEST CODE EPA602 NAME EPA method 602

Date & Time Collected not specified Category

A-Chlorobenzene and m-xylene co-elute. Quantitated as chlorobenzene unless otherwise noted.

RADIAN CORPORATION

Received: 09/15/87

RAS - Austin REPORT
Results by Sample

Work Order # 87-09-082

SAMPLE ID reagent blank

FRACTION 03A TEST CODE XYLENE NAME Xylenes, EPA 602
Date & Time Collected not specified Category ______

VERIFIED CL

ANALYST CL
INSTRMT D

INJECTD 09/16/87

FILE # ______

UNITS ug/L

CAS #	COMPOUND	RESULT	DET LIMIT
106-42-3	p-Xylene	ND	0.2
108-38-3	m-Xylene-A	ND	0.2
95-47-6	o-Xylene	ND	0.1

SURROGATES

98-08-8 a,a,a-Trifluorotoluene N/A% recovery

NOTES AND DEFINITIONS FOR THIS REPORT.

- DET LIMIT = DETECTION LIMIT
- ND = not detected at detection limit
- NA = not analyzed
- * = less than 5 times the detection limit
- N\A = not available
- Second column confirmation NOT performed unless otherwise noted.
- Q = daily EPA standard recovery outside 95% confidence interval.
- Chlorobenzene and m-xylene co-elute. Quantitated as chlorobenzene unless otherwise noted.

RADIAN CORPORATION

 RAS - Austin REPORT Work Order # 87-09-082
Received: 09/15/87 NonReported Work

FRACTION AND TEST CODES FOR WORK NOT REPORTED ELSEWHERE

01B : SPR602
02B : SPR602

APPENDIX B

LITHOLOGIC LOGS

LITHOLOGIC LOG

LOCATION MAP:

___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: BRC LOCATION ID: MW-11

SITE COORDINATES (ft.):

N ____ E ____

GROUND ELEVATION (ft. MSL): ____

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: AIR CASING DRIVER ROTARY

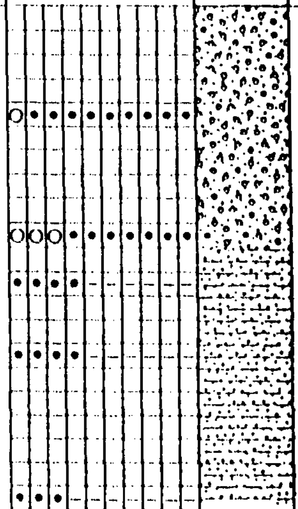
DRILLING CONTR.: BEEMAN

DATE STARTED: 7-31-87 DATE COMPLETED: 7-31-87

FIELD REP.: KASZUBA/SELKE

COMMENTS: STEAM CLEANED RIG AND ALL TOOLS PRIOR TO DRILLING.

LOCATION DESCRIPTION: TD 21'



Depth	Drilling Time Scale:	Sample Type and Interval	Lithologic Description	
5		0- 5'	0 - 5'	SAND, mod yelsh brn (10YR5/4), fine to med. gr. sand w/minor crs gr. sand and pebble gravel (up to 1"). Unconsolidated, moderately well sorted, subrounded, no odor.
10		5-10'	5 -10'	GRAVELLY SAND, olive gray (5Y4/1), fine to med. gr. sand w/minor crs gr. sand unconsolidated, mod. well sorted, subrounded, gravel clasts (½" to 2") subrounded. Moderate degradation odor.
15		10-12½'	10 -12.½'	SANDY CLAY, lt. olive gray (5Y5/2), fine to med. gr. sand in clay matrix no odor.
		12½-15'	12½-15'	SANDY CLAY, as above.
20		15-21'	15 -21'	SANDY CLAY, yelsh gray (5Y7/2), fine gr. sand in clay matrix, clay chips up to 1½" from moderately consolidated clay (or weathered shale).
25			NOTE:	Saturation from ~7-8' to ~12½'
30				
35				
40				
45				
50				

LITHOLOGIC LOG

LOCATION MAP:

___1/4 ___1/4 ___1/4 ___1/4 S___ T___ R___

SITE ID: BRC LOCATION ID: MW-12

SITE COORDINATES (ft.):

N ________ E ________

GROUND ELEVATION (ft. MSL): ________

STATE: NEW MEXICO COUNTY: SAN JUAN

DRILLING METHOD: AIR CASING DRIVER ROTARY

DRILLING CONTR.: BEEMAN BROTHERS

DATE STARTED: 8-1-87 DATE COMPLETED: 8-1-87

FIELD REP.: KASZUBA

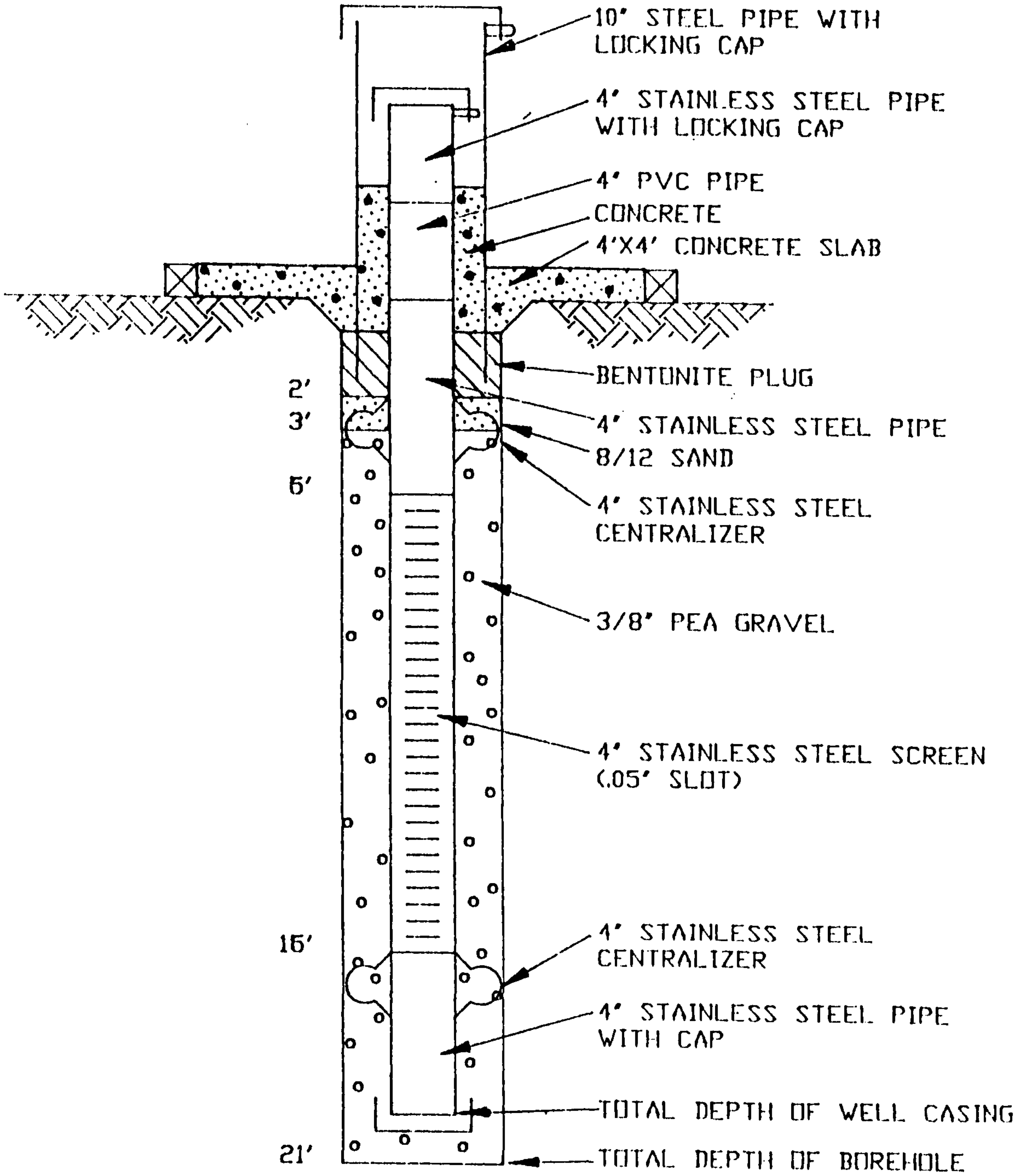
COMMENTS: SATURATED FROM ~5'--~12'. TD=17'. STEAM-CLEANED ALL TOOLS PRIOR TO DRILLING.

LOCATION DESCRIPTION: ________

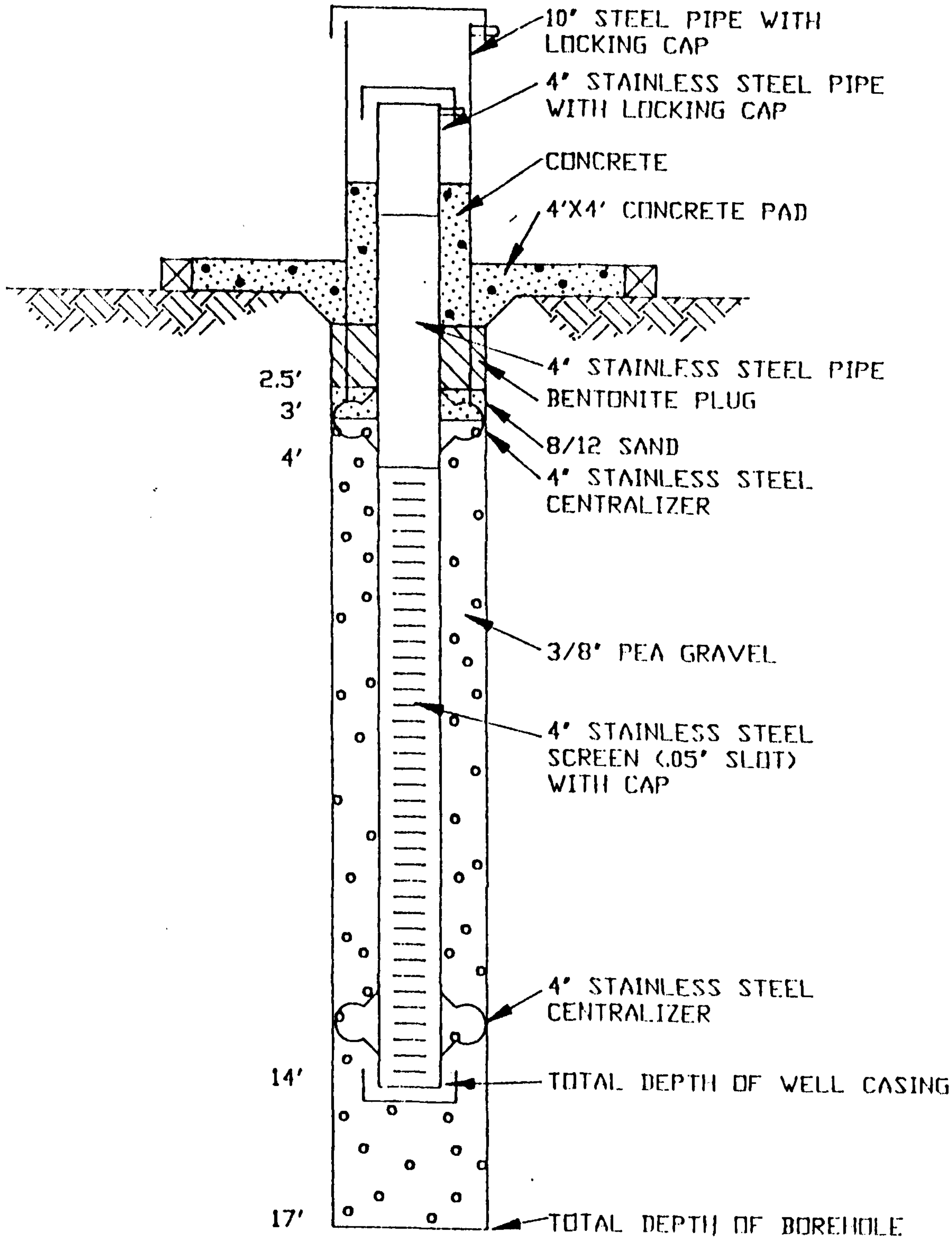
Depth	Drilling Time Scale:	Sample Type and Interval	Lithologic Description
5		0- 5'	0- 5' SAND, mod yellowish brwn (10YR5/4), fine-to med-grained sand, unconsolidated, well-sorted, subrounded. No HC odor. Saturated @ ~5'.
		5- 9'	5- 9' SAND, as above. Saturated. Gravelly sand @ 9'. Subrounded gravel, 2" dia.
10		9-10'	9-10' SANDY CLAY, dusky yellow (5Y6/4), fine-to med-gr sand in clay matrix. No HC odor. Saturated.
15		10-15'	10-15' SANDY CLAY, as above. Minor chips of clay (shale), ~10%. Saturated to ~12'.
		15-16'	15-16' SANDY CLAY, as above. Clay chips up to ½" (moderately consolidated clay or weathered shale). Contains <10% gypsum. No HC odor.
20		16-17'	16-17' CLAYEY SAND, dusky yellow (5Y6/4), sand is fine-grained, well-sorted, No HC odor.
25			
30			
35			
40			
45			
50			

APPENDIX C

MONITOR WELL COMPLETION DIAGRAMS, MATERIAL SPECIFICATIONS, PUMP SPECIFICATIONS



MONITOR WELL MW-11



MONITOR WELL MW-12

PVC PLASTIC PRODUCTS

- Sonic welded wires and rods produce a high-strength PVC screen with continuous slots.
- More open area per given slot size than any other non-metallic screen available.
- Resists corrosion from salts and gases commonly found in either fresh or salt waters.
- The only continuous slot non-metallic screen available without a restricting pipe base.
- Coarse threads reduce make up time and lessen chances of cross-threading.
- Chemically inert O-ring produces tight, leak-proof joints.
- Thermally attached fittings avoid need for field solvent welding which can jeopardize sample accuracy.
- PVC product threads are compatible with stainless steel product threads.
- Stainess steel locking cap can be used with PVC casing.
- Screen and casing individually wrapped for sanitary protection during shipment. Special cleaning procedures are used on each piece prior to packaging.

SCREENS

SCREEN SIZE	DIAMETER (IN.)		SHIP WT (LB/FT)	OPEN AREA	
	O.D.	I.D.		10-SLOT (.010")	20-SLOT (.020")
2 INCH	2.375	1.875	0.8	6.8	12.8
4 INCH	4.620	4.000	1.7	11.9	22.2
5 INCH	5.563	4.810	2.5	13.1	24.7
6 INCH	6.625	5.690	3.2	13.2	25.0

CASING

CASING SIZE	CASING O.D. (IN.)	FITTING I.D. (IN.)	SHIP WT (LB/FT)
2 INCH	2.375	2.067	0.7
4 INCH	4.500	4.026	2.0
5 INCH	5.563	5.033	2.7
6 INCH	6.625	5.993	3.5

- 2 and 4 inch casing are Schedule 40; 5 and 6 inch sizes are SDR21.
- All casing meets ASTM F480 81 specifications.

MATERIALS STRENGTH DATA

NOMINAL SIZE	O.D. (IN.)	I.D. (IN.)	WT LB/FT	STRENGTH			
				COLLAPSE (PSI)	TENSILE (LB)	COLUMN (LB)[1]	JOINT TENSILE (LB)
2" sched. 40 casing	2.375	2.067	.64	307	7,500	90	1,800
2" sched. 80 casing	2.375	1.939	.88	947	9,875	125	1,800
2" wire wound screen	2.375	1.875	.8	99	1,800	25	1,800
4" sched. 40 casing	4.500	4.026	1.9	158	22,200	1,030	6,050
4" sched. 80 casing	4.500	3.826	2.6	494	30,850	1,375	6,050
4" wire wound screen	4.620	4.000	1.7	79	2,250	150	6,050
5" sdr-21 casing	5.563	5.033	2.8	110	30,870	2,200	6,050
5" sched. 80 casing	5.563	4.813	3.9	324	42,780	2,940	6,050
5" wire wound screen	5.560	4.810	2.5	79	4,610	307	6,050
6" sdr-21 casing	6.625	5.993	4.0	110	43,840	4,440	4,000
6" sched. 80 casing	6.625	5.761	5.4	292	58,830	5,760	4,000
6" wire wound screen	6.620	5.680	3.7	87	5,770	552	4,000

1. For all column calculations: span = 20 ft, hinged one end, fixed other end.
2. For PVC, Y_p = 7,000psi, E = 415,000psi, μ = .5.

STAINLESS STEEL PRODUCTS

- Stainless steel provides high strength, long life and minimum interference with sample analyses.
- The material of choice when organic contaminants are present.
- Continuous slot construction produces high per cent open area. Greater volume of water can enter a shorter length of screen which allows more representative sampling.
- Flush joints between screen and casing mean sampling devices won't hang up inside. Filter pack and backfill won't bridge outside.
- Patented locking cap available for protection of the well.
- Coarse thread minimizes make-up time and reduces chance of cross-threading.
- Chemically inert O-ring creates a stronger, tighter seal for leak-proof screen and casing joints.
- Readily available in type 304 stainless steel. 316 stainless steel and other metals available upon request.
- Drive points available in 1¼ in. and 2 in. diameter.
- Screen and casing individually wrapped for sanitary protection during shipment. Special cleaning procedures are used on each screen and length of casing prior to packaging.

SCREENS

SCREEN SIZE	DIAMETER (IN.)		SHIP WT (LB/FT)	OPEN AREA (IN.²)	
	O.D.	I.D.		10-SLOT (.010")	20-SLOT (.020")
1¼ INCH	1.660	1.130	3.0	9.7	17.0
2 INCH	2.375	1.900	4.0	13.2	23.1
4 INCH	4.500	4.000	6.0	25.8	44.9
5 INCH	5.563	5.000	7.5	31.3	54.6
6 INCH	6.625	6.065	9.0	29.5	52.9

CASING

CASING SIZE	CASING O.D. (IN.)	FITTING I.D. (IN.)	SHIP WT (LB/FT)
1¼ INCH	1.660	1.380	1.2
2 INCH	2.375	2.067	1.7
4 INCH	4.500	4.026	4.0
5 INCH	5.563	5.047	6.5
6 INCH	6.625	6.065	7.7

■ Casing is Schedule 5S and meets ASTM spec A312 or A778.

MATERIALS STRENGTH DATA

NOMINAL SIZE	O.D. (IN.)	I.D. (IN.)	WT LB/FT	STRENGTH			
				COLLAPSE (PSI)	TENSILE (LB)	COLUMN (LB)¹	JOINT TENSILE (LB)
2" sched. 40 casing	2.375	2.067	3.653	3,526	85,900	6,350	15,900
2" sched. 5 casing	2.375	2.245	1.604	896	37,760	3,000	15,900
2" wire wound screen	2.375	1.900	4.0	1,665	10,880	810	15,900
4" sched. 40 casing	4,500	4.026	10.790	2,672	254,400	69,000	81,750
4" sched. 5 casing	4,500	4.334	3.915	315	92,000	26,800	81,750
4" wire wound screen	4.500	4.000	6.0	249	16,320	4,500	81,750
5" sched. 40 casing	5.563	5.047	14.6	2,231	343,200	145,490	91,500
5" sched. 5 casing	5.563	5.345	6.4	350	148,800	66,660	91,500
5" wire wound screen	5.560	5.030	4.8	134	38,600	13,040	91,500
6" sched. 40 casing	6.625	6.065	19.0	1,942	444,800	270,000	94,500
6" sched. 5 casing	6.625	6.407	7.6	129	178,400	113,660	94,500
6" wire wound screen	6.620	6.090	5.5	176	54,000	19,170	94,500

1. For all column calculations: span = 20 ft, hinged one end, fixed other end.
2. For stainless steel: Tensile strength = 80,000 psi

OUR TOP OF THE LINE
Specialty Sands

Modern filtration and gravel pack methods require a filter medium that is 98% within specifications. This type of screening efficiency was virtually unheard of several years ago. Today, we produce these exotic materials on a daily basis. In fact, if you order a specialty sand, we'll screen it to a 99% spec to further assure satisfaction after shipping and handling.

Additional Exotic Sand Tests

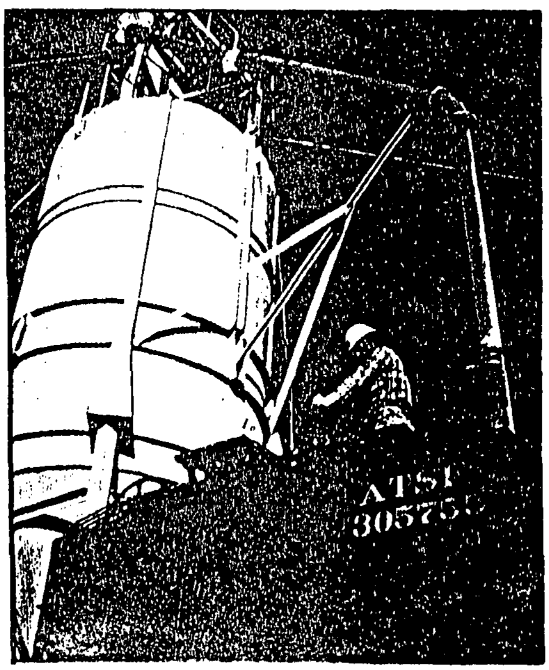
Test	Sample Designation 10-14	Sample Designation 10-16	Specification Limit
Mud-Acid Soluble, Wt. %:			
Frac Sand	1.74	1.96	2.00 Max.
Gravel Pack Sand	0.91	0.89	1.00 Max.
Gravel Pack Crush Strength			
Gove Canyon 20-40 %	3.20		4.00 Max.

Size	98-100% Passing	98-100% Retained
6-9	#6 sieve	#10 sieve
8-12	#8	#12
10-14	#10	#14
10-16	#10	#16
16-20	#16	#20
20-30	#20	#30
20-40	#20	#40
40-60	#40	#60

Note: Materials processed to your Uniformity Coefficient and Effective Size, by separate quotation.

A Word of Caution—Since test results do vary, it is recommended that you confirm with your own lab your specification requirements and the physical and chemical characteristics of this product. We give no warranty for our products either expressed or implied.

Warning: This material contains free silica—do not breathe dust. May cause delayed lung injury. Wear government approved respirators and follow OSHA Safety and Health Standards for Silica.



Common Applications of CSSI Products:

- Water Well Gravel Pack
- Waste Water Treatment Filtration
- Water Filtration
- Hydro-fracturing Sand
- Oil and Gas Well Gravel Pack
- Industrial Grout
- Sandblasting Sand
- Foundry Sand
- Glass Sand

Colorado Silica Sand, Inc.
3250 Drennan Industrial Loop
P.O. Box 15615
Colorado Springs, CO 80935
Telephone (303) 390-7969
TWX 910-920-4992

THE MAINSTAY OF OUR BUSINESS
Standard Products

We have two distinctly different types of deposits to serve a complete spectrum of industries. Our Colorado Springs deposits are unique in that the sand sizes range from 4 mesh to 100 mesh. Our Gove Canyon Sand is better suited to serve the finer size applications and exotic specialty sands.

COLORADO SPRINGS SAND

Chemical Determination Description	Sample Size Designation Mesh				
	−4 +8	−8 +12	−10 +20	−20 +40	−40
SiO_2, % (Coffeen Method)	97.3	98.2	97.8	94.5	83.9
Al_2O, %	0.45	0.49	1.20	3.20	7.08
MgO, %	0.01	0.01	0.01	0.01	0.03
CaO, %	0.02	0.02	0.03	0.03	0.07
K_2O, %	0.17	0.21	0.60	2.12	4.96
Na_2O, %	0.05	0.06	0.17	0.34	0.58
Fe_2O_3, %	0.15	0.14	0.12	0.17	0.79
TiO_2, %	0.02	0.02	0.02	0.02	0.14
LOI, %	0.26	0.40	0.33	0.21	0.43
Feldspar	1.50	1.80	5.10	15.60	34.60
Acid Soluble, 15% HCl, %	0.28	0.07	0.34	0.32	0.98
Mud Acid Solubility (3HF:12HCl)	1.10	1.41	2.26	4.44	6.21
Acid Demand at Ph 3	2.80	0.31	0.31	3.80	5.60
at Ph 5	0.80	0.90	1.00	1.60	2.80
at Ph 7	0.40	0.50	0.60	1.10	1.80
Specific Gravity	2.63	2.64	2.62	2.63	2.61
AWWA Porosity	45.20	45.20	45.60	47.10	48.20

GOVE CANYON SAND

Chemical Determination Description	Sample Size Designation Mesh	
	−20 +40	−40 +140M
Fe_2O_3	0.040	0.053
CaO	0.025	0.055
Al_2O_3	0.12	0.37
MgO	0.013	0.022
Na_2O	0.010	0.013
K_2O	0.048	0.19
TiO_2	0.013	0.012
LOI (1000°C)	0.30	0.18
SiO_2 (by difference)	99.43	99.10
Acid Solubility (15% HCL)	0.15	0.22
Mud Acid Solubility (3HF:12HCl)	2.2	5.1
Acid Demand at pH 3	6.3	6.5
at pH 5	5.5	4.9
at pH 7	4.3	3.8
Specific Gravity	2.62	2.58
Bulk Density—uncompacted #/ft³	89.6	93.3
compacted	97.0	98.7
AWWA Porosity	44.7	
Krumbein Roundness	.6 - .8	
Sphericity	.6 - .8	

No apparent fusion at 2810°F

Colorado Silica Sand, Inc.

3250 Drennan Industrial Loop
P.O. Box 15615
Colorado Springs, Colorado 80935
Phone (303) 390-7969
TWX: 910-920-4992

CONVERSION CHART

OPENINGS		U.S.	TYLER
Millimeters	Inches	STANDARD	MESH
5.66	0.223	3-1/2	3-1/2
4.76	0.187	4	4
4.00	0.157	5	5
3.36	0.132	6	6
2.83	0.111	7	7
2.38	0.0937	8	8
2.00	0.0787	10	9
1.68	0.0661	12	10
1.41	0.0555	14	12
1.19	0.0469	16	14
1.00	0.0394	18	16
.841	0.0331	20	20
.707	0.0278	25	24
.595	0.0234	30	28
.500	0.0197	35	32
.420	0.0165	40	35
.354	0.0139	45	42
.297	0.0117	50	48
.250	0.0098	60	60
.210	0.0083	70	65
.177	0.0070	80	80
.149	0.0059	100	100
.125	0.0049	120	115
.105	0.0041	140	150
.088	0.0035	170	170
.074	0.0029	200	200

GCL Recovery Pump

The GCL recovery pump, designed and perfected by Geoscience Consultants, Ltd. (GCL) is engineered to cost-effectively recover floating hydrocarbons and associated contaminated ground water from small diameter wells. Its design offers several important benefits:

- Efficient, non-explosive design
- Reliable, cost-effective operation
- Fits wells as small as 2" diameter
- Components are readily accessible and replaceable
- Minimizes pumped water associated with floating liquids
- Excellent results in low-yield wells (<2 gpm)
- Single pump, low cost design
- Stainless steel (304) Unibody construction

The pump skims floating liquids when installed at the proper level in a well. The air-powered pump operates on a pulsating cycle as follows:

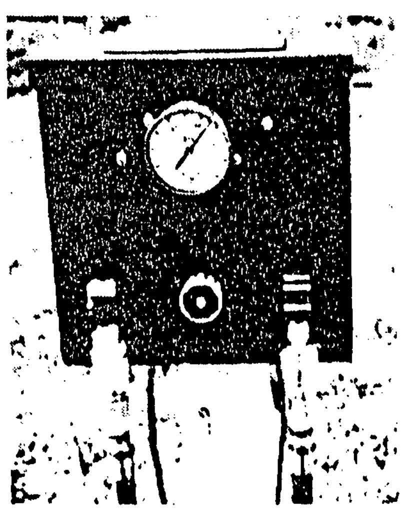
- The cylindrical body of the pump fills with floating liquids from the top.
- When the pump becomes full of liquid, automatic sensors apply air pressure which forces up the discharge hose to the well head.
- After liquid discharge, air pressure is removed and the pump again fills with floating liquids.
- Operation of the pump is controlled by float switches and electro-pneumatic controls; the direction of flow is controlled by check valves in both the inlet and outlet.

The pump operates on the principle of pneumatic ejection. Pneumatic ejectors have been used reliably for many years in sewage lift stations.

The GCL pump offers many advantages not found on any other currently available competitive product. These unique advantages are briefly described below:

- Miniature float switches are installed inside the pump body to sense when the pump is full and when it is empty. These custom-made float switches, along with their associated circuitry, provide precise control of pump operation. Other commercially available pump designs use electric or pneumatic timers to cycle the pump on and off.
- A specically designed free-flowing check valve is used at the pump inlet to provide for unrestricted flow into the pump, allowing faster filling and less clogging with emulsified hydrocarbon and sand.
- Pump components are readily accessible and easily replaceable.

The GCL pump is ideal for small diameter or low-yield hydrocarbon recovery wells. It has proven its usefulness in many UST clean-ups and RCRA/CERCLA corrective actions.



Specifications

TYPE: Top-filling, automatic cycling, air-operated displacement pump for removing liquids and contaminants from monitor or recovery wells. Pump is supplied complete with controls and 50 feet of hose and control cable, ready to be placed in a well and plugged into a standard 115 V outlet and air compressor.

DIAMETER: 1.6 in. OD. Inquire about larger diameter models.

LENGTH: 5 ft. 6 in.

MATERIALS: Type 304 stainless steel case with brass fittings, PE discharge tube, and oil-resistant rubber air and water hoses.

RATE: 0.5 to 0.75 gpm depending on pumping depth, inlet head and air pressure

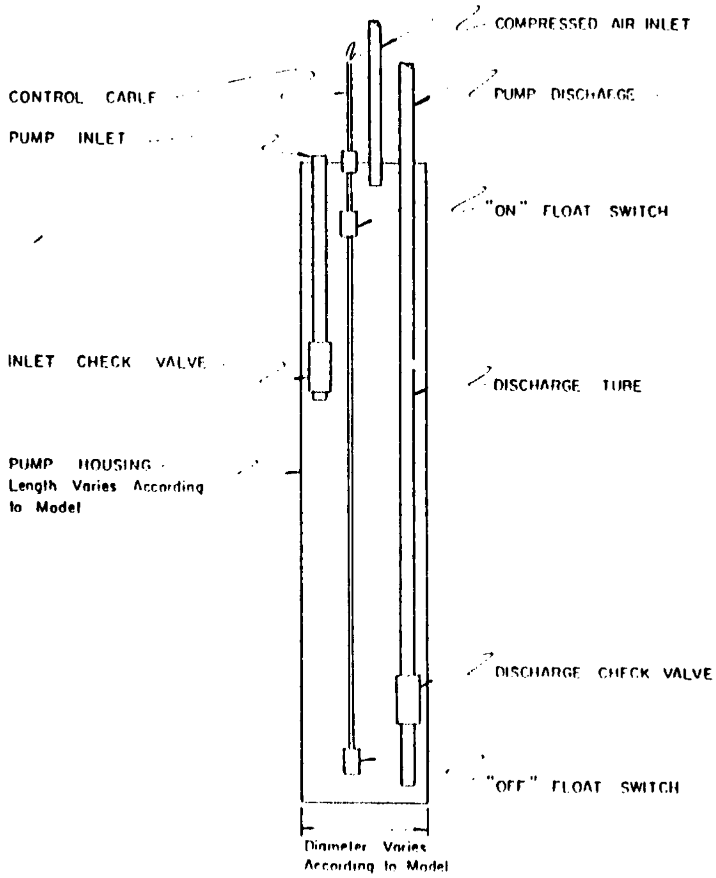
CONTROLLER: Weatherproof control box with air regulator, pressure gauge, power supply, control relay, solenoid valve and ancillary components.

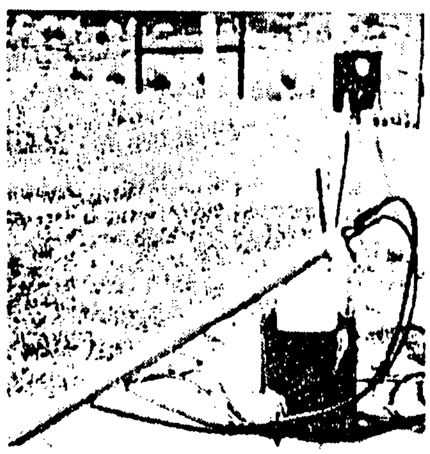
FLOW METER: A cycle counter is used to determine cumulative flow based on the measured quantity per cycle.

POWER REQUIREMENTS: 115 vac, 1 amp power input is converted in the control box to 24 vac operating voltage. A remote 24 vac supply is available.

AIR REQUIREMENTS: 50 psi compressed air at 0.25 cfm

WARRANTY
GCL pumps carry a 90 day parts and labor warranty against defective materials or workmanship.





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APPENDIX D

GCL STANDARD OPERATING PROCEDURE FOR AQUIFER TEST PUMPING

DRAFT

1.0 PURPOSE

To define procedures that shall be used while performing pump and aquifer tests.

2.0 SCOPE

Properly conducted pump and aquifer tests are useful for defining the yield of recovery wells, the extent of contaminant capture zones during recovery operations, and the transmissive and storage properties of contaminated aquifers. Results of aquifer and pump tests can be used to aid in the determination of groundwater velocity and rates of advective contaminant plume migration and in the development of remedial action strategies for contaminated aquifers.

The following guidelines should be used to conduct these tests in a consistent and technically defensible manner. Since the same data is to be collected regardless of whether pump performance or aquifer properties are to be evaluated, the test will henceforth be referred to as a pump test throughout the remainder of this document.

3.0 PROCEDURE

3.1 PUMP TEST DESIGN

The pump test should be carefully designed prior to its actual implementation in order to minimize the possibility of test failure. Failure of the test may be attributed to any number of factors, including unsatisfactory well construction or development, inadequate test duration, malfunctioning equipment, or poor well placement. Time expended in planning the test on the basis of expected aquifer and pump properties will be worth the effort if a useless test can be avoided. Always plan the test according to expected conditions and incorporate features that can be used to alter procedures in the event that contingencies arise.

3.1.1 Determine Well Placement

Evaluate the methods that were used to install private wells near the proposed pump test site. If necessary, talk to well owners or drillers in order to obtain detailed well construction specifications. If these wells were constructed, completed and developed properly, they may be used as monitor wells. Since even the best well-construction documentation will contain some uncertainty, it is not recommended that existing wells be used as pump wells. The potential for vertical migration of contaminants through poorly-sealed wells is usually sufficient reason for not using an existing well as the pump well.

When siting for proposed wells, try to keep pump and observation wells within a homogeneous area of the aquifer where the piezometric gradient is small so that conditions will better conform to the Theis assumptions. Stay away from roads or railways; movement of cars or trains may introduce significant perturbations to the drawdown data during the test. Try to stay away from obvious recharge boundaries such as lakes, reservoirs, or flowing streams and from potential barrier boundaries related to lateral changes in lithology to lower-permeability units.

Observation wells should be located sufficiently close to the pump well to permit rapid, accurate measurement of hydraulic response but, in the case of aquifer testing, sufficiently far to allow representative, regional estimates of aquifer properties to be obtained. Observation wells should be placed close to the pump well in unconfined aquifers because pumping stresses are not propagated rapidly or over large distance under unconfined conditions. They can be placed at much farther distances under confined conditions due to the more rapid, areally-extensive drawdown response characteristic of confined aquifers. Placement of observation wells should also be based on expected transmissivity and estimated sustainable discharge. For low transmissivity or small sustainable discharge, pumping stresses will not propagate over significant distances, and the distance between pump and observation wells should be smaller than for the case of large transmissivity or discharge. It is recommended that drawdown observation wells be placed anywhere from 10 to 100 meters (30 to 300 feet) from the pump well in unstratified aquifers and from 100 to 250 meters (300 to 700 feet) in thick, stratified aquifers to minimize the effects of stratification (Driscoll, 1979; Kruseman and DeRidder, 1970). When in doubt, place observation wells sufficiently close to the pump well to minimize drawdown response time and to reduce the potential for insufficient drawdown and boundary effects.

If the pump well is partially-penetrating, observation wells should be placed at a distance of 1.5 b $(K_r/K_2)^{1/2}$, where b= initial aquifer saturated thickness, K_r=estimated horizontal hydraulic conductivity, and K_2=estimated vertical hydraulic conductivity (Stallman, 1971). Induced vertical flow will become negligible at this distance.

At least one observation well should be monitored during a pump test, since the storage coefficient cannot be calculated on the basis of drawdown response observed only at the pump well. Clearly, a greater number of observation wells will produce the most extensive amount of information relating to transmissive and storage characteristics of the aquifer, including anisotropy, delayed yield, and vertical leakage properties. Use of data from more than one observation well allows pump-test analysis on the basis of drawdown versus distance data as well as drawdown versus time data. Moreover, use of a large number of observation wells makes it less likely that nonrepresentative results or poor well development will adversely bias the test results, since average aquifer properties can be defined using data observed at all observation wells.

If pre-test water-level variations are not monitored, at least one observation well should be located outside of the expected cone of depression in order to monitor natural changes in depth to water due to variation of barometric pressure or other uncontrollable stresses affecting static water levels. Due to the high cost of well construction relative to the worth of this information, an existing well should be used for this purpose whenever possible.

Always install and develop the pump well before installing any observation wells. If discharge sufficient to produce measurable drawdown in the pump well can not be sustained, the pump test will be a failure regardless of how well-constructed and well-developed the observation wells are. Transmissivity estimates obtained from slug, bailer or packer tests performed at the pump well should be used to refine the observation-well placement strategy.

3.1.2 Estimate Sustainable Well Discharge

Use estimated transmissivities obtained from previous pump, slug, bailer, or packer tests performed in the aquifer or in similar hydrologic media to calculate a sustainable discharge rate that will produce measurable drawdown in proposed pump and observation wells. Recovery data obtained following well development is also acceptable for estimating aquifer transmissivity. If core samples are available, estimate the hydraulic conductivity of each layer within the proposed screen interval, multiply by its approximate thickness, and sum over the entire depth corresponding to the screen interval. Using the estimate of transmissivity and an assumed storage coefficient based on observation of the incidence of clay or shale layers in the cores and an estimate of recharge, use the Theis equation to calculate the rate of discharge required to generate measurable drawdown at the pump and observation wells throughout the proposed duration of the test.

A number of practical considerations must be accounted for in defining sustainable well discharge during the test. Although a high discharge rate will generate large and rapid drawdown responses and will tend to mask small, uncontrollable natural water-level fluctuations related to diurnal evapotranspiration cycles or changes in barometric pressure, a large discharge rate may generate a volume of pumped water that exceeds the capacity of existing treatment and storage facilities. A high rate of discharge may also produce excessive well-entry velocities and friction losses that would tend to cause overestimated drawdown. Moreover, a high discharge rate could potentially dewater a significant proportion of the saturated thickness at the pump well, causing distorting partial penetration effects if vertical velocity components become sufficiently large. The hydrogeologist or geologist planning the test must consider all of these factors when defining the optimal rate of discharge at the proposed pump well.

3.1.3 Identify Optimal Pump-Test Duration

The optimal test duration will depend on the type of aquifer and on the degree of accuracy required in calculating specific discharge, transmissivity, and storativity. In general, the test should be sufficiently long to allow drawdown response to approach steady-state conditions within the bounds of measurement error, usually to the nearest 0.01 ft. Steady-state conditions are attained quickly in confined systems due to the elastic response of such aquifers. Twenty-four hour testing is usually sufficient to attain steady-state conditions in confined systems, while 2 or 3 days are generally required to attain steady-state conditions in unconfined aquifers. Longer duration tests yield more reliable data because Theis curve-matching procedures are more sensitive to the overall data when a fully-defined curve is generated. Tests of long duration also permit more comprehensive analysis of situations involving non-ideal aquifer behavior, including those influenced by boundary effects, partial penetration, delayed yield, vertical leakage, and conversion from artesian to water-table conditions. Since the marginal costs associated with continuing the pump test are generally small relative to the costs of design, equipment acquisition, and test set-up, the test should be conducted for as long a time as possible or until steady-state conditions are practically attained.

3.1.4 Install Pump Well and Observation Wells

> Refer to the GCL Standard Operating Procedure for Well Construction regarding general specifications for construction and completion of pump and observation wells.

Pump wells should be constructed in such a way as to produce measurable drawdown response in the aquifer when pumped at a sustainable rate of discharge. The diameter of the pump well must be sufficiently large to accommodate a pump with the desired capacity, and will ultimately depend on the sustainable discharge. Pump-well diameter should be made as small as possible in order to minimize distorting borehole storage effects and to maximize changes in drawdown per unit volume of discharged water, but sufficiently large to pump at the expected sustainable rate.

Whenever possible, the pump well casing should be screened to the bottom of the aquifer being tested to avoid problems associated with partial-penetration effects. If the pump well is to be used as a contaminant-recovery well, the well should be screened at least through 70 percent to 80 percent of the saturated thickness at the well to obtain 90 percent of the maximum yield (Kruseman and DeRidder, 1970). A long screen allows horizontal flow components to become dominant and is especially desirable when penetrating a highly-stratified aquifer for which vertical flow components greatly distort the transmissivity analysis.

The screened area of the pump well casing should be sufficiently large to maintain a well-entrance velocity of less than 0.1 ft/sec (Driscoll, 1986). If the discharge rate divided by screen area is greater than 0.1 ft/sec, friction losses may become significant and could produce overestimated drawdown. Screen size and gravel pack should be selected on the basis of aquifer grain size (see GCL Standard Operating Procedure for Well Construction).

As for the case of pump-well construction, smallest diameter casing should be used in constructing observation wells in order to minimize time lag effects due to borehole storage and to maximize drawdown response per unit volume of withdrawal. Screened intervals at all observation wells should be centered at the midpoint of the pump-well screen. If storage in a saturated clay layer is to be evaluated, the pump and observation wells should be screened in the clay only. If leakage through a saturated clay layer is to be analyzed, the observation well should be screened in the aquifer on the side of the clay layer opposite to the side in which the pump well is completed. The pump and observation wells should be properly sealed at the clay layer to prevent vertical seepage of water along the gravel pack. Refer to the GCL Standard Operating Procedure for Well Construction for details regarding sealing techniques.

Geologic or geophysical logging should be performed in representative boreholes at the pump test site prior to installation of casing. Information obtained from the logs can be used to refine estimates of transmissivity, sustainable discharge and well-placement and well-completion strategies as an ongoing process. The well heads should be surveyed in as soon as possible after all wells have been installed and developed. The survey must include northing, easting, elevation of land surface, and elevation of the drawdown measuring point. A map that includes this information should be constructed to aid test observers in locating widely-scattered observation wells.

Since pump wells are generally used as contaminant-recovery wells during subsequent implementation of remedial-action plans, frequently the pump well and some observation wells will be located within contaminated regions of the stressed aquifer. To the extent that contaminated ground water will be drawn radially toward the pump well, performance of the pump test will not exacerbate the contamination problem. It is imperative, however, that contaminated ground water in the stressed aquifer not be allowed to migrate vertically through underlying confining clay layers and into lower unstressed units in response to pump-testing, even if those units have already been impacted by the contaminant.

If a downward head differential occurs naturally between the stressed unit and underlying unstressed units and if contamination has affected the aquifer over a long period of time, some contamination of the underlying units has probably already occurred through the confining layer and pump-testing will somewhat alleviate the contamination potential by reducing the downward gradient. If an upward gradient prevails prior to the test, potential for contamination of the underlying units is already negligible and will be made even more negligible during pumping as the upward gradient becomes more pronounced. In either case, pump-testing in itself will not produce additional contamination potential. Potential for contamination of underlying units will occur, however, if the pump and observation well boreholes extend into the underlying units and if the installed wells are not sealed and completed properly. Under conditions of improper well completion and sealing, existing downward gradients would tend to accelerate downward migration of pollutants through the permeable gravel pack. Refer to the GCL Standard Operating Procedure for Well Construction for acceptable well-construction procedures.

Cross-contamination between pump and observation wells located in the plume area and observation wells sited in uncontaminated areas is an additional mechanism for increasing the extent of contamination beneath the site. All drilling equipment must undergo decontamination prior to installation of each borehole according to the procedures outlined in the GCL Standard Operating Procedure for Well Construction.

3.2 PERFORMANCE OF PUMP TEST

3.2.1 Obtain Required Equipment

Check out all equipment that will or may be needed to perform the pump test, including pump, data logger, steel tapes or probes, chalk, a valve or meter for measuring discharge, intake and discharge lines, air compressor, power source, watches, water quality sampling equipment, pump-test sheets, double- and semi-log paper, and pencils. Confirm that this equipment will be available during the scheduled pump-test duration in advance of the test.

The pump should be selected on the basis of expected sustainable well discharge. Maximum pump capacity should exceed the sustainable discharge rate. It should be capable of maintaining this rate for the planned duration of the test. 1 1/4-inch and 2-inch diameter air-lift pumps are available for discharges in the ranges of 0.5-1 gpm and 1-2 gpm, respectively. A 4-inch diameter centrifugal-jet pump is available for discharge in the range of 2-10 gpm. For discharge in excess of 10 gpm, a submersible pump will be acquired in the near future. Limitations of the pumps and accessory equipment are such that pumping will not be efficient when depth to water exceeds roughly 200 feet.

A data logger is available for automatic recording of water levels in pump and observation wells. The logger is currently capable of simultaneously recording drawdown at up to 6 wells and storing 24000 bytes of data. Pressure transducers, which are particularly useful if wells are deep, if perched water drains along the well screen, or if the well casing is crooked, are used to record changes in water level throughout the test. Two transducers are capable of measuring drawdowns of up to 40 feet, while drawdowns of up to 12 feet can be observed using the remaining 4 transducers. If more than six wells are to be monitored simultaneously, water-level probes must be used to measure drawdown in the remaining wells. Refer to the Enviro-Labs Groundwater Monitoring System Operations Manual for further details regarding calibration and use of the data logger. The data logger should be tested for operating condition in Albuquerque an calibrated at the test site.

Water level probes or steel tape and chalk must be checked out if the data logger will not be available for use during the pump test or if more than six wells are to be monitored. Probes shall be tested in Albuquerque and calibrated in the field immediately prior to the test. The physical condition of the steel tape must be observed in Albuquerque.

If the pump discharge line includes a discharge measuring valve, make sure that it is operating properly before leaving Albuquerque. If a discharge meter is to be used, it should be tested in Albuquerque and calibrated in the field prior to the test. Intake and discharge line should be examined for cracks or obstructions in Albuquerque.

Samples of pumped groundwater should be obtained at the pump well during or after the test in order to determine ambient water quality near the well. If sampling cannot be performed concurrently with pumping, as is the case for air-lift pumps, the sample must be obtained before and after the test. pH and temperature should also be observed prior to and following the test. pH and water temperature probes must be tested in Albuquerque and calibrated at the site. Refer to the GCL Standard Operating Policy for Water Quality Sampling for details regarding required sampling equipment and for procedures governing sampling and preservations of samples.

3.2.2 Prepare for the Pump Test

Slug, bailer, post-development recovery, or packer tests should be performed in the pump and observation wells prior to the test in order to further refine the estimate of sustainable discharge. Procedures for performing these types of tests are summarized in Bouwer (1978), Lohman (1979), and Freeze and Cherry (1979). If results of these tests at the pump well yield aquifer parameters that differ greatly from initial estimates used for designing the test, it may be necessary to alter the discharge rate or observation-well locations to generate sufficient drawdown response.

Measuring points for each well should be painted or notched onto the casing and should be used consistently throughout the test. If any changes in the measuring points are made, they must be thoroughly documented. Water level probes or pressure transducers must be tested in Albuquerque and calibrated in the field prior to the test. It should be established that water level probes, transducers, or steel tapes can be inserted into the casing free from obstruction.

Water levels should be observed either prior to the test or after recovery in order to determine the magnitude of natural water-level variations due to diurnal evapotranspiration cycles, changes in barometric pressure, or uncontrollable pumping stresses not related to the test. Ideally, these fluctuations should be measured for a period of time equal to twice the pump test duration (Kruseman and DeRidder, 1970). Alternatively, a well estimated to be outside of the cone of depression induced by pumping can be observed for natural water-level variations during the test if a suitable existing well is found.

Prior to the test, it should be established that pump power is reliable and that the pump is in good operating condition. If the pump fails early in the test, it may be necessary to wait for recovery and perform the pump test again.

After measuring the static water level, a step test should be performed by progressively increasing discharge until the pump capacity is almost exceeded or until the pump well is dewatered. If the pump well is to be used for contaminant recovery, the step test will aid in determining the success of the proposed remedial action strategy. A step test will also permit identification of the maximum sustainable rate of discharge during the subsequent pump test.

Before performing the step or pump tests, it should be established that the water conveyance system is in good operating condition. If the pumped water is to be stored to prevent its recharge into the pumped aquifer, the storage tank should be of sufficient volume to retain water pumped throughout the step- and pump-test durations. If pumped water is not to be stored, it should be conveyed to a location where it can be discharged without the potential for re-entering the pumped aquifer during the tests. In the event that the selected discharge point is not located sufficiently far from the pumped aquifer, the occurrence of recharge may become evident during the step test. If recharge appears to be occurring, the discharge point location should be altered and the step test re-initiated after recovery. Under no conditions is contaminated water to be discharged to the land surface. If pre-test quality sampling indicate the presence of contamination, ground water storage facilities must be incorporated into the test design.

3.2.3 Conduct the Pump Test

After all watches have been synchronized and complete recovery from the step test attained, the pump should be set at the midpoint of the pump well screen and operated at the estimated sustainable discharge rate. Typically, anywhere from 24 to 72 hours will be required to return to static conditions after the step test. If multiple screens have been installed in the well, make sure that the screen in the unit of interest is packed off from the other screens.

The optimal time between depth-to-water measurements depends on the expected hydraulic response, but generally should conform to the schedule below for pump and observation wells (Driscoll, 1986):

Pump Well:

t(min)	Measurement Time Interval (min)
0-10	0.5-1
10-15	1
15-60	5

60-300	30
300-1440	60
1440-shut down	480

Observation Well:

t(min)	Measurement Time Interval (min)
0-60	2
60-120	5
120-240	10
240-360	30
360-1440	60
1440-shut down	480

More frequent or less frequent measurements may be obtained, depending upon the tranmissivity and storativity of the aquifer and resulting rate of change in water levels. In general, 10 measurements per time log cycle, spread uniformly throughout each cycle when plotted on a log scale, are adequate for obtaining reliable estimates of aquifer properties (Stallman, 1971). Early-time data is particularly critical if non-ideal behavior distorts drawdown during later times. All time and depth-to-water observations must be recorded on pump test data sheets.

Discharge should be monitored at lease once every hour (Kruseman and DeRidder, 1970). Variations in discharge may be attributed to changes in the rpm of gas-powered pumps but should not be a problem when an electric pump is used. If discharge varies, it should be thoroughly documented for later use during analysis of the data. Discharge measurements must be recorded on pump test data sheets.

Drawdown versus time data should be plotted in the field in order to determine whether late-stage, flat portions of the curves have been attained, indicating that steady-state conditions are being approached. Since data in late parts of the curve do not affect the curve-matching procedure as strongly as early-time data, the pump test can be terminated when steady-state conditions have been attained within the limits of measurement error. Field plotting of the data also permits early detection of problems associated with poor well development or malfunctioning equipment. Five-cycle double and semi-logarithmic data should be suitable for plotting data observed during most tests. If the initial saturated thickness at the pump or observation well is known, drawdown in an unconfined aquifer subject to significant dewatering must be adjusted for decreasing transmissivity using the Jacob relation (Kruseman and DeRidder, 1970):

$$s' = s - \frac{s^2}{2D}$$

where s′ = drawdown adjusted for decreasing transmissivity [L]
s = observed drawdown [L]
D = initial saturated thickness [L]

These calculations may be performed after the pump test unless D is very small. For small saturated thickness, correction for unconfined flow will be significant and will greatly affect plots of the data.

Step and pump tests should be referred to by number, with tests of a given type numbered consecutively in time. Numbering should begin with 1 and proceed in ascending order. A "P" must be appended to the number to denote that a pump test was performed, while an appended "S" will correspond to step test results. Other letters will be used to denote bailer, slug, packer, and recovery tests.

3.2.4 Conduct the Recovery Test

Time versus depth-to-water data should be obtained during recovery of the stressed aquifer after pumping is terminated. This data provides a check on the transmissivity values calculated on the basis of pump-test data, and also is insensitive to changes in discharge frequently encountered during the pump test. The same measurement schedule should be adhered to during recovery as was used during pumping (Driscoll, 1986). Recovery should be observed for a time period equivalent to the duration of pumping or until steady-state is attained within the limits of measurement error. Time since pump shutoff must be recorded on the pump test data sheet in the t′ column.

A recovery test shall be numbered the same as the pump test immediately preceding it, but will have an appended "R" rather than a "P". For example, the first pump test performed at a site will be labelled 1P, while the subsequent recovery test will be referred to as 1R.

3.2.5 Submit Data

Copies of all data should be submitted to the Task Leader and Project Manager. Data required for analysis of aquifer properties are listed below along with maximum permissible error bounds (Stallman, 1971).

Data	Permissible Error
Discharge rate (Q) [gpm]	± 10 %
Depth to Water (DTW) [ft]	± 0.01 ft
Time of DTW Measurement (t,t′) [min]	± 1 % time since start of pumping
Distance to Pump Well (r) [a,b] [ft]	± 0.5 %
Measuring Point Elevation [b] [ft]	± 0.01 ft
Land Surface Elevation [b] [ft]	± 0.1 ft

a calculated using surveyed northings and eastings of pump and observation wells or equal to pump-well radius for observed pump-well drawdown data

b obtained from surveyed elevation data

All other data required for analysis, including drawdown (s), drawdown adjusted for unconfined conditions (s'), and dimensionless recovery time (t/t'), can be calculated from the listed data.

Other required information includes project name, billing code, test location, test number, date(s) of test, survey data, a map of all well locations, and the name of the field representative supervising the test. In addition, all deviations from referenced procedures or unusual occurrences must be thoroughly documented. This information must be attached to the pump test data sheet, photocopied, and supplied to the Task Leader and Project Manager. The Task Leader will be responsible for making certain that all data is entered into the computer system and filed in hard-copy form in Albuquerque.

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Stallman, R.W., 1971, Aquifer-Test Design, Observation and Data Analysis, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 3, Chapter B1.

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Reviewed By: [signature] 3/4/87
Quality Assurance Officer

Approved By: [signature]
Manager of Technical Projects

APPENDIX E

CALCULATION SUMMARIES

MINIMUM TEST DURATION FOR GENERATING
A RESPONSE IN WELL MW-4

$$s_{min} = 0.01 \text{ ft} = \frac{Q}{4\pi T} W_{min}$$

$$K = 1.29 \times 10^{-4} \text{ ft/sec}$$
$$= 7.74 \times 10^{-3} \text{ ft/min}$$

$$T = (7.74 \times 10^{-3} \text{ ft/min})(5.7 \text{ ft})$$
$$= 4.41 \times 10^{-2} \text{ ft}^2\text{/min}$$

$$Q = (2 \text{ gal/min})(1 \text{ ft}^3/7.481 \text{ gal})$$
$$= 0.27 \text{ ft}^3\text{/min}$$

$$W_{min} = \frac{0.01}{Q} 4\pi T$$

$$= \frac{0.01}{0.27} 4\pi (4.41 \times 10^{-2})$$

$$= 2.05 \times 10^{-2}$$

$$u_{max} = 2.7 = \frac{r^2 S_{min}}{4 T t_{min}}$$

$$t_{min} = \frac{r^2 S_{min}}{4T(2.7)} = \frac{(380 \text{ ft})^2(0.10)}{4(4.41 \times 10^{-2} \text{ ft}^2\text{/min})(2.7)}$$

$$= 3.03 \times 10^4 \text{ min}$$
$$= 21 \text{ days}$$

MAXIMUM RATE OF DISCHARGE THAT WOULD NOT DEWATER ALLUVIUM

$$u = \frac{r^2S}{4Kbt}$$

$$= \frac{(0.5\text{ ft})^2(0.20)}{4(7.74 \times 10^{-3}\text{ ft/min})(5.7\text{ ft})(1440\text{ min})}$$

$$= 1.97 \times 10^{-4}$$

$$W = 8.0$$

$$s = \frac{Q}{4\pi kb} \quad W$$

$$Q = \frac{s\ 4\pi kb}{W}$$

$$= \frac{(5.7)(4)\pi(7.74 \times 10^{-3})(5.7)}{8.0}$$

$$= 0.40\ \frac{\text{ft}^3}{\text{min}}$$

$$= 3.0\text{ gpm}$$

TRANSMISSIVITY FROM PUMP TEST #1 DATA

$$s = \frac{Q}{4\pi T} W$$

$$Q = 1.3 \text{ gpm } \frac{1 \text{ ft}^3}{7.481 \text{ gal}} = 0.17 \frac{\text{ft}^3}{\text{min}}$$

$$s = 3.25 \text{ X } 10^{-1} \text{ ft}$$

$$W = 1$$

$$T = \frac{Q}{4\pi s} W$$

$$= \frac{0.17}{4\pi(3.25 \text{ X } 10^{-1})} (1)$$

$$= 4.16 \text{ X } 10^{-2} \frac{\text{ft}^2}{\text{min}}$$

$$K = \frac{T}{\bar{b}}$$

$$\bar{b} = 3.11 \text{ ft}$$

$$K = \frac{4.16 \text{ X } 10^{-2} \text{ ft}^2/\text{min}}{3.11 \text{ ft}} = 1.34 \text{ X } 10^{-2} \text{ ft/min}$$

$$= 2.23 \text{ X } 10^{-4} \text{ ft/sec}$$

TRANSMISSIVITY FROM PUMP TEST #2 DATA

$$s = \frac{Q}{4\pi T} W$$

$$Q = 2 \frac{gal}{min} \quad \frac{1\ ft^3}{7.481\ gal} = 0.27 \frac{ft^3}{min}$$

$$s = 7.8 \times 10^{-1}\ ft$$

$$W = 1$$

$$T = \frac{Q}{4\pi s} W = \frac{0.27}{4\pi(7.8 \times 10^{-1})} \quad (1)$$

$$= 2.73 \times 10^{-2} \frac{ft^2}{min}$$

$$K = \frac{T}{\bar{b}}$$

$$\bar{b} = 2.34\ ft$$

$$K = \frac{2.73 \times 10^{-2}\ ft^2/min}{2.34\ ft} = 1.17 \times 10^{-2}\ ft/min$$

$$= 1.95 \times 10^{-4}\ ft/sec$$

TRANSMISSIVITY FROM RECOVERY TEST #1 DATA

$$T = \frac{2.3Q}{4\pi\Delta s'}$$

$$Q = 0.17 \frac{ft^3}{min}$$

$$\Delta s' = 2.50 \text{ ft}$$

$$T = \frac{2.3(0.17)}{4\pi(2.50)} = 1.25 \times 10^{-2} \frac{ft^2}{min}$$

$$K = \frac{T}{\bar{b}}$$

$$\bar{b} = 1.06 \text{ ft}$$

$$K = \frac{1.25 \times 10^{-2} \text{ ft}^2/\text{min}}{4.64 \text{ ft}} = 2.69 \times 10^{-3} \text{ ft/min}$$

$$= 4.49 \times 10^{-5} \text{ ft/sec}$$

TRANSMISSIVITY FROM RECOVERY TEST #2 DATA

$$T = \frac{2.3Q}{4\pi\Delta s'}$$

$$Q = 0.27 \frac{ft^3}{min}$$

$$\Delta s' = 2.65 \text{ ft}$$

$$T = \frac{2.3(0.27)}{4\pi(2.65)} = 1.87 \times 10^{-2} \text{ ft}^2/\text{min}$$

$$K = \frac{T}{\bar{b}}$$

$$\bar{b} = 4.99 \text{ ft}$$

$$K = \frac{1.87 \times 10^{-2} \text{ ft}^2/\text{min}}{4.99 \text{ ft}} = 3.75 \times 10^{-3} \text{ ft/min}$$

$$= 6.25 \times 10^{-5} \text{ ft/sec}$$

TRANSMISSIVITY FROM BRC-11
RECOVERY TEST DATA

$$T = \frac{2.3Q}{4\pi\Delta s'}$$

$$Q = \frac{0.8\text{ gpm }(207.5\text{ min}) + 0.75\text{ gpm }(280 - 207.5\text{ min})}{280}$$

$$= \frac{166 + 54.4}{280}$$

$$= 0.79\text{ gpm}$$

$$Q = 0.79\text{ gpm }\frac{1\text{ ft}^3}{7.481\text{ gal}} = 0.106\ \frac{\text{ft}^3}{\text{min}}$$

$$\Delta s' = 1.03\text{ ft}$$

$$T = \frac{2.3(0.106)}{4\pi(1.03)} = 1.88 \times 10^{-2}\ \frac{\text{ft}^2}{\text{min}}$$

$$\bar{b} = 10 - (6.04 - (10+4+4)/12)$$

$$= 5.46\text{ ft}$$

$$K = \frac{T}{\bar{b}} = \frac{1.88 \times 10^{-2}}{1.34\text{ ft}}\quad \text{ft}^2/\text{min}$$

$$= 1.40 \times 10^{-2}\text{ ft/min}$$

$$= 2.34 \times 10^{-4}\text{ ft/sec}$$

APPENDIX F

RAW TRANSDUCER DATA - PUMP TEST #1

APPENDIX F

Raw Transducer Data - Pump Test #1

00:01:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	15.35	7	35	8	12.15
00:02:00	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	15.27	7	35	8	12.15
00:02:01	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	15.13	7	35	8	12.15
00:02:03	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	15.05	7	35	8	12.15
00:02:04	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.93	7	35	8	12.15
00:02:05	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.82	7	35	8	12.15
00:02:06	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.71	7	35	8	12.15
00:02:08	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.61	7	35	8	12.15
00:02:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.53	7	35	8	12.15
00:02:10	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.44	7	35	8	12.15
00:02:11	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.35	7	35	8	12.15
00:02:13	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.26	7	35	8	12.15
00:02:14	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.16	7	35	8	12.15
00:02:15	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.07	7	35	8	12.15
00:02:16	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.99	7	35	8	12.15
00:02:18	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.96	7	35	8	12.15
00:02:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.94	7	35	8	12.15
00:02:20	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.94	7	35	8	12.15
00:02:21	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.95	7	35	8	12.15
00:02:23	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.96	7	35	8	12.15
00:02:24	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.97	7	35	8	12.15
00:02:25	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.98	7	35	8	12.15
00:02:26	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.00	7	35	8	12.15
00:02:28	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.01	7	35	8	12.15
00:02:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.02	7	35	8	12.15
00:02:30	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.03	7	35	8	12.15
00:02:31	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.05	7	35	8	12.15
00:02:33	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.07	7	35	8	12.15
00:02:34	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.09	7	35	8	12.15

															8	12.15
[redacted]:02:36	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.12	7	35	8	12.15
00:02:38	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.13	7	35	8	12.15
[redacted]:02:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.14	7	35	8	12.15
[redacted]:02:40	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.16	7	35	8	12.15
00:02:41	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.17	7	35	8	12.15
[redacted]:02:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.18	7	35	8	12.15
00:02:44	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.19	7	35	8	12.15
[redacted]:02:45	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.21	7	35	8	12.15
[redacted]:02:46	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.21	7	35	8	12.15
00:02:48	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.22	7	35	8	12.15
[redacted]:02:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.24	7	35	8	12.15
00:02:50	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.24	7	35	8	12.15
[redacted]:02:51	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.25	7	35	8	12.15
[redacted]:02:53	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.26	7	35	8	12.15
00:02:54	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.26	7	35	8	12.15
[redacted]:02:55	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.27	7	35	8	12.15
00:02:56	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.28	7	35	8	12.15
[redacted]:02:58	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.28	7	35	8	12.15
[redacted]:02:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.29	7	35	8	12.15
00:03:00	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.29	7	35	8	12.15
[redacted]:03:01	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.29	7	35	8	12.15
00:03:03	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.29	7	35	8	12.15
[redacted]:03:04	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.30	7	35	8	12.15
[redacted]:03:05	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.31	7	35	8	12.15
00:03:06	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.30	7	35	8	12.15
[redacted]:03:08	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.31	7	35	8	12.15
00:03:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.31	7	35	8	12.15
[redacted]:03:10	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35	8	12.15
[redacted]:03:11	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35	8	12.15
00:03:13	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35	8	12.15
[redacted]:03:14	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.31	7	35	8	12.15
00:03:15	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35		

	8	12.15												
[redacted]:03:18	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
00:03:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
00:03:20	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
[redacted]:03:21	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
00:03:23	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
[redacted]:03:24	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
00:03:25	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
[redacted]:03:26	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
[redacted]:03:28	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
00:03:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
[redacted]:03:30	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
00:03:31	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
[redacted]:03:33	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.31	7	35
	8	12.15												
[redacted]:03:34	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
00:03:35	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	35
	8	12.15												
[redacted]:03:36	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.31	7	35
	8	12.15												
00:03:38	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.31	7	35
	8	12.15												
[redacted]:03:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.31	7	35
	8	12.15												
[redacted]:03:44	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.30	7	35
	8	12.15												
00:03:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.30	7	35
	8	12.15												
[redacted]:03:54	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.29	7	35
	8	12.15												
00:03:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.28	7	35
	8	12.15												
[redacted]:04:04	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.27	7	35
	8	12.15												
[redacted]:04:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.26	7	35
	8	12.15												
00:04:14	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.25	7	35
	8	12.15												
[redacted]:04:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.25	7	35
	8	12.15												
00:04:24	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.24	7	35
	8	12.15												
[redacted]:04:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.23	7	35
	8	12.15												
[redacted]:04:34	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.22	7	35
	8	12.15												
00:04:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.21	7	35
	8	12.15												
[redacted]:04:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.20	7	35
	8	12.15												
00:04:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.18	7	35

	8	12.15												
0:05:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.15	7	35
	8	12.15												
00:05:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.13	7	35
	8	12.15												
0:05:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.12	7	35
	8	12.15												
0:05:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.10	7	35
	8	12.15												
00:05:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.09	7	35
	8	12.15												
0:06:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.07	7	35
	8	12.15												
00:06:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.05	7	35
	8	11.97												
0:06:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.05	7	35
	8	12.14												
0:06:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.03	7	35
	8	11.87												
00:06:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.03	7	35
	8	11.98												
0:06:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.01	7	35
	8	12.12												
00:07:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.98	7	35
	8	11.84												
0:07:19	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.99	7	35
	8	11.97												
0:07:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.96	7	35
	8	12.14												
00:07:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.94	7	35
	8	12.15												
0:07:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.92	7	35
	8	11.87												
00:07:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.94	7	35
	8	12.15												
0:08:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.90	7	35
	8	12.15												
0:08:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.88	7	35
	8	12.15												
00:08:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.86	7	35
	8	12.15												
0:08:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.85	7	35
	8	12.15												
00:08:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.84	7	35
	8	12.15												
0:08:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.83	7	35
	8	12.16												
0:09:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.81	7	35
	8	11.98												
00:09:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.80	7	35
	8	12.15												
0:09:29	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.79	7	35
	8	12.15												
00:09:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.78	7	35
	8	12.15												
0:09:49	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.76	7	35
	8	12.15												
0:09:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.77	7	35
	8	12.15												
00:10:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.75	7	35
	8	12.16												
0:10:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.75	7	35
	8	12.16												
00:10:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.73	7	35

	8	12.16												
00:10:49	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.71	7	35
	8	11.98												
00:10:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.72	7	35
	8	12.15												
00:11:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.69	7	35
	8	12.15												
00:11:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.67	7	35
	8	12.15												
00:11:29	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.67	7	35
	8	12.15												
00:11:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.65	7	35
	8	12.15												
00:11:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.64	7	35
	8	12.16												
00:11:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.63	7	35
	8	11.87												
00:12:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.63	7	35
	8	11.96												
00:12:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.63	7	35
	8	11.87												
00:12:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.63	7	35
	8	11.97												
00:12:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.60	7	35
	8	12.15												
00:13:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.54	7	35
	8	12.15												
00:14:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.49	7	35
	8	12.15												
00:15:39	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.43	7	35
	8	12.16												
00:16:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.40	7	36
	8	12.16												
00:17:39	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.36	7	36
	8	12.16												
00:18:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.31	7	36
	8	12.14												
00:19:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.28	7	36
	8	12.15												
00:20:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.24	7	36
	8	12.15												
00:21:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.21	7	36
	8	12.15												
00:22:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.17	7	36
	8	12.15												
00:23:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.14	7	36
	8	12.15												
00:24:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.12	7	36
	8	12.15												
00:25:39	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.09	7	36
	8	12.15												
00:26:39	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.05	7	36
	8	12.15												
00:27:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.03	7	36
	8	12.15												
00:28:39	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.01	7	36
	8	12.15												
00:29:39	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.98	7	36
	8	12.15												
00:30:39	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.96	7	36
	8	12.15												
00:31:39	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.94	7	36
	8	12.14												
00:50:00	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	12.58	7	35

	8	12.?1													
[redacted]1:10:00	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	12.30	7	33
	8	12.14													
01:20:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	12.20	7	34
	8	12.14													
[redacted]1:20:57	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	12.19	7	34
	8	12.14													
01:20:58	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	12.18	7	34
	8	12.14													
[redacted]1:20:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	12.17	7	34
	8	12.14													
[redacted]1:21:01	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	12.12	7	34
	8	12.14													
01:21:02	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	12.08	7	34
	8	12.14													
[redacted]1:21:03	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	12.04	7	34
	8	12.14													
01:21:04	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	12.00	7	34
	8	12.14													
[redacted]1:21:06	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.96	7	34
	8	12.14													
[redacted]1:21:07	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.93	7	34
	8	12.14													
01:21:08	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.89	7	34
	8	12.14													
[redacted]1:21:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.86	7	34
	8	12.14													
01:21:11	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.82	7	34
	8	12.14													
[redacted]1:21:12	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.79	7	34
	8	12.14													
[redacted]1:21:13	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.76	7	34
	8	12.14													
01:21:14	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.72	7	34
	8	12.14													
[redacted]1:21:16	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.69	7	34
	8	12.14													
01:21:17	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.66	7	34
	8	12.14													
[redacted]1:21:18	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.63	7	34
	8	12.14													
[redacted]1:21:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.60	7	34
	8	12.14													
01:21:21	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.57	7	34
	8	12.14													
[redacted]1:21:22	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.54	7	34
	8	12.14													
01:21:23	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.5?	7	34
	8	12.14													
[redacted]1:21:24	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.49	7	34
	8	12.14													
[redacted]1:21:26	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.46	7	34
	8	12.14													
01:21:27	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.43	7	34
	8	12.14													
[redacted]1:21:28	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.41	7	34
	8	12.14													
01:21:29	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.39	7	34
	8	12.14													
[redacted]1:21:30	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.36	7	34
	8	12.14													
[redacted]1:21:32	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.34	7	34
	8	12.14													
01:21:33	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.31	7	34

															8	12.14
01:21:35	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.27	7	34	8	12.14
01:21:37	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.24	7	34	8	12.14
01:21:38	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.22	7	34	8	12.14
01:21:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.19	7	34	8	12.14
01:21:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.17	7	34	8	12.14
01:21:42	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.15	7	34	8	12.14
01:21:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.12	7	34	8	12.14
01:21:44	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.10	7	34	8	12.14
01:21:45	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.08	7	34	8	12.14
01:21:47	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.05	7	34	8	12.14
01:21:48	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.03	7	34	8	12.14
01:21:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.01	7	34	8	12.14
01:21:50	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.98	7	34	8	12.14
01:21:52	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.96	7	34	8	12.14
01:21:53	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.94	7	34	8	12.14
01:21:54	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.91	7	34	8	12.14
01:21:55	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.90	7	34	8	12.14
01:21:57	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.87	7	34	8	12.14
01:21:58	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.85	7	34	8	12.14
01:21:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.83	7	34	8	12.14
01:22:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.81	7	34	8	12.14
01:22:02	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.78	7	34	8	12.14
01:22:03	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.76	7	34	8	12.14
01:22:04	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.74	7	34	8	12.14
01:22:05	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.72	7	34	8	12.14
01:22:07	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.70	7	34	8	12.14
01:22:08	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.68	7	34	8	12.14
01:22:09	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.65	7	34	8	12.14
01:22:10	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.63	7	34	8	12.14
01:22:12	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.61	7	34	8	12.14
01:22:16	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.54	7	34	8	12.14
01:22:21	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.45	7	34	8	[illegible]

Time	1	2	3	4	5	6	7	8
								12.14
01:22:31	0.00	7.39	0.00	0.00	0.00	10.29	34	12.14
01:22:36	0.00	7.39	0.00	0.00	0.00	10.21	34	12.14
01:22:41	0.00	7.39	0.00	0.00	0.00	10.12	34	12.14
01:22:46	0.00	7.39	0.00	0.00	0.00	10.04	34	12.14
01:22:51	0.00	7.39	0.00	0.00	0.00	9.96	34	12.14
01:22:56	0.00	7.39	0.00	0.00	0.00	9.88	34	12.14
01:23:01	0.00	7.39	0.00	0.00	0.00	9.80	34	12.14
01:23:06	0.00	7.39	0.00	0.00	0.00	9.71	34	12.14
01:23:11	0.00	7.39	0.00	0.00	0.00	9.62	34	12.14
01:23:21	0.00	7.39	0.00	0.00	0.00	9.44	34	12.14
01:23:31	0.00	7.39	0.00	0.00	0.00	9.25	34	12.14
01:23:41	0.00	7.39	0.00	0.00	0.00	9.04	34	12.14
01:23:51	0.00	7.39	0.00	0.00	0.00	8.80	34	12.14
01:24:01	0.00	7.39	0.00	0.00	0.00	8.50	34	12.14
01:24:11	0.00	7.39	0.00	0.00	0.00	8.18	34	12.14
01:24:21	0.00	7.39	0.00	0.00	0.00	8.06	34	12.14
01:24:31	0.00	7.39	0.00	0.00	0.00	8.05	34	12.14
01:24:41	0.00	7.39	0.00	0.00	0.00	8.05	34	12.14
01:24:51	0.00	7.39	0.00	0.00	0.00	8.05	34	12.14
01:25:01	0.00	7.39	0.00	0.00	0.00	8.05	34	12.14
01:25:11	0.00	7.39	0.00	0.00	0.00	8.05	34	12.14
01:25:21	0.00	7.39	0.00	0.00	0.00	8.09	34	12.14
01:25:31	0.00	7.39	0.00	0.00	0.00	8.06	34	12.14
01:25:41	0.00	7.39	0.00	0.00	0.00	8.07	34	12.14
01:25:51	0.00	7.39	0.00	0.00	0.00	8.05	34	12.14
01:26:01	0.00	7.39	0.00	0.00	0.00	8.05	34	12.14
01:26:11	0.00	7.39	0.00	0.00	0.00	8.09	34	12.14
01:26:21	0.00	7.39	0.00	0.00	0.00	8.04	34	12.14
01:26:31	0.00	7.39	0.00	0.00	0.00	8.04	34	12.14
01:26:41	0.00	7.39	0.00	0.00	0.00	8.06	34	12.14
01:26:51	0.00	7.39	0.00	0.00	0.00	8.13	34	12.14
01:27:01	0.00	7.39	0.00	0.00	0.00	8.12	34	

	8	12.14													
1:27:21	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.67	7	34	
	8	12.14													
01:27:31	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.88	7	34	
	8	12.14													
1:27:41	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	9.05	7	34	
	8	12.14													
1:27:51	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	9.23	7	34	
	8	12.14													
01:28:01	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	9.40	7	34	
	8	12.14													
1:28:11	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.57	7	34	
	8	12.14													
01:28:21	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.64	7	34	
	8	12.14													
1:28:31	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.79	7	34	
	8	12.14													
1:28:41	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.97	7	34	
	8	12.14													
01:28:51	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.08	7	34	
	8	12.14													
1:29:01	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	[illegible]	7	34	
	8	12.14													
01:29:11	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.42	7	34	
	8	12.14													
1:29:21	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.43	7	34	
	8	12.14													
1:29:31	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.52	7	34	
	8	12.14													
01:29:41	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.61	7	34	
	8	12.14													
1:29:51	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.72	7	34	
	8	12.14													
01:30:01	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.81	7	34	
	8	12.14													
1:31:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.34	7	34	
	8	12.14													
1:31:29	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.36	7	34	
	8	12.14													
01:31:30	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.37	7	34	
	8	12.14													
1:31:31	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.36	7	34	
	8	12.14													
01:31:33	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.35	7	34	
	8	12.14													
1:31:34	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.33	7	34	
	8	12.14													
1:31:35	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.32	7	34	
	8	12.14													
01:31:36	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.30	7	34	
	8	12.14													
1:31:38	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.28	7	34	
	8	12.14													
01:31:39	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.26	7	34	
	8	12.14													
1:31:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.24	7	34	
	8	12.14													
1:31:41	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	[illegible]	7	34	
	8	12.14													
01:31:43	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.21	7	34	
	8	12.14													
1:31:44	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.19	7	34	
	8	12.14													
01:31:45	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.17	7	34	

	8	12.13													
01:31:48	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.14	7	34	
	8	12.14													
01:31:49	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.13	7	34	
	8	12.14													
01:31:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.11	7	34	
	8	12.14													
01:31:51	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.10	7	34	
	8	12.14													
01:31:52	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	11.09	7	34	
	8	12.13													
01:31:54	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.07	7	34	
	8	12.14													
01:31:55	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.07	7	34	
	8	12.14													
01:31:56	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.05	7	34	
	8	12.14													
01:31:57	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.05	7	34	
	8	12.14													
01:31:59	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.03	7	34	
	8	12.14													
01:32:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.02	7	34	
	8	12.14													
01:32:01	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.01	7	34	
	8	12.14													
01:32:02	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.00	7	34	
	8	12.14													
01:32:04	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.99	7	34	
	8	12.14													
01:32:05	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.98	7	34	
	8	12.14													
01:32:06	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.97	7	34	
	8	12.14													
01:32:07	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.95	7	34	
	8	12.14													
01:32:09	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.94	7	34	
	8	12.14													
01:32:10	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.94	7	34	
	8	12.14													
01:32:11	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.92	7	34	
	8	12.14													
01:32:12	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.91	7	34	
	8	12.14													
01:32:14	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.91	7	34	
	8	12.14													
01:32:15	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.90	7	34	
	8	12.14													
01:32:16	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.88	7	34	
	8	12.14													
01:32:17	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.88	7	34	
	8	12.14													
01:32:19	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.87	7	34	
	8	12.14													
01:32:20	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.85	7	34	
	8	12.13													
01:32:21	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.84	7	34	
	8	12.14													
01:32:22	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.84	7	34	
	8	12.14													
01:32:24	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.82	7	34	
	8	12.14													
01:32:25	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.82	7	34	
	8	12.14													
01:32:26	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.80	7	34	
	8	12.13													

	8	12.14												
[redacted]:32:29	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.78	7	34
	8	12.14												
01:32:30	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.77	7	34
	8	12.14												
[redacted]:32:31	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.76	7	34
	8	12.14												
[redacted]:32:32	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.76	7	34
	8	12.14												
01:32:34	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.75	7	34
	8	12.14												
[redacted]:32:35	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.74	7	34
	8	12.13												
01:32:36	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.73	7	34
	8	12.14												
[redacted]:32:37	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.72	7	34
	8	12.14												
[redacted]:32:39	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.71	7	34
	8	12.14												
01:32:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.70	7	34
	8	12.14												
[redacted]:32:41	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.68	7	34
	8	12.14												
01:32:42	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.68	7	34
	8	12.14												
[redacted]:32:44	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.67	7	34
	8	12.14												
[redacted]:32:48	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.64	7	34
	8	12.14												
01:32:53	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.60	7	34
	8	12.14												
[redacted]:32:58	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.56	7	34
	8	12.14												
01:33:03	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.52	7	34
	8	12.14												
[redacted]1:33:08	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.48	7	34
	8	12.14												
[redacted]1:33:13	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.45	7	34
	8	12.14												
01:33:18	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.42	7	34
	8	12.14												
[redacted]1:33:23	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.37	7	34
	8	12.14												
01:33:28	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.33	7	34
	8	12.14												
[redacted]1:33:33	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.29	7	34
	8	12.14												
[redacted]1:33:38	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.25	7	34
	8	12.14												
01:33:43	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.20	7	34
	8	12.14												
[redacted]1:33:53	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.14	7	34
	8	12.14												
01:34:03	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.07	7	34
	8	12.14												
[redacted]1:34:13	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.99	7	34
	8	12.14												
[redacted]1:34:23	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.93	7	34
	8	12.14												
01:34:33	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.85	7	34
	8	12.14												
[redacted]1:34:43	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.79	7	34
	8	12.13												
01:34:53	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.73	7	34

[redacted]

	8	12.14														
01:35:13	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.57	7	34		
	8	12.14														
01:35:23	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.50	7	34		
	8	12.13														
01:35:33	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.42	7	34		
	8	12.13														
01:35:43	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.33	7	34		
	8	12.14														
01:35:53	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.25	7	34		
	8	12.14														
01:36:03	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.17	7	34		
	8	12.13														
01:36:13	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.06	7	34		
	8	12.14														
01:36:23	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.97	7	34		
	8	12.14														
01:36:33	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.87	7	34		
	8	12.13														
01:36:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.77	7	34		
	8	12.14														
01:36:53	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.68	7	34		
	8	12.13														
01:37:03	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.57	7	34		
	8	12.13														
01:37:13	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.47	7	34		
	8	12.13														
01:37:23	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.36	7	34		
	8	12.13														
01:37:33	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.26	7	34		
	8	12.13														
01:37:43	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.15	7	34		
	8	12.13														
01:37:53	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.04	7	34		
	8	12.13														
01:38:03	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.94	7	34		
	8	12.13														
01:38:13	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.82	7	34		
	8	12.13														
01:38:23	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.70	7	34		
	8	12.13														
01:38:33	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.57	7	34		
	8	12.13														
01:38:43	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.44	7	34		
	8	12.13														
01:38:53	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.32	7	34		
	8	12.13														
01:39:03	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.19	7	34		
	8	12.13														
01:39:13	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.06	7	34		
	8	12.13														
01:39:23	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.92	7	34		
	8	12.13														
01:39:33	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.79	7	34		
	8	12.14														
01:39:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.68	7	34		
	8	12.13														
01:39:53	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.54	7	34		
	8	12.13														
01:40:03	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.40	7	34		
	8	12.13														
01:40:13	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.27	7	34		
	8	12.13														
01:40:23	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.14	7	34		

	8	12.13												
1:40:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.88	7	34
	8	12.13												
01:40:53	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.75	7	34
	8	12.13												
1:41:03	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.61	7	34
	8	12.13												
01:41:13	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.47	7	34
	8	12.13												
1:41:23	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.31	7	34
	8	12.13												
1:41:33	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.14	7	34
	8	12.13												
01:41:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.97	7	34
	8	12.13												
1:42:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.68	7	34
	8	12.13												
01:43:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.68	7	34
	8	12.13												
1:44:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.68	7	34
	8	12.13												
1:45:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.68	7	34
	8	12.13												
01:46:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.68	7	34
	8	12.13												
1:47:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.68	7	34
	8	12.13												
01:48:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.68	7	34
	8	12.13												
1:49:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.61	7	34
	8	12.13												
1:50:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.30	7	34
	8	12.13												
01:51:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.07	7	33
	8	12.13												
1:52:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.61	7	33
	8	12.13												
01:53:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.67	7	33
	8	12.13												
1:54:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.67	7	33
	8	12.13												
1:55:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.67	7	33
	8	12.13												
01:56:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.67	7	33
	8	12.13												
1:57:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.67	7	33
	8	12.13												
01:58:43	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	4.67	7	33
	8	12.13												
1:59:43	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	4.67	7	33
	8	12.13												

APPENDIX G

RAW TRANSDUCER DATA - PUMP TEST #2

APPENDIX G

Raw Transducer Data - Pump Test #2

00:44:48	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	15.03	7	15	8	12.03
00:44:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.97	7	14	8	12.03
00:44:50	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.88	7	14	8	12.03
00:44:52	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.87	7	14	8	12.03
00:44:53	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.85	7	14	8	12.03
00:44:54	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.84	7	14	8	12.03
00:44:55	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.83	7	14	8	12.03
00:44:57	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.81	7	14	8	12.03
00:44:58	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.80	7	14	8	12.03
00:44:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.77	7	14	8	12.03
00:45:00	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.76	7	14	8	12.03
00:45:02	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.74	7	14	8	12.03
00:45:03	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.73	7	14	8	12.03
00:45:04	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.71	7	14	8	12.03
00:45:05	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.69	7	14	8	12.03
00:45:07	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.68	7	14	8	12.03
00:45:08	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.67	7	14	8	12.03
00:45:09	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.65	7	15	8	12.03
00:45:10	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.64	7	14	8	12.03
00:45:12	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.63	7	15	8	12.03
00:45:13	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.62	7	15	8	12.03
00:45:14	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.60	7	15	8	12.03
00:45:15	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.59	7	15	8	12.03
00:45:17	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.58	7	15	8	12.03
00:45:18	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.57	7	15	8	12.03
00:45:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.56	7	15	8	12.03
00:45:20	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.55	7	15	8	12.03
00:45:22	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.54	7	15	8	12.03
00:45:23	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.52	7	15	8	12.03

															8	12.03
00:45:25	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.50	7	15	8	12.03
00:45:27	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.49	7	15	8	12.03
00:45:28	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.48	7	15	8	12.03
00:45:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.47	7	15	8	12.03
00:45:30	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.46	7	15	8	12.03
00:45:32	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.45	7	15	8	12.03
00:45:33	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.44	7	15	8	12.03
00:45:34	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.43	7	15	8	12.03
00:45:35	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.42	7	15	8	12.03
00:45:37	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.42	7	15	8	12.03
00:45:38	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.40	7	15	8	12.03
00:45:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.39	7	15	8	12.03
00:45:40	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.38	7	15	8	12.03
00:45:41	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.37	7	15	8	12.03
00:45:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.36	7	15	8	12.03
00:45:44	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.35	7	15	8	12.03
00:45:45	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.34	7	15	8	12.03
00:45:46	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.33	7	15	8	12.03
00:45:48	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.32	7	15	8	12.03
00:45:49	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	14.31	7	15	8	12.03
00:45:50	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.31	7	15	8	12.03
00:45:51	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.30	7	15	8	12.03
00:45:53	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.29	7	15	8	12.03
00:45:54	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	14.28	7	15	8	12.03
00:45:55	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.27	7	15	8	12.03
00:45:56	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.26	7	15	8	12.03
00:45:58	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.25	7	15	8	12.03
00:45:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.25	7	15	8	12.03
00:46:00	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.23	7	15	8	12.03
00:46:01	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.22	7	15	8	12.03
00:46:03	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.21	7	15	8	12.04
00:46:07	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	14.18	7	15	8	12.04

00:46:17	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	14.11	7	15	8	12.03
00:46:22	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	14.07	7	15	8	12.03
00:46:27	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.04	7	15	8	12.03
00:46:32	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	14.01	7	15	8	12.03
00:46:37	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.97	7	15	8	12.03
00:46:42	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.93	7	15	8	12.03
00:46:47	1	0.00	2	7:39	3	0.00	4	0.00	5	0.00	6	13.90	7	15	8	12.03
00:46:52	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.88	7	15	8	12.03
00:46:57	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.84	7	15	8	12.03
00:47:02	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.81	7	15	8	12.03
00:47:12	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.75	7	15	8	12.03
00:47:22	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.69	7	15	8	12.03
00:47:32	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	13.63	7	15	8	12.03
00:47:42	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.57	7	15	8	12.03
00:47:52	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.51	7	15	8	12.03
00:48:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.45	7	15	8	12.03
00:48:12	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.39	7	15	8	12.03
00:48:22	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.34	7	15	8	12.03
00:48:32	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.29	7	15	8	12.03
00:48:42	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.24	7	15	8	12.03
00:48:52	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.19	7	15	8	12.03
00:49:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.14	7	15	8	12.03
00:49:12	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.11	7	15	8	12.03
00:49:22	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.07	7	15	8	12.03
00:49:32	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	13.02	7	15	8	12.03
00:49:42	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.98	7	15	8	12.03
00:49:52	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.94	7	15	8	12.03
00:50:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.90	7	15	8	12.03
00:50:12	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.86	7	15	8	12.03
00:50:22	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.82	7	15	8	12.03
00:50:32	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.79	7	15	8	12.03
00:50:42	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.74	7	15	8	12.03

	8	12.03												
00:51:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.67	7	15
	8	12.03												
00:51:12	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.64	7	15
	8	12.03												
00:51:22	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.60	7	15
	8	12.03												
00:51:32	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.57	7	15
	8	12.03												
00:51:42	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.53	7	15
	8	12.03												
00:51:52	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.50	7	15
	8	12.03												
00:52:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.46	7	15
	8	12.03												
00:52:12	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.42	7	15
	8	12.03												
00:52:22	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.39	7	15
	8	12.03												
00:52:32	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.37	7	15
	8	12.03												
00:52:42	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.35	7	15
	8	12.03												
00:52:52	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.33	7	15
	8	12.03												
00:53:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.30	7	15
	8	12.03												
00:53:12	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.28	7	15
	8	12.03												
00:53:22	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.25	7	15
	8	12.03												
00:53:32	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.23	7	15
	8	12.03												
00:53:42	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.21	7	15
	8	12.03												
00:53:52	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.19	7	15
	8	12.03												
00:54:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.17	7	15
	8	12.03												
00:54:12	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.14	7	15
	8	12.03												
00:54:22	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.12	7	15
	8	12.03												
00:54:32	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.10	7	15
	8	11.27												
00:54:42	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.08	7	15
	8	12.03												
00:54:52	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.06	7	15
	8	12.03												
00:55:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	12.04	7	15
	8	12.03												
00:56:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	11.92	7	15
	8	12.03												
00:57:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	11.81	7	15
	8	12.03												
00:58:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	11.69	7	15
	8	12.03												
00:59:02	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	11.59	7	15
	8	12.03												
01:00:00	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	11.47	7	15
	8	12.03												
01:00:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	11.46	7	15
	8	12.03												
01:01:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	11.35	7	15
	8	12.03												

															8	12.03
1:03:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	11.15	7	15	8	12.03
01:04:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	11.02	7	15	8	12.03
1:05:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	10.91	7	15	8	12.03
01:06:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	10.80	7	15	8	12.03
1:07:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	10.69	7	16	8	12.03
1:08:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	10.58	7	16	8	12.06
01:09:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	10.47	7	16	8	12.03
1:10:00	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	10.36	7	16	8	12.03
01:10:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	10.36	7	16	8	12.03
1:11:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	10.24	7	16	8	12.03
1:12:03	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	10.14	7	16	8	12.03
01:13:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	10.04	7	16	8	12.03
1:14:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	9.93	7	16	8	12.09
01:20:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	9.30	7	16	8	12.10
1:30:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	7.54	7	16	8	12.13
1:40:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	5.61	7	16	8	12.14
01:50:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	5.61	7	17	8	12.14
2:00:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	5.61	7	17	8	12.07
02:10:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	6.01	7	19	8	12.11
2:20:00	1	0.00	2	7.36	3	0.00	4	0.00	5	0.00	6	6.73	7	20	8	12.04
2:30:00	1	0.00	2	7.36	3	0.00	4	0.00	5	0.00	6	7.16	7	21	8	12.03
02:40:00	1	0.00	2	7.36	3	0.00	4	0.00	5	0.00	6	7.45	7	23	8	12.03
2:50:00	1	0.00	2	7.36	3	0.00	4	0.00	5	0.00	6	7.62	7	24	8	12.05
03:00:00	1	0.00	2	7.35	3	0.00	4	0.00	5	0.00	6	7.70	7	25	8	12.03
3:10:00	1	0.00	2	7.36	3	0.00	4	0.00	5	0.00	6	7.71	7	26	8	12.02
3:20:00	1	0.00	2	7.36	3	0.00	4	0.00	5	0.00	6	7.65	7	27	8	12.02
03:30:00	1	0.00	2	7.35	3	0.00	4	0.00	5	0.00	6	7.50	7	29	8	12.03
3:40:00	1	0.00	2	7.35	3	0.00	4	0.00	5	0.00	6	7.51	7	30	8	12.01
03:50:00	1	0.00	2	7.36	3	0.00	4	0.00	5	0.00	6	8.67	7	31	8	12.01
4:00:00	1	0.00	2	7.36	3	0.00	4	0.00	5	0.00	6	8.62	7	32	8	12.01
4:10:00	1	0.00	2	7.36	3	0.00	4	0.00	5	0.00	6	8.52	7	33	8	12.01
04:20:00	1	0.00	2	7.36	3	0.00	4	0.00	5	0.00	6	8.39	7	34	8	12.01

	8	[illegible]												
04:40:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	8.00	7	37
	8	12.00												
04:50:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	5.66	7	38
	8	12.00												
05:00:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	5.59	7	38
	8	12.04												
05:10:00	1	0.00	2	7.37	3	0.00	4	0.00	5	0.00	6	5.60	7	38
	8	12.00												
05:20:00	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.60	7	39
	8	12.00												
05:30:00	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.60	7	39
	8	11.99												
05:40:00	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.59	7	39
	8	11.99												
05:50:00	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.59	7	39
	8	11.99												
06:00:00	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.59	7	39
	8	11.99												

APPENDIX H

s vs. t - Pump Test #1

APPENDIX H

s vs. t - Pump Test #1

PUMP WELL DRAWDOWN

TIME (MIN/SEC)		UNCORRECTED/CORRECTED	
.00/	0.	.00/	.00
.02/	1.	.00/	.00
.03/	2.	.17/	.17
.07/	4.	.30/	.29
.08/	5.	.42/	.40
.10/	6.	.53/	.51
.12/	7.	.64/	.60
.15/	9.	.74/	.69
.17/	10.	.82/	.76
.18/	11.	.91/	.84
.20/	12.	1.00/	.91
.23/	14.	1.09/	.99
.25/	15.	1.19/	1.07
.27/	16.	1.28/	1.14
.28/	17.	1.36/	1.20
.32/	19.	1.39/	1.22
.33/	20.	1.41/	1.24
.35/	21.	1.41/	1.24
.37/	22.	1.40/	1.23
.40/	24.	1.39/	1.22
.42/	25.	1.38/	1.21
.43/	26.	1.37/	1.21
.45/	27.	1.35/	1.19
.48/	29.	1.34/	1.18
.50/	30.	1.33/	1.17
.52/	31.	1.32/	1.17
.53/	32.	1.30/	1.15
.57/	34.	1.28/	1.14
.58/	35.	1.26/	1.12
.60/	36.	1.25/	1.11
.62/	37.	1.23/	1.10
.65/	39.	1.22/	1.09
.67/	40.	1.21/	1.08
.68/	41.	1.19/	1.07
.70/	42.	1.18/	1.06
.73/	44.	1.17/	1.05
.75/	45.	1.16/	1.04
.77/	46.	1.14/	1.03
.78/	47.	1.14/	1.03
.82/	49.	1.13/	1.02
.83/	50.	1.11/	1.00
.85/	51.	1.11/	1.00
.87/	52.	1.10/	.99
.90/	54.	1.09/	.99
.92/	55.	1.09/	.99
.93/	56.	1.08/	.98
.95/	57.	1.07/	.97
.98/	59.	1.07/	.97
1.00/	60.	1.06/	.96
1.02/	61.	1.06/	.96
1.03/	62.	1.06/	.96
1.07/	64.	1.06/	.96
1.08/	65.	1.05/	.95
1.10/	66.	1.04/	.95
1.12/	67.	1.05/	.95
1.15/	69.	1.04/	.95

1.18/	71.	1.03/	.94
1.20/	72.	1.03/	.94
1.23/	74.	1.03/	.94
1.25/	75.	1.04/	.95
1.27/	76.	1.03/	.94
1.28/	77.	1.03/	.94
1.32/	79.	1.03/	.94
1.33/	80.	1.03/	.94
1.35/	81.	1.03/	.94
1.37/	82.	1.03/	.94
1.40/	84.	1.03/	.94
1.42/	85.	1.03/	.94
1.43/	86.	1.03/	.94
1.45/	87.	1.03/	.94
1.48/	89.	1.03/	.94
1.50/	90.	1.03/	:94
1.52/	91.	1.03/	.94
1.53/	92.	1.03/	.94
1.57/	94.	1.04/	.95
1.58/	95.	1.03/	.94
1.60/	96.	1.03/	.94
1.62/	97.	1.04/	.95
1.65/	99.	1.04/	.95
1.67/	100.	1.04/	.95
1.75/	105.	1.05/	.95
1.83/	110.	1.05/	.95
1.92/	115.	1.06/	.96
2.00/	120.	1.07/	.97
2.08/	125.	1.08/	.98
2.17/	130.	1.09/	.99
2.25/	135.	1.10/	.99
2.33/	140.	1.10/	.99
2.42/	145.	1.11/	1.00
2.50/	150.	1.12/	1.01
2.58/	155.	1.13/	1.02
2.67/	160.	1.14/	1.03
2.83/	170.	1.15/	1.03
3.00/	180.	1.17/	1.05
3.17/	190.	1.18/	1.06
3.33/	200.	1.20/	1.07
3.50/	210.	1.22/	1.09
3.67/	220.	1.23/	1.10
3.83/	230.	1.25/	1.11
4.00/	240.	1.26/	1.12
4.17/	250.	1.28/	1.14
4.33/	260.	1.30/	1.15
4.50/	270.	1.30/	1.15
4.67/	280.	1.32/	1.17
4.83/	290.	1.32/	1.17
5.00/	300.	1.34/	1.18
5.17/	310.	1.37/	1.21
5.33/	320.	1.36/	1.20
5.50/	330.	1.39/	1.22
5.67/	340.	1.41/	1.24
5.83/	350.	1.43/	1.25
6.00/	360.	1.41/	1.24
6.17/	370.	1.45/	1.27
6.33/	380.	1.47/	1.28
6.50/	390.	1.49/	1.30
6.67/	400.	1.50/	1.30
6.83/	410.	1.51/	1.31
7.00/	420.	1.52/	1.32
7.17/	430.	1.54/	1.33
7.33/	440.	1.53/	1.32
[illegible]	[illegible]	[illegible]	[illegible]

7.83/	470.	1.57/	1.35
8.00/	480.	1.58/	1.36
8.17/	490.	1.60/	1.38
8.33/	500.	1.60/	1.38
8.50/	510.	1.62/	1.39
8.67/	520.	1.63/	1.40
8.83/	530.	1.64/	1.40
9.00/	540.	1.63/	1.40
9.17/	550.	1.66/	1.42
9.33/	560.	1.68/	1.43
9.50/	570.	1.68/	1.43
9.67/	580.	1.70/	1.45
9.83/	590.	1.71/	1.45
10.00/	600.	1.72/	1.46
10.17/	610.	1.72/	1.46
10.33/	620.	1.72/	1.46
10.50/	630.	1.72/	1.46
10.67/	640.	1.75/	1.48
11.67/	700.	1.81/	1.52
12.67/	760.	1.86/	1.56
13.67/	820.	1.92/	1.60
14.67/	880.	1.95/	1.62
15.67/	940.	1.99/	1.64
16.67/	1000.	2.04/	1.67
17.67/	1060.	2.07/	1.69
18.67/	1120.	2.11/	1.72
19.67/	1180.	2.14/	1.74
20.67/	1240.	2.18/	1.76
21.67/	1300.	2.21/	1.78
22.67/	1360.	2.23/	1.79
23.67/	1420.	2.27/	1.82
24.67/	1480.	2.30/	1.84
25.67/	1540.	2.32/	1.85
26.67/	1600.	2.34/	1.86
27.67/	1660.	2.37/	1.88
28.67/	1720.	2.39/	1.89
29.67/	1780.	2.41/	1.90
48.02/	2881.	2.77/	2.10
58.02/	3481.	2.91/	2.17
68.02/	4081.	3.05/	2.23
78.02/	4681.	3.15/	2.28
78.97/	4738.	3.16/	2.28
78.98/	4739.	3.17/	2.29
79.00/	4740.	3.18/	2.29
79.03/	4742.	3.23/	2.31
79.05/	4743.	3.27/	2.33
79.07/	4744.	3.31/	2.35
79.08/	4745.	3.35/	2.37
79.12/	4747.	3.39/	2.38
79.13/	4748.	3.42/	2.39
79.15/	4749.	3.46/	2.41
79.17/	4750.	3.49/	2.42
79.20/	4752.	3.53/	2.44
79.22/	4753.	3.56/	2.45
79.23/	4754.	3.59/	2.46
79.25/	4755.	3.63/	2.47
79.28/	4757.	3.66/	2.48
79.30/	4758.	3.69/	2.50
79.32/	4759.	3.72/	2.51
79.33/	4760.	3.75/	2.52
79.37/	4762.	3.78/	2.53
79.38/	4763.	3.81/	2.54
79.40/	4764.	3.83/	2.54
79.42/	4765.	3.86/	2.55
79.45/	4767.	3.89/	2.56

79.48/ 4769.	3.94/ 2.58
79.50/ 4770.	3.96/ 2.58
79.52/ 4771.	3.99/ 2.59
79.55/ 4773.	4.01/ 2.60
79.57/ 4774.	4.04/ 2.61
79.58/ 4775.	4.06/ 2.61
79.60/ 4776.	4.08/ 2.62
79.63/ 4778.	4.11/ 2.63
79.65/ 4779.	4.13/ 2.63
79.67/ 4780.	4.16/ 2.64
79.68/ 4781.	4.18/ 2.65
79.72/ 4783.	4.20/ 2.65
79.73/ 4784.	4.23/ 2.66
79.75/ 4785.	4.25/ 2.67
79.77/ 4786.	4.27/ 2.67
79.80/ 4788.	4.30/ 2.68
79.82/ 4789.	4.32/ 2.68
79.83/ 4790.	4.34/ 2.69
79.85/ 4791.	4.37/ 2.69
79.88/ 4793.	4.39/ 2.70
79.90/ 4794.	4.41/ 2.70
79.92/ 4795.	4.44/ 2.71
79.93/ 4796.	4.45/ 2.71
79.97/ 4798.	4.48/ 2.72
79.98/ 4799.	4.50/ 2.72
80.00/ 4800.	4.52/ 2.73
80.02/ 4801.	4.54/ 2.73
80.05/ 4803.	4.57/ 2.74
80.07/ 4804.	4.59/ 2.74
80.08/ 4805.	4.61/ 2.75
80.10/ 4806.	4.63/ 2.75
80.13/ 4808.	4.65/ 2.75
80.15/ 4809.	4.67/ 2.76
80.17/ 4810.	4.70/ 2.76
80.18/ 4811.	4.72/ 2.77
80.22/ 4813.	4.74/ 2.77
80.28/ 4817.	4.81/ 2.78
80.37/ 4822.	4.90/ 2.79
80.45/ 4827.	4.98/ 2.80
80.53/ 4832.	5.06/ 2.81
80.62/ 4837.	5.14/ 2.82
80.70/ 4842.	5.23/ 2.83
80.78/ 4847.	5.31/ 2.84
80.87/ 4852.	5.39/ 2.84
80.95/ 4857.	5.47/ 2.85
81.03/ 4862.	5.55/ 2.85
81.12/ 4867.	5.64/ 2.85

AVERAGE DRAWDOWN = 2.59

APPENDIX I

s vs. t - Pump Test #2

APPENDIX I

s vs. t - Pump Test #2

PUMP WELL DRAWDOWN

TIME(MIN/SEC)		UNCORRECTED/CORRECTED	
.00/	0.	.00/	.00
.02/	1.	.06/	.06
.03/	2.	.15/	.15
.07/	4.	.16/	.16
.08/	5.	.18/	.18
.10/	6.	.19/	.19
.12/	7.	.20/	:20
.15/	9.	.22/	.22
.17/	10.	.23/	.23
.18/	11.	.26/	.25
.20/	12.	.27/	.26
.23/	14.	.29/	.28
.25/	15.	.30/	.29
.27/	16.	.32/	.31
.28/	17.	.34/	.33
.32/	19.	.35/	.34
.33/	20.	.36/	.35
.35/	21.	.38/	.37
.37/	22.	.39/	.38
.40/	24.	.40/	.39
.42/	25.	.41/	.40
.43/	26.	.43/	.41
.45/	27.	.44/	.42
.48/	29.	.45/	.43
.50/	30.	.46/	.44
.52/	31.	.47/	.45
.53/	32.	.48/	.46
.57/	34.	.49/	.47
.58/	35.	.51/	.49
.60/	36.	.51/	.49
.62/	37.	.53/	.51
.65/	39.	.54/	.51
.67/	40.	.55/	.52
.68/	41.	.56/	.53
.70/	42.	.57/	.54
.73/	44.	.58/	.55
.75/	45.	.59/	.56
.77/	46.	.60/	.57
.78/	47.	.61/	.58
.82/	49.	.61/	.58
.83/	50.	.63/	.60
.85/	51.	.64/	.60
.87/	52.	.65/	.61
.88/	53.	.66/	.62
.92/	55.	.67/	.63
.93/	56.	.68/	.64
.95/	57.	.69/	.65
.97/	58.	.70/	.66
1.00/	60.	.71/	.67
1.02/	61.	.72/	.67
1.03/	62.	.72/	.67
1.05/	63.	.73/	.68
1.08/	65.	.74/	.69
1.10/	66.	.75/	.70
1.12/	67.	.76/	.71
1.13/	68.	.77/	.72

1.1[illegible]/	71.	.7[illegible]/	.7[illegible]
1.20/	72.	.80/	.74
1.22/	73.	.81/	.75
1.25/	75.	.82/	.76
1.32/	79.	.85/	.79
1.40/	84.	.89/	.82
1.48/	89.	.92/	.85
1.57/	94.	.96/	.88
1.65/	99.	.99/	.90
1.73/	104.	1.02/	.93
1.82/	109.	1.06/	.96
1.90/	114.	1.10/	.99
1.98/	119.	1.13/	1.02
2.07/	124.	1.15/	1.03
2.15/	129.	1.19/	1.07
2.23/	134.	1.22/	1.09
2.40/	144.	1.28/	1.14
2.57/	154.	1.34/	1.18
2.73/	164.	1.40/	1.23
2.90/	174.	1.46/	1.27
3.07/	184.	1.52/	1.32
3.23/	194.	1.58/	1.36
3.40/	204.	1.64/	1.40
3.57/	214.	1.69/	1.44
3.73/	224.	1.74/	1.47
3.90/	234.	1.79/	1.51
4.07/	244.	1.84/	1.54
4.23/	254.	1.89/	1.58
4.40/	264.	1.92/	1.60
4.57/	274.	1.96/	1.62
4.73/	284.	2.01/	1.66
4.90/	294.	2.05/	1.68
5.07/	304.	2.09/	1.71
5.23/	314.	2.13/	1.73
5.40/	324.	2.17/	1.76
5.57/	334.	2.21/	1.78
5.73/	344.	2.24/	1.80
5.90/	354.	2.29/	1.83
6.07/	364.	2.32/	1.85
6.23/	374.	2.36/	1.87
6.40/	384.	2.39/	1.89
6.57/	394.	2.43/	1.91
6.73/	404.	2.46/	1.93
6.90/	414.	2.50/	1.95
7.07/	424.	2.53/	1.97
7.23/	434.	2.57/	1.99
7.40/	444.	2.61/	2.01
7.57/	454.	2.64/	2.03
7.73/	464.	2.66/	2.04
7.90/	474.	2.68/	2.05
8.07/	484.	2.70/	2.06
8.23/	494.	2.73/	2.08
8.40/	504.	2.75/	2.09
8.57/	514.	2.78/	2.10
8.73/	524.	2.80/	2.11
8.90/	534.	2.82/	2.12
9.07/	544.	2.84/	2.13
9.23/	554.	2.86/	2.14
9.40/	564.	2.89/	2.16
9.57/	574.	2.91/	2.17
9.73/	584.	2.93/	2.18
9.90/	594.	2.95/	2.19
10.07/	604.	2.97/	2.20
10.23/	614.	2.99/	2.21
11.23/	674.	3.11/	2.26

14.23/	854.	3.44/	2.40
15.20/	912.	3.56/	2.45
15.25/	915.	3.57/	2.45
16.25/	975.	3.68/	2.49
17.25/	1035.	3.77/	2.52
18.25/	1095.	3.88/	2.56
19.25/	1155.	4.01/	2.60
20.25/	1215.	4.12/	2.63
21.25/	1275.	4.23/	2.66
22.25/	1335.	4.34/	2.69
23.25/	1395.	4.45/	2.71
24.25/	1455.	4.56/	2.74
25.20/	1512.	4.67/	2.76
25.25/	1515.	4.67/	2.76
26.25/	1575.	4.79/	2.78
27.25/	1635.	4.89/	2.79
28.20/	1692.	4.99/	2.81
29.20/	1752.	5.10/	2.82

AVERAGE DRAWDOWN = 3.36

APPENDIX J

RAW TRANSDUCER DATA - RECOVERY TEST #1

APPENDIX J

Raw Transducer Data - Recovery Test #1

02:14:36	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.87	7	33	8	12.12
02:14:37	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	4.90	7	33	8	12.12
02:14:38	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	4.92	7	33	8	12.12
02:14:39	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	4.96	7	33	8	12.12
02:14:41	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	4.99	7	33	8	12.12
02:14:42	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.01	7	33	8	12.12
02:14:43	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.04	7	33	8	12.12
02:14:44	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.07	7	33	8	12.12
02:14:46	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.10	7	33	8	12.12
02:14:47	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.13	7	33	8	12.12
02:14:48	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.16	7	33	8	12.12
02:14:49	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.19	7	33	8	12.12
02:14:51	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.22	7	33	8	12.12
02:14:52	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.24	7	33	8	12.12
02:14:53	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.27	7	33	8	12.12
02:14:54	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.30	7	33	8	12.12
02:14:56	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.33	7	33	8	12.12
02:14:57	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.36	7	33	8	12.12
02:14:58	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.39	7	33	8	12.12
02:14:59	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.41	7	33	8	12.12
02:15:01	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.44	7	33	8	12.12
02:15:02	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.46	7	33	8	12.12
02:15:03	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.49	7	33	8	12.12
02:15:04	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.51	7	33	8	12.12
02:15:05	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.54	7	33	8	12.12
02:15:07	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.56	7	33	8	12.12
02:15:08	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.58	7	33	8	12.12
02:15:09	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.60	7	33	8	12.12
02:15:10	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.63	7	33		

															8	12.12
0[redacted]:15:13	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.68	7	33	8	12.12
02:15:14	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.70	7	33	8	12.12
0[redacted]:15:15	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.72	7	33	8	12.12
0[redacted]:15:17	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.74	7	33	8	12.12
02:15:18	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.76	7	33	8	12.12
0[redacted]:15:19	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.79	7	33	8	12.12
02:15:20	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.81	7	33	8	12.12
0[redacted]:15:22	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.83	7	33	8	12.12
0[redacted]:15:23	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.85	7	33	8	12.12
02:15:24	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.87	7	33	8	12.12
0[redacted]:15:25	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.89	7	33	8	12.12
02:15:27	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.92	7	33	8	12.12
0[redacted]:15:28	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	5.94	7	33	8	12.12
0[redacted]:15:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.96	7	33	8	12.12
02:15:30	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	5.99	7	33	8	12.12
0[redacted]:15:31	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.01	7	33	8	12.12
02:15:33	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.03	7	33	8	12.12
0[redacted]:15:34	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.05	7	33	8	12.12
0[redacted]:15:35	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.07	7	33	8	12.12
02:15:36	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.09	7	33	8	12.12
0[redacted]:15:38	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.12	7	33	8	12.12
02:15:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.14	7	33	8	12.12
0[redacted]:15:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.16	7	33	8	12.12
0[redacted]:15:41	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.18	7	33	8	12.12
02:15:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.21	7	33	8	12.12
0[redacted]:15:44	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.23	7	33	8	12.12
02:15:45	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.25	7	33	8	12.12
0[redacted]:15:46	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.27	7	33	8	12.12
0[redacted]:15:48	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.29	7	33	8	12.12
02:15:49	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.32	7	33	8	12.12
0[redacted]:15:50	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.34	7	33	8	12.12
02:15:55	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.42	7	33		

	8	12.12												
0[redacted]:16:05	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.60	7	33
	8	12.12												
02:16:10	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.69	7	33
	8	12.12												
0[redacted]:16:15	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.77	7	33
	8	12.12												
0[redacted]:16:20	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.87	7	33
	8	12.12												
02:16:25	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	6.95	7	33
	8	12.12												
0[redacted]:16:30	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.04	7	33
	8	12.12												
02:16:35	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.13	7	33
	8	12.12												
0[redacted]:16:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.22	7	33
	8	12.12												
0[redacted]:16:45	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.31	7	33
	8	12.12												
02:16:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.39	7	33
	8	12.12												
0[redacted]:17:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.57	7	33
	8	12.12												
02:17:10	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.74	7	33
	8	12.12												
0[redacted]:17:20	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	7.92	7	33
	8	12.12												
0[redacted]:17:30	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.08	7	33
	8	12.12												
02:17:40	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.24	7	33
	8	12.12												
0[redacted]:17:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.39	7	33
	8	12.12												
02:18:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.55	7	33
	8	12.12												
0[redacted]:18:10	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	8.69	7	33
	8	12.12												
0[redacted]:18:20	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.83	7	33
	8	12.12												
02:18:30	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.98	7	33
	8	12.12												
0[redacted]:18:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.12	7	33
	8	12.12												
02:18:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.26	7	33
	8	12.12												
0[redacted]:19:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.40	7	33
	8	12.12												
0[redacted]:19:10	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.53	7	33
	8	12.12												
02:19:20	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.66	7	33
	8	12.12												
0[redacted]:19:30	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.78	7	33
	8	12.12												
02:19:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.88	7	33
	8	12.12												
0[redacted]:19:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	9.98	7	33
	8	12.12												
0[redacted]:20:00	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	10.07	7	33
	8	12.12												
02:20:10	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.15	7	33
	8	12.12												
0[redacted]:20:20	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.23	7	33
	8	12.12												
02:20:30	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.31	7	33

Time																
															8	11.85
[redacted]:20:50	1	0.00	2	7.41	3	0.00	4	0.00	5	0.00	6	10.49	7	33	8	11.93
02:21:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.56	7	33	8	12.10
[redacted]:21:10	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.63	7	33	8	12.11
02:21:20	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.70	7	33	8	12.11
[redacted]:21:30	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.79	7	33	8	12.11
[redacted]:21:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	10.87	7	33	8	12.11
02:21:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.02	7	33	8	12.11
[redacted]:22:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.09	7	33	8	12.11
02:22:10	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.16	7	33	8	12.11
[redacted]:22:20	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.24	7	33	8	12.11
[redacted]:22:30	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.31	7	33	8	12.11
02:22:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.37	7	33	8	12.11
[redacted]:22:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.44	7	33	8	12.11
02:23:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.50	7	33	8	12.11
[redacted]:23:10	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.56	7	33	8	12.11
[redacted]2:23:20	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.61	7	33	8	12.11
02:23:30	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.67	7	33	8	12.11
[redacted]2:23:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.72	7	33	8	12.11
02:23:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.77	7	33	8	12.11
[redacted]2:24:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.82	7	33	8	12.11
[redacted]2:24:10	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.87	7	33	8	12.11
02:24:20	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.90	7	33	8	12.11
[redacted]2:24:30	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.94	7	33	8	12.11
02:24:40	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	11.98	7	33	8	12.11
[redacted]2:24:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	12.02	7	33	8	12.11
[redacted]2:25:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	12.22	7	33	8	12.11
02:26:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	12.38	7	33	8	12.11
[redacted]2:27:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	12.53	7	32	8	12.11
02:28:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	12.67	7	32	8	12.11
[redacted]2:29:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	12.80	7	32	8	12.11
[redacted]2:30:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	12.92	7	32	8	12.11
02:31:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.04	7	32	8	12.11

	8	12.11												
02:33:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.24	7	32
	8	12.11												
02:34:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.32	7	32
	8	12.11												
02:35:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.40	7	32
	8	12.11												
02:36:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.47	7	31
	8	12.11												
02:37:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.54	7	31
	8	12.11												
02:38:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.61	7	31
	8	12.11												
02:39:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.68	7	31
	8	12.11												
02:40:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.74	7	31
	8	12.11												
02:41:50	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	13.80	7	31
	8	11.90												
02:42:50	1	0.00	2	7.41	3	0.00	4	0.00	5	0.00	6	13.87	7	31
	8	11.89												
02:43:50	1	0.00	2	7.41	3	0.00	4	0.00	5	0.00	6	13.92	7	31
	8	11.89												
02:45:00	1	0.00	2	7.41	3	0.00	4	0.00	5	0.00	6	13.98	7	31
	8	12.08												
02:55:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	14.31	7	31
	8	12.16												
03:05:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	14.54	7	31
	8	12.09												
03:15:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	14.70	7	31
	8	12.09												
03:25:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	14.82	7	31
	8	12.09												
03:35:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	14.90	7	31
	8	12.08												
03:45:00	1	0.00	2	7.40	3	0.00	4	0.00	5	0.00	6	14.96	7	30
	8	12.09												
03:55:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.99	7	30
	8	12.09												
04:05:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	15.06	7	30
	8	12.09												

APPENDIX K

RAW TRANSDUCER DATA - RECOVERY TEST #2

APPENDIX K

Raw Transducer Data - Recovery Test #2

06:14:42	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.60	7	38	8	11.99
06:14:43	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.62	7	38	8	11.99
06:14:44	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.64	7	38	8	11.99
06:14:46	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.66	7	38	8	11.99
06:14:47	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.68	7	38	8	11.99
06:14:48	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.71	7	38	8	11.99
06:14:49	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.73	7	38	8	11.99
06:14:51	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.76	7	38	8	11.99
06:14:52	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.73	7	38	8	11.99
06:14:53	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.59	7	38	8	11.99
06:14:54	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.58	7	38	8	11.99
06:14:56	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.60	7	38	8	11.99
06:14:57	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.62	7	38	8	11.99
06:14:58	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.64	7	38	8	11.99
06:15:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.73	7	38	8	11.99
06:15:08	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.82	7	38	8	11.99
06:15:13	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	5.92	7	38	8	11.99
06:15:18	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.01	7	38	8	11.99
06:15:23	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	6.10	7	38	8	11.99
06:15:28	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	6.21	7	38	8	11.99
06:15:33	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	6.31	7	38	8	11.99
06:15:38	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	6.39	7	38	8	11.99
06:15:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.48	7	38	8	11.99
06:15:48	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	6.56	7	38	8	11.99
06:15:53	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	6.64	7	38	8	11.99
06:15:58	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.72	7	38	8	11.99
06:16:14	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	6.98	7	38	8	11.99
06:16:15	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	6.99	7	38	8	11.99
06:16:16	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.01	7	38	8	11.99

	8	11.99														
6:16:19	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.05	7	38		
	8	11.99														
06:16:20	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.07	7	38		
	8	11.99														
6:16:21	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.09	7	38		
	8	11.99														
06:16:22	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.11	7	38		
	8	11.99														
6:16:24	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.13	7	38		
	8	11.99														
6:16:25	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.15	7	38		
	8	11.99														
06:16:26	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.17	7	38		
	8	11.99														
6:16:27	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.18	7	38		
	8	11.99														
06:16:29	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.20	7	38		
	8	11.99														
6:16:30	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.22	7	38		
	8	11.99														
6:16:31	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.24	7	38		
	8	11.99														
06:16:32	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.26	7	38		
	8	11.99														
6:16:34	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.28	7	38		
	8	11.99														
06:16:35	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.30	7	38		
	8	11.99														
6:16:36	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.32	7	38		
	8	11.99														
6:16:37	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.34	7	38		
	8	11.99														
06:16:39	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.36	7	38		
	8	11.99														
6:16:40	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.38	7	38		
	8	11.99														
06:16:41	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.39	7	38		
	8	11.99														
6:16:42	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.41	7	38		
	8	11.99														
6:16:44	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.43	7	38		
	8	11.99														
06:16:45	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.45	7	38		
	8	11.99														
6:16:46	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.47	7	38		
	8	11.99														
06:16:47	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.49	7	38		
	8	11.99														
6:16:49	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.51	7	38		
	8	11.99														
6:16:50	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.53	7	38		
	8	11.99														
06:16:51	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.55	7	38		
	8	11.99														
6:16:52	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.57	7	38		
	8	11.99														
06:16:53	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.58	7	38		
	8	11.99														
6:16:55	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.61	7	38		
	8	11.99														
6:16:56	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.62	7	38		
	8	11.99														
06:16:57	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.64	7	38		
	8	[illegible]														

															8	11.99
06:17:00	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.68	7	38	8	11.99
[redacted]:17:01	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.70	7	38	8	11.99
[redacted]:17:02	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.72	7	38	8	11.99
06:17:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.74	7	38	8	11.99
[redacted]:17:05	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.76	7	38	8	11.99
06:17:06	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.77	7	38	8	11.99
[redacted]:17:07	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.79	7	38	8	11.99
[redacted]:17:08	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.81	7	38	8	11.99
06:17:10	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.83	7	38	8	11.99
[redacted]:17:11	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.85	7	38	8	11.99
06:17:12	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.86	7	38	8	11.99
[redacted]:17:13	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.88	7	38	8	11.99
[redacted]:17:15	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.90	7	38	8	11.99
06:17:16	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	7.92	7	38	8	11.99
[redacted]:17:17	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.94	7	38	8	11.99
06:17:18	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.96	7	38	8	11.99
[redacted]:17:20	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.97	7	38	8	11.99
[redacted]:17:21	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	7.99	7	38	8	11.99
06:17:22	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	8.01	7	38	8	11.99
[redacted]:17:23	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	8.03	7	38	8	11.99
06:17:25	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	8.04	7	38	8	11.99
[redacted]:17:26	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.06	7	38	8	11.99
[redacted]:17:27	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.08	7	38	8	11.99
06:17:28	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.09	7	38	8	11.99
[redacted]:17:33	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.15	7	38	8	11.99
06:17:38	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.22	7	38	8	11.99
[redacted]:17:43	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.28	7	38	8	11.99
[redacted]:17:48	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.34	7	38	8	11.99
06:17:53	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.41	7	38	8	11.99
[redacted]:17:58	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	8.47	7	38	8	11.99
06:18:03	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	8.53	7	38	8	11.99
[redacted]:18:08	1	0.00	2	7.38	3	0.00	4	0.00	5	0.00	6	8.60	7	38	8	11.99

06:18:18	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.72	7	38	8	11.99
06:18:23	1	0.00	2	7.39	3	0.00	4	0.00	5	0.00	6	8.79	7	38	8	11.99
06:18:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	8.83	7	38	8	12.00
06:18:38	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	8.96	7	38	8	12.00
06:18:48	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	9.08	7	38	8	12.00
06:18:58	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	9.20	7	38	8	12.00
06:19:08	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	9.32	7	38	8	12.00
06:19:18	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	9.44	7	38	8	12.00
06:19:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	9.55	7	38	8	12.00
06:19:38	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	9.65	7	38	8	12.00
06:19:48	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	9.74	7	38	8	12.00
06:19:58	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	9.82	7	38	8	12.00
06:20:08	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	9.90	7	38	8	12.00
06:20:18	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	9.97	7	38	8	12.00
06:20:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.03	7	38	8	12.00
06:20:38	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.10	7	38	8	12.00
06:20:48	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.16	7	38	8	12.00
06:20:58	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.23	7	38	8	12.00
06:21:08	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.29	7	38	8	12.00
06:21:18	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.36	7	38	8	12.00
06:21:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.42	7	38	8	12.00
06:21:38	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.49	7	38	8	12.00
06:21:48	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.56	7	38	8	12.00
06:21:58	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.62	7	38	8	12.03
06:22:08	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.69	7	38	8	12.03
06:22:18	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.75	7	38	8	12.01
06:22:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.81	7	38	8	12.01
06:22:38	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.87	7	38	8	12.01
06:22:48	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.94	7	38	8	12.01
06:22:58	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.00	7	38	8	12.01
06:23:08	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	10.96	7	38	8	12.01
06:23:18	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.09	7	38	8	12.03

															8	12.01
[redacted]:23:38	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.22	7	38	8	12.03
06:23:48	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.27	7	38	8	12.01
[redacted]:23:58	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.32	7	38	8	12.03
06:24:08	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.37	7	38	8	12.01
[redacted]:24:18	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.42	7	38	8	12.03
[redacted]:24:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.46	7	38	8	12.01
06:24:38	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.50	7	38	8	12.01
[redacted]:24:48	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.55	7	38	8	12.00
06:24:58	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.58	7	38	8	12.00
[redacted]:25:08	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.61	7	38	8	12.00
[redacted]:25:18	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.65	7	38	8	12.03
06:25:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.69	7	38	8	12.03
[redacted]:25:38	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.72	7	38	8	12.01
06:25:48	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.75	7	38	8	12.00
[redacted]:25:58	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.78	7	38	8	12.03
[redacted]:26:08	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.81	7	38	8	12.00
06:26:18	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.84	7	38	8	12.00
[redacted]:26:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	11.88	7	38	8	12.03
06:27:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	12.03	7	37	8	12.03
[redacted]:28:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	12.17	7	37	8	12.00
[redacted]:29:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	12.31	7	37	8	12.00
06:30:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	12.43	7	37	8	12.00
[redacted]:31:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	12.54	7	37	8	12.03
06:32:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	12.65	7	36	8	12.00
[redacted]:33:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	12.76	7	36	8	12.00
[redacted]:34:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	12.86	7	36	8	12.00
06:35:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	12.94	7	36	8	12.00
[redacted]:36:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.02	7	35	8	12.00
06:37:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.10	7	35	8	12.00
[redacted]:38:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.17	7	35	8	12.00
[redacted]:39:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.23	7	35	8	12.00
06:40:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.30	7	34	8	12.00

06:42:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.42	7	34	8	12.00
06:43:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.48	7	34	8	12.00
06:44:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.53	7	33	8	11.99
06:45:28	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.56	7	33	8	11.99
06:47:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.65	7	33	8	11.99
06:57:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	13.99	7	32	8	11.99
07:07:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.22	7	30	8	11.99
07:17:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.39	7	29	8	11.98
07:27:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.51	7	30	8	11.97
07:37:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.61	7	31	8	11.96
07:47:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.67	7	31	8	11.96
07:57:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.73	7	33	8	11.96
08:07:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.77	7	34	8	11.95
08:17:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.81	7	35	8	11.95
08:27:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.84	7	36	8	11.94
08:37:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.86	7	35	8	11.94
08:47:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.89	7	34	8	11.94
08:57:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.91	7	33	8	11.94
09:07:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.93	7	32	8	11.93
09:17:00	1	0.00	2	0.00	3	0.00	4	0.00	5	0.00	6	14.95	7	31	8	11.93

APPENDIX L

s′ vs. t/t′ - Recovery Test #1

APPENDIX L

s' vs. t/t' - Recovery Test #1

T/T'	PUMP WELL DRAWDOWN(FT) UNCORRECTED/CORRECTED
28.42	5.69/ 2.85
27.50	5.57/ 2.85
26.65	5.47/ 2.85
25.85	5.37/ 2.84
25.09	5.28/ 2.83
24.39	5.20/ 2.83
23.72	5.12/ 2.82
23.09	5.04/ 2.81
22.49	4.94/ 2.80
21.92	4.86/ 2.79
21.39	4.79/ 2.78
20.88	4.72/ 2.77
20.39	4.65/ 2.75
19.93	4.56/ 2.74
19.49	4.48/ 2.72
19.07	4.33/ 2.69
18.67	4.26/ 2.67
18.28	4.19/ 2.65
17.92	4.11/ 2.63
17.56	4.04/ 2.61
17.23	3.98/ 2.59
16.90	3.91/ 2.57
16.59	3.85/ 2.55
16.29	3.79/ 2.53
16.00	3.74/ 2.51
15.72	3.68/ 2.49
15.46	3.63/ 2.47
15.20	3.58/ 2.46
14.95	3.53/ 2.44
14.71	3.48/ 2.42
14.48	3.45/ 2.41
14.25	3.41/ 2.39
14.03	3.37/ 2.37
13.82	3.33/ 2.36
12.69	3.13/ 2.27
11.74	2.97/ 2.20
10.94	2.82/ 2.12
10.25	2.68/ 2.05
9.64	2.55/ 1.98
9.11	2.43/ 1.91
8.65	2.31/ 1.84
8.23	2.21/ 1.78
7.85	2.11/ 1.72
7.52	2.03/ 1.67
7.21	1.95/ 1.62
6.93	1.88/ 1.57
6.68	1.81/ 1.52
6.45	1.74/ 1.47
6.23	1.67/ 1.43
6.03	1.61/ 1.38
5.85	1.55/ 1.34
5.68	1.48/ 1.29
5.52	1.43/ 1.25

[illegible]	[illegible]	[illegible]
3.19	.65/	.61
2.88	.53/	.51
2.65	.45/	.43
2.46	.39/	.38
2.32	.36/	.35
2.20	.29/	.28

AVERAGE DRAWDOWN = 1.06

APPENDIX M

s′ vs. t/t′ - Recovery Test #2

APPENDIX M

s' vs. t/t' - Recovery Test #2

T/T'	PUMP WELL DRAWDOWN(FT) UNCORRECTED/CORRECTED
72.46	5.59/ 2.85
69.97	5.48/ 2.85
67.64	5.38/ 2.84
65.47	5.29/ 2.84
63.44	5.21/ 2.83
61.53	5.13/ 2.82
59.73	5.06/ 2.81
58.04	5.00/ 2.81
56.44	4.93/ 2.80
54.93	4.87/ 2.79
53.50	4.80/ 2.78
52.14	4.74/ 2.77
50.86	4.67/ 2.76
49.63	4.61/ 2.75
48.47	4.54/ 2.73
47.35	4.47/ 2.72
46.29	4.41/ 2.70
45.28	4.34/ 2.69
44.31	4.28/ 2.67
43.38	4.22/ 2.66
42.49	4.16/ 2.64
41.64	4.09/ 2.62
40.82	4.03/ 2.61
40.04	4.07/ 2.62
39.28	3.94/ 2.58
38.56	3.86/ 2.55
37.86	3.81/ 2.54
37.18	3.76/ 2.52
36.54	3.71/ 2.50
35.91	3.66/ 2.48
35.30	3.61/ 2.47
34.72	3.57/ 2.45
34.15	3.53/ 2.44
33.61	3.48/ 2.42
33.08	3.45/ 2.41
32.57	3.42/ 2.39
32.07	3.38/ 2.38
31.59	3.34/ 2.36
31.13	3.31/ 2.35
30.67	3.28/ 2.34
30.24	3.25/ 2.32
29.81	3.22/ 2.31
29.40	3.19/ 2.30
29.00	3.15/ 2.28
26.81	3.00/ 2.21
24.93	2.86/ 2.14
23.31	2.72/ 2.07
21.90	2.60/ 2.01
20.66	2.49/ 1.95
19.55	2.38/ 1.88
18.56	2.27/ 1.82
17.67	2.17/ 1.76
16.87	2.09/ 1.71
[illegible]	[illegible]

14.87	1.86/ 1.56
14.31	1.80/ 1.52
13.79	1.73/ 1.47
13.32	1.68/ 1.43
12.87	1.61/ 1.38
12.46	1.55/ 1.34
12.08	1.50/ 1.30
11.72	1.47/ 1.28
11.21	1.38/ 1.21
8.80	1.04/ .95
7.31	.81/ .75
6.29	.64/ .60
5.56	.52/ .50
5.01	.42/ .40
4.57	.36/ .35
4.22	.30/ .29
3.94	.26/ .25
3.70	.22/ .22
3.49	.19/ .19
3.32	.17/ .17
3.17	.14/ .14
3.03	.12/ .12
2.91	.10/ .10
2.81	.08/ .08

AVERAGE DRAWDOWN = .71

APPENDIX N

s′ vs. t/t′ - Recovery Test at Well MW-11

APPENDIX N

s' vs. t/t' - Recovery Test at Well MW-11

t(min)	t'(min)	t/t'	s'(ft)	Corrected[a] s'(ft)
280.25	0.25	1121	2.76	2.06
280.50	0.50	561	2.71	2.04
280.75	0.75	374	2.63	2.00
281.00	1.00	281	2.51	1.93
281.25	1.25	225	2.42	1.88
281.50	1.50	188	2.38	1.86
281.75	1.75	161	2.34	1.84
282.00	2.00	141	2.25	1.79
282.50	2.5	113	2.17	1.74
283.00	3.0	94	2.09	1.69
283.50	3.5	81	2.00	1.63
284.50	4.5	63	1.86	1.54
285	5	57	1.76	1.48
286	6	48	1.67	1.42
287	7	41	1.54	1.32
288	8	36	1.46	1.27
289	9	32	1.38	1.21
290	10	29	1.34	1.18
295	15	20	1.25	1.11
300	20	15	0.96	0.88
305	25	12	0.84	0.78

[a] b = 5.44 ft

APPENDIX O

STEADY STATE HYDRAULIC HEAD SIMULATION INPUT DATA

APPENDIX O

STEADY-STATE HYDRAULIC HEAD SIMULATION INPUT DATA

INTERACTIVE MICROCOMPUTER PLASM

INPUT DATA PRINTOUT

System of units used = ENGLISH (gal-day-ft)
Number of time steps= 1
Initial time step= 365 days
Number of rows and columns= 18 25
Allowed error in head between iteration= .45
Unconfined conditions.
Water balance not in effect
Predictor in effect.

INITIAL HEAD

```
0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.5503E+04
     0.5503E+04 0.5503E+04 0.5504E+04 0.5504E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.5502E+04
     0.5519E+04 0.5519E+04 0.5500E+04 0.5503E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.5502E+04
     0.5522E+04 0.5522E+04 0.5500E+04 0.5503E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04 0.9999E+04
     0.9999E+04 0.9999E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5501E+04 0.5501E+04 0.5501E+04
     0.5501E+04 0.5501E+04 0.5501E+04 0.5501E+04 0.5501E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04

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     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.9999E+04 0.5499E+04 0.5499E+04
     0.5516E+04 0.5516E+04 0.5516E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04
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     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.5499E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.5499E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
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     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.9999E+04 0.5499E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.9999E+04 0.5499E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.9999E+04 0.5498E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.9999E+04 0.5498E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

0.9999E+04 0.9999E+04 0.9999E+04 0.5498E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
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     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

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     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

0.5497E+04 0.5497E+04 0.5498E+04 0.5498E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
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     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5503E+04 0.9999E+04 0.9999E+04

0.5497E+04 0.5498E+04 0.5498E+04 0.5498E+04 0.5499E+04
     0.5499E+04 0.5499E+04 0.5499E+04 0.5499E+04 0.5500E+04
     0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04 0.5500E+04
     0.5500E+04 0.5501E+04 0.5501E+04 0.5501E+04 0.5502E+04
     0.5502E+04 0.5503E+04 0.5503E+04 0.9999E+04 0.9999E+04
```

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0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

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      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.1313E+04
      0.1360E+04 0.1407E+04 0.1454E+04 0.1500E+04 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.1254E+04
      0.7596E+06 0.7596E+06 0.7571E+06 0.1377E+04 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.1207E+04
      0.7601E+06 0.7601E+06 0.7571E+06 0.1377E+04 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.9732E+03 0.9842E+03 0.9966E+03
      0.1009E+04 0.1020E+04 0.1032E+04 0.1043E+04 0.1056E+04
      0.1067E+04 0.1079E+04 0.1090E+04 0.1114E+04 0.1160E+04
      0.7571E+06 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.9113E+03 0.7571E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.8300E+03 0.8535E+03
      0.7593E+06 0.7593E+06 0.7593E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.8011E+03 0.7593E+06 0.7593E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
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      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.7901E+03 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
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      0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.7791E+03 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.7601E+03 0.7571E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
      0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 [illegible]
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     0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.7571E+03 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.7447E+03 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
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     0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.7337E+03 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.7213E+03 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
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     0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.6979E+03 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.5575E+03 0.6043E+03 0.6277E+03 0.6511E+03 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
     0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.5506E+03 0.6428E+03 0.6883E+03 0.7350E+03 0.7805E+03
     0.8025E+03 0.8259E+03 0.8493E+03 0.8672E+03 0.8947E+03
     0.9181E+03 0.9402E+03 0.9635E+03 0.9814E+03 0.1001E+04
     0.1020E+04 0.1041E+04 0.1060E+04 0.1101E+04 0.1170E+04
     0.1239E+04 0.1308E+04 0.1377E+04 0.0000E+00 0.0000E+00


                     TRANSMISSIVITY IN J-DIRECTION

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.1313E+04
     0.1360E+04 0.1407E+04 0.1454E+04 0.1500E+04 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.1254E+04
     0.7596E+06 0.7596E+06 0.7571E+06 0.1377E+04 0.0000E+00
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 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.1207E+04
 0.7601E+06 0.7601E+06 0.7571E+06 0.1377E+04 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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 0.1067E+04 0.1079E+04 0.1090E+04 0.1114E+04 0.1160E+04
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 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.8300E+03 0.8335E+03
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 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

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 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

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 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

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 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

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 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

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 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00
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 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.6979E+03 0.7571E+06
 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
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 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.5575E+03 0.6043E+03 0.6277E+03 0.6511E+03 0.7571E+06
 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
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 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06 0.7571E+06
 0.7571E+06 0.7571E+06 0.1377E+04 0.0000E+00 0.0000E+00

0.5506E+03 0.6420E+03 0.6883E+03 0.7350E+03 0.7805E+03
 0.8025E+03 0.8259E+03 0.8493E+03 0.8672E+03 0.8947E+03
 0.9181E+03 0.9402E+03 0.9635E+03 0.9814E+03 0.1001E+04
 0.1020E+04 0.1041E+04 0.1060E+04 0.1101E+04 0.1170E+04
 0.1239E+04 0.1308E+04 0.1377E+04 0.0000E+00 0.0000E+00
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STORAGE COEFFICIENT

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 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E+23
 0.1000E+23 0.1000E+23 0.1000E+23 0.1000E+23 0.1000E-21

0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21
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 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E+23
 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E+23 0.1000E-21

0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21
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 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E+23 0.1000E-21

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 0.1000E-21 0.1000E-21 0.1000E+23 0.1000E+23 0.1000E+23
 0.1000E+23 0.1000E+23 0.1000E+23 0.1000E+23 0.1000E+23
 0.1000E+23 0.1000E+23 0.1000E+23 0.1000E+23 0.1000E+23
 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E+23 0.1000E-21

0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21
 0.1000E-21 0.1000E+23 0.1000E-21 0.1000E-21 0.1000E-21
 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21
 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21
 0.1000E-21 0.1000E-21 0.1000E+23 0.1000E-21 0.1000E-21

0.1000E-21 0.1000E-21 0.1000E-21 0.1000E+23 0.1000E+23
 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21
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0.1000E-21 0.1000E-21 0.1000E+23 0.1000E-21 0.1000E-21

0.1000E-21 0.1000E-21 0.1000E+23 0.1000E-21 0.1000E-21
0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21
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0.1000E-21 0.1000E-21 0.1000E+23 0.1000E-21 0.1000E-21

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0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21
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0.1000E-21 0.1000E-21 0.1000E+23 0.1000E-21 0.1000E-21

0.1000E+23 0.1000E+23 0.1000E+23 0.1000E+23 0.1000E-21
0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21
0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21 0.1000E-21
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0.1000E+23 0.1000E+23 0.1000E+23 0.1000E+23 0.1000E+23
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0.1000E+23 0.1000E+23 0.1000E+23 0.1000E+23 0.1000E+23

0.1000E+23 0.1000E+23 0.1000E+23 0.1000E-21 0.1000E-21

NET DISCHARGE

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     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 -.1270E-02 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 -.1270E-02 0.0000E+00 0.0000E+00

0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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     -.1270E-02 -.1270E-02 -.1270E-02 -.1270E-02 -.1270E-02
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0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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     -.1270E-02 -.1270E-02 0.0000E+00 0.0000E+00 0.0000E+00

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LEAKANCE

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0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
     0.0000E+00 0.0000E+00 [illegible]
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SOURCE BED HEAD

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     0.5519E+04 0.5519E+04 0.0000E+00 0.0000E+00 0.0000E+00

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     0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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CONFINING BED BOTTOM

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0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
    0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
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    0.5515E+04 0.5515E+04 0.0000E+00 0.0000E+00 0.0000E+00

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    0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
    0.0000E+00 0.0000E+00 0.0000E+00 0.5492E+04 0.0000E+00
    0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
    0.5518E+04 0.5518E+04 0.0000E+00 0.0000E+00 0.0000E+00

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HYDRAULIC CONDUCTIVITY IN THE I DIRECTION
(unadjusted)

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          HYDRAULIC CONDUCTIVITY IN THE J DIRECTION
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0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03
     0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03
     0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03
     0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03
     0.1376E+03 0.1376E+03 0.1376E+03 0.0000E+00 0.0000E+00

0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03
     0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03
     0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03
     0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03 0.1376E+03
     0.1376E+03 0.1376E+03 0.1376E+03 0.0000E+00 0.0000E+00
```

ELEVATION OF BOTTOM OF AQUIFER

```
0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.0000E+00 0.0000E+00 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.0000E+00 0.0000E+00 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 [illegible]
```

```
0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
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     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04

0.5491E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04
     0.5492E+04 0.5492E+04 0.5492E+04 0.5492E+04 0.5493E+04
     0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04 0.5493E+04
```

hese are the DELY values (i.e. column spacing)

The spacing between node 2 and node 3 is 100
The spacing between node 3 and node 4 is 100
The spacing between node 4 and node 5 is 100
The spacing between node 5 and node 6 is 50
The spacing between node 6 and node 7 is 50
The spacing between node 7 and node 8 is 50
The spacing between node 8 and node 9 is 50
The spacing between node 9 and node 10 is 50
The spacing between node 10 and node 11 is 50
The spacing between node 11 and node 12 is 50
The spacing between node 12 and node 13 is 50
The spacing between node 13 and node 14 is 50
The spacing between node 14 and node 15 is 50
The spacing between node 15 and node 16 is 50
The spacing between node 16 and node 17 is 50
The spacing between node 17 and node 18 is 50
The spacing between node 18 and node 19 is 100
The spacing between node 19 and node 20 is 200
The spacing between node 20 and node 21 is 200
The spacing between node 21 and node 22 is 200
The spacing between node 22 and node 23 is 200
The spacing between node 23 and node 24 is 200
The spacing between node 24 and node 25 is 200

These are the DELY values (i.e. row spacing)

The spacing between node 1 and node 2 is 300
The spacing between node 2 and node 3 is 250
The spacing between node 3 and node 4 is 200
The spacing between node 4 and node 5 is 200
The spacing between node 5 and node 6 is 200
The spacing between node 6 and node 7 is 200
The spacing between node 7 and node 8 is 100
The spacing between node 8 and node 9 is 50
The spacing between node 9 and node 10 is 50
The spacing between node 10 and node 11 is 50
The spacing between node 11 and node 12 is 50
The spacing between node 12 and node 13 is 50
The spacing between node 13 and node 14 is 50
The spacing between node 14 and node 15 is 50
The spacing between node 15 and node 16 is 100
The spacing between node 16 and node 17 is 200
The spacing between node 17 and node 18 is 400

APPENDIX P

STEADY STATE HYDRAULIC HEAD
SIMULATION OUTPUT DATA

APPENDIX P

STEADY-STATE HYDRAULIC HEAD SIMULATION OUTPUT DATA

```
ITER =  1   ER =  81240.58    TIME =  365
ITER =  2   ER =  70.37451    TIME =  365
ITER =  3   ER =  53.91602    TIME =  365
ITER =  4   ER =  33.07813    TIME =  365
ITER =  5   ER =  31.13232    TIME =  365
ITER =  6   ER =  19.46631    TIME =  365
ITER =  7   ER =  20.13623    TIME =  365
ITER =  8   ER =  12.38574    TIME =  365
ITER =  9   ER =  13.75586    TIME =  365
ITER =  10   ER =  8.299316   TIME =  365
ITER =  11   ER =  9.806152   TIME =  365
ITER =  12   ER =  5.835938   TIME =  365
ITER =  13   ER =  7.243164   TIME =  365
ITER =  14   ER =  4.287109   TIME =  365
ITER =  15   ER =  5.528809   TIME =  365
ITER =  16   ER =  3.301758   TIME =  365
ITER =  17   ER =  4.306152   TIME =  365
ITER =  18   ER =  2.561035   TIME =  365
ITER =  19   ER =  3.413574   TIME =  365
ITER =  20   ER =  2.056152   TIME =  365
ITER =  21   ER =  2.745117   TIME =  365
ITER =  22   ER =  1.702148   TIME =  365
ITER =  23   ER =  2.225098   TIME =  365
ITER =  24   ER =  1.368652   TIME =  365
ITER =  25   ER =  1.819336   TIME =  365
ITER =  26   ER =  1.137695   TIME =  365
ITER =  27   ER =  1.500977   TIME =  365
ITER =  28   ER =  .9599609   TIME =  365
ITER =  29   ER =  1.217285   TIME =  365
ITER =  30   ER =  .7792969   TIME =  365
ITER =  31   ER =  .9912109   TIME =  365
ITER =  32   ER =  .6455078   TIME =  365
ITER =  33   ER =  .7988281   TIME =  365
ITER =  34   ER =  .5415039   TIME =  365
ITER =  35   ER =  .6650391   TIME =  365
ITER =  36   ER =  .4477539   TIME =  365
```

CATEGORY PRINTOUT

```
%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999
9999%9999%9999%9999%9999%9999%9999%9999%9999
9998%9999%9998%9998%9999%9998%9998%9998%9998%9998%9998%9998%9998%9998%9998%9998
%9998%9999%9999%5502%5502%5503%5503%5503%5503
%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999
9999%9999%9999%5502%5502%5502%5502%5502%5502
%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999%9999
%9999%9999%9999%5501%5502%5502%5502%5503%5503
9999%9999%9999%9999%9999%9999%9999%5500%5500%5500%5500%5500%5500%5500%5500%5500
5500%5500%5501%5504%5502%5502%5502%5503%5503
%9999%9999%9999%9999%9999%9999%5499%5499%5500%5500%5500%5500%5500%5500%5500%5500
5501%5501%5501%5501%5502%5502%5503%5502%9999
9999%9999%9999%5499%5499%5499%5499%5499%5499%5500%5500%5500%5500%5500%5500%5500
%5501%5501%5501%5502%5502%5502%5502%5503%9999
%9999%9999%5498%5499%5499%5499%5499%5499%5499%5500%5500%5500%5500%5500%5500%5501
5501%5501%5501%5502%5502%5502%5502%5503%9999
%9999%9999%5498%5498%5499%5499%5499%5499%5499%5499%5500%5500%5500%5500%5500%5501
%5501%5501%5501%5502%5502%5502%5503%5503%9999
9999%9999%5498%5498%5498%5499%5499%5499%5499%5499%5500%5500%5500%5500%5500%5501
5501%5501%5501%5502%5502%5502%5503%5503%9999
%9999%9999%5498%5498%5498%5499%5499%5499%5499%5499%5500%5500%5500%5500%5500%5501
```

```
%5501%5501%5501%5502%5502%5502%5503%5503%9999
9999%9999%9999%5498%5498%5498%5499%5499%5499%5499%5499%5500%5500%5500%5500%5500
%5501%5501%5501%5502%5502%5502%5503%5503%9999
%9999%9999%9999%5498%5498%5498%5499%5499%5499%5499%5499%5500%5500%5500%5500%5500
5501%5501%5501%5502%5502%5502%5503%5503%9999
9999%9999%9999%5498%5498%5498%5499%5499%5499%5499%5499%5500%5500%5500%5500%5500
%5501%5501%5501%5501%5502%5502%5502%5503%9999
9999%9999%9999%5498%5498%5498%5498%5499%5499%5499%5499%5499%5500%5500%5500%5500
5500%5501%5501%5501%5502%5502%5502%5503%9999
%5497%5497%5497%5497%5498%5498%5498%5499%5499%5499%5499%5499%5500%5500%5500%5500
%5500%5501%5501%5501%5502%5502%5502%5503%9999
5497%5497%5498%5498%5498%5498%5499%5499%5499%5499%5499%5499%5500%5500%5500%5500
%5500%5500%5501%5501%5502%5502%5503%5503%9999
```

```
 Time =   365  days
                                HEAD (ft or m)

 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00
 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00
 9999.00 9999.00 9999.00 9999.00 9999.00
 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00
 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 5502.54
 5502.88 5503.22 5503.56 5503.90 5503.90
 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00
 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 5502.11
 5502.80 5502.82 5502.86 5503.00 5503.00
 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00
 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 5501.77
 5502.80 5502.82 5502.84 5503.00 5503.00
 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 5500.07 5500.15 5500.24
 5500.33 5500.41 5500.50 5500.58 5500.67 5500.75 5500.84 5500.92 5501.09 5501.43
 5502.75 5502.84 5502.94 5503.00 5503.00
 9999.00 9999.00 9999.00 9999.00 9999.00 9999.00 5499.62 5499.84 5500.01 5500.16
 5500.28 5500.40 5500.51 5500.63 5500.74 5500.87 5501.01 5501.18 5501.44 5501.83
 5502.46 5502.78 5503.00 5503.00 9999.00
 9999.00 9999.00 9999.00 5499.03 5499.20 5499.42 5499.57 5499.73 5499.89 5500.08
 5500.23 5500.38 5500.52 5500.66 5500.80 5500.96 5501.15 5501.37 5501.65 5502.00
 5502.42 5502.76 5503.00 5503.00 9999.00
 9999.00 9999.00 5498.82 5499.01 5499.13 5499.31 5499.51 5499.68 5499.85 5500.02
 5500.19 5500.35 5500.51 5500.67 5500.84 5501.03 5501.24 5501.47 5501.76 5502.08
 5502.42 5502.75 5503.00 5503.00 9999.00
 9999.00 9999.00 5498.74 5498.93 5499.08 5499.25 5499.43 5499.61 5499.79 5499.97
 5500.14 5500.32 5500.49 5500.67 5500.86 5501.06 5501.29 5501.54 5501.81 5502.12
 5502.43 5502.75 5503.00 5503.00 9999.00
 9999.00 9999.00 5498.66 5498.79 5498.97 5499.16 5499.36 5499.54 5499.73 5499.92
 5500.10 5500.29 5500.47 5500.66 5500.86 5501.08 5501.31 5501.56 5501.84 5502.14
 5502.44 5502.75 5503.00 5503.00 9999.00
 9999.00 9999.00 5498.66 5498.58 5498.85 5499.07 5499.28 5499.48 5499.67 5499.86
 5500.06 5500.25 5500.44 5500.64 5500.85 5501.07 5501.31 5501.57 5501.85 5502.14
 5502.44 5502.75 5503.00 5503.00 9999.00
 9999.00 9999.00 9999.00 5498.50 5498.76 5498.99 5499.20 5499.41 5499.61 5499.81
 5500.01 5500.20 5500.40 5500.61 5500.82 5501.04 5501.29 5501.55 5501.83 5502.13
 5502.43 5502.74 5503.00 5503.00 9999.00
 9999.00 9999.00 9999.00 5498.41 5498.68 5498.91 5499.14 5499.35 5499.56 5499.76
 5499.96 5500.15 5500.35 5500.56 5500.77 5501.00 5501.24 5501.51 5501.79 5502.10
 5502.41 5502.73 5503.00 5503.00 9999.00
 9999.00 9999.00 9999.00 5498.33 5498.61 5498.85 5499.08 5499.30 5499.50 5499.71
 5499.90 5500.10 5500.30 5500.50 5500.71 5500.93 5501.17 5501.44 5501.73 5502.05
 5502.38 5502.72 5503.00 5503.00 9999.00
 9999.00 9999.00 9999.00 5498.24 5498.53 5498.79 5499.03 5499.25 5499.46 5499.66
 5499.85 5500.04 5500.23 5500.43 5500.63 5500.84 5501.08 5501.34 5501.65 5501.98
 5502.34 5502.70 5503.00 5503.00 9999.00
```

5502.27	5502.67	5503.00	5503.00	9999.00					
5497.05	5497.39	5497.56	5497.73	5498.43	5498.75	5498.99	5499.19	5499.37	5499.56
5499.74	5499.91	5500.09	5500.25	5500.41	5500.59	5500.78	5501.00	5501.32	5501.73
5502.16	5502.61	5503.00	5503.00	9999.00					
5497.00	5497.67	5498.00	5498.34	5498.67	5498.83	5499.00	5499.17	5499.30	5499.50
5499.67	5499.83	5500.00	5500.13	5500.27	5500.41	5500.56	5500.70	5501.00	5501.50
5502.00	5502.50	5503.00	5503.00	9999.00					

APPENDIX Q

GCL PORTABLE GAS CHROMATOGRAPH SPECIFICATIONS STANDARD OPERATING PROCEDURE

MANUAL OF STANDARD OPERATING PROCEDURES | DATE: 11/11/87

EFFECTIVE: 11/11/87

SUPERSEDES:

SAMPLING AND GAS CHROMATOGRAPHIC ANALYSIS FOR SOILS AND GROUNDWATER

PURPOSE

The purpose for a Standard Operating Procedure (SOP) is to establish a consistent procedure for the sampling and analysis of BTEX in soil and ground-water samples, and to provide QA in the resulting data.

SCOPE

The scope of this SOP will include the collection, storage, and the subsequent Head-Space Analysis (HSA) of soil and ground-water samples with a Photovac 10S50 Portable Gas Chromatograph (GC).

PROCEDURE

1.0 <u>SOIL SAMPLING</u>

1.1 A borehole is made, with a continuous sampler or some equivalent boring device, to a pre-determined depth.

1.2 The entire soil core is carefully removed from the hole. A 250 mL container, with teflon-lined lid, is filled with samples such that there is equal volumes of soil and headspace in the container. Care must be taken to insure that the sampling implement is clean prior to sampling, and that volatiles are not released by excess agitation of the sample.

1.3 The container is immediately sealed to prevent the loss of volatile compounds from the sample.

1.4 Samples will be stored in an ice-chest or refrigerator at 4.0°C to preserve them for analysis. If analysis is to be performed within 1 hour of sampling, no preservation is necessary.

1.5 Chain-of-Custody seals must be applied to samples which will not be analyzed within 1 hour of collection.

2.0 GROUND-WATER SAMPLING

2.1 Ground-water samples are removed from monitor wells using a clean, bottom-filling bailer and polyethylene rope. Prior to sampling, the bailer will be rinsed with the water from the monitor well to avoid possible field contamination.

2.2 After rinsing, a sample is removed from the well and is carefully transferred into a 40 mL septum vial. The vial is filled such that there are equal volumes of water and head-space.

2.3 The container is immediately sealed and inverted for storage to prevent the loss of volatile compounds from the sample.

2.4 Samples will be stored in an ice-chest or refrigerator at 4.0°C to preserve them for analysis. If analysis is to be performed within 1 hour of sampling, no preservation is necessary.

2.5 Chain-of-Custody seals must be applied to samples which will not be analyzed within 1 hour of collection.

3.0 <u>HEADSPACE ANALYSIS</u>

2.1 Approximately 60 mins. prior to analysis, the sample containers should be removed from cold storage so that they can equilibrate at room temperature.

2.2 After sample equilibration, and immediately before analysis, the sample is vigorously shaken for 30 secs. to increase the distribution of BTEX into the headspace.

2.3 For Soil Samples, a 10 mL glass syringe is used to remove 8 mL of headspace gas from the container and 1 mL of the sample is then injected into the GC as described in Figure 1.

2.4 For water samples, 1 mL of headspace gas is taken from the vial using a 2 mL syringe. The sample is then injected directly into the GC for analysis.

2.5 Syringe needles must be wiped clean between each contact with sample container and GC septum.

2.6 Clean needles and syringes must be used for each sample injection.

4.0 QUALITY CONTROL

3.1 Samples can be contaminated by diffusion of volatile organics through the sample container during shipment and storage. A field sample blank prepared from reagent water and carried through sampling and analysis can serve as a check on such contamination.

3.2 Before analyzing any samples, the analyst should demonstrate through the analysis of a water method blank that all glassware and instruments are interfesence-free. Each time a set of samples is to be analyzed, a series of calibration standards is analyzed to provide the detection limits and the means for quantitation of the samples.

3.3 Calibration Standards will be injected every 6 samples to insure continuing calibration of the GC.

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