LONG-TERM MONITORING SYSTEM DESIGN REPORT

Pantex Plant

Amarillo, Texas

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Long-Term Monitoring System Design Report
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ACRONYMS

4ADNT	4-amino,2,6-dinitrotoluene
B&W Pantex	Babcock & Wilcox Technical Services, Pantex, LLC
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CMS/FS	Corrective Measure Study/Feasibility Study
COPC	Constituents of potential concern
COV	Coefficient of variation
Cr(VI)	Hexavalent chromium
EPA	United States Environmental Protection Agency
FCT	Former Cooling Tower
FGZ	Fine-grained zone
GSI	Groundwater Services, Incorporated
GWPS	Groundwater Protection Standard
HE	High explosive
HSU	Hydrostratigraphic unit
LTMO	Long-term monitoring optimization
MAROS	Monitoring and Remediation Optimization System
NNSA	National Nuclear Security Administration
NWS	National Weather Service
OSTP	Old Sewage Treatment Plant
PTC	Princeton Transport Code
PQL	Practical quantitation limit
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RDX	Research Development Explosive (cyclo-trimethylene trinitramine)
RFI	RCRA Facility Investigation
ROD	Record of Decision
RRS	Risk Reduction Standard
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TCEQ	Texas Commission on Environmental Quality
TTU	Texas Tech University
USDOE	U.S. Department of Energy
WMG	Waste management group
WWTF	Wastewater Treatment Facility

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1. INTRODUCTION

This report presents the proposed long-term groundwater monitoring (LTM) well network that was developed using statistical methods, fate and transport modeling, and site-specific knowledge for the evaluation of response actions (corrective/remedial actions) for Pantex Plant and monitoring uncertainties near source areas. This report also presents the methods for evaluation of the response actions based on the monitoring well network for Pantex Plant. Collected data are evaluated against expected conditions for each well. Contingency actions for unexpected conditions are provided in the *Pantex Plant Ogallala Aquifer and Perched Groundwater Contingency Plan*.

Pantex Plant is located on the plains of the Texas Panhandle, 17 miles northeast of Amarillo as shown in Figure 1-1. The Ogallala Aquifer, part of the High Plains aquifer system, is the principal water-bearing unit and provides a primary source of water for the region. Additionally, bodies of perched groundwater above the Ogallala Aquifer occur beneath much of Pantex Plant. Areas of this perched groundwater zone have been contaminated as a result of past wastewater discharges from legacy operations at the facility. Contaminated sites at the surface are separated from groundwater in either the perched zone or the Ogallala Aquifer by a 200- to 500-ft (61- to 153-m) thick unsaturated zone. In areas where perched groundwater is present, a second vadose zone occurs above the Ogallala Aquifer. A full description of the hydrogeology for Pantex is provided in Appendix A.

The primary purpose of the LTM network is to ensure that Remedial Action Objectives (RAOs) are being achieved. The data collected from the LTM network will be evaluated in annual and semi-annual progress reports, with a full evaluation of the effectiveness of the response actions in a 5-year review. The LTM network will also be reevaluated during the 5-year review to determine if changes are required to the network or the remedies to meet remedial action objectives presented in the Record of Decision (ROD) (B&W Pantex and Sapere Consulting, 2008).

The perched groundwater monitoring network is designed to monitor plume stability, response action effectiveness, and uncertainty management, as described in greater detail in Section 1.3. The many components of the selected remedy for perched groundwater are intended to work together to create conditions that both stabilize and cleanup the contaminants. The pump and treat systems in the southeast perched groundwater and the Playa 1 area focus on affecting the hydraulics of the system, that is groundwater removal as a means of reducing the potential for both vertical and lateral migration of contaminants. With this understanding, the primary metric for success of the pump and treat systems is perched groundwater thickness, as determined through periodic water level measurements. Routine monitoring for this parameter will provide the basis for determining flow direction, gradient, and thickness. These determinations will aid the prediction of plume movement and rate, as well as vertical flux of contaminants. A secondary benefit of the pump and treat systems is contaminant mass removal. Therefore, chemical analysis is also important as it allows the risk posed by the contaminant plumes to be evaluated periodically.

The southeast and Zone 11 *in situ* treatment systems target contaminant mass removal as a means of cleaning up the perched groundwater and protecting the underlying Ogallala Aquifer from future degradation that could affect its use as a drinking water source. These systems are down gradient of the perched groundwater plumes, in the areas that pose the greatest potential for vertical migration to the Ogallala Aquifer. Chemical analysis and parameters associated with redox potential of the perched groundwater will provide the most important information for determining the effectiveness of these systems. Evaluation of downgradient wells will provide information regarding the effectiveness of the treatment on the perched groundwater.

1.1. REGULATORY REQUIREMENTS

Long-term monitoring (LTM) is required to confirm future expected conditions within the perched groundwater and the Ogallala Aquifer at the Pantex Plant site. This plan is being provided in accordance with Article 8.5 of the Interagency Agreement, as part of the Remedial Design Submittal Package, Section VIII.F of Compliance Plan No. 50284, as part of the Corrective Measures Implementation Work Plan, and as part of the Compliance Plan Application to modify the Compliance Plan (CP-50284) to include the response (corrective) action provisions.

Uncertainty management objectives are included in the development of the plan to fulfill conditions of approval for the Resource Conservation and Recovery Act (RCRA) Facility Investigation Reports presented by Texas Commission on Environmental Quality (TCEQ) and United States Environmental Protection Agency (EPA). Long-term monitoring of perched groundwater and the Ogallala Aquifer will result in obtaining data to identify any unknown contaminant migration pathways. Should data be acquired that confirms an unexpected condition, the conceptual site model assumptions would be evaluated to determine the cause and mitigation measures would be assessed and implemented, as necessary, to maintain protection of human health and the environment. Contingency actions for unexpected conditions are presented in the *Pantex Plant Ogallala Aquifer and Perched Groundwater Contingency Plan*.

1.2. DESIGN STRATEGY

A LTM design strategy was formulated by the Pantex Core Team, a four-member committee established to facilitate better communication and streamline decision-making through the integrated RCRA-Comprehensive Environmental Response Compensation and Liability Act (CERCLA) cleanup process at Pantex Plant. The Core Team includes one member each from EPA, TCEQ, U.S. Department of Energy (USDOE)/ National Nuclear Security Administration (NNSA), and Babcock & Wilcox Technical Services, Pantex, LLC (B&W Pantex). The following steps outline the LTM network design strategy:

1. Develop monitoring objectives for each water-bearing unit.
2. Evaluate the existing well network in each water-bearing unit (Ogallala Aquifer and perched groundwater) with respect to each objective to identify areas where additional monitoring is needed.
3. Use statistical or mathematical monitoring network optimization tools to evaluate the existing well network and optimize the spatial distribution and frequency of monitoring.
4. Combine the results of the different evaluation methods to develop the final LTM network.

This design strategy was applied separately to perched groundwater and the Ogallala Aquifer to develop a LTM network for each aquifer. The monitoring objectives are described in the following section. The combined results of the different evaluations and final network designs are presented in Section 2 for perched groundwater and in Section 3 for the Ogallala Aquifer.

1.3. LONG-TERM MONITORING NETWORK OBJECTIVES

1.3.1 Perched Groundwater

Three objectives were identified for monitoring wells in perched groundwater: Plume Stability, Response Action Effectiveness, and Uncertainty Management. Some of the Response Action Effectiveness wells will be used to satisfy requirements under the Compliance Plan for Point of Compliance with the

Groundwater Protection Standards (GWPS). Some of the Uncertainty Management Wells will be used to satisfy requirements in the Compliance Plan for periodic evaluation of the closest water bearing unit near sources of contamination.

1.3.1.1 Plume Stability

The purpose of plume stability wells is to determine if impacted areas (plumes) of perched groundwater are expanding and affecting clean perched groundwater and to monitor the changes occurring within the perched plumes. Plume stability wells are located along the edges of the perched plumes where GWPSs are currently being met (note that some areas of perched groundwater are currently impacted above GWPSs to the extent of perched saturation and should show a decline in concentrations over time) and within perched plumes in areas where plumes may be expanding. The focus of monitoring in plume stability wells will be on constituents specific to the plume, Zone, waste management group (WMG), or unit where the well is located. The expected conditions for the plume stability wells are that changes in concentrations of constituents can be identified over time at various locations within and around the plumes.

1.3.1.2 Response Action Effectiveness

The purpose of response action effectiveness wells is to determine the effectiveness of response measures, indicate when RAOs for perched groundwater have been achieved, and validate modeling results or provide data that can be used to refine modeling. The focus of monitoring in response action effectiveness wells will be on constituents specific to the plume, Zone, WMG, or unit where the well is located. The expected conditions for the response action effectiveness wells are that, over time, indicators of the reduction in volume, toxicity and mobility of constituents will be observed. These indicators may include stable or decreasing concentrations of constituents or declining water levels in areas where response measures have been implemented.

1.3.1.3 Uncertainty Management

The purpose of uncertainty management wells in perched groundwater is to confirm expected conditions identified in the RCRA Facility Investigations (RFIs) and ensure there are not any deviations, fill potential data gaps, and fulfill LTM requirements for soil units evaluated in a baseline risk assessment. Uncertainty management wells are located downgradient of risk assessment units, using a Zone or WMG approach, in areas where perched groundwater is the underlying groundwater or downgradient of known source areas, such as the ditches and playas that contributed much of the constituent mass currently found in perched groundwater. Uncertainty management wells will be used to confirm expected conditions for each Zone, WMG, or unit through monitoring.

Some of the Uncertainty Management Wells will also be used to satisfy requirements in the Compliance Plan for periodic evaluation of wells near sources of contamination to ensure that new contamination is not found over time. Pantex recommends this sampling be conducted every 5 years to correspond to the 5-year review and will focus on wells near the source areas.

1.3.2 <u>Ogallala Aquifer</u>

Two objectives were identified for monitoring wells in the Ogallala Aquifer: Early Detection and Uncertainty Management. Specific wells in the Ogallala Aquifer serve as Point of Exposure wells to also satisfy requirements in the Compliance Plan. Some of the Uncertainty Management Wells were used to satisfy requirements in the Compliance Plan for periodic evaluation of the closest water bearing unit near sources of contamination.

1.3.2.1 Early Detection

The purpose of early detection wells is to identify breakthrough of constituents to the Ogallala Aquifer from overlying perched groundwater, if present, or potential source areas in the unsaturated zone before potential points of exposure have been impacted. Early detection wells are located downgradient of potential source areas, such as impacted areas of perched groundwater, along the edge of the known extent of impacted perched groundwater, and upgradient of potential points of exposure (i.e., the Pantex property boundary). Wells downgradient of potential source areas are located as close to the source area as possible; in some cases these wells must be moved further downgradient because of the risk of creating a migration pathway to the Ogallala Aquifer by drilling through impacted perched groundwater. The focus of monitoring in early detection wells will be on indicator constituents, such as conservative species and degradation products that will most likely be detected following breakthrough to the aquifer. Because of the cleanup actions that have been implemented to protect the Ogallala Aquifer, the expected conditions for the early detection wells are that constituents are not detected above background, the practical quantitation limit (PQL), or GWPSs and that constituents do not reach potential points of exposure above GWPSs.

1.3.2.2 Uncertainty Management

The purpose of uncertainty management wells in the Ogallala Aquifer is to confirm expected conditions identified in the RFIs and ensure there are not any deviations, fill potential data gaps, and fulfill LTM requirements for soil units closed to RRS 3. Uncertainty management wells will be located downgradient of RRS 3 units, using a Zone or WMG approach, in areas where perched groundwater is not present, or downgradient of potential source areas, such as impacted areas of perched groundwater and along the edge of the known extent of impacted perched groundwater.

Some of the Uncertainty Management Wells were also used to satisfy requirements in the Compliance Plan for periodic evaluation of wells near sources of contamination to ensure that new contamination is not found over time. Pantex recommends this sampling be conducted every 5 years to correspond to the 5-year review and will focus on wells near the source areas.

Figure 1-1. Pantex Plant Location Map

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2. PERCHED GROUNDWATER

This section summarizes the development of the LTM network for perched groundwater beneath Pantex Plant and presents the final LTM network. The strategy used to develop the monitoring network is presented in Section 1.2 and comprised the following steps:

1. Develop monitoring objectives.
2. Evaluate the existing well network with respect to each objective to identify areas where additional monitoring is needed.
3. Use statistical or mathematical monitoring network optimization tools to evaluate the existing well network and optimize the spatial distribution and frequency of monitoring.
4. Combine the results of the different evaluation methods to develop the final LTM network.

The monitoring objectives developed for perched groundwater are described in Section 2.1, the evaluation of the existing well network with respect to each objective is discussed in Section 2.2, and a summary of the statistical monitoring network optimization is provided in Section 2.3. The final LTM network is presented in Section 2.4 with a justification for each proposed new well.

2.1. MONITORING OBJECTIVES

The monitoring objectives developed for perched groundwater, described in Section 1.3.1, are plume stability, response action effectiveness, and uncertainty management. Plume stability wells are intended to determine if constituent plumes in perched groundwater are expanding and to monitor the changes occurring within the plumes. Monitoring in plume stability wells will be focused on constituents specific to the plume, Zone, WMG, or unit where the well is located. Two major plumes, defined by spatial extent, are found in perched groundwater. The southeast plume occurs beneath the eastern side of Pantex Plant and extends southeast beneath TTU property and across FM 2373. The extent of the southeast plume is defined primarily by the extents of RDX and hexavalent chromium, but high explosives, volatiles, and inorganics comprise the plume. The RDX and hexavalent chromium plumes are shown in Figure 2-1 and Figure 2-2. The Zone 11 plume occurs beneath Zone 11 and extends northeast to Playa 1 and south beneath TTU property. Perchlorate defines the extent of the Zone 11 plume, but TCE and other volatiles and high explosives are also found within the plume. The perchlorate plume is shown in Figure 2-3.

Response action effectiveness wells are used to determine the effectiveness of response measures, indicate when RAOs for perched groundwater have been achieved, and validate modeling results or provide data that can be used to refine modeling. Remediation of perched groundwater in the two major plumes will be accomplished through the use of four response action systems. The Southeast Pump and Treat System, Playa 1 Pump and Treat System, and Southeast In Situ Bioremediation System have been installed for the southeast plume. The locations of these systems are shown on Figure 2-1 and Figure 2-2. The Zone 11 In Situ Bioremediation System, designed to intercept the Zone 11 plume, is currently under construction south of Zone 11, as depicted in Figure 2-3.

Uncertainty management wells in perched groundwater provide information to confirm expected conditions identified in the RFIs and ensure there are not any deviations, fill potential data gaps, and fulfill LTM requirements for soil units closed to RRS 3. These wells are discussed further in Section 2.4.2.

2.2. EVALUATION OF EXISTING WELL NETWORK

The existing (as of May 2008) perched groundwater monitoring network, shown in Figure 2-4, was evaluated with respect to each objective to identify areas where additional monitoring is needed. This evaluation resulted in the proposed addition of six wells (PTX06-1130, PTX06-1131, PTX06-1133, PTX06-1146, PTX06-1147, and PTX06-1150) to the network to satisfy the monitoring objectives. Two additional wells (PTX06-1148 and PTX06-1149) were added to provide information for the design and to monitor effectiveness of the Zone 11 ISB response action.

Based on evaluation of the existing network, PTX-BEG3 is recommended for removal from the LTM system. This well was drilled to a depth of 434 ft by the Bureau of Economic Geology in 1992 to gather geologic information as part of the initial investigation. The lower part of the boring was plugged, but the completed well was screened 28 ft into the FGZ. Analytical data from PTX-BEG3 collected since 1992 do not indicate the presence of contamination. However, because this well is in the northeastern corner of Pantex where constituents have been detected in perched groundwater at nonactionable levels, it will be plugged and abandoned as a precaution against providing a pathway through the FGZ.

The proposed perched groundwater LTM network as well as the monitoring objectives satisfied by each existing and proposed well is shown on Figure 2-5.

2.3. SUMMARY OF LONG-TERM MONITORING OPTIMIZATION RECOMMENDATIONS

The current groundwater monitoring network was evaluated by Dr. Mindy Vanderford of GSI Environmental, Inc. using a formal qualitative approach as well as using statistical tools found in the Monitoring and Remediation Optimization System (MAROS) software. MAROS was developed by Groundwater Services, Inc. for the Air Force Center for Engineering and the Environment. Dr. Vanderford made recommendations for perched groundwater sampling frequency and location based on current hydrogeologic conditions and articulated LTM goals for the system. The recommendations for the monitoring network are based on a technical review, balancing both the statistical results with goals of the monitoring system and anticipated site management decisions. The summary presented below was taken from the *Groundwater Monitoring Network Optimization* report (GSI, 2008) included in Appendix B.

2.3.1 Project Goals and Objectives

The goal of the long-term monitoring optimization (LTMO) process is to review the current groundwater monitoring program and provide recommendations for improving the efficiency and accuracy of the network in supporting monitoring objectives. Specifically, the LTMO process provides information on site characterization, plume stability, sufficiency and redundancy of monitoring locations, and the appropriate frequency of network sampling. The end product of the LTMO process at Pantex Plant is a recommendation for specific sampling locations and frequencies that best address site monitoring goals and objectives.

2.3.2 Results

The monitoring system for perched groundwater was evaluated using analytical and hydrogeologic data from sampling events conducted between January 2000 and May 2007. Perched groundwater was divided into three sectors for analysis based on the direction of groundwater flow, source areas, and major constituents associated with each sector. Investigation wells were grouped into networks according to the defined sectors. The Southeast Sector monitoring network consists of wells in perched groundwater extending south from Playa 1 to the eastern and southern extent of perched groundwater including Zone 12. The Southwest Sector monitoring network includes and extends west and south of Zone 11.

Investigation wells south of Zone 12 were included in both the Southwest and Southeast Sector spatial analyses to account for possible variability in groundwater flow. The North Sector includes groundwater north of Zones 11 and 12 in the vicinity of Playa 1. Pantex Plant perched groundwater analytical data were evaluated using a combination of statistical analyses for priority COCs and consideration of qualitative issues such as hydrogeology, potential receptors, and monitoring goals to produce general recommendations for monitoring. The recommended network reduces monitoring effort and cost in some areas, but includes the addition of new wells in areas where further characterization would support site-monitoring goals and also increases data collection effort in some areas to provide a dataset that fulfills statistical requirements for evaluating the effects of the remedies discussed in the Corrective Measure Study/Feasibility Study (CMS/FS) (BWXT, 2007b). A summary of the recommended changes to the monitoring network is presented in Table 2-1.

2.4. LONG-TERM MONITORING NETWORK FOR PERCHED GROUNDWATER

The recommendations from the LTMO analysis were combined with the results of the evaluation against monitoring objectives to develop the final proposed well network shown in Figure 2-5. The following section describes how the recommendations from the LTMO analysis were incorporated into the final proposed well network. Section 2.4.2 provides an analysis of how the proposed well network satisfies the requirement for LTM to address uncertainties regarding the vertical extent of constituents beneath soil release units.

2.4.1 Incorporation of LTMO Recommendations

As described in Section 2.3.2, the perched groundwater was divided into three sectors for analysis based on the direction of groundwater flow, source areas, and major constituents associated with each sector. These sectors were further refined according to the extents of constituent plumes, as shown in Figure 2-6, to allow a list of specific indicator constituents to be developed for each area for the Compliance Plan. The most widespread and mobile contaminants at Pantex, such as high explosives and VOCs, will be included on the indicator lists for all areas. Additional contaminants identified only in specific areas of perched groundwater (e.g., hexavalent chromium or perchlorate) will only be included in the indicator lists for certain areas.

The Southeast sector was extended to include several wells on the western side of Zone 12. In the Southwest sector, the extent of perched groundwater underlying Zone 10, Playa 2, and southwest of Zone 4 in the western portion of the sector was removed from the sector. The remainder of the Southwest sector, encompassing the area affected by migration of perchlorate from Zone 11, was renamed the Zone 11 sector. In the North sector, the area surrounding the Burning Ground and Playa 3 was defined as the Burning Ground area. The area north and northwest of Playa 1 encompassing the northern portion of the RDX plume was retained as the North sector, while the remaining portions of the North and Southwest sectors were grouped into a Miscellaneous area. The Miscellaneous area includes wells near Zone 10, Playa 2, Pantex Lake, and the Old Sewage Treatment Plant.

The proposed LTM network for perched groundwater is shown in Figure 2-5. The final network includes a total of 107 perched wells. New wells proposed for addition to the network are explained in Table 2-2. All seven new wells recommended in the LTMO analysis were included in the final network.

Four of the seven wells recommended in the LTMO analysis for elimination from the network based on the spatial redundancy analysis were retained because these wells fulfill one or more of the monitoring objectives. The other three wells (PTX06-1087, PTX07-1P03, and PTX10-1008) monitor unaffected groundwater and were removed. None of these wells will be plugged and abandoned because all wells are useful for obtaining water level measurements. Additionally, several wells in the Miscellaneous Area were recommended for 5-year sampling intervals.

Table 2-3 provides a complete list of all wells in the proposed long-term monitoring network for perched groundwater. The table includes the LTM objectives to be satisfied by each proposed well, the metrics to be used in evaluating data collected from the well, the expected condition, and proposed monitoring frequency. Evaluation metrics include water level trends, comparison of concentrations to the GWPS, and concentration trends; these metrics and the expected conditions are discussed in Section 5. Additional details on monitoring, including analyte lists, sampling procedures, and analysis methods, are provided in the *Sampling and Analysis Plan* (B&W Pantex, 2009).

The final perched LTM network consists of:

- 108 perched wells – 19 of those wells will be monitored for continued dry conditions, with 89 sampled for laboratory analysis.
- 51 wells recommended to be sampled semi-annually, 31 wells recommended for annual sampling, and 7 wells recommended for 5-year sampling of indicator constituents. Corrosion parameters will also be collected to evaluate potential corrosion influence in stainless steel wells that are sampled for chromium.
- Wells near the *in situ* bioremediation systems will be sampled as needed to evaluate system performance. This sampling will be specific to the type of contaminants that are being treated and to verify required water quality conditions in the aquifer.
- A subset of the wells in the Southeast, North, and Zone 11 monitoring areas will be sampled for natural attenuation parameters to evaluate the natural breakdown of RDX and chlorinated solvents.
- All wells will have water levels checked semi-annually.
- 41 wells are recommended for 5-year sampling of a modified 40 CFR Part 264 Appendix IX groundwater list to satisfy uncertainty management requirements. Corrosion parameters will also be collected at stainless steel wells.

A table listing all wells and their coordinates (northings and eastings) is included in Appendix D.

2.4.2 Monitoring of Soil Release Units

TCEQ and EPA conditionally approved the investigations of soil release units with a requirement for LTM downgradient of release units to address uncertainties regarding the vertical extent of constituents. For purposes of monitoring the soil release units, the units were grouped by Zone or Waste Management Group and downgradient wells were identified in the first groundwater encountered. The perched LTM network contains an adequate number of wells to monitor soil units across the plant where the perched groundwater is the first groundwater encountered. Landfill areas to the west have adequate cover material and results of investigations indicate that soil contamination is limited, so downward migration of contamination is unlikely. Additionally, downgradient Ogallala Aquifer wells will be used to monitor for those units.

Soil release units and perched groundwater monitoring wells are shown in Figure 2-8. A listing of the soil release units and the associated downgradient monitoring wells is provided in Table 2-4. This list contains all units that were evaluated in a baseline risk assessment. In addition to monitoring for indicator contaminants in perched groundwater, these wells will also be monitored for a larger list of analytes (based on a modified 40 CFR Part 264 Appendix IX list provided in the Sampling and Analysis Plan) on a 5-year sampling interval.

Table 2-1. Summary of LTMO Recommendations

Sector	Recommended Well Additions		Recommended Well Removals	
Southeast	2	PTX06-1130, PTX06-1135	1	PTX06-1014
Southwest	4	PTX06-1126, PTX06-1127, PTX06-1131, PTX06-1134	6	PTX06-1006, PTX06-1087, PTX07-1P02, PTX07-1P03, PTX07-1Q02, and PTX10-1008
North	1	PTX06-1136	None	

Table 2-2. Proposed New Long-Term Monitoring Wells for Perched Groundwater

Well Identifier	Location	Purpose
PTX06-1130 PTX06-1146 PTX06-1147	East of FM 2373	Provide information regarding the effects of the Southeast Pump and Treat System and help characterize the nature and extent of perched groundwater impacts east of FM 2373.
PTX06-1131	Southwest of Zone 10	Monitor for the potential migration of constituents from release units in Zone 10. No perched groundwater impacts have been identified associated with Zone 10 in the three existing wells in this area, but these wells were installed to monitor the landfills northwest of Zone 10.
PTX06-1133	Near the southeastern extent of perched groundwater	Monitor the stability of the southeast plume fringe where plume has migrated beyond the existing wells.
PTX06-1126 PTX06-1127 PTX06-1148 PTX06-1149 PTX06-1150	TTU property south of Zone 11	Monitor the stability of the Zone 11 plume and effectiveness of Zone 11 ISB corrective action. Wells PTX06-1126 and PTX06-1127 were installed in early 2008 to monitor the stability of the Zone 11 plume on USDOE property and to provide information about the distribution of concentrations within the plume.
PTX06-1134	TTU property southwest of Zone 11	Delineate perchlorate plume downgradient of PTX06-1012.
PTX06-1135	TTU property south of Zone 11	Reduce spatial uncertainty in the vicinity of PTX06-1036, PTX06-1052, and PTX06-1053. A new well in this area may be beneficial for monitoring concentrations of hexavalent chromium and RDX and other high explosives.
PTX06-1136	North of Zone 4	Delineate RDX in perched groundwater downgradient of PTX06-1050.

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Table 2-3. Proposed Long-Term Monitoring Network for Perched Groundwater

Indicator Area[1]	Well ID	LTM Objectives	Progress Report Metrics	Expected Condition	Indicator List[2] Monitoring Frequency	Appendix IX Monitoring List[3]	Appendix IX Monitoring Frequency
Burning Ground	PTX01-1001	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Semi-Annual	Y	5 Yrs
Burning Ground	PTX01-1002	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Burning Ground	PTX01-1004	Plume Stability	Dry	Remain dry	NA	N	NA
Burning Ground	PTX01-1008	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	Y	5 Yrs
Burning Ground	PTX01-1009	Plume Stability	Dry	Remain dry	NA	N	NA
Miscellaneous	PTX04-1001	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	5 Yrs	Y	5 Yrs
Miscellaneous	PTX04-1002	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX06-1049	Plume Stability, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	N	NA
Miscellaneous	PTX06-1055	Plume Stability	Dry	Remain dry	NA	N	NA
Miscellaneous	PTX06-1071	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	5 Yrs	Y	5 Yrs
Miscellaneous	PTX06-1080	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	5 Yrs	N	NA
Miscellaneous	PTX06-1081	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Miscellaneous	PTX06-1082	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	5 Yrs	Y	5 Yrs
Miscellaneous	PTX06-1083	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	5 Yrs	Y	5 Yrs
Miscellaneous	PTX06-1085	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX06-1086	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX06-1096A	Plume Stability, Uncertainty Management	Dry	Remain dry	NA	N	NA
Miscellaneous	PTX06-1097	Plume Stability, Uncertainty Management	Dry	Remain dry	NA	N	NA
Miscellaneous	PTX06-1131	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	Y	5 Yrs
Miscellaneous	PTX07-1Q01	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX07-1Q02	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX07-1Q03	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	Y	5 Yrs
Miscellaneous	PTX07-1R03	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	5 Yrs	Y	5 Yrs
Miscellaneous	PTX08-1010	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	5 Yrs	Y	5 Yrs
North	OW-WR-38	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	Y	5 Yrs
North	PTX06-1048A	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
North	PTX06-1050	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
North	PTX06-1136	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
North	PTX07-1O01	Plume Stability, Uncertainty Management, Response Action Effectiveness	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
North	PTX07-1O02	Plume Stability, Uncertainty Management, Response Action Effectiveness	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
North	PTX07-1O03	Plume Stability, Uncertainty Management, Response Action Effectiveness	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
North	PTX07-1O06	Plume Stability, Uncertainty Management, Response Action Effectiveness	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Southeast	PTX06-1002A	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Southeast	PTX06-1003	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	Y	5 Yrs
Southeast	PTX06-1010	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
Southeast	PTX06-1013	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA

Indicator Area[1]	Well ID	LTM Objectives	Progress Report Metrics	Expected Condition	Indicator List[2] Monitoring Frequency	Appendix IX Monitoring List[3]	Appendix IX Monitoring Frequency
Southeast	PTX06-1014	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1015	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1023	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1030	Response Action Effectiveness	Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1031	Response Action Effectiveness	Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1034	Response Action Effectiveness	Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1036	Plume Stability	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Southeast	PTX06-1037	Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Southeast	PTX06-1038	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1039A	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1040	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1041	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1042	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1045	Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Southeast	PTX06-1046	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1047A	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1051	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1052	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1069	Plume Stability	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Southeast	PTX06-1088	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Southeast	PTX06-1089	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1090	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1091	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1093	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1094	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1095A	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1098	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1100	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1101	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1102	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1103	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Long-term stabilization of concentrations	Semi-Annual	N	NA
Southeast	PTX06-1118	Response Action Effectiveness	Trend/Compare to GWPS	Long-term stabilization of concentrations	Annual	N	NA
Southeast	PTX06-1119	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1120	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1121	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1122	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1123	Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Southeast	PTX06-1124	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1125	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1130	Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	N	NA

Indicator Area[1]	Well ID	LTM Objectives	Progress Report Metrics	Expected Condition	Indicator List[2] Monitoring Frequency	Appendix IX Monitoring List[3]	Appendix IX Monitoring Frequency
Southeast	PTX06-1133	Plume Stability	Dry	Remain dry	NA	N	NA
Southeast	PTX06-1135	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
Southeast	PTX06-1146	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
Southeast	PTX06-1147	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
Southeast	PTX08-1002	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Southeast	PTX08-1009	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Southeast, Zone 11	PTX06-1008	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
Southeast, Zone 11	PTX06-1011	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	Y	5 Yrs
Southeast, Zone 11	PTX06-1053	Plume Stability, Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Semi-Annual	N	NA
Southeast, Zone 11	PTX08-1007	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
Southeast, Zone 11	PTX08-1008	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Southeast, Zone 11	PTX10-1013	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
Zone 11	PTX06-1005	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Semi-Annual	Y	5 Yrs
Zone 11	1114-MW4	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
Zone 11	PTX06-1006	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Annual	N	NA
Zone 11	PTX06-1007	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Annual	Y	5 Yrs
Zone 11	PTX06-1012	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Zone 11	PTX06-1035	Plume Stability	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Semi-Annual	N	NA
Zone 11	PTX06-1073A	Plume Stability	Dry	Remain dry	NA	N	NA
Zone 11	PTX06-1077A	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	Y	5 Yrs
Zone 11	PTX06-1126	Plume Stability, Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
Zone 11	PTX06-1127	Plume Stability, Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
Zone 11	PTX06-1134	Plume Stability	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	N	NA
Zone 11	PTX06-1148	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Zone 11	PTX06-1149	Plume Stability	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Zone 11	PTX06-1150	Plume Stability, Response Action Effectiveness	Trend/Compare to GWPS	Below GWPS in 2–5 years	Semi-Annual	N	NA
Zone 11	PTX07-1P02	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Semi Annual	Y	5 Yrs
Zone 11	PTX07-1P05	Uncertainty Management	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	Y	5 Yrs
Zone 11	PTX08-1001	Uncertainty Management, Response Action Effectiveness	Water Level, Trend/Compare to GWPS	Decreasing water levels, Long-term stabilization of concentrations	Annual	Y	5 Yrs
Zone 11	PTX08-1003	Plume Stability	Trend/Compare to GWPS	Stable or decreasing trend below GWPS	Annual	N	NA
Zone 11	PTX08-1005	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs
Zone 11	PTX08-1006	Uncertainty Management	Trend/Compare to GWPS	Long-term decreasing trend	Semi-Annual	Y	5 Yrs

1 The indicator monitoring lists are set according to the monitoring areas. The indicator monitoring lists can be found in the Pantex Sampling and Analysis Plan, Table IIIA of the Corrective Action Compliance Plan, and are shown on Figure 2-6.
2 Refer to the latest approved Pantex Sampling and Analysis Plan (B&W Pantex) or the Corrective Action Compliance Plan Table IIIA for the indicator monitoring lists.
3 A full list of constituents to be monitored is required for uncertainty management. A modified Appendix IX has been recommended for the Corrective Action Compliance Plan Application (Table III) and in the Pantex Sampling and Analysis Plan.

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Table 2-4. Monitoring of Soil Release Units for Perched Groundwater

Grouping	Release Units	Perched Wells
Zone 10		
WMG 12	AOC 3a: Former Boiler House Areas, Zone 10 AOC 14: Battery Storage Area, Scrap/Salvage Yard, (10-9) SVS 3: Carbon Black Burial Area-Zone 10 (Duplicate of SWMU 67) SVS 8: Abandoned Zone 10 Landfill Construction Debris Landfill SWMU 68d: Active Sanitary Landfill SWMU 84: Scrap and Salvage Yard, Bldg 10-9 SWMU 143a: Former Waste Drum Storage Areas/Bldg 10-9 SWMU 143b: Former Waste Drum Storage Areas/Bldg 10-7 SWMU 144: Zone 10 TNT Settling Pit (10-13) SWMU 145: Zone 10 TNT Settling Pit (10-17) SWMU 146: Zone 10 TNT Settling Pit (10-26) Zone 10 Building Construction Debris Landfills (5) Zone 10 Construction Debris Berms (A-I)	PTX07-1Q01 PTX07-1Q02 PTX07-1Q03 PTX06-1131
Zone 11		
WMG 1	AOC 8a: Solvent Leaks (Pad 11-12) AOC 8b: Solvent Leaks (Pad 11-13) SVS 2: Zone 11 Parallel Depression Near Bldg 11-26 SVS 5: Landfill East of 11-13 Pad (Construction Debris from Bldgs 11-12,11-13) SWMU 60: Landfill 9 (Group III) Building Demolition Debris Landfill SWMU 61: Landfill 10 (Group III) Building Demolition Debris Landfill SWMU 147: Zone 11 TNT Settling Pit (11-13) SWMU 149: Zone 11 TNT Settling Pit (11-26) SWMU 150: Building 11-12	1114-MW4 PTX08-1005 PTX08-1006 PTX06-1126 PTX06-1127
WMG 2	AOC 1: Transformer Leak Near 11-14A AOC 8c: Solvent Leaks (PAD 11-17) SWMU 3: Bldg 11-44 Drainage Ditch SWMU 12: Drainage Ditch Near 11-14 Pond & Pipeline SWMU 86: Waste Accumulation Area 11-14 Solvent Storage Shed SWMU 117: 11-44 HE Settling Tank SWMU 118: Bldg 11-44 Equalization Basin SWMU 119a: Bldg 11-44 HE Particulate Filters SWMU 120a: Bldg 11-44 Activated Carbon Filters SWMU 148: Zone 11 TNT Settling Pit (11-17)	
WMG 3	AOC 7a: Sulfuric Acid Spills (11-36) AOC 8d: Solvent Leaks (Pad 11-22) AOC 8e: Solvent Leaks (Bldg 11-36) SWMU 5/08: Drainage Ditch 11-36 SWMU 113: Overflows From 11-36 Collection System/Sump Unassigned Former Leaching Bed N of Bldg 11-50 & W of Bldg 11-36	
WMG 4	SWMU 5-09a: Building 11-17 Drainage Ditch SWMU 5/09b: Drainage Ditch 11-20 SWMU 5/11: Zone 11 Main Drainage Ditch SWMU 13: Surface Impoundment Solar Evaporation Pits at Bldg 11-51 SWMU 87: Building 11-20 Solvent Storage Shed Unassigned Evaporation Pit, East of Bay 3, Bldg 11-20 Unassigned Evaporation Pit, South of Bay 11, West of Bay 6, Bldg 11-20	
N/A	Unassigned - Former 11-15 Pond	

Table 2-4. Monitoring of Soil Release Units for Perched Groundwater, continued

Grouping	Release Units	Perched Wells
Zone 12		
WMG 5	AOC 7c: Sulfuric Acid Spills (12-64) SWMU 5/06a: Drainage Ditch 12-44 SWMU 5/06b: Drainage Ditch 12-81 SWMU 56: Landfill 5 (Group III) Building Construction Debris Landfill SWMU 57: Landfill 6 (Group III) Building Construction Debris Landfill SWMU 68a North: Original Misc Purpose Sanitary Landfill SWMU 103: Former Battery Storage Area, Bldg 12-81 SWMU 135: Subsurface Leach Beds, Bldg 12-44	PTX08-1008 PTX08-1009
N/A	SWMU 5-12b: Perimeter Drainage Ditch from Zone 12 to SWMU 5-143c	
WMG 6/7	AOC 10a: Building 12-43A Pesticide Rinse Area AOC 13a: Former Cooling Tower in Zone 12 (Pad) AOC 13b: Former Cooling Tower in Zone 12 (Piping/Soil) SWMU 1: Bldg 12-17 Drainage Ditch SWMU 2: Bldg 12-43 Drainage Ditch SWMU 5/04a: Drainage Ditch 12-19 SWMU 5/04b: Drainage Ditch 12-73 SWMU 5/05: Drainage Ditch Between Bldgs 12-21 & 12-24 SWMU 5/07: Drainage Ditch 12-41 SWMU 5/12a: Zone 12 Main Drainage Ditch SWMU 54: Landfill 3 SWMU 55: Landfill 4 SWMU 119b: High Explosives Filters SWMU 120b: Carbon Filters SWMU 121: High Explosives Settling Tank SWMU 122a: Bldg 12-43 Equalization Tank/Soil SWMU 122b: Bldg 12-24N/12-43 Vicinity Soil SWMU 123: Concrete Sump & Waste Water Treatment Unit	PTX06-1002A PTX06-1003 PTX06-1005 PTX06-1010 PTX06-1011 PTX06-1088 PTX06-1095A PTX08-1007 PTX08-1009
WMG 9	AOC 5: Electrical Equipment Bone Yard near Building 12-5 AOC 10b: Pesticide Rinse Area (Bldg 12-51) AOC 12: Bldg 12-5D Paint Shop Area/ Solvent Pit SWMU 5-02a: Building 12-51 Drainage Ditch SWMU 5/02b: Drainage Ditch 12-67 SWMU 5-02c: Building 12-110 Drainage Ditch Capacitor Bank Rupture Zone 12	PTX06-1002A PTX06-1003
WMG 10	AOC 15: DDT Release at Bldg 12-35 SWMU 5/01a: Drainage Ditch Bldg 12-5 SWMU 5/01b: Drainage Ditch Bldg 12-5B Bldg 12-5 Concrete Sump	PTX10-1013
N/A	SWMU 136: Subsurface Leaching Systems, Bldg 12-59	PTX06-1008
Burning Ground		
WMG 13	SWMU 8: Playa 3 SWMU 14-24: Burning Ground-Explosive Burn Pads SWMU 25: Burning Ground-Explosive Burn Pad 11 SWMU 26: Burning Ground-Explosive Burn Pad 12 SWMU 27 Burning Ground-Explosive Burn Pad 13 SWMU 37: Burning Ground-Landfill 1 SWMU 38: Burning Ground-Landfill 2 SWMU 39: Burning Ground-Landfill 3 SWMU 40: Burning Ground-Landfill 4	PTX01-1001 PTX01-1002 PTX01-1008

Table 2-4. Monitoring of Soil Release Units for Perched Groundwater, continued

Grouping	Release Units	Perched Wells
	SWMU 41: Burning Ground-Landfill 5 SWMU 42: Burning Ground-Landfill 6 SWMU 43: Burning Ground-Landfill 7 SWMU 44: Burning Ground-Landfill 8 SWMU 45: Explosive Burn Cage SWMU 46: Explosive Burn Cage SWMU 47: Burning Ground-Evaporation Pit SWMU 48: Burning Ground Solvent Evaporation Pans SWMU 49: Burning Ground Solvent Evaporation Pans SWMU 50: Burning Ground Solvent Evaporation Pans SWMU 51: Burning Ground Solvent Evaporation Pans SWMU 52: Burn Racks and Flashing Pits Unassigned Burning Ground-Explosive Burn Pad 16 Unassigned: Demonstration Facilities	
Other Units		
WMG 11 North	SWMU 6: Playa 1	OW-WR-38 PTX08-1001 PTX08-1002
WMG 11 North	SWMU 68b: General Purpose Sanitary Landfill 1	PTX07-1O01 PTX07-1O02 PTX07-1O03 PTX07-1O06
WMG 11 North	SWMU 82: Nuclear Weapon Accident Residue Storage	PTX06-1050
WMG 11 South	SWMU 5/13 (a, b, and c): Drainage Ditch to Playa 1	PTX06-1002A PTX06-1007 PTX08-1001 PTX08-1002 PTX10-1013
WMG 11 South	SWMU 68c: General Purpose Sanitary Landfill 2	PTX07-1P05
N/A	AOC 11: Fire Training Area Burn Pits	PTX06-1077A
N/A	SWMU 4: Building 11-50 Drainage Ditch	PTX08-1005
N/A	SWMU 5-15a & b: Drainage Ditch to Playa 4	PTX06-1053 PTX06-1134
N/A	SWMU 7: Playa 2	PTX06-1085 PTX06-1086
N/A	SWMU 9: Playa 4	PTX06-1053
N/A	SWMU 10: Pantex Lake	PTX06-1082 PTX06-1083
N/A	SWMU 58: Landfill 7	PTX06-1077A
N/A	SWMU 64: Landfill 13	PTX07-1R03
N/A	SVS 7a and 7b: Igloo Demolition Debris Landfills Zone 4 (SVS 7a) and Zone 5 (SVS 7b)	PTX06-1049 PTX06-1096A PTX06-1097

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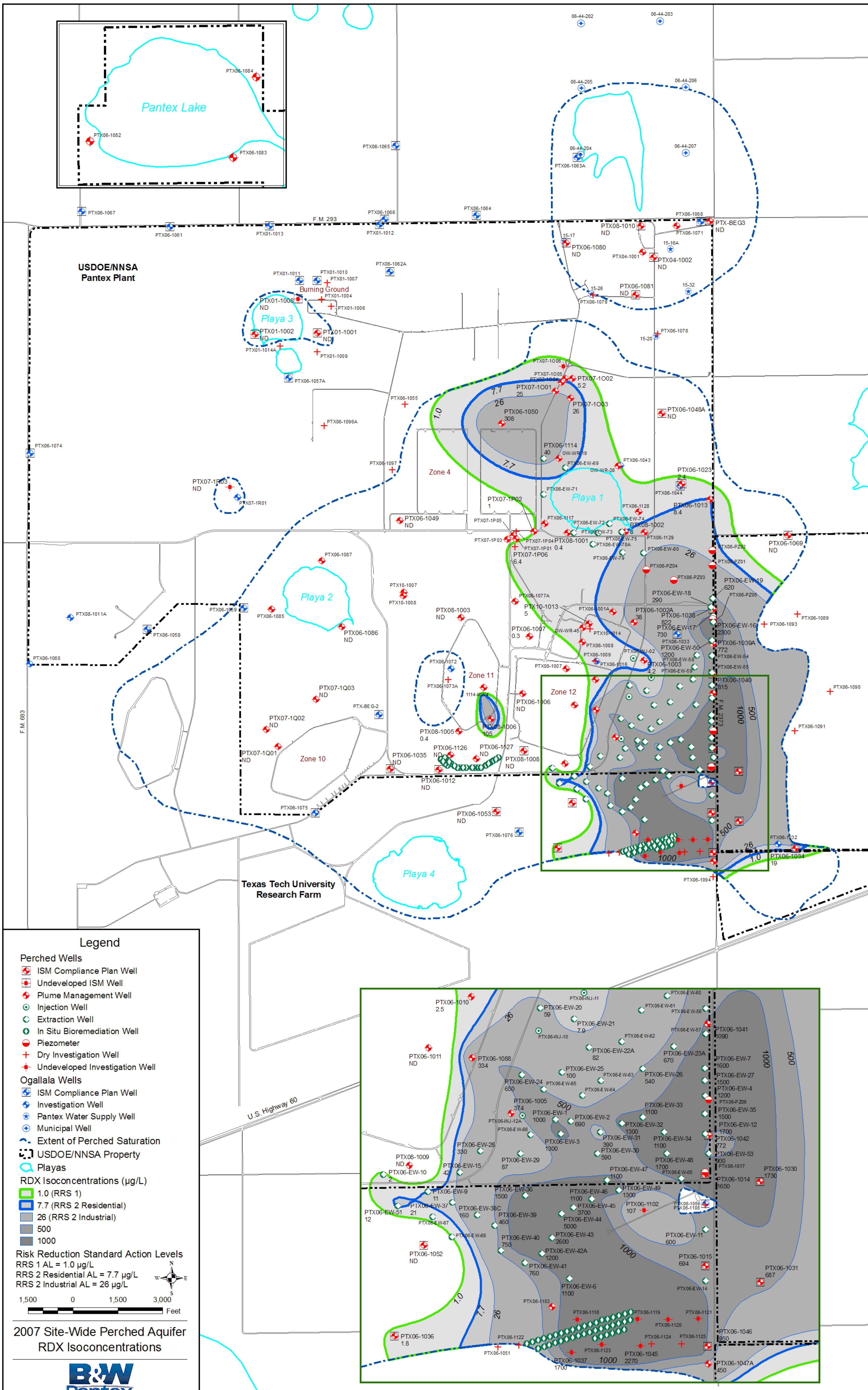

Figure 2-1. Perched Groundwater RDX Isoconcentrations

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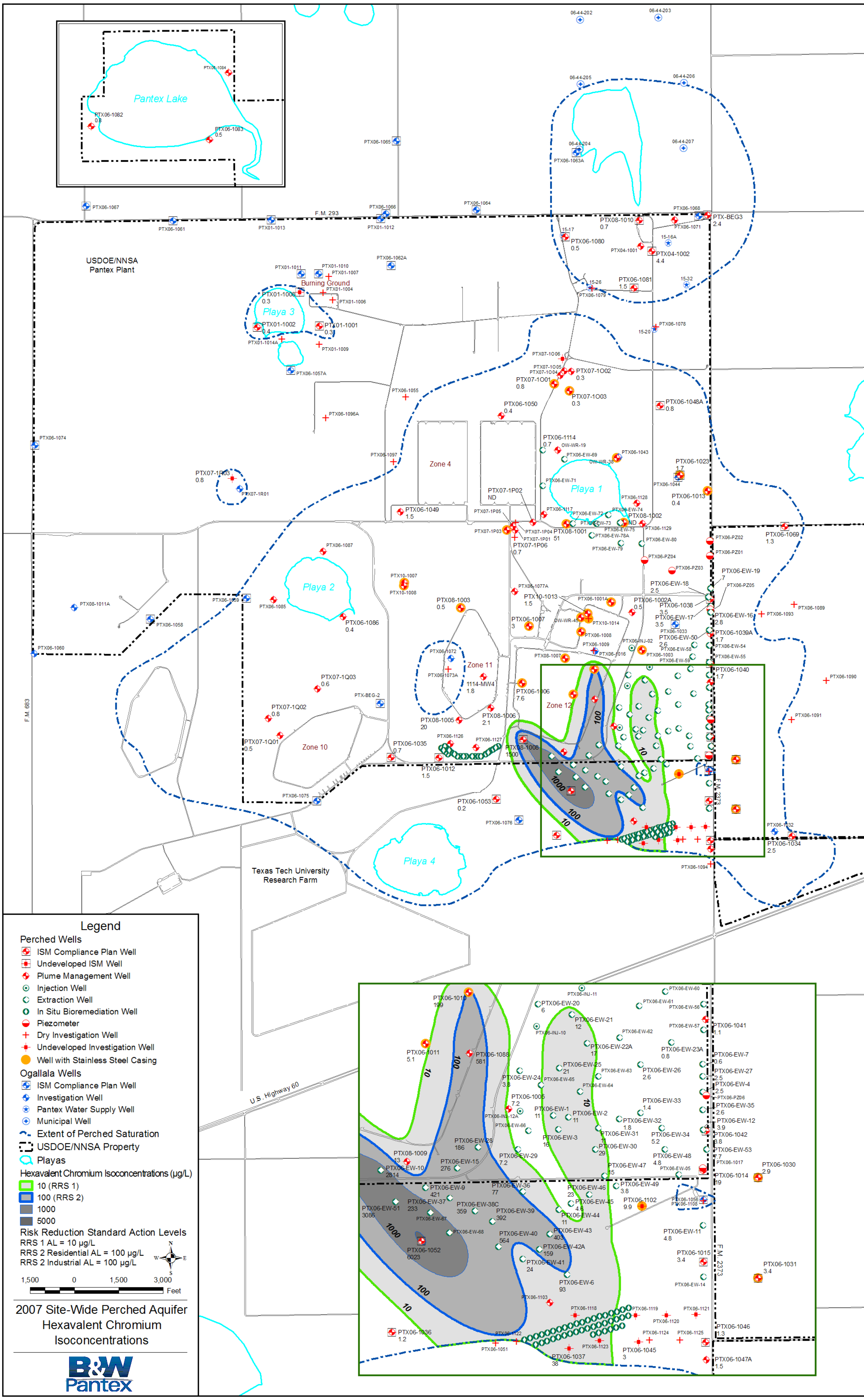

Figure 2-2. Perched Groundwater Hexavalent Chromium Isoconcentrations

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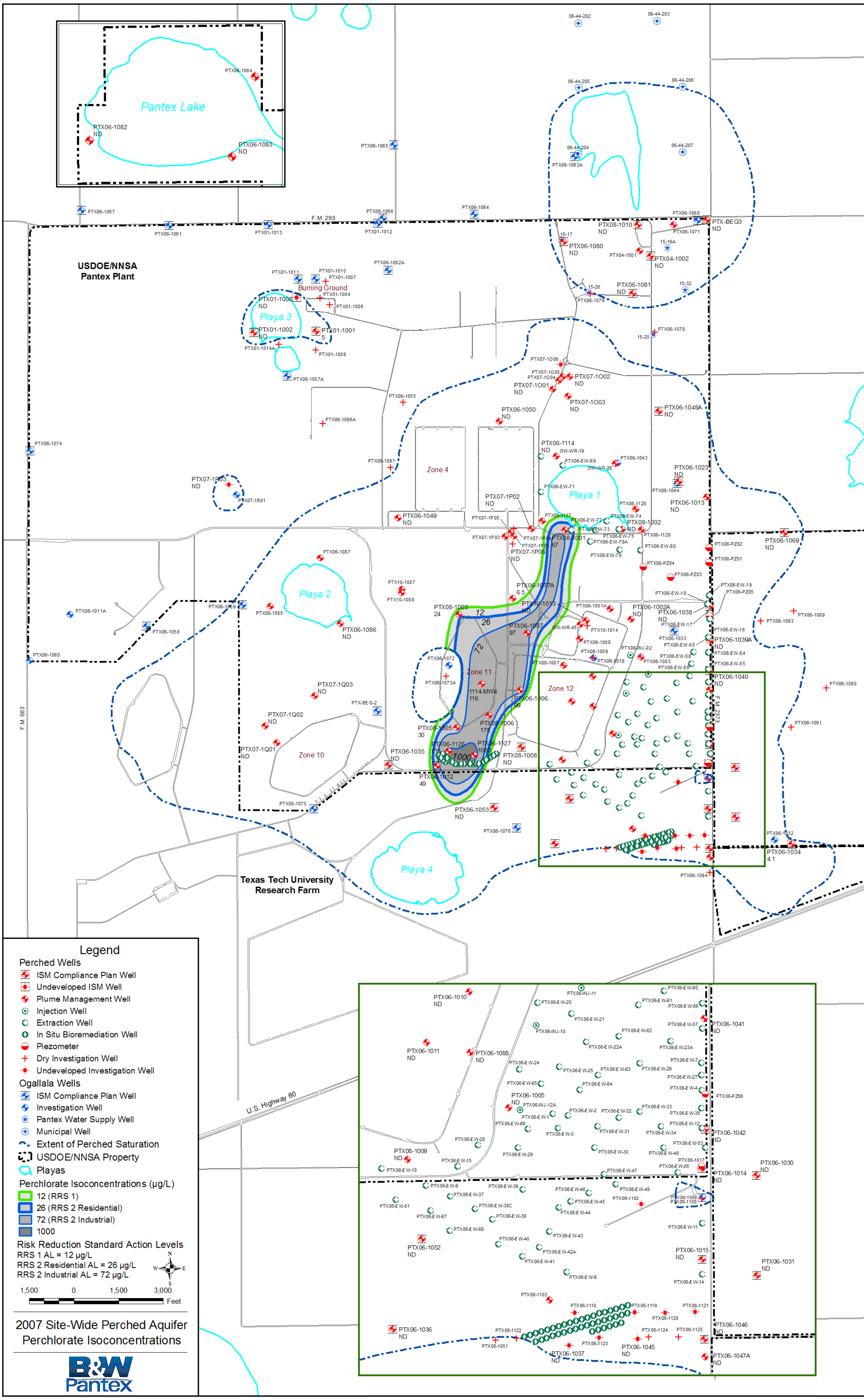

Figure 2-3. Perched Groundwater Perchlorate Isoconcentrations

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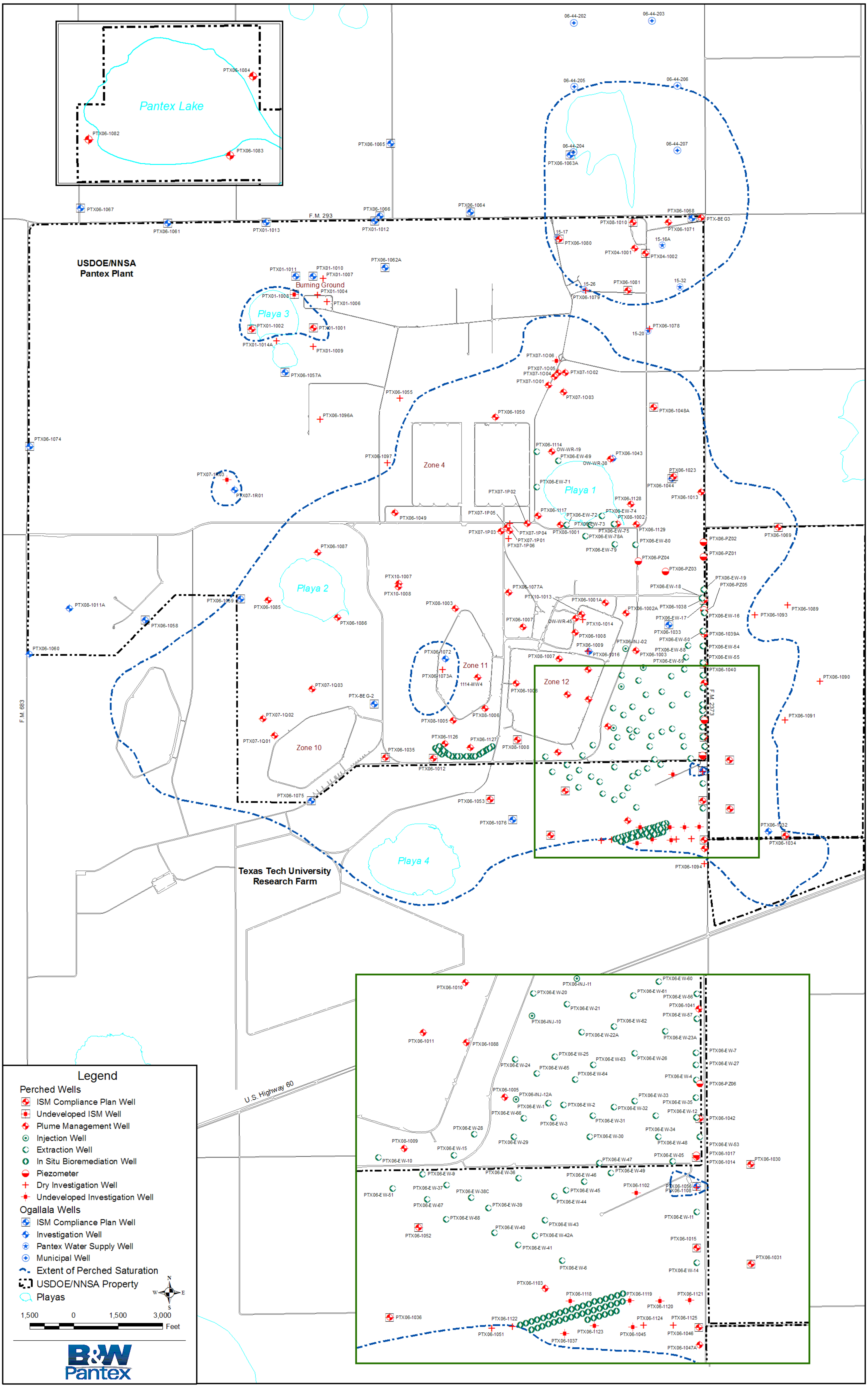

Figure 2-4. Well Location Map

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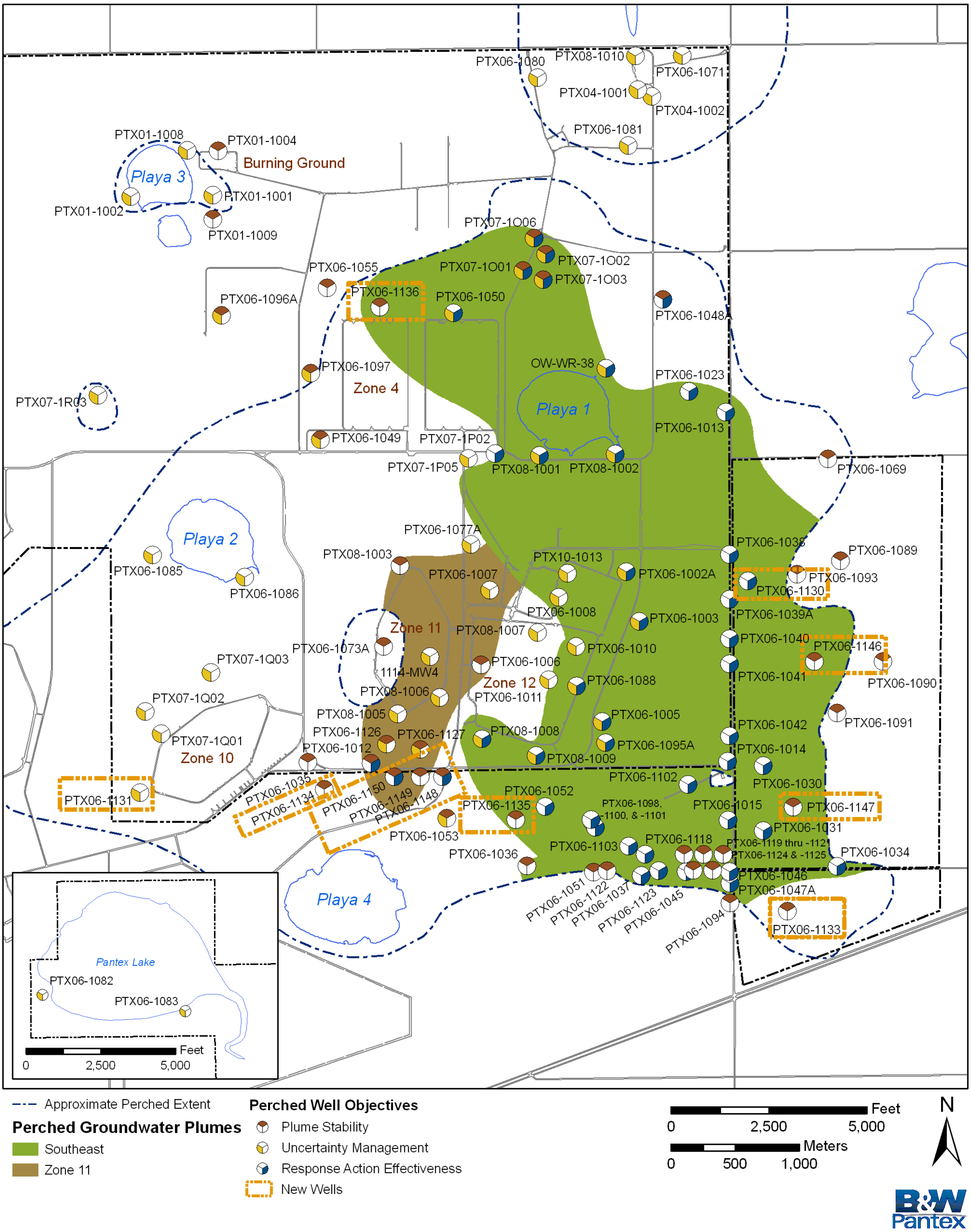

Figure 2-5. Perched Groundwater Long-Term Monitoring Network

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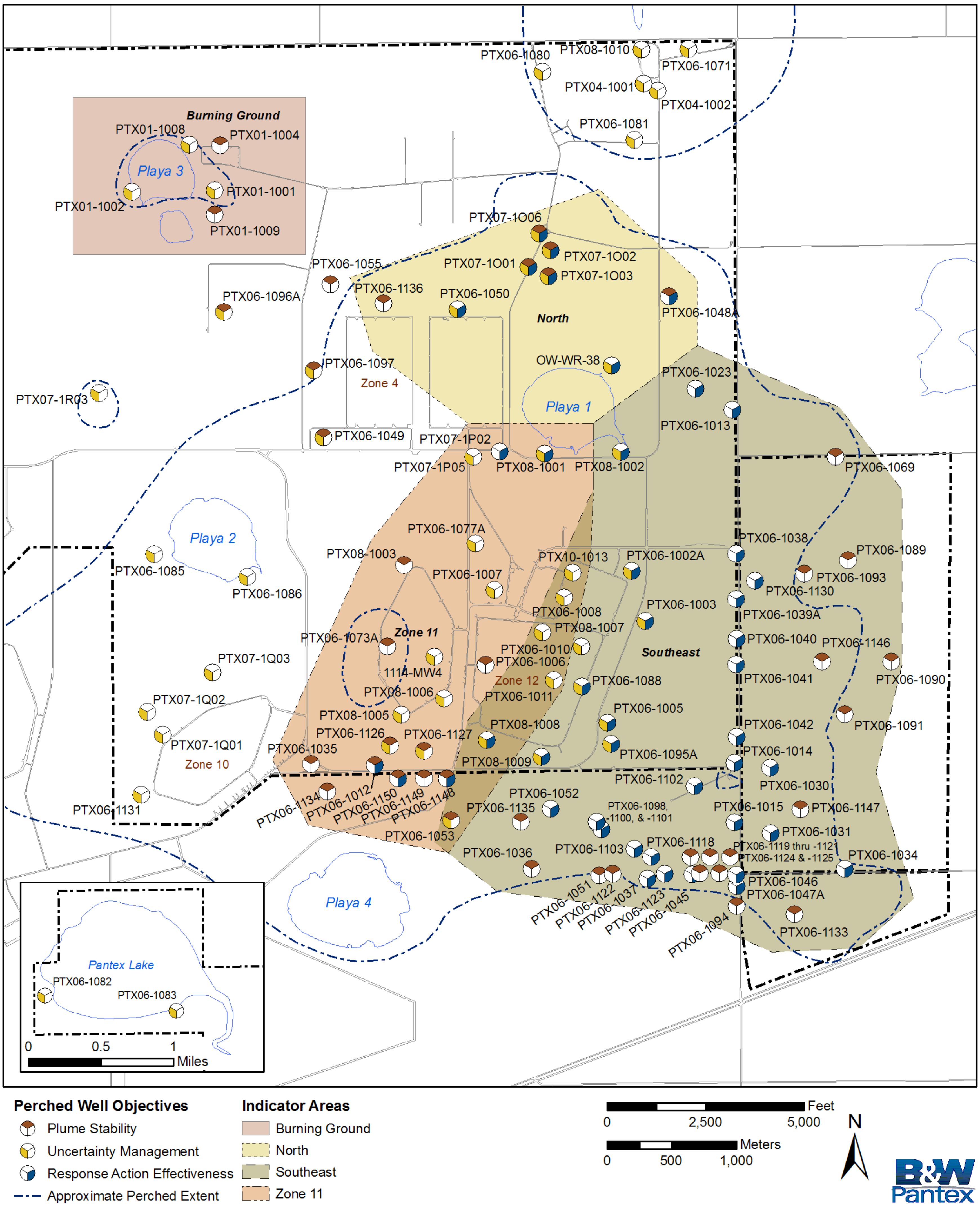

Indicator Constituents	Indicator Area				
	Burning Ground	Miscellaneous	North	Southeast	Zone 11
Primary List (Explosives, VOCs, Boron)	x	x	x	x	x
Chromium (Total & Hexavalent)				x	
1,4-Dioxane					x
Perchlorate	x				x

Primary Indicator Constituent List

High Explosives (9)	*VOCs (7)*
2-Amino-4,6-dinitrotoluene	1,2-Dichloroethane
4-Amino-2,6-dinitrotoluene	Chloroform
1,3-Dinitrobenzene	PCE
2,4-Dinitrotoluene	TCE
2,6-Dinitrotoluene	*cis*-1,2-Dichloroethene
HMX	*trans*-1,2-Dichloroethene
RDX	Vinyl Chloride
1,3,5-Trinitrobenzene	*Metals (1)*
TNT	Boron

Figure 2-6. Indicator Constituent Areas for Perched Groundwater

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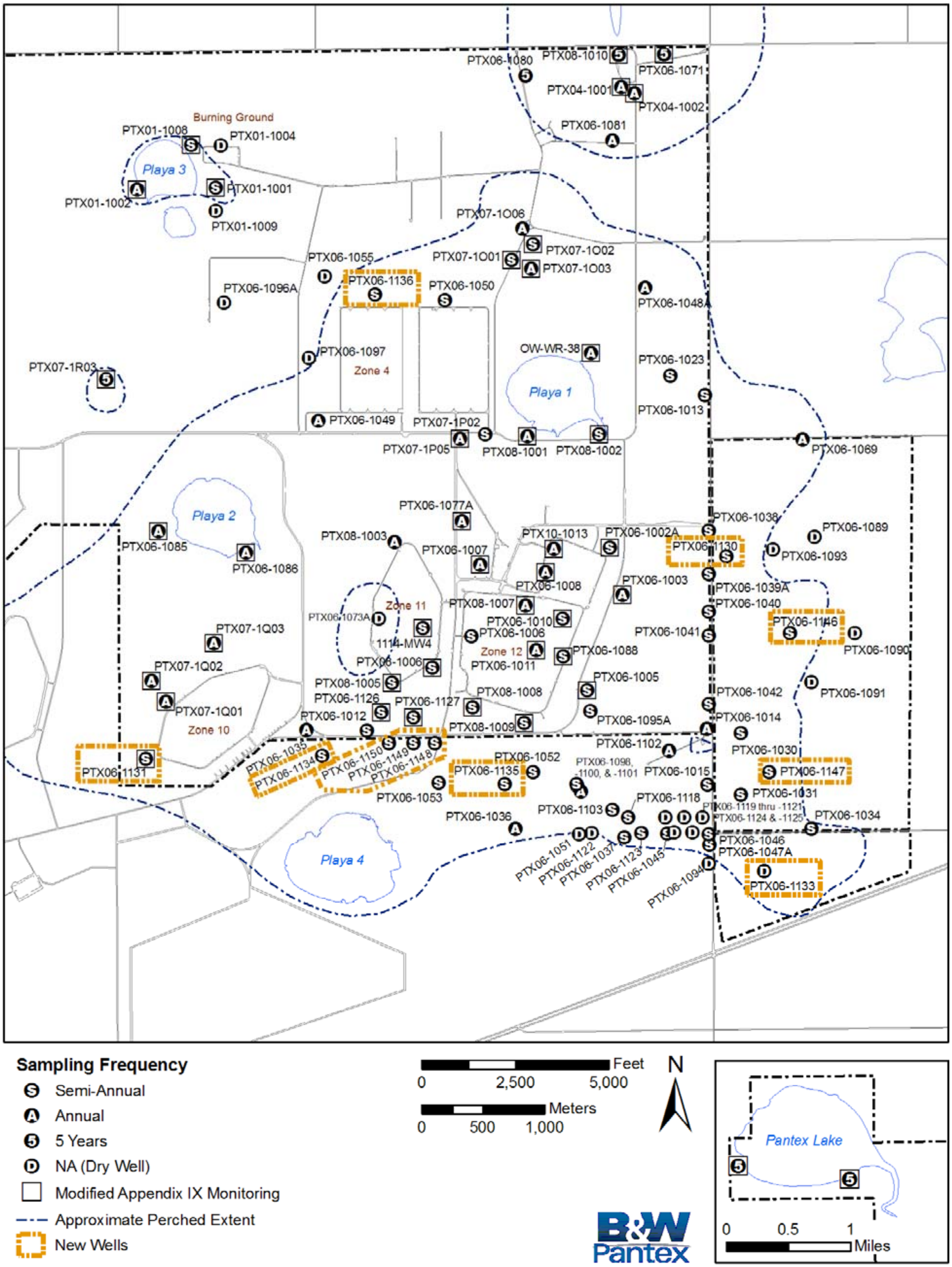

Figure 2-7. Sampling Frequency for Perched Groundwater

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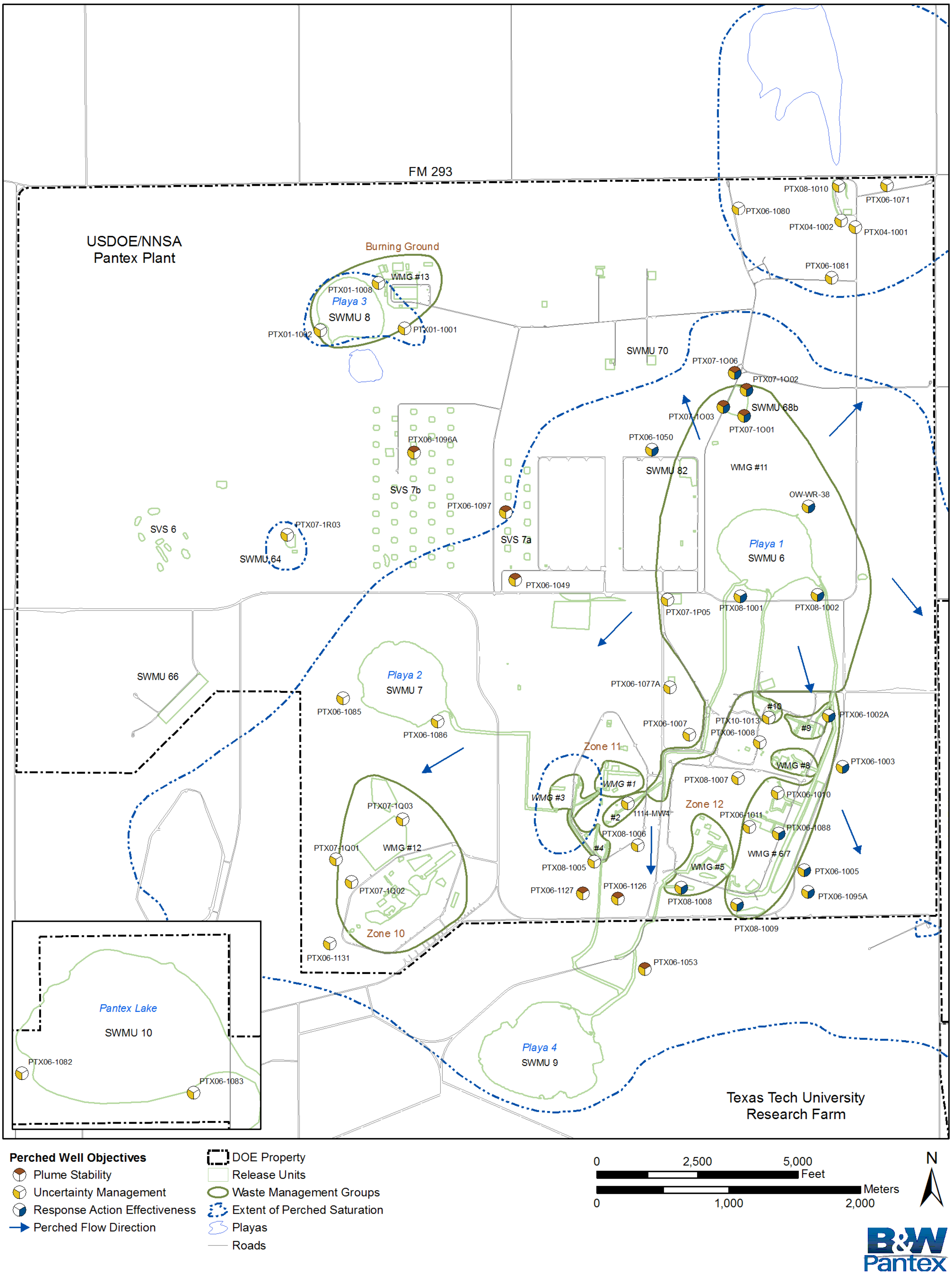

Figure 2-8. Monitoring of Soil Release Units for Perched Groundwater

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3. OGALLALA AQUIFER

This section describes the development of the LTM network for the Ogallala Aquifer beneath Pantex Plant. The general strategy used to develop the monitoring network is presented in Section 1.2. This strategy was adapted for the Ogallala Aquifer well network and comprised the following steps:

1. Develop monitoring objectives.

2. Use mathematical monitoring network optimization tools to optimize the spatial distribution of monitoring for early detection of potential impacts to the Ogallala Aquifer from perched groundwater.

3. Evaluate the existing well network with respect to each objective to identify areas where monitoring is needed.

4. Combine the results of the different evaluation methods to develop the final LTM network.

The monitoring objectives developed for the Ogallala Aquifer are early detection and uncertainty management. These objectives were described in Section 1.3.1. A summary of the monitoring network optimization is provided in Section 3.1, and the evaluation of the existing well network with respect to each objective is discussed in Section 3.2. The final LTM network is presented in Section 3.3.

3.1. SUMMARY OF MONITORING WELL PLACEMENT OPTIMIZATION

As part of the evaluation of the need for additional monitoring wells to be installed near Pantex Plant for early detection of potential groundwater impacts to the Ogallala Aquifer, an optimization tool was used to identify best locations for these new monitoring wells in the area east of FM 2373. This is the area where modeling predicted contaminants in perched groundwater might migrate to the Ogallala Aquifer (BWXT Pantex/SAIC, 2007). This assessment was performed independently by Mr. Larry Deschaine of Science Applications International Corporation (SAIC), using the Plumefinder technology developed by Dr. George Pinder at the University of Vermont Research Center for Groundwater Remediation Design. Mr. Deschaine made recommendations for the locations of 3 new Ogallala Aquifer monitoring wells using the Plumefinder technology and incorporating the results of previous modeling. The summary presented below was taken from the *Optimization of Monitoring Well Placement for Breakthrough Detection in the Ogallala Aquifer* report (SAIC, 2008), included in Appendix B.

3.1.1 Analysis Methods

This effort focused on the area east of FM 2373, downgradient of the area where modeling predicted contaminants in perched groundwater might migrate through the FGZ (BWXT Pantex/SAIC, 2007). Because of its widespread occurrence in perched groundwater and relatively high mobility, the high explosive compound RDX was modeled to determine the best locations for the wells. Although source strength and location are not directly measured, insight can be gleaned from the corrective measures study/feasibility study (CMS/FS) (BWXT Pantex/SAIC, 2007) modeling efforts.

The Ogallala Aquifer beneath the impacted perched groundwater is not accessible for investigation, because of the concern that drilling through perched groundwater may create pathways allowing the spread of contamination. As a result, irreducible uncertainty stemming from a lack of field data is present in the area of interest. The uncertainty specifically pertains to the hydraulic conductivity, potentiometric surface, and the elevation of the redbeds marking the base of the aquifer.

Modeling is combined with optimal estimation techniques to address this uncertainty. Specifically, geostatistical representations of the Ogallala Aquifer hydraulic conductivity fields are coupled with flow and transport simulations to determine the areas of greatest uncertainty in potential RDX plume location. This approach, known as the “PlumeFinder,” is technology which integrates groundwater flow and transport simulation, geostatistical simulation, Monte Carlo simulation, and Kalman filter analysis to optimize monitoring well locations. In the analysis conducted, plume location (plume fringe) is defined as the 1 ppb isopleth contour for RDX and investigated over a 50-year simulation period. The areas of greatest uncertainty in the 1 ppb isopleth location then become candidates for new well locations, which in turn reduce the uncertainty in plume delineation by the maximum amount possible. To locate the leading edge of the RDX plume, both the retardation of RDX and potential biodegradation were ignored. This results in a conservative estimate (shortest travel time) to the fringe of the eastern perched groundwater while identifying the best location for early detection monitoring well placement. The actual travel time for RDX to migrate within the Ogallala Aquifer, if it occurs, is expected to be longer than simulated in this analysis.

3.1.2 Results

Delineation of potential future plumes can be improved by adding three new monitoring wells (PTX06-1137, PTX06-1138, and PTX06-1139) at locations determined using the PlumeFinder technology in combination with previous modeling results. These locations are shown in Figure 3-1. Installation of new wells, in concert with the existing Ogallala Aquifer monitoring wells, increases the certainty of early plume detection. A new well located using PlumeFinder reduces the maximum measure of uncertainty of plume delineation beyond the fringe of the perched aquifer by 72 percent. Two additional wells located beyond the eastern extent of perched groundwater provide early detection of potential contamination originating along the fringe of perched groundwater. Because most of the projected plume is beneath the perched aquifer, most of the uncertainty in its extent resides there. This demonstrates the contribution of irreducible uncertainty resulting from safe investigative practices, i.e., imposing the constraint that no wells be drilled through the perched groundwater to investigate a hypothetical plume.

3.2. EVALUATION OF EXISTING WELL NETWORK

The existing Ogallala Aquifer monitoring network was evaluated with respect to each objective to identify areas where additional monitoring is needed. This evaluation resulted in the proposed addition of four wells (PTX06-1140, PTX06-1141, PTX06-1143, and PTX06-1144) to the network in areas downgradient of perched contaminant plumes or soil release units to satisfy the early detection and uncertainty management monitoring objectives. The results of this evaluation are summarized in Table 3-1. These wells are identified on Figure 3-1.

A total of eight existing wells (PTX06-1059, PTX06-1060, PTX06-1063A, PTX06-1065, PTX06-1066, PTX06-1067, PTX06-1074, and PTX06-1075) were proposed for removal from the network because they either do not satisfy any of the monitoring objectives or will be replaced by one of the proposed new wells.

Four of these wells (PTX06-1063A, PTX06-1065, PTX06-1066, and PTX06-1067) are located north of the northern boundary of USDOE/NNSA property (Pantex Plant). Justification for removing these wells from the monitoring network is two-fold. First, removal eliminates ingress/egress (i.e., Access Agreements) with neighboring landowners. Second, Ogallala monitoring wells currently exist onsite along the northern boundary and, with one additional well (PTX06-1144) discussed above, will satisfy the LTM objectives. Removal of the four wells from the monitoring network decreases the number of samples but does not compromise the capability of the network. The following discussion addresses each offsite well and the justification for removal from the monitoring network.

- PTX06-1063A is located approximately 2,100 ft north of the USDOE boundary, immediately adjacent to the City of Amarillo well #623. Samples cannot be collected from PTX06-1063A while #623 is pumping because of the cone of depression caused by the production well. Well PTX06-1144 is proposed as a replacement for this well.

- PTX06-1065 is located about 2,600 ft north of the USDOE boundary, far enough from any release units that information from this well is of limited use. Other wells onsite (PTX01-1010, PTX01-1011, PTX01-1012, PTX01-1013, and PTX01-1062A) lie upgradient of this well and provide the necessary monitoring information to satisfy the monitoring objectives.

- PTX06-1066 is located immediately downgradient (about 230 ft) of existing onsite well PTX01-1012 and is therefore redundant.

- PTX06-1067 does not provide useful information regarding potential contamination sources at Pantex because it is near the northwest corner of the USDOE boundary and is not downgradient of any soil release units or impacted perched groundwater.

The other four wells (PTX06-1059, PTX06-1060, PTX06-1074, and PTX06-1075) proposed for elimination from the network are located along the western or southwestern boundaries of the USDOE/NNSA property upgradient of any soil release units or impacted perched groundwater associated with Pantex Plant. Therefore, these wells do not satisfy any of the monitoring objectives. These wells will be retained for monitoring of upgradient water quality in the Ogallala Aquifer.

3.3. LONG-TERM MONITORING NETWORK FOR THE OGALLALA AQUIFER

The recommendations from the PlumeFinder analysis were combined with the results of the evaluation against monitoring objectives to develop the final proposed well network shown in Figure 3-1 and 3-2 for each monitoring area. The proposed network includes 19 existing wells and seven new wells. In addition, four upgradient wells located along the southern and western boundaries of Pantex Plant will be retained for upgradient boundary monitoring, but are not included in the LTM network. The frequency of sampling for the Ogallala LTM network is provided in Table 3-2 and is depicted in Figure 3-3.

3.3.1 Final Network Recommendations

Table 3-2 provides a complete list of all wells in the proposed long-term monitoring network for the Ogallala Aquifer along with the LTM objectives, evaluation metrics, and proposed sampling frequency of each well. The LTM network is depicted in Figures 3-1 and 3-2.

- The final recommended network for the Ogallala Aquifer includes 26 monitoring locations, with 48 groundwater samples analyzed annually.

- Semiannual sampling is recommended for 22 locations. Annual sampling is recommended at 4 locations.

- All wells will be sampled for indicator constituents.

- Because the definition of uncertainty management wells is different for the Ogallala, only a small subset of uncertainty management wells was identified for monitoring of soil release units.

- A larger list of constituents (Modified Appendix IX list as presented in the Sampling and Analysis Plan) is recommended to be monitored every five years in 9 uncertainty management wells near soil source areas.

A table listing all wells and their coordinates (northings and eastings) is included in Appendix B.

3.3.2 Monitoring of Soil Release Units

TCEQ and EPA conditionally approved the investigations of soil release units with a requirement for LTM downgradient of release units to address uncertainties regarding the vertical extent of constituents. For purposes of monitoring the soil release units, the units were grouped by Zone or Waste Management Group and downgradient wells were identified in the first groundwater encountered. Because the first groundwater encountered beneath the most of the soil units is the perched groundwater, there are fewer Ogallala uncertainty wells to be monitored at source areas for the modified Appendix IX list (see Table 3-2 and Figure 3-3 for wells proposed for the 5-year modified Appendix IX monitoring). The Ogallala wells proposed for soil uncertainty management adequately address units outside of the perched groundwater footprint. There are few Ogallala wells on the western side of Pantex. Landfill areas to the west have adequate cover material and results of investigations indicate that soil contamination is limited, so downward migration of soil contaminants is unlikely. Downgradient Ogallala wells will be used to monitor for landfill units to the west.

Soil release units and monitoring wells are shown in Figure 3-4. A listing of the soil release units and the associated downgradient monitoring wells is provided in Table 3-3.

Table 3-1. Proposed New Long-Term Monitoring Wells for the Ogallala Aquifer

Well Identifier	Location	Purpose
PTX06-1137 PTX06-1138 PTX06-1139	East of FM 2373	Provide early detection monitoring downgradient of the southeast perched groundwater plume as recommended in the PlumeFinder analysis.
PTX06-1140	East of FM 2373	Provide early detection monitoring downgradient of the southeast perched groundwater plume, supplement to the three wells recommended in the PlumeFinder analysis.
PTX06-1141	Northwest of Zone 4	Monitor downgradient of several soil release units on the western side of Pantex Plant and adjacent to the northwestern extent of perched groundwater.
PTX06-1143	Near the northern extent of perched groundwater north of Playa 1	Monitor downgradient of the impacted perched groundwater northwest of Playa 1 and downgradient of soil release units.
PTX06-1144	Northern Pantex property boundary	Monitor downgradient of the firing sites and several other soil release units.

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Table 3-2. Proposed Long-Term Monitoring Network for the Ogallala Aquifer

Indicator Area[1]	Well ID[2]	LTM Objectives	Progress Report Metrics	Expected Condition	Indicator List[3] Monitoring Frequency	Multiple Sampling Depth Frequency[4]	Appendix IX Monitoring List[5]	Appendix IX Monitoring Frequency[6]
Northwest	PTX01-1010	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX01-1011	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX01-1012	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Northwest	PTX01-1013	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Northwest	PTX06-1057A	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	NA	Y	5 Yrs
Northwest	PTX06-1058	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	NA	Y	5 Yrs
Northwest	PTX06-1061	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	NA	N	NA
Northwest	PTX06-1062A	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX06-1064	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	5 Yrs
Northwest	PTX06-1068	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Northwest	PTX06-1072	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX06-1141	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Annual	I, 5-Yr	Y	5 Yrs
Northwest	PTX06-1143	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 5-Yr	Y	5 Yrs
Northwest	PTX06-1144	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 5-Yr	N	NA
Northwest	PTX07-1R01	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	Y	5 Yrs
Northwest	PTX-BEG-2	Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast	PTX06-1032	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast	PTX06-1056	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast	PTX06-1137	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 5-Yr	N	NA
Southeast	PTX06-1138	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 5-Yr	N	NA
Southeast	PTX06-1139	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 5-Yr	N	NA
Southeast	PTX06-1140	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	I, 5-Yr	N	NA
Southeast/Northwest	PTX06-1033	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast/Northwest	PTX06-1043	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast/Northwest	PTX06-1044	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA
Southeast/Northwest	PTX06-1076	Early Detection, Uncertainty Management	Compare to GWPS	Below background/PQL and GWPS	Semi-Annual	NA	N	NA

1 The indicator monitoring lists are set according to the monitoring areas.
2 Monitor wells on the west/southwest boundary are not listed here but are depicted in Figures 3-1 and 3-2. These wells do not support the LTM objective but they are used to monitor upgradient water quality.
3 Refer to the Pantex Sampling and Analysis Plan (B&W Pantex, September 2008) or the Corrective Action Compliance Plan Table IIIA for the indicator monitoring lists.
4 The new wells that will be completed with blanks between the screened intervals were selected for this sampling because the intervals could be isolated during sampling. These wells will be sampled initially, before the pumps are installed. Pumps will be removed and sampling will be conducted to correspond to the 5-year sampling event for the 5-Year Review under CERCLA and the Compliance Plan. These samples will be analyzed for the indicator list of constituents.
5 A full list of constituents to be monitored is required for uncertainty management. A modified Appendix IX has been recommended for the Corrective Action Compliance Plan Application (Table III) and in the Pantex Sampling and Analysis Plan (B&W Pantex, September 2008).
6 The Appendix IX monitoring list and 5-year frequency are applied to wells near source areas where the uppermost aquifer may be affected (outside the perched groundwater).

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Table 3-3. Monitoring of Soil Release Units for the Ogallala Aquifer

Grouping	Release Units	Ogallala Wells
Burning Ground		
WMG 13	SWMU 8: Playa 3 SWMU 14-24: Burning Ground-Explosive Burn Pads SWMU 25: Burning Ground-Explosive Burn Pad 11 SWMU 26: Burning Ground-Explosive Burn Pad 12 SWMU 27 Burning Ground-Explosive Burn Pad 13 SWMU 37: Burning Ground-Landfill 1 SWMU 38: Burning Ground-Landfill 2 SWMU 39: Burning Ground-Landfill 3 SWMU 40: Burning Ground-Landfill 4 SWMU 41: Burning Ground-Landfill 5 SWMU 42: Burning Ground-Landfill 6 SWMU 43: Burning Ground-Landfill 7 SWMU 44: Burning Ground-Landfill 8 SWMU 45: Explosive Burn Cage SWMU 46: Explosive Burn Cage SWMU 47: Burning Ground-Evaporation Pit SWMU 48: Burning Ground Solvent Evaporation Pans SWMU 49: Burning Ground Solvent Evaporation Pans SWMU 50: Burning Ground Solvent Evaporation Pans SWMU 51: Burning Ground Solvent Evaporation Pans SWMU 52: Burn Racks and Flashing Pits Unassigned Burning Ground-Explosive Burn Pad 16 Unassigned: Demonstration Facilities	PTX01-1010 PTX01-1011 PTX06-1062A
WMG 3	AOC 7a: Sulfuric Acid Spills (11-36) AOC 8d: Solvent Leaks (Pad 11-22) AOC 8e: Solvent Leaks (Bldg 11-36) SWMU 5/08: Drainage Ditch 11-36 SWMU 113: Overflows From 11-36 Collection System/Sump Unassigned Former Leaching Bed N of Bldg 11-50 & W of Bldg 11-36	PTX06-1072
Other Units		
N/A	SWMU 64: Landfill 13	PTX07-1R01
N/A	SWMU 66: Landfill 15 Demolition Debris Landfill	PTX06-1058
N/A	SWMU 70: Firing Site 5	PTX06-1143
N/A	SVS 6: Unnumbered Zone 7 Landfills Demolition Debris Landfills	PTX06-1057A
N/A	SVS 7a and 7b: Igloo Demolition Debris Landfills Zone 4 (SVS 7a) and Zone 5 (SVS 7b)	PTX06-1141

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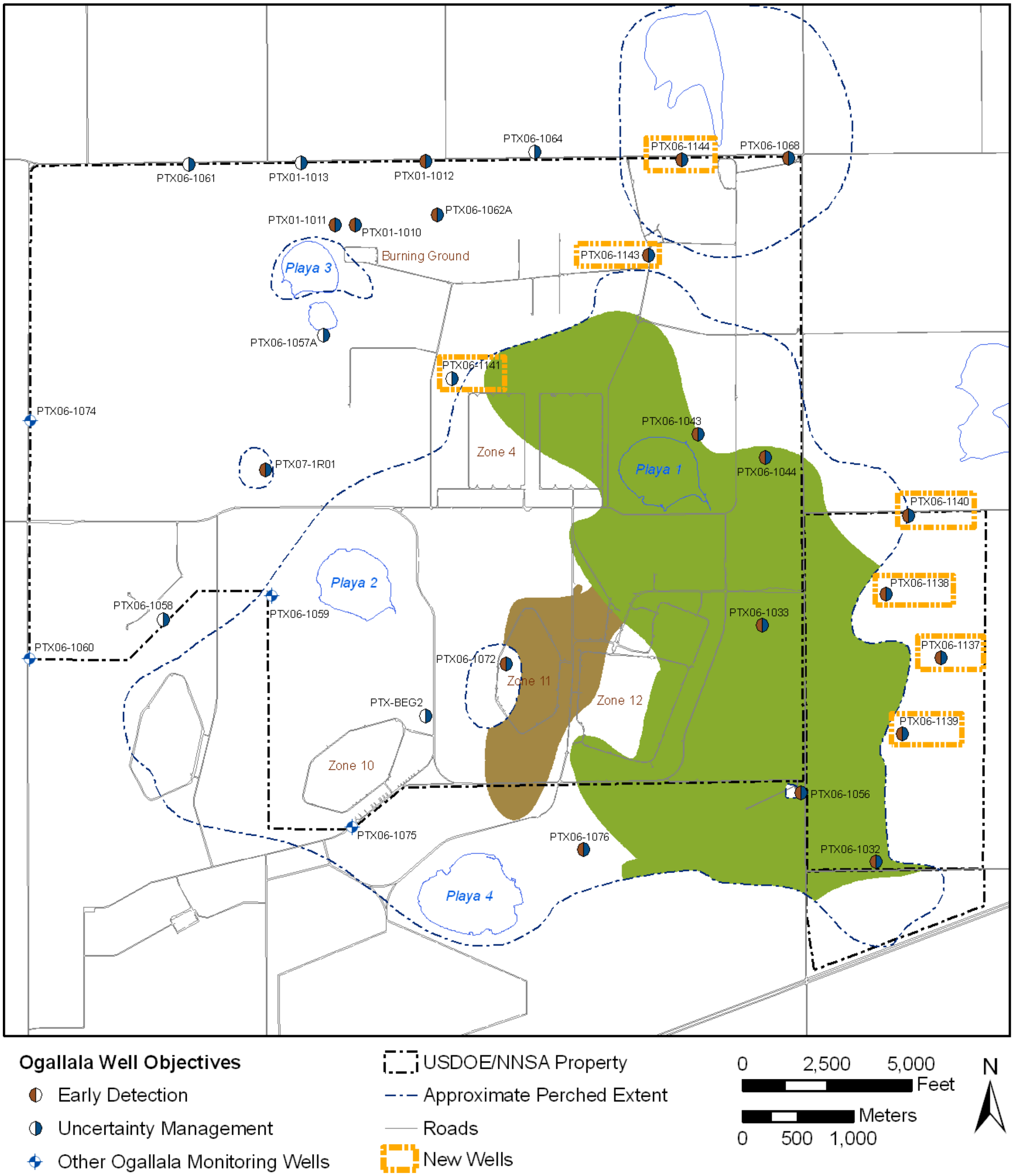

B&W Pantex

Figure 3-1. Ogallala Aquifer Long-Term Monitoring Network

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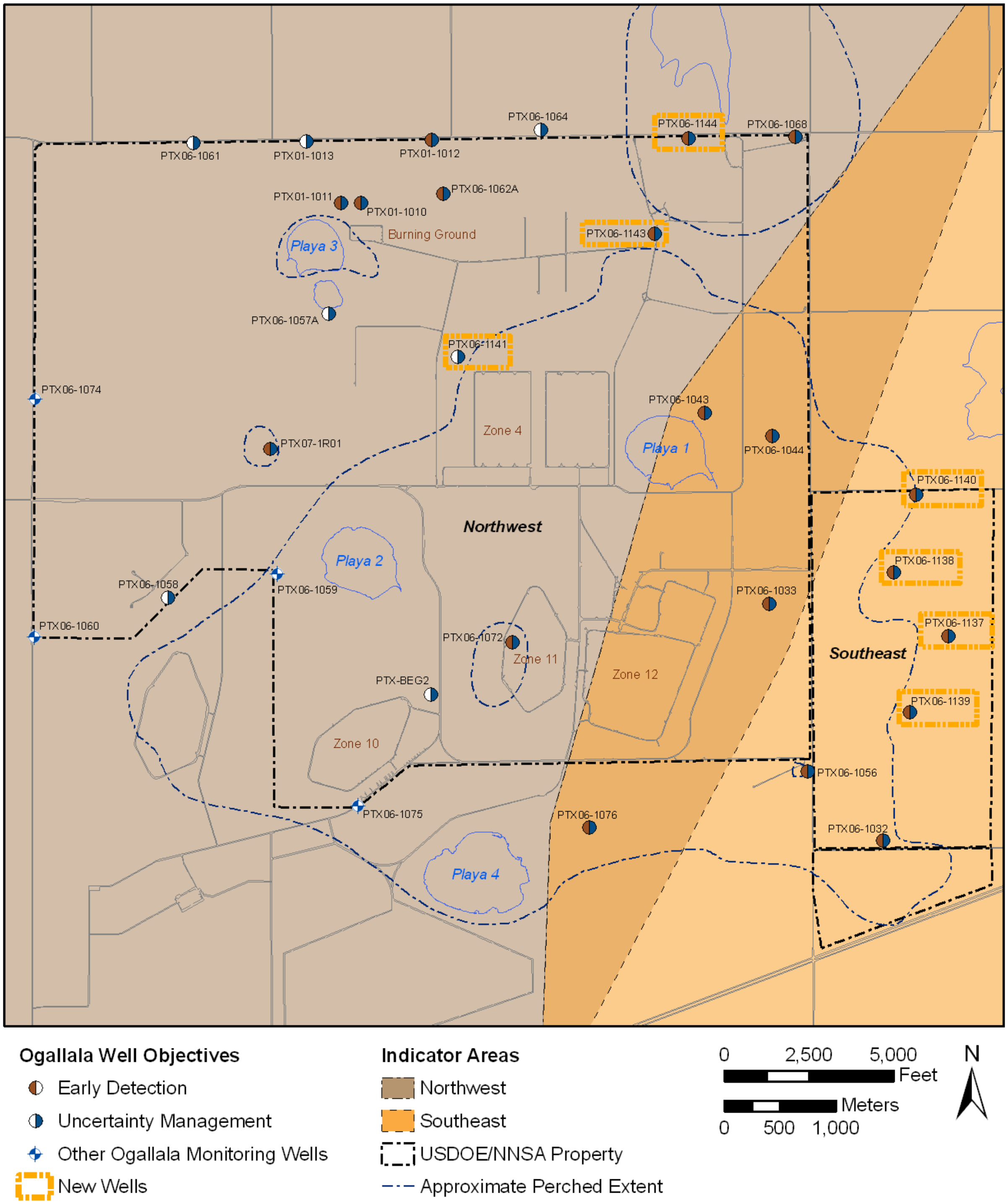

Indicator Constituents	Indicator Area	
	Southeast	Northwest
Primary List (Explosives, VOCs, Boron)	x	x
Chromium (Total & Hexavalent)	x	
Perchlorate		x

Figure 3-2. Indicator Constituent Areas for the Ogallala Aquifer

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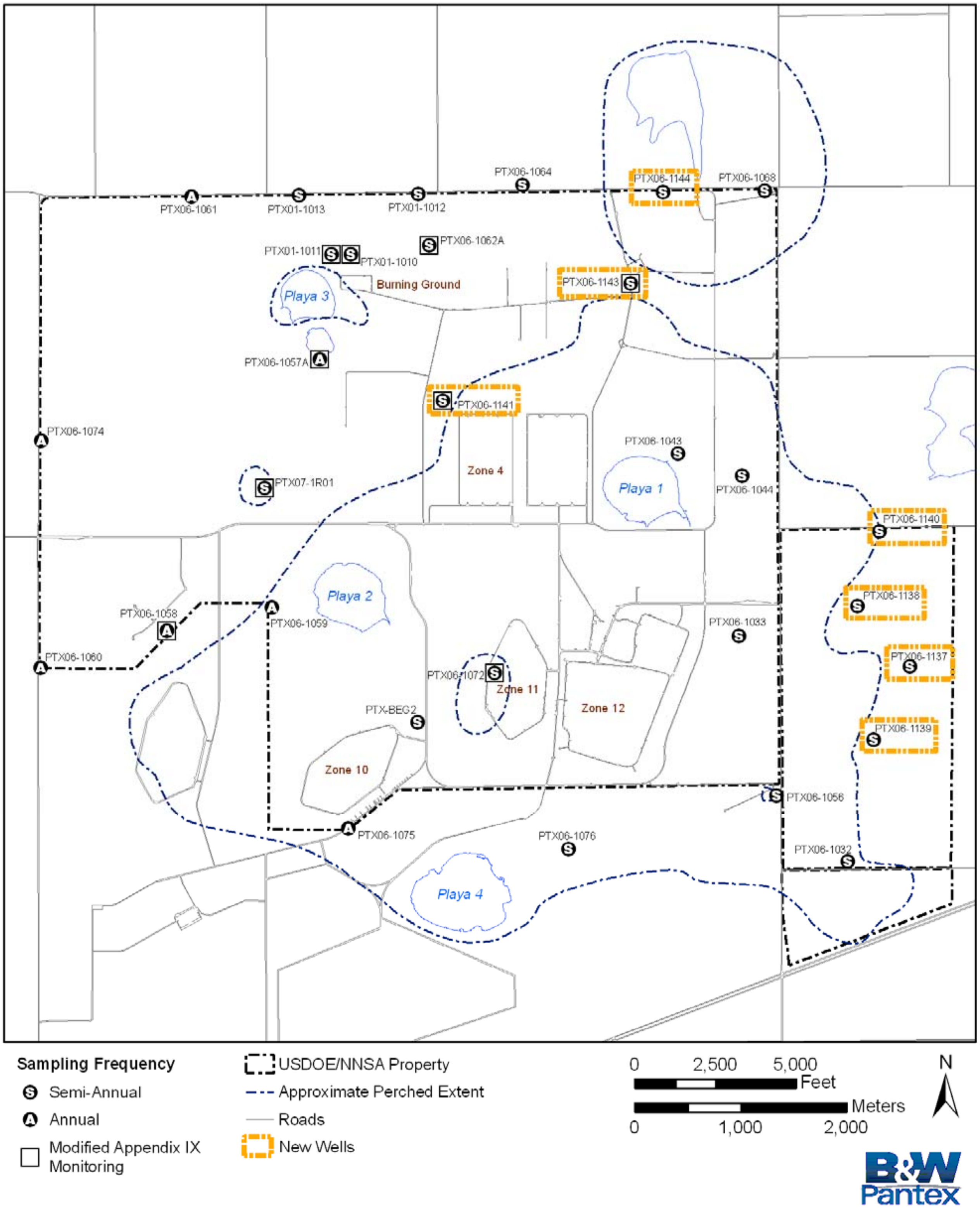

Figure 3-3. Ogallala LTM Network Sampling Frequency

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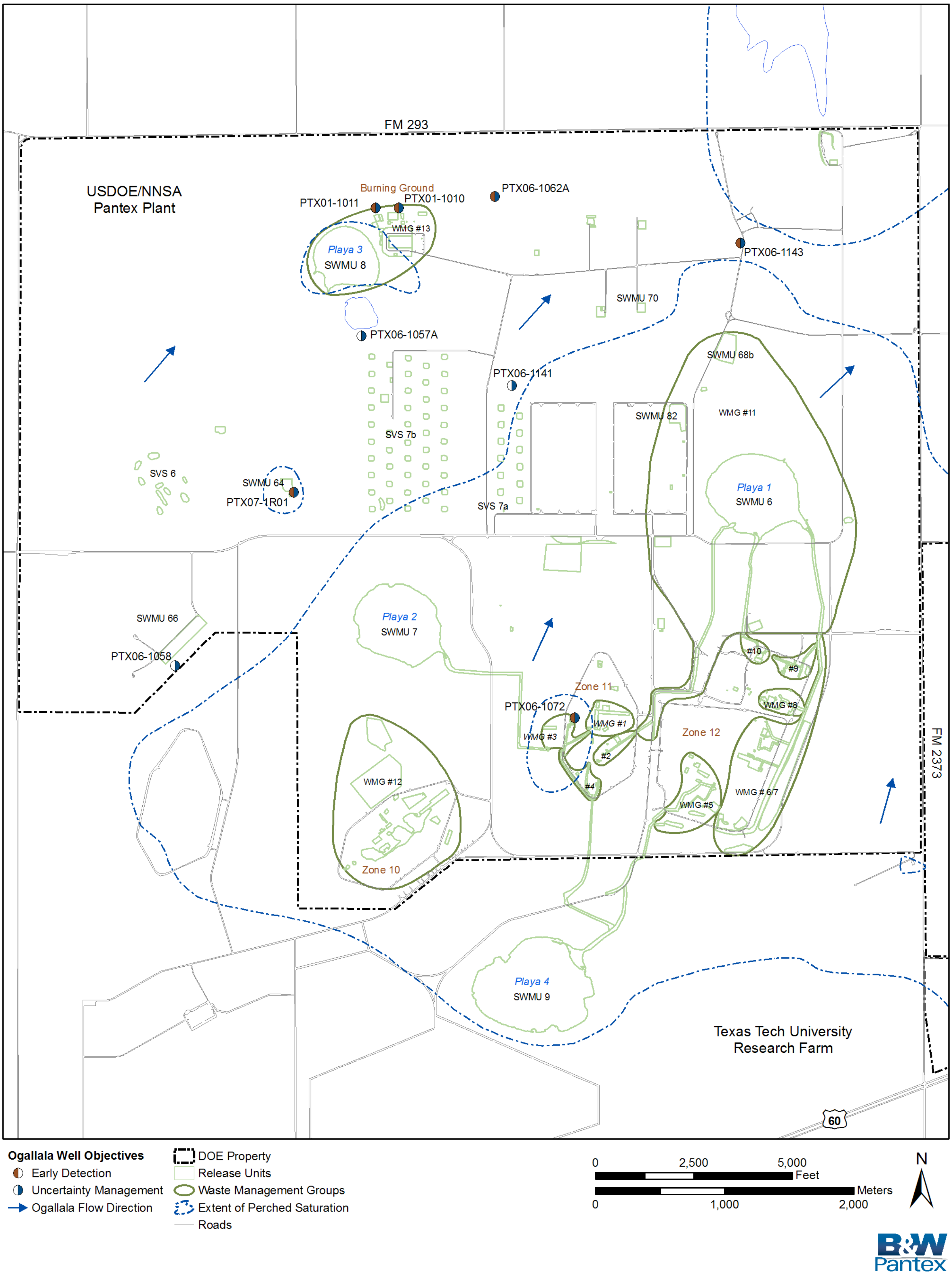

Figure 3-4. Monitoring of RRS 3 Soil Release Units for the Ogallala Aquifer

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4. MONITORING WELL CONSTRUCTION

This section describes the screened intervals and the sample intake placement for each LTM Network well. The well construction information is presented for perched and Ogallala wells that will be part of the LTM Network.

4.1. PERCHED WELL CONSTRUCTION AND SCREENED INTERVALS

New perched monitoring wells will be constructed in accordance with the standard Compliance Plan Attachment B Well Specifications with one exception—the wells will be screened across the entire perched saturated interval. This construction allows for better monitoring of declining perched groundwater levels as the response action process is implemented to remove the water and beneficially use it, instead of injecting it back into the perched zone. A modified Attachment B Well Specification sheet is included in Appendix E to this report. Well completion and lithologic logs for existing perched wells that will be part of the LTM Network are presented in Appendix F.

4.2. PERCHED SAMPLE INTAKE PLACEMENT

Table 4-1 provides the sample intake placement for perched monitoring wells. This placement corresponds to the sampling depth in the well. Most of the wells that comprise the LTM Network have already been installed, so the sample intake levels listed reflect the actual current placement. Recommendations for sample intake placement are also included for new wells. Because many sample intakes were installed in the upper saturated thickness of the groundwater, as water levels decline, the sample intake levels will require adjustment to maintain the ability to sample from the upper 5 feet of saturated thickness.

4.3. OGALLALA WELL CONSTRUCTION AND SCREENED INTERVALS

Most Ogallala Aquifer wells were previously installed as part of the investigation and are screened across the entire saturated thickness. Construction completion and lithologic logs for the existing Ogallala Aquifer monitoring wells that will be part of the LTM Network are provided in Appendix F. Some of these wells, PTX01-1012, PTX06-1044, PTX06-1056, and, PTX06-1068 were evaluated by the USGS in July and August 2008 to determine if different lithologies intercepted by the screens are more transmissive than others, resulting in intervals of preferential flow. Results of the USGS flow study, presented in Appendix B, indicate that more transmissive zones generally occur within the lower depths of the aquifer from Playa 1 to the south. Therefore, the screened intervals for the new wells will intercept the entire saturated interval. The uppermost part of the aquifer will be sampled in areas close to a potential source of contaminants and the deeper part of the aquifer will be the target for wells intended to monitor for contaminants at a point distal to a potential source.

All new Ogallala Aquifer monitoring wells will be installed with screens that provide flexibility to sample from both the uppermost part of the aquifer and the deeper part of the aquifer. The wells will intercept the upper 30 to 100 feet of saturation using multiple screened intervals (no greater than 40 ft each) separated by blank casing. The decision of the upper screen intervals for each well is based on the anticipated decline of the water table. The blank casing separating the screen segments will be 15 ft long. The blank casing sections will enable placement of inflatable packers to isolate the upper screened interval. The inflatable packers and dedicated pumps will be adjusted as necessary to account for the declining Ogallala

Aquifer water table. The modified Attachment B Well Specifications and proposed well screen construction for each of the new Ogallala Aquifer monitoring wells are presented in Appendix E.

A field geologist will record the lithology observed during drilling, and geophysical logs will be recorded in each fluid-filled borehole immediately after reaching total depth. Geophysical logging will consist of spontaneous potential, natural gamma, and resistivity (16 inch and 64 inch). The field geologist will interpret these logs to determine final adjustments to construction of the screens for monitoring of transmissive zones within the aquifer. Upper screen segments and blank casing sections may also be adjusted based on interpretation of the field information. Deeper screen segments will be constructed to intercept the most transmissive zones while blocking off major clay and silt-containing units with blank casing sections. The screen construction decision process is described in greater detail in Appendix F.

4.4. OGALLALA SAMPLE INTAKE PLACEMENT

Table 4-2 provides the proposed sample intake placement for Ogallala Aquifer monitoring wells. This placement corresponds to the sampling depth in the well. Most of the wells that comprise the LTM Network have already been installed, so the sample intake levels reflect the actual current placement. Some sample intake placements have been adjusted based on the results of the USGS flow study and correlation to lithologic descriptions acquired during drilling of each existing well. Recommendations for sample intake placement are also included for the proposed new wells, but may be adjusted after the acquiring lithologic descriptions and geophysical logs. Figure 4-1 presents the Ogallala Aquifer wells and their sample intake placements and approximate saturated thickness (some wells are not completed to the base of the aquifer, so only the in-well saturated thickness can be calculated).

Initial sampling in the new Ogallala Aquifer wells will be conducted at multiple depths. Dedicated sample pumps will then be installed in the wells at the proposed sample intake depth. Routine samples at the proposed frequency for indicator constituents will be obtained from this depth. At the 5-year sampling event, the dedicated sample pumps will be removed and samples will be obtained from multiple depths in the new wells.

Table 4-1. Sample Intake Information for Perched Groundwater Wells

Well ID	Status	Groundwater Elevation[1] (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness[2] (ft)	Bottom of Screen Elevation (ft amsl)
1114-MW4	Active	3276.83	3264.4	12.4	18.4	3258.5
OW-WR-38	Active	3302.99	3293.0	10.0	15.0	3288.0
PTX01-1001	Active	3277.87	3270.3	7.6	7.8	3270.1
PTX01-1002	Active	3294.95	3286.2	8.7	11.5	3283.5
PTX01-1008	Undeveloped	3292.91	3289.2	3.7	5.2	3287.7
PTX04-1001	Active	3305.72	3295.4	10.4	18.5	3287.3
PTX04-1002	Active	3305.48	3300.1	5.4	18.6	3286.8
PTX06-1002A	Active	3286.20	3276.1	10.1	17.8	3268.4
PTX06-1003	Active	3279.58	3275.1	4.5	6.7	3272.9
PTX06-1005	Active	3263.93	3247.2	16.7	21.1	3242.8
PTX06-1006	Active	3276.56	3258.6	17.9	25.9	3250.7
PTX06-1007	Active	3280.18	3275.7	4.5	25.7	3254.5
PTX06-1008	Active	3282.70	3280.8	1.9	11.9	3270.8
PTX06-1010	Active	3284.67	3267.4	17.3	22.4	3262.2
PTX06-1011	Active	3272.43	3259.5	12.9	21.8	3250.6
PTX06-1012	Active	3268.88	3257.4	11.5	14.4	3254.5
PTX06-1013	Active	3295.07	3289.4	5.7	10.7	3284.4
PTX06-1014	Active	3258.71	3253.5	5.2	9.1	3249.6
PTX06-1015	Active	3246.26	3243.8	2.4	4.6	3241.6
PTX06-1023	Active	3298.47	3296.1	2.4	8.5	3290.0
PTX06-1030	Active	3252.32	3245.3	7.0	7.1	3245.2
PTX06-1031	Active	3247.12	3240.1	7.0	7.3	3239.8
PTX06-1034	Active	3242.56	3238.1	4.5	8.0	3234.5
PTX06-1035	Active	3267.11	3259.3	7.8	12.8	3254.3
PTX06-1036	Active	3251.64	3250.6	1.0	1.5	3250.1
PTX06-1037	Undeveloped	3248.36	3246.3	2.0	2.5	3245.9
PTX06-1038	Active	3279.68	3277.9	1.8	20.9	3258.8

Table 4-1. Sample Intake Information for Perched Groundwater Wells (continued)

Well ID	Status	Groundwater Elevation[1] (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness[2] (ft)	Bottom of Screen Elevation (ft amsl)
PTX06-1039A	Active	3274.52	3268.2	6.3	14.4	3260.1
PTX06-1040	Active	3270.87	3264.8	6.0	18.3	3252.6
PTX06-1041	Active	3270.38	3254.5	15.9	33.2	3237.2
PTX06-1042	Active	3261.37	3256.3	5.1	11.8	3249.6
PTX06-1045	Undeveloped	3244.16	3243.8	0.4	1.2	3242.9
PTX06-1046	Active	3245.65	3236.7	9.0	14.5	3231.2
PTX06-1047A	Active	3247.30	3243.0	4.3	7.7	3239.6
PTX06-1048A	Active	3304.53	3300.4	4.1	7.9	3296.7
PTX06-1049	Active	3281.83	3259.3	22.5	38.6	3243.3
PTX06-1050	Active	3299.70	3282.2	17.5	34.9	3264.8
PTX06-1052	Active	3262.27	3254.6	7.6	16.0	3246.3
PTX06-1053	Active	3271.13	3267.8	3.4	9.0	3262.1
PTX06-1069	Active	3278.42	3275.4	3.1	5.1	3273.4
PTX06-1071	Active	3305.45	3288.9	16.5	38.1	3267.4
PTX06-1077A	Active	3282.73	No Dedicated Pump[3]	NA	10.0	3272.7
PTX06-1080	Active	3268.29	3264.0	4.3	18.4	3249.9
PTX06-1081	Active	3303.73	3301.2	2.6	17.5	3286.3
PTX06-1082	Active	3294.27	3289.3	5.0	6.6	3287.6
PTX06-1083	Active	3291.63	3277.9	13.7	21.0	3270.6
PTX06-1085	Active	3268.71	3253.3	15.4	23.7	3245.0
PTX06-1086	Active	3270.36	3232.5	37.9	46.1	3224.3
PTX06-1088	Active	3271.94	3259.1	12.8	26.1	3245.8
PTX06-1095A	Active	3263.09	3258.8	4.3	18.8	3244.3
PTX06-1098	Active	3257.07	No Dedicated Pump[3]	NA	17.6	3239.5
PTX06-1100	Active	3256.57	No Dedicated Pump[3]	NA	13.8	3242.8
PTX06-1101	Active	3256.42	No Dedicated Pump[3]	NA	14.6	3241.9
PTX06-1102	Undeveloped	3254.13	3249.7	4.5	7.6	3246.6
PTX06-1103	Active	3249.56	No Dedicated Pump[3]	NA	21.6	3227.9

Table 4-1. Sample Intake Information for Perched Groundwater Wells (continued)

Well ID	Status	Groundwater Elevation[1] (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness[2] (ft)	Bottom of Screen Elevation (ft amsl)
PTX06-1118	Undeveloped	3250.39	No Dedicated Pump [3]	NA	1.6	3248.8
PTX06-1120	Undeveloped	3248.49	No Dedicated Pump [3]	NA	5.5	3243.0
PTX06-1121	Undeveloped	3247.71	No Dedicated Pump [3]	NA	2.8	3244.9
PTX06-1123	Undeveloped	3248.85	No Dedicated Pump [3]	NA	1.8	3247.0
PTX06-1126	Active	3270.92	3262.9	8.1	20.4	3250.6
PTX06-1127	Active	3271.85	3265.1	6.7	25.2	3246.6
PTX07-1O01	Active	3297.14	3296.1	1.1	5.0	3292.1
PTX07-1O02	Active	3297.87	3290.9	7.0	7.2	3290.7
PTX07-1O03	Active	3300.17	3297.4	2.8	9.4	3290.8
PTX07-1O06	Undeveloped	3289.66	3288.2	1.5	1.7	3288.0
PTX07-1P02	Active	3298.52	3283.9	14.6	17.0	3281.5
PTX07-1P05	Active	3296.66	3294.6	2.1	3.9	3292.8
PTX07-1Q01	Active	3265.47	3250.8	14.7	17.5	3248.0
PTX07-1Q02	Active	3265.20	3248.7	16.5	29.3	3235.9
PTX07-1Q03	Active	3267.91	3260.5	7.4	41.5	3226.4
PTX07-1R03	Undeveloped	3318.45	3316.0	2.5	5.0	3313.5
PTX08-1001	Active	3298.16	3291.2	7.0	9.6	3288.5
PTX08-1002	Active	3296.38	3293.2	3.1	10.1	3286.2
PTX08-1003	Active	3276.72	3262.6	14.2	24.4	3252.3
PTX08-1005	Active	3272.09	3259.1	13.0	14.6	3257.5
PTX08-1006	Active	3273.77	3269.3	4.5	34.7	3239.0
PTX08-1007	Active	3277.98	3264.2	13.8	22.9	3255.1
PTX08-1008	Active	3269.30	3263.6	5.8	24.1	3245.2
PTX08-1009	Active	3265.24	3253.6	11.7	17.7	3247.6
PTX08-1010	Active	3305.92	3304.6	1.4	21.9	3284.0
PTX10-1013	Active	3289.85	3276.0	13.8	17.9	3271.9
PTX06-1130	Proposed		To Be Determined	~5		
PTX06-1131	Proposed		To Be Determined	< 5		

Table 4-1. Sample Intake Information for Perched Groundwater Wells (continued)

Well ID	Status	Groundwater Elevation[1] (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness[2] (ft)	Bottom of Screen Elevation (ft amsl)
PTX06-1133	Proposed	Dry	No Dedicated Pump	NA	0	
PTX06-1134	Proposed		To Be Determined	~5		
PTX06-1135	Proposed		To Be Determined	< 5		
PTX06-1136	Proposed		To Be Determined	~5		
PTX06-1146	Proposed		To Be Determined	~5		
PTX06-1147	Proposed		To Be Determined	~5		
PTX06-1148	Proposed		To Be Determined	~5		
PTX06-1149	Proposed		To Be Determined	~5		
PTX06-1150	Proposed		To Be Determined	~5		
PTX01-1004	Dry	Dry	No Dedicated Pump	NA	0	3298.2
PTX01-1009	Dry	Dry	No Dedicated Pump	NA	0	3280.51
PTX06-1051	Dry	Dry	No Dedicated Pump	NA	0	3239.72
PTX06-1055	Dry	Dry	No Dedicated Pump	NA	0	3273.36
PTX06-1073A	Dry	Dry	No Dedicated Pump	NA	0	3274.07
PTX06-1089	Dry	Dry	No Dedicated Pump	NA	0	3263.13
PTX06-1090	Dry	Dry	No Dedicated Pump	NA	0	3254.78
PTX06-1091	Dry	Dry	No Dedicated Pump	NA	0	3261.24
PTX06-1093	Dry	Dry	No Dedicated Pump	NA	0	3274.42
PTX06-1094	Dry	Dry	No Dedicated Pump	NA	0	3243.49
PTX06-1096A	Dry	Dry	No Dedicated Pump	NA	0	3301.14
PTX06-1097	Dry	Dry	No Dedicated Pump	NA	0	3266.95
PTX06-1119	Dry	Dry	No Dedicated Pump	NA	0	3249.8
PTX06-1122	Dry	Dry	No Dedicated Pump	NA	0	3249.84
PTX06-1124	Dry	Dry	No Dedicated Pump	NA	0	3243.99
PTX06-1125	Dry	Dry	No Dedicated Pump	NA	0	3243.76

[1]Based on December 2008 measurements for most wells.
[2]Saturated thickness above the bottom of the well screen.
[3]No dedicated sample pumps have been installed in these wells because the wells have not been routinely sampled or because the well has low yield or limited saturated thickness. Dedicated sample pumps may be installed in one or more of these wells in the future.

Table 4-2. Sample Intake Information for Ogallala Aquifer Wells

Well ID	Status	Groundwater Elevation[1] (ft amsl)	Sample Intake Elevation (ft amsl)	Sample Intake Depth (ft below top of GW)	Screened Saturated Thickness[2] (ft)	Bottom of Screen Elevation (ft amsl)
PTX01-1010	Active	3087.79	3081.2	6.6	358.8	2729.0
PTX01-1011	Active	3090.10	3019.1	71.0	307.3	2782.8
PTX01-1012	Active	3074.81	3067.7	7.1	397.8	2677.1
PTX01-1013	Active	3089.17	3011.4	77.8	372.1	2717.0
PTX06-1032	Active	3134.20	3102.0	32.2	36.9	3097.3
PTX06-1033	Active	3097.41	3084.5	12.9	105.1	2992.3
PTX06-1043	Active	3081.77	2910.1	171.7	188.7	2893.1
PTX06-1044	Active	3059.93	3045.5	14.5	133.8	2926.1
PTX06-1056	Active	3137.48	3126.8	10.7	76.8	3060.7
PTX06-1057A	Active	3105.99	To Be Determined	~20	296.6	2809.4
PTX06-1058	Active	3168.25	To Be Determined	~20	131.3	3037.0
PTX06-1061	Active	3100.40	3091.9	8.5	371.8	2728.6
PTX06-1062A	Active	3077.25	3068.8	8.5	395.5	2681.8
PTX06-1064	Active	3059.57	3053.2	6.4	289.3	2770.2
PTX06-1068	Active	3024.11	3004.1	20.0	289.2	2734.9
PTX06-1072	Active	3137.26	3127.2	10.1	132.9	3004.4
PTX06-1076	Active	3179.95	3170.3	9.6	14.3	3165.7
PTX07-1R01	Active	3125.31	To Be Determined	~20	151.0	2974.3
PTX-BEG2	Active	3156.99	3148.7	8.3	33.3	3123.7
PTX06-1137	Proposed		To Be Determined	~15		
PTX06-1138	Proposed		To Be Determined	~15		
PTX06-1139	Proposed		To Be Determined	~15		
PTX06-1140	Proposed		To Be Determined	~15		
PTX06-1141	Proposed		To Be Determined	~20		
PTX06-1143	Proposed		To Be Determined	~20		
PTX06-1144	Proposed		To Be Determined	> 150		

[1]Based on December 2008 measurements for most wells.
[2]Saturated thickness above the bottom of the well screen.

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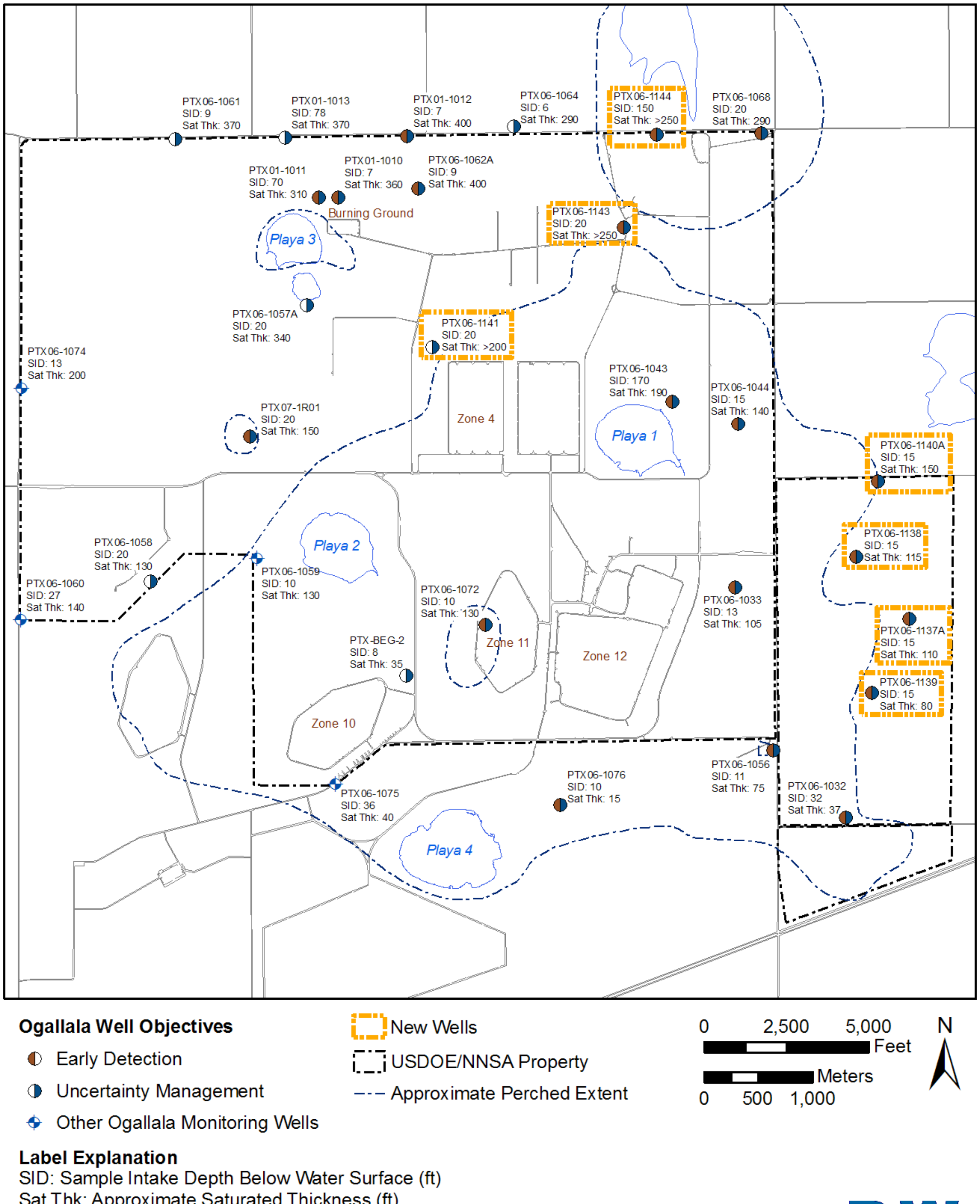

Figure 4-1. Sample Intake Depths for Ogallala Aquifer Wells

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5. EVALUATION OF MONITORING DATA

Selection of the final remedy through the CERCLA process creates a need for modification of the Compliance Plan to include the Corrective Action Requirements. Accordingly, Pantex must identify the methods for evaluating the response action systems that comprise the final remedy. This section provides the methods that will be used to evaluate the various objectives identified in this report. The data collected according to this LTM plan will also support the 5-Year Review required under the IAG and the Compliance Plan.

5.1. PROGRESS REPORT EVALUATION

The semi-annual and annual progress reports required through CP-50284 and the IAG will include evaluations of the available data from the monitoring networks. The annual report will provide a full evaluation of the response action systems, while the semi-annual report will only provide a comparison of data to the GWPS.

The data will be evaluated with respect to the remedial action objectives in the ROD and the response actions installed for Pantex. The following will be evaluated:

- Plume stability
- Evaluation of soil stabilization measures (uncertainty management)
- Achievement of cleanup standards (response action effectiveness)
- COC concentrations in the perched groundwater and Ogallala Aquifer (early detection)
- Groundwater use controls.

The data collected from the LTM system will support evaluation of all objectives including groundwater use controls. Table 5-1 presents each objective and describes how the data will be used for evaluation. The expected conditions identified for each well are included in Tables 2-1 and 3-1, and will be used in data evaluations.

5.2. 5-YEAR REVIEW

A 5-year review is required under the Compliance Plan and the IAG. Data collected for the LTM system will also support the 5-year review. The evaluations performed for the annual report will be reviewed collectively to determine the performance of the response actions across a 5-year time period. This is completed to determine if the response actions need to be adjusted to better meet the RAOs. In addition, the LTM design will be reevaluated using similar to those used for this report. Adjustments to the network will be made as necessary and updated through this design report.

Table 5-1. Groundwater Monitoring Data Evaluation Matrix

Objective	Information Evaluation	Output from Evaluation
Plume stability	Water levels	Hydrographs, water level trending, map of water level trends, saturated thickness map, water elevation map, current conditions of dry wells
	Concentration trends	Concentrations trends in each well, map of concentration trends by constituent
Soil Stabilization Measures (Uncertainty Management)	Review of indicator monitoring data for Ogallala and perched Uncertainty Management wells	Data trend determinations at source areas
	Review of 5-Year data collection (modified Appendix IX monitoring)	Identification of new constituents, if any
Achievement of Cleanup Standards (Response Action Effectiveness)	Evaluation of data against GWPS	Table of data listing all wells that exceed the GWPS
	Concentration trends	Response Action Effectiveness wells concentration trends
	Evaluation of ISB performance data	Determine if complete breakdown is occurring, and if amendment continues to be effective. Compare downgradient wells data to GWPS to determine if system is reducing concentrations to acceptable levels and if conditions in the aquifer are suitable for continuing degradation
	Evaluation of extraction well capture zones	Text and map depicting capture zone analysis
	Evaluation of MNA data	Determine if RDX and other HEs are breaking down in wells selected for this analysis
Prevent Contaminants from Exceeding Cleanup Standards in the Ogallala Aquifer (Early Detection)	Evaluation of data collected at Ogallala Aquifer wells	Comparison of data to background and GWPS.
	Evaluate trends, if necessary (e.g., metals, or other low level detections that may occur)	Concentration trend charts and discussion

5.3. EVALUATION METRICS

Most methods for the evaluation are based on simple comparisons to established values, such as the practical quantitation limit (PQL), background, or GWPS. Statistical analyses of concentration trends in each well will be conducted using the methods described in the following sections. Well hydrographs will be provided for all monitoring wells, and a linear regression trend analysis will be used to determine if water levels are declining as stated in the cleanup objectives for the perched groundwater.

5.3.1.1 Statistical Concentration Trend Analysis

The general change in concentration, or trend, of a particular constituent in a well can be quantified using a statistical trend analysis method. The methods to be used, including a nonparametric Mann-Kendall analysis and a parametric linear regression, were adapted from the AFCEE Monitoring And Remediation Optimization System (MAROS) Software. The following descriptions of the statistical trend analysis methods were adapted from the MAROS Version 2.2 User's Guide (AFCEE, 2007).

With actual site measurements, apparent concentration trends may often be obscured by data scatter arising from non-ideal hydrogeologic or sampling and analysis conditions. However, even though the scatter may be of such magnitude as to yield a poor fit (typically characterized by a low correlation coefficient, e.g., $R^2 << 1$) for the first-order relationship, parametric and nonparametric methods can be utilized to obtain confidence intervals on the estimated first-order coefficient, i.e., the slope of the log-transformed data. Nonparametric tests such as the Mann-Kendall test for trend are suitable for analyzing data that do not follow a normal distribution. Nonparametric methods focus on the location of the probability distribution of the sampled population, rather than specific parameters of the population. The outcome of the test is not determined by the overall magnitude of the data points, but depends on the ranking of individual data points. Assumptions on the distribution of the data are not necessary for nonparametric tests. The Mann-Kendall test for trend is a nonparametric test which has no distributional assumptions and irregularly spaced measurement periods are permitted. The advantage gained by this approach involves the cases where outliers in the data would produce biased estimates of the least squares estimated slope.

Parametric tests such as first-order regression analysis make assumptions on the normality of the data distribution, allowing results to be affected by outliers in the data in some cases. However, more accurate trend assessments using parametric methods result from data where there is a normal distribution of the residuals. Therefore, when the data are normally distributed, the nonparametric Mann-Kendall test is not as efficient.

5.3.1.1.1 Mann-Kendall Analysis

General

The Mann-Kendall test is a non-parametric statistical procedure that is well suited for analyzing trends in data over time (Gilbert, 1987). The Mann-Kendall test can be viewed as a nonparametric test for zero slope of the first-order regression of time-ordered concentration data versus time. The AFCEE MAROS Tool includes this test to assist in the analysis of groundwater plume stability. The Mann-Kendall test does not require any assumptions as to the statistical distribution of the data (e.g. normal, lognormal, etc.) and can be used with data sets which include irregular sampling intervals and missing data. The Mann-Kendall test is designed for analyzing a single groundwater constituent, multiple constituents are analyzed separately. For this evaluation, a decision matrix was used to determine the "Concentration Trend" category for each well, as presented in Table 5-2.

Mann-Kendall Statistic (S)

The Mann-Kendall statistic (S) measures the trend in the data. Positive values indicate an increase in constituent concentrations over time, whereas negative values indicate a decrease in constituent concentrations over time. The strength of the trend is proportional to the magnitude of the Mann-Kendall Statistic (i.e., large magnitudes indicate a strong trend). Data for performing the Mann-Kendall Analysis must be in time sequential order. The first step is to determine the sign of the difference between consecutive sample results. Sgn(x_j–x_k) is an indicator function that results in the values 1, 0, or –1 according to the sign of (x_j–x_k), where j > k. The function is calculated as follows:

$$\begin{aligned} \mathrm{sgn}(x_j - x_k) &= 1 \qquad \text{if } x_j - x_k > 0 \\ \mathrm{sgn}(x_j - x_k) &= 0 \qquad \text{if } x_j - x_k = 0 \\ \mathrm{sgn}(x_j - x_k) &= -1 \qquad \text{if } x_j - x_k < 0 \end{aligned}$$

The Mann-Kendall statistic (S) is defined as the sum of the number of positive differences minus the number of negative differences or

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \mathrm{sgn}\left(x_j - x_k\right).$$

The ***confidence in the trend*** for the Mann-Kendall statistic is calculated using a Kendall probability table (e.g. Hollander, M. and Wolfe, D.A., 1973). By assessing the S result along with the number of samples, n, the Kendall table provides the probability of rejecting the null hypothesis (H_0 = no trend) for a given level of significance. MAROS calculates a “confidence level” percentage by subtracting the probability (*p*) from 1 (Confidence = 1-*p* %). Confidence of 90% represents a significance level of $\alpha = 0.1$, and 95% confidence corresponds to $\alpha = 0.05$. The resulting confidence in the trend is applied in the Mann Kendall trend analysis.

Average

The arithmetic mean of a sample of n values of a variable is the average of all the sample values written as

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

Standard Deviation

The standard deviation is the square root of the average of the square of the deviations from the sample mean written as

$$s = \sqrt{\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2}{n-1}}.$$

The standard deviation is a measure of how the value fluctuates about the arithmetic mean of the data.

Coefficient of Variation (COV)

The Coefficient of Variation (COV) is a statistical measure of how the individual data points vary about the mean value. The coefficient of variation, defined as the standard deviation divided by the average or

$$C.O.V. = \frac{s}{\overline{x}}$$

Values less than or near 1.00 indicate that the data form a relatively close group about the mean value. Values larger than 1.00 indicate that the data show a greater degree of scatter about the mean.

Results and Interpretation of Results: Mann-Kendall Analysis

The concentration data are used to calculate COV and S for each well with at least four sampling events. A “Concentration Trend” and “Confidence in Trend” are reported for each well with at least four sampling events. If data are insufficient, the well trend analysis is not conducted.

The COV is a statistical measure of how the individual data points vary about the mean value. Values less than or near 1.0 indicate that the data form a relatively close group about the mean value. Values larger than 1.0 indicate that the data show a greater degree of scatter about the mean. The Mann-Kendall statistic (S) measures the trend in the data. Positive values indicate an increase in constituent concentrations over time, whereas negative values indicate a decrease in constituent concentrations over time. The strength of the trend is proportional to the magnitude of S (i.e., larger magnitudes indicate a stronger trend). The “Confidence in Trend” (1-*p*) is the statistical probability that the constituent concentration is increasing (S>0) or decreasing (S<0). The null hypothesis (no trend) is rejected for confidence above 90%.

The “Concentration Trend” for each well is determined according to the rules in the decision matrix (Table 5-2), where COV is the coefficient of variation. The MAROS Mann-Kendall Analysis Decision Matrix was developed by Groundwater Services Inc. for AFCEE. Strongly increasing or decreasing trends indicate a higher level of statistical significance. The confidence can be used as a qualitative measure of the statistical strength of the trend when evaluating the overall stability of the plume.

5.3.1.1.2 Linear Regression Analysis

General

Linear regression is a parametric statistical procedure that is typically used for analyzing trends in data over time. However, with the usual approach of interpreting the log slope of the regression line, concentration trends may often be obscured by data scatter arising from non-ideal hydrogeologic or sampling and analysis conditions. Even though the scatter may be of such magnitude as to yield a poor goodness of fit (typically characterized by a low correlation coefficient, e.g., $R^2 << 1$) for the first-order relationship, confidence intervals can nonetheless be constructed on the estimated first-order coefficient, i.e., the slope of the log-transformed data. Using this type of analysis, a higher degree of scatter simply corresponds to a wider confidence interval about the average log slope. Assuming the sign (i.e., positive or negative) of the estimated log slope is correct, a level of confidence that the slope is not zero can be easily determined. Thus, despite a poor fit, the overall trend in the data may still be ascertained, where low levels of confidence correspond to “Stable” or “No Trend” conditions (depending on the degree of scatter) and higher levels of confidence indicate the stronger likelihood of a trend. The coefficient of variation, defined as the standard deviation divided by the average, is used as a secondary measure of scatter to distinguish between “Stable” or “No Trend” conditions for negative slopes. The linear regression analysis is designed for analyzing a single groundwater constituent, multiple constituents are analyzed separately. For this evaluation, a decision matrix was used to determine the “Concentration Trend” category for each well, as presented in Table 5-3.

Linear Regression

The objective of linear regression analysis is to find the trend in the data through the estimation of the log slope as well as placing confidence limits on the log slope of the trend. Regression begins with the specification of a model to be fitted. A linear relationship is one expressed by a linear equation. The linear regression analysis is performed on log(concentration) versus time. The regression model assumes that for a fixed value of x (sample date) the expected value of y (log concentration) is some function. For a particular value, x_i or sample date the predicted value for y (log concentration) is given by

$$\hat{y}_i = a + bx_i$$

The fit of the predicted values to the observed values (x_i, y_i) are summarized by the difference between the observed value y_i and the predicted value $\hat{y}_i$ (the residual value). A reasonable fit to the line is found by making the residual values as small as possible. The method of least squares is used to obtain estimates of the model parameters (a, b) that minimize the sum of the squared residuals, S^2 or the measure of the distance between the estimate and the values we want to predict (the y's).

$$S^2 = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2$$

The values for the intercept (a) and the slope (b) of the line that minimize the sum of the squared residuals (S^2), are given by

$$b = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n} (x_i - \bar{x})^2} \qquad \text{and} \qquad a = \bar{y} - b\bar{x}$$

where $\bar{x}$ and $\bar{y}$ are the mean x and y (log concentration) values in the dataset.

In order to test the confidence on the regression trend, there is a need to place confidence limits on the slope of the regression line. In this stage of the trend analysis, it is assumed that for each x value, the y-distribution is normal. A t-test may be used to test that the true slope is different from zero. This t-test is preferentially used on data that is not serially correlated or seasonally cyclic or skewed.

The variance of y_i (σ^2) is estimated by the quantity $S^2_{y|x}$ where this quantity is defined as

$$S^2_{y|x} = \frac{\sum_{i-1}^{n} (y_i - \hat{y}_i)^2}{n-2}$$

where n is the number of samples.

The estimation of the standard deviation or standard error of the slope (s.e.b.) is defined as

$$s.e.b. = \sqrt{\frac{S^2_{y|x}}{\sum_{i-1}^{n} (x_i - \bar{x}_i)^2}}$$

To test significance of the slope calculated, the following t-test result can be used to find the confidence interval for the slope.

$$t = \frac{b}{s.e.b.}$$

The t result along with the degrees of freedom (n–2) are used to find the confidence in the trend by utilizing a t-distribution table found in most statistical textbooks (e.g. Fisher, L.D. and van Belle, G., 1993). The resulting confidence in the trend is utilized in the linear regression trend analysis.

Results and Interpretation of Results: Linear Regression Analysis
The concentration data are used to calculate the COV and the first-order coefficient (log slope) for each well with at least four sampling events. A "Concentration Trend" and "Confidence in Trend" are reported for each well with at least four sampling events. If data are insufficient, the well trend analysis is not conducted.

The COV is a statistical measure of how the individual data points vary about the mean value. Values less than or near 1.0 indicate that the data form a relatively close group about the mean value. Values larger than 1.0 indicate that the data show a greater degree of scatter about the mean.

The Log Slope measures the trend in the data. Positive values indicate an increase in constituent concentrations over time, whereas negative values indicate a decrease in constituent concentrations over time.

The "Confidence in Trend" is the statistical probability that the constituent concentration is increasing (log slope > 0) or decreasing (log slope < 0).

The "Concentration Trend" for each well is determined according to the rules in the decision matrix (Table 5-3), where COV is the coefficient of variation. The MAROS Linear Regression Analysis Decision Matrix was developed in-house by Groundwater Services Inc. for AFCEE.

5.3.1.2 Water Level Trend Analysis

A similar linear regression trend analysis will be used with water level measurements to determine if water levels are declining as stated in the cleanup objectives for the perched groundwater. For water level trend analysis, the measured water levels are the y values. These values are not log-transformed before applying the regression analysis.

5.3.1.3 Comparison to GWPS

Data collected at each well will be directly compared to the GWPS for each constituent to determine if concentrations exceed the GWPS. Wells that exceed the GWPS will be highlighted.

5.3.1.4 Dry

Dry wells will be checked semi-annually for water. If sufficient water is found to allow sample collection, the well will be sampled according to the appropriate indicator list, and the data collected will be evaluated accordingly.

5.4. EXPECTED CONDITIONS

The expected condition designated for each well provides a context for evaluating the monitoring data from the well based on the monitoring history, knowledge of plume movement and source area conditions, and expected impacts of remedial action systems. The range of expected conditions were classified into six categories presented below.

<u>Below background/PQL and GWPS:</u> Concentrations are not expected to exceed background/PQL or the GWPS. This conditions applies to wells that are located outside the extent of a plume or that have not produced exceedances of RRS1 in historical sampling data.

<u>Stable or decreasing trend below GWPS:</u> Concentrations are below the GWPS and are expected to remain stable or decrease over time. This condition applies to wells that have exhibited a decline of concentrations to below the GWPS or that have a history of detections below the GWPS.

<u>Decreasing water levels, Long-term stabilization of concentrations:</u> These wells are within the influence of the groundwater extraction systems, so water levels are expected to decline over time. Concentrations are expected to stabilize as the pump and treat systems continue to remove contaminant mass from the perched groundwater.

<u>Below GWPS in 2–5 years:</u> These wells are downgradient of the ISB systems, so concentrations are expected to decrease as groundwater passing through the treatment zone migrates to the wells. The decrease in concentrations may not be evident until sufficient time has passed to allow treated groundwater to travel the distance from the treatment zone to the well at the pore water velocity.

<u>Long-term decreasing trend:</u> These wells are outside the zone of influence of the groundwater extraction systems and are not downgradient of an ISB system. Concentrations in these wells are expected to slowly decrease through natural attenuation processes including dispersion, dilution, and degradation.

<u>Remain dry:</u> These wells are beyond the extent of perched saturation and serve as plume stability wells. These wells will be watched to ensure that the perched groundwater, and the contaminant plumes, is not expanding. The expected condition for these wells is that water will not be found.

Table 5-2. MAROS Mann-Kendall Analysis Decision Matrix

Mann-Kendall Statistic	Confidence in Trend	Concentration Trend
S > 0	> 95%	Increasing
S > 0	90–95%	Probably Increasing
S > 0	< 90%	No Trend
S ≤ 0	< 90% and COV ≥ 1	No Trend
S ≤ 0	< 90% and COV < 1	Stable
S < 0	90–95%	Probably Decreasing
S < 0	> 95%	Decreasing

Table 5-3. MAROS Linear Regression Analysis Decision Matrix

Log Slope	Confidence in Trend	Concentration Trend
Positive	> 95%	Increasing
Positive	90–95%	Probably Increasing
Positive	< 90%	No Trend
Negative	< 90% and COV ≥ 1	No Trend
Negative	< 90% and COV < 1	Stable
Negative	90–95%	Probably Decreasing
Negative	> 95%	Decreasing

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6. SUMMARY AND CONCLUSIONS

This report documents the development of the proposed long-term groundwater monitoring well network and the methods for evaluation of the response actions based on the monitoring well network for Pantex Plant.

Pantex is proposing that a total of 134 perched and Ogallala wells be monitored. Twenty-six Ogallala monitor wells and 108 perched wells are recommended for monitoring. The objectives for the development of the network are to evaluate the following:

Perched

- Plume stability
- Response Action Effectiveness
- Uncertainty Management

Ogallala

- Early Detection
- Uncertainty Management

The frequency of sampling and the monitoring lists were recommended to evaluate each well for indicator parameters (as presented in the *Sampling and Analysis Plan*, B&W Pantex 2009). In addition, a larger list of constituents (modified Appendix IX as presented in the *Sampling and Analysis Plan*) is recommended for monitoring every 5 years to be used in conjunction with the 5-Year Review required by the Compliance Plan and CERCLA. The monitoring well network will also be reviewed each 5 years to make recommended changes.

The well construction designs for new perched and Ogallala wells were recommended to ensure that final monitoring well placement and sampling will allow for early detection of contaminants and to evaluate the final remedial actions at Pantex.

This plan also provides the methods for evaluating compliance with the response action objectives for the perched groundwater at Pantex. These evaluations will be performed in the semi-annual and annual reports, as required. Evaluations include comparison of monitoring data against the applicable standards, concentration trending, evaluation of water levels, and evaluation of well conditions.

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APPENDIX A

Hydrogeologic Description of Pantex Plant

A. HYDROGEOLOGY

This appendix describes the hydrogeologic setting of Pantex Plant, including geology and water resources.

A.1. TOPOGRAPHY

Pantex Plant is located in the Texas Panhandle on the High Plains portion of the Great Plains Physiographic Province. This area is a broad, flat plateau that gently slopes east and south and is known as the *Llano Estacado* (Spanish for "Staked Plain"). Topographic elevation across Pantex Plant ranges from approximately 3,501 to 3,595 feet (1,067 to 1,096 m) above mean sea level (amsl), with an average elevation of approximately 3,554 feet (1,083 m) amsl (Table A-1). The topography is relatively flat with slopes ranging from approximately 0.00005 in upland areas to approximately 0.07 near closed drainage basins containing ephemeral lakes (known as playas). The average topographic slope across the Plant area is approximately 0.006 (Table A-1).

A.2. LOCAL GEOLOGY

The shallow subsurface stratigraphy in the area of Pantex Plant is comprised of the following geologic units (in order of increasing age of formation and depth below land surface):

- Blackwater Draw Formation (Pleistocene Epoch)
- Ogallala Formation (Pliocene Epoch)
- Dockum Group (Triassic Period)
- Permian Quartermaster Formation (Permian Period) where the Dockum Group is not present.

The vertical dimensions of the geologic units are summarized in Table A-1. More detailed information regarding the local geology is presented in the *Subsurface Modeling Report* (BWXT Pantex and SAIC, 2004).

The Blackwater Draw, the uppermost hydrostratigraphic unit (HSU) consists of eolian silts and sands with an approximately 20-foot (6-m) thick lower unit composed of silty sand and caliche. The upper surface of the Blackwater Draw is defined by surface topography. Numerous depressions representing the playa basins are apparent on the land surface. These depressions range from a few feet to more than 46 feet (14 m) in relief and from several hundred feet to 1 mile (1.6 km) or more in diameter (ANL and BMI, 1995). Sediments beneath the playas contain thick sequences, roughly 16 to 60 ft (5 to 18 m), of lake sediments that are highly variable in lateral and vertical extent (Hovorka, 1995). The lake sediments interfinger with the Blackwater Draw sediments near the edges of the playa basins. The Blackwater Draw Formation and the availability of water control infiltration and recharge, especially to perched groundwater.

Underlying the Blackwater Draw Formation is the Ogallala Formation. The Ogallala sediments consist of coarse-grained fluvial sequences that fill the floors of paleovalleys and fine upward from gravel to fine sand. The fining-upward sequences contain channel sands and gravels overlain by finer overbank deposits (Gustavson, 1994). Fine-grained eolian deposits overlie the coarse fluvial sediments. Regionally, the thickness of the Ogallala Formation ranges from a few feet to over 900 feet (274 m). A massive caliche caprock layer generally defines the top of the Ogallala Formation (and the base of the Blackwater Draw Formation); however, it is not continuous in extent below Pantex Plant. Where present, the caprock layer consists of a hard, dense, finely crystalline caliche.

Underlying the Ogallala Formation is the Dockum Group. Where present, the Dockum Group is estimated to be approximately 200 feet (61 m) thick in the Plant area (Johns, 1989). Identification of the Dockum Group from the Ogallala Formation is more difficult than the identification of the Permian Redbeds or the Quartermaster Formation. The Quartermaster Formation is made up of red shale or clay with sandstone, dolomite, or gypsum. The Permian Redbeds have very low permeability values; therefore, there are limited permeable pathways between the Ogallala and Permian rocks (Nativ, 1988).

A.3. GROUNDWATER RESOURCES

A.3.1 Ogallala Aquifer

The principal source of groundwater for the region is the Ogallala Aquifer, the primary unit of the High Plains Aquifer, comprising the highly permeable basal sediments of the Ogallala Formation throughout the Southern High Plains. The Ogallala Aquifer provides water for municipal water supplies, crop irrigation, livestock operations, and industry and is the sole water source for Pantex Plant.

The High Plains Aquifer has been developed extensively with more than 96% of the total withdrawal used for irrigation (McGuire, 2004). During 2000, approximately 121,000 acre-feet of water were pumped from the aquifer in Carson County (PGCD, 2003). About 97,300 acre-feet, or 80%, were withdrawn for irrigation (PWPG, 2005). Because this volume of discharge greatly exceeds the amount of recharge, water levels in the aquifer are declining. Water level changes in the High Plains Aquifer from the time prior to substantial ground-water irrigation development (about 1950) to 2003 are illustrated in Figure A-1. In this figure, declines in western Carson County near Pantex Plant range from about 25 ft (7.6 m) to more than 150 feet (46 m). According to the Panhandle Groundwater Conservation District, the average water level in Carson County declined 31 feet (9.4 m) from 1964 to 2004 (PGCD, 2004). Beneath the northern part of Pantex Plant, water levels have dropped more than 130 feet (40 m) since 1942 and are currently declining at rates greater than 1 foot (0.3 m) per year.

The Ogallala Aquifer in Carson County was estimated to contain about 17.5 million acre-feet of groundwater in 1960 (Knowles, et al., 1984). In 2000, the volume in storage had declined to about 15.3 million acre-feet (PWPG, 2005). It is the stated goal of the Panhandle Groundwater Conservation District to conserve and preserve the limited supply of groundwater in the district while maintaining the economic viability of all resource user groups. To meet this goal, the District has instituted a conservation management policy to retain 50% of the 1998 groundwater supply in 2048 (PCGD, 2003). According to Groundwater Availability Modeling conducted as part of regional water planning, about 65% of the year 2000 groundwater supply in Carson County is projected to remain in 2050 (PWPG, 2005).

Regionally, the Ogallala water table slopes from northwest to southeast, generally following the regional topographic surface. In the vicinity of Pantex Plant, however, the water table slopes from southwest to northeast, as shown in Figure A-2, in response to extensive pumping from the City of Amarillo Carson County well field located north of Pantex Plant. Figure A-3, showing the approximate saturated thickness of the Ogallala Aquifer near Pantex, indicates an area of limited saturation in the aquifer on the eastern side of the Texas Tech University (TTU) property. As water levels in the aquifer continue to decline, this area of limited saturation will expand. Figure A-2 includes the locations of Ogallala Aquifer monitoring wells in the vicinity of Pantex Plant. This monitoring network was used to determine the water levels and potentiometric surface of the Ogallala Aquifer beneath the Plant.

A.3.2 Perched Groundwater

Localized bodies of perched groundwater occur above the Ogallala Aquifer throughout the Southern High Plains (Mullican, 1997). These localized zones occur where focused recharge from playa lakes has ponded on top of an aquitard, referred to as the fine-grained zone (FGZ). Figure A-4 includes the locations of perched groundwater monitoring wells in the vicinity of Pantex Plant. This monitoring network was used to determine the water levels and potentiometric surface of perched groundwater beneath the Plant. Three primary areas of perched groundwater beneath Pantex Plant are shown in Figure A-5. The largest area of perched groundwater underlying Pantex Plant is associated with natural recharge from Playas 1, 2, and 4, treated wastewater discharge to Playa 1, and historical releases to the ditches draining Zones 11 and 12. Smaller areas of perched groundwater are associated with Playa 3 (near the Burning Ground) and Pratt Playa (near the northeast corner of Pantex Plant).

Perched groundwater does not discharge to the surface, is not a source of drinking water for Pantex Plant, nor is it used for any Pantex Plant industrial operations. Treated water from the perched groundwater pump and treat system, and treated wastewater meeting Pantex Plant permitted discharge requirements, is used for subsurface irrigation onsite. Because perched groundwater is the shallowest water-bearing zone in the area, it is the first groundwater unit affected by the migration of constituents released from Pantex Plant Solid Waste Management Units (SWMUs). Units impacted by constituents at the surface are separated from groundwater in either the perched zone or the Ogallala Aquifer by a 200- to 500-foot (61- to 153-m) thick unsaturated zone. Vertical flow between perched groundwater and the Ogallala Aquifer is limited by the FGZ. In areas where perched groundwater is present, a second unsaturated zone occurs between the perched groundwater and the Ogallala Aquifer. Because of the thin saturated thickness of perched groundwater, flow in the perched zone is controlled by the topography of the FGZ and by localized sources of recharge, such as Playa 1. As a result, groundwater flow directions in the perched groundwater vary spatially in response to local topography and recharge. Perched groundwater northeast of Playa 1 is limited to Pantex Plant because of the limited extent of the perched groundwater in that area.

As a result of historical waste management practices that occurred at Pantex Plant from the early 1950s to approximately the late 1980s, portions of the main perched groundwater are impacted by contaminants, primarily in the areas beneath and downgradient of Zones 11 and 12 and Playa 1. The most prevalent contaminant in perched groundwater is Research Development Explosive compound cyclo-trimethylene trinitramine (RDX), a high explosive (HE) compound used at Pantex Plant since it began operations in the early 1950s. The approximate extent of RDX impacts in perched groundwater at Pantex Plant is shown in Figure A-6. In this figure, the highest concentrations of RDX are observed south of the Plant boundary on TTU property, and along the eastern Plant boundary. Current concentrations observed are much lower near the known source areas (WMG 6/7, SWMU 5-13c, and Playa 1). The lower concentrations near the source areas indicate that influx of RDX to perched groundwater was much greater in the past, the observed nature and extent of RDX impacts are a result of historical releases, and improved waste management practices have mitigated continuing influx of RDX to the perched groundwater. The *Groundwater RFIR* (Stoller, 2004) provides a complete discussion of the nature and extent of constituents in perched groundwater.

A.4. SOIL CHARACTERISTICS

Surficial soils at Pantex Plant are predominantly Pullman clay loams. Subsurface soils are considered part of the Blackwater Draw and Ogallala Formations. The Pullman clay loam series dominates the upland, and Randall clay dominates the playa bottoms. Lazbuddie and Lofton soils occur on the playa benches, and Pep and Estacado soils occur on the playa side slopes.

A.5. METEOROLOGY AND CLIMATOLOGY

The climate in the Texas Panhandle is typical of continental interiors. It is mainly semi-arid, with mild winters and hot, dry summers and is characterized by large variations in daily temperature extremes, low relative humidity, and irregular rainfall of moderate amounts. Thunderstorms occur approximately 49 days per year and can produce tornadoes (DOC, 1997). Pantex Plant is in a windy area and in a moderate- to high-hazard zone for tornadoes.

Based on National Weather Service (NWS) records, average annual precipitation for Amarillo is 19.9 inches (50.5 cm). The average annual temperature is 57.1ºF (13.9ºC), with a normal low temperature in January of 21.2ºF (-6.0ºC) and a normal high temperature in July of 91.7ºF (33.2ºC). Average wind speeds at the Amarillo NWS station are 13.1 mph (21.1 kph) based on a 33-year period of record (BPX/MHC, 1998). The prevailing wind direction is from the south for May through September and from the southwest for the remainder of the year (DOC, 1997). Analysis of NWS meteorological data for 1990 indicates local winds were predominantly from the south and southwest directions approximately 41% of the time with an average wind speed of 13.4 mph (21.6 kph). The gross lake-surface evaporation rate averages 73 inches (185 cm) per year, as measured from 1950 through 1975 (BPX/MHC, 1997).

A.6. SURFACE WATER

The principal surface water features of the Southern High Plains are the numerous shallow playas and small stream valleys or draws. Stream drainage patterns are poorly developed because of the low relief of the plains. Streams occur as long, shallow draws following the general slope of the land surface at widely spaced intervals. The drainage areas of the streams and draws are limited to narrow belts of land. Playa basins drain the larger, interfluvial areas and generally do not contribute runoff to streams. The perennial surface water feature closest to Pantex Plant is the Canadian River, located approximately 17 miles (27 km) to the north. The river flows in a generally eastward direction into Lake Meredith, a constructed reservoir. A few smaller streams are located south and east of Pantex Plant along the High Plains Escarpment. These streams are tributaries of the Red River and include 1) the Salt Fork of the Red River, about 20 miles (32 km) southeast of Pantex Plant; 2) the Prairie Dog Town Fork of the Red River, 25 miles (40 km) southwest of Pantex Plant; and 3) Sweetwater Creek, about 50 miles (80 km) east of Pantex Plant. During flood events at Pantex Plant, surface water may flow to offsite playas but runoff from Pantex Plant does not flow into the Canadian River, Lake Meredith, or any of the smaller streams.

Three playas are located at Pantex Plant, as shown on Figure A-4. Playa 1 is north of Zone 12, Playa 2 is west-northwest of Zone 11, and Playa 3 is included in the Burning Ground WMG. Playa 4 is located on TTU property, south of Zone 11. A large playa basin is located on Pantex Lake property, 2.5 miles (4 km) northeast of the Pantex Plant boundary. Other playas are present in the area and each constitutes a separate drainage basin with no surface drainage outlets. Most surface water runoff from Pantex Plant flows into the onsite playas. Historically, treated and untreated industrial wastewater was discharged directly to the ditches and flowed to the playas. Waste management practices were improved in the 1980s and all industrial discharges to the ditches were eliminated by 1999. Additionally, Playa 1 and Pantex Lake have received treated wastewater from the Old Sewage Treatment Plant (OSTP) and the current Wastewater Treatment Facility (WWTF). The treated wastewater discharge is currently routed to a subsurface irrigation system in accordance with permit requirements. Occasionally, treated wastewater is discharged to Playa 1 in compliance with permit requirements. Playas 2 and 3 and Pantex Lake receive only storm water runoff.

Table A-1. Vertical Dimension of Geologic Features within Pantex Plant Boundary[a]

	Geologic Features	High ft	High m	Low ft	Low m	Average[b] ft	Average[b] m
Elevation[c]	Topographic Elevation (Top of Blackwater Draw Formation)	3594.6	1095.6	3501.2	1067.2	3553.6	1083.1
	Topographic Slope (ft/ft)	0.07	0.07	0.00005	0.00005	0.006	0.006
	Elevation of Base of Blackwater Draw Formation (Top of Ogallala Formation and Caprock Caliche)	3532.9	1076.8	3436.9	1047.6	3480.6	1060.9
	Elevation of the Base of the Caprock Caliche	3522.4	1073.6	3426.3	1044.3	3470.5	1057.8
	Elevation of the Perched Water Table Surface	3321.9	1012.5	3257.4	992.8	3283.4	1000.8
	Elevation of the Top of the FGZ	3341.5	1018.5	3111.1	948.3	3277.5	999.0
	Elevation of the Base of the FGZ	3309.6	1008.8	3031.5	924.0	3226.3	983.4
	Top of Ogallala Water Table	3210.4	978.5	2677.2	816.0	3115.6	949.6
	Elevation of the Base of the Ogallala Formation (Top of the Dockum Group and Redbeds)	3152.4	960.9	2679.2	816.6	2895.9	882.7
Depth below ground surface (bgs)	Depth bgs to Base of Blackwater Draw Formation (Top of Ogallala Formation and Caprock Caliche)	105.0	32.0	33.6	10.2	72.9	22.2
	Depth bgs to Base of Caprock Caliche	115.0	35.0	43.6	13.3	83.0	25.3
	Depth bgs to Perched Water Table Surface	297.9	90.8	195.1	59.5	256.7	78.2
	Depth bgs to Top of FGZ	321.7	98.1	223.5	68.1	276.0	84.1
	Depth bgs to Base of FGZ	431.1	131.4	267.5	81.5	327.1	99.7
	Depth bgs to Ogallala Water Table Surface	507.5	154.7	343.5	104.7	437.9	133.5
	Depth bgs to Base of Ogallala Formation (Top of the Dockum Group and Redbeds)	888.9	270.9	390.9	119.2	657.6	200.4
Thickness	Thickness of Blackwater Draw Formation	105.5	32.2	33.6	10.2	72.8	22.2
	Thickness of Caprock Caliche	23.2	7.1	0.5	0.2	7.1	2.2
	Saturated Thickness of Perched Groundwater	79.4	24.2	0.0	0.0	22.0	6.7
	Thickness of FGZ	157.1	47.9	8.7	2.6	51.1	15.6
	Lower Ogallala Unsaturated Thickness	221.1	67.4	0.0	0.0	110.8	33.8
	Saturated Thickness of Ogallala Aquifer	406.2	123.8	29.0	8.8	219.7	67.0
	Thickness of Ogallala Formation (Total)	821.6	250.4	316.4	96.5	584.7	178.2

Note: Water surface information is based on April 2000 measurements collected from monitoring, investigation, municipal, private, and extraction wells (See Table 2-3 of Subsurface Modeling Report [BWXT Pantex and SAIC, 2004] for list of wells included).
[a]Table taken from the Subsurface Modeling Report (BWXT Pantex and SAIC, 2004)
[b]Averages were calculated as the arithmetic mean of the interpolated surfaces within the Pantex Plant boundary.
[c]Elevation data is amsl.

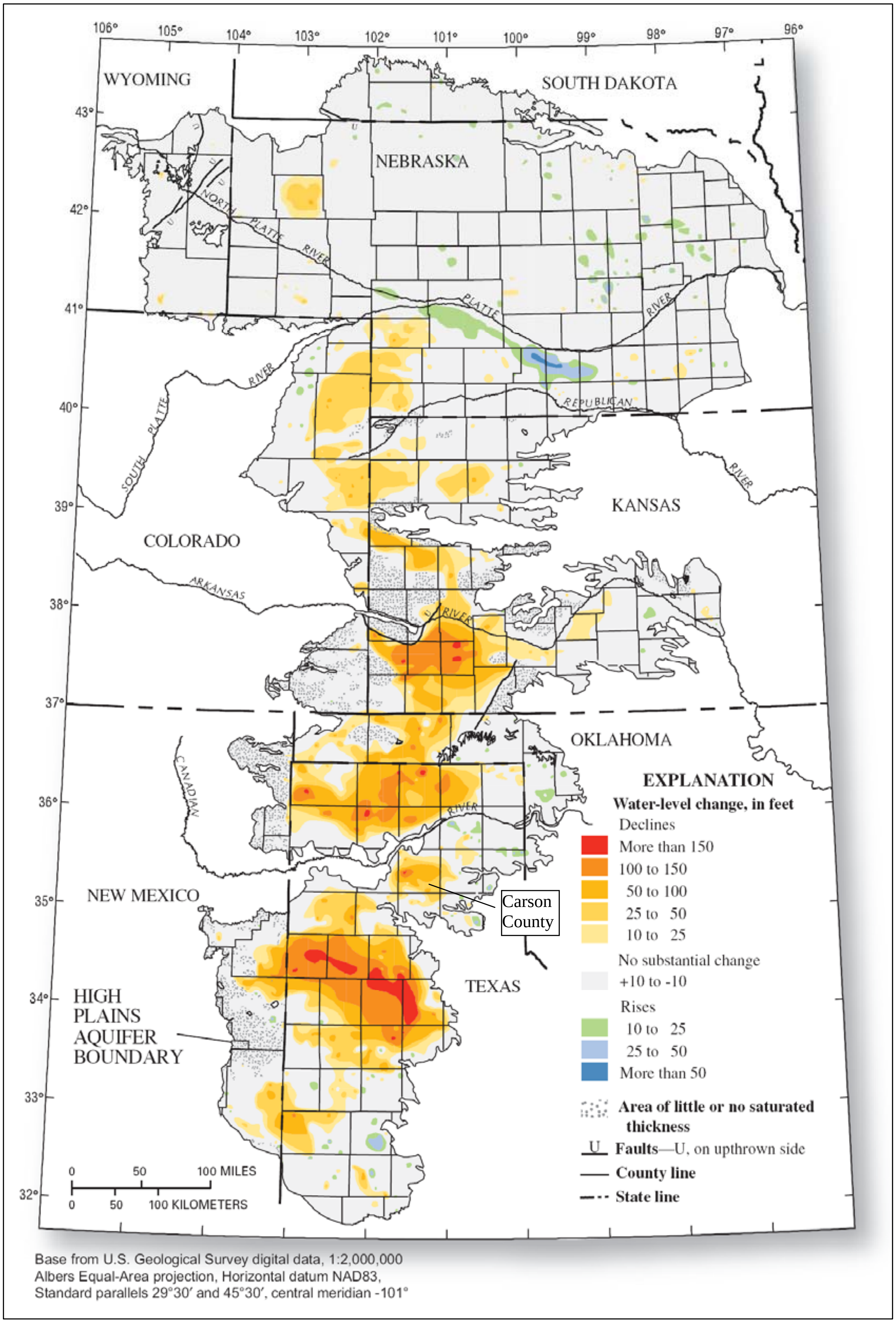

Figure A-1. Water-Level Changes in the High Plains Aquifer, Predevelopment to 2003 (Modified from Mcguire, 2004)

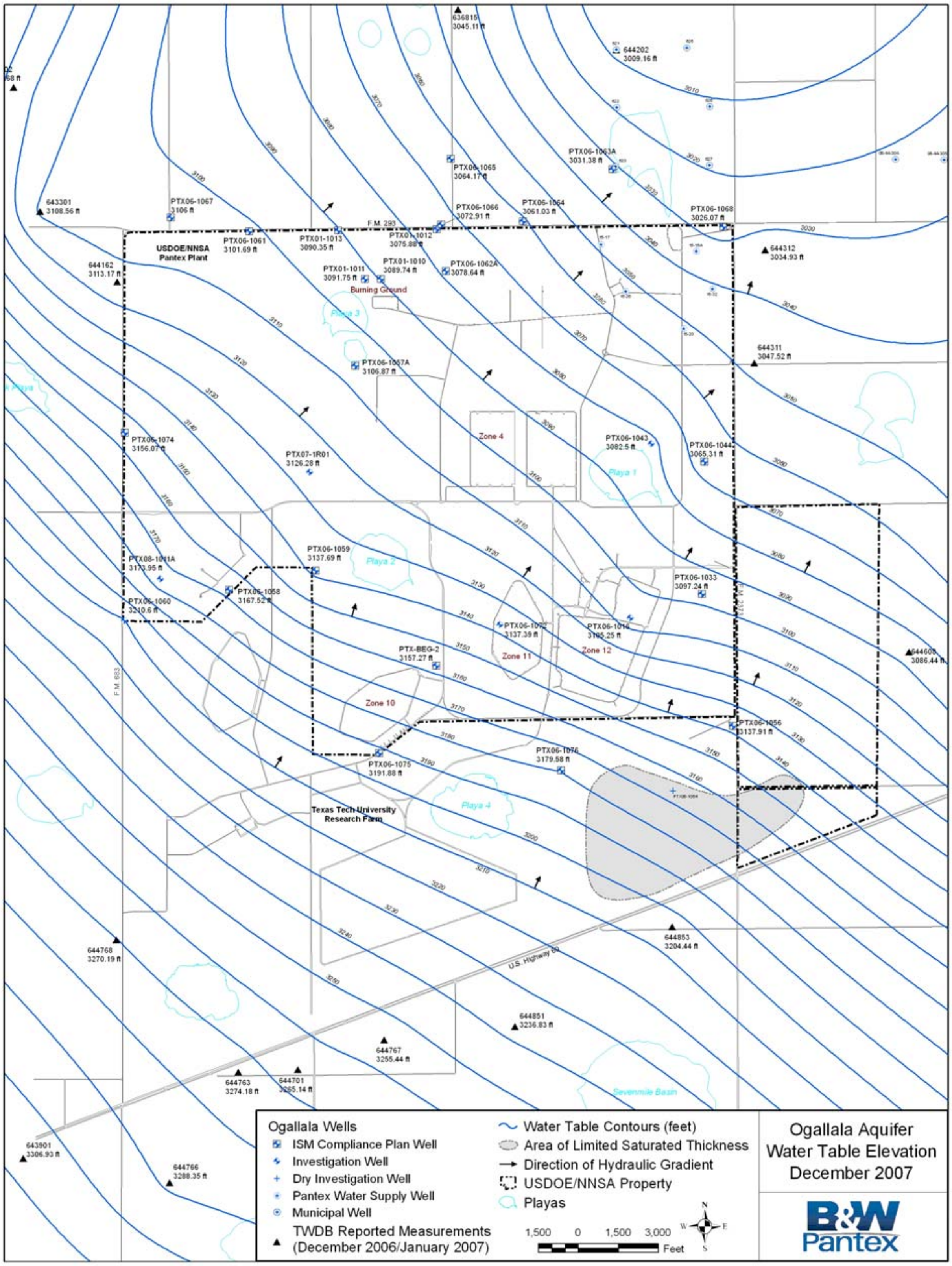

Figure A-2. Ogallala Aquifer Water Levels at Pantex Plant, December 2007

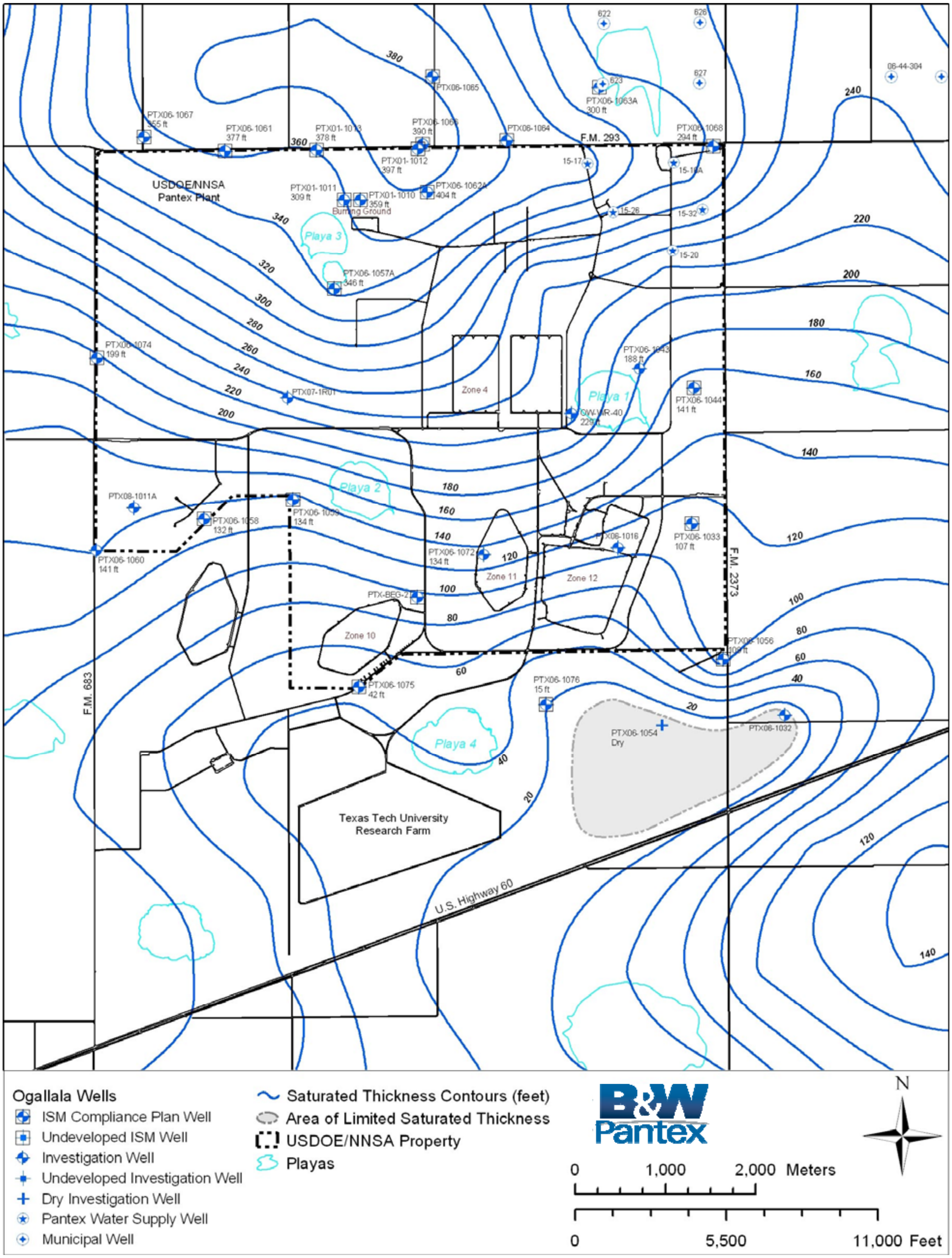

Figure A-3. Approximate Saturated Thickness of the Ogallala Aquifer, December 2004

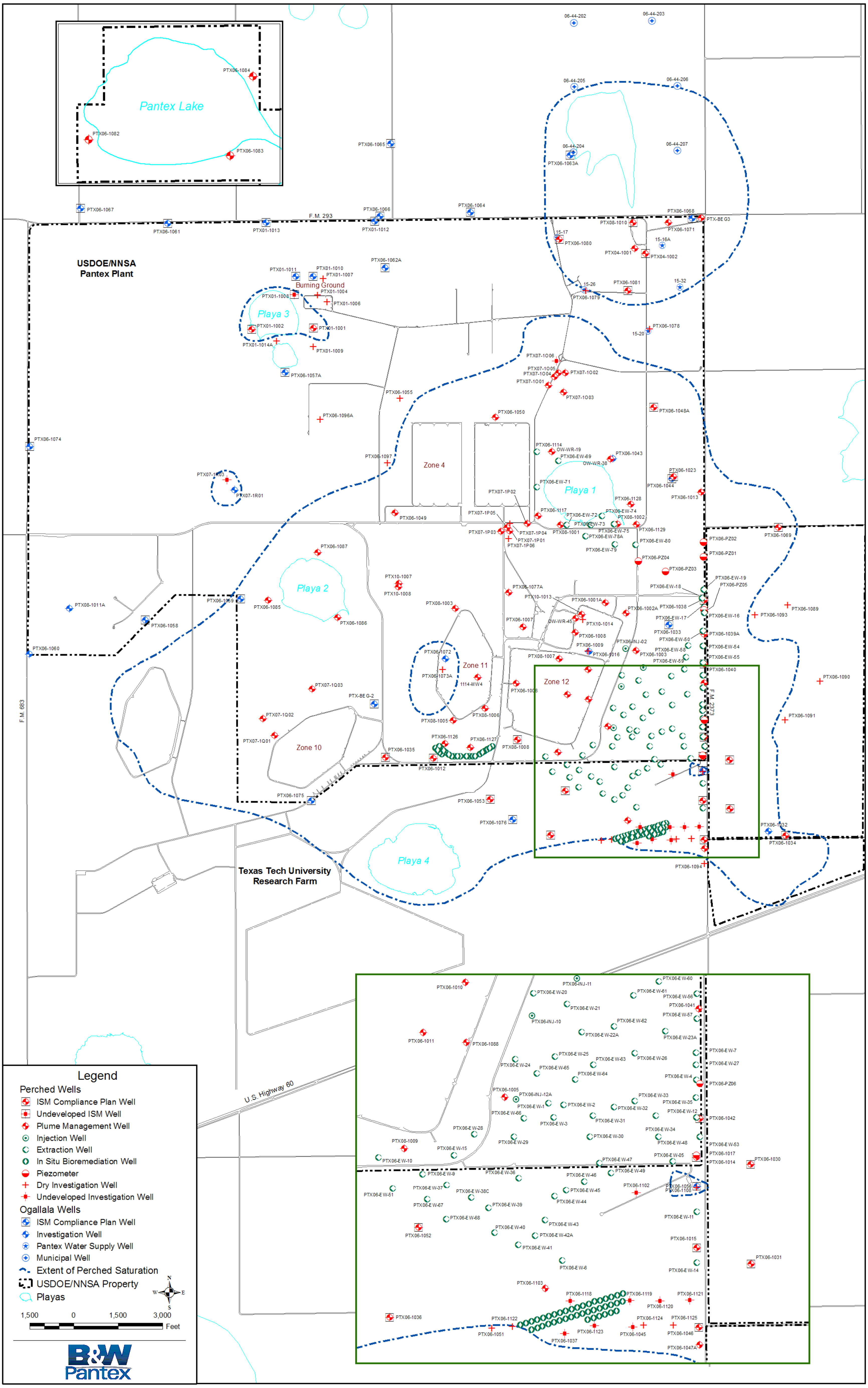

Figure A-4. Well Location Map

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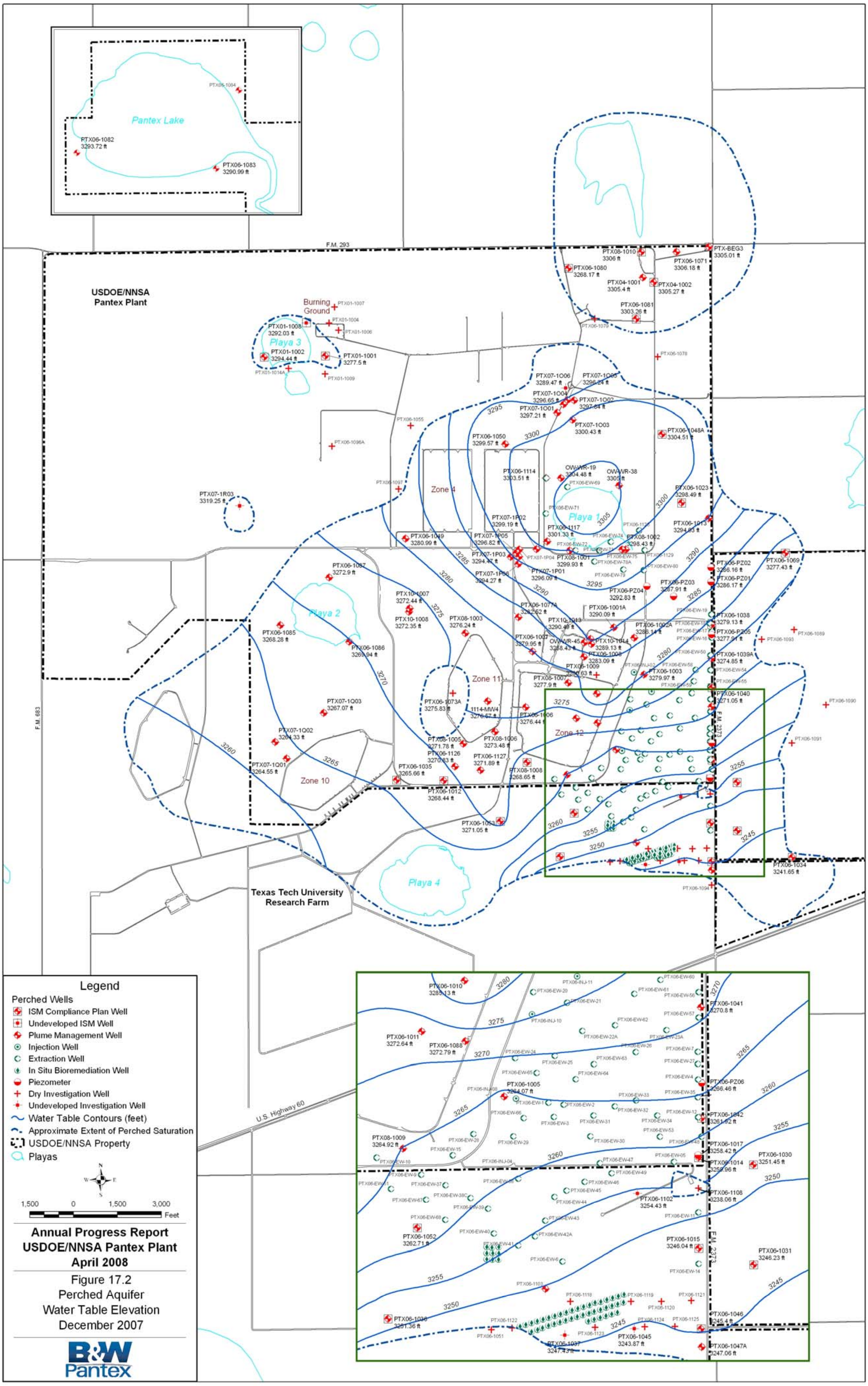

Figure A-5. Perched Groundwater Water Levels at Pantex Plant

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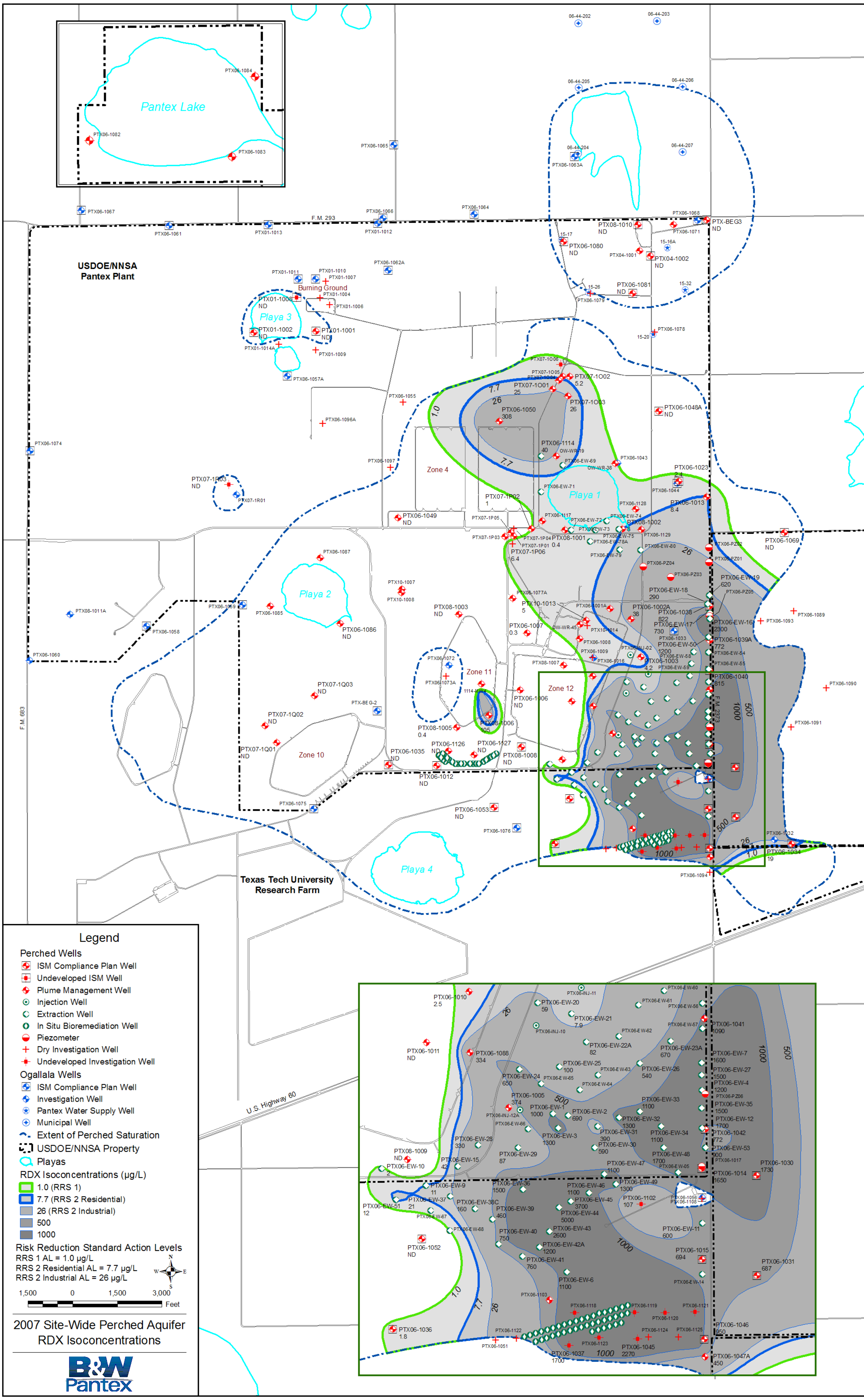

Figure A-6. Perched Groundwater RDX Isoconcentrations

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Appendix B

Groundwater Monitoring Network Optimization (GSI, 2008)

Optimization of Monitoring Well Placement for Breakthrough Detection in the Ogallala Aquifer (SAIC, 2008)

Analysis of Vertical Flow During Ambient and Pumping Conditions in Four Monitoring Wells at the Pantex Plant, Carson County, Texas, July—September 2008 (USGS, 2009)

G-3262

Groundwater Monitoring Network Optimization

Perched Groundwater Unit, Pantex Plant

Prepared for:
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February 12, 2008

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ABBREVIATIONS

2ADNT	2-Amino, 4,6-dinitrotoluene
24DNT	2,4-Dinitrotoluene
26DNT	2,6-Dinitrotoluene
4ADNT	4-Amino, 2,6-dinitrotoluene
AEC	Atomic Energy Commission
AOC	Area of Concern
AR	Area Ratio
ARARs	Applicable or Relevant and Appropriate Requirements
BGS	Below Ground Surface
BRA	Baseline Risk Assessment
CES	Cost Effective Sampling
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Constituent of Concern
COPC	Constituent of Potential Concern
COV	Coefficient of Variation
CR	Concentration Ratio
CSM	Conceptual Site Model
EDD	Electronic Data Deliverable
ESD	Explanation of Significant Difference
FGZ	Fine Grained Zone
GIS	Geographic Information System
HE	High Explosive
HHRA	Human Health Risk Assessment

HMX	High melting explosive (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)
HSCB	Hypothetical Statistical Compliance Boundary
ICM	Interim Corrective Measures
LTM	Long-Term Monitoring
LTMO	Long-Term Monitoring Optimization
MAROS	Monitoring and Remediation Optimization Software
MCES	Modified Cost Effective Sampling
MCL	Maximum Contaminant Level
MK	Mann-Kendall Trend
MSC	Medium Specific Concentration
MSL	Mean Sea Level
NAPL	Non-Aqueous Phase Liquid
NPL	National Priorities List
O&M	Operation and Maintenance
OU	Operable Unit
PDWS	Primary Drinking Water Standard
PGPTS	Perched Groundwater Pump and Treat System
PLSF	Preliminary Location Sampling Frequency
POC	Point of Compliance
POE	Point of Exposure
PRG	Preliminary Remediation Goal
PRP	Potentially-Responsible Party
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act

RDX	Research Department Explosive (Hexahydro-1,3,5-trinitro-1,3,5-triazine)
RI	Remedial Investigation
ROD	Record of Decision
RRR	Risk Reduction Rules
RRS	Risk Reduction Standards
SF	Slope Factor
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TCEQ	Texas Commission on Environmental Quality
TNT	Trinitrotoluene
TTU	Texas Tech University
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WMG	Waste Management Group

GROUNDWATER MONITORING NETWORK OPTIMIZATION
PANTEX PLANT

EXECUTIVE SUMMARY

The following report reviews and provides recommendations for improving the efficacy of the groundwater monitoring network for perched groundwater underlying the Pantex Plant, near Amarillo, Texas in Carson County. The Pantex Plant consists of several historic manufacturing, storage and disposal locations associated with maintaining the United States' nuclear arsenal. As a result of historic waste management practices, perched groundwater underlying the facility is affected by various constituents associated with munitions production and equipment maintenance.

The current groundwater monitoring network has been evaluated using a formal qualitative approach as well as using statistical tools found in the Monitoring and Remediation Optimization System software (MAROS). Recommendations are made for groundwater sampling frequency and location based on current hydrogeologic conditions and articulated long-term monitoring (LTM) goals for the system. The recommendations presented below are based on a technical review, balancing both the statistical results with goals of the monitoring system and anticipated site management decisions. Final decisions on the locations and frequency of groundwater sampling will be made by B&W Pantex, DOE and regulators. The following report evaluates the monitoring system for perched groundwater using analytical and hydrogeologic data from sampling events conducted between January 2000 and May 2007.

Site Groundwater Monitoring Goals and Objectives

Goals for long-term protection of human health and the environment at Pantex have been articulated in the Corrective Measure Study/Feasibility Study (CMS/FS, BWXT, 2007b) as Remedial Action Objectives (RAO). Remedial actions for perched groundwater have been proposed that fulfill the following objectives:

- Reduce exposure risk posed by impacted perched groundwater through contact prevention;
- Achieve cleanup goals for constituents of concern (COCs) at points of exposure (POE) in the perched groundwater (at property boundaries and/or areas sensitive to vertical migration);
- Prevent growth of perched groundwater COC plumes;
- Prevent constituents of potential concern (COPCs) from exceeding regulatory screening levels (MCLs/MSCs) in the Ogallala Aquifer.

Long-term groundwater monitoring of the perched unit is an essential component of confirming that the RAOs are met. The perched groundwater monitoring network at Pantex must address a number of monitoring objectives.

- A primary goal for the network is to define and delineate groundwater exceeding applicable regulatory standards. Monitoring data from the site network are used to support institutional controls by identifying and delineating areas of affected groundwater.

- A second goal for the network is to monitor changes in the plumes over time including changes in concentrations at source areas and tails.
- A third goal of the monitoring network is to evaluate the efficacy of the chosen remedy or remedies to control and reduce concentrations of constituents. One aspect of this objective is to document natural attenuation of chemical constituents.
- The network will also provide sufficient data to optimize remediation systems.
- The final goal of the network is to provide early warning for potential impacts to the Ogallala Aquifer.

Project Goals and Objectives

The goal of the long-term monitoring optimization (LTMO) process is to review the current groundwater monitoring program and provide recommendations for improving the efficiency and accuracy of the network in supporting site monitoring objectives discussed above. Specifically, the LTMO process provides information on the site characterization, stability of the plume, sufficiency and redundancy of monitoring locations and the appropriate frequency of network sampling. Tasks involved in the LTMO process include:

- Evaluate well locations and screened intervals within the context of the hydrogeologic regime to determine if the site is well characterized;
- Evaluate overall plume stability through trend and moment analysis;
- Evaluate individual well concentration trends over time for target chemicals of potential concern (COPCs);
- Develop sampling location recommendations based on an analysis of spatial uncertainty;
- Develop sampling frequency recommendations based on qualitative and quantitative statistical analysis results;
- Evaluate individual well analytical data for statistical sufficiency and identify locations that have achieved clean-up goals.

The end product of the LTMO process at the Pantex Plant is a recommendation for specific sampling locations and frequencies that best address site monitoring goals and objectives listed above.

Results

Perched groundwater was divided into three sectors for analysis. Investigation wells were grouped into networks based on the direction of groundwater flow, source areas and major constituents associated with each sector. The Southeast Sector monitoring network consists of wells in perched groundwater extending south from Playa 1 and east and south of Zones 11 and 12. The Southwest Sector monitoring network includes and extends west and south of Zone 11. Investigation wells south of Zone 12 were included in both the Southwest and Southeast Sector spatial analyses to account for possible variability in groundwater flow. The North Sector includes groundwater north of Zones 11 and 12 in the vicinity of Playa 1. Statistical and qualitative evaluations of Pantex Plant perched groundwater analytical data have been conducted with results summarized below:

Southeast Sector

- Priority constituents in the Southeast Sector include RDX and 4-amino,2,6-dinitrotoluene (4ADNT). Groundwater affected by other COPCs is within the extent of groundwater affected by RDX. Hexavalent chromium (Cr(VI)) affects perched groundwater in the area between the Southeast and Southwest Sectors and was considered in the analysis of both monitoring networks.
- Several downgradient monitoring locations indicate increasing concentration trends for RDX and 4ADNT.
- Estimates of total dissolved mass over time indicate that the mass of RDX is stable within the plume. Estimates of dissolved mass of 4ADNT over time show more variability and may exhibit a weakly increasing trend consistent with degradation of the TNT parent compound.
- Estimates for the center of mass for the RDX and 4ADNT plumes indicate some expansion downgradient consistent with decreasing trends in the source and groundwater extraction areas and increasing concentration trends downgradient.
- Data provided by monitoring locations along the eastern boundary of the DOE property in conjunction with data from the Southeast Sector extraction wells may provide redundant information.
- Areas of concentration uncertainty exist within the plume south of Zone 12 near PTX06-1036 and the eastern edge of the plume in the area where the perched unit pinches out.
- Because of increasing concentration trends, and possible expansion of the plume, frequent (semiannual) monitoring of Southeast Sector wells is indicated.

Southwest Sector

- Priority constituents in the Southwest Sector include trichloroethene (TCE) and perchlorate. Groundwater affected by high explosives (HE) exists under the industrial area of Zone 11, but is not as widespread as that of the Southeast Sector.
- Over 50% of wells in the Southwest Sector monitor groundwater with low to no detections of COPCs, resulting in non-detect or no trend results for individual wells in the Sector. Increasing concentration trends for perchlorate are found at one location south of Zone 11 (PTX06-1012), while increasing TCE trends are found at two locations in the same area.
- Estimates for plume-wide total dissolved mass of perchlorate and TCE show no trends; however, estimates of the center or mass for the TCE plume over time are moving downgradient. Increasing distance between the source and center of mass for TCE is consistent with increasing trends in the downgradient region of this plume.
- Redundant locations were identified on the western edge of the plume in areas with very low concentrations of site COPCs.
- One area of concentration uncertainty was found in the region of PTX06-1012.
- Rates of concentration change are low over much of the Sector, consistent with a recommendation for reduced sampling frequency. The area between wells 1114-MW4 and PTX06-1012 was identified as an area of more rapid concentration change.

North Sector

- The only COC identified for the North Sector is RDX.
- The majority of monitoring locations in the North Sector are not affected by constituents above regulatory screening levels.
- Statistical trend evaluation results indicate many non-detect locations or wells showing intermittent detections (no trend). Concentration trends for RDX in the North Sector show decreasing trends just south of Playa 1. An increasing RDX trend was found at PTX06-1050 indicating possible spread of the plume to the northwest of the main perched groundwater unit.
- Due to the limited number of monitoring locations, moment analysis was not conducted for the North Sector.
- No wells in the North Sector were identified as redundant.
- One area of higher concentration uncertainty was found west of PTX06-1050.
- Rates of concentration change in the North Sector support a dramatic reduction in sampling frequency for many locations.

Recommendations

The following general recommendations are made based on the findings summarized above and those described in Section 3 below. General recommendations for monitoring are based on a combination of statistical results of analyses for priority COCs and a consideration of qualitative issues such as hydrogeology, potential receptors and monitoring goals. Detailed recommendations are presented in Section 4 and summarized on Table 16 and Figure 8.

The recommended network increases data collection effort in some areas to provide a dataset that fulfills statistical requirements for evaluating the effect of the remedies discussed in the CMS/FS (BWXT, 2007b). The recommended network reduces monitoring effort and cost in some areas, but recommends the addition of new wells in areas where further characterization would support site monitoring goals.

Southeast Sector

- The final recommended network for the Southeast Sector includes 29 investigation well locations, with approximately 51 groundwater samples collected annually. Data from 48 active extraction wells should be evaluated along with data from the investigation wells to characterize the Sector.
- Semiannual monitoring is recommended for 20 of 31 wells in the Southeast Sector. Seven wells in the source area or in areas of stable concentration trends are recommended for annual sampling. Three wells are intermittently or permanently dry and should be monitored for saturation, annually.
- Southeast Sector well PTX06-1014 is recommended for elimination from the routine monitoring program.
- Two new locations are recommended for the Southeast Sector. One new location is recommended for the area between PTX06-1036 and PTX06-1052. The other new location is recommended for the area east of PTX06-1039. New wells are recommended for semiannual sampling until a statistically significant dataset has been collected.

Southwest Sector

- The final recommended network for the Southwest Sector includes 22 monitoring locations, with an average of 27.5 groundwater samples analyzed annually.
- Six existing locations were found to provide redundant information and are recommended for elimination from routine monitoring in the Southwest Sector: PTX06-1006, PTX06-1087, PTX07-1P02, PTX07-1P03, PTX07-1Q02, and PTX10-1008 (Wells identified as redundant may be sampled to reduce uncertainty in some locations).
- Overall, four new groundwater monitoring locations are recommended for the Southwest Sector. Two new wells are recommended for the southern area of the perched unit to delineate constituents in the Southwest Sector. Two new locations south of PTX08-1005 are recommended to decrease spatial uncertainty in the area of the TCE/perchlorate plume near Zone 11.
- Semiannual sampling is recommended for four current wells (1114-MW4, PTX06-1012, PTX08-1005, and PTX08-1006) and for the four proposed new locations. Annual sampling is recommended at 9 locations, and biennial sampling is recommended for five perimeter wells.

North Sector

- The final recommendation for the North Sector monitoring network is to include a total of 21 investigation wells, with an average of 18 samples collected annually.
- No wells are recommended for elimination from the North Sector networks. However, many locations are recommended for dramatically reduced sampling frequency. If low to non-detect conditions persist in isolated perched groundwater in the future, some of these wells may be eliminated.
- One new monitoring location is recommended to delineate the RDX plume in the North Sector. The new monitoring location is recommended for an area downgradient of PTX06-1050 at the edge of the saturated unit.

Additional Recommendations

- Groundwater monitoring data as well as well construction and location information should continue to be managed in a site-wide relational database.
- Capture zone analysis for the perched groundwater extraction system in the Southeast Sector is recommended and should continue to be presented annually, as required by Compliance Plan No. 50284.
- Reevaluate the network in 5 years after any additional remedies have been implemented and a statistically significant dataset has been collected.

1.0 INTRODUCTION

The Pantex Plant in Carson County, Texas is an active facility owned by the United States Department of Energy/National Nuclear Security Administration (DOE/NNSA). The primary mission of the plant is to assemble, disassemble and evaluate nuclear weapons from the US stockpile, to develop, fabricate and test explosives and explosive components and provide secure storage for material from the above activities. The Pantex Plant is permitted as a hazardous waste facility under the Resource Conservation and Recovery Act (RCRA) and is a National Priorities Listed (NPL) site administered under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, Superfund).

The site is located approximately 17 miles northeast of Amarillo, Texas in Carson County in US Environmental Protection Agency (EPA) Region VI. The plant covers over 10,000 acres with additional property consisting of a 1,000 acre tract at Pantex Lake and over 5,000 acres owned by Texas Tech University (TTU) as a buffer around the site. Industrial operations occur on approximately 2,000 acres. Constituents associated with site manufacturing and testing activities currently affect soil and groundwater at the facility. Investigation and remediation activities have been on-going since the 1980s.

Groundwater monitoring plays a critical role in long-term environmental restoration of the Pantex Plant Site. The purpose of the following evaluation is to review the current groundwater monitoring network and provide recommendations for improving the efficiency and accuracy of the network for supporting site management decisions.

At the Pantex Plant, groundwater monitoring goals define why data are collected and how data from the site will be used. The groundwater monitoring network at Pantex must address the following monitoring objectives.

- *Define and delineate groundwater exceeding applicable regulatory standards.* Monitoring data from the site network are used to support institutional controls by identifying and delineating areas of affected groundwater.
- *Monitor changes in the plumes over time including changes in concentrations at source areas and tails.*
- *Evaluate the efficacy of the chosen remedy or remedies to control and reduce concentrations of constituents.* One aspect of this objective is to document natural attenuation of chemical constituents.
- *Provide sufficient data to optimize remedial systems.*
- *Provide early warning for potential impacts to the Ogallala formation or off-site receptors.*
- *Comply with regulatory requirements.*

In order to recommend an optimized network that addresses the stated monitoring objectives, spatial and analytical data from the site were analyzed using a series of quantitative and qualitative tools.
Tasks performed during Long-Term Monitoring Optimization (LTMO) process include:

- Evaluate well locations and screened intervals within the context of the hydrogeologic regime to determine if the site is well characterized;
- Evaluate overall plume stability through trend and moment analysis;
- Evaluate individual well concentration trends over time for target constituents of concern (COPCs);
- Develop sampling location recommendations based on an analysis of spatial uncertainty;
- Develop sampling frequency recommendations based on both qualitative and quantitative statistical analysis results;
- Evaluate individual well analytical data for statistical sufficiency and identify locations that have achieved clean-up goals.

A discussion of site background and regulatory context for the Pantex Plant Site is provided in Section 1 below. Section 2 details the analytical and statistical approach taken during the LTMO evaluation. A detailed discussion of results is provided in Section 3. Summary conclusions and recommendations are presented in Section 4.0.

1.1 Site Background and Regulatory History

The Pantex Plant site is located in the Texas Panhandle, in a historically agricultural area. Plant operations began in 1942 under the Army Ordnance Corps, manufacturing conventional munitions and high explosives (HE) such as trinitrotoluene (TNT). The Plant was briefly deactivated at the end of the World War II, and the property sold to TTU. In 1951, the site was reclaimed for use by the Atomic Energy Commission (AEC) to produce both nuclear weapons and HE compounds. Radioactive materials have not been manufactured at the facility but components containing radioactive materials are managed at the site. Compounds such as TNT, High Melting Explosive (HMX, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine) and Research Department Explosive (RDX, Hexahydro-1,3,5-trinitro-1,3,5-triazine) have been manufactured and used at the site.

Supervision of the site was eventually transferred to the DOE and NNSA. The Pantex Plant is currently managed as a government-owned, contractor-operated facility, overseen by DOE/NNSA and operated by Babcock & Wilcox Technical Services Pantex, LLC (B&W Pantex, formerly BWXT Pantex). As the prime contractor, B&W Pantex also directs environmental activities including investigation and remediation of areas impacted by past waste management practices.

In the late 1980's, environmental investigation and restoration activities began at DOE facilities across the country. Under the authority of the 1984 RCRA Hazardous and Solid Waste Amendments, the EPA conducted a *RCRA Facility Assessment* of the Pantex Plant in 1988. EPA identified Solid Waste Management Units (SWMUs) and Areas of Concern (AOC) containing environmental media possibly subject to interim corrective measures (ICMs). The RCRA Facility Investigation (RFI) identified operational areas at the site and groupings of corrective action units in common watersheds termed waste management groups (WMGs). Conceptual Site Models

(CSMs) were developed to describe the location and movement of constituents for each WMG.

In 1991 EPA, in cooperation with the Texas Commission on Environmental Quality (TCEQ) (formerly Texas Natural Resource Conservation Commission [TNRCC]), issued a Hazardous Waste permit to the Pantex Plant. In the same year, the Pantex Plant was proposed for the NPL for chemical constituents in both soil and groundwater. The Pantex Plant was formally listed in 1994, and a Memorandum of Agreement (MOA) between TCEQ and EPA established TCEQ as lead agency for oversight of remediation of chemical releases.

Since 1994, on-going interim investigation, remediation and corrective action measures have been conducted, and an integrated approach to address both CERCLA and RCRA requirements has been developed. A Record of Decision (ROD) for the Pantex Plant has not been issued. ICMs to date have been implemented as non-time critical removal actions under CERCLA for perched groundwater. Specific remedies in place include extensive groundwater extraction wells in the perched unit (perched groundwater pump and treat system [PGPTS]).

Environmental regulatory oversight of the Pantex Plant is, therefore, exercised under RCRA and CERCLA as well as other applicable Texas state regulations. All non-radiological environmental restoration activities at the Pantex Plant are conducted under the State of Texas Risk Reduction Rules (RRR) (30 TAC §335 Subchapter S, 1993). TCEQ defines three Risk Reduction Standards (RRS) for closure of affected sites. In 2005, EPA and TCEQ completed technical reviews of investigations for SWMUs at Pantex, and identified the appropriate RRS to be applied to the majority of Plant SWMUs. Most areas of perched groundwater evaluated in the following report will be covered under RRS 3. RRS 3 allows for COPCs to remain in place as long as the risk posed by those COPCs is not greater than the target risk values provided in the regulations. Cleanup goals under RRS 3 also allow the use of long-term site controls such as institutional and engineering controls to attain regulatory compliance. The long-term groundwater monitoring network for the perched unit is, therefore, an important component of compliance under RRS 3.

Under RRS 3, cleanup values known as Media Specific Concentrations (MSCs) can be derived using site-specific information detailed in the various BRA and Baseline Human Health Risk Assessment (BHHRA) Reports (BWXT, 2006). MSCs for the Pantex Plant are listed in the CMS/FS (BWXT, 2007) and have been used as the screening levels to evaluate the groundwater monitoring network.

RCRA Facility Investigations (RFIs) have been conducted for corrective action units at Pantex and have defined sources and the extent of impacts for several corrective action units. The Baseline Risk Assessments (BRA) for areas anticipated to be managed under RRS 3 have also been completed. A Corrective Measures Study/Feasibility Study (CMS/FS) (BWXT, 2007b), including evaluation of remedial options for the Site, was issued in September, 2007. Remedial actions for perched groundwater are anticipated to include continuation of the groundwater extraction system (PGPTS) and other ICMs already in place, as well as addition of new vertical extraction wells in the east/southeast and in the vicinity of Playa 1. Targeted *in situ* redox manipulation and enhanced bioremediation are proposed for the southeast fringe of perched groundwater. Natural attenuation processes will be a component of any remedial action chosen. Long-term groundwater monitoring will be required to confirm progress toward remedial goals.

1.2 Geology and Hydrogeology

The Pantex Plant lies on the High Plains portion of the Great Plains Physiographic Province in the Texas Panhandle. The area, known as the Llano Estacado is a broad, flat, plateau with topographic elevation across the site ranging between 3,501 feet above mean sea level (ft amsl) to 3,595 ft amsl. The average topographic slope across the Plant area is approximately 0.006 feet, and Plant surface water tends to drain to the on-site playas.

The uppermost hydrostratigraphic unit (HSU) at the Pantex Plant is the Blackwater Draw (BWD). The BWD extends up to 90 ft below ground surface (bgs) at the site, and is largely unsaturated. The unit consists of silts and sands and an approximately 20-foot thick lower unit composed of silty sand and caliche. The playas are depressions in the BWD.

The Ogallala Formation underlies the Blackwater Draw and is composed of coarse-grained fluvial sequences including channel sands and gravels overlain by finer overbank deposits. The Ogallala Formation in Texas is the southernmost extension of a major water-bearing unit that extends north to Nebraska and is exploited for municipal water supplies as well as crop irrigation and industrial water supplies. The Ogallala Aquifer is the principal municipal water supply for the city of Amarillo, which operates a municipal well field north of the Pantex Plant. The Ogallala Aquifer provides potable and industrial water for the Pantex Plant as well as agricultural water for the TTU property to the south.

A Caliche Caprock layer generally defines the top of the Ogallala Formation, but is not continuous across the entire Pantex Plant. The Caprock consists of a hard, dense and finely crystalline caliche. In the Pantex area, the Ogallala Formation consists of upper and lower permeable units separated by a Fine Grained Zone (FGZ). The FGZ consists of low-permeability silts and clays and varies in thickness from over 150 ft to less than 10 ft. The FGZ slopes down toward the southeast corner of the Pantex Plant. The upper unit of the Ogallala formation contains discontinuous areas of perched groundwater underlain by the FGZ. The Ogallala Aquifer resides in the lower permeable unit beneath the FGZ.

Underlying the Ogallala Formation are the lower permeability Dockum Group and Permian Quartermaster Formation, where the Dockum Group is not present.

1.2.1 Playas

The Texas Panhandle region is characterized by a number of topographic depressions or playas (playa lakes) that drain larger land areas but do not connect with other surface drainage outlets. Historically, playa lakes provide limited recharge of perched groundwater in the area of the Pantex Plant, in response to irregular, moderate precipitation events. The playas hold water temporarily, and because of the soil, hydrology and vegetation, they are frequently classified as (non-jurisdictional) wetlands. Three playas are present in the vicinity of industrial operations at the Pantex Plant and received the majority of surface runoff from the property, as well as, permitted discharges of treated effluent from the waste water treatment facility. Along with drainage ditches, the playas have served as groundwater recharge areas for perched groundwater underlying the Plant. With elimination of industrial discharges, discontinuation of routine discharges from the wastewater treatment facility, and the implementation of institutional controls, efforts are on-going to reduce recharge to the perched groundwater through these routes.

Playa 1 is north of Zone 12, and served as a receiving pond for treated and untreated waste water originating from the Zone 12 industrial area for many years. Most industrial discharges to plant ditches were discontinued in the 1980s and the remainder, including steam condensate discharges, were eliminated by 1999. Currently, occasional permitted discharges enter Playa 1 along with storm water runoff. Playa 2 is west/northwest of Zone 11, and Playa 3 is part of the Burning Ground WMG. Playas 2 and 3 receive only surface water runoff. A large playa basin associated with the Pantex Lake property lies 2.5 miles north of the main facility and Playa 4 is located on TTU property to the south.

1.2.2 Perched Groundwater

Perched groundwater is encountered at various locations across the Texas Panhandle in the upper permeable unit of the Ogallala Formation. At the Pantex Plant, groundwater from recharge areas, in particular playa lakes, tends to mound on top of the low permeability FGZ. The FGZ separates perched groundwater from the lower Ogallala aquifer.

Perched groundwater is found in three main areas under the Pantex Plant. The largest area of perched groundwater lies beneath Playa 1 and extends beneath Zones 11 and 12, pinching out on the TTU property to the south and off-site to the east (see Figure 1). Groundwater in this unit is associated with recharge from Playas 1, 2 and 4 and drainage ditches associated with Zones 11 and 12. Isolated areas of perched groundwater also occur under the Burning Ground (near Playa 3) and in the northeast corner of the Pantex Plant (near Pratt Playa). While groundwater in the perched units meets the technical definition of a potential drinking water source, no water supply wells are drilled into the unit for either drinking water or industrial water supply on-site and all public drinking water supply wells in the vicinity are drilled into the Ogallala Aquifer, with the exception of one perched groundwater well on offsite property north of the northeast corner of Pantex near Pratt Playa. The perched groundwater does not discharge to surface water bodies and hydraulic connection with the Ogallala is limited by the FGZ.

The extent and chemistry of the largest perched groundwater unit has been influenced by historic waste and water management practices associated with industrial activity at the plant. From the early 1950s to the 1980's portions of the main perched groundwater were impacted by constituents of potential concern (COPCs) and artificially high recharge originating from plant industrial processes. Because of mounding in the vicinity of Playa 1 and the topography of the FGZ, groundwater flow in the main perched unit tends to be radial, with the surface sloping to the southeast, south and east of Zone 12, and sloping to the southwest, west of Zone 11. Groundwater north of Playa 1 tends to flow to the north (see Figure 1 for potentiometric surface data). Radial flow within the main perched unit is the reason why the monitoring network was divided into sectors for the LTMO analysis (see Sectors identified on Figure 2 and described under Section 2.1.1).

Saturated thickness of perched groundwater varies across the unit with a high of approximately 70 feet beneath Playa 1 to 0 feet at the extreme edges of the unit. Depth to groundwater varies from about 215 feet near Playa 1 to approximately 280 feet at the south of the main perched unit under TTU property. Beneath the perched groundwater, the FGZ consists of low permeability silts and clays ranging from a few feet in thickness to more than 100 feet below Playa 1. The FGZ tends to isolate perched water from deeper strata; however, the FGZ becomes more course and permeable in areas to the south and east of the main Plant.

1.2.3 Ogallala Formation

The Ogallala Aquifer is encountered at depths of 400 to 500 feet bgs beneath the Pantex Plant with the water table sloping from southwest to northeast locally under the influence of the municipal well field. The saturated thickness of the Ogallala varies from less than 30 feet to over 400 feet. Removal of water from the Ogallala aquifer for municipal, industrial and large-scale agricultural uses has reduced the saturated thickness in many areas of the aquifer.

Based on monitoring data, the Ogallala Aquifer has not been impacted by releases from the Pantex Plant above conservative screening levels (see Figure 2 for current Ogallala monitoring well locations). The Ogallala Aquifer was considered as part of a potential exposure scenario during the Baseline Human Health Risk Assessment (Baseline HHRA). While the Ogallala does not currently pose an exposure risk to receptors, modeling results indicate that the Ogallala may be impacted by COPCs present in the perched groundwater at some time in the future. For this reason, groundwater in the Ogallala will be monitored for possible impacts in the future. The monitoring network for the Ogallala was not evaluated for this report, but is being evaluated elsewhere, using appropriate tools.

2.0 ANALYTICAL APPROACH

Evaluation of the groundwater monitoring network for the Pantex Plant consisted of both quantitative and qualitative methods. A quantitative statistical evaluation of the site was conducted using tools in the MAROS software. The qualitative evaluation reviewed hydrogeologic conditions, well construction and placement. Both quantitative statistical and qualitative evaluations were combined using a 'lines of evidence' approach to recommend a final groundwater monitoring strategy to support site monitoring objectives.

2.1 MAROS Method

The MAROS 2.2 software was used to evaluate the LTM network at the Pantex Plant. MAROS is a collection of tools in one software package that is used in an explanatory, non-linear but linked fashion to statistically evaluate groundwater monitoring programs. The tool includes models, statistics, heuristic rules, and empirical relationships to assist in optimizing a groundwater monitoring network system. Results generated from the software tool can be used to develop lines of evidence, which, in combination with professional judgment, can be used to inform regulatory decisions for safe and economical long-term monitoring of groundwater plumes. A summary description of each tool used in the analysis is provided in Appendix A of this report. For a detailed description of the structure of the software and further utilities, refer to the MAROS 2.2 User Manual (AFCEE, 2003) or Aziz, et al. (2003).

In MAROS 2.2, two levels of analysis are used for optimizing long-term monitoring plans: 1) an overview statistical evaluation with interpretive trend analysis based on temporal trend analysis resulting in plume stability information; and 2) a more detailed statistical optimization based on spatial and temporal redundancy reduction methods (see Appendix A or the MAROS Users Manual (AFCEE, 2003)).

2.1.1 Well Groups

Perched groundwater underlying the Pantex Plant is encountered in areas associated with natural and anthropogenic recharge from playa lakes and drainage ditches. Perched groundwater is not continuous across the site, and groundwater flow within the largest perched unit is radial from a mound underlying Playa 1 (see Figure 1). Because of the spatial heterogeneity in aquifer characteristics, perched unit investigation wells (monitoring wells) at the Pantex Plant were separated into analysis groups by sector in order to perform the MAROS analysis. Investigation wells were grouped according to predominant groundwater flow direction, sources and major constituents of concern (COCs).

Because MAROS is designed to evaluate two-dimensional monitoring networks, well depths and screened intervals were reviewed to determine if the well groups should be chosen based on depth. Perched groundwater in the upper Ogallala formation has a maximum saturated thickness of approximately 70 ft., with an average saturated thickness close to 20 ft (B&W Pantex well database). Median screen lengths for wells are approximately 25 feet. The unit is fairly homogeneous (with little to no channelization or fractures). Perched groundwater wells were considered to be screened at approximately the same depth, so well groups were not separated based on vertical heterogeneity in the aquifer. Well groups used in this report are defined for the purpose of the LTMO analysis and do not correspond with other classifications for site modeling.

Spatial sectors defined for the analysis are summarized in the table below and illustrated on Figure 2. The 75 investigation wells used in the core analysis are listed in Table 1, by sector. Data from extraction wells in the Southeast Sector were included to provide spatial information and concentration trends in this area. Data from each sector were evaluated separately for priority COCs, plume stability, spatial sufficiency, well redundancy, monitoring frequency and, where appropriate, data sufficiency. Some individual wells were included in more than one zone, with the final monitoring recommendation for the well based on the most conservative results for that well.

MAROS Analysis Group Name	Comment
Southeast Sector	The Southeast Sector monitoring network consists of wells in perched groundwater extending south from Playa 1 and east and south of Zones 11 and 12. Both onsite and offsite wells are included in one analysis group. The Southeast Zone network includes 31 groundwater monitoring wells. Data from 48 groundwater extraction wells were included in the analysis in order to provide better spatial coverage of the area. The Southeast Sector is a priority monitoring area due to the magnitude of COC concentrations and possible thinning of the FGZ in this area.
Southwest Sector	The Southwest Sector monitoring network includes and extends west and south of Zone 11. (No groundwater quality data were available for Zone 9 wells (FPOP)). Investigation wells south of Zone 12 were included in both the Southwest and Southeast Sector spatial analyses to account for possible variability in groundwater flow.
North Sector	Groundwater north of Zones 11 and 12 and Playa 1 is discontinuous and less impacted than the Southeast and Southwest Sectors. Wells in this Sector were analyzed for individual trends, but large scale spatial analysis was not appropriate for this Sector. The North Sector includes wells at Pantex Lake.

GSI ENVIRONMENTAL

2.1.2 COC Choice

The varying groundwater flow directions, complex sources and commingled plumes cause widespread spatial heterogeneity in constituent concentrations at the Pantex Plant. In order to better evaluate the importance of each well in the network, each monitoring location was evaluated individually for priority constituents of concern (COCs). To identify priority COCs for individual sampling locations, the maximum concentration found for a constituent at each well between 2000 and 2007 was divided by the corresponding MSC or relevant regulatory screening level. The COC concentrations that exceeded the screening level by the highest ratio were identified as priority COCs for the individual well. The COC with the highest concentration relative to the screening level ratio for each investigation well is identified in Table 1 along with the ratio. Other Priority COCs (those with screening level ratios over 1) determined for each monitoring location are also listed in Table 1.

The COC most often identified as a priority at individual wells was RDX. For locations where the Risk Ratio is below 1, no constituents are detected above MSCs and no plume exists in that location. The dataset was not examined for statistical outliers, and, at some locations, a single detection of a compound caused the compound to be designated the priority for that well. Boron is frequently detected at Pantex area wells, but boron concentrations do not routinely exceed the RRS 2 screening level of 3.3 mg/L (see Table 1).

MAROS includes a short module that provides recommendations on prioritizing COCs on a plume-wide basis. Prioritization is based on *toxicity*, *prevalence*, and *mobility* of the compound. The toxicity ranking is calculated by examining a representative concentration (i.e. mean, median, etc.) for each compound for the entire plume. The representative concentration is then compared to the screening level (MSC) for that compound. COCs are ranked according to the extent the representative concentration exceeds the screening level. Ranking according to prevalence is performed by counting the number of wells in the network where concentrations are above screening levels and by identifying the number of wells where the compound is detected. COCs with the greatest detection frequency and the largest percentage of wells above screening levels are prioritized. Constituents found over screening levels are ranked for mobility based on Kd (sorption partition coefficient). The MAROS ranking was performed for each Sector network at Pantex.

2.1.3 Plume Stability

Within MAROS, historical analytical data are analyzed to develop a conclusion about plume stability. If a plume is found to be stable, in many cases, the number of locations and monitoring frequency can be reduced without loss of information. Plume stability results are assessed from time-series concentration data with the application of two types of statistical tools: individual well concentration trend analyses and plume-wide moment analysis.

Individual well concentrations are evaluated using both Mann-Kendall and Linear Regression trend tools. The Mann-Kendall nonparametric evaluation is considered one of the best methods to evaluate concentration trends as it does not assume the data fit a particular distribution (Gilbert, 1987). Individual well concentration trends were calculated for priority COPCs for the time period 2000 to 2007. Individual well Mann-Kendall trends were also used in the sampling frequency analysis, where trends determined for the 2004 to 2007 interval were compared with trends calculated using the entire dataset for each well. During the final 'lines of evidence' evaluation, individual well concentration trends are considered along with summary statistics such as percent detection and historic maximum concentration to recommend sampling frequencies for wells in the network.

Moment analysis algorithms in MAROS are simple approximations of complex calculations and are meant to estimate the total dissolved mass (zeroth moment), center of mass (first moment) and spread of mass (second moment) in the plume and the trend for each of these estimates over time. Trends in the total dissolved mass can indicate effective removal processes (decreasing trends) or plume stability. The zeroth moment is not intended to be an accurate calculation of total mass in the plumes at the Pantex Plant. The estimate of mass is based on a uniform saturated thickness or rough approximations of saturated thickness and porosity at each monitoring location, and perched groundwater underlying the Pantex Plant varies between roughly 0-70 feet in saturated thickness. The zeroth moment is a tool to determine if mass tends to increase or decrease within the extent of the monitoring network over time. So, only the trends for the zeroth moments are reported.

Trends for the first moment indicate the relative amount of mass upgradient vs. downgradient and the change in the distance of the center of mass from the source over time. Trends in the second moment indicate the relative distribution of mass between the center of the plume and the edge.

2.1.4 Well Redundancy and Sufficiency

Spatial analysis modules in MAROS recommend elimination of sampling locations that have little impact on the historical characterization of a contaminant plume while identifying areas in the plume where additional data are needed. For details on the redundancy and sufficiency analyses, see Appendix A or the MAROS Users Manual (AFCEE, 2003).

Sample locations are evaluated in MAROS for their importance in providing information to define concentrations within the groundwater plume. Wells identified as providing information redundant with surrounding wells are recommended for elimination from the program. (Note: elimination from the program does not necessarily mean plugging and abandoning the well. See Section 2.3 below.)

Well sufficiency is evaluated in MAROS using the same spatial analysis as that for redundancy. Areas identified as having unacceptably high or unexplained levels of concentration uncertainty are recommended for additional monitoring locations.

The well redundancy and sufficiency analysis uses the Delaunay method and is designed to select the minimum number of sampling locations based on the spatial analysis of the relative importance of each sampling location in the monitoring network. The importance of each sampling location is assessed by calculating a slope factor (SF) and concentration and area ratios (CR and AR respectively). Sampling locations with a high SF provide unique information and are retained in the network. Locations with low SF are considered for removal. Areas defined by many wells with high SF may be candidates for new well locations.

Monitoring networks at the Pantex Plant were defined for constituents based on source areas and continuous areas of perched groundwater with similar groundwater flow direction. SF's were calculated for all wells in the Southeast and Southwest Sectors of the Pantex Plant and the results were used to determine the importance of each well in the network for defining the extent of concentrations for the primary COCs in these areas. Monitoring locations in the North Sector have limited hydrologic connection, either by virtue of discontinuous groundwater, very low concentrations or because of variable flow directions. For this reason, spatial analysis in the North Sector provides limited information, and network recommendations are based on individual well trends and qualitative information.

The results from the Delaunay method and the method for determining new sampling locations are derived solely from the spatial configuration of the monitoring network and the spatial pattern of the contaminant plume based on a two-dimensional assumption. No parameters such as the hydrogeologic conditions are considered in the analysis. Therefore, qualitative information, professional judgment and regulatory considerations must be used to inform final decisions.

2.1.5 Sampling Frequency

MAROS uses a Modified Cost Effective Sampling (MCES) method to optimize sampling frequency for each location based on the magnitude, direction, and uncertainty of its concentration trends. The MCES method was developed on the basis of the Cost Effective Sampling (CES) method developed by Ridley et al. (1995). The MCES method estimates a conservative lowest-frequency sampling schedule for a given groundwater monitoring location that still provides needed information for regulatory and remedial decision-making.

MAROS has recommended a preliminary location sampling frequency (PLSF) for each monitoring location for perched groundwater at the Pantex Plant based on a combination of recent and long-term trends and the magnitude and rate of concentration change. The PLSF has been reviewed qualitatively and a final optimal sampling frequency has been recommended consistent with monitoring objectives and regulatory requirements.

2.1.6 Data Sufficiency

The MAROS Data Sufficiency module employs simple statistical methods to evaluate whether analytical data are adequate both in quantity and in quality to confirm the achievement of regulatory clean-up goals. Statistical tests for the MAROS module were taken from the USEPA *Methods for Evaluating the Attainment of Cleanup Standards Volume 2: Groundwater* statistical guidance document (USEPA, 1992). The statistical methods are designed to evaluate plumes where the majority of analytical results have dropped below screening levels. As perched water at the Pantex Plant is still in the remedial choice stage of regulation, this statistical package was not employed during the analysis of the network in the Southeast and Southwest Sectors. The analysis was performed for North Sector locations with significant percentages of non-detect results.

2.2 Data Input, Consolidation and Site Assumptions

Groundwater analytical data from the Pantex Plant area were supplied by B&W Pantex from the site database (BWXT, 2007a), supplemented with information from historic site reports and the CMS/FS (BWXT, 2007b). Groundwater monitoring locations included in the evaluation are listed in Table 1, with additional details provided on extraction wells in Appendix B Table B.1.

Chemical analytical data collected between January 2000 and July 2007 and well information data were organized in a database, from which summary statistics were calculated. In all, 75 investigation well locations in the perched unit were considered in the network evaluation for the Pantex Plant.

In order to provide reasonable consistency in statistical comparisons, analyses have been limited to certain time-frames. Individual well trend evaluations were performed for data collected between January 2000 and July 2007. The data represent a 7 year record for many wells, and provide an indication of long-term trends in site constituent concentrations. Some monitoring locations have been added to the network between 2000 and 2005 or sampled infrequently. Where possible, statistical trends have been calculated for recently-installed locations using their full data record.

For sample locations with more than 40 sample events (n>40), data were consolidated quarterly. That is, for locations with more than one sample result for one calendar quarter (3 month period), the average concentration was used in the statistical analysis. Duplicate samples were also averaged to develop one result for each COPC for each time-interval.

To ensure a consistent number and identity of wells for the moment analysis, site data were consolidated annually for the analysis. An average concentration for each well for each year was calculated by the software. Estimates of total dissolved mass, center of mass and spread of mass were calculated for each year 2000 – 2007 based on the average concentration at each monitoring point. Trends for each of the moments are based on the Mann-Kendall evaluation of each moment calculated for each year 2000 – 2007.

For the spatial analysis (well redundancy and sufficiency) and for the sample frequency analysis, recent data collected between July 2005 and July 2007 were used. This interval provides at least seven quarters of data for most locations under relatively consistent operation of the ICMs.

2.3 Qualitative Evaluation

Multiple factors should be considered in developing recommendations for monitoring at sites undergoing long-term groundwater restoration. The LTMO process for the Pantex Plant includes developing a 'lines of evidence' approach, combining statistical analyses with qualitative review to recommend an improved monitoring network. Results from the statistical analyses in combination with a qualitative review were used to determine continuation or cessation of monitoring at each well location, addition of new locations, and proposed frequency of monitoring for those locations retained in the network.

The primary consideration in developing any monitoring network is to ensure that information, collected efficiently, supports site management decisions. Site information needs are reflected in the monitoring objectives for the network. For this reason, any proposed changes to the network are reviewed to be consistent with and supportive of the stated monitoring objectives. The qualitative review process starts with evaluating each monitoring location for the role it plays supporting site monitoring objectives. For example, a location may provide vertical or horizontal delineation of the plume or may provide information on decay rates in the source area. Each well in the perched groundwater network was evaluated for its contribution to site monitoring objectives.

A recommendation to eliminate chemical analytical monitoring at a particular location based on the data reviewed does not necessarily constitute a recommendation to physically abandon the well. A change in site conditions might warrant resumption of monitoring at some time in the future. In some cases, stakeholders may pursue a comprehensive monitoring event for all historic wells every five to ten years to provide a broad view of plume changes over time.

In general, continuation of water level or hydrogeologic measurements at all site wells is recommended. Data on hydraulic gradients and potentiometric surfaces are often relatively inexpensive to collect and can be used to support model development and resource planning.

Qualitative evaluation for sampling frequency recommendations includes looking at factors such as the rate of change of concentrations, the groundwater flow velocity, and the type and frequency of decisions that must be made about the site. Additionally, consideration is given to the concentration at a particular location relative to the regulatory screening level, the length of the monitoring history and the location relative to potential receptors.

3.0 RESULTS

3.1 Southeast Perched Groundwater Sector

Data from 31 monitoring wells at various depths were included in the network analysis for the Southeast Sector along with data from 48 extraction wells (see Figure 3). Investigation well locations are listed in Table 1 with the size of the dataset for each well, and major COCs detected. Extraction well information is listed in Appendix B Table 1. Data from a total of 79 monitoring locations were considered in the analysis of the Southeast Sector.

Perched groundwater in the Southeast Sector has been subjected to extensive site characterization efforts, as well as a comprehensive modeling effort (BWXT, 2006; BWXT, 2007). The source areas for the Southeast Sector have been identified as Zones 11 and 12 and the ditch running alongside these industrial units draining to Playa 1. Groundwater flow is to the east/southeast from the source areas. The highest concentrations of COCs are located south and east of the DOE property boundary (see Figure 3), with lower concentrations at the historic source.

Based on results from site characterization efforts, affected groundwater in the Southeast Sector extends to the point where the saturation ends. Figure 3 indicates the location of wells drilled to the depth of perched water to the southern and eastern extents that were found to be dry. Delineation of affected groundwater in this Sector is defined by wells that provide data on the extent of saturation. Perched water does not release to surface water and its hydraulic connectivity with the Ogallala is limited by the presence of the FGZ; therefore, affected groundwater in this area is largely delineated.

3.1.1 COC Choice

Priority constituents for each individual well in the Southeast Sector are indicated on Table 1. A sector-wide evaluation of priority COCs was performed in the MAROS software and the results are indicated in the Table 3 MAROS COC Assessment for the Southeast Sector.

Based on toxicity and prevalence metrics, the two primary COCs for the Southeast Sector are RDX and 4ADNT. The median RDX concentration in the Southeast Sector network is approximately two orders of magnitude above the MSC. RDX concentrations exceed the MSC at 69 of 79 locations evaluated while 4ADNT exceeds at 63 of 79 locations. Table 3 provides details of how the COCs were ranked by toxicity, prevalence and mobility in the Southeast Sector. While other constituents were considered (Cr(VI), TNT, 2ADNT, 24DNT, TCE) in the analyses, the monitoring network was optimized specifically to address management of the RDX and 4ADNT affected groundwater. Plumes of TCE and TNT are entirely contained within the greater RDX affected groundwater. Groundwater affected by Cr(VI) exists to the south of Zones 11 and 12 and is also considered in the analysis of the Southwest Sector.

The results of the MAROS COC Assessment are shown on Table 3, but are specific to the monitoring network evaluation and are not meant to supplant the BRA's, which use different metrics to evaluate risk.

3.1.2 Plume Stability

3.1.2.1 Concentration Trends

Individual well concentration trends for the two priority COCs using the Mann-Kendall method (2000 to 2007) are summarized in the table below with detailed results shown in Table 4 and illustrated on Figures 3 and 4. Detailed Mann-Kendall reports for major COCs for each well in the network are located in Appendix B.

COC	Total Wells	Pantex Plant Southeast Perched Groundwater Mann-Kendall Trend Results by Number of Wells				
		Nondetect	Decreasing or Probably Decreasing	Stable	Increasing or Probably Increasing	No Trend or Insufficient Data
RDX	79	1 (1%)	38 (48%)	12 (15%)	19 (24%)	9 (11%)
4ADNT	79	5 (6%)	32 (41%)	15 (19%)	15 (19%)	12 (15%)
2ADNT	79	10 (12%)	35 (44%)	10 (12%)	9 (11%)	15 (19%)
TNT	79	21 (26%)	21 (26%)	7 (9%)	14 (18%)	16 (20%)

For the major HE COCs, the majority of locations evaluated for RDX and 4ADNT show decreasing (D or PD) to stable (S) Mann-Kendall trend results. Other COCs, such as TNT and 2ADNT show higher percentages of wells with no detections. No Trend (NT) statistical results are found at locations with high variance in the data or a limited number of detections of COCs.

Roughly 20% of wells monitor groundwater with increasing concentration trends. Increasing concentration trends are found in areas of the plume downgradient from extraction wells and in areas where the saturated thickness drops off. Areas with increasing concentration trends occur on the perimeter of the plume, as constituents from historic sources are transported to the terminus of the groundwater unit. Extraction wells in the center of the plume have largely decreasing concentration trends.

In the Southeast Sector Cr(VI) is less prevalent than the HE compounds with the plume limited to an area south of Zone 12. Interpretation of trend results for Cr(VI) is complicated by the change in analytical detection limits within the dataset. Well locations PTX06-1012, PTX06-1035 and PTX06-1036 show historic non-detect results between 2000 and 2005. Analytical detection limits were reduced in August 2005, resulting in detectable results in subsequent analyses. Locations with higher concentrations of Cr(VI) show decreasing trends (PTX06-1010, PTX08-1008, and PTX06-1052) indicating a shrinking plume in this area.

3.1.2.2 Moments

Moment analysis was used to estimate the dissolved mass (zeroth moment), center of mass (first moment) and distribution of mass (second moment) for the plumes and the trends for these metrics over time. In order to ensure a consistent number and identity of wells for each moment estimate, an annual average concentration for each well was calculated. For the Southeast Sector, data from both investigation and extraction wells were used to estimate the moments. Moments were calculated using both a uniform saturated thickness (30 ft) and variable saturated thickness using estimates of saturated thickness from the database. The number of wells in the sampling program each year for RDX (including extraction wells) range between 68 locations in 2007 to 76 in 2005.

Mann-Kendall trends of moments were evaluated for annually consolidated data 2000-2007. Trends for estimates of the zeroth, first and second moments for both RDX and 4ADNT for the Southeast Sector are shown in the table below, and first moments for RDX and 4ADNT are illustrated on Figure 4. MAROS reports for zeroth, first and second moments for other COPCs are located in Appendix B. Moment results were the same for both uniform and variable saturated thickness assumptions, except where noted.

Moment Type	**Constituent**	
	RDX Trend	**4ADNT Trend**
Zeroth (Total Dissolved Mass)	Stable	Probably Increasing*
First (Center of Mass)	Increasing	Probably Increasing
Second (Spread of Mass)	Increasing/Stable	No Trend/ No Trend

*Result for uniform saturated thickness. Variable thickness resulted in No Trend.

Statistical results indicate that the total dissolved mass of RDX in the plume has been stable between 2000 and 2007. The zeroth moment for 4ADNT shows a probably increasing trend using uniform saturated thickness and No Trend when specific saturated thicknesses are used. These results indicate a possible weakly increasing trend, indicating that dissolved mass of 4ADNT within the network may be increasing due to degradation of the parent compound (TNT). Zeroth moments for 2ADNT are stable while TNT results indicated probably decreasing mass (consistent with possible transformation processes).

First moments, or the distance of the center of mass from the source, are statistically increasing over time for RDX and probably increasing for 4ADNT. However, the change in the center of mass is not significant, given the scale of the plume in this area (see Figure 4). Increasing first moments are often seen when source concentrations decrease, leaving relatively more of the total mass in the tail region. For RDX and 4ADNT, individual well concentration trends are decreasing at the source and in the center of the plume (under the influence of the extraction wells) and some peripheral areas show increasing concentrations. As a result, the center of mass for the priority constituents is shifting slightly to the east over time. First moments for TNT and 2ADNT show no trend.

Second moments are a measure of the distribution of mass about the center of mass in the plume. Second moments in the direction of groundwater flow (X direction) for RDX, TNT and 2,4DNT indicate that the mass in the center of the plume is decreasing relative to the mass on the edges of the plume (increasing second moment). An increasing second moment is consistent with the removal of mass from the center of the plume by the PGPTS. Second moments for 4ADNT show no trend, indicating no significant change in the distribution of mass within the plume.

Considering the overall results of the moment analysis, the plumes in the Southeast Sector are largely stable, with little change in total mass and distribution of mass, largely decreasing concentrations in the source and center of the plume. Slowly changing conditions are consistent with a reduced frequency of monitoring.

3.1.3 Redundancy and Sufficiency

The spatial redundancy analysis was performed for the network using RDX and 4ADNT as the priority COCs. (Note: Spatial analyses were also performed for TNT, 2ADNT and Cr(VI) and were considered as supporting information for final network recommendations).

Data collected between the 3rd quarter 2005 and 2007 were used in the spatial optimization. Summary results for the redundancy analysis are presented on Table 5 and include average SF (the estimate of uncertainty surrounding the well) and the MAROS recommendation for retention or elimination of the well from the network for each perched unit investigation well for RDX and 4ADNT. The preliminary MAROS recommendations were reviewed and a final recommendation for inclusion in the network is indicated. Extraction wells were included in the analysis, but were not considered for removal from the monitoring network.

Although several investigation well locations were identified by the software as candidates for removal for individual compounds, no single well was identified as redundant for all COCs analyzed. Based on a qualitative review of the network and associated regulatory requirements, all wells, but one, were recommended for retention in the monitoring network for the immediate future. Location PTX06-1014 was recommended for elimination from routine monitoring as it has very low SFs for all COCs examined. PTX06-1014 is redundant with PTX06-1042, PTX06-1030 and PTX06-1102.

Monitoring wells along the DOE property in the vicinity of the extraction wells have low SF due to the density of data generated in this area. The lack of concentration uncertainty in this area is indicated on Figure 5 by several ‘S’ (small uncertainty) indicators in the Delaunay triangles formed between the property line wells and the extraction wells. Very low SFs were calculated for locations along the eastern border of the DOE property for RDX and 4ADNT. While these wells (PTX06-1038, PTX06-1039A, PTX06-1014, PTX06-1015, etc.) tend to provide some redundant information, they are retained in the network due to the detection of increasing concentration trends and the absence of monitoring locations to the east. Well redundancy along the DOE property line should be reevaluated in 5 years after collection of additional data. If low SFs are calculated after additional data collection efforts, the wells should be considered for removal from the routine monitoring network.

Well sufficiency for the network is evaluated using calculated SFs as measures of concentration uncertainty. MAROS uses the Delaunay triangulation and SF calculations to identify areas with high concentration uncertainties, but new wells are added only in locations where uncertainty is unexplained by site characteristics. The Southeast Sector network has a number of characteristics that contribute to concentration uncertainty. Source areas along the west include a line source (the ditch) and other sources that are spatially as well as temporally discontinuous. Radial groundwater flow and the drying of the unit on the edges also contribute to higher calculated uncertainties.

Results of the well sufficiency analysis for RDX are shown on Figure 5. Figure 5 shows the polygons created by the triangulation method and indicates areas of high uncertainty with an “L” or an “E” in the center of the triangle. For the Southeast Sector network, areas of high concentration uncertainty for RDX exist in the source area, largely as a result of the heterogeneity of the source and radial groundwater flow. No new wells are recommended for the source area as concentration uncertainty is explained by flow conditions.

Another area of spatial uncertainty exists south of the source in the area between PTX06-1052 and PTX06-1036. Sampling results for PTX06-1052 show no detections of RDX, 4ADNT or TNT. However, monitoring locations around PTX06-1052 show consistent detections of site HEs. Concentration uncertainty in the area may be exacerbated by dry and intermittently dry wells (PTX06-1037 and 1045) on the southern border of the unit. Conversely, for Cr(VI), the area around PTX06-1052 represents some of the highest concentrations (with decreasing trends) found in the perched unit, while adjacent well PTX06-1053 monitors groundwater with no detections of Cr(VI) Results of the sufficiency analysis indicate a new well in the vicinity of PTX06-1052, PTX06-1053 and PTX06-1036 may be beneficial for characterizing concentrations of RDX, Cr(VI), TNT and 4ADNT in the area.

Better characterization of the area south of Zone 12 will provide information on COC migration patterns from possible sources west of the Southeast Sector. Additional information in this area will improve delineation of Cr(VI) affected groundwater and provide data on continued attenuation of Cr(VI). Temporal trend results for Cr(VI) south of Zone 12 will provide better information when more samples are collected using the new analytical detection limits, especially for wells with relatively low concentrations such as PTX06-1036, PTX06-1012 and PTX06-1035.

A second new monitoring location is recommended for the saturated area east of the line of monitoring wells on the eastern DOE property boundary. Results of TNT and 24DNT sufficiency analyses indicate the Delaunay triangle east of PTX06-1041 between PTX06-1030 and PTX06-1069 has high concentration uncertainty (TNT SF=0.8, 24DNT SF=0.6 at PTX06-1041). Higher concentration uncertainties are often found in areas bounded by wells with low or intermittent detections of COCs (PTX06-1069) and areas of higher concentrations (PTX06-1041) separated by large distances. A new well would help delineate the extent and trend of concentrations on the eastern edge of the perched unit. Currently, wells in this area show increasing concentration trends for RDX and 4ADNT, but due to consistent detections, this area does not exhibit high statistical concentration uncertainties for these compounds.

3.1.4 Sampling Frequency

Table 6 summarizes the results of the MAROS preliminary sampling frequency analysis. Recent (2005-2007) and overall rates (2000-2007) of concentration change for RDX and 4ADNT were determined along with the recent and overall Mann-Kendall trends. The software recommends a preliminary sampling frequency based on review of recent and overall rates and trends. Detailed results of the analysis are shown on Table 6 with final sampling recommendations from a 'lines of evidence approach' listed on Table 7 and Table 16. The sampling frequency suggested by the software (MAROS Recommended Frequency) was compared against the current frequency and site monitoring goals. A final recommended frequency was determined based on both MAROS generated recommendations and site-specific qualitative analyses.

Groundwater monitoring to date at the Pantex Plant has focused on characterizing the nature and extent of affected groundwater. For this reason, the sampling intervals for investigation wells have not been consistent. Many locations are currently sampled once annually, and, therefore, do not have sufficient data (4 samples) to evaluate a recent trend 2005- 2007. In some cases, wells have been installed recently (PTX06-1095A), and do not have a statistically significant dataset. For locations with a limited recent dataset, MAROS often recommends conservative (more frequent) sampling frequency. For wells with a longer sampling record (sampling prior to 2000), and low rates of concentration change, a reduced sampling frequency is appropriate. The MAROS preliminary sampling frequency recommendation for the network varies from quarterly to annual sampling for the Southeast Sector.

A total of 31 investigation wells were analyzed using the MCES method. Three wells in the Southeast Sector are listed as dry to intermittently dry in the site database (BWXT, 2007a). Dry wells are recommended for inclusion in the hydrogeologic monitoring program to monitor water levels at these locations. Of the remaining 28 locations, one well is recommended for exclusion from the program. Well PTX06-1014 was determined to be redundant with well PTX06-1042. Other wells identified as possibly redundant were recommended for inclusion in the monitoring network until the final remedy is established.

The majority of the remaining investigation wells (20) are recommended for semiannual sampling. Several wells recommended for semiannual sampling have increasing concentration trends for RDX and 4ADNT. Semiannual sampling is recommended to provide a statistically significant dataset to evaluate the efficacy of the remedy over the next few years. Wells near the source are recommended for annual sampling as concentrations are generally decreasing. The table below summarizes the current monitoring frequency for wells in the network and the sampling frequency recommended after the lines of evidence evaluation.

Monitoring Wells	Recommended Well Sampling Frequency		
	Sampling Frequency	Current Sampling Frequency	Sampling Frequency Recommendation
	Quarterly	0	0
	Semi-annual	16	22
	Annual	12	7
	Biennial	0	0
Total Samples (average per year)		**44**	**51**
Total Wells		**28**	**29**

The Sampling Frequency Recommendation includes 2 new locations to be sampled semiannually. The current sampling frequency is estimated from the sample dates in the site analytical database (BWXT Pantex, 2007). Three dry wells in the Southeast Sector are recommended for inspection and hydrogeologic monitoring at an annual frequency.

A summary of the final network recommendations for the Southeast Sector are shown on Table 7 and on Figure 8. Table 7 lists lines of evidence used in making each recommendation and a short description of the function of each well in achieving site monitoring goals. The combination of annual and semiannual frequencies will ensure temporal coverage to “define and enclose” the plume as well as providing a record of attenuation of high concentrations in the interior and edges of the sector. The final proposed network increases sampling effort in the near future, but will provide data for improved statistical analyses within the next 5 years.

3.2 Southwest Sector

Data from 29 investigation well locations were used in the analysis of the Southwest Sector. Wells located south of Zone 12 (PTX06-1036, PTX06-1052, PTX06-1053, PTX08-1008, PTX08-1009) were used in both Southeast and Southwest spatial analyses to account for the diverging groundwater flow directions. Source areas for the Southwest Sector include Zones 11 and 12; however, the area was not impacted by the drainage ditch from Zone 12 to Playa 1, to any great extent. Sources in the Southwest were more isolated, therefore; COC plumes in the Southwest Sector are not as extensive. The Southwest Sector is characterized by large areas of very low to non-detect results with isolated areas of higher concentrations. Areas above MSCs include TCE and perchlorate affected groundwater underlying Zone 11.

Individual plumes within the Southwest Sector perched unit are largely delineated by unaffected wells down and cross-gradient. Affected groundwater is well delineated to the north and west of the perched unit. Perimeter wells PTX07-1Q01 and PTX07-1Q02 north to PTX06-1085 and PTX06-1087 monitor groundwater below site MSCs. Perched groundwater south of PTX06-1035 on TTU may require more wells to provide delineation between areas of affected groundwater and the edge of the perched unit.

3.2.1 COC Choice

Priority constituents for each individual well in the Southwest Sector are indicated on Table 1. The analytical dataset includes some results that may be outliers, so not all priority constituents identified on Table 1 are detected consistently at the location indicated. Risk ratios below 1 indicate the groundwater is not affected above regulatory screening levels at the locations indicated. A sector-wide evaluation of priority COCs was performed in the MAROS software and the results are indicated on Table 8 MAROS COC Assessment for the Southwest Sector. Cr(VI) is identified as a priority COC for a limited number of wells in the Southwest Sector. The priority COCs for the design of the Southwest monitoring network are perchlorate, TCE, and 4ADNT.

3.2.2 Plume Stability

3.2.2.1 Concentration Trends

Individual well concentration trends for wells in the Southwest Sector are summarized on Table 9. Summary results are presented in the table below.

The percentage of monitoring locations with no detections for specific COCs is very high in the Southwest Sector, consistent with the observation that the plumes within this sector are isolated.

COC	Total Wells	Pantex Plant Southwest Perched Groundwater Mann-Kendall Trend Results by Number of Wells				
		Nondetect	Decreasing or Probably Decreasing	Stable	Increasing or Probably Increasing	No Trend or Insufficient Data
Perchlorate	29	15 (52%)	5 (17%)	3 (10%)	1 (3%)	5 (17%)
TCE	29	15 (52%)	1 (3%)	4 (14%)	2 (7%)	7 (24%)
4ADNT	29	17 (58%)	2 (7%)	2 (7%)	1 (3%)	7 (24%)

Mann-Kendall trend results for perchlorate are illustrated on Figure 6. Locations with the highest concentrations of perchlorate show strongly decreasing concentration trends (1114-MW4, PTX08-1005, and PTX08-1006) or stable trends (PTX06-1007). Locations within the plume with low to intermittent detections show No Trend results (datasets with intermittent non-detect results often have high coefficients of variation (COV)). One location, PTX06-1012, shows an increasing concentration trend for perchlorate and a probably increasing trend for TCE. PTX06-1012 is downgradient from Zone 11 and is not bounded to the south by other investigation wells.

TCE affected groundwater is encountered in roughly the same area as perchlorate affected groundwater (see Figure 6). Locations with detections of TCE indicate largely stable to no trend results. The only area of possibly increasing TCE concentrations is located between wells 1114-MW4 and PTX06-1012, where probably increasing trends indicate an area that may require more monitoring effort. Strongly decreasing trends were calculated at location PTX06-1052, at the interface between the Southeast and Southwest flow directions.

4ADNT affected groundwater is not widespread in the Southwest Sector, and is more closely associated with Zone 12. The 4ADNT plume is largely east or commingled with perchlorate and TCE affected groundwater. Locations monitoring the highest Cr(VI) concentrations (PTX08-1008, PTX06-1010 and PTX06-1052) show decreasing concentration trends. Locations monitoring the edge of the Cr(VI) plume show intermittent detections, and require a larger dataset to interpret trends in this area.

3.2.2.2 Moments

Mann-Kendall trends of moments were evaluated for annually consolidated data 2000-2007. Trends for estimates of the zeroth, first and second moments for TCE and perchlorate for the Southwest Sector are shown in the table below. Detailed MAROS reports for zeroth, first and second moments are located in Appendix B.

Moment Type	**Constituent**	
	TCE Trend	**Perchlorate Trend**
Zeroth (Total Dissolved Mass)	No Trend	Stable
First (Center of Mass)	Increasing	No Trend
Second (Spread of Mass)	Stable/Increasing	No Trend/Increasing

Total mass estimates of TCE and perchlorate are not changing rapidly within the current network. Moment results for 4ADNT and RDX indicate stable mass estimates for these COCs. For perchlorate, the distribution of mass within the plume is not changing rapidly. There is some evidence of dilution of mass in the center of the plume for both TCE and perchlorate (increasing second moments). First moment estimates for TCE are increasing, indicating that the plume may still be expanding in the direction of groundwater flow. This result is consistent with increasing trends at location PTX06-1012.

<u>3.2.3 Redundancy and Sufficiency</u>

Summary results for the redundancy analysis for the Southwest Sector are presented on Table 10 and include average SF (the estimate of uncertainty surrounding the well) for each perched unit investigation well for perchlorate and TCE. Locations with SF approaching 0 are often recommended for elimination from routine monitoring, while locations with high SF provide unique information in the immediate spatial region and are retained. In the Southwest Sector, many wells monitoring unaffected groundwater have higher SF's, due to the distance between these locations and locations on the edge of the plumes. Non-detect or intermittent detections are an example of conditions that result in statistical concentration uncertainty that can be explained by site data (in this case, censored data). Some wells with high SF have been recommended for elimination from routine monitoring based on qualitative issues as the software can identify non-detect wells as having higher concentration uncertainty.

Location PTX06-1006 is recommended for exclusion from routine monitoring as it is redundant with PTX06-1011. Perimeter locations PTX06-1087, PTX07-1P02, PTX07-1P03, PTX07-1Q02 and PTX10-1008 that monitoring unaffected groundwater are recommended for elimination from the monitoring network as well.

The well sufficiency analysis identified the area south of Zone 11 between wells PTX08-1006, PTX06-1012, PTX06-1053 and PTX06-1008 as having high concentration uncertainty. Location PTX06-1012 shows increasing concentration trends for perchlorate and TCE, and no downgradient wells currently exist to define the extent of the trend. A new monitoring location is recommended for the area south of PTX06-1012. One to two new monitoring locations are recommended for the area between PTX06-1012 and PTX08-1005 to account for uncertainty in groundwater flow directions in this area. A new location has been recommended to delineate groundwater near the DOE property boundary south of Zone 10. Groundwater south of Zone 10 is anticipated to be unaffected by COPCs above MSCs, with the new well functioning as a point of compliance (POC) well for the Southwest Sector.

3.2.4 Sampling Frequency

Detailed results of the sampling frequency analysis for the Southwest Sector are shown on Table 11 with final recommendations listed on Table 12. Table 12 lists the lines of evidence used in making sampling recommendations and a brief description of the function of the well in the network. Locations included in both the Southeast and Southwest spatial analyses were recommended for sampling at the more conservative frequency of the two analyses.

Sampling frequencies for 24 wells in the Southwest Sector were determined. The current sampling frequency for this sector is largely annual, with seven locations not sampled in the recent time-frame (2005-2007). Currently, 17 wells are sampled routinely in this sector.

Based on results of the redundancy and sufficiency analyses, six locations are recommended for formal elimination from the network while four new locations in perched groundwater are recommended. The proposed new locations are recommended for semiannual sampling until 4-6 sample results are collected to provide statistical trend information. The final proposed network is illustrated on Figure 8 and summarized in the table below. New wells are included under the sampling frequency recommendation (Total Wells below) as well as locations that have not been sampled frequently in the recent time period.

Based on results of the temporal analysis, four current locations are recommended for semiannual sampling. Wells monitoring groundwater with high or increasing concentrations of TCE and perchlorate, such as 1114-MW4 and PTX08-1005 are recommended for semiannual sampling to capture changes in concentrations in this area. Wells monitoring groundwater with stable trends or infrequent detections are recommended for annual sampling. Perimeter or POC wells are recommended for biennial sampling. The final proposed network increases sampling effort in the near future, but will provide for a statistically significant dataset within 5 years.

Monitoring Wells	Recommended Well Sampling Frequency		
	Sampling Frequency	Current Sampling Frequency	Sampling Frequency Recommendation
	Quarterly	0	0
	Semi-annual	2	8
	Annual	14	9
	Biennial	1	5
Total Samples (average per year)		**18.5**	**27.5**
Total Wells		**17**	**22**

The Sampling Frequency Recommendation includes 4 new locations to be sampled semiannually. The current sampling frequency is estimated from the sample dates in the site analytical database (BWXT Pantex, 2007a).

3.3 North Sector

3.3.1 COC Choice

Priority constituents for each individual well in the North Sector are indicated on Table 1. Eighteen locations were considered in the North Sector analysis. Two locations at the Pantex Lake property were not analyzed as perched groundwater in this area is not affected by COCs associated with site activities. As with the Southwest Sector, many locations do not exceed MSCs (risk ratios below 1) and the primary COC may not be detected routinely at a location.

A sector-wide evaluation of priority COCs was performed in the MAROS software. The only COC identified as a priority sector-wide was RDX. Other constituents are present in perched groundwater at low levels or over limited spatial extents. Isolated areas of perched groundwater are found underlying the Burning Grounds and in the far northeast area of the property. Perched groundwater in these areas is characterized by fairly low detections of site COPCs and limited opportunity for mobility.

The North Sector includes the area of the main perched groundwater unit north of Playa 1. Perched groundwater in this area is affected by waste water drained to Playa 1 from industrial operations in Zone 12. A groundwater mound located just to the north of Playa 1 (see Figure1) causes radial flow in the North Sector. The RDX and 4ADNT plumes that extend south from Playa 1 were evaluated under section 3.1 above. Analyses of the North Sector included the area between Playa 1 and the extent of the perched unit and the area around SWMU 68b.

3.3.2 Plume Stability

3.3.2.1 Concentration Trends

Selected individual well concentration trends for wells in the North Sector for various COPCs are listed on Table 13 and illustrated on Figure 7. The majority of locations do not have detections of COPCs above MSCs. The only area of groundwater routinely affected above MSCs is the RDX plume north of Playa 1. A summary of Mann-Kendall trend results for the North Sector is shown below. No locations in the North Sector show decreasing trends for RDX (while several locations in the northern Southeast and Southwest Sectors show decreasing trends). One location, PXT06-1050 shows an increasing trend, with average concentrations above the MSC. Well PTX06-1114 has been installed upgradient of PTX06-1050 to define trends in the area, but the location has insufficient data to evaluate a trend at this time. No wells are currently located downgradient of PTX06-1050.

COC	Total Wells	Pantex Plant Southwest Perched Groundwater Mann-Kendall Trend Results by Number of Wells				
		Nondetect	Decreasing or Probably Decreasing	Stable	Increasing or Probably Increasing	No Trend or Insufficient Data
RDX	18	9 (50%)	0	3 (17%)	1 (5%)	5 (28%)

3.3.2.2 Moments

The moment analysis was not conducted for the North Sector as fewer than six wells were present in any individual network monitoring a common source area and groundwater flow direction. Outside of the main perched groundwater unit, COCs are not detected above MSCs on a consistent basis. Plume stability for affected groundwater in the North Sector was determined by evaluating delineation and individual well concentration trends.

3.3.3 Redundancy and Sufficiency

As with the moment analyses, network spatial redundancy and sufficiency analyses require greater than six monitoring locations with detections to evaluate stability within a network. For the North Sector, redundancy and sufficiency were evaluated using qualitative methods.

The area north of Playa 1 is the only area in the North Sector where groundwater consistently exceeds MSCs. RDX concentrations appear to be increasing downgradient of Playa 1 in the area of PTX06-1050. Addition of a well downgradient (west) of PTX06-1050 is recommended to define the extent and trend of RDX in the area. Wells in the main perched unit north of Playa 1 should be sampled semiannually until a sufficient dataset has been collected to evaluate dissolved RDX in the area.

3.3.4 Sampling Frequency

Detailed results of the sampling frequency analysis for the North Sector are shown on Table 14. Final recommendations are listed on Table 15, along with lines of evidence used to support the recommendation and a description of the function of each well in the network. Only data for the overall rate of change and overall concentration trends are shown on Table 14 as there were an insufficient number of sampling events to evaluate recent rates of change and trends (2005 – 2007). Analytical results from many locations show no detections or only intermittent detections of site COPCs.

Final sampling frequency recommendations are summarized in the table below. Due to the limited extent of affected groundwater, a reduction in monitoring effort over the majority of the North Sector is recommended.

Monitoring Wells	Recommended Well Sampling Frequency		
	Sampling Frequency	**Current Sampling Frequency**	**Sampling Frequency Recommendation**
	Quarterly	0	0
	Semi-annual	10	5
	Annual	6	4
	Biennial	4	5
	5 year interval	4	7
Total Samples (average per year)		**29**	**18**
Total Wells		**20**	**21**

The Sampling Frequency Recommendation includes 1 new location to be sampled semiannually. The current sampling frequency is estimated from the sample dates in the site analytical database (BWXT Pantex, 2007).

For wells located in the northeast corner of the DOE property boundary, a combination of biennial and 5-year sampling intervals was recommended. The perched groundwater in this area is isolated from the main perched groundwater unit, and is in an area where the FGZ is thick. COPCs are not detected above screening levels with regularity. A five-year sampling interval will provide data to demonstrate compliance with regulatory requirements over the long-term. A five-year sampling interval is also suggested for PTX07-1R03, located in an isolated area of perched groundwater.

Semiannual monitoring is recommended for wells monitoring RDX affected groundwater in the main perched unit (PTX06-1114, PTX06-1050, PTX07-1O01 and PTX07-1O02) and for the proposed new location. Annual monitoring is suggested for wells defining the outer edge of the plumes.

The final recommended sampling frequencies for all Pantex Plant sampling locations is provided on Table 16.

3.3.5 Data Sufficiency

Data sufficiency analysis is appropriate for sampling locations very close to meeting cleanup objectives. Several locations in the North Sector monitor groundwater with very few to no detections of COPCs. Data sufficiency analysis determines if and when a sufficient number of samples have been collected from a location to confirm that the groundwater is statistically below the cleanup goal and if the site has attained cleanup (USEPA, 1992). A Student's T-Test with power analysis and Sequential T-Test were performed on North Sector data. Results from these statistical tests are shown on Table 15. The Students T-test and power analysis identifies if groundwater locations statistically below the MSC with 80% power. The Sequential T-Test, a more rigorous analysis, identifies locations that have 'attained' cleanup, those where continued monitoring would provide a statistically significant dataset, and those locations far from achieving the cleanup goal.

Well locations where data meet the statistical standard of 'clean' can be used as POC or delineation points for regulatory purposes, or their monitoring frequency can be dramatically reduced without loss of information to support management decisions.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The primary goal of developing an optimized monitoring strategy at the Pantex Plant is to create a dataset that fully supports site management decisions and risk reduction goals while minimizing time and expense associated with collecting and interpreting analytical data. A summary of the final recommended monitoring network is presented on Table 16 and illustrated on Figure 8. The recommended network increases data collection effort in some areas to provide a dataset that fulfills statistical requirements for evaluating the effect of the remedies discussed in the CMS/FS (BWXT, 2007b). The recommended network reduces monitoring effort and cost in some areas, but recommends the addition of new wells in areas where further characterization would support site monitoring goals.

Tasks identified in Section 1 were performed for the current network. A summary of general results for each task is presented below:

- *Evaluate well locations and screened intervals within the context of the hydrogeologic regime to determine if the site is well characterized.*

  Result: Part of the network optimization process is to identify possible gaps in site characterization that may require additional sampling locations or site investigation. Based on well locations, screened intervals and hydrogeologic characteristics, affected groundwater in perched units is well characterized and delineated, in most areas. In some areas, the extent of affected groundwater is defined by the extent of perched groundwater, with perimeter wells dry. Areas that may benefit from additional delineation have been identified in the Southwest Sector southwest of Zone 11, in the North Sector northwest of Playa 1 and in the far eastern area of perched groundwater. Areas recommended for additional delineation are all near the perimeter of the perched unit where saturated thickness decreases. Recommendations for new delineation locations are based on both qualitative and quantitative statistical evaluations.

  Source areas have been well investigated and conceptual site models have been developed for all areas of affected groundwater (BWXT, 2007b). The majority of wells in the network have a sufficiently large dataset to perform statistical calculations.

  Recommendation: Monitoring network optimization is appropriate for the site at this time; however, further network evaluation may be beneficial after the final remedies are instituted (including installation of new extraction and *in situ* redox manipulation systems). Network recommendations presented in this report focus on collecting information over the next five years to support future assessment of remedy efficacy and delineation of affected groundwater. The monitoring network should be reevaluated after five years to determine if the system can be further optimized.

Areas of perched groundwater that are recommended for additional delineation include the area east of the DOE property in the vicinity of well PTX06-1040. The perched groundwater pinches out in this area, so delineation may be a function of confirming the limit of saturation.

Two new groundwater delineation locations are recommended for the area south/southwest of the main perched unit in the Southwest Sector to delineate constituents in this area.

An additional delineation well is also recommended for the area north and west of Playa 1 to characterize the RDX plume west of PTX06-1050.

- *Evaluate overall plume stability through trend and moment analysis. Evaluate individual well concentration trends over time for target chemicals of potential concern (COPCs);*

  Result: The groundwater plumes in the Southeast Sector are largely stable under the influence of the extraction system and limited by the extent of saturation in the perched unit. Statistically increasing concentration trends are found for RDX and 4ADNT at downgradient locations in the Southeast Sector; however, the magnitude of increase is low compared with the overall concentrations at these locations.

  An evaluation of moments in the Southeast Sector shows that total dissolved mass estimates are stable for RDX, and variable to possibly increasing for 4ADNT. Center of mass estimates for RDX and 4ADNT are statistically increasing (moving downgradient) slightly, consistent with increasing individual well trends at downgradient locations and decreasing concentration trends in the source and extraction well areas. The movement of the center of mass downgradient is not significant compared to the overall scale of the plume. Estimates of the distribution of mass about the center of mass (second moments) for RDX indicate some redistribution of mass from the center to the edge of the plume in the direction of groundwater flow. Overall results of the stability analysis indicate the plumes are largely stable with slow increases in the proportion of constituent mass in groundwater on the edges of the plume.

  The primary plumes in the Southwest Sector include TCE and perchlorate affected groundwater near Zone 11 and HE plumes near Zone 12. Individual well trends for perchlorate are largely decreasing with the exception of an increasing trend found at downgradient location PTX06-1012. Moments for perchlorate show no trend to stable trends within the current network, indicating a fairly stable plume.

  Individual well trends for TCE in the Southeast Sector are largely stable or show no trend. However, concentrations at wells 1114-MW4 and PTX06-1012 show probably increasing trends. Increasing trends at some downgradient locations are reflected in an increasing trend for the center of mass over time. Lines of evidence indicate some expansion of Zone 11 affected groundwater in the southerly direction.

The majority of monitoring locations in the North Sector are not affected by constituents above MSCs and statistical evaluation results indicate many locations where groundwater shows no detections or intermittent detections (no trend). Concentration trends for RDX in the North Sector show decreasing trends just south of Playa 1. An increasing RDX trend was found at PTX06-1050 indicating possible spread of the plume to the northwest of the main perched groundwater unit. Due to the limited number of monitoring locations, moment analysis was not conducted for the North Sector.

Recommendation: Monitoring frequency can be reduced for plumes where groundwater concentrations are not changing rapidly and where plumes are stable. Areas where reduced monitoring effort is appropriate have been identified in the North and Southwest Sectors (see Table 16 for final recommendations).

Concentrations are still changing in the Southeast, although the plume has been stabilized by installation of the PGPTS. The recommendation is to continue to collect data in Southeast Sector during the installation and early implementation of proposed remedies to provide a sufficient dataset to demonstrate the efficacy of future remedies.

- *Develop sampling location recommendations based on an analysis of spatial uncertainty;*

Result: Well redundancy analysis for the Southeast Sector indicates that wells installed along the DOE property boundary may provide redundant information when analyzed alongside data from the PGPTS. However, as these wells are the monitoring locations farthest downgradient to the east and monitor the property boundary, most are recommended for inclusion in the monitoring program until installation of additional remedy systems are completed. One investigation well in this area was recommended for elimination from routine monitoring.

Spatial uncertainty analysis for the Southeast Sector indicated high concentration uncertainty in the area south of Zone 12 and in the area east of the DOE property. High concentration uncertainty was found for RDX, Cr(VI) and 4ADNT for the southern location and for TNT and 2ADNT in the eastern area. Two new wells are recommended. Similarly, delineation of concentrations south of Zone 12 and east of PTX06-1053 would benefit from addition of a well to monitor possible transport of COCs through the area. The Southeast Sector will most likely be the focus of additional remedial activities, and providing data from the area immediately west of proposed remedial operations will support assessment of remedial effectiveness in this area (see Figure 8 for proposed new well locations).

For the Southwest Sector, wells monitoring unaffected groundwater on the western edge of the plume were found to provide redundant information based on a qualitative review and are formally recommended for removal from the routine monitoring program. Statistical redundancy was found in the area of PTX06-1006, near Zone 12. The spatial sufficiency analysis for the Southwest Sector identified an area of unexplained concentration uncertainty in the vicinity of PTX06-1012, and three new monitoring locations are recommended for this area.

Rather than recommending wells for elimination in the North Sector, delineation or POC wells were identified for reduced sampling frequency.

Recommendation: For the Southeast Sector well PTX06-1014 was determined to be redundant with well PTX06-1042, and is recommended for elimination from the routine monitoring program.

Two new locations are recommended for the Southeast Sector. One new location is recommended for the area between PTX06-1036 and PTX06-1052. Another new location is recommended for the area east of PTX06-1039A.

Six locations were found to provide redundant information and are recommended for elimination from routine monitoring in the Southwest Sector: PTX06-1006, PTX06-1087, PTX07-1P02, PTX07-1P03, PTX07-1Q02, and PTX10-1008.

Overall, four new groundwater monitoring locations are recommended for the Southwest Sector. Two new wells are recommended to delineate affected groundwater in the southern area of the perched unit. The wells are outside the current network southwest of PTX06-1012 and southwest of PTX06-1035. Two new locations south of PTX08-1005 are recommended to decrease spatial uncertainty in the area of the TCE/perchlorate plume near Zone 11 between PTX08-1005 and PTX06-1012.

No wells are recommended for elimination from the North Sector networks. However, many locations are recommended for dramatically reduced sampling frequency. If low to non-detect conditions persist in isolated perched units in the future, some of these wells may be eliminated.

One new monitoring location is recommended to delineate the RDX plume in the North Sector. The new monitoring location is recommended for an area downgradient (west) of PTX06-1050 at the edge of the saturated unit.

- *Develop sampling frequency recommendations based on both qualitative and quantitative statistical analysis results;*

Result: Preliminary sampling frequency recommendations generated by MAROS for RDX in the Southeast Sector included many recommendations for quarterly sampling due to the small number of recent sampling events during the past two years and due to increasing concentration trends at sampling locations. Sampling frequency recommendations for 4ADNT affected wells were less frequent. After a qualitative review of the network, a semiannual sampling frequency was recommended for most monitoring locations in the Southeast Sector. The qualitative review considered that additional historic data were available for many of the locations and that the perched groundwater unit is largely isolated from most exposure pathways, poses a limited risk and is covered by institutional controls to prevent contact with human or ecological receptors.

Locations in the Southeast Sector source area and in the northern area are recommended for annual sampling based on low rates of concentration change and decreasing concentration trends.

Many monitoring locations in the Southwest and North Sectors were recommended for reduced sampling frequency due to the number of non-detect results and the very low rate of change of concentrations in this sector.

Recommendation: Recommendations for sampling frequency were made based on the rate of concentration change, the magnitude and direction of concentration change and the need to acquire a statistically significant dataset over the next five years. Sampling frequency recommendations are summarized on Table 16 and Figure 8.

Southeast Sector investigation wells were recommended for a largely semiannual to annual sampling frequency. Of the 31 locations evaluated, 20 are recommended for semiannual sampling. Annual sampling frequency is appropriate for source area locations with decreasing trends and locations within the plume with low rates of concentration change.

Monitoring locations in the Southwest Sector that serve to delineate the extent of perched groundwater (outer edge wells) are recommended for biennial sampling. Interior monitoring locations that may characterize historic source areas or areas north of the source are recommended for annual sampling. Semiannual sampling is recommended for locations monitoring the perchlorate and TCE plume near Zone 11 and for recommended new locations.

In the North Sector, semiannual sampling is recommended for wells monitoring RDX affected groundwater in the main perched unit (PTX06-1114, PTX06-1050, PTX07-1O01 and PTX07-1O02) and for the proposed new location. Annual monitoring is suggested for wells defining the outer edge of the plumes.

Dramatically reduced monitoring is recommended for isolated perched groundwater near property boundaries in the North Sector. Biennial sampling is recommended for wells PTX01-1002, PTX04-1002, PTX06-1081, PTX07-1O06 and PTX-BEG3, while 5 year intervals are recommended for PTX04-1001, PTX06-1071, PTX06-1080, PTX06-1082, PTX06-1083, PTX07-1R03 and PTX08-1010.

- *Evaluate individual well analytical data for statistical sufficiency and identify locations that have achieved clean-up goals (North Sector only).*

  Result: Data sufficiency was evaluated for North Sector investigation wells for RDX (other COPCs were statistically below MSCs). 15 locations in the North Sector had sufficient data to perform the analysis and of those, 10 monitor groundwater statistically below the MSC for RDX (7.7 ug/L) with 80% statistical power. Nine of the 10 wells below MSCs had sufficient data to demonstrate that groundwater was not affected by RDX using the Sequential T-Test. Wells with sufficient data to demonstrated "attainment" of groundwater regulatory standards can be considered as POC locations or can be considered for reduced sampling frequency.

  Recommendation: Results from the data sufficiency analysis were used as one 'line of evidence' to reduce sampling frequency for several North Sector groundwater monitoring locations (see Table 15).

Additional Recommendations

- Groundwater monitoring data as well as well construction and location information should continue to be managed in a site-wide relational database.
- Capture zone analysis for the PGPTS extraction system in the Southeast Sector is recommended and should continue to be presented annually, as required by Compliance Plan No. 50284.
- Additional monitoring locations for the Ogallala Aquifer are recommended to ensure vertical delineation of the perched groundwater plume and to provide early warning if affected groundwater migrates through the FGZ.
- Reevaluate the network in 5 years after any additional remedies have been implemented and a statistically significant dataset has been collected.

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GROUNDWATER MONITORING NETWORK OPTIMIZATION
Pantex Plant

Carson County, Texas

TABLES

TABLE 1
PANTEX PLANT INVESTIGATION WELLS: PERCHED GROUNDWATER

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Earliest Sample Date	Most Recent Sample Date	Number of Samples (2000-2007)	Primary COC at Well	Risk Ratio	Monitoring Constituents					
						RDX	Cr (VI)	Perchlorate	Boron	TCE	4ADNT
Southeast Sector											
PTX06-1002A	7/26/2000	5/7/2007	7	RDX	6.23E+00	X				X	
PTX06-1003	5/1/2000	10/25/2006	7	RDX	2.05E+00				X		
PTX06-1005	1/26/2000	5/7/2007	8	RDX	1.74E+02	X	X			X	X
PTX06-1010	5/8/2000	5/17/2007	8	Cr (VI)	1.17E+02	X	X			X	
PTX06-1011	10/23/2000	5/17/2007	7	RDX	6.52E+00	X				X	
PTX06-1013*	11/20/2000	5/2/2007	11	RDX	1.49E+00	X					
PTX06-1014	11/30/2000	1/15/2007	14	RDX	2.31E+02	X			X		X
PTX06-1015	4/25/2000	2/15/2007	13	RDX	8.95E+01	X					X
PTX06-1023*	4/24/2000	1/17/2007	12	RDX	6.97E-01						
PTX06-1030	2/7/2000	2/12/2007	15	RDX	2.70E+02	X			X		X
PTX06-1031	2/7/2000	2/12/2007	15	RDX	8.71E+01	X					X
PTX06-1034	2/10/2000	2/12/2007	13	RDX	1.01E+01	X					X
PTX06-1036	3/20/2001	2/14/2007	13	4ADNT	9.17E-01						
PTX06-1037**	1/25/2000	5/17/2005	5	RDX	3.64E+02	X	X		X		X
PTX06-1038	1/31/2000	1/15/2007	14	RDX	1.79E+02	X					X
PTX06-1039A	1/31/2000	5/7/2007	11	RDX	1.77E+02	X			X		X
PTX06-1040	1/31/2000	1/15/2007	14	RDX	1.64E+02	X			X		X
PTX06-1041	1/24/2000	11/1/2006	12	RDX	1.69E+02	X			X		X
PTX06-1042	1/24/2000	1/15/2007	16	RDX	3.44E+02	X			X		X
PTX06-1045**	9/12/2000	10/23/2006	12	RDX	2.75E+02	X					X
PTX06-1046	1/5/2000	2/7/2007	17	RDX	1.24E+02	X					X
PTX06-1047A	3/20/2000	5/2/2007	14	RDX	5.84E+01	X					X
PTX06-1052	3/17/2000	2/14/2007	15	Cr (VI)	7.00E+01		X				
PTX06-1053	3/17/2000	2/14/2007	17	4ADNT	5.25E+00						X
PTX06-1069*	10/30/2001	7/26/2006	11	TNT	1.17E-01						
PTX06-1088	6/11/2003	5/17/2007	8	RDX	5.42E+01	X	X			X	X
PTX06-1095A	2/22/2007	5/8/2007	3	BORON	1.20E-01				X		
PTX06-1102**	6/1/2000	10/23/2006	10	RDX	1.57E+02	X					X
PTX08-1002*	2/1/2000	10/25/2006	7	RDX	3.60E+01	X			X		
PTX08-1008	2/1/2000	1/17/2007	11	Cr (VI)	1.40E+02		X				
PTX08-1009*	2/22/2001	5/22/2007	7	RDX	3.87E+00		X				
Southwest Sector											
1114-MW4	4/22/2002	5/21/2007	3	PERCHLORATE	1.29E+01			X		X	
PTX06-1006	7/27/2000	7/31/2003	3	Cr (VI)	1.00E-01						
PTX06-1007	4/17/2001	4/29/2003	3	4ADNT	1.23E+01			X			X
PTX06-1008	2/1/2000	10/27/2004	4	TCE	5.76E+00		X			X	
PTX06-1012	10/23/2000	1/30/2007	12	PERCHLORATE	1.68E+00			X			
PTX06-1035	4/19/2001	1/30/2007	10	4ADNT	1.92E+00						X
PTX06-1077A	2/20/2002	8/7/2006	4	TCE	3.04E+00					X	
PTX06-1085	5/27/2003	2/26/2004	4	BORON	7.56E-03						
PTX06-1086	5/27/2003	5/16/2007	8	RDX	2.44E+00	X					
PTX06-1087	5/27/2003	2/26/2004	4	BORON	8.86E-03						
PTX07-1Q01	4/16/2001	11/2/2006	5	26DNT	1.17E-01						
PTX07-1Q02	5/3/2001	11/2/2006	5	Cr (VI)	1.00E-01						
PTX07-1Q03	4/16/2001	5/16/2007	7	RDX	3.44E+00	X					
PTX08-1003	10/19/2000	11/2/2006	6	PERCHLORATE	1.47E+00			X			
PTX08-1005	4/25/2000	10/26/2006	6	TCE	2.52E+01					X	
PTX08-1006	4/25/2000	5/21/2007	8	4ADNT	3.87E+01	X		X		X	X
PTX08-1007	10/23/2000	7/30/2003	2	TCE	3.20E+00			X		X	
PTX10-1008	10/30/2001	10/26/2004	6	BORON	1.49E-02						
PTX10-1013	7/31/2000	10/26/2006	6	TCE	2.32E+01					X	
PTX06-1049*	3/16/2000	5/14/2007	11	TCE	3.08E-01						
PTX07-1P02*	1/23/2001	5/8/2007	6	RDX	5.45E-01		X				
PTX07-1P03*	4/19/2000	7/31/2003	4	RDX	9.61E-01						
PTX07-1P06*	3/15/2000	10/25/2006	10	RDX	1.42E+01	X					
PTX08-1001*	4/19/2001	5/8/2007	7	PERCHLORATE	2.71E+00		X	X			X

See Notes End of Table

TABLE 1
PANTEX PLANT INVESTIGATION WELLS: PERCHED GROUNDWATER

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Earliest Sample Date	Most Recent Sample Date	Number of Samples (2000-2007)	Primary COC at Well	Risk Ratio	Monitoring Constituents					
						RDX	Cr (VI)	Perchlorate	Boron	TCE	4ADNT
North Sector											
PTX01-1001	2/8/2000	5/14/2007	27	PERCHLORATE	5.62E+00			X			
PTX01-1002	4/17/2000	5/16/2007	26	PERCHLORATE	2.15E-01						
PTX01-1008**	8/1/2000	2/21/2007	13	TCE	1.46E+00						
PTX04-1001	1/26/2000	10/27/2003	6	TCE	4.00E-01						
PTX04-1002	1/22/2001	1/29/2007	12	26DNT	6.03E-01		X				
PTX06-1048A	3/16/2000	1/17/2007	15	TCE	8.20E-01						
PTX06-1050	3/20/2000	10/24/2006	10	RDX	7.09E+01	X			X		
PTX06-1071	8/20/2001	10/28/2004	8	Cr(VI)	1.16E-01						
PTX06-1080	8/9/2005	1/31/2007	12			No COPCs from site activities					
PTX06-1081	7/18/2002	1/31/2007	12	26DNT	3.65E-01						
PTX06-1114	2/22/2007	5/21/2007	2	RDX	4.10E+00	X					
PTX07-1O01	4/24/2000	10/24/2006	6	RDX	6.83E+00	X					
PTX07-1O02	4/18/2001	10/24/2006	3	RDX	1.23E+00						
PTX07-1O03	4/18/2001	5/14/2007	7	RDX	5.01E+00	X					
PTX07-1O06**	9/7/2000	10/28/2004	10	26DNT	2.40E-01						
PTX07-1R03**	5/29/2001	11/2/2006	8	Cr(VI)	1.90E-01						
PTX08-1010	8/9/2005	1/31/2007	15			No COCs above analytical detection limits					
PTX-BEG3	3/22/2001	1/29/2007	13	4ADNT	3.17E-01						
PTX06-1082	5/15/2003	11/1/2006	7			No COPCs from site activities					
PTX06-1083	5/15/2003	11/1/2006	7			No COPCs from site activities					

Notes:

1. Wells listed are investigation wells in current monitoring program. Extraction wells used in the analysis are listed in Appendix B.
   * = Well included in more than one Sector for spatial analysis.
   ** = Wells that are dry or intermittently dry, as indicated in database (BWXT, 2007a).
2. Data from B&W Pantex Plant database received September, 2007 (BWXT, 2007a).
3. Sampling dates for wells range from January 2000 (earliest sample dates) to July, 2007 (most recent sample dates). Data before 2000 may be available for some locations, but were not used in the analysis.
4. The priority chemical of concern (COC) at each well is the constituent detected at the highest level normalized by the MSC or appropriate RRS.
   The ratio is the maximum concentration of the COC divided by the screening level concentration. Values below 1 indicate no groundwater affected above MSC.
5. Number of samples is the number of individual sample dates in the database, results from duplicate samples from the same date are averaged and counted as one sample.
6. Monitoring constituents are those where the average concentration 2000-2007 is above the MSC.
7. RDX = Hexahydro, 1,3,5-trinitro, 1,3,5-triazine; TCE = trichloroethene, 4ADNT = 4-Amino, 2,6-dinitrotoluene; Cr(VI) = Hexavalent Chromium.
   26DNT = 2,6-dinitrotoluene.

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TABLE 2
AQUIFER INPUT PARAMETERS

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Parameter	Units	Southeast	Southwest	North
Current Plume Length	ft	7000	6000	Various
Maximum Plume Length	ft	7000	6000	Various
Plume Width	ft	6400	6000	Various
Seepage Velocity (ft/yr)*	ft/yr	140	62	70
Distance to Receptors	ft	8000	10000	8000
Groundwater Fluctuations	--	No	No	No
Source Treatment	--	Pump and treat		
Plume Type	--	Explosives, VOCs		
NAPL Present		No	No	No
Number of investigation wells	--	31	29	29
Parameter		**Value**		
Groundwater flow direction		S/SE	S/SW	Various (45)
Porosity	--	0.25	0.25	0.25
Source Location near Well	--	PTX06-1010	PTX08-1006	Playa 1 (various)
Source X-Coordinate	ft	639886.625	636400.4375	639580.323
Source Y-Coordinate	ft	3758067	3756761.75	3764100.313
Coordinate System		NAD 83 SP Texas North FT		
Average Saturated Thickness Perched Zone	ft	30		
Priority Constituents		**MSC**	**Basis**	**Sectors Affected**
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	ug/L	7.7	GW-Res$_{c}$	All
4-Amino-2,6-Dinitrotoluene (4ADNT)	ug/L	1.2	GW-Res$_{NCAdj}$	All
2-Amino-4,6-Dinitrotoluene (2ADNT)	ug/L	1.2	GW-Res$_{NCAdj}$	Southeast
2,4,6-Trinitrotoluene (TNT)	ug/L	3.6	GW-Res$_{NCAdj}$	Southeast
2,4-Dinitrotoluene (24DNT)	ug/L	1	PQL	Southeast
Chromium (VI)	ug/L	100	MCL	Southeast
Perchlorate	ug/L	26	GW-Res$_{NC}$	Southwest
Trichloroethene	ug/L	5	MCL	Southwest

Notes:
1. Aquifer data from CMS/FS (BWXT, 2007a).
2. Priority COCs defined by prevalence, toxicity and mobility.
3. Saturated thickness represents an estimated average for the perched unit, which ranges from 0 to 70 ft in saturated thickness.
4. * = a range of transmissivites are present in the aquifer, and groundwater velocity is estimated for each sector.
5. MSC = Medium Specific Concentration, from CMS/FS (BWXT, 2007b).
   GW-Resc = TCEQ Standard No. 2 Groundwater MSC for Residential Use; NC = Noncarcinogenic; C = Carcinogenic;
   Adj = Value adjusted for a cumulative hazard index of 1; PQL = Practical Quantitation Limit; MCL = USEPA Maximum Contaminant Level.

MAROS COC Assessment

Project: Pantex SE **User Name:** MV

Location: SouthEast **State:** Texas

Toxicity:

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIA	7.7E-01	7.7E-03	9948.3%
4-AMINO-2,6-DINITROTOLUENE	7.5E-03	1.2E-03	524.2%
CHROMIUM, HEXAVALENT	5.8E-01	1.0E-01	480.9%
2-AMINO-4,6-DINITROTOLUENE	6.9E-03	1.2E-03	474.7%
2,4-DINITROTOLUENE	5.6E-03	1.0E-03	458.0%
2,4,6-TRINITROTOLUENE	9.7E-03	3.6E-03	170.2%
2,6-DINITROTOLUENE	1.7E-03	1.0E-03	66.0%
TRICHLOROETHYLENE (TCE)	6.8E-03	5.0E-03	35.6%
1,4-DIOXANE (P-DIOXANE)	8.1E-03	7.7E-03	4.8%

Note: Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations are then compared with the chosen PRG for that compound, with the percentage exceedance from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Exceedances	Percent Exceedances	Total detects
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE	ORG	79	69	87.3%	78
4-AMINO-2,6-DINITROTOLUENE	ORG	79	63	79.7%	74
2-AMINO-4,6-DINITROTOLUENE	ORG	79	55	69.6%	69
2,4-DINITROTOLUENE	ORG	79	51	64.6%	59
2,4,6-TRINITROTOLUENE	ORG	79	32	40.5%	58
CHROMIUM, HEXAVALENT	MET	55	16	29.1%	53
2,6-DINITROTOLUENE	ORG	78	20	25.6%	34
TRICHLOROETHYLENE (TCE)	ORG	79	19	24.1%	66
1,4-DIOXANE (P-DIOXANE)	ORG	34	0	0.0%	7

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total exceedances (values above the chosen PRGs) are compared to the total number of wells to determine the prevalence of the compound.

Mobility:

Contaminant of Concern	Kd
1,4-DIOXANE (P-DIOXANE)	0.000479
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZI	0.00741
4-AMINO-2,6-DINITROTOLUENE	0.0985
2-AMINO-4,6-DINITROTOLUENE	0.0985
2,4,6-TRINITROTOLUENE	0.0985
2,6-DINITROTOLUENE	0.15
2,4-DINITROTOLUENE	0.15
TRICHLOROETHYLENE (TCE)	0.297
CHROMIUM, HEXAVALENT	14

TABLE 3 COC Assessment Southeast Sector

Project: Pantex SE | **User Name:** MV

Location: SouthEast | **State:** Texas

Note: Top COCs by mobility were determined by examining each detected compound in the dataset and comparing their mobilities (Koc's for organics, assume foc = 0.001, and Kd's for metals).

Contaminants of Concern (COC's)

HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

2,4-DINITROTOLUENE

2-AMINO-4,6-DINITROTOLUENE

2,4,6-TRINITROTOLUENE

2,6-DINITROTOLUENE

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TABLE 4
INVESTIGATION WELL TREND SUMMARY RESULTS SOUTHEAST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

WellName	Number of Samples (2000 - 2007)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend	Linear Regression Trend	Overall Trend Result
RDX Southeast Sector										
PTX06-1002A	7	7	100%	**48**	Yes	**39.9**	Yes	S	S	S
PTX06-1003	7	6	86%	**16**	Yes	3.0	No	NT	NT	NT
PTX06-1005	8	8	100%	**1,340**	Yes	**581**	Yes	PD	PD	PD
PTX06-1010	8	6	75%	**673**	Yes	**181**	Yes	D	D	D
PTX06-1011	7	2	29%	**50**	Yes	7.3	No	NT	NT	NT
PTX06-1013	11	11	100%	**12**	Yes	**8.4**	Yes	I	I	I
PTX06-1014	14	14	100%	**1,780**	Yes	**1210**	Yes	I	I	I
PTX06-1015	13	13	100%	**689**	Yes	**366**	Yes	I	I	I
PTX06-1023	12	12	100%	5	No	3.9	No	S	S	S
PTX06-1030	15	15	100%	**2,080**	Yes	**1340**	Yes	I	I	I
PTX06-1031	15	15	100%	**671**	Yes	**331.0**	Yes	I	I	I
PTX06-1034	13	7	54%	**78**	Yes	**11.5**	Yes	I	I	I
PTX06-1036	13	6	46%	2	No	0.6	No	I	I	I
PTX06-1037	5	5	100%	**2,800**	Yes	**1860**	Yes	S	PD	S
PTX06-1038	14	14	100%	**1,380**	Yes	**795**	Yes	D	D	D
PTX06-1039A	11	11	100%	**1,360**	Yes	**702**	Yes	PD	D	D
PTX06-1040	14	14	100%	**1,260**	Yes	**874**	Yes	NT	NT	NT
PTX06-1041	12	12	100%	**1,300**	Yes	**885**	Yes	NT	D	S
PTX06-1042	16	16	100%	**2,650**	Yes	**1020**	Yes	S	PD	S
PTX06-1045	12	12	100%	**2,120**	Yes	**1160**	Yes	I	I	I
PTX06-1046	17	17	100%	**952**	Yes	**692**	Yes	I	I	I
PTX06-1047A	14	5	36%	**450**	Yes	**66**	Yes	I	I	I
PTX06-1052	15	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1053	17	2	12%	7	No	0.5	No	NT	PI	PI
PTX06-1069	11	1	9%	0.1	No	0.1	No	S	S	ND*
PTX06-1088	8	8	100%	**417**	Yes	**319**	Yes	PD	S	S
PTX06-1095A	3	1	33%	0.6	No	0.3	No	N/A	N/A	N/A
PTX06-1102	10	10	100%	**1,210**	Yes	**288**	Yes	PD	D	D
PTX08-1002	7	7	100%	**277**	Yes	**132**	Yes	PD	D	D
PTX08-1008	11	2	18%	0.1	No	0.1	No	S	PD	S
PTX08-1009	7	4	57%	**30**	Yes	2.6	No	NT	NT	NT
4ADNT Southeast Sector										
PTX06-1002A	7	6	86%	1	No	0.619	No	S	NT	S
PTX06-1003	7	2	29%	0.31	No	0.13	No	S	PD	S
PTX06-1005	8	5	63%	**7.5**	Yes	**2.37**	Yes	PI	NT	PI
PTX06-1010	8	3	38%	**3.7**	Yes	1.1	No	D	D	D
PTX06-1011	7	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1013	11	1	9%	0.094	No	0.0995	No	S	I	ND*
PTX06-1014	13	12	92%	**32.9**	Yes	**8.94**	Yes	D	S	PD
PTX06-1015	13	13	100%	**22.3**	Yes	**14.7**	Yes	S	D	PD
PTX06-1023	12	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1030	13	12	92%	**10.1**	Yes	**5**	Yes	I	PI	PI
PTX06-1031	14	14	100%	**4.7**	Yes	**2.66**	Yes	I	I	I
PTX06-1034	15	14	93%	**3.9**	Yes	**1.81**	Yes	I	I	I
PTX06-1036	13	10	77%	1.1	No	0.387	No	D	D	D
PTX06-1037	5	5	100%	**22**	Yes	**18.1**	Yes	S	S	S
PTX06-1038	14	12	86%	**32.9**	Yes	**13.3**	Yes	NT	NT	NT
PTX06-1039A	11	9	82%	**21.1**	Yes	**8.47**	Yes	PI	NT	PI
PTX06-1040	14	14	100%	**29.2**	Yes	**17.8**	Yes	S	S	S
PTX06-1041	12	12	100%	**28.4**	Yes	**18.2**	Yes	NT	NT	NT
PTX06-1042	16	11	69%	**10.1**	Yes	**3.32**	Yes	I	I	I
PTX06-1045	11	7	64%	**12.9**	Yes	**4.7**	Yes	NT	NT	NT
PTX06-1046	17	11	65%	**15.8**	Yes	**5.16**	Yes	I	I	I
PTX06-1047A	14	5	36%	**9.3**	Yes	**1.86**	Yes	I	I	I
PTX06-1052	15	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1053	17	13	76%	**6.3**	Yes	**1.64**	Yes	I	I	I
PTX06-1069	11	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1088	8	6	75%	**4.6**	Yes	**1.98**	Yes	NT	PI	PI
PTX06-1095A	3	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1102	9	7	78%	**8.51**	Yes	**3.35**	Yes	S	NT	S
PTX08-1002	7	4	57%	**2.8**	Yes	0.636	No	NT	NT	NT
PTX08-1008	11	9	82%	**1.8**	Yes	0.531	No	S	S	S
PTX08-1009	7	3	43%	**3.02**	Yes	0.771	No	NT	I	PI

Notes

1. Trends were evaluated for data collected between January 2000 and May 2007.
2. Number of Samples is the number of samples for the compound at this location during 2000 - 2007.
   Number of Detects is the number of samples where the compound was detected at this location.
3. The maximum concentration for the COC is the maximum analytical result analyzed between 2000 and 2007. Results above MSCs are indicated in **Bold**.
4. MSCs = Medium Specific Concentration from Corrective Measure Study. RDX = 7.7 ug/L; 4ADNT = 1.2 ug/L.
5. Maximum and average concentrations for wells with no detections are representative of the detection limits for the analyses.
6. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend;
   NT = No Trend; ND = well has all non-detect results for COC; ND* = one detection for compound, may be unaffected.
7. Mann-Kendall trend results are illustrated on Figure 3.

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TABLE 5
WELL REDUNDANCY ANALYSIS SUMMARY RESULTS SOUTHEAST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	RDX Average Slope Factor	Preliminary Statistical Result	4ADNT Average Slope Factor	Preliminary Statistical Result	Recommendation After Qualitative Review
PTX06-1002A	0.31	Retain	0.34	Retain	Retain
PTX06-1003	0.88	Retain	1.00	Retain	Retain
PTX06-1005	*0.20*	Retain	*0.19*	Retain	Retain
PTX06-1010	0.39	Retain	1.00	Retain	Retain
PTX06-1011	0.64	Retain	1.00	Retain	Retain
PTX06-1013	0.59	Retain	1.00	Retain	Retain
PTX06-1014	*0.04*	Retain	*0.09*	**Eliminate**	**Eliminate**
PTX06-1015	*0.05*	Retain	*0.14*	**Eliminate**	Retain, Consider future elimination
PTX06-1023	0.45	Retain	1.00	Retain	Retain
PTX06-1030	*0.07*	Retain	*0.13*	**Eliminate**	Retain
PTX06-1031	*0.03*	Retain	0.25	Retain	Retain
PTX06-1034	0.32	Retain	*0.14*	Retain	Retain
PTX06-1036	0.51	Retain	0.72	Retain	Retain
PTX06-1037	N/A	Retain	N/A	Retain	Retain
PTX06-1038	*0.04*	Retain	*0.05*	**Eliminate**	Retain, Consider future elimination
PTX06-1039A	*0.00*	**Eliminate**	*0.11*	Retain	Retain, Consider future elimination
PTX06-1040	*0.09*	Retain	0.28	Retain	Retain
PTX06-1041	*0.06*	Retain	0.20	Retain	Retain
PTX06-1042	*0.04*	Retain	*0.09*	**Eliminate**	Retain, Consider future elimination
PTX06-1045	*0.12*	Retain	*0.12*	Retain	Retain
PTX06-1046	*0.09*	Retain	*0.15*	Retain	Retain
PTX06-1047A	*0.12*	Retain	*0.08*	Retain	Retain
PTX06-1052	1.00	Retain	1.00	Retain	Retain
PTX06-1053	0.66	Retain	0.82	Retain	Retain
PTX06-1069	1.00	Retain	1.00	Retain	Retain
PTX06-1088	0.30	Retain	0.51	Retain	Retain
PTX06-1095A	1.00	Retain	1.00	Retain	Retain
PTX06-1102	0.41	Retain	N/A	Retain	Retain
PTX08-1002	0.27	Retain	0.49	Retain	Retain
PTX08-1008	1.00	Retain	0.49	Retain	Retain
PTX08-1009	0.92	Retain	0.33	Retain	Retain

Notes:
1. Slope Factor (SF) is the difference between the actual concentration and the concentration estimated from nearby wells normalized by the actual concentration. Slope factors close to 1 show the concentrations cannot be estimated from the adjacent wells, and the well is important in the network.
2. Slope factors were calculated using data collected between July 2005 and May 2007.
3. Well locations with slope factors below 0.3 and area ratios below 0.8 were considered for elimination.
4. N/A = Locations with insufficient data between 2005 - 2007 to calculate a slope factor.
5. Locations identified for future elimination should be reviewed, and possibly removed from the program after 5 years of data collection.

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TABLE 6
SAMPLING FREQUENCY ANALYSIS RESULTS SOUTHEAST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Recent Concentration Rate of Change [mg/yr]	Recent MK Trend (2005-2007)	Sampling Frequency Based on Recent Data (2005-2007)	Overall Concentration Rate of Change [mg/yr]	Overall MK Trend (2000 - 2007)	Sampling Frequency Based on Overall Data (2000 - 2007)	MAROS Recommended Sampling Frequency	Current Sampling Frequency
RDX Southeast Sector								
PTX06-1002A	--	N/A	--	-9.85E-07	S	Quarterly	Quarterly	Annual
PTX06-1003	--	N/A	--	-3.56E-06	NT	Annual	Annual	Annual
PTX06-1005	--	N/A	--	-4.16E-04	PD	Quarterly	Quarterly	Annual
PTX06-1010	--	N/A	--	-2.26E-04	D	Quarterly	Quarterly	Annual
PTX06-1011	--	N/A	--	8.34E-06	NT	Quarterly	Quarterly	Annual
PTX06-1013	--	N/A	--	1.32E-06	I	Quarterly	Quarterly	Annual
PTX06-1014	3.06E-04	S	Quarterly	2.30E-04	I	Quarterly	Quarterly	Semiannual
PTX06-1015	-3.23E-04	S	Annual	2.39E-04	I	Quarterly	Quarterly	Semiannual
PTX06-1023	-4.84E-06	S	Annual	-3.68E-07	S	Annual	Annual	Semiannual
PTX06-1030	-2.47E-04	S	Annual	2.89E-04	I	Quarterly	Quarterly	Semiannual
PTX06-1031	1.03E-04	S	Quarterly	2.63E-04	I	Quarterly	Quarterly	Semiannual
PTX06-1034	-9.48E-05	S	Annual	1.45E-05	I	Semiannual	Semiannual	Semiannual
PTX06-1036	-4.28E-07	S	Annual	9.17E-07	I	Annual	Biennial	Semiannual
PTX06-1037*	--	N/A	--	--	S	--	--	Dry
PTX06-1038	2.44E-04	NT	Quarterly	-1.13E-04	D	Annual	Quarterly	Semiannual
PTX06-1039A	--	N/A		-1.51E-04	PD	Quarterly	Quarterly	Annual
PTX06-1040	-2.06E-04	S	Annual	4.17E-05	NT	Quarterly	Quarterly	Semiannual
PTX06-1041	--	N/A		-2.93E-06	NT	Quarterly	Quarterly	Annual
PTX06-1042	-5.64E-04	S	Annual	-1.83E-04	S	Annual	Annual	Semiannual
PTX06-1045*	--	N/A		4.56E-04	I	Quarterly	Quarterly	Annual
PTX06-1046	5.74E-05	NT	Quarterly	1.70E-04	I	Quarterly	Quarterly	Semiannual
PTX06-1047A	--	N/A	--	1.46E-04	I	Quarterly	Quarterly	Annual
PTX06-1052	--	ND	Annual	-3.62E-39	ND	Annual	Biennial	Semiannual
PTX06-1053	-1.10E-05	NT	Annual	5.65E-07	NT	Annual	Annual	Semiannual
PTX06-1069	--	N/A	--	-5.04E-09	S	Annual	Annual	Semiannual
PTX06-1088	--	N/A	--	-4.63E-05	PD	Quarterly	Quarterly	Annual
PTX06-1095A	--	N/A	--	--	N/A	--	Annual	New Location
PTX06-1102*	--	N/A	--	-1.86E-04	PD	Quarterly	Quarterly	Biennial
PTX08-1002	--	N/A	--	-5.81E-05	PD	Quarterly	Quarterly	Annual
PTX08-1008	--	S	Annual	-6.51E-09	S	Annual	Biennial	Semiannual
PTX08-1009	--	N/A	--	2.06E-06	NT	Quarterly	Quarterly	Annual

See Notes End of Table

TABLE 6
SAMPLING FREQUENCY ANALYSIS RESULTS SOUTHEAST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Recent Concentration Rate of Change [mg/yr]	Recent MK Trend (2005-2007)	Sampling Frequency Based on Recent Data (2005-2007)	Overall Concentration Rate of Change [mg/yr]	Overall MK Trend (2000 - 2007)	Sampling Frequency Based on Overall Data (2000 - 2007)	MAROS Recommended Sampling Frequency	Current Sampling Frequency
4ADNT Southeast Sector								
PTX06-1002A	--	N/A	--	5.68E-08	S	Semiannual	Semiannual	Annual
PTX06-1003	--	N/A	--	-4.91E-08	S	Annual	Annual	Annual
PTX06-1005	--	N/A	--	1.18E-06	PI	Quarterly	Quarterly	Annual
PTX06-1010	--	N/A	--	-1.43E-06	D	Annual	Annual	Annual
PTX06-1011	--	N/A	--	0.00E+00	S	Annual	Annual	Annual
PTX06-1013	--	N/A	--	1.36E-10	S	Annual	Annual	Annual
PTX06-1014	-9.81E-06	S	Annual	-3.31E-06	D	Annual	Annual	Semiannual
PTX06-1015	-6.14E-06	S	Annual	-3.77E-07	S	Annual	Annual	Semiannual
PTX06-1023	0.00E+00	S	Annual	0.00E+00	S	Annual	Biennial	Semiannual
PTX06-1030	1.18E-05	I	Quarterly	2.53E-06	I	Semiannual	Quarterly	Semiannual
PTX06-1031	-9.84E-07	S	Annual	7.25E-07	I	Annual	Annual	Semiannual
PTX06-1034	-5.49E-07	S	Annual	1.58E-06	I	Annual	Annual	Semiannual
PTX06-1036	-8.09E-09	S	Annual	-3.82E-07	D	Annual	Biennial	Semiannual
PTX06-1037*	--	N/A	--	--	N/A	--	--	Dry
PTX06-1038	1.09E-05	NT	Quarterly	2.76E-06	NT	Semiannual	Quarterly	Semiannual
PTX06-1039A	--	N/A	--	3.82E-06	PI	Quarterly	Quarterly	Annual
PTX06-1040	2.79E-06	NT	Semiannual	-1.38E-06	S	Annual	Semiannual	Semiannual
PTX06-1041	--	N/A	--	7.15E-08	NT	Quarterly	Quarterly	Annual
PTX06-1042	-3.42E-06	S	Annual	2.39E-06	I	Semiannual	Semiannual	Semiannual
PTX06-1045*	--	N/A	--	3.34E-06	NT	Quarterly	Quarterly	Annual
PTX06-1046	1.22E-05	NT	Quarterly	3.22E-06	I	Semiannual	Quarterly	Semiannual
PTX06-1047A	--	N/A	--	3.55E-06	I	Quarterly	Quarterly	Annual
PTX06-1052	0.00E+00	S	Annual	-3.62E-39	S	Annual	Biennial	Semiannual
PTX06-1053	-6.32E-06	D	Annual	1.63E-06	I	Annual	Annual	Semiannual
PTX06-1069	--	N/A	--	-4.26E-39	S	Annual	Annual	Semiannual
PTX06-1088	--	N/A	--	3.08E-06	NT	Quarterly	Quarterly	Annual
PTX06-1095A	--	N/A	--	0.00E+00	N/A	Annual	Annual	New Location
PTX06-1102*	--	--	--	--	--	--	--	Biennial
PTX08-1002	--	N/A	--	-1.22E-07	NT	Annual	Annual	Annual
PTX08-1008	-7.85E-07	D	Annual	1.43E-08	S	Annual	Biennial	Semiannual
PTX08-1009	--	N/A	--	1.12E-06	NT	Quarterly	Quarterly	Annual

Notes:
1. 'Recent' concentration rate of change and MK trends are calculated from data collected 2005 - 2007.
2. MK = Mann Kendall Trend; D = Decreasing, PD = Probably Decreasing, S = Stable, NT = No Trend, PI = Probably Increasing, I = Increasing, ND = Non-detect, N/A = insufficient data, less than 4 sample events for time interval indicated.
3. Overall rate of change and MK trend are for the full data set (2000-2007) for each well.
4. MAROS Recommended Sampling Frequency is the sampling frequency from MAROS based on both recent and overall trends.
5. Current sampling frequency is the approximate sampling frequency currently implemented.
6. The final recommended sampling frequency is listed on Table 7, and is based on a combination of qualitative and statistical evaluations.
7. * = Well is dry or intermittently dry. Dry wells should be evaluated periodically for saturation.

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TABLE 7
FINAL RECOMMENDED MONITORING NETWORK SOUTHEAST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	RDX Percent Detection	RDX Mann Kendall Trend	RDX Average SF	4ADNT Percent Detection	4ADNT Mann Kendall Trend	4ADNT Average SF	Sampling Recommendation	Rationale
Southeast Sector								
PTX06-1002A	100%	S	0.31	86%	S	0.34	Semiannual	Source monitoring for RDX
PTX06-1003	86%	NT	0.88	29%	S	1.00	Annual	Downgradient from source, spatially important to track reduction in concentrations.
PTX06-1005	100%	PD	0.20	63%	PI	0.19	Semiannual	Downgradient from source, spatially important to track reduction in concentrations.
PTX06-1010	75%	D	0.39	38%	D	1.00	Semiannual	Source area monitors decreasing trends
PTX06-1011	29%	NT	0.64	0%	ND	1.00	Annual	Monitors near TCE plume, near variable groundwater flow direction.
PTX06-1013	100%	I	0.59	9%	S	1.00	Semiannual	Monitors northern edge of Southeast Sector near Playa1.
PTX06-1014	100%	I	0.04	92%	D	0.09	***Eliminate***	Redundant with PTX06-1030, PTX06 1042.
PTX06-1015	100%	I	0.05	100%	S	0.14	Semiannual	Downgradient, center of plume, monitors movement of COCs toward edge of unit.
PTX06-1023	100%	S	0.45	0%	ND	1.00	Annual	Delineates northern most area of Southeast Sector near Playa 1.
PTX06-1030	100%	I	0.07	92%	I	0.13	Semiannual	Easternmost well, monitors edge of plume before unit pinches out.
PTX06-1031	100%	I	0.03	100%	I	0.25	Semiannual	Easternmost well, monitors edge of plume before unit pinches out.
PTX06-1034	54%	I	0.32	93%	I	0.14	Semiannual	Easternmost well, monitors edge of plume before unit pinches out.
PTX06-1036	46%	I	0.51	77%	D	0.72	Annual	Delineates southern edge of plume, monitors movement of COCs from south of Zones 11 and 12 toward southern edge of perched unit.
PTX06-1037	100%	S	N/A	100%	S	N/A	Annual HG	Well possibly dry, perform hydrogeologic monitoring to confirm saturation status.
PTX06-1038	100%	D	0.04	86%	NT	0.05	Semiannual	Monitors decreasing trends along DOE property line, consider removing from program after 4 more sampling events.
PTX06-1039A	100%	PD	0.00	82%	PI	0.11	Semiannual	Monitors DOE property boundary, no wells east of this point, may be redundant, but more data required.
PTX06-1040	100%	NT	0.09	100%	S	0.28	Semiannual	Monitors high concentrations along DOE property line, no wells in saturated perched groundwater east of this point.
PTX06-1041	100%	NT	0.06	100%	NT	0.20	Semiannual	Monitors high concentrations along DOE property line, no wells in saturated perched groundwater east of this point.
PTX06-1042	100%	S	0.04	69%	I	0.09	Annual	Monitors high concentrations along DOE property line, no wells in saturated perched groundwater east of this point.

See Notes End of Table

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TABLE 7
FINAL RECOMMENDED MONITORING NETWORK SOUTHEAST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

	RDX			4ADNT				
Well Name	Percent Detection	Mann Kendall Trend	Average SF	Percent Detection	Mann Kendall Trend	Average SF	Sampling Recommendation	Rationale
Southeast Sector								
PTX06-1045	100%	I	0.12	64%	NT	0.12	Annual HG	Well possibly dry, perform hydrogeologic monitoring to confirm saturation status.
PTX06-1046	100%	I	0.09	65%	I	0.15	Semiannual	Monitors southern extent of perched unit, high and increasing concentrations of COCs.
PTX06-1047A	36%	I	0.12	36%	I	0.08	Semiannual	Monitors southern extent of perched unit, high and increasing concentrations of COCs.
PTX06-1052	0%	ND	1.00	0%	ND	1.00	Annual	Monitors unaffected groundwater south of source.
PTX06-1053	12%	NT	0.66	76%	I	0.82	Semiannual	Delineates 4ADNT plume to south, near groundwater flow divide, early warning for movement of COCs to south/southeastern extent of perched groundwater.
PTX06-1069	9%	S	1.00	0%	ND	1.00	Annual	Delineation of northern sector of perched groundwater.
PTX06-1088	100%	PD	0.30	75%	NT	0.51	Semiannual	Source area monitors decreasing trends, important for 1,3,5-trinitrobenzene.
PTX06-1095A	33%	N/A	1.00	0%	ND	1.00	Semiannual	Downgradient from source, spatially important to track reduction in concentrations.
PTX06-1102	100%	PD	0.41	78%	S	N/A	Annual HG	Well possibly dry, perform hydrogeologic monitoring to confirm saturation status.
PTX08-1002	100%	PD	0.27	57%	NT	0.49	Semiannual	Monitors decreasing source area near Playa 1
PTX08-1008	18%	S	1.00	82%	S	0.49	Semiannual	Chromium monitoring location
PTX08-1009	57%	NT	0.92	43%	NT	0.33	Semiannual	Chromium monitoring location

Notes:
1. HG = Well is either dry or intermittently dry; monitor well at indicated frequency for saturation.
2. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine result;
NT = No Trend; ND = well has all non-detect results for COC indicated.
3. Mann-Kendall trends for 2000 - 2007 are shown.
4. SF = Slope Factor. SF close to 1 indicates well provides unique information in network. SF near 0 indicates well may be redundant.
5. Percent detection is the ratio of the number of detections to the number of samples for the compound indicated multiplied by 100.

MAROS COC Assessment

Project: Pantex SW **User Name:** MV

Location: Southwest Area **State:** Texas

Toxicity:

Contaminant of Concern	Representative Concentration (mg/L)	PRG (mg/L)	Percent Above PRG
CHROMIUM, HEXAVALENT	3.6E-01	1.0E-01	260.9%
4-AMINO-2,6-DINITROTOLUENE	2.0E-03	1.2E-03	67.7%
PERCHLORATE	3.4E-02	2.6E-02	31.9%
TRICHLOROETHYLENE (TCE)	6.1E-03	5.0E-03	21.4%

Note: Top COCs by toxicity were determined by examining a representative concentration for each compound over the entire site. The compound representative concentrations are then compared with the chosen PRG for that compound, with the percentage exceedance from the PRG determining the compound's toxicity. All compounds above exceed the PRG.

Prevalence:

Contaminant of Concern	Class	Total Wells	Total Exceedances	Percent Exceedances	Total detects
TRICHLOROETHYLENE (TCE)	ORG	29	7	24.1%	14
PERCHLORATE	INO	29	6	20.7%	14
4-AMINO-2,6-DINITROTOLUENE	ORG	29	4	13.8%	11
CHROMIUM, HEXAVALENT	MET	29	2	6.9%	23

Note: Top COCs by prevalence were determined by examining a representative concentration for each well location at the site. The total exceedances (values above the chosen PRGs) are compared to the total number of wells to determine the prevalence of the compound.

Mobility:

Contaminant of Concern	Kd
PERCHLORATE	
4-AMINO-2,6-DINITROTOLUENE	0.0985
TRICHLOROETHYLENE (TCE)	0.297
CHROMIUM, HEXAVALENT	14

Note: Top COCs by mobility were determined by examining each detected compound in the dataset and comparing their mobilities (Koc's for organics, assume foc = 0.001, and Kd's for metals).

Contaminants of Concern (COC's)

TRICHLOROETHYLENE (TCE)

PERCHLORATE

4-AMINO-2,6-DINITROTOLUENE

HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

CHROMIUM, HEXAVALENT

TABLE 9
INVESTIGATION WELL TREND SUMMARY RESULTS SOUTHWEST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson, Texas

Well Name	Number of Samples (2000 - 2007)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend	Linear Regression Trend	Overall Trend Result
TCE Southwest Sector										
1114-MW4	6	6	100%	**14.7**	Yes	**8.97**	Yes	PI	I	PI
PTX06-1006	3	1	33%	0.5	No	0.5	No	N/A	N/A	N/A
PTX06-1007	6	5	83%	0.8	No	0.5	No	S	S	S
PTX06-1008	5	5	100%	**28.8**	Yes	**15.1**	Yes	S	S	S
PTX06-1012	12	4	33%	2.3	No	0.8	No	PI	I	PI
PTX06-1035	10	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX06-1036	13	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX06-1049	11	1	9%	1.5	No	0.6	No	NT	PI	ND*
PTX06-1052	15	7	47%	1.4	No	0.7	No	D	D	D
PTX06-1053	17	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX06-1077A	6	5	83%	**15.2**	Yes	**10.3**	Yes	NT	NT	NT
PTX06-1085	4	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX06-1086	8	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX06-1087	4	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX07-1P02	7	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX07-1P03	4	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX07-1P06	10	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX07-1Q01	5	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX07-1Q02	5	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX07-1Q03	7	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX08-1001	7	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX08-1003	6	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX08-1005	6	6	100%	**126.0**	Yes	**57.1**	Yes	NT	NT	NT
PTX08-1006	8	8	100%	**8**	Yes	**5.3**	Yes	S	S	S
PTX08-1007	4	4	100%	**16.0**	Yes	**13.6**	Yes	S	S	S
PTX08-1008	11	3	27%	1	No	0.5	No	NT	PI	PI
PTX08-1009	8	6	75%	2.1	No	1.0	No	NT	NT	NT
PTX10-1008	6	0	0%	0.5	No	0.5	No	ND	ND	ND
PTX10-1013	7	7	100%	**116.0**	Yes	**46.5**	Yes	NT	PI	PI
Perchlorate Southwest Sector										
1114-MW4	5	5	100%	**336**	Yes	**236**	Yes	D	D	D
PTX06-1006	4	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX06-1007	6	6	100%	**128**	Yes	**111**	Yes	S	S	S
PTX06-1008	4	1	25%	5.04	No	2.39	No	NT	NT	ND*
PTX06-1012	12	4	33%	**43.8**	Yes	12.6	No	I	I	I
PTX06-1035	10	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX06-1036	12	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX06-1049	9	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX06-1052	14	1	7%	4.57	No	1.72	No	S	PD	ND*
PTX06-1053	16	4	25%	5.72	No	2.35	No	D	D	D
PTX06-1077A	4	2	50%	5.99	No	3.48	No	NT	PI	PI
PTX06-1085	4	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX06-1086	8	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX06-1087	4	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX07-1P02	7	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX07-1P03	4	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX07-1P06	9	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX07-1Q01	5	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX07-1Q02	5	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX07-1Q03	7	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX08-1001	7	7	100%	**70.5**	Yes	**61.1**	Yes	NT	PI	PI
PTX08-1003	7	7	100%	**38.3**	Yes	**31.2**	Yes	D	D	D
PTX08-1005	5	5	100%	**386**	Yes	**230**	Yes	D	D	D
PTX08-1006	9	9	100%	**408**	Yes	**178**	Yes	D	D	D
PTX08-1007	3	2	67%	12.3	No	7	No	N/A	N/A	N/A
PTX08-1008	12	1	8%	5.05	No	1.8	No	S	D	ND*
PTX08-1009	7	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX10-1008	6	0	0%	1.5	No	1.5	No	ND	ND	ND
PTX10-1013	7	2	29%	6.79	No	2.75	No	NT	NT	NT

See Notes End of Table

TABLE 9
INVESTIGATION WELL TREND SUMMARY RESULTS SOUTHWEST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson, Texas

Well Name	Number of Samples (2000 - 2007)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend	Linear Regression Trend	Overall Trend Result
4ADNT Southwest Sector										
1114-MW4	3	1	33%	0.545	No	0.248	No	N/A	N/A	N/A
PTX06-1006	3	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1007	3	3	100%	**14.8**	Yes	**11.7**	Yes	N/A	N/A	N/A
PTX06-1008	4	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1012	12	1	8%	0.079	No	0.0977	No	NT	NT	ND*
PTX06-1035	10	8	80%	**48.5**	Yes	**5.65**	Yes	NT	NT	NT
PTX06-1036	13	10	77%	1.1	No	0.387	No	D	D	D
PTX06-1049	11	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1052	15	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1053	17	13	76%	**6.3**	Yes	**1.64**	Yes	I	I	I
PTX06-1077A	4	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1085	4	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1086	8	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX06-1087	4	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX07-1P02	6	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX07-1P03	4	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX07-1P06	10	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX07-1Q01	5	1	20%	0.072	No	0.1	No	S	S	ND*
PTX07-1Q02	5	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX07-1Q03	7	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX08-1001	7	1	14%	**2.4**	Yes	0.4	No	NT	PD	ND*
PTX08-1003	6	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX08-1005	6	6	100%	**2.3**	Yes	1.5	Yes	D	D	D
PTX08-1006	8	8	100%	**47.8**	Yes	**38.1**	Yes	NT	NT	NT
PTX08-1007	2	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX08-1008	11	9	82%	**1.8**	Yes	0.5	No	S	S	S
PTX08-1009	7	3	43%	**3.02**	Yes	0.8	No	NT	I	PI
PTX10-1008	6	0	0%	0.1	No	0.1	No	ND	ND	ND
PTX10-1013	6	0	0%	0.1	No	0.1	No	ND	ND	ND

Notes

1. Trends were evaluated for data collected between January 2000 and May 2007.
2. Number of Samples is the number of samples for the compound at this location.
   Number of Detects is the number of samples where the compound was detected at this location.
3. Maximum Result is the maximum concentration for the COC analyzed between 2000 and 2007. Results above MSCs are indicated in **Bold**.
4. Screening level from Corrective Measure Study. TCE = 5 ug/L; Perchlorate = 26 ug/L; 4ADNT = 1.2 ug/L.
5. Maximum and average concentrations for wells with no detections are representative of the detection limits for the analyses.
6. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend;
   NT = No Trend; ND = well has all non-detect results for COC, ND* = one detection for compound, may be unaffected.

TABLE 10
WELL REDUNDANCY ANALYSIS SUMMARY RESULTS SOUTHWEST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Perchlorate Average Slope Factor	Preliminary Statistical Result	TCE Average Slope Factor	Preliminary Statistical Result	Recommendation After Qualitative Review
1114-MW4	0.49	Retain	0.43	Retain	Retain
PTX06-1006	N/A		N/A		***Eliminate*** (redundant with PTX06-1011)
PTX06-1007	0.74	Retain	0.65	Retain	Retain
PTX06-1008	N/A		N/A		Retain (TCE)
PTX06-1012	0.89	Retain	0.39	Retain	Retain
PTX06-1035	0.83	Retain	0.33	Retain	Retain
PTX06-1036*	0.00	Retain	0.05	Retain	Retain (SE)
PTX06-1049	0.74	Retain	0.22	Retain	Retain
PTX06-1052*	0.00	Retain	0.17	Retain	Retain (SE)
PTX06-1053*	0.64	Retain	0.16	Retain	Retain (SE)
PTX06-1077A	N/A		0.56	Retain	Retain
PTX06-1085	N/A		N/A		Retain
PTX06-1086	0.79	Retain	0.41	Retain	Retain
PTX06-1087	N/A		N/A		***Eliminate***
PTX07-1P02	0.89	Retain	0.26	Retain	***Eliminate***
PTX07-1P03	N/A		N/A		***Eliminate***
PTX07-1P06	0.88	Retain	0.03	Retain	Retain
PTX07-1Q01	0.86	Retain	0.77	Retain	Retain
PTX07-1Q02	0.36	Retain	0.24	Retain	***Eliminate***
PTX07-1Q03	0.89	Retain	0.60	Retain	Retain
PTX08-1001	0.75	Retain	0.25	Retain	Retain
PTX08-1003	0.29	Retain	0.43	Retain	Retain
PTX08-1005	N/A	Retain	0.62	Retain	Retain
PTX08-1006	0.25	Retain	0.08	Eliminate	Retain (4ADNT)
PTX08-1007	N/A	Retain	N/A		Retain (TCE)
PTX08-1008*	0.74	Retain	0.18	Retain	Retain (SE)
PTX08-1009*	0.91	Retain	0.29	Retain	Retain (SE)
PTX10-1008	N/A		N/A		***Eliminate***
PTX10-1013	0.87	Retain	0.78	Retain	Retain

Notes:
1. Slope Factor (SF) is the difference between the actual concentration and the concentration estimated from nearby wells normalized by the actual concentration. Slope factors close to 1 show the concentrations cannot be estimated from the nearby wells, and the well is important in the network.
2. Slope factors were calculated using data collected between July 2005 and May 2007.
3. Well locations with slope factors below 0.3 and area ratios below 0.8 were considered for elimination. () = well retained for Southeast (SE) or for other COC indicated.
4. N/A = Locations with insufficient data between 2005 - 2007 to calculate a slope factor.
5. Wells recommended for elimination are not recommended for plugging and abandonment, but should be retained for hydrogeologic monitoring.
6. * = Well included in Southeast network, recommendation based on COCs from Southeast Sector.

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TABLE 11
SAMPLING FREQUENCY ANALYSIS RESULTS SOUTHWEST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Recent Concentration Rate of Change [mg/yr]	Recent MK Trend (2005-2007)	Sampling Frequency Based on Recent Data (2005-2007)	Overall Concentration Rate of Change [mg/yr]	Overall MK Trend (2000 - 2007)	Sampling Frequency Based on Overall Data (2000 - 2007)	MAROS Recommended Sampling Frequency	Current Sampling Frequency
TCE Southwest Sector								
1114-MW4	6.52E-06	NT	Annual	5.62E-06	PI	Annual	Annual	Annual
PTX06-1006	--	N/A	--	--	N/A	--	N/A	Not Sampled
PTX06-1007	--	N/A	Annual	-7.70E-08	S	Annual	Annual	Annual
PTX06-1008	--	N/A	Semiannual	-3.60E-06	S	Semiannual	Semiannual	Annual (to 2004)
PTX06-1012	1.80E-06	PI	Annual	6.12E-07	PI	Annual	Biennial	Semiannual
PTX06-1035	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Semiannual
PTX06-1036	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Semiannual
PTX06-1049	2.85E-07	NT	Annual	1.49E-07	NT	Annual	Biennial	Annual
PTX06-1052	-6.16E-08	S	Annual	-2.97E-07	D	Annual	Biennial	Semiannual
PTX06-1053	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Semiannual
PTX06-1077A	--	N/A	Quarterly	4.61E-06	NT	Quarterly	Quarterly	Annual
PTX06-1085	--	ND	Annual	0.00E+00	ND	Annual	Annual	Not Sampled
PTX06-1086	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Annual
PTX06-1087	--	ND	Annual	0.00E+00	ND	Annual	Annual	Not Sampled
PTX07-1P02	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Annual
PTX07-1P03	--	ND	--	--	ND	--	N/A	Not Sampled
PTX07-1P06	--	ND	Annual	0.00E+00	ND	Annual	Annual	Annual
PTX07-1Q01	--	ND	Annual	0.00E+00	ND	Annual	Annual	Annual
PTX07-1Q02	--	ND	Annual	0.00E+00	ND	Annual	Annual	Biennial
PTX07-1Q03	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Annual
PTX08-1001	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Annual
PTX08-1003	--	ND	Annual	0.00E+00	ND	Annual	Annual	Annual
PTX08-1005	--	N/A	Quarterly	1.97E-05	NT	Quarterly	Quarterly	Annual
PTX08-1006	1.56E-07	S	Annual	-1.07E-06	S	Annual	Annual	Annual
PTX08-1007	--	N/A	--	--	N/A	--	N/A	Not Sampled
PTX08-1008	1.12E-07	NT	Annual	5.63E-08	NT	Annual	Biennial	Semiannual
PTX08-1009	1.05E-06	NT	Annual	1.90E-07	NT	Annual	Biennial	Annual
PTX10-1008	--	ND	Annual	0.00E+00	ND	Annual	Annual	Not Sampled
PTX10-1013	--	N/A	Quarterly	2.53E-05	NT	Quarterly	Quarterly	Annual

See Notes End of Table

TABLE 11
SAMPLING FREQUENCY ANALYSIS RESULTS SOUTHWEST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Recent Concentration Rate of Change [mg/yr]	Recent MK Trend (2005-2007)	Sampling Frequency Based on Recent Data (2005-2007)	Overall Concentration Rate of Change [mg/yr]	Overall MK Trend (2000 - 2007)	Sampling Frequency Based on Overall Data (2000 - 2007)	MAROS Recommended Sampling Frequency	Current Sampling Frequency
Perchlorate Southwest Sector								
1114-MW4	-1.98E-04	D	Annual	-1.09E-04	D	Annual	Annual	Annual
PTX06-1006	--	ND	--	--	ND	--	--	Not Sampled
PTX06-1007	--	N/A	Quarterly	-5.84E-06	S	Quarterly	Quarterly	Annual
PTX06-1008	--	N/A	Annual	5.41E-07	NT	Annual	Annual	Annual (to 2004)
PTX06-1012	4.75E-05	PI	Annual	1.80E-05	I	Annual	Annual	Semiannual
PTX06-1035	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Semiannual
PTX06-1036	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Semiannual
PTX06-1049	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Annual
PTX06-1052	0.00E+00	S	Annual	-4.11E-07	S	Annual	Biennial	Semiannual
PTX06-1053	0.00E+00	S	Annual	-1.06E-06	D	Annual	Biennial	Semiannual
PTX06-1077A	--	N/A	--	--	N/A	--	--	Not Sampled
PTX06-1085	--	ND	Annual	0.00E+00	ND	Annual	Annual	Not Sampled
PTX06-1086	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Annual
PTX06-1087	--	ND	Annual	0.00E+00	ND	Annual	Annual	Not Sampled
PTX07-1P02	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Annual
PTX07-1P03	--	ND	--	--	ND	--	N/A	Not Sampled
PTX07-1P06	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Annual	Annual
PTX07-1Q01	--	ND	Annual	0.00E+00	ND	Annual	Annual	Annual
PTX07-1Q02	--	ND	Annual	0.00E+00	ND	Annual	Annual	Biennial
PTX07-1Q03	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Annual
PTX08-1001	4.63E-06	NT	Annual	1.12E-05	NT	Annual	Annual	Annual
PTX08-1003	--	N/A	Quarterly	-6.41E-06	D	Quarterly	Quarterly	Annual
PTX08-1005	--	N/A	--	--	N/A	--	--	Annual
PTX08-1006	1.79E-05	NT	Annual	-1.06E-04	D	Annual	Annual	Annual
PTX08-1007	--	ND	--	--	N/A	--	N/A	Not Sampled
PTX08-1008	0.00E+00	S	Annual	-7.34E-07	S	Annual	Biennial	Semiannual
PTX08-1009	0.00E+00	ND	Annual	0.00E+00	ND	Annual	Biennial	Annual
PTX10-1008	--	ND	Annual	0.00E+00	ND	Annual	Annual	Not Sampled
PTX10-1013	--	N/A	Annual	1.20E-06	NT	Annual	Annual	Annual

Notes:
1. 'Recent' concentration rate of change and MK trends are calculated from data collected 2005 - 2007.
2. MK = Mann Kendall Trend; D = Decreasing, PD = Probably Decreasing, S = Stable, NT = No Trend, PI = Probably Increasing, I = Increasing, ND = Non-detect, N/A = insufficient data, less than 4 sample events for time interval indicated.
3. Overall rate of change and MK trend are for the full data set (2000-2007) for each well.
4. MAROS Recommended Sampling Frequency is the sampling frequency from MAROS based on both recent and overall trends.
5. Current sampling frequency is the approximate sampling frequency currently implemented.
6. The final recommended sampling frequency is based on a combination of qualitative and statistical evaluations.
7. * = Well is dry or intermittently dry. Dry wells should be evaluated periodically for saturation.

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TABLE 12
FINAL RECOMMENDED MONITORING NETWORK SOUTHWEST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	TCE			Perchlorate			Sampling Recommendation	Rationale
	Percent Detection	Mann Kendall Trend	Average SF	Percent Detection	Mann Kendall Trend	Average SF		
Southwest Sector								
1114-MW4	100%	PI	0.43	100%	D	0.49	Semiannual	Monitors area of high TCE and Perchlorate, new well installation south of current location should require 2 yrs of semiannual monitoring, consider reducing to annual monitoring after 2 yrs.
PTX06-1006	33%	N/A	N/A	0%	ND	N/A	Eliminate	Largely non-detect, does not provide unique information.
PTX06-1007	83%	S	0.65	100%	S	0.74	Annual	Defines edge of perchlorate plume, stable trends.
PTX06-1008	100%	S	N/A	25%	NT	N/A	Annual	Defines western edge of TCE source; stable trends.
PTX06-1012	33%	PI	0.39	33%	I	0.89	Semiannual	Defines area of high concentrations for TCE and perchlorate, monitor semiannually after installation of new wells for approximately 3 years.
PTX06-1035	0%	ND	0.33	0%	ND	0.83	Annual	Delineates plume to non-detect at southern edge.
PTX06-1036*	0%	ND	0.05	0%	ND	0.00	Annual	Delineates southern edge of Southeast Sector, monitors movement of COCs from south of Zones 11 and 12 toward southern edge of perched unit.
PTX06-1049	9%	NT	0.22	0%	ND	0.74	Biennial	Monitors far northern edge of Southwestern Sector, delineates some COCs to non-detect.
PTX06-1052*	47%	D	0.17	7%	S	0.00	Annual	Non-detect well, south of source area.
PTX06-1053*	0%	ND	0.16	25%	D	0.64	Semiannual	Delineates 4ADNT plume to south, near groundwater flow divide, early warning for movement of COCs to south/southeastern extent of perched groundwater.
PTX06-1077A	83%	NT	0.56	50%	NT	N/A	Annual	Delineated edge of perchlorate and TCE plume to west.
PTX06-1085	0%	ND	N/A	0%	ND	N/A	Biennial	Delineates perched unit to the west of Playa 2, largely non-detect for all COCs.
PTX06-1086	0%	ND	0.41	0%	ND	0.79	Biennial	Delineates western edge of plume, largely non-detect, reduce monitoring frequency.
PTX06-1087	0%	ND	N/A	0%	ND	N/A	Eliminate	Redundant with other wells in this area, delineates plume, keep for hydrogeologic monitoring.

See notes end of table.

TABLE 12
FINAL RECOMMENDED MONITORING NETWORK SOUTHWEST SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

	TCE			Perchlorate				
Well Name	Percent Detection	Mann Kendall Trend	Average SF	Percent Detection	Mann Kendall Trend	Average SF	Sampling Recommendation	Rationale
Southwest Sector								
PTX07-1P02	0%	ND	0.26	0%	ND	0.89	Eliminate	Monitors area around SWMU 68c, largely non-detect and redundant with other locations.
PTX07-1P03	0%	ND	N/A	0%	ND	N/A	Eliminate	Monitors area around SWMU 68c, largely non-detect and redundant with other locations.
PTX07-1P06	0%	ND	0.03	0%	ND	0.88	Annual	Monitors area around SWMU 68c for RDX.
PTX07-1Q01	0%	ND	0.77	0%	ND	0.86	Biennial	Delineates Southwest Sector to southwest, retain as delineation point at reduced sampling frequency.
PTX07-1Q02	0%	ND	0.24	0%	ND	0.36	Eliminate	Redundant with PTX07-1Q01.
PTX07-1Q03	0%	ND	0.60	0%	ND	0.89	Biennial	Monitors upgradient of SWMU 68d, largely non-detect reduce frequency of sampling.
PTX08-1001	0%	ND	0.25	100%	NT	0.75	Annual	Monitors northern edge of perchlorate plume.
PTX08-1003	0%	ND	0.43	100%	D	0.29	Annual	Monitors southern extent of perched unit, high and increasing concentrations of COCs.
PTX08-1005	100%	NT	0.62	100%	D	N/A	Semiannual	Defines area of high concentrations for TCE and perchlorate, monitor semiannually after installation of new wells for approximately 3 years.
PTX08-1006	100%	S	0.08	100%	D	0.25	Semiannual	Defines area of high concentrations for TCE and perchlorate, monitor semiannually after installation of new wells for approximately 3 years.
PTX08-1007	100%	S	N/A	67%	N/A	N/A	Annual	Delineates edge of TCE plume, largely stable trends.
PTX08-1008*	27%	NT	0.18	8%	S	0.74	Semiannual	Chromium monitoring location
PTX08-1009*	75%	NT	0.29	0%	ND	0.91	Semiannual	Chromium monitoring location
PTX10-1008	0%	ND	N/A	0%	ND	N/A	Eliminate	Investigated groundwater at AOC 6b; non-detect so eliminate from program.
PTX10-1013	100%	NT	0.78	29%	NT	0.87	Annual	Monitors decreasing source area near Playa 1

Notes:
1. HG = Well is either dry or intermittently dry; monitor well at indicated frequency for saturation.
2. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend; NT = No Trend; ND = well has all non-detect results for COC indicated.
3. Mann-Kendall trends for 2000 - 2007 are shown.
4. SF = Slope Factor. SF close to 1 indicates well provides unique information in network. SF near 0 indicates well may be redundant.

TABLE 13
INVESTIGATION WELL TREND SUMMARY RESULTS NORTH SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

WellName	Number of Samples (2000 - 2007)	Number of Detects	Percent Detection	Maximum Concentration [ug/L]	Maximum Above MSC?	Average Concentration [ug/L]	Average Above MSC?	Mann-Kendall Trend	Linear Regression Trend	Overall Trend Result
RDX North Sector										
PTX04-1002	12	7	58%	0.4	No	0.2	No	S	S	S
PTX06-1013	10	10	100%	**12**	Yes	**8.4**	Yes	PI	I	PI
PTX06-1023	12	12	100%	5	No	3.9	No	S	S	S
PTX06-1050	10	10	100%	**546**	Yes	**281**	Yes	I	I	I
PTX06-1069	11	1	9%	0.2	No	0	No	S	S	ND*
PTX06-1114	2	1	50%	**32**	Yes	**15.9**	Yes	N/A	N/A	N/A
PTX07-1O01	6	6	100%	**53**	Yes	**42**	Yes	NT	NT	NT
PTX07-1O02	3	3	100%	**10**	Yes	7	No	N/A	N/A	N/A
PTX07-1O03	7	7	100%	**39**	Yes	**31**	Yes	S	PD	S
PTX07-1P02	6	5	83%	4	No	2	No	D	PD	D
PTX07-1P06	10	10	100%	**109**	Yes	**41**	Yes	D	D	D
PTX07-1R03	8	1	13%	0.2	No	0.1	No	NT	S	ND*
PTX08-1001	7	3	43%	0.9	No	0.3	No	NT	NT	NT
PTX08-1002	7	7	100%	**277**	Yes	**132**	Yes	PD	D	D
PTX08-1010	14	2	14%	0.3	No	0.1	No	S	S	S
4ADNT North Sector										
PTX01-1001	23	2	9%	0.20	No	0.11	No	NT	NT	NT
PTX06-1013	10	1	10%	0.09	No	0.10	No	NT	I	ND*
PTX06-1048A	15	5	33%	0.19	No	0.11	No	S	NT	S
PTX06-1050	10	8	80%	**4.6**	Yes	**2.26**	Yes	NT	NT	NT
PTX06-1114	2	2	100%	0.474	No	0.5	No	N/A	N/A	N/A
PTX07-1O01	6	5	83%	0.74	No	0.5	No	NT	NT	NT
PTX07-1O03	7	3	43%	0.1	No	0.1	No	NT	NT	NT
PTX08-1001	7	1	14%	**2.4**	Yes*	0.4	No	NT	PD	ND*
PTX08-1002	7	4	57%	**2.8**	Yes	0.6	No	NT	NT	NT
PTX-BEG3	13	11	85%	0.53	No	0.3	No	PI	NT	PI
Perchlorate North Sector										
PTX01-1001	24	16	67%	**146**	Yes	20.9	No	NT	NT	NT
PTX01-1002	24	2	8%	5.59	No	1.7	No	S	D	PD
PTX06-1048A	14	1	7%	4.93	No	1.76	No	S	S	ND*
TCE North Sector										
PTX01-1001	25	15	60%	**17**	Yes	4.3	No	PI	I	PI
PTX01-1008	14	7	50%	**7**	Yes	1.3	No	D	D	D
PTX04-1001	7	7	100%	**2**	Yes	1.5	No	S	S	S
PTX04-1002	14	13	93%	1.4	No	0.9	No	D	D	D
PTX06-1048A	15	14	93%	4.1	No	2.9	No	D	S	PD
PTX06-1081	12	10	83%	0.8	No	0.6	No	PI	NT	PI
PTX07-1O01	5	1	20%	0.4	No	0.5	No	S	PD	ND*
PTX07-1O02	4	4	100%	1.0	No	0.9	No	I	I	I
PTX07-1O06	9	5	56%	0.9	No	0.6	No	NT	NT	NT
PTX08-1010	14	2	14%	0.4	No	0.5	No	NT	I	PI

Notes

1. Only wells where the COC indicated was detected are shown. Trends were evaluated for data collected between January 2000 and May 2007.
2. Number of Samples is the number of samples for the compound at this location during 2000 - 2007.
   Number of Detects is the number of samples where the compound was detected at this location.
3. The maximum concentration for the COC is the maximum analytical result analyzed between 2000 and 2007. Results above MSCs are indicated in **Bold**.
4. MSCs = Medium Specific Concentration from Corrective Measure Study. RDX = 7.7 ug/L; 4ADNT = 1.2 ug/L; TCE = 5ug/L; Cr = 100 ug/L; Perchlorate = 26ug/L..
5. No exceedances of Cr(VI) were found in North Sector wells.
6. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend;
   NT = No Trend; ND = well has all non-detect results for COC; ND* = one detection for compound, may be unaffected.

TABLE 14
SAMPLING FREQUENCY ANALYSIS RESULTS NORTH SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Priority Constituent at Location	Overall Concentration Rate of Change [mg/yr]	Overall MK Trend (2000 - 2007)	Sampling Frequency Based on Overall Data (2000 - 2007)	MAROS Recommended Sampling Frequency	Current Sampling Frequency
TCE Southwest Sector						
PTX01-1001	PERCHLORATE	-2.39E-06	NT	Annual	Biennial	Semiannual
PTX01-1002	PERCHLORATE	-2.53E-07	S	Annual	Biennial	Semiannual
PTX01-1008*	TCE	-1.51E-06	D	Annual	Biennial	Semiannual
PTX04-1001	TCE	--	S	--	--	Semiannual (to 2003)
PTX04-1002	26DNT	8.34E-08	NT	Annual	Annual	Semiannual
PTX06-1048A	TCE	-7.00E-07	D	Annual	Annual	Semiannual
PTX06-1050	RDX	7.74E-05	I	Quarterly	Quarterly	Semiannual
PTX06-1071	Cr(VI)	--	N/A	--	--	Not Sampled
PTX06-1080	1,4-DIOXANE	--	N/A	--	--	Semiannual
PTX06-1081	26DNT	5.72E-08	NT	Annual	Biennial	Semiannual
PTX06-1114	RDX	0.00E+00	N/A	Quarterly	Quarterly	Semiannual
PTX07-1O01	RDX	1.69E-06	NT	Quarterly	Quarterly	Annual
PTX07-1O02	RDX	0.00E+00	N/A	Quarterly	Quarterly	Annual
PTX07-1O03	RDX	-2.90E-06	S	Annual	Annual	Annual
PTX07-1O06*	26DNT	1.34E-08	NT	Annual	Annual	Semiannual (to 2004)
PTX07-1R03*	Cr(VI)	--	NT	--	--	Annual
PTX08-1010	1,4-DIOXANE	--	N/A	--	--	Semiannual
PTX-BEG3	4ADNT	-7.78E-08	S	Annual	Annual	Semiannual (to 2005)

Notes:
1. The priority chemical of concern (COC) at each well is the constituent detected at the highest level normalized by the MSC.
2. MK = Mann Kendall Trend; D = Decreasing, PD = Probably Decreasing, S = Stable, NT = No Trend, PI = Probably Increasing, I = Increasing, ND = Non-detect, N/A = insufficient data, less than 4 sample events for time interval indicated.
3. Recent data frequency is the estimated sample frequency based on the recent trend.
4. Overall rate of change and MK trend are for the full data set (2000-2007) for each well.
5. MAROS Recommended Sampling Frequency is the sampling frequency from MAROS based on both recent and overall trends.
6. Current sampling frequency is the approximate sampling frequency currently implemented.
7. The final recommended sampling frequency is based on a combination of qualitative and statistical evaluations.
8. * = Well is dry or intermittently dry. Dry wells should be evaluated periodically for saturation.

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TABLE 15
FINAL RECOMMENDED MONITORING NETWORK PERCHED NORTH SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Priority COPC	Maximum Above MSC?	Percent Detection	Below MSC (Student's T-Test)	Attained Cleanup to MSC (Sequential T-Test)	MK Trend	Sampling Frequency Recommendation	Rationale
North Sector								
PTX01-1001	PERCHLORATE	Yes	67%	NO	Continue Sampling	NT	Annual	Monitors area around SWMU 28-36, isolated perched groundwater in area, low level detections of perchlorate; reduced sampling frequency until statistically significant dataset is attained..
PTX01-1002	PERCHLORATE	No	8%	YES	Attained	S	Biennial	Monitors area around SWMU 28-36, isolated perched groundwater in area, perchlorate statistically below MSCs. Retain for infrequent monitoring.
PTX01-1008	TCE	Yes	50%	YES	Continue Sampling	D	Annual	Monitors area around SWMU 28-36, isolated perched groundwater in area, low level detections of TCE.
PTX04-1001	TCE	No	100%	N/C	N/C	S	Every 5 years	Detections of TCE below MSCs. Monitors SWMU 140, NE corner of DOE property. Sample for EPA 5 year review to confirm groundwater unaffected.
PTX04-1002	2,6DNT	No	8%	YES	Continue Sampling	NT	Biennial	Detections of TCE and RDX below MSCs. Monitors SWMU 140, NE corner of DOE property, reduced sampling frequency until statistically significant dataset is attained.
PTX06-1048A	TCE	No	93%	YES	Continue Sampling	D	Annual	Low level detections of TCE; Delineates north/northeast of perched unit.
PTX06-1050	RDX	Yes	100%	NO	Not Attained	I	Semiannual	Monitors area northwest of Playa 1, area of highest concentration in North Sector.
PTX06-1071	Cr(VI)	No	12%	N/C	N/C	NT	Every 5 years	Only one detection for Cr(VI), non-detect for other COPCs, Monitors SWMU 140, NE corner of DOE property. Sample for EPA 5 year review to confirm groundwater unaffected.
PTX06-1080	None	No		N/C	N/C	ND	Every 5 years	No confirmed detections of COPCs, Monitors SWMU 140, NE corner of DOE property. Sample for EPA 5 year review to confirm groundwater unaffected.
PTX06-1081	2,6DNT	No	8%	YES	Continue Sampling	NT	Biennial	Only one detection of 26DNT, TCE detected below MSCs (but possibly increasing trend). Monitors SWMU 140, NE corner of DOE property. Sample to confirm TCE is not above MSCs.
PTX06-1114	RDX	Yes	50%	N/C	N/C	N/A	Semiannual	Monitors area between Playa 1 and PTX06-1050. Continue collecting data to evaluate RDX plume in this area.

See Notes End of Table

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TABLE 15
FINAL RECOMMENDED MONITORING NETWORK PERCHED NORTH SECTOR

LONG-TERM MONITORING OPTIMIZATION
PANTEX PLANT
Carson County, Texas

Well Name	Priority COPC	Maximum Above MSC?	Percent Detection	Below MSC (Student's T-Test)	Attained Cleanup to MSC (Sequential T-Test)	MK Trend	Sampling Frequency Recommendation	Rationale
North Sector								
PTX07-1O01	RDX	Yes	100%	NO	Not Attained	NT	Semiannual	Monitors SWMU 68b. Continue monitoring to characterize RDX plume in this area.
PTX07-1O02	RDX	Yes	100%	N/C	N/C	N/A	Semiannual	Monitors SWMU 68b. Continue monitoring to characterize RDX plume in this area.
PTX07-1O03	RDX	Yes	100%	NO	Not Attained	S	Annual	Monitors SWMU 68b. Continue monitoring to characterize RDX plume in this area.
PTX07-1O06	2,6DNT	No	20%	YES	Attained	NT	Biennial	Monitors SWMU 68b. Sporadic detections of COPCs below MSCs. Monitor to delineate RDX plume to south.
PTX07-1R03	Cr(VI)	No	50%	NO	Continue Sampling	PI	Every 5 years	Very low detections of Cr(VI), monitors SWMU 64, only well in vicinity
PTX08-1010	None	No		N/C	N/C		Every 5 years	Sporadic trace detections of COPCs, detections of HMX below MSCs, Monitors SWMU 140, NE corner of DOE property. Sample for EPA 5 year review to confirm groundwater unaffected.
PTX-BEG3	4ADNT	No	78%	YES	Continue Sampling	PI	Biennial	Detections of 4ADNT below MSCs near detection limits; Monitors SWMU 140, NE corner of DOE property. Retain to confirm groundwater below regulatory standards at property boundary.
PTX06-1082	None	No					Every 5 years	Monitor area to confirm no facility related COPCs are present.
PTX06-1083	None	No					Every 5 years	

Notes:
1. MSC = Medium Specific Concentration.
2. Student's T-test identifies groundwater statistically below MSC. N/C = Not calculated.
3. Sequential T-test identifies groundwater that has statistically achieved cleanup with high confidence. Attained = groundwater has attained cleanup; Continue Sampling = dataset does not achieve statistical significance; Not Attained = groundwater above limit.
4. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend; NT = No Trend; ND = well has all non-detect results for COC indicated; N/C not calculated.
5. Mann-Kendall trends for 2000 - 2007 are shown.

GSI ENVIRONMENTAL

TABLE 16
SUMMARY MONITORING NETWORK RECOMMENDATIONS PERCHED GROUNDWATER

LONG-TERM MONITORING OPTIMIZATION

PANTEX PLANT
Carson County, Texas

Investigation Wells Recommended for Semiannual Monitoring							
Southeast Sector	20	PTX06-1002A	PTX06-1005	PTX06-1010	PTX06-1013	PTX06-1015	PTX06-1030
		PTX06-1031	PTX06-1034	PTX06-1038	PTX06-1039A	PTX06-1040	PTX06-1041
		PTX06-1046	PTX06-1047A	PTX06-1053*	PTX06-1088	PTX06-1095A	PTX08-1002
		PTX08-1008*	PTX08-1009*				
Southwest Sector	4	1114-MW4	PTX06-1012	PTX08-1005	PTX08-1006		
North Sector	4	PTX06-1114	PTX06-1050	PTX07-1O01	PTX07-1O02		
Investigation Wells Recommended for Annual Monitoring							
Southeast Sector	7	PTX06-1003	PTX06-1011	PTX06-1023	PTX06-1036	PTX06-1042	PTX06-1052
		PTX06-1069					
Southwest Sector	9	PTX06-1007	PTX06-1008	PTX06-1035	PTX06-1077A	PTX07-1P06	PTX08-1001
		PTX08-1003	PTX08-1007	PTX10-1013			
North Sector	4	PTX01-1001	PTX01-1008	PTX06-1048A	PTX07-1O03		
Investigation Wells Recommended for Biennial or Greater Monitoring							
Southeast Sector	0	None					
Southwest Sector	5	PTX06-1049	PTX06-1085	PTX06-1086	PTX07-1Q01	PTX07-1Q03	
North Sector	12	PTX04-1001	PTX06-1071	PTX06-1080	PTX07-1R03	PTX08-1010	PTX06-1083
		PTX06-1082	PTX01-1002	PTX04-1002	PTX06-1081	PTX07-1O06	PTX-BEG3
New Investigation Wells Recommended							
Southeast	2						
Southwest Sector	4						
North Sector	1						
Investigation Wells Recommended for Hydrogeologic Monitoring (dry or redundant locations)							
Southeast	4	PTX06-1102	PTX06-1045	PTX06-1037	PTX06-1014		
Southwest Sector	6	PTX10-1008	PTX07-1Q02	PTX07-1P03	PTX07-1P02	PTX06-1087	PTX06-1006
North Sector	0	None					

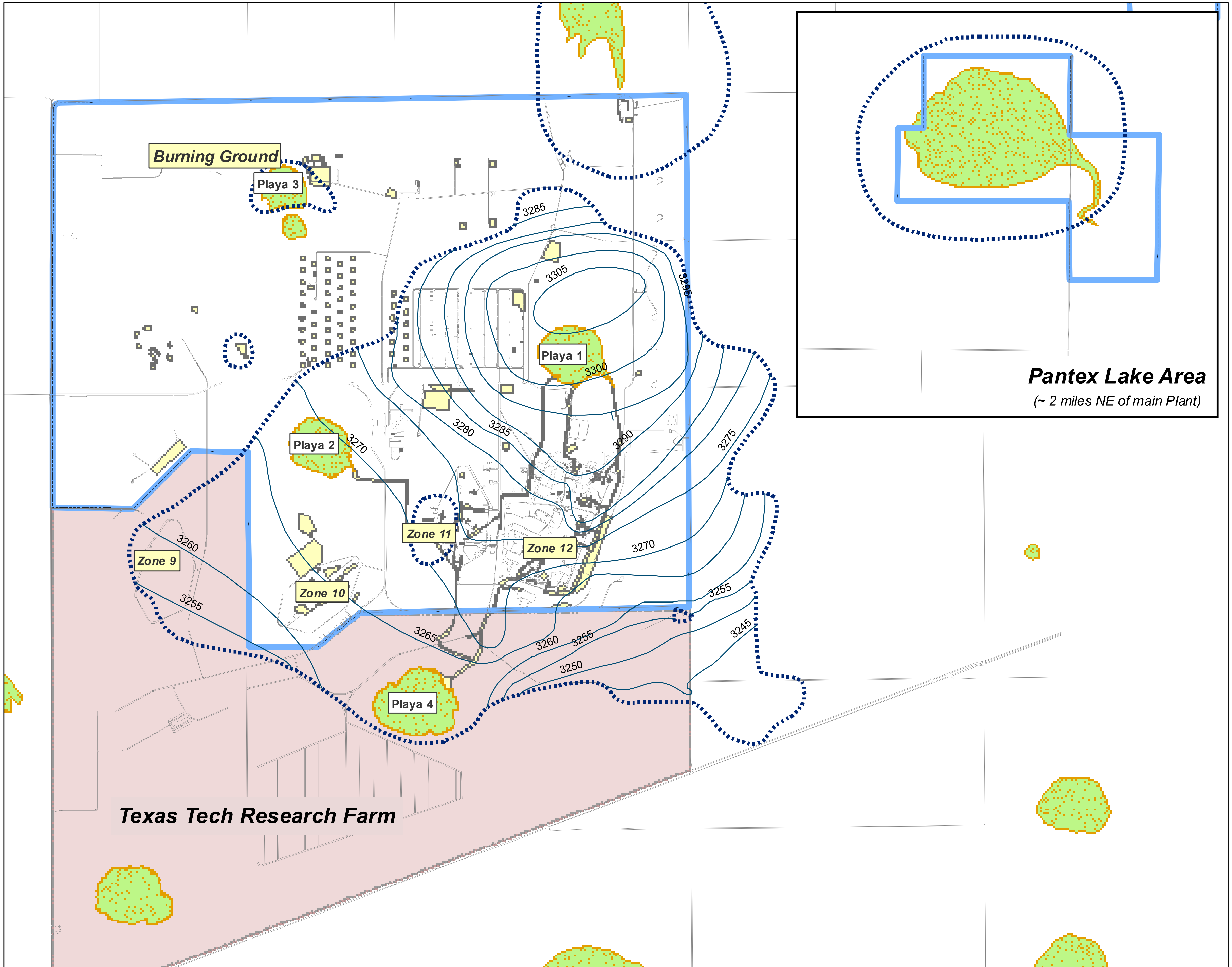
Notes: Lines of evidence supporting monitoring recommendations for each well are shown on Tables 7,12, and 15.

** Indicates well used to characterize more than one Sector.*

GROUNDWATER MONITORING NETWORK OPTIMIZATION
Pantex Plant

Carson County, Texas

FIGURES



N

LEGEND

- Water Table Elevation 2006 Perched Groundwater
- Extent of Perched Water
- Pantex Roads
- USDOE Property
- Playa Lakes
- SWMU
- Texas Tech University Property

Notes:

1. Geographic data from BWXT Pantex September 2007.
2. Perched groundwater extent and groundwater elevations from 2006 data BWXT Pantex.
3. The Pantex Lake area is approximately 2 miles northeast of the main Plant.
4. Groundwater elevations for main plant indicated in ft. amsl.

Scale (ft)

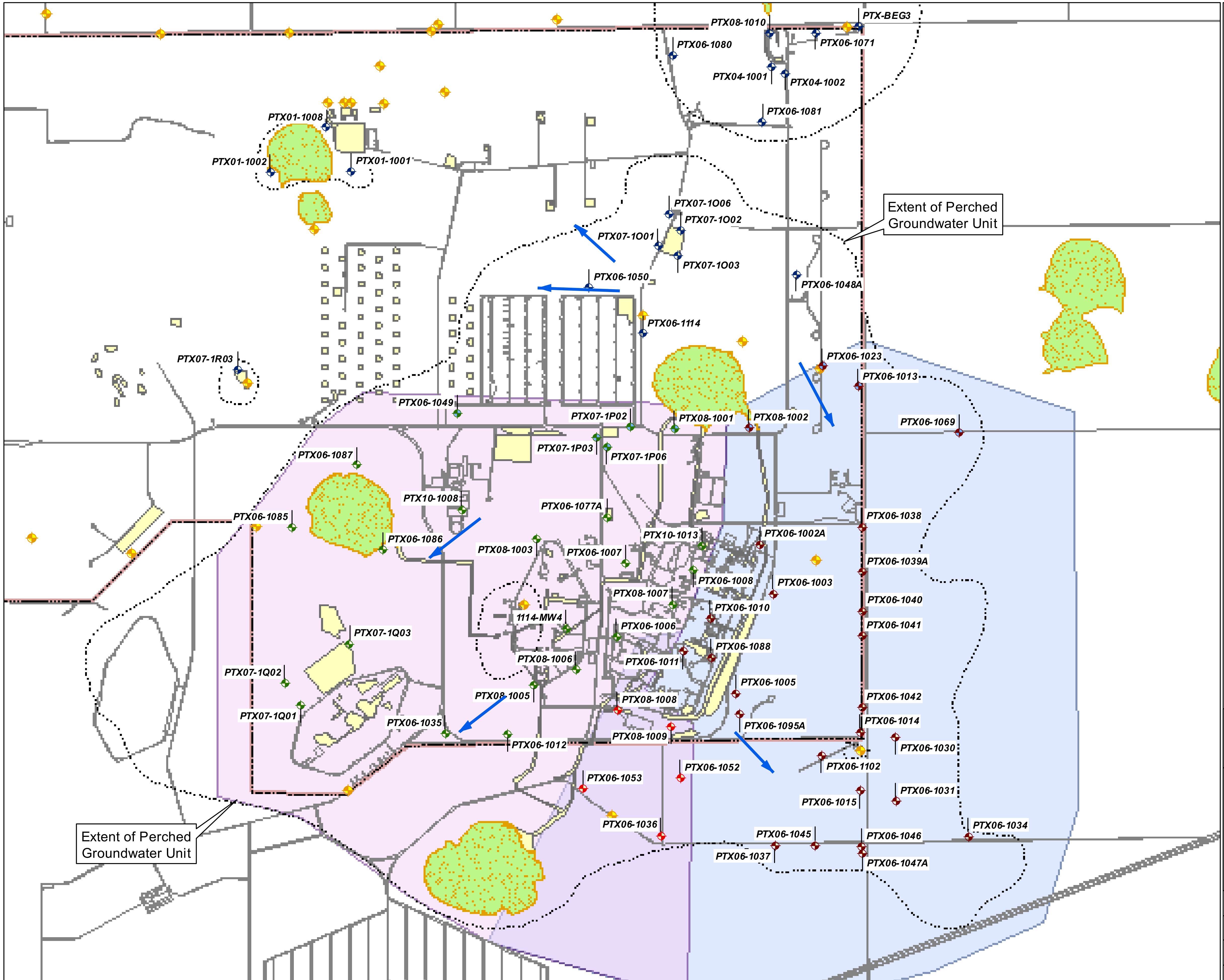
0 1,750 3,500

GSI ENVIRONMENTAL

PANTEX PLANT VICINITY

Carson County, Trxas

GIS Job No.	G-3262	Issued:	12-FEB-2008
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	----
Appv'd By:	MV		**FIGURE 1**



N

LEGEND

Investigation Well Groups

- North Area
- North/Southeast Areas
- North/Southwest Areas
- Southeast Area
- Southwest Area
- Southeast/Southwest Areas
- Ogallala Wells (Current)

- Extent of Perched Water
- USDOE Property
- Playa Lakes
- SWMU
- Southwest Sector
- Southeast Sector
- Approximate Groundwater Flow Direction

Notes:

1. Only investigation well locations are indicated. Well ID's for perched groundwater wells are shown.
2. Approximate groundwater flow directions from 2006 potentiometric measurements.

Scale (ft)

0 1,250 2,500

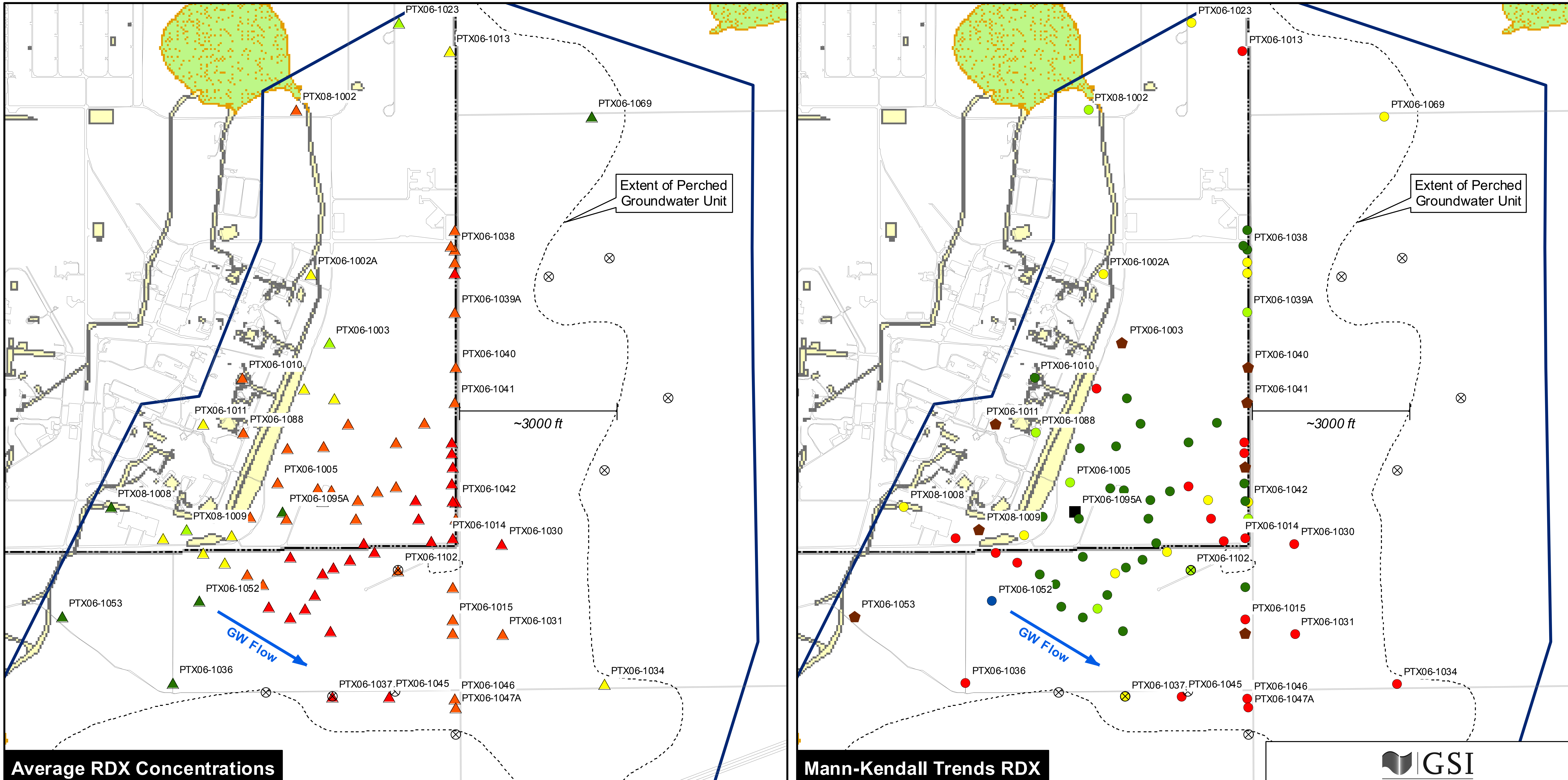
GSI ENVIRONMENTAL

PANTEX PERCHED GROUNDWATER

Investigation Well Locations

Pantex Plant
Carson County, Texas

GIS Job No.	G-3262	Issued:	12-FEB-2008
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	----
Appv'd By:	MV		**FIGURE 2**



LEGEND

Average RDX Concentration [mg/L]

- ND - 0.001
- 0.001 - 0.007
- 0.007 - 0.05
- 0.05 - 1.0
- > 1.0

RRS 2 RDX = 0.0077 mg/L

Mann-Kendall Trend RDX

- Decreasing
- Probably Decreasing
- Stable
- Probably Increasing
- Increasing
- Non Detect (2000-2007)
- No Trend
- Insufficient Data
- Dry Wells

Notes:

1. Average RDX concentrations calculated using lowest detection limit substituted for ND values. Data 2000-2007.
2. Mann-Kendall trends were determined for RDX 2000-2007.
3. Investigation wells are labeled with their well ID. Extraction wells are not labeled.
4. See Pantex Vicinity legend for description of site features.

N

Scale (ft)

0 900 1,800

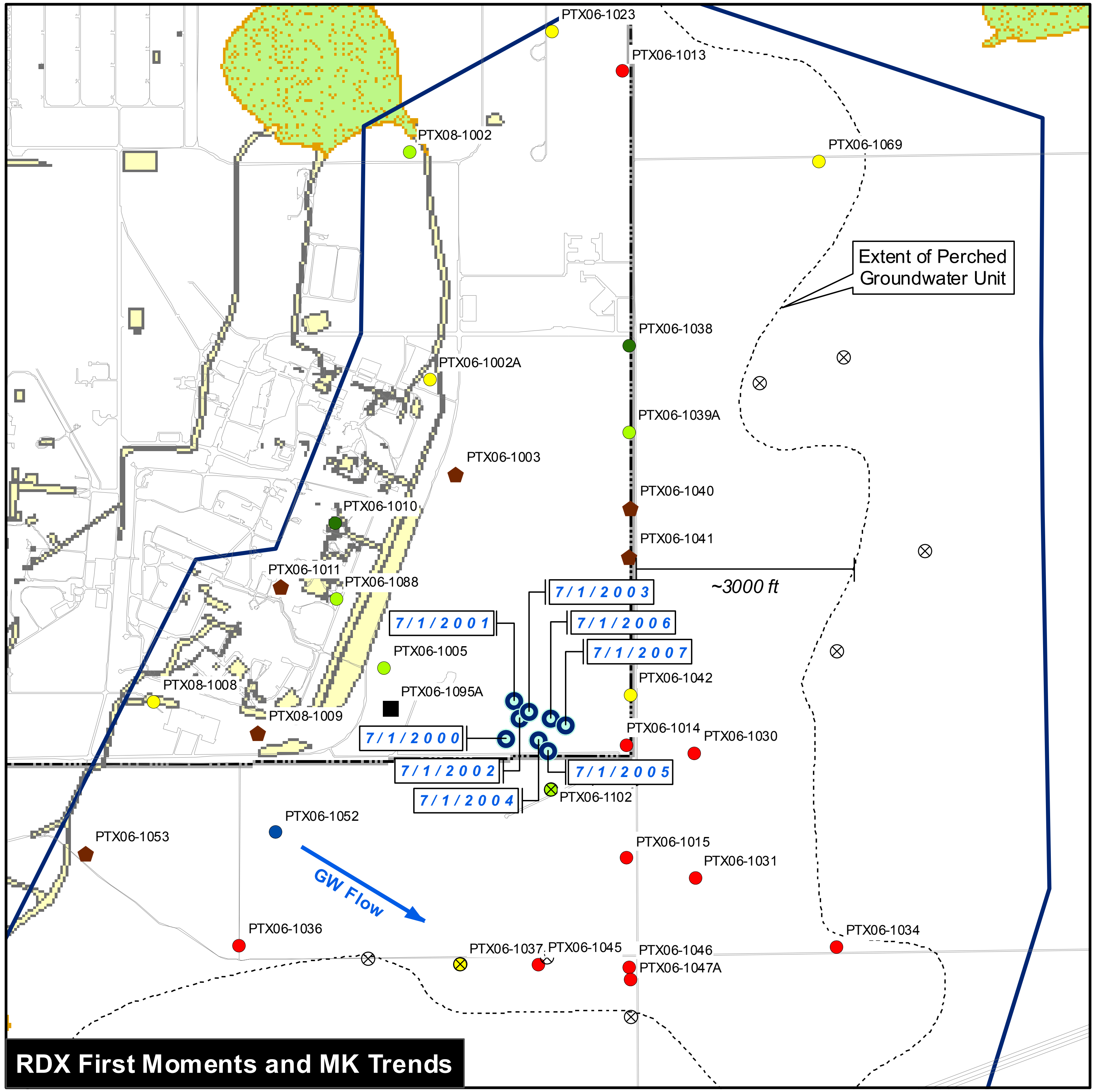
GSI ENVIRONMENTAL

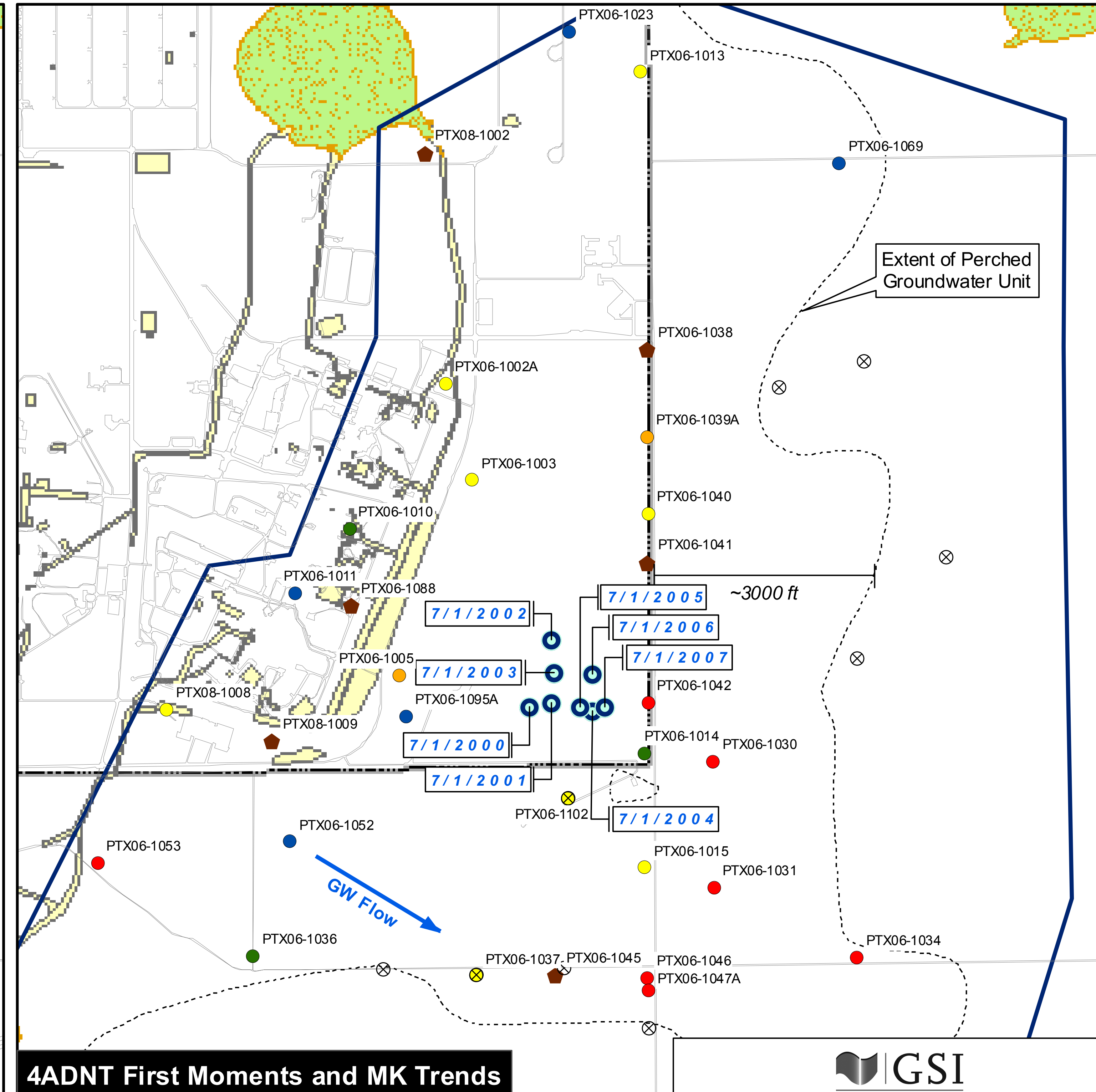
PANTEX SOUTHEAST SECTOR PERCHED GROUNDWATER

RDX Average Concentrations and Mann-Kendall Trends

Pantex Plant
Carson County, Texas

GIS Job No.	G-3262	Issued:	12-FEB-2008
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	----
Appv'd By:	MV		**FIGURE 3**





LEGEND

⊗ Dry Wells Perched Unit

First Moments (Center of Mass)

Mann-Kendall Trend

- Decreasing
- Probably Decreasing
- Stable
- Probably Increasing
- Increasing
- Non Detect (2000-2007)
- No Trend
- Insufficient Data

MSC RDX = 0.0077 mg/L; 4ADNT = 0.0012mg/L

Notes:

1. First Moments indicate the center of mass estimated based on annually consolidated analytical data from the well network. The effective date of the First Moment estimate is shown.
2. Mann-Kendall trends were determined for RDX and 4ADNT 2000-2007.
3. Only results for investigation wells are shown.

N

Scale (ft)

0 900 1,800

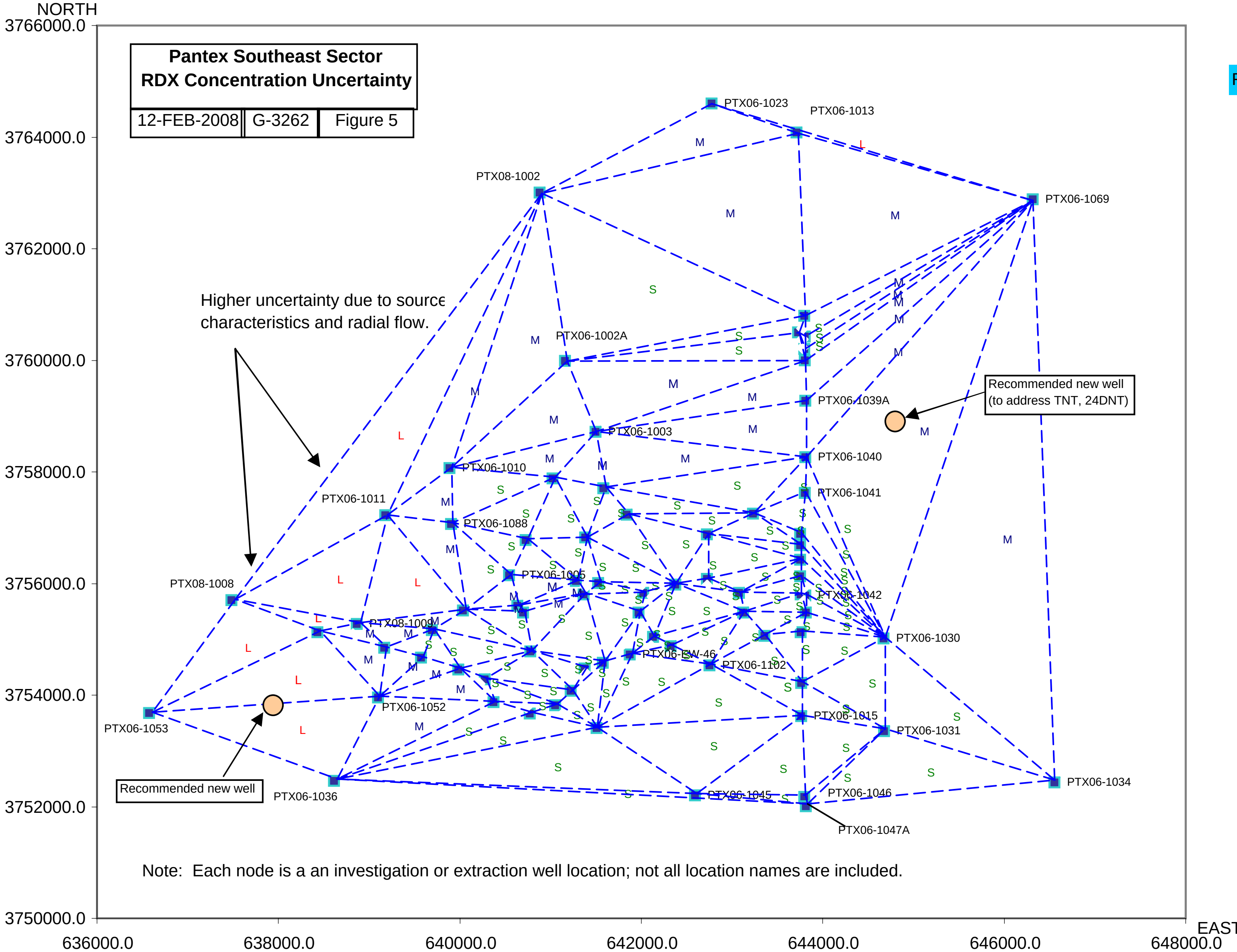
GSI ENVIRONMENTAL

PANTEX SOUTHEAST PERCHED

RDX and 4ADNT First Moments and Mann-Kendall Trends

Pantex Plant
Carson County, Texas

GIS Job No.	G-3262	Issued:	12-FEB-2008
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	----
Appv'd By:	MV		**FIGURE 4**



New Location
Analysis for

RDX Network Uncertainty

Existing
Locations

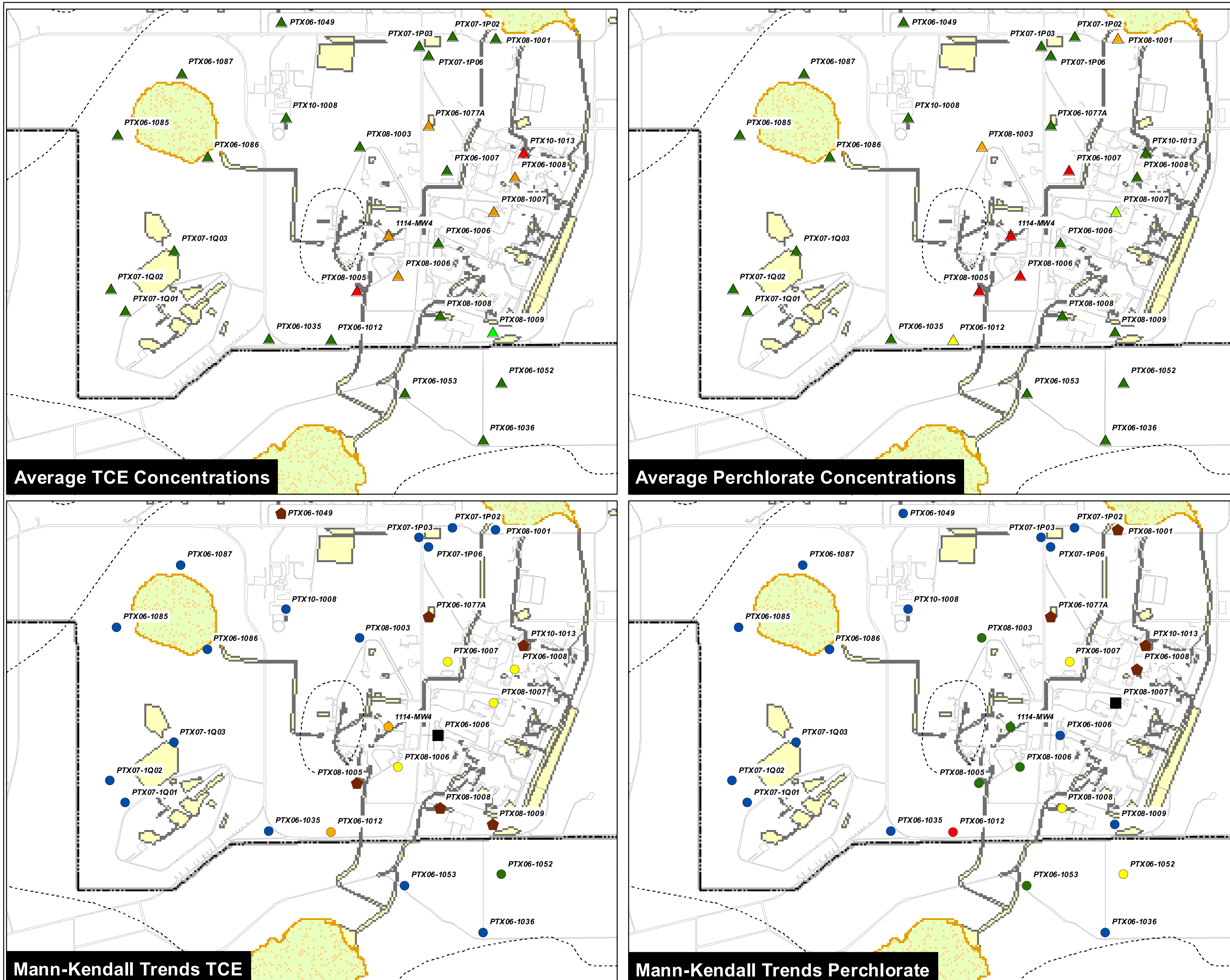
Potential areas for new locations are indicated by triangles with a high SF level.

Estimated SF Level:
S - Small
M - Moderate
L - Large
E - Extremely large

High SF -> high estimation error -> possible need for new locations

Low SF -> low estimation error -> no need for new locations

Back to Access



N

LEGEND

Average Concentrations [mg/L]

	TCE	Perchlorate
▲	ND - 0.001	ND - 0.005
▲	0.001 - 0.004	0.005 - 0.01
▲	0.004 - 0.005	0.01 - 0.026
▲	0.005 - 0.015	0.026 - 0.1
▲	> 0.015	> 0.1

MSC TCE = 0.005 mg/L; Perchlorate = 0.026 mg/L

Mann-Kendall Trends

- Decreasing
- Probably Decreasing
- Stable
- Probably Increasing
- Increasing
- Non Detect (2000-2007)
- No Trend
- Insufficient Data

Notes:

1. Mann-Kendall trends were determined for TCE and perchlorate 2000-2007.
2. Only results for investigation wells are shown.
3. Average concentrations calculated using lowest detection limit substituted for ND values.

Scale (ft)

0 1,400 2,800

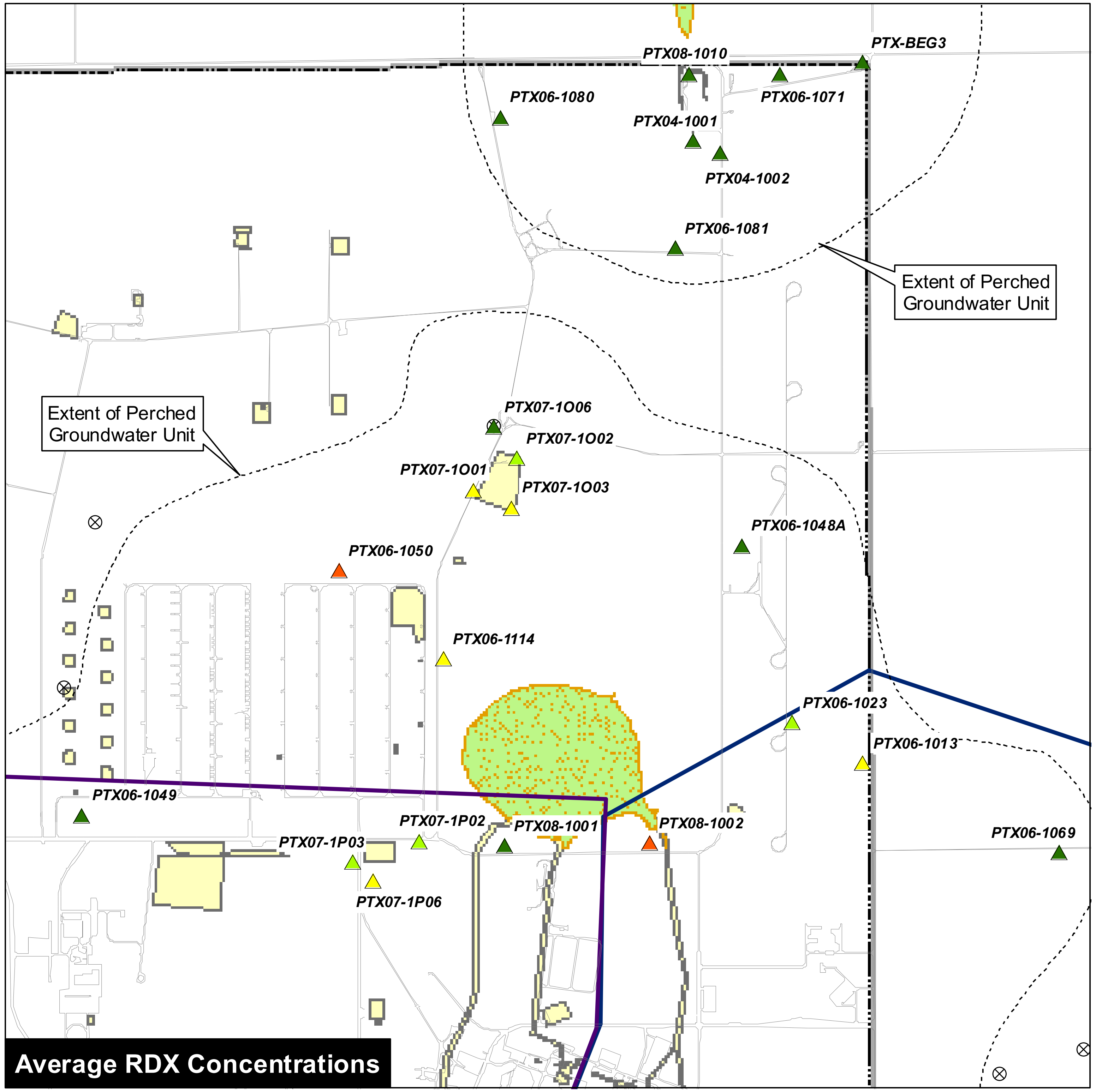
GSI ENVIRONMENTAL

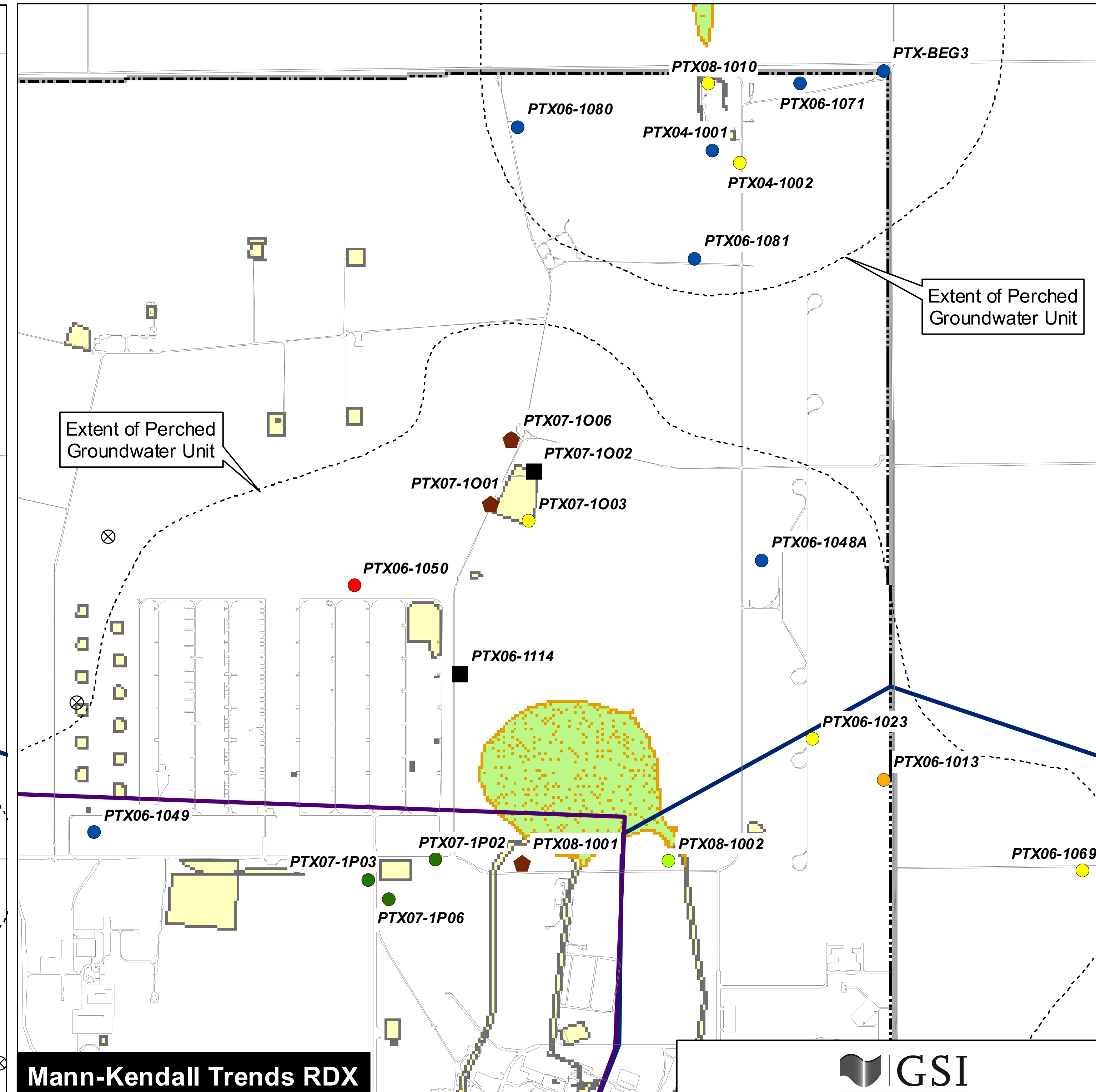
PANTEX SOUTHWEST SECTOR

TCE And Perchlorate Average Concentrations and Mann-Kendall Trends

Pantex Plant
Carson County, Texas

GIS Job No.	G-3262	Issued:	12-FEB-2008
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	----
Appv'd By:	MV		FIGURE 6





LEGEND

Average RDX Concentration [mg/L]

- ND - 0.001
- 0.001 - 0.007
- 0.007 - 0.05
- 0.05 - 1.0
- \> 1.0

Mann-Kendall Trend RDX

- Decreasing
- Probably Decreasing
- Stable
- Probably Increasing
- Increasing
- Non Detect (2000-2007)
- No Trend
- Insufficient Data

RRS 2 RDX = 0.0077 mg/L

Notes:

1. Average RDX concentrations calculated using lowest detection limit substituted for ND values. Data 2000-2007.
2. Mann Kendall trends were determined for RDX 2000-2007.
3. RDX is not detected in the area of the Burning Ground, Playa 3 and Pantex Lake.

N

Scale (ft)

0 900 1,800

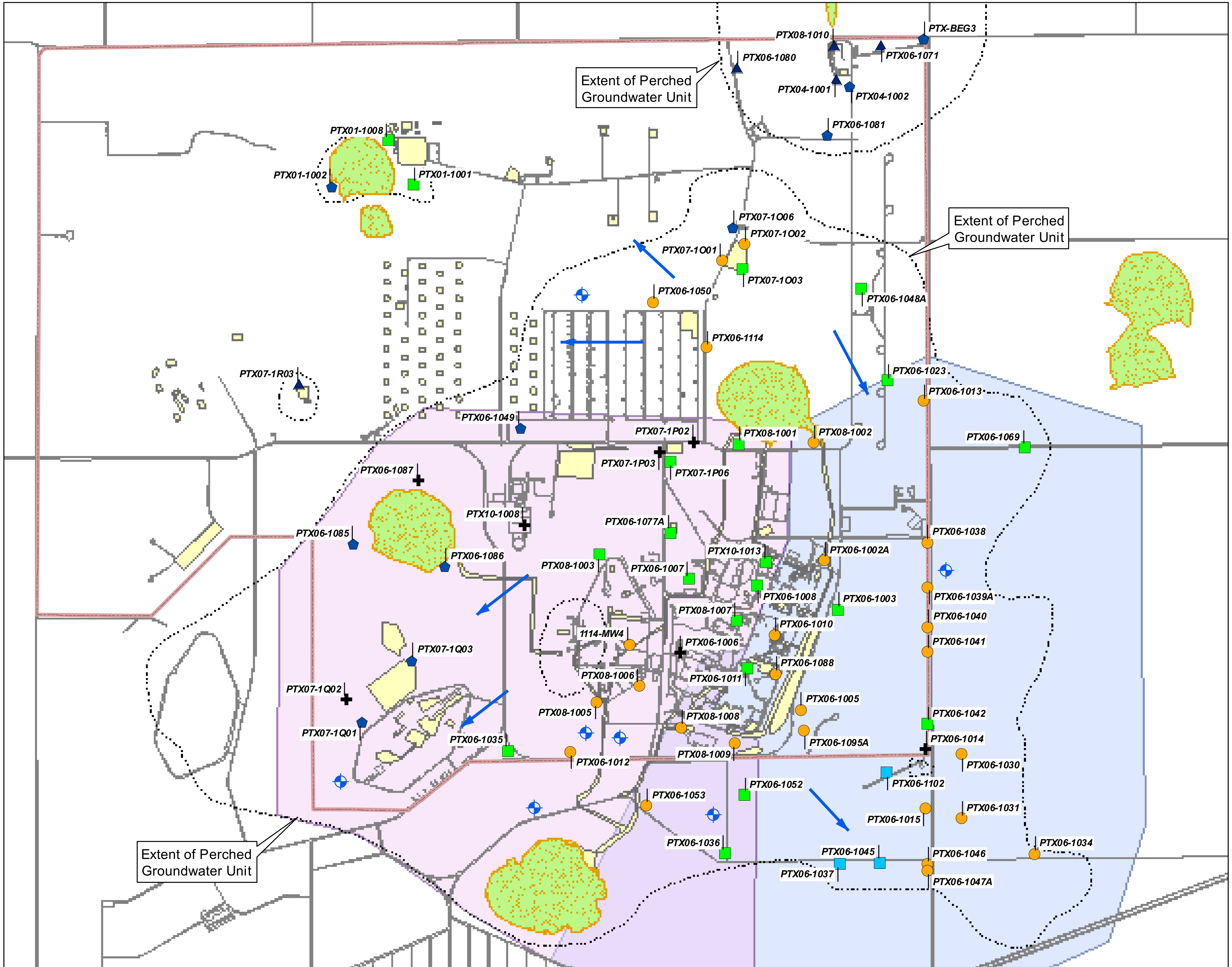
GSI ENVIRONMENTAL

PANTEX NORTH SECTOR PERCHED GROUNDWATER

RDX Average Concentrations and Mann-Kendall Trends

Pantex Plant
Carson County, Texas

GIS Job No.	G-3262	Issued:	12-FEB-2008
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	----
Appv'd By:	MV		**FIGURE 7**



N

LEGEND

Recommended Sampling Frequency

- Semiannual
- Annual
- Annual HG
- Biennial
- Every 5 years
- Eliminate from routine monitoring
- Perched Proposed New Location

- Extent of Perched Water
- USDOE Property
- Playa Lakes
- SWMU
- Southwest Sector
- Southeast Sector
- Approximate Groundwater Flow Direction

Scale (ft)
0 1,250 2,500

GSI ENVIRONMENTAL

PANTEX PERCHED GROUNDWATER RECOMMENDED MONITORING NETWORK

Pantex Plant
Carson County, Texas

GIS Job No.	G-3262	Issued:	12-FEB-2008
Drawn By:	CDM	Revised:	----
Chk'd By:	MV	Map ID:	----
Appv'd By:	MV		**FIGURE 8**

GROUNDWATER MONITORING NETWORK OPTIMIZATION
Pantex Plant

Carson County, Texas

APPENDIX A:

MAROS 2.2 Methodology

APPENDIX A
MAROS 2.2 METHODOLOGY

Contents

MAROS METHODOLOGY

MAROS is a collection of tools in one software package that is used in an explanatory, non-linear but linked fashion. The tool includes models, statistics, heuristic rules, and empirical relationships to assist the user in optimizing a groundwater monitoring network system. The final optimized network maintains adequate delineation while providing information on plume dynamics over time. Results generated from the software tool can be used to develop lines of evidence, which, in combination with expert opinion, can be used to inform regulatory decisions for safe and economical long-term monitoring of groundwater plumes. For a detailed description of the structure of the software and further utilities, refer to the MAROS 2.2 Manual (AFCEE, 2003; http://www.gsi-net.com/software/MAROS_V2_1Manual.pdf) and Aziz et al., 2003.

1.0 MAROS Conceptual Model

In MAROS 2.2, two levels of analysis are used for optimizing long-term monitoring plans: 1) an overview statistical evaluation with interpretive trend analysis based on temporal trend analysis and plume stability information; and 2) a more detailed statistical optimization based on spatial and temporal redundancy reduction methods (see Figures A.1 and A.2 for further details). In general, the MAROS method applies to 2-D aquifers that have relatively simple site hydrogeology. However, for a multi-aquifer (3-D) system, the user has the option to apply the statistical analysis layer-by-layer.

The overview statistics or interpretive trend analysis assesses the general monitoring system category by considering individual well concentration trends, overall plume stability, hydrogeologic factors (e.g., seepage velocity, and current plume length), and the location of potential receptors (e.g., property boundaries or drinking water wells). The method relies on temporal trend analysis to assess plume stability, which is then used to determine the general monitoring system category. Since the monitoring system category is evaluated for both source and tail regions of the plume, the site wells are divided into two different zones: the source zone and the tail zone.

Source zone monitoring wells could include areas with non-aqueous phase liquids (NAPLs), contaminated vadose zone soils, and areas where aqueous-phase releases have been introduced into ground water. The source zone generally contains locations with historical high ground water concentrations of the COCs. The tail zone is usually the area downgradient of the contaminant source zone. Although this classification is a simplification of the plume conceptual model, this broadness makes the user aware on an individual well basis that the concentration trend results can have a different interpretation depending on the well location in and around the plume. The location and type of the individual wells allows further interpretation of the trend results, depending on what type of well is being analyzed (e.g., remediation well, leading plume edge well, or monitoring well). General recommendations for the monitoring network frequency and density are suggested based on heuristic rules applied to the source and tail trend results.

The detailed statistics level of analysis or sampling optimization consists of well redundancy and well sufficiency analyses using the Delaunay method, a sampling frequency analysis using the Modified Cost Effective Sampling (MCES) method and a data sufficiency analysis including statistical power analysis. The well redundancy analysis is designed to minimize monitoring locations and the Modified CES method is designed to minimize the frequency of sampling. The data sufficiency analysis uses simple statistical methods to assess the sampling record to determine if groundwater concentrations are statistically below target levels and if the current monitoring network and record is sufficient in terms of evaluating concentrations at downgradient locations.

2.0 Data Management

In MAROS, ground water monitoring data can be imported from simple database-format Microsoft® Excel spreadsheets, Microsoft Access tables, previously created MAROS database archive files, or entered manually. Monitoring data interpretation in MAROS is based on historical analytical data from a consistent set of wells over a series of sampling events. The analytical data is composed of the well name, coordinate location, constituent, result, detection limit and associated data qualifiers. Statistical validity of the concentration trend analysis requires constraints on the minimum data input of at least four wells (ASTM 1998) in which COCs have been detected. Individual sampling locations need to include data from at least six most-recent sampling events. To ensure a meaningful comparison of COC concentrations over time and space, both data quality and data quantity need to be considered. Prior to statistical analysis, the user can consolidate irregularly sampled data or smooth data that might result from seasonal fluctuations or a change in site conditions. Because MAROS is a terminal analytical tool designed for long-term planning, impacts of seasonal variation in the water unit are treated on a broad scale, as they relate to multi-year trends.

Imported ground water monitoring data and the site-specific information entered in Site Details can be archived and exported as MAROS archive files. These archive files can be appended as new monitoring data becomes available, resulting in a dynamic long-term monitoring database that reflects the changing conditions at the site (i.e. biodegradation, compliance attainment, completion of remediation phase, etc.). For wells with a limited monitoring history, addition of information as it becomes available can change the frequency or identity of wells in the network.

3.0 Site Details

Information needed for the MAROS analysis includes site-specific parameters such as seepage velocity and current plume length and width. Information on the location of potential receptors relative to the source and tail regions of the plume is entered at this point. Part of the trend analysis methodology applied in MAROS focuses on where the monitoring well is located, therefore the user needs to divide site wells into two different zones: the source zone or the tail zone. Although this classification is a simplification of the well function, this broadness makes the user aware on an individual well basis that the concentration trend results can have a different interpretation depending on the well location in and around the plume. It is up to the user to make further interpretation of the trend results, depending on what type of well is being analyzed (e.g., remediation well, leading plume edge well, or monitoring well). The Site Details section of MAROS contains a preliminary map of well locations to confirm well coordinates.

4.0 Constituent Selection

A database with multiple COCs can be entered into the MAROS software. MAROS allows the analysis of up to 5 COCs concurrently and users can pick COCs from a list of compounds existing in the monitoring data. MAROS runs separate optimizations for each compound. For sites with a single source, the suggested strategy is to choose one to three priority COCs for the optimization. If, for example, the site contains multiple chlorinated volatile organic compounds (VOCs), the standard sample chemical analysis will evaluate all VOCs, so the sample locations and frequency should based on the concentration trends of the most prevalent, toxic or mobile compounds. If different chemical classes are present, such as metals and chlorinated VOCs, choose and evaluate the priority constituent in each chemical class.

MAROS includes a short module that provides recommendations on prioritizing COCs based on toxicity, prevalence, and mobility of the compound. The toxicity ranking is determined by examining a representative concentration for each compound for the entire site. The representative concentration is then compared to the screening level (PRG or MCL) for that compound and the COCs are ranked according to the representative concentrations percent exceedence of the screening level. The evaluation of prevalence is performed by determining a representative concentration for each well location and evaluating the total exceedences (values above screening levels) compared to the total number of wells. Compounds found over screening levels are ranked for mobility based on Kd (sorption partition coefficient). The MAROS COC assessment provides the relative ranking of each COC, but the user must choose which COCs are included in the analysis.

5.0 Data Consolidation

Typically, raw data from long-term monitoring have been measured irregularly in time or contain many non-detects, trace level results, and duplicates. Therefore, before the data can be further analyzed, raw data are filtered, consolidated, transformed, and possibly smoothed to allow for a consistent dataset meeting the minimum data requirements for statistical analysis mentioned previously.

MAROS allows users to specify the period of interest in which data will be consolidated (i.e., monthly, bi-monthly, quarterly, semi-annual, yearly, or a biennial basis). In computing the representative value when consolidating, one of four statistics can be used: median, geometric mean, mean, and maximum. Non-detects can be transformed to one half the reporting or method detection limit (DL), the DL, or a fraction of the DL. Trace level results can be represented by their actual values, one half of the DL, the DL, or a fraction of their actual values. Duplicates are reduced in MAROS by one of three ways: assigning the average, maximum, or first value. The reduced data for each COC and each well can be viewed as a time series in a graphical form on a linear or semi-log plot generated by the software.

6.0 Overview Statistics: Plume Trend Analysis

Within the MAROS software there are historical data analyses that support a conclusion about plume stability (e.g., increasing plume, etc.) through statistical trend analysis of historical monitoring data. Plume stability results are assessed from time-series concentration data with the application of three statistical tools: Mann-Kendall Trend analysis, linear regression trend analysis and moment analysis. The two trend methods are used to estimate the concentration trend for each well and each COC based on a statistical trend analysis of concentrations versus time at each well. These trend analyses are then consolidated to give the user a general plume stability estimate and general monitoring frequency and density recommendations (see Figures A.1 through A.3 for further step-by-step details). Both qualitative and quantitative plume information can be gained by these evaluations of monitoring network historical data trends both spatially and temporally. The MAROS Overview Statistics are the foundation the user needs to make informed optimization decisions at the site. The Overview Statistics are designed to allow site personnel to develop a better understanding of the plume behavior over time and understand how the individual well concentration trends are spatially distributed within the plume. This step allows the user to gain information that will support a more informed decision to be made in the next level or detailed statistics optimization analysis.

6.1 Mann-Kendall Analysis

The Mann-Kendall test is a statistical procedure that is well suited for analyzing trends in data over time. The Mann-Kendall test can be viewed as a non-parametric test for zero slope of the first-order regression of time-ordered concentration data versus time. One advantage of the Mann-Kendall test is that it does not require any assumptions as to the statistical distribution of the data (e.g. normal, lognormal, etc.) and can be used with data sets which include irregular sampling intervals and missing data. The Mann-Kendall test is designed for analyzing a single groundwater constituent, multiple constituents are analyzed separately. The Mann-Kendall S statistic measures the trend in the data: positive values indicate an increase in concentrations over time and negative values indicate a decrease in concentrations over time. The strength of the trend is proportional to the magnitude of the Mann-Kendall statistic (i.e., a large value indicates a strong trend). The confidence in the trend is determined by consulting the S statistic and the sample size, n, in a Kendall probability table such as the one reported in Hollander and Wolfe (1973).

The concentration trend is determined for each well and each COC based on results of the S statistic, the confidence in the trend, and the Coefficient of Variation (COV). The decision matrix for this evaluation is shown in Table 3. A Mann-Kendall statistic that is greater than 0 combined with a confidence of greater than 95% is categorized as an Increasing trend while a Mann-Kendall statistic of less than 0 with a confidence between 90% and 95% is defined as a probably Increasing trend, and so on.

Depending on statistical indicators, the concentration trend is classified into six categories:

- Decreasing (D),
- Probably Decreasing (PD),
- Stable (S),
- No Trend (NT),
- Probably Increasing (PI)
- Increasing (I).

These trend estimates are then analyzed to identify the source and tail region overall stability category (see Figure 2 for further details).

6.2 Linear Regression Analysis

Linear Regression is a parametric statistical procedure that is typically used for analyzing trends in data over time. Using this type of analysis, a higher degree of scatter simply corresponds to a wider confidence interval about the average log-slope. Assuming the sign (i.e., positive or negative) of the estimated log-slope is correct, a level of confidence that the slope is not zero can be easily determined. Thus, despite a poor goodness of fit, the overall trend in the data may still be ascertained, where low levels of confidence correspond to "Stable" or "No Trend" conditions (depending on the degree of scatter) and higher levels of confidence indicate the stronger likelihood of a trend. The linear regression analysis is based on the first-order linear regression of the log-transformed concentration data versus time. The slope obtained from this log-transformed regression, the confidence level for this log-slope, and the COV of the untransformed data are used to determine the concentration trend. The decision matrix for this evaluation is shown in Table 4.

To estimate the confidence in the log-slope, the standard error of the log-slope is calculated. The coefficient of variation, defined as the standard deviation divided by the average, is used as a secondary measure of scatter to distinguish between "Stable" or "No Trend" conditions for negative slopes. The Linear Regression Analysis is designed for analyzing a single groundwater constituent; multiple constituents are analyzed separately, (up to five COCs simultaneously). For this evaluation, a decision matrix developed by Groundwater Services, Inc. is also used to determine the "Concentration Trend" category (plume stability) for each well.

Depending on statistical indicators, the concentration trend is classified into six categories:

- Decreasing (D),
- Probably Decreasing (PD),
- Stable (S),
- No Trend (NT),
- Probably Increasing (PI)
- Increasing (I).

The resulting confidence in the trend, together with the log-slope and the COV of the untransformed data, are used in the linear regression analysis decision matrix to determine the concentration trend. For example, a positive log-slope with a confidence of less than 90% is categorized as having No Trend whereas a negative log-slope is considered Stable if the COV is less than 1 and categorized as No Trend if the COV is greater than 1.

6.3 Overall Plume Analysis

General recommendations for the monitoring network frequency and density are suggested based on heuristic rules applied to the source and tail trend results.

Individual well trend results are consolidated and weighted by the MAROS according to user input, and the direction and strength of contaminant concentration trends in the source zone and tail zone for each COC are determined. Based on

- **i)** the consolidated trend analysis,
- **ii)** hydrogeologic factors (e.g., seepage velocity), and
- **iii)** location of potential receptors (e.g., wells, discharge points, or property boundaries),

the software suggests a general optimization plan for the current monitoring system in order to efficiently but effectively monitor groundwater in the future. A flow chart utilizing the trend analysis results and other site-specific parameters to form a general sampling frequency and well density recommendation is outlined in Figure 2. For example, a generic plan for a shrinking petroleum hydrocarbon plume (BTEX) in a slow hydrogeologic environment (silt) with no nearby receptors would entail minimal, low frequency sampling of just a few indicators. On the other hand, the generic plan for a chlorinated solvent plume in a fast hydrogeologic environment that is expanding but has very erratic concentrations over time would entail more extensive, higher frequency sampling. The generic plan is based on a heuristically derived algorithm for assessing future sampling duration, location and density that takes into consideration plume stability. For a detailed description of the heuristic rules used in the MAROS software, refer to the MAROS 2.2Manual (AFCEE, 2003).

6.4 Moment Analysis

An analysis of moments can help resolve plume trends, where the zeroth moment shows change in dissolved mass vs. time, the first moment shows the center of mass location vs. time, and the second moment shows the spread of the plume vs. time. Moment calculations can predict how the plume will change in the future if further statistical analysis is applied to the moments to identify a trend (in this case, Mann Kendall Trend Analysis is applied). The trend analysis of moments can be summarized as:

- Zeroth Moment: An estimate of the total mass of the constituent for each sample event
- First Moment: An estimate of the center of mass for each sample event
- Second Moment: An estimate of the spread of the plume around the center of mass

The role of moment analysis in MAROS is to provide a relative estimate of plume stability and condition within the context of results from other MAROS modules. The Moment analysis algorithms in MAROS are simple approximations of complex calculations and are meant to estimate changes in total mass, center of mass and spread of mass for complex well networks. The Moment Analysis module is sensitive to the number and arrangement of wells in each sampling event, so, changes in the number and identity of wells during monitoring events, and the parameters chosen for data consolidation can cause changes in the estimated moments.

Plume stability may vary by constituent, therefore the MAROS Moment analysis can be used to evaluate multiple COCs simultaneously which can be used to provide a quick way of comparing individual plume parameters to determine the size and movement of constituents relative to one another. Moment analysis in the MAROS software can also be used to assist the user in evaluating the impact on plume delineation in future sampling events by removing identified "redundant" wells from a long-term monitoring program (this analysis was not performed as part of this study, for more details on this application of moment analysis refer to the MAROS Users Manual (AFCEE, 2003)).

The **zeroth moment** is the sum of concentrations for all monitoring wells and is a mass estimate. The zeroth moment calculation can show high variability over time, largely due to the fluctuating concentrations at the most contaminated wells as well as varying monitoring well network. Plume analysis and delineation based exclusively on concentration can exhibit fluctuating temporal and spatial values. The mass estimate is also sensitive to the extent of the site monitoring well network over time. The zeroth moment trend over time is determined by using the Mann-Kendall Trend Methodology. The zeroth Moment trend test allows the user to understand how the plume mass has changed over time. Results for the trend include: Increasing, probably Increasing, no trend, stable, probably decreasing, decreasing or not applicable (N/A) (Insufficient Data). When considering the results of the zeroth moment trend, the following factors should be considered which could effect the calculation and interpretation of the plume mass over time: 1) Change in the spatial distribution of the wells sampled historically 2) Different wells sampled within the well network over time (addition and subtraction of well within the network). 3) Adequate versus inadequate delineation of the plume over time

The **first moment** estimates the center of mass, coordinates (Xc and Yc) for each sample event and COC. The changing center of mass locations indicate the movement of the center of mass over time. Whereas, the distance from the original source location to the center of mass locations indicate the movement of the center of mass over time relative to the original source. Calculation of the first moment normalizes the spread by the concentration indicating the center of mass. The first moment trend of the distance to the center of mass over time shows movement of the plume in relation to the original source location over time. Analysis of the movement of mass should be viewed as it relates to 1) the original source location of contamination 2) the direction of groundwater flow and/or 3) source removal or remediation. Spatial and temporal trends in the center of mass can indicate spreading or shrinking or transient movement based on season variation in rainfall or other hydraulic considerations. No appreciable movement or a neutral trend in the center of mass would indicate plume stability. However, changes in the first moment over time do not necessarily completely characterize the changes in the concentration distribution (and the mass) over time. Therefore, in order to fully characterize the plume the First Moment trend should be compared to the zeroth moment trend (mass change over time).

The **second moment** indicates the spread of the contaminant about the center of mass (Sxx and Syy), or the distance of contamination from the center of mass for a particular COC and sample event. The Second Moment represents the spread of the plume over time in both the x and y directions. The Second Moment trend indicates the spread of the plume about the center of mass. Analysis of the spread of the plume should be viewed as it relates to the direction of groundwater flow. An Increasing trend in the second moment indicates an expanding plume, whereas a declining trend in the second moment indicates a shrinking plume. No appreciable movement or a neutral trend in the center of mass would indicate plume stability. The second moment provides a measure of the spread of the concentration distribution about the plume's center of mass.

However, changes in the second moment over time do not necessarily completely characterize the changes in the concentration distribution (and the mass) over time. Therefore, in order to fully characterize the plume the Second Moment trend should be compared to the zeroth moment trend (mass change over time).

7.0 Detailed Statistics: Optimization Analysis

Although the overall plume analysis shows a general recommendation regarding sampling frequency reduction and a general sampling density, a more detailed analysis is also available with the MAROS 2.2 software in order to allow for further reductions on a well-by-well basis for frequency, well redundancy, well sufficiency and sampling sufficiency. The MAROS Detailed Statistics allows for a quantitative analysis for spatial and temporal optimization of the well network on a well-by-well basis. The results from the Overview Statistics should be considered along with the MAROS optimization recommendations gained from the Detailed Statistical Analysis described previously. The MAROS Detailed Statistics results should be reassessed in view of site knowledge and regulatory requirements as well as in consideration of the Overview Statistics (Figure 2).

The Detailed Statistics or Sampling Optimization MAROS modules can be used to determine the minimal number of sampling locations and the lowest frequency of sampling that can still meet the requirements of sampling spatially and temporally for an existing monitoring program. It also provides an analysis of the sufficiency of data for the monitoring program.

Sampling optimization in MAROS consists of four parts:

- Well redundancy analysis using the Delaunay method
- Well sufficiency analysis using the Delaunay method
- Sampling frequency determination using the Modified CES method
- Data sufficiency analysis using statistical power analysis.

The well redundancy analysis using the Delaunay method identifies and eliminates redundant locations from the monitoring network. The well sufficiency analysis can determine the areas where new sampling locations might be needed. The Modified CES method determines the optimal sampling frequency for a sampling location based on the direction, magnitude, and uncertainty in its concentration trend. The data sufficiency analysis examines the risk-based site cleanup status and power and expected sample size associated with the cleanup status evaluation.

7.1 Well Redundancy Analysis – Delaunay Method

The well redundancy analysis using the Delaunay method is designed to select the minimum number of sampling locations based on the spatial analysis of the relative importance of each sampling location in the monitoring network. The approach allows elimination of sampling locations that have little impact on the historical characterization of a contaminant plume. An extended method or wells sufficiency analysis, based on the Delaunay method, can also be used for recommending new sampling locations.

Details about the Delaunay method can be found in Appendix A.2 of the MAROS Manual (AFCEE, 2003).

Sampling Location determination uses the Delaunay triangulation method to determine the significance of the current sampling locations relative to the overall monitoring network. The Delaunay method calculates the network Area and Average concentration of the plume using data from multiple monitoring wells. A slope factor (SF) is calculated for each well to indicate the significance of this well in the system (i.e. how removing a well changes the average concentration.)

The Sampling Location optimization process is performed in a stepwise fashion. Step one involves assessing the significance of the well in the system, if a well has a small SF (little significance to the network), the well may be removed from the monitoring network. Step two involves evaluating the information loss of removing a well from the network. If one well has a small SF, it may or may not be eliminated depending on whether the information loss is significant. If the information loss is not significant, the well can be eliminated from the monitoring network and the process of optimization continues with fewer wells. However if the well information loss is significant then the optimization terminates. This sampling optimization process allows the user to assess "redundant" wells that will not incur significant information loss on a constituent-by-constituent basis for individual sampling events.

7.2 Well Sufficiency Analysis – Delaunay Method

The well sufficiency analysis, using the Delaunay method, is designed to recommend new sampling locations in areas *within* the existing monitoring network where there is a high level of uncertainty in contaminant concentration. Details about the well sufficiency analysis can be found in Appendix A.2 of the MAROS Manual (AFCEE, 2003).

In many cases, new sampling locations need to be added to the existing network to enhance the spatial plume characterization. If the MAROS algorithm calculates a high level of uncertainty in predicting the constituent concentration for a particular area, a new sampling location is recommended. The Slope Factor (SF) values obtained from the redundancy evaluation described above are used to calculate the concentration estimation error for each triangle area formed in the Delaunay triangulation. The estimated SF value for each area is then classified into four levels: Small, Moderate, Large, or Extremely large (S, M, L, E) because the larger the estimated SF value, the higher the estimation error at this area. Therefore, the triangular areas with the estimated SF value at the Extremely large or Large level can be candidate regions for new sampling locations.

The results from the Delaunay method and the method for determining new sampling locations are derived solely from the spatial configuration of the monitoring network and the spatial pattern of the contaminant plume. No parameters such as the hydrogeologic conditions are considered in the analysis. Therefore, professional judgment and regulatory considerations must be used to make final decisions.

7.3 Sampling Frequency Determination - Modified CES Method

The Modified CES method optimizes sampling frequency for each sampling location based on the magnitude, direction, and uncertainty of its concentration trend derived from its recent and historical monitoring records. The Modified Cost Effective Sampling (MCES) estimates a conservative lowest-frequency sampling schedule for a given groundwater monitoring location that still provides needed information for regulatory and remedial decision-making. The MCES method was developed on the basis of the Cost Effective Sampling (CES) method developed by Ridley et al (1995). Details about the MCES method can be found in Appendix A.9 of the MAROS Manual (AFCEE, 2003).

In order to estimate the least frequent sampling schedule for a monitoring location that still provides enough information for regulatory and remedial decision-making, MCES employs three steps to determine the sampling frequency. The first step involves analyzing frequency based on recent trends. A preliminary location sampling frequency (PLSF) is developed based on the rate of change of well concentrations calculated by linear regression along with the Mann-Kendall trend analysis of the most recent monitoring data (see Figure 3). The variability within the sequential sampling data is accounted for by the Mann-Kendall analysis. The rate of change vs. trend result matrix categorizes wells as requiring annual, semi-annual or quarterly sampling. The PLSF is then reevaluated and adjusted based on overall trends. If the long-term history of change is significantly greater than the recent trend, the frequency may be reduced by one level.

The final step in the analysis involves reducing frequency based on risk, site-specific conditions, regulatory requirements or other external issues. Since not all compounds in the target being assessed are equally harmful, frequency is reduced by one level if recent maximum concentration for a compound of high risk is less than 1/2 of the Maximum Concentration Limit (MCL). The result of applying this method is a suggested sampling frequency based on recent sampling data trends and overall sampling data trends and expert judgment.

The final sampling frequency determined from the MCES method can be Quarterly, Semiannual, Annual, or Biennial. Users can further reduce the sampling frequency to, for example, once every three years, if the trend estimated from Biennial data (i.e., data drawn once every two years from the original data) is the same as that estimated from the original data.

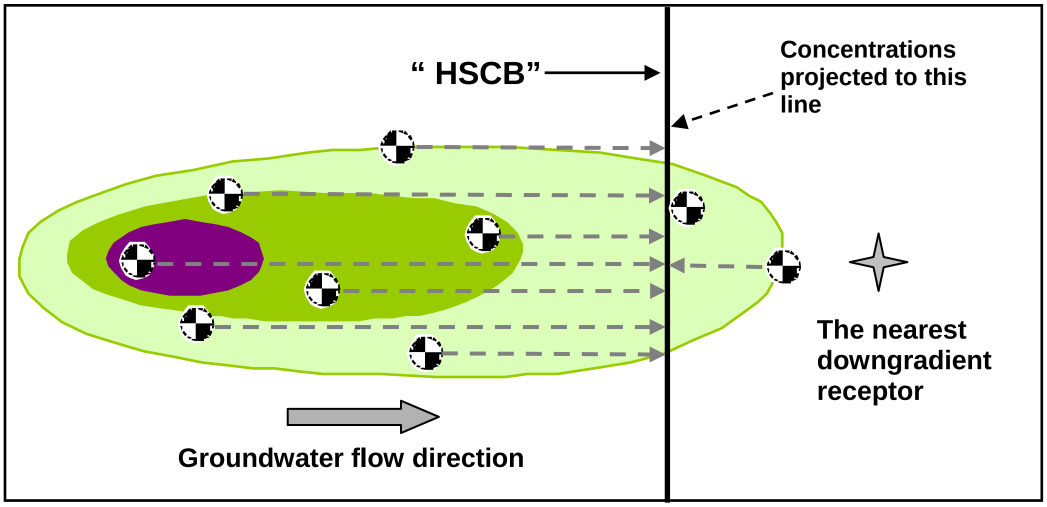
7.4 Data Sufficiency Analysis – Power Analysis

The MAROS Data Sufficiency module employs simple statistical methods to evaluate whether the collected data are adequate both in quantity and in quality for revealing changes in constituent concentrations. The first section of the module evaluates individual well concentrations to determine if they are statistically below a target screening level. The second section includes a simple calculation for estimating projected groundwater concentrations at a specified point downgradient of the plume. A statistical Power analysis is then applied to the projected concentrations to determine if the downgradient concentrations are statistically below the cleanup standard. If the number of projected concentrations is below the level to provide statistical significance, then the number of sample events required to statistically confirm concentrations below standards is estimated from the Power analysis.

Before testing the cleanup status for individual wells, the stability or trend of the contaminant plume should be evaluated. Only after the plume has reached stability or is reliably diminishing can we conduct a test to examine the cleanup status of wells. Applying the analysis to wells in an expanding plume may cause incorrect conclusions and is less meaningful.

Statistical power analysis is a technique for interpreting the results of statistical tests. The Power of a statistical test is a measure of the ability of the test to detect an effect given that the effect actually exists. The method provides additional information about a statistical test: 1) the power of the statistical test, i.e., the probability of finding a difference in the variable of interest when a difference truly exists; and 2) the expected sample size of a future sampling plan given the minimum detectable difference it is supposed to detect. For example, if the mean concentration is lower than the cleanup goal but a statistical test cannot prove this, the power and expected sample size can tell the reason and how many more samples are needed to result in a significant test. The additional samples can be obtained by a longer period of sampling or an increased sampling frequency. Details about the data sufficiency analysis can be found in Appendix A.6 of the MAROS Manual (AFCEE, 2003).

When applying the MAROS power analysis method, a hypothetical statistical compliance boundary (HSCB) is assigned to be a line perpendicular to the groundwater flow direction (see figure below). Monitoring well concentrations are projected onto the HSCB using the distance from each well to the compliance boundary along with a decay coefficient. The projected concentrations from each well and each sampling event are then used in the risk-based power analysis. Since there may be more than one sampling event selected by the user, the risk-based power analysis results are given on an event-by-event basis. This power analysis can then indicate if target are statistically achieved at the HSCB. For instance, at a site where the historical monitoring record is short with few wells, the HSCB would be distant; whereas, at a site with longer duration of sampling with many wells, the HSCB would be close. Ultimately, at a site the goal would be to have the HSCB coincide with or be within the actual compliance boundary (typically the site property line).



In order to perform a risk-based cleanup status evaluation for the whole site, a strategy was developed as follows.

- Estimate concentration versus distance decay coefficient from plume centerline wells.
- Extrapolate concentration versus distance for each well using this decay coefficient.
- Comparing the extrapolated concentrations with the compliance concentration using power analysis.

Results from this analysis can be *Attained* or *Not Attained*, providing a statistical interpretation of whether the cleanup goal has been met on the site-scale from the risk-based point of view. The results as a function of time can be used to evaluate if the monitoring system has enough power at each step in the sampling record to indicate certainty of compliance by the plume location and condition relative to the compliance boundary. For example, if results are *Not Attained* at early sampling events but are *Attained* in recent sampling events, it indicates that the recent sampling record provides a powerful enough result to indicate compliance of the plume relative to the location of the receptor or compliance boundary.

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TABLE 1 Mann-Kendall Analysis Decision Matrix (Aziz, et. al., 2003)		
Mann-Kendall Statistic	**Confidence in the Trend**	**Concentration Trend**
S > 0	> 95%	Increasing
S > 0	90 - 95%	Probably Increasing
S > 0	< 90%	No Trend
S ≤ 0	< 90% and COV ≥ 1	No Trend
S ≤ 0	< 90% and COV < 1	Stable
S < 0	90 - 95%	Probably Decreasing
S < 0	> 95%	Decreasing

TABLE 2 Linear Regression Analysis Decision Matrix (Aziz, et. al., 2003)		
Confidence in the Trend	**Log-slope**	
	Positive	**Negative**
< 90%	No Trend	COV < 1 Stable COV > 1 No Trend
90 - 95%	Probably Increasing	Probably Decreasing
> 95%	Increasing	Decreasing

MAROS: Decision Support Tool

MAROS is a collection of tools in one software package that is used in an explanatory, non-linear fashion. The tool includes models, geostatistics, heuristic rules, and empirical relationships to assist the user in optimizing a groundwater monitoring network system while maintaining adequate delineation of the plume as well as knowledge of the plume state over time. Different users utilize the tool in different ways and interpret the results from a different viewpoint.

↓

Overview Statistics

What it is: Simple, qualitative and quantitative plume information can be gained through evaluation of monitoring network historical data trends both spatially and temporally. The MAROS Overview Statistics are the foundation the user needs to make informed optimization decisions at the site.

What it does: The Overview Statistics are designed to allow site personnel to develop a better understanding of the plume behavior over time and understand how the individual well concentration trends are spatially distributed within the plume. This step allows the user to gain information that will support a more informed decision to be made in the next level of optimization analysis.

What are the tools: Overview Statistics includes two analytical tools:

1) **Trend Analysis:** includes Mann-Kendall and Linear Regression statistics for individual wells and results in general heuristically-derived monitoring categories with a suggested sampling density and monitoring frequency.

2) **Moment Analysis:** includes dissolved mass estimation (0^{th} Moment), center of mass (1^{st} Moment), and plume spread (2^{nd} Moment) over time. Trends of these moments show the user another piece of information about the plume stability over time.

What is the product: A first-cut blueprint for a future long-term monitoring program that is intended to be a foundation for more detailed statistical analysis.

↓

Detailed Statistics

What it is: The MAROS Detailed Statistics allows for a quantitative analysis for spatial and temporal optimization of the well network on a well-by-well basis.

What it does: The results from the Overview Statistics should be considered along side the MAROS optimization recommendations gained from the Detailed Statistical Analysis. The MAROS Detailed Statistics results should be reassessed in view of site knowledge and regulatory requirements as well as the Overview Statistics.

What are the tools: Detailed Statistics includes four analytical tools:

1) **Sampling Frequency Optimization:** uses the Modified CES method to establish a recommended future sampling frequency.

2) **Well Redundancy Analysis:** uses the Delaunay Method to evaluate if any wells within the monitoring network are redundant and can be eliminated without any significant loss of plume information.

3) **Well Sufficiency Analysis:** uses the Delaunay Method to evaluate areas where new wells are recommended within the monitoring network due to high levels of concentration uncertainty.

4) **Data Sufficiency Analysis:** uses Power Analysis to assess if the historical monitoring data record has sufficient power to accurately reflect the location of the plume relative to the nearest receptor or compliance point.

What is the product: List of wells to remove from the monitoring program, locations where monitoring wells may need to be added, recommended frequency of sampling for each well, analysis if the overall system is statistically powerful to monitor the plume.

Figure 1. MAROS Decision Support Tool Flow Chart

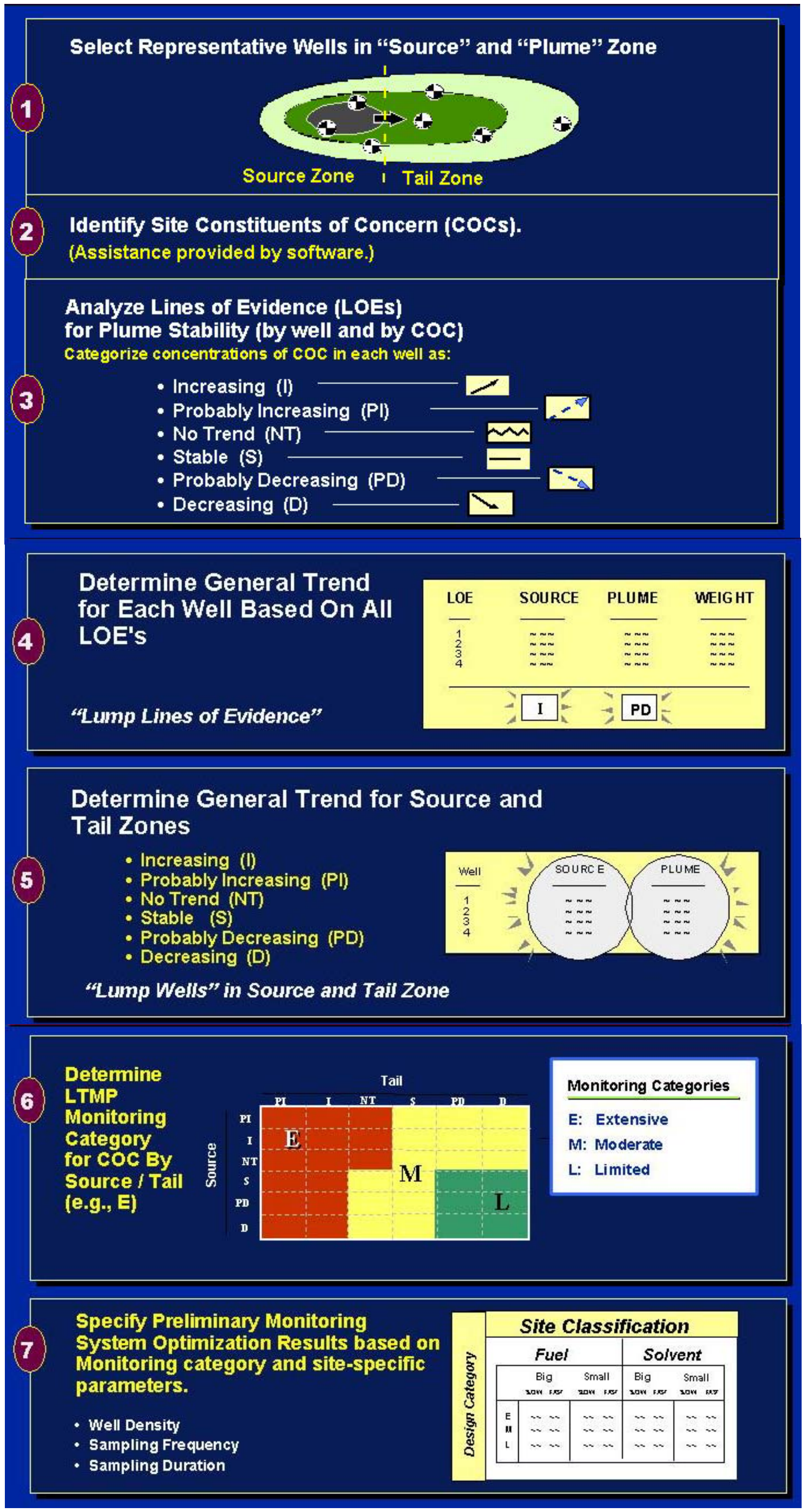


Figure 2:
MAROS Overview Statistics Trend Analysis Methodology

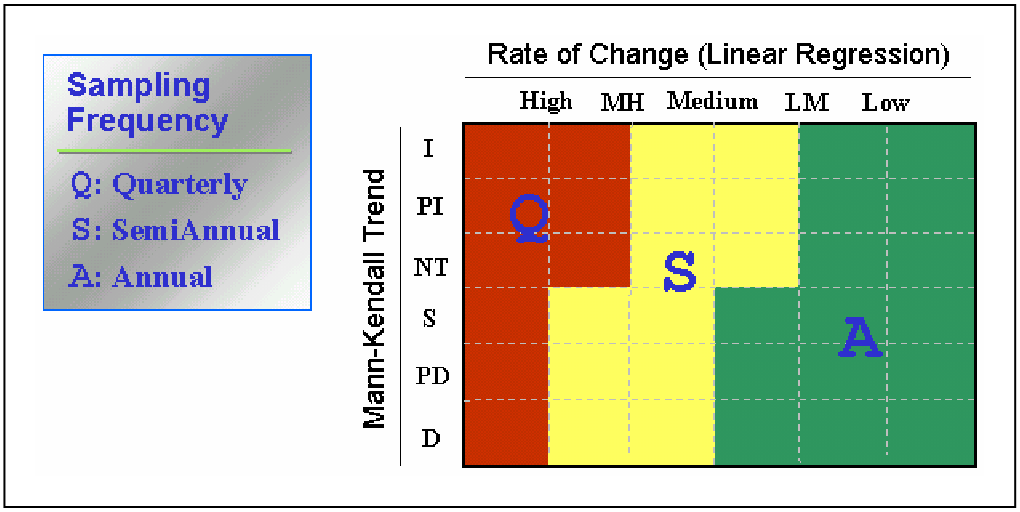


Figure 3. Decision Matrix for Determining Provisional Frequency (*Figure A.3.1 of the MAROS Manual (AFCEE 2003*)

GROUNDWATER MONITORING NETWORK OPTIMIZATION
Pantex Plant

Carson County, Texas

APPENDIX B:

MAROS Supporting Information

Table B.1 Extraction Well Trend Summary Results RDX

TABLE B.1
EXTRACTION WELL TREND SUMMARY RESULTS RDX: 2000-2007

LONG-TERM MONITORING OPTIMIZATION
PANTEX FACILITY
Carson County, Texas

WellName	Number of Samples	Number of Detects	Percent Detection	Maximum Result [ug/L]	Max Result Above Standard?	Average Result [ug/L]	Average Result Above Standard?	Mann-Kendall Trend	Average Slope Factor
RDX Southeast Sector									
PTX06-EW-1	21	21	100%	1,600	Yes	926	Yes	D	0.08
PTX06-EW-10	22	19	86%	560	Yes	26	Yes	I	0.41
PTX06-EW-11	23	23	100%	1,300	Yes	794	Yes	D	0.07
PTX06-EW-12	22	22	100%	2,600	Yes	1,500	Yes	D	0.04
PTX06-EW-14	10	10	100%	1,360	Yes	674	Yes	NT	
PTX06-EW-15	25	25	100%	62	Yes	37	Yes	S	0.16
PTX06-EW-16	24	24	100%	2,300	Yes	1,510	Yes	S	0.14
PTX06-EW-17	23	23	100%	970	Yes	722	Yes	S	0.03
PTX06-EW-18	18	18	100%	1,100	Yes	536	Yes	D	0.02
PTX06-EW-19	23	23	100%	920	Yes	662	Yes	D	0.11
PTX06-EW-2	21	21	100%	1,040	Yes	733	Yes	D	0.02
PTX06-EW-20	23	23	100%	180	Yes	46	Yes	I	0.10
PTX06-EW-21	23	23	100%	110	Yes	40	Yes	D	0.48
PTX06-EW-22A	22	22	100%	910	Yes	154	Yes	D	0.08
PTX06-EW-23A	21	21	100%	1,400	Yes	772	Yes	D	0.04
PTX06-EW-24	22	22	100%	1,600	Yes	732	Yes	D	0.20
PTX06-EW-25	21	21	100%	840	Yes	271	Yes	D	0.09
PTX06-EW-26	23	23	100%	2,200	Yes	710	Yes	D	0.07
PTX06-EW-27	21	21	100%	2,500	Yes	1,060	Yes	I	0.02
PTX06-EW-28	20	20	100%	1,500	Yes	721	Yes	D	0.29
PTX06-EW-29	24	24	100%	1,800	Yes	580	Yes	D	0.26
PTX06-EW-3	23	23	100%	2,260	Yes	1,330	Yes	D	0.08
PTX06-EW-30	22	22	100%	1,600	Yes	798	Yes	D	0.04
PTX06-EW-31	22	22	100%	1,000	Yes	486	Yes	D	0.10
PTX06-EW-32	23	23	100%	1,400	Yes	672	Yes	D	0.03
PTX06-EW-33	22	22	100%	1,200	Yes	673	Yes	I	0.04
PTX06-EW-34	23	23	100%	1,800	Yes	1,200	Yes	S	0.01
PTX06-EW-35	22	22	100%	2,700	Yes	1,480	Yes	D	0.02
PTX06-EW-36	21	21	100%	2,600	Yes	1,130	Yes	D	0.11
PTX06-EW-37	21	21	100%	400	Yes	35	Yes	I	0.20
PTX06-EW-38C	22	22	100%	6,800	Yes	409	Yes	D	0.08
PTX06-EW-39	24	24	100%	1,300	Yes	611	Yes	D	0.05
PTX06-EW-4	25	25	100%	1,800	Yes	1,050	Yes	NT	0.01
PTX06-EW-40	22	22	100%	7,100	Yes	1,100	Yes	D	0.12
PTX06-EW-41	16	16	100%	15,000	Yes	1,730	Yes	D	0.07
PTX06-EW-42A	24	24	100%	8,100	Yes	1,340	Yes	PD	0.06
PTX06-EW-43	19	19	100%	5,500	Yes	2,420	Yes	D	0.05
PTX06-EW-44	24	24	100%	25,000	Yes	4,020	Yes	S	0.07
PTX06-EW-45	22	22	100%	4,900	Yes	3,320	Yes	D	0.06
PTX06-EW-46	24	24	100%	8,600	Yes	1,260	Yes	D	0.04
PTX06-EW-47	17	17	100%	1,900	Yes	1,250	Yes	D	0.02
PTX06-EW-48	22	22	100%	2,000	Yes	1,080	Yes	I	0.05
PTX06-EW-49	24	24	100%	10,000	Yes	1,380	Yes	S	0.04
PTX06-EW-5	18	18	100%	2,400	Yes	1,360	Yes	I	0.06
PTX06-EW-53	9	9	100%	1,400	Yes	923	Yes	PD	0.06
PTX06-EW-6	20	20	100%	5,920	Yes	2,540	Yes	D	0.03
PTX06-EW-7	25	25	100%	3,200	Yes	1,390	Yes	I	0.05
PTX06-EW-9	16	16	100%	290	Yes	32	Yes	I	0.22

Notes:
1. Extraction wells part of PGPTS in Southest Sector. Values for RDX 2000-2007.
2. Number of Samples is the number of samples analyzed for the compound at this location.
   Number of Detects is the number of samples where the compound has been detected at this location.
3. Maximum Result is the maximum concentration for the COC analyzed between 2000 and 2007.
4. Screening level from Corrective Measure Study. RDX = 7.7 ug/L.
6. D = Decreasing; PD = Probably Decreasing; S = Stable; PI = Probably Increasing; I = Increasing; N/A = Insufficient Data to determine trend;
   NT = No Trend; ND = well has all non-detect results for COC; ND* = Non-detect except for one trace value.
7. Mann-Kendall trend results are illustrated on Figure 3.

February 12, 2008

GROUNDWATER MONITORING NETWORK OPTIMIZATION
Pantex Plant

Carson County, Texas

APPENDIX B:

Southeast Sector MAROS Reports

Mann-Kendall Reports

MAROS Moment Reports Southeast Sector
Zeroth Moments
First Moments
Second Moments

MAROS Mann-Kendall Statistics Summary

Project: Pantex SE

User Name: MV

Location: SouthEast

State: Texas

Time Period: 1/15/2000 **to** 7/15/2007

Consolidation Period: No Time Consolidation

Consolidation Type: Geometric Mean

Duplicate Consolidation: Average

ND Values: Specified Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
2,4,6-TRINITROTOLUENE								
PTX06-1002A	T	7	0	0.00	0	43.7%	Yes	ND
PTX06-1003	S	7	6	0.86	-11	93.2%	No	PD
PTX06-1005	S	8	6	1.14	-9	83.2%	No	NT
PTX06-1010	S	6	2	1.91	-9	93.2%	No	PD
PTX06-1011	S	7	0	0.00	0	43.7%	Yes	ND
PTX06-1013	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1014	T	13	0	0.00	0	47.6%	Yes	ND
PTX06-1015	T	13	1	0.22	12	74.5%	No	NT
PTX06-1023	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1030	T	13	5	1.18	-30	96.2%	No	D
PTX06-1031	T	13	0	0.00	0	47.6%	Yes	ND
PTX06-1034	T	15	1	0.73	6	59.6%	No	NT
PTX06-1036	T	13	0	0.00	0	47.6%	Yes	ND
PTX06-1037	T	5	0	0.00	0	40.8%	Yes	ND
PTX06-1038	T	14	12	0.55	4	56.4%	No	NT
PTX06-1039A	T	11	6	1.52	23	95.7%	No	I
PTX06-1040	T	14	1	3.46	7	62.6%	No	NT
PTX06-1041	T	11	4	1.97	28	98.4%	No	I
PTX06-1042	T	15	0	0.00	0	48.0%	Yes	ND
PTX06-1045	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1046	T	16	0	0.00	0	48.2%	Yes	ND
PTX06-1047A	T	14	0	0.00	0	47.8%	Yes	ND
PTX06-1052	T	15	0	0.00	0	48.0%	Yes	ND
PTX06-1053	T	17	0	0.00	0	48.4%	Yes	ND
PTX06-1069	T	11	1	0.42	-4	59.0%	No	S
PTX06-1088	S	8	8	0.51	-24	99.9%	No	D
PTX06-1095A	T	3	0	0.00	0	0.0%	Yes	ND
PTX06-1102	T	8	0	0.00	0	45.2%	Yes	ND
PTX06-EW-1	T	21	21	0.73	-168	100.0%	No	D
PTX06-EW-10	T	20	1	3.53	13	65.0%	No	NT
PTX06-EW-11	T	21	3	1.14	-53	94.2%	No	PD
PTX06-EW-12	T	19	2	1.17	-35	88.1%	No	NT
PTX06-EW-14	T	8	1	1.57	-7	76.4%	No	NT
PTX06-EW-15	T	25	25	0.31	-113	99.6%	No	D
PTX06-EW-16	T	25	24	0.36	-95	98.7%	No	D
PTX06-EW-17	T	23	23	0.30	-88	99.0%	No	D
PTX06-EW-18	T	18	18	0.87	-104	100.0%	No	D
PTX06-EW-19	T	20	2	4.38	-37	87.7%	No	NT

Project: Pantex SE **User Name:** MV

Location: SouthEast **State:** Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
2,4,6-TRINITROTOLUENE								
PTX06-EW-2	T	21	21	0.14	-114	100.0%	No	D
PTX06-EW-20	T	23	23	0.66	19	68.1%	No	NT
PTX06-EW-21	T	23	23	0.47	-170	100.0%	No	D
PTX06-EW-22	T	22	22	0.43	-83	99.0%	No	D
PTX06-EW-23	T	22	22	0.25	-14	64.2%	No	S
PTX06-EW-24	T	21	21	0.27	-90	99.7%	No	D
PTX06-EW-25	T	21	21	0.63	-181	100.0%	No	D
PTX06-EW-26	T	23	23	0.57	59	93.7%	No	PI
PTX06-EW-27	T	17	0	0.00	0	48.4%	Yes	ND
PTX06-EW-28	T	20	20	0.33	-107	100.0%	No	D
PTX06-EW-29	T	23	22	0.49	-158	100.0%	No	D
PTX06-EW-3	T	23	23	0.49	-198	100.0%	No	D
PTX06-EW-30	T	20	2	0.91	31	83.3%	No	NT
PTX06-EW-31	T	19	8	1.45	111	100.0%	No	I
PTX06-EW-32	T	20	1	2.68	17	69.6%	No	NT
PTX06-EW-33	T	19	13	0.93	120	100.0%	No	I
PTX06-EW-34	T	20	18	0.53	119	100.0%	No	I
PTX06-EW-35	T	19	5	0.84	73	99.5%	No	I
PTX06-EW-36	T	19	18	0.57	-85	99.9%	No	D
PTX06-EW-37	T	21	3	3.91	-51	93.4%	No	PD
PTX06-EW-38	T	22	22	1.68	-187	100.0%	No	D
PTX06-EW-39	T	22	21	0.62	-20	70.2%	No	S
PTX06-EW-4	T	21	10	1.04	108	100.0%	No	I
PTX06-EW-40	T	20	20	0.33	-10	61.3%	No	S
PTX06-EW-41	T	16	15	1.64	21	81.3%	No	NT
PTX06-EW-42	T	21	17	1.16	123	100.0%	No	I
PTX06-EW-43	T	14	11	0.69	72	100.0%	No	I
PTX06-EW-44	T	20	20	0.39	145	100.0%	No	I
PTX06-EW-45	T	17	16	0.49	111	100.0%	No	I
PTX06-EW-46	T	20	10	1.06	91	99.9%	No	I
PTX06-EW-47	T	14	0	0.00	0	47.8%	Yes	ND
PTX06-EW-48	T	19	4	2.52	62	98.5%	No	I
PTX06-EW-49	T	21	1	4.41	-20	71.5%	No	NT
PTX06-EW-5	T	16	4	3.71	24	84.7%	No	NT
PTX06-EW-53	T	9	0	0.00	0	46.0%	Yes	ND
PTX06-EW-6	T	17	2	1.66	-29	87.4%	No	NT
PTX06-EW-7	T	22	1	0.64	-21	71.1%	No	S
PTX06-EW-9	T	14	0	0.00	0	47.8%	Yes	ND
PTX08-1002	T	7	7	0.24	-9	88.1%	No	S
PTX08-1008	T	11	0	0.00	0	46.9%	Yes	ND
PTX08-1009	T	7	1	0.40	-2	55.7%	No	S
2,4-DINITROTOLUENE								
PTX06-1002A	T	7	0	0.00	0	43.7%	Yes	ND
PTX06-1003	S	7	3	0.98	1	50.0%	No	NT
PTX06-1005	S	8	4	1.32	-14	94.6%	No	PD
PTX06-1010	S	7	0	0.00	0	43.7%	Yes	ND
PTX06-1011	S	7	0	0.00	0	43.7%	Yes	ND
PTX06-1013	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1014	T	13	10	1.52	1	50.0%	No	NT

Project: Pantex SE **User Name:** MV

Location: SouthEast **State:** Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
2,4-DINITROTOLUENE								
PTX06-1015	T	13	0	0.00	0	47.6%	Yes	ND
PTX06-1023	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1030	T	14	0	0.00	0	47.8%	Yes	ND
PTX06-1031	T	14	0	0.00	0	47.8%	Yes	ND
PTX06-1034	T	15	2	0.36	9	65.1%	No	NT
PTX06-1036	T	13	0	0.00	0	47.6%	Yes	ND
PTX06-1037	T	6	0	0.00	0	42.3%	Yes	ND
PTX06-1038	T	14	11	1.15	-16	79.1%	No	NT
PTX06-1039A	T	11	9	0.69	18	90.5%	No	PI
PTX06-1040	T	13	2	0.71	19	86.1%	No	NT
PTX06-1041	T	12	11	0.71	36	99.3%	No	I
PTX06-1042	T	15	0	0.00	0	48.0%	Yes	ND
PTX06-1045	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1046	T	17	1	0.04	4	54.8%	No	NT
PTX06-1047A	T	14	0	0.00	0	47.8%	Yes	ND
PTX06-1052	T	15	1	0.15	-4	55.8%	No	S
PTX06-1053	T	17	0	0.00	14	70.1%	Yes	ND
PTX06-1069	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1088	S	8	2	1.75	7	76.4%	No	NT
PTX06-1095A	T	3	0	0.00	0	0.0%	Yes	ND
PTX06-1102	T	8	0	0.00	0	45.2%	Yes	ND
PTX06-EW-1	T	20	20	1.03	-135	100.0%	No	D
PTX06-EW-10	T	20	1	0.57	13	65.0%	No	NT
PTX06-EW-11	T	20	1	0.57	3	52.6%	No	NT
PTX06-EW-12	T	18	10	1.49	71	99.7%	No	I
PTX06-EW-14	T	7	0	0.00	0	43.7%	Yes	ND
PTX06-EW-15	T	25	23	0.54	-148	100.0%	No	D
PTX06-EW-16	T	24	24	1.04	-213	100.0%	No	D
PTX06-EW-17	T	23	23	1.13	-160	100.0%	No	D
PTX06-EW-18	T	16	14	1.08	-91	100.0%	No	D
PTX06-EW-19	T	18	13	2.36	69	99.6%	No	I
PTX06-EW-2	T	20	20	0.97	-139	100.0%	No	D
PTX06-EW-20	T	22	17	0.88	62	95.8%	No	I
PTX06-EW-21	T	23	22	0.86	-175	100.0%	No	D
PTX06-EW-22	T	21	20	1.17	-147	100.0%	No	D
PTX06-EW-23	T	21	21	1.13	-125	100.0%	No	D
PTX06-EW-24	T	20	20	0.62	-74	99.2%	No	D
PTX06-EW-25	T	20	20	1.21	-131	100.0%	No	D
PTX06-EW-26	T	21	20	1.21	-125	100.0%	No	D
PTX06-EW-27	T	17	15	0.98	2	51.6%	No	NT
PTX06-EW-28	T	20	19	1.02	-110	100.0%	No	D
PTX06-EW-29	T	22	19	1.51	-144	100.0%	No	D
PTX06-EW-3	T	22	22	1.35	-144	100.0%	No	D
PTX06-EW-30	T	18	7	0.64	42	93.9%	No	PI
PTX06-EW-31	T	18	17	0.78	-49	96.6%	No	D
PTX06-EW-32	T	19	5	3.23	-14	67.4%	No	NT
PTX06-EW-33	T	22	21	0.91	-88	99.4%	No	D
PTX06-EW-34	T	22	21	0.93	-130	100.0%	No	D
PTX06-EW-35	T	19	12	2.23	76	99.7%	No	I
PTX06-EW-36	T	19	18	1.55	-123	100.0%	No	D
PTX06-EW-37	T	21	2	4.03	-35	84.6%	No	NT

Project: Pantex SE **User Name:** MV

Location: SouthEast **State:** Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
2,4-DINITROTOLUENE								
PTX06-EW-38	T	22	21	3.00	-179	100.0%	No	D
PTX06-EW-39	T	21	16	1.84	-52	93.8%	No	PD
PTX06-EW-4	T	20	17	1.34	31	83.3%	No	NT
PTX06-EW-40	T	21	21	2.73	-163	100.0%	No	D
PTX06-EW-41	T	15	15	3.07	-63	99.9%	No	D
PTX06-EW-42	T	20	19	1.50	-113	100.0%	No	D
PTX06-EW-43	T	17	16	1.00	-44	96.2%	No	D
PTX06-EW-44	T	22	22	1.71	-150	100.0%	No	D
PTX06-EW-45	T	19	19	1.14	-125	100.0%	No	D
PTX06-EW-46	T	21	20	0.84	-106	99.9%	No	D
PTX06-EW-47	T	14	1	0.13	-7	62.6%	No	S
PTX06-EW-48	T	19	19	1.04	-46	94.2%	No	PD
PTX06-EW-49	T	21	2	4.50	-35	84.6%	No	NT
PTX06-EW-5	T	18	16	1.01	-84	100.0%	No	D
PTX06-EW-53	T	9	9	0.43	9	79.2%	No	NT
PTX06-EW-6	T	16	11	0.94	57	99.5%	No	I
PTX06-EW-7	T	22	19	1.56	37	84.3%	No	NT
PTX06-EW-9	T	14	1	0.91	11	70.5%	No	NT
PTX08-1002	T	7	6	0.47	-1	50.0%	No	S
PTX08-1008	T	11	0	0.00	0	46.9%	Yes	ND
PTX08-1009	T	7	0	0.00	0	43.7%	Yes	ND
2-AMINO-4,6-DINITROTOLUENE								
PTX06-1002A	T	7	0	0.00	0	43.7%	Yes	ND
PTX06-1003	S	7	2	0.17	-7	80.9%	No	S
PTX06-1005	S	8	4	1.06	6	72.6%	No	NT
PTX06-1010	S	7	4	1.17	-10	90.7%	No	PD
PTX06-1011	S	7	0	0.00	0	43.7%	Yes	ND
PTX06-1013	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1014	T	13	12	0.69	-56	100.0%	No	D
PTX06-1015	T	13	4	1.41	12	74.5%	No	NT
PTX06-1023	T	12	2	0.06	-15	82.8%	No	S
PTX06-1030	T	13	4	1.08	36	98.5%	No	I
PTX06-1031	T	14	6	1.38	-3	54.3%	No	NT
PTX06-1034	T	15	9	1.10	10	66.9%	No	NT
PTX06-1036	T	13	0	0.00	0	47.6%	Yes	ND
PTX06-1037	T	5	2	1.71	5	82.1%	No	NT
PTX06-1038	T	14	12	0.50	-10	68.6%	No	S
PTX06-1039A	T	11	10	0.46	21	94.0%	No	PI
PTX06-1040	T	14	8	1.13	46	99.4%	No	I
PTX06-1041	T	11	8	0.68	8	70.3%	No	NT
PTX06-1042	T	15	10	1.23	47	99.0%	No	I
PTX06-1045	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1046	T	16	1	0.26	7	60.5%	No	NT
PTX06-1047A	T	14	0	0.00	0	47.8%	Yes	ND
PTX06-1052	T	15	0	0.00	0	48.0%	Yes	ND
PTX06-1053	T	17	0	0.00	0	48.4%	Yes	ND
PTX06-1069	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1088	S	8	7	0.46	6	72.6%	No	NT
PTX06-1095A	T	3	0	0.00	0	0.0%	Yes	ND

Project: Pantex SE **User Name:** MV

Location: SouthEast **State:** Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
2-AMINO-4,6-DINITROTOLUENE								
PTX06-1102	T	8	3	1.77	-6	72.6%	No	NT
PTX06-EW-1	T	20	20	0.38	-90	99.8%	No	D
PTX06-EW-10	T	20	1	3.33	13	65.0%	No	NT
PTX06-EW-11	T	20	19	0.55	81	99.6%	No	I
PTX06-EW-12	T	22	22	0.50	118	100.0%	No	I
PTX06-EW-14	T	7	1	1.76	-6	76.4%	No	NT
PTX06-EW-15	T	21	11	0.52	-37	86.0%	No	S
PTX06-EW-16	T	25	25	0.36	-186	100.0%	No	D
PTX06-EW-17	T	23	23	0.27	-144	100.0%	No	D
PTX06-EW-18	T	18	18	0.39	-107	100.0%	No	D
PTX06-EW-19	T	23	23	0.25	-56	92.6%	No	PD
PTX06-EW-2	T	20	20	0.38	-143	100.0%	No	D
PTX06-EW-20	T	20	11	0.86	64	98.0%	No	I
PTX06-EW-21	T	23	21	0.70	-177	100.0%	No	D
PTX06-EW-22	T	22	22	1.59	-82	99.0%	No	D
PTX06-EW-23	T	22	22	0.22	-94	99.7%	No	D
PTX06-EW-24	T	21	21	0.38	-36	85.3%	No	S
PTX06-EW-25	T	20	20	0.51	-99	100.0%	No	D
PTX06-EW-26	T	23	23	0.36	-7	56.2%	No	S
PTX06-EW-27	T	21	21	0.40	-10	60.6%	No	S
PTX06-EW-28	T	20	20	0.44	-48	93.6%	No	PD
PTX06-EW-29	T	23	22	0.85	-188	100.0%	No	D
PTX06-EW-3	T	23	23	0.58	-159	100.0%	No	D
PTX06-EW-30	T	23	23	0.28	26	74.4%	No	NT
PTX06-EW-31	T	22	22	0.38	-161	100.0%	No	D
PTX06-EW-32	T	23	23	0.42	-98	99.6%	No	D
PTX06-EW-33	T	22	22	0.41	-55	93.6%	No	PD
PTX06-EW-34	T	23	23	0.45	-144	100.0%	No	D
PTX06-EW-35	T	20	19	0.52	-84	99.7%	No	D
PTX06-EW-36	T	21	20	0.58	-113	100.0%	No	D
PTX06-EW-37	T	21	1	2.05	-18	69.4%	No	NT
PTX06-EW-38	T	22	22	1.88	-55	93.6%	No	PD
PTX06-EW-39	T	24	24	0.75	-100	99.4%	No	D
PTX06-EW-4	T	25	25	0.26	-3	51.9%	No	S
PTX06-EW-40	T	22	22	1.32	-138	100.0%	No	D
PTX06-EW-41	T	16	16	1.96	-41	96.5%	No	D
PTX06-EW-42	T	23	23	3.05	-202	100.0%	No	D
PTX06-EW-43	T	19	19	0.75	-84	99.9%	No	D
PTX06-EW-44	T	23	23	1.85	-133	100.0%	No	D
PTX06-EW-45	T	22	22	0.34	-55	93.6%	No	PD
PTX06-EW-46	T	24	24	0.97	-124	99.9%	No	D
PTX06-EW-47	T	16	16	0.39	39	95.7%	No	I
PTX06-EW-48	T	22	22	0.39	-144	100.0%	No	D
PTX06-EW-49	T	21	18	3.26	151	100.0%	No	I
PTX06-EW-5	T	19	19	0.42	-97	100.0%	No	D
PTX06-EW-53	T	9	9	0.29	-18	96.2%	No	D
PTX06-EW-6	T	20	20	0.47	-66	98.3%	No	D
PTX06-EW-7	T	25	25	0.42	-106	99.3%	No	D
PTX06-EW-9	T	14	1	2.40	11	70.5%	No	NT
PTX08-1002	T	7	4	1.05	0	43.7%	No	NT
PTX08-1008	T	11	1	0.42	-6	64.8%	No	S

Project: Pantex SE **User Name:** MV

Location: SouthEast **State:** Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
2-AMINO-4,6-DINITROTOLUENE								
PTX08-1009	T	7	1	0.78	-2	55.7%	No	S
4-AMINO-2,6-DINITROTOLUENE								
PTX06-1002A	T	7	6	0.45	0	43.7%	No	S
PTX06-1003	S	7	2	0.61	-5	71.9%	No	S
PTX06-1005	S	8	5	1.11	13	92.9%	No	PI
PTX06-1010	S	8	3	1.41	-16	96.9%	No	D
PTX06-1011	S	7	0	0.00	0	43.7%	Yes	ND
PTX06-1013	T	11	1	0.02	0	46.9%	No	S
PTX06-1014	T	13	12	0.65	-29	95.6%	No	D
PTX06-1015	T	13	13	0.34	-8	66.2%	No	S
PTX06-1023	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1030	T	13	12	0.68	33	97.5%	No	I
PTX06-1031	T	14	14	0.37	37	97.6%	No	I
PTX06-1034	T	15	14	0.80	73	100.0%	No	I
PTX06-1036	T	13	10	0.85	-43	99.6%	No	D
PTX06-1037	T	5	5	0.19	-4	75.8%	No	S
PTX06-1038	T	14	12	0.59	22	87.2%	No	NT
PTX06-1039A	T	11	9	0.74	18	90.5%	No	PI
PTX06-1040	T	14	14	0.31	-3	54.3%	No	S
PTX06-1041	T	12	12	0.32	10	72.7%	No	NT
PTX06-1042	T	16	11	0.90	60	99.7%	No	I
PTX06-1045	T	11	7	1.22	5	61.9%	No	NT
PTX06-1046	T	17	11	0.99	44	96.2%	No	I
PTX06-1047A	T	14	5	1.83	35	96.9%	No	I
PTX06-1052	T	15	0	0.00	0	48.0%	Yes	ND
PTX06-1053	T	17	13	1.15	96	100.0%	No	I
PTX06-1069	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1088	S	8	6	0.96	10	86.2%	No	NT
PTX06-1095A	T	3	0	0.00	0	0.0%	Yes	ND
PTX06-1102	T	9	7	0.95	-1	50.0%	No	S
PTX06-EW-1	T	19	18	0.50	-43	92.8%	No	PD
PTX06-EW-10	T	20	12	2.76	109	100.0%	No	I
PTX06-EW-11	T	24	23	0.29	29	75.4%	No	NT
PTX06-EW-12	T	22	21	0.43	10	59.9%	No	NT
PTX06-EW-14	T	11	10	0.51	-6	64.8%	No	S
PTX06-EW-15	T	25	23	0.63	-127	99.9%	No	D
PTX06-EW-16	T	25	24	0.39	-61	91.9%	No	PD
PTX06-EW-17	T	23	22	0.39	-83	98.5%	No	D
PTX06-EW-18	T	18	17	0.41	-34	89.3%	No	S
PTX06-EW-19	T	23	22	0.33	-61	94.3%	No	PD
PTX06-EW-2	T	19	14	0.66	-47	94.6%	No	PD
PTX06-EW-20	T	21	9	0.92	14	65.1%	No	NT
PTX06-EW-21	T	22	7	3.16	-62	95.8%	No	D
PTX06-EW-22	T	21	12	2.33	-16	67.3%	No	NT
PTX06-EW-23	T	21	21	0.28	-45	90.7%	No	PD
PTX06-EW-24	T	19	16	0.54	89	99.9%	No	I
PTX06-EW-25	T	18	8	0.78	-24	80.6%	No	S
PTX06-EW-26	T	23	23	0.58	-105	99.7%	No	D
PTX06-EW-27	T	21	21	0.41	100	99.9%	No	I

Project: Pantex SE **User Name:** MV

Location: SouthEast **State:** Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
4-AMINO-2,6-DINITROTOLUENE								
PTX06-EW-28	T	19	19	0.31	-30	84.3%	No	S
PTX06-EW-29	T	23	20	0.70	-171	100.0%	No	D
PTX06-EW-3	T	22	21	0.44	-116	100.0%	No	D
PTX06-EW-30	T	23	23	0.52	-63	94.9%	No	PD
PTX06-EW-31	T	22	22	0.55	-97	99.7%	No	D
PTX06-EW-32	T	23	23	0.32	-155	100.0%	No	D
PTX06-EW-33	T	22	22	0.32	-32	80.7%	No	S
PTX06-EW-34	T	23	23	0.66	-140	100.0%	No	D
PTX06-EW-35	T	22	21	0.58	105	99.9%	No	I
PTX06-EW-36	T	20	20	0.39	-18	70.7%	No	S
PTX06-EW-37	T	21	21	0.69	-112	100.0%	No	D
PTX06-EW-38	T	22	21	0.50	-116	100.0%	No	D
PTX06-EW-39	T	24	24	0.63	-182	100.0%	No	D
PTX06-EW-4	T	25	24	0.45	139	100.0%	No	I
PTX06-EW-40	T	22	21	0.43	-137	100.0%	No	D
PTX06-EW-41	T	16	15	0.75	-35	93.6%	No	PD
PTX06-EW-42	T	23	23	3.59	1	50.0%	No	NT
PTX06-EW-43	T	18	18	0.43	-45	95.2%	No	D
PTX06-EW-44	T	23	23	1.46	-42	85.9%	No	NT
PTX06-EW-45	T	21	21	0.27	-49	92.6%	No	PD
PTX06-EW-46	T	24	24	2.22	-76	96.9%	No	D
PTX06-EW-47	T	17	17	0.28	-35	91.8%	No	PD
PTX06-EW-48	T	22	22	0.52	-100	99.8%	No	D
PTX06-EW-49	T	23	23	1.60	-144	100.0%	No	D
PTX06-EW-5	T	19	18	0.56	-60	98.1%	No	D
PTX06-EW-53	T	9	9	0.35	-3	58.0%	No	S
PTX06-EW-6	T	20	19	0.81	-86	99.8%	No	D
PTX06-EW-7	T	25	24	0.35	104	99.2%	No	I
PTX06-EW-9	T	16	15	0.41	-39	95.7%	No	D
PTX08-1002	T	7	4	1.53	4	66.7%	No	NT
PTX08-1008	T	11	9	0.87	-8	70.3%	No	S
PTX08-1009	T	7	3	1.54	7	80.9%	No	NT
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE								
PTX06-1002A	T	7	7	0.14	-5	71.9%	No	S
PTX06-1003	S	7	6	1.93	-7	80.9%	No	NT
PTX06-1005	S	8	8	0.84	-14	94.6%	No	PD
PTX06-1010	S	8	6	1.25	-15	95.8%	No	D
PTX06-1011	S	7	2	2.59	1	50.0%	No	NT
PTX06-1013	T	11	11	0.19	23	95.7%	No	I
PTX06-1014	T	14	14	0.26	35	96.9%	No	I
PTX06-1015	T	13	13	0.65	60	100.0%	No	I
PTX06-1023	T	12	12	0.23	-10	72.7%	No	S
PTX06-1030	T	15	15	0.26	47	99.0%	No	I
PTX06-1031	T	15	15	0.66	97	100.0%	No	I
PTX06-1034	T	13	7	1.87	55	100.0%	No	I
PTX06-1036	T	13	6	1.17	43	99.6%	No	I
PTX06-1037	T	5	5	0.36	-6	88.3%	No	S
PTX06-1038	T	14	14	0.20	-35	96.9%	No	D
PTX06-1039A	T	11	11	0.31	-21	94.0%	No	PD

Project: Pantex SE

User Name: MV

Location: SouthEast

State: Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE								
PTX06-1040	T	14	14	0.15	9	66.6%	No	NT
PTX06-1041	T	12	12	0.24	2	52.7%	No	NT
PTX06-1042	T	16	16	0.39	-18	77.5%	No	S
PTX06-1045	T	12	12	0.34	38	99.6%	No	I
PTX06-1046	T	17	17	0.22	88	100.0%	No	I
PTX06-1047A	T	14	5	2.31	37	97.6%	No	I
PTX06-1052	T	15	0	0.00	0	48.0%	Yes	ND
PTX06-1053	T	17	2	3.15	23	81.5%	No	NT
PTX06-1069	T	11	1	0.14	-4	59.0%	No	S
PTX06-1088	S	8	8	0.15	-14	94.6%	No	PD
PTX06-1095A	T	3	1	0.00	0	0.0%	No	N/A
PTX06-1102	T	10	10	1.14	-16	90.7%	No	PD
PTX06-EW-1	T	21	21	0.37	-65	97.4%	No	D
PTX06-EW-10	T	22	19	4.55	87	99.3%	No	I
PTX06-EW-11	T	23	23	0.31	-202	100.0%	No	D
PTX06-EW-12	T	22	22	0.34	-94	99.7%	No	D
PTX06-EW-14	T	10	10	0.52	3	56.9%	No	NT
PTX06-EW-15	T	25	25	0.33	-43	83.5%	No	S
PTX06-EW-16	T	24	24	0.35	-40	83.1%	No	S
PTX06-EW-17	T	23	23	0.26	-16	65.3%	No	S
PTX06-EW-18	T	18	18	0.49	-78	99.9%	No	D
PTX06-EW-19	T	23	23	0.23	-120	100.0%	No	D
PTX06-EW-2	T	21	21	0.20	-85	99.5%	No	D
PTX06-EW-20	T	23	23	1.06	101	99.6%	No	I
PTX06-EW-21	T	23	23	0.72	-211	100.0%	No	D
PTX06-EW-22	T	22	22	1.18	-120	100.0%	No	D
PTX06-EW-23	T	21	21	0.27	-83	99.4%	No	D
PTX06-EW-24	T	22	22	0.45	-136	100.0%	No	D
PTX06-EW-25	T	21	21	0.88	-166	100.0%	No	D
PTX06-EW-26	T	23	23	0.63	-104	99.7%	No	D
PTX06-EW-27	T	21	21	0.41	111	100.0%	No	I
PTX06-EW-28	T	20	20	0.47	-120	100.0%	No	D
PTX06-EW-29	T	24	24	0.69	-203	100.0%	No	D
PTX06-EW-3	T	23	23	0.38	-181	100.0%	No	D
PTX06-EW-30	T	22	22	0.35	-92	99.6%	No	D
PTX06-EW-31	T	22	22	0.47	-159	100.0%	No	D
PTX06-EW-32	T	23	23	0.38	-123	100.0%	No	D
PTX06-EW-33	T	22	22	0.48	155	100.0%	No	I
PTX06-EW-34	T	23	23	0.31	-38	83.4%	No	S
PTX06-EW-35	T	22	22	0.41	-94	99.7%	No	D
PTX06-EW-36	T	21	21	0.56	-97	99.9%	No	D
PTX06-EW-37	T	21	21	2.42	100	99.9%	No	I
PTX06-EW-38	T	22	22	1.95	-142	100.0%	No	D
PTX06-EW-39	T	24	24	0.60	-79	97.4%	No	D
PTX06-EW-4	T	25	25	0.33	30	74.9%	No	NT
PTX06-EW-40	T	22	22	0.67	-143	100.0%	No	D
PTX06-EW-41	T	16	16	1.13	-47	98.2%	No	D
PTX06-EW-42	T	24	24	1.14	-57	91.7%	No	PD
PTX06-EW-43	T	19	19	0.54	-53	96.6%	No	D
PTX06-EW-44	T	24	24	0.65	-50	88.7%	No	S
PTX06-EW-45	T	22	22	0.22	-120	100.0%	No	D

Project: Pantex SE

User Name: MV

Location: SouthEast

State: Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE								
PTX06-EW-46	T	24	24	0.70	-100	99.4%	No	D
PTX06-EW-47	T	17	17	0.31	-75	99.9%	No	D
PTX06-EW-48	T	22	22	0.39	117	100.0%	No	I
PTX06-EW-49	T	24	24	0.63	-8	56.8%	No	S
PTX06-EW-5	T	18	18	0.24	78	99.9%	No	I
PTX06-EW-53	T	9	9	0.23	-16	94.0%	No	PD
PTX06-EW-6	T	20	20	0.64	-130	100.0%	No	D
PTX06-EW-7	T	25	25	0.32	127	99.9%	No	I
PTX06-EW-9	T	16	16	2.19	72	100.0%	No	I
PTX08-1002	T	7	7	0.70	-11	93.2%	No	PD
PTX08-1008	T	11	2	0.09	-15	85.9%	No	S
PTX08-1009	T	7	4	2.10	-8	84.5%	No	NT

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Zeroth Moment Analysis

Project: Pantex SE Sector

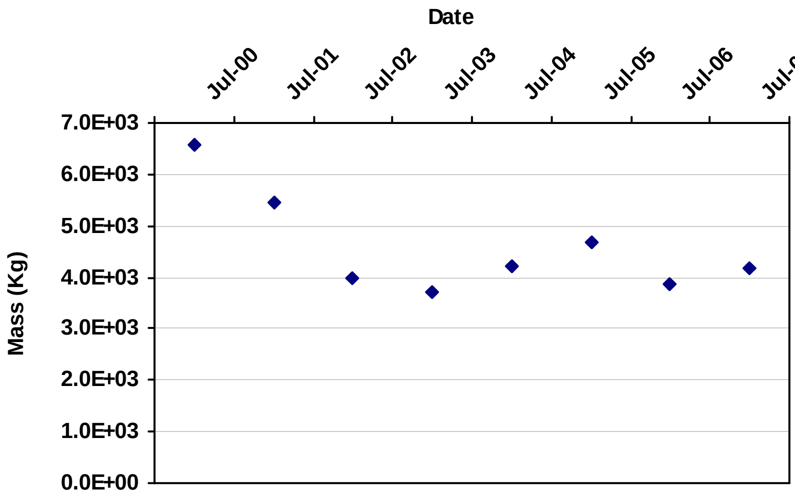
User Name: MV

Location: SouthEast

State: Texas

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 30 ft

Mann Kendall S Statistic:

-10

Confidence in Trend:

86.2%

Coefficient of Variation:

0.21

Zeroth Moment Trend:

S

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2000	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	6.6E+03	72
7/1/2001	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	5.5E+03	74
7/1/2002	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	4.0E+03	75
7/1/2003	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	3.7E+03	75
7/1/2004	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	4.2E+03	73
7/1/2005	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	4.7E+03	76
7/1/2006	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	3.9E+03	75
7/1/2007	HEXAHYDRO-1,3,5-TRINITRO-1,3,5-T	4.2E+03	68

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS Zeroth Moment Analysis

Project: Pantex SE 4ADNT

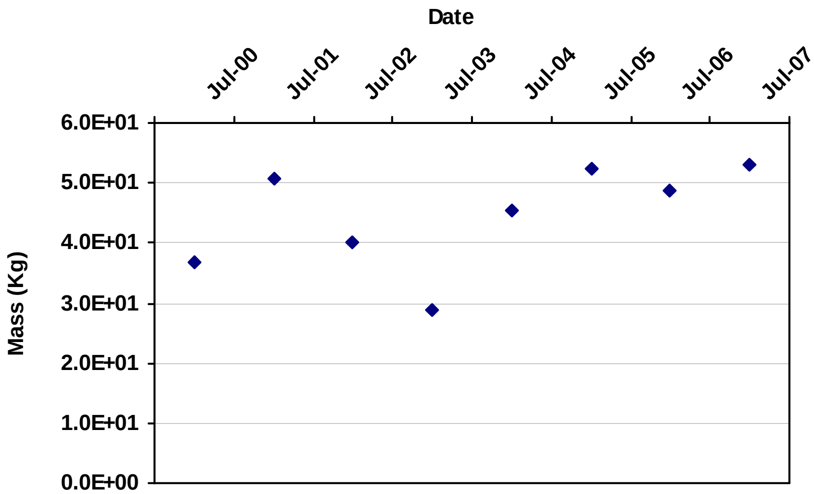
User Name: MV

Location: Southeast

State: Texas

COC: 4-AMINO-2,6-DINITROTOLUENE

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 30 ft

Mann Kendall S Statistic:

14

Confidence in Trend:

94.6%

Coefficient of Variation:

0.19

Zeroth Moment Trend:

PI

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2000	4-AMINO-2,6-DINITROTOLUENE	3.7E+01	68
7/1/2001	4-AMINO-2,6-DINITROTOLUENE	5.1E+01	68
7/1/2002	4-AMINO-2,6-DINITROTOLUENE	4.0E+01	75
7/1/2003	4-AMINO-2,6-DINITROTOLUENE	2.9E+01	75
7/1/2004	4-AMINO-2,6-DINITROTOLUENE	4.5E+01	74
7/1/2005	4-AMINO-2,6-DINITROTOLUENE	5.2E+01	76
7/1/2006	4-AMINO-2,6-DINITROTOLUENE	4.9E+01	73
7/1/2007	4-AMINO-2,6-DINITROTOLUENE	5.3E+01	68

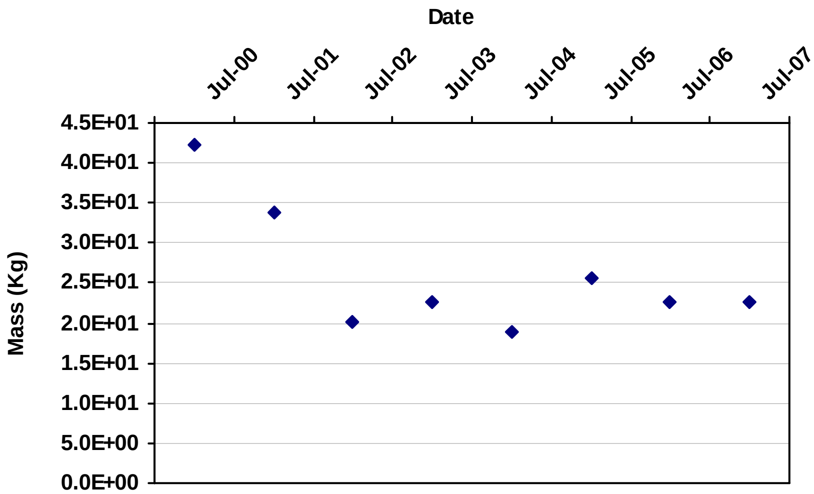
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS Zeroth Moment Analysis

Project: Pantex SE Sector
User Name: MV
Location: SouthEast
State: Texas

COC: 2-AMINO-4,6-DINITROTOLUENE

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 30 ft

Mann Kendall S Statistic:

-10

Confidence in Trend:

86.2%

Coefficient of Variation:

0.30

Zeroth Moment Trend:

S

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2000	2-AMINO-4,6-DINITROTOLUENE	4.2E+01	71
7/1/2001	2-AMINO-4,6-DINITROTOLUENE	3.4E+01	68
7/1/2002	2-AMINO-4,6-DINITROTOLUENE	2.0E+01	74
7/1/2003	2-AMINO-4,6-DINITROTOLUENE	2.3E+01	75
7/1/2004	2-AMINO-4,6-DINITROTOLUENE	1.9E+01	74
7/1/2005	2-AMINO-4,6-DINITROTOLUENE	2.6E+01	76
7/1/2006	2-AMINO-4,6-DINITROTOLUENE	2.3E+01	75
7/1/2007	2-AMINO-4,6-DINITROTOLUENE	2.3E+01	68

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS Zeroth Moment Analysis

Project: Pantex SE Sector

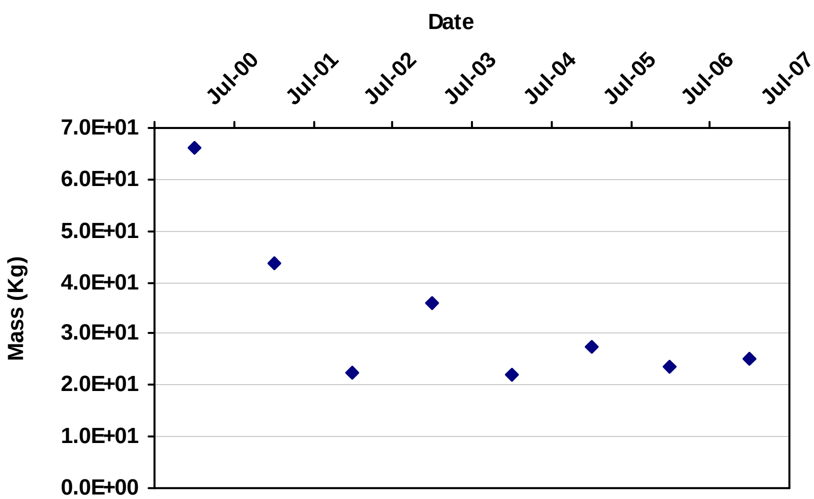
User Name: MV

Location: SouthEast

State: Texas

COC: 2,4,6-TRINITROTOLUENE

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 30 ft

Mann Kendall S Statistic:

-12

Confidence in Trend:

91.1%

Coefficient of Variation:

0.46

Zeroth Moment Trend:

PD

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2000	2,4,6-TRINITROTOLUENE	6.6E+01	58
7/1/2001	2,4,6-TRINITROTOLUENE	4.4E+01	46
7/1/2002	2,4,6-TRINITROTOLUENE	2.3E+01	74
7/1/2003	2,4,6-TRINITROTOLUENE	3.6E+01	75
7/1/2004	2,4,6-TRINITROTOLUENE	2.2E+01	74
7/1/2005	2,4,6-TRINITROTOLUENE	2.8E+01	76
7/1/2006	2,4,6-TRINITROTOLUENE	2.3E+01	75
7/1/2007	2,4,6-TRINITROTOLUENE	2.5E+01	68

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS Zeroth Moment Analysis

Project: Pantex SE Sector

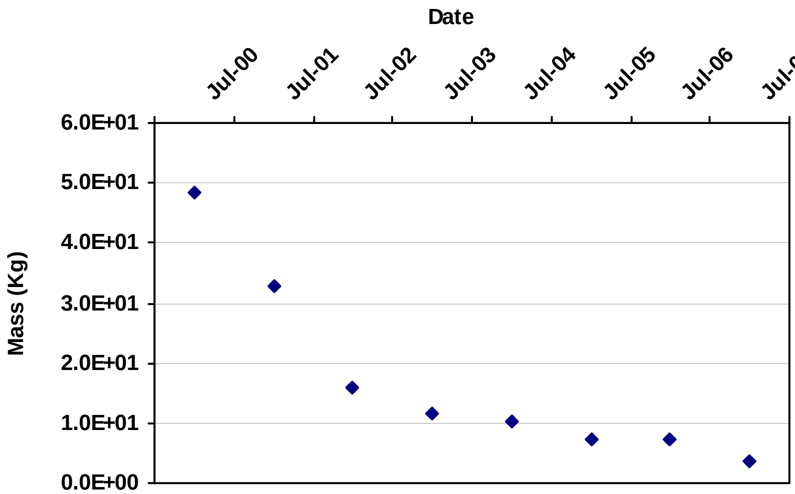
User Name: MV

Location: SouthEast

State: Texas

COC: 2,4-DINITROTOLUENE

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 30 ft

Mann Kendall S Statistic:

-28

Confidence in Trend:

100.0%

Coefficient of Variation:

0.90

Zeroth Moment Trend:

D

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2000	2,4-DINITROTOLUENE	4.8E+01	61
7/1/2001	2,4-DINITROTOLUENE	3.3E+01	60
7/1/2002	2,4-DINITROTOLUENE	1.6E+01	75
7/1/2003	2,4-DINITROTOLUENE	1.2E+01	75
7/1/2004	2,4-DINITROTOLUENE	1.0E+01	74
7/1/2005	2,4-DINITROTOLUENE	7.2E+00	76
7/1/2006	2,4-DINITROTOLUENE	7.1E+00	75
7/1/2007	2,4-DINITROTOLUENE	3.7E+00	68

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

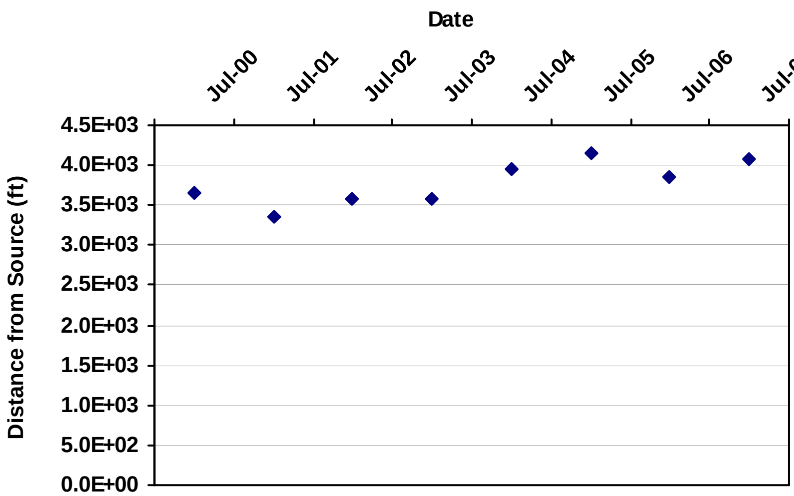
MAROS First Moment Analysis

Project: Pantex SE Sector **User Name:** MV

Location: SouthEast **State:** Texas

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Distance from Source to Center of Mass



Mann Kendall S Statistic: 16

Confidence in Trend: 96.9%

Coefficient of Variation: 0.07

First Moment Trend: I

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2000	HEXAHYDRO-1,3,5-TRINITRO	642,159	3,755,213	3,648	72
7/1/2001	HEXAHYDRO-1,3,5-TRINITRO	642,270	3,755,709	3,352	74
7/1/2002	HEXAHYDRO-1,3,5-TRINITRO	642,347	3,755,474	3,575	75
7/1/2003	HEXAHYDRO-1,3,5-TRINITRO	642,462	3,755,563	3,592	75
7/1/2004	HEXAHYDRO-1,3,5-TRINITRO	642,602	3,755,185	3,959	73
7/1/2005	HEXAHYDRO-1,3,5-TRINITRO	642,726	3,755,051	4,143	76
7/1/2006	HEXAHYDRO-1,3,5-TRINITRO	642,751	3,755,476	3,862	75
7/1/2007	HEXAHYDRO-1,3,5-TRINITRO	642,962	3,755,385	4,080	68

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

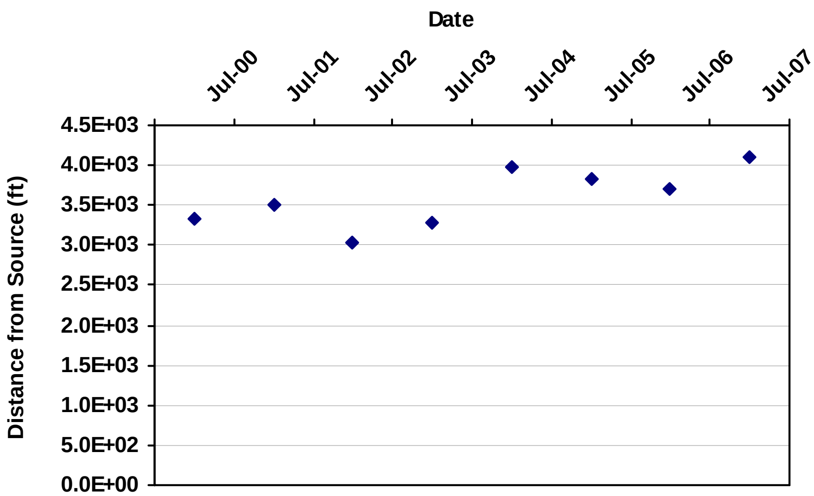
MAROS First Moment Analysis

Project: Pantex SE 4ADNT **User Name:** MV

Location: Southeast **State:** Texas

COC: 4-AMINO-2,6-DINITROTOLUENE

Distance from Source to Center of Mass



Mann Kendall S Statistic: 14

Confidence in Trend: 94.6%

Coefficient of Variation: 0.10

First Moment Trend: PI

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2000	4-AMINO-2,6-DINITROTOLUE	642,251	3,755,727	3,327	68
7/1/2001	4-AMINO-2,6-DINITROTOLUE	642,537	3,755,791	3,493	68
7/1/2002	4-AMINO-2,6-DINITROTOLUE	642,537	3,756,604	3,027	75
7/1/2003	4-AMINO-2,6-DINITROTOLUE	642,578	3,756,182	3,285	75
7/1/2004	4-AMINO-2,6-DINITROTOLUE	643,070	3,755,680	3,979	74
7/1/2005	4-AMINO-2,6-DINITROTOLUE	642,920	3,755,726	3,831	76
7/1/2006	4-AMINO-2,6-DINITROTOLUE	643,074	3,756,165	3,712	73
7/1/2007	4-AMINO-2,6-DINITROTOLUE	643,250	3,755,727	4,097	68

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

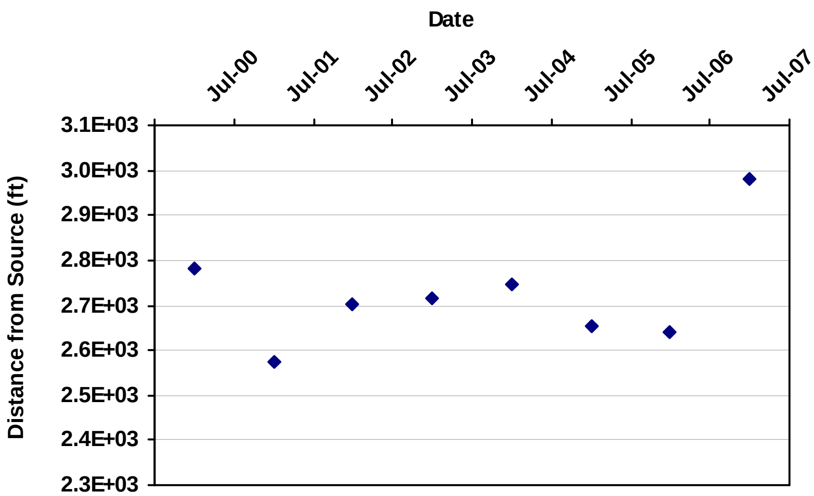
MAROS First Moment Analysis

Project: Pantex SE Sector **User Name:** MV

Location: SouthEast **State:** Texas

COC: 2-AMINO-4,6-DINITROTOLUENE

Distance from Source to Center of Mass



Mann Kendall S Statistic: 2

Confidence in Trend: 54.8%

Coefficient of Variation: 0.05

First Moment Trend: NT

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2000	2-AMINO-4,6-DINITROTOLUE	641,928	3,756,175	2,783	71
7/1/2001	2-AMINO-4,6-DINITROTOLUE	642,076	3,756,716	2,572	68
7/1/2002	2-AMINO-4,6-DINITROTOLUE	642,123	3,756,552	2,701	74
7/1/2003	2-AMINO-4,6-DINITROTOLUE	642,339	3,756,903	2,714	75
7/1/2004	2-AMINO-4,6-DINITROTOLUE	642,406	3,756,970	2,747	74
7/1/2005	2-AMINO-4,6-DINITROTOLUE	642,414	3,757,263	2,652	76
7/1/2006	2-AMINO-4,6-DINITROTOLUE	642,460	3,757,468	2,641	75
7/1/2007	2-AMINO-4,6-DINITROTOLUE	642,434	3,756,517	2,982	68

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

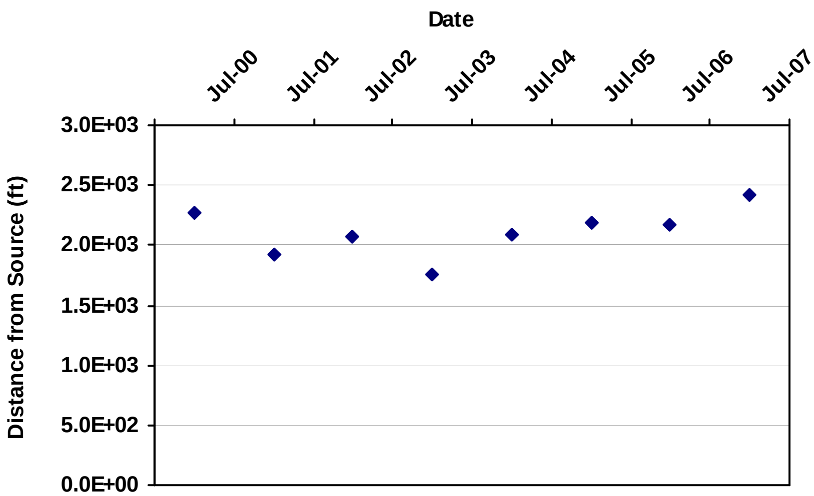
MAROS First Moment Analysis

Project: Pantex SE Sector **User Name:** MV

Location: SouthEast **State:** Texas

COC: 2,4,6-TRINITROTOLUENE

Distance from Source to Center of Mass



Mann Kendall S Statistic: 10

Confidence in Trend: 86.2%

Coefficient of Variation: 0.10

First Moment Trend: NT

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2000	2,4,6-TRINITROTOLUENE	641,619	3,756,608	2,264	58
7/1/2001	2,4,6-TRINITROTOLUENE	641,636	3,757,256	1,928	46
7/1/2002	2,4,6-TRINITROTOLUENE	641,598	3,756,904	2,069	74
7/1/2003	2,4,6-TRINITROTOLUENE	641,506	3,757,403	1,750	75
7/1/2004	2,4,6-TRINITROTOLUENE	641,473	3,756,697	2,096	74
7/1/2005	2,4,6-TRINITROTOLUENE	641,783	3,756,986	2,182	76
7/1/2006	2,4,6-TRINITROTOLUENE	641,887	3,757,209	2,176	75
7/1/2007	2,4,6-TRINITROTOLUENE	641,861	3,756,676	2,415	68

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

MAROS First Moment Analysis

Project: Pantex SE Sector

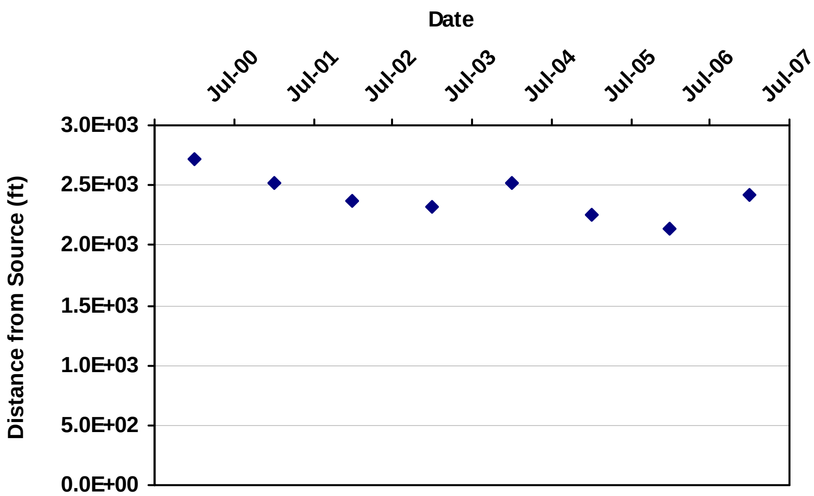
User Name: MV

Location: SouthEast

State: Texas

COC: 2,4-DINITROTOLUENE

Distance from Source to Center of Mass



Mann Kendall S Statistic:

-16

Confidence in Trend:

96.9%

Coefficient of Variation:

0.07

First Moment Trend:

D

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2000	2,4-DINITROTOLUENE	641,558	3,755,913	2,726	61
7/1/2001	2,4-DINITROTOLUENE	641,475	3,756,119	2,513	60
7/1/2002	2,4-DINITROTOLUENE	641,641	3,756,462	2,377	75
7/1/2003	2,4-DINITROTOLUENE	642,023	3,757,168	2,317	75
7/1/2004	2,4-DINITROTOLUENE	642,333	3,757,491	2,513	74
7/1/2005	2,4-DINITROTOLUENE	642,100	3,757,609	2,259	76
7/1/2006	2,4-DINITROTOLUENE	642,015	3,757,844	2,140	75
7/1/2007	2,4-DINITROTOLUENE	641,934	3,756,772	2,422	68

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

MAROS Second Moment Analysis

Project: Pantex SE Sector

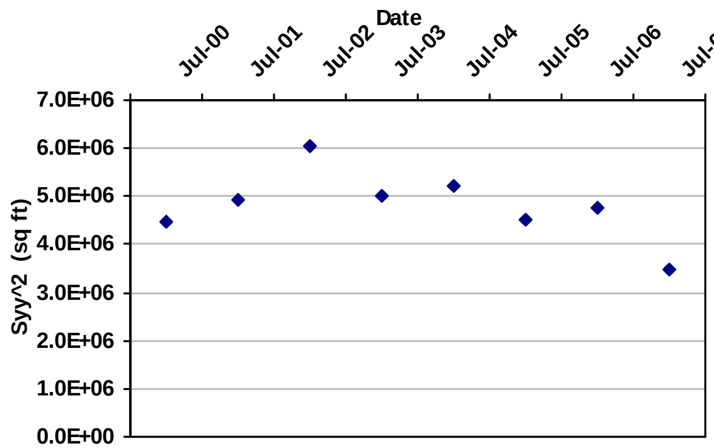
User Name: MV

Location: SouthEast

State: Texas

COC: HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE

Change in Plume Spread Over Time

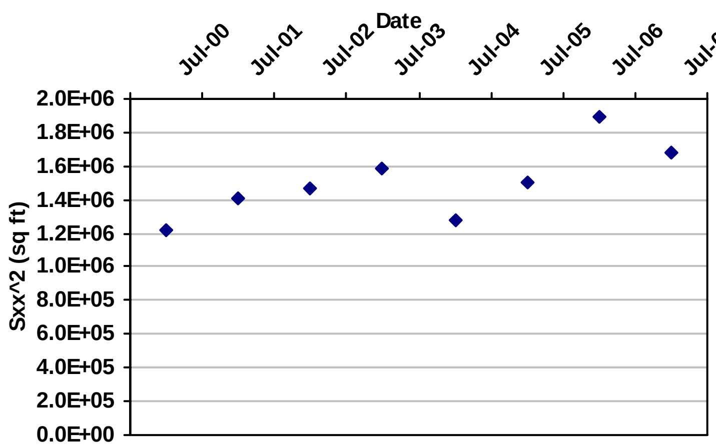


Mann Kendall S Statistic: -6

Confidence in Trend: 72.6%

Coefficient of Variation: 0.15

Second Moment Trend: S



Mann Kendall S Statistic: 18

Confidence in Trend: 98.4%

Coefficient of Variation: 0.14

Second Moment Trend: I

Data Table:

Effective Date	Constituent	Sigma XX (sq ft)	Sigma YY (sq ft)	Number of Wells
7/1/2000	HEXAHYDRO-1,3,5-TRINITRO	1,214,949	4,460,930	72
7/1/2001	HEXAHYDRO-1,3,5-TRINITRO	1,404,749	4,939,131	74
7/1/2002	HEXAHYDRO-1,3,5-TRINITRO	1,471,765	6,057,858	75
7/1/2003	HEXAHYDRO-1,3,5-TRINITRO	1,580,992	4,991,454	75
7/1/2004	HEXAHYDRO-1,3,5-TRINITRO	1,280,090	5,203,529	73
7/1/2005	HEXAHYDRO-1,3,5-TRINITRO	1,497,309	4,513,285	76
7/1/2006	HEXAHYDRO-1,3,5-TRINITRO	1,892,321	4,762,973	75
7/1/2007	HEXAHYDRO-1,3,5-TRINITRO	1,680,100	3,486,567	68

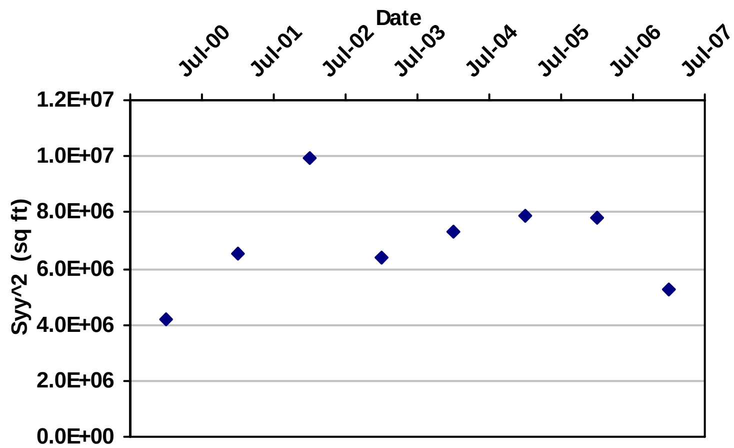
MAROS Second Moment Analysis

Project: Pantex SE 4ADNT **User Name:** MV

Location: Southeast **State:** Texas

COC: 4-AMINO-2,6-DINITROTOLUENE

Change in Plume Spread Over Time

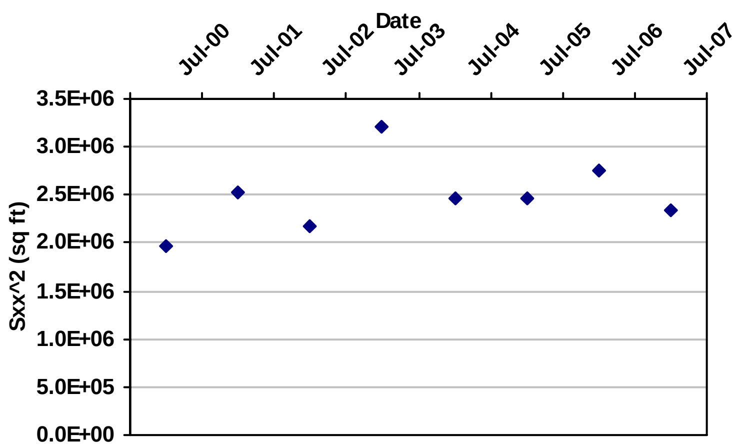


Mann Kendall S Statistic: 4

Confidence in Trend: 64.0%

Coefficient of Variation: 0.25

Second Moment Trend: NT



Mann Kendall S Statistic: 4

Confidence in Trend: 64.0%

Coefficient of Variation: 0.15

Second Moment Trend: NT

Data Table:

Effective Date	Constituent	Sigma XX (sq ft)	Sigma YY (sq ft)	Number of Wells
7/1/2000	4-AMINO-2,6-DINITROTOLUE	1,968,575	4,185,079	68
7/1/2001	4-AMINO-2,6-DINITROTOLUE	2,533,682	6,533,223	68
7/1/2002	4-AMINO-2,6-DINITROTOLUE	2,168,864	9,937,686	75
7/1/2003	4-AMINO-2,6-DINITROTOLUE	3,207,589	6,400,940	75
7/1/2004	4-AMINO-2,6-DINITROTOLUE	2,466,528	7,298,288	74
7/1/2005	4-AMINO-2,6-DINITROTOLUE	2,454,444	7,895,568	76
7/1/2006	4-AMINO-2,6-DINITROTOLUE	2,744,309	7,786,041	73
7/1/2007	4-AMINO-2,6-DINITROTOLUE	2,335,936	5,270,230	68

February 12, 2008

GROUNDWATER MONITORING NETWORK OPTIMIZATION
Pantex Plant

Carson County, Texas

APPENDIX B:

Southwest Sector MAROS Reports

MAROS Mann-Kendall Statistics Summary

Project: Pantex SW

User Name: MV

Location: Southwest Area

State: Texas

Time Period: 1/15/2000 **to** 4/15/2007

Consolidation Period: No Time Consolidation

Consolidation Type: Geometric Mean

Duplicate Consolidation: Average

ND Values: Specified Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
4-AMINO-2,6-DINITROTOLUENE								
1114-MW4	S	3	1	0.00	0	0.0%	No	N/A
PTX06-1006	T	3	0	0.00	0	0.0%	Yes	ND
PTX06-1007	S	3	3	0.00	0	0.0%	No	N/A
PTX06-1008	T	4	0	0.00	0	37.5%	Yes	ND
PTX06-1012	T	12	1	0.08	5	60.6%	No	NT
PTX06-1035	T	10	8	2.67	-8	72.9%	No	NT
PTX06-1036	T	13	10	0.85	-43	99.6%	No	D
PTX06-1049	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1052	S	15	0	0.00	0	48.0%	Yes	ND
PTX06-1053	T	17	13	1.15	96	100.0%	No	I
PTX06-1077A	T	4	0	0.00	0	37.5%	Yes	ND
PTX06-1085	T	4	0	0.00	0	37.5%	Yes	ND
PTX06-1086	T	8	0	0.00	0	45.2%	Yes	ND
PTX06-1087	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P02	T	6	0	0.00	0	42.3%	Yes	ND
PTX07-1P03	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P06	S	10	0	0.00	0	46.4%	Yes	ND
PTX07-1Q01	T	5	1	0.13	-2	59.2%	No	S
PTX07-1Q02	T	5	0	0.00	0	40.8%	Yes	ND
PTX07-1Q03	T	7	0	0.00	0	43.7%	Yes	ND
PTX08-1001	T	7	1	2.03	-6	76.4%	No	NT
PTX08-1003	T	6	0	0.00	0	42.3%	Yes	ND
PTX08-1005	S	6	6	0.47	-13	99.2%	No	D
PTX08-1006	S	8	8	0.25	4	64.0%	No	NT
PTX08-1007	T	2	0	0.00	0	0.0%	Yes	ND
PTX08-1008	S	11	9	0.87	-8	70.3%	No	S
PTX08-1009	S	7	3	1.54	7	80.9%	No	NT
PTX10-1008	T	6	0	0.00	0	42.3%	Yes	ND
PTX10-1013	S	6	0	0.00	0	42.3%	Yes	ND
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE								
1114-MW4	S	3	0	0.00	0	0.0%	Yes	ND
PTX06-1006	T	3	0	0.00	0	0.0%	Yes	ND
PTX06-1007	S	3	2	0.00	0	0.0%	No	N/A
PTX06-1008	T	4	0	0.00	0	37.5%	Yes	ND
PTX06-1012	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1035	T	10	0	0.00	0	46.4%	Yes	ND
PTX06-1036	T	13	6	1.17	43	99.6%	No	I

Project: Pantex SW

User Name: MV

Location: Southwest Area

State: Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE								
PTX06-1049	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1052	S	15	0	0.00	0	48.0%	Yes	ND
PTX06-1053	T	17	2	3.15	23	81.5%	No	NT
PTX06-1077A	T	4	0	0.00	0	37.5%	Yes	ND
PTX06-1085	T	4	0	0.00	0	37.5%	Yes	ND
PTX06-1086	T	8	1	2.61	5	68.3%	No	NT
PTX06-1087	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P02	T	6	5	0.79	-13	99.2%	No	D
PTX07-1P03	T	4	4	0.20	-6	95.8%	No	D
PTX07-1P06	S	10	10	0.84	-33	99.9%	No	D
PTX07-1Q01	T	5	0	0.00	0	40.8%	Yes	ND
PTX07-1Q02	T	5	0	0.00	0	40.8%	Yes	ND
PTX07-1Q03	T	7	1	2.51	4	66.7%	No	NT
PTX08-1001	T	7	3	0.99	1	50.0%	No	NT
PTX08-1003	T	6	0	0.00	0	42.3%	Yes	ND
PTX08-1005	S	6	6	0.99	-13	99.2%	No	D
PTX08-1006	S	8	8	0.77	26	100.0%	No	I
PTX08-1007	T	2	2	0.00	0	0.0%	No	N/A
PTX08-1008	S	11	2	0.09	-15	85.9%	No	S
PTX08-1009	S	7	4	2.10	-8	84.5%	No	NT
PTX10-1008	T	6	1	0.00	-1	50.0%	No	S
PTX10-1013	S	6	4	1.48	-4	70.3%	No	NT
PERCHLORATE								
1114-MW4	S	5	5	0.38	-8	95.8%	No	D
PTX06-1006	T	4	0	0.00	0	37.5%	Yes	ND
PTX06-1007	S	6	6	0.09	-5	76.5%	No	S
PTX06-1008	T	4	1	0.74	1	50.0%	No	NT
PTX06-1012	T	12	4	1.46	32	98.4%	No	I
PTX06-1035	T	10	0	0.00	0	46.4%	Yes	ND
PTX06-1036	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1049	T	9	0	0.00	0	46.0%	Yes	ND
PTX06-1052	S	14	1	0.48	-13	74.1%	No	S
PTX06-1053	T	16	4	0.66	-38	95.2%	No	D
PTX06-1077A	T	4	2	0.67	5	89.6%	No	NT
PTX06-1085	T	4	0	0.00	0	37.5%	Yes	ND
PTX06-1086	T	8	0	0.00	0	45.2%	Yes	ND
PTX06-1087	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P02	T	7	0	0.00	0	43.7%	Yes	ND
PTX07-1P03	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P06	S	9	0	0.00	0	46.0%	Yes	ND
PTX07-1Q01	T	5	0	0.00	0	40.8%	Yes	ND
PTX07-1Q02	T	5	0	0.00	0	40.8%	Yes	ND
PTX07-1Q03	T	7	0	0.00	0	43.7%	Yes	ND
PTX08-1001	T	7	7	0.23	9	88.1%	No	NT
PTX08-1003	T	7	7	0.18	-17	99.5%	No	D
PTX08-1005	S	5	5	0.60	-10	99.2%	No	D
PTX08-1006	S	9	9	0.65	-22	98.8%	No	D
PTX08-1007	T	3	2	0.00	0	0.0%	No	N/A
PTX08-1008	S	12	1	0.57	-11	74.9%	No	S

Project: Pantex SW **User Name:** MV

Location: Southwest Area **State:** Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
PERCHLORATE								
PTX08-1009	S	7	0	0.00	0	43.7%	Yes	ND
PTX10-1008	T	6	0	0.00	0	42.3%	Yes	ND
PTX10-1013	S	7	2	0.80	5	71.9%	No	NT
TRICHLOROETHYLENE (TCE)								
1114-MW4	S	6	6	0.50	9	93.2%	No	PI
PTX06-1006	T	3	1	0.00	0	0.0%	No	N/A
PTX06-1007	S	6	5	0.26	-8	89.8%	No	S
PTX06-1008	T	5	5	0.64	-2	59.2%	No	S
PTX06-1012	T	12	4	0.79	22	92.4%	No	PI
PTX06-1035	T	10	0	0.00	0	46.4%	Yes	ND
PTX06-1036	T	13	0	0.00	0	47.6%	Yes	ND
PTX06-1049	T	11	1	0.53	8	70.3%	No	NT
PTX06-1052	S	15	7	0.52	-46	98.8%	No	D
PTX06-1053	T	17	0	0.00	0	48.4%	Yes	ND
PTX06-1077A	T	6	5	0.59	7	86.4%	No	NT
PTX06-1085	T	4	0	0.00	0	37.5%	Yes	ND
PTX06-1086	T	8	0	0.00	0	45.2%	Yes	ND
PTX06-1087	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P02	T	7	0	0.00	0	43.7%	Yes	ND
PTX07-1P03	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P06	S	10	0	0.00	0	46.4%	Yes	ND
PTX07-1Q01	T	5	0	0.00	0	40.8%	Yes	ND
PTX07-1Q02	T	5	0	0.00	0	40.8%	Yes	ND
PTX07-1Q03	T	7	0	0.00	0	43.7%	Yes	ND
PTX08-1001	T	7	0	0.00	0	43.7%	Yes	ND
PTX08-1003	T	6	0	0.00	0	42.3%	Yes	ND
PTX08-1005	S	6	6	0.62	7	86.4%	No	NT
PTX08-1006	S	8	8	0.41	-4	64.0%	No	S
PTX08-1007	T	4	4	0.13	-2	62.5%	No	S
PTX08-1008	S	11	3	0.17	5	61.9%	No	NT
PTX08-1009	S	8	6	0.52	1	50.0%	No	NT
PTX10-1008	T	6	0	0.00	0	42.3%	Yes	ND
PTX10-1013	S	7	7	0.67	7	80.9%	No	NT

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)- Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Zeroth Moment Analysis

Project: Pantex SW

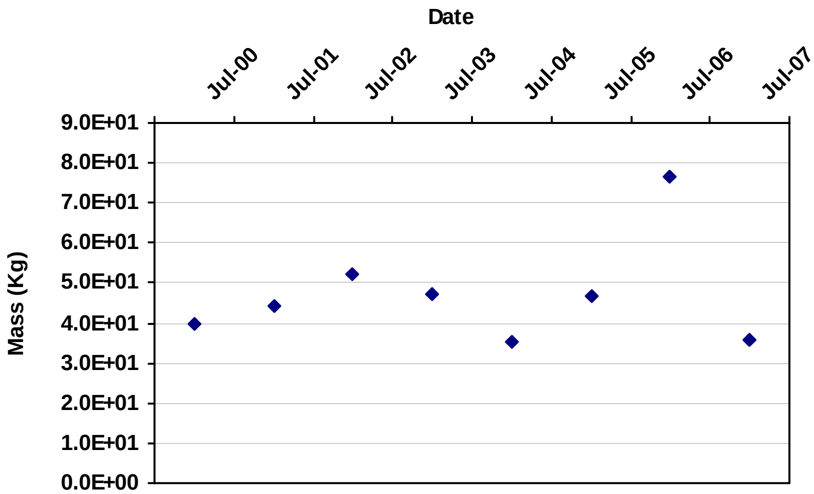
User Name: MV

Location: Southwest Area

State: Texas

COC: TRICHLOROETHYLENE (TCE)

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 50 ft

Mann Kendall S Statistic:

2

Confidence in Trend:

54.8%

Coefficient of Variation:

0.28

Zeroth Moment Trend:

NT

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2000	TRICHLOROETHYLENE (TCE)	4.0E+01	13
7/1/2001	TRICHLOROETHYLENE (TCE)	4.4E+01	24
7/1/2002	TRICHLOROETHYLENE (TCE)	5.2E+01	26
7/1/2003	TRICHLOROETHYLENE (TCE)	4.7E+01	29
7/1/2004	TRICHLOROETHYLENE (TCE)	3.6E+01	21
7/1/2005	TRICHLOROETHYLENE (TCE)	4.7E+01	22
7/1/2006	TRICHLOROETHYLENE (TCE)	7.7E+01	22
7/1/2007	TRICHLOROETHYLENE (TCE)	3.6E+01	14

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS Zeroth Moment Analysis

Project: Pantex SW

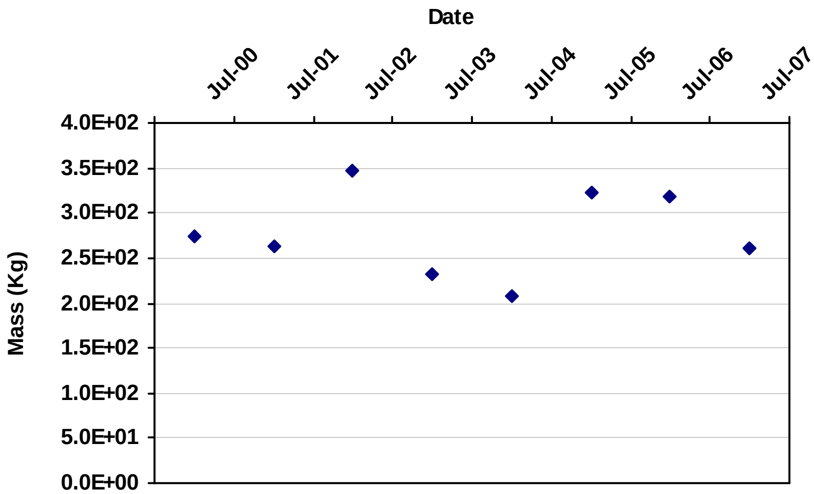
User Name: MV

Location: Southwest Area

State: Texas

COC: PERCHLORATE

Change in Dissolved Mass Over Time



Porosity: 0.25

Saturated Thickness:

Uniform: 50 ft

Mann Kendall S Statistic:

-4

Confidence in Trend:

64.0%

Coefficient of Variation:

0.17

Zeroth Moment Trend:

S

Data Table:

Effective Date	Constituent	Estimated Mass (Kg)	Number of Wells
7/1/2000	PERCHLORATE	2.7E+02	13
7/1/2001	PERCHLORATE	2.6E+02	24
7/1/2002	PERCHLORATE	3.5E+02	26
7/1/2003	PERCHLORATE	2.3E+02	28
7/1/2004	PERCHLORATE	2.1E+02	21
7/1/2005	PERCHLORATE	3.2E+02	20
7/1/2006	PERCHLORATE	3.2E+02	20
7/1/2007	PERCHLORATE	2.6E+02	14

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect. Moments are not calculated for sample events with less than 6 wells.

MAROS First Moment Analysis

Project: Pantex SW

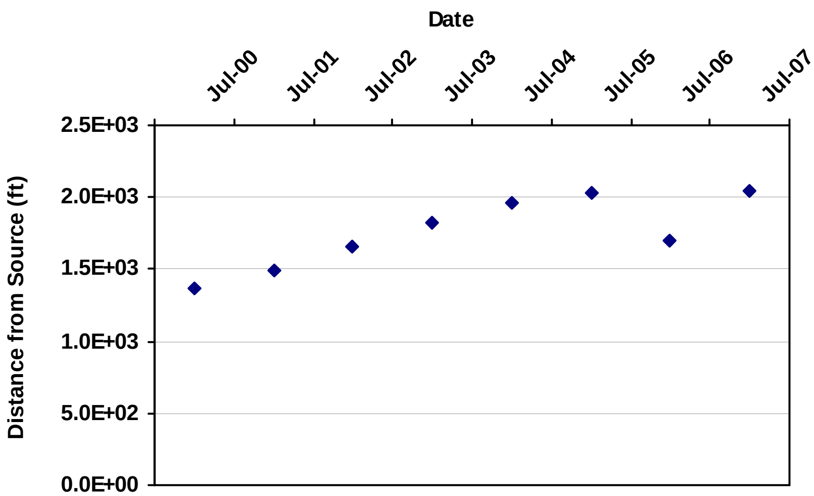
User Name: MV

Location: Southwest Area

State: Texas

COC: TRICHLOROETHYLENE (TCE)

Distance from Source to Center of Mass



Mann Kendall S Statistic:

22

Confidence in Trend:

99.8%

Coefficient of Variation:

0.14

First Moment Trend:

I

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2000	TRICHLOROETHYLENE (TCE)	636,899	3,758,041	1,373	13
7/1/2001	TRICHLOROETHYLENE (TCE)	635,809	3,758,125	1,486	24
7/1/2002	TRICHLOROETHYLENE (TCE)	636,115	3,758,390	1,653	26
7/1/2003	TRICHLOROETHYLENE (TCE)	635,217	3,758,149	1,823	29
7/1/2004	TRICHLOROETHYLENE (TCE)	636,064	3,758,701	1,968	21
7/1/2005	TRICHLOROETHYLENE (TCE)	636,179	3,758,781	2,031	22
7/1/2006	TRICHLOROETHYLENE (TCE)	635,987	3,758,410	1,700	22
7/1/2007	TRICHLOROETHYLENE (TCE)	635,672	3,758,672	2,044	14

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

MAROS First Moment Analysis

Project: Pantex SW

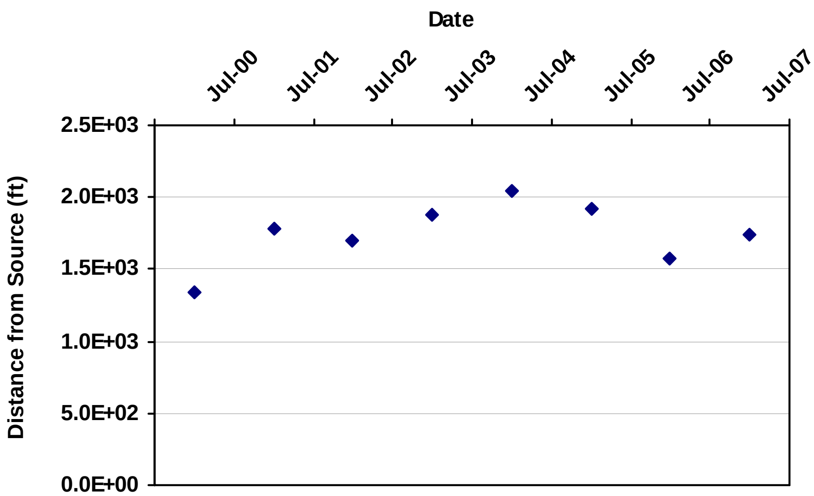
User Name: MV

Location: Southwest Area

State: Texas

COC: PERCHLORATE

Distance from Source to Center of Mass



Mann Kendall S Statistic: 6

Confidence in Trend: 72.6%

Coefficient of Variation: 0.12

First Moment Trend: NT

Data Table:

Effective Date	Constituent	Xc (ft)	Yc (ft)	Distance from Source (ft)	Number of Wells
7/1/2000	PERCHLORATE	636,108	3,758,072	1,342	13
7/1/2001	PERCHLORATE	635,515	3,758,300	1,775	24
7/1/2002	PERCHLORATE	635,862	3,758,369	1,695	26
7/1/2003	PERCHLORATE	635,733	3,758,525	1,885	28
7/1/2004	PERCHLORATE	635,763	3,758,705	2,045	21
7/1/2005	PERCHLORATE	635,970	3,758,630	1,917	20
7/1/2006	PERCHLORATE	635,873	3,758,252	1,580	20
7/1/2007	PERCHLORATE	636,279	3,758,496	1,738	14

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events). Moments are not calculated for sample events with less than 6 wells.

MAROS Second Moment Analysis

Project: Pantex SW

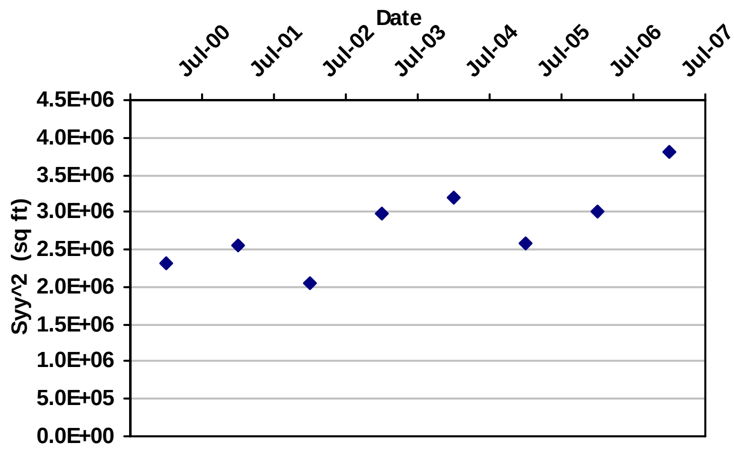
User Name: MV

Location: Southwest Area

State: Texas

COC: PERCHLORATE

Change in Plume Spread Over Time

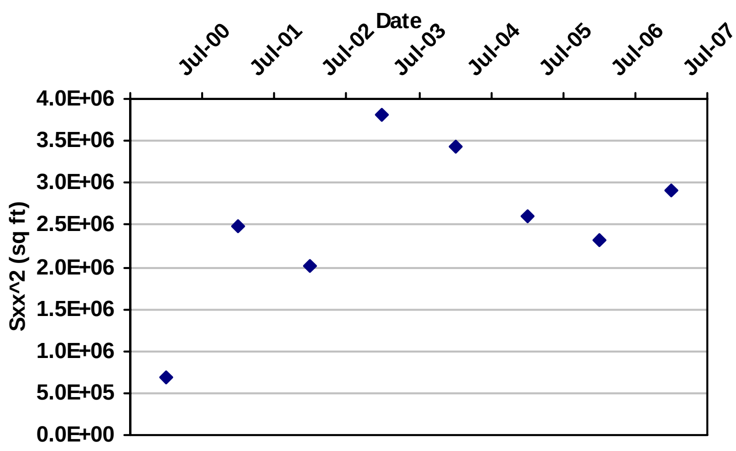


Mann Kendall S Statistic: 18

Confidence in Trend: 98.4%

Coefficient of Variation: 0.20

Second Moment Trend: I



Mann Kendall S Statistic: 8

Confidence in Trend: 80.1%

Coefficient of Variation: 0.38

Second Moment Trend: NT

Data Table:

Effective Date	Constituent	Sigma XX (sq ft)	Sigma YY (sq ft)	Number of Wells
7/1/2000	PERCHLORATE	674,631	2,319,199	13
7/1/2001	PERCHLORATE	2,492,690	2,548,386	24
7/1/2002	PERCHLORATE	2,018,251	2,041,502	26
7/1/2003	PERCHLORATE	3,808,129	2,974,789	28
7/1/2004	PERCHLORATE	3,435,859	3,198,986	21
7/1/2005	PERCHLORATE	2,604,765	2,578,513	20
7/1/2006	PERCHLORATE	2,328,383	2,996,988	20
7/1/2007	PERCHLORATE	2,903,960	3,820,155	14

February 12, 2008

GROUNDWATER MONITORING NETWORK OPTIMIZATION
Pantex Plant

Carson County, Texas

APPENDIX B:

North Sector MAROS Reports

MAROS Mann-Kendall Statistics Summary

Project: Pantex North

User Name: MV

Location: North/Playa 1

State: Texas

Time Period: 1/15/2000 **to** 4/15/2007

Consolidation Period: No Time Consolidation

Consolidation Type: Geometric Mean

Duplicate Consolidation: Average

ND Values: Specified Detection Limit

J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
2,6-DINITROTOLUENE								
PTX01-1001	T	25	0	0.00	0	49.1%	Yes	ND
PTX01-1002	T	25	0	0.00	0	49.1%	Yes	ND
PTX01-1008	T	13	0	0.00	0	47.6%	Yes	ND
PTX04-1001	T	5	0	0.00	0	40.8%	Yes	ND
PTX04-1002	T	12	1	1.02	9	70.4%	No	NT
PTX06-1013	T	10	2	0.77	7	70.0%	No	NT
PTX06-1023	T	12	1	0.01	-5	60.6%	No	S
PTX06-1048A	T	15	0	0.00	0	48.0%	Yes	ND
PTX06-1049	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1050	S	10	0	0.00	5	63.6%	Yes	ND
PTX06-1069	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1071	T	8	0	0.00	0	45.2%	Yes	ND
PTX06-1080	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1081	T	12	1	0.63	9	70.4%	No	NT
PTX06-1114	T	2	0	0.00	0	0.0%	Yes	ND
PTX07-1O01	S	6	0	0.00	0	42.3%	Yes	ND
PTX07-1O02	T	3	0	0.00	0	0.0%	Yes	ND
PTX07-1O03	T	7	0	0.00	0	43.7%	Yes	ND
PTX07-1O06	T	10	2	0.40	7	70.0%	No	NT
PTX07-1P02	T	6	0	0.00	0	42.3%	Yes	ND
PTX07-1P03	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P06	S	10	1	0.40	9	75.8%	No	NT
PTX07-1R03	T	8	0	0.00	0	45.2%	Yes	ND
PTX08-1001	T	6	0	0.00	0	42.3%	Yes	ND
PTX08-1002	S	7	0	0.00	0	43.7%	Yes	ND
PTX08-1010	T	14	0	0.00	0	47.8%	Yes	ND
PTX-BEG3	T	13	0	0.00	0	47.6%	Yes	ND
4-AMINO-2,6-DINITROTOLUENE								
PTX01-1001	T	23	2	0.23	21	69.9%	No	NT
PTX01-1002	T	25	0	0.00	0	49.1%	Yes	ND
PTX01-1008	T	13	0	0.00	0	47.6%	Yes	ND
PTX04-1001	T	6	0	0.00	0	42.3%	Yes	ND
PTX04-1002	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1013	T	10	1	0.02	1	50.0%	No	NT
PTX06-1023	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1048A	T	15	5	0.25	0	48.0%	No	S
PTX06-1049	T	11	0	0.00	0	46.9%	Yes	ND

Project: Pantex North | **User Name:** MV

Location: North/Playa 1 | **State:** Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
4-AMINO-2,6-DINITROTOLUENE								
PTX06-1050	S	10	8	0.68	14	87.3%	No	NT
PTX06-1069	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1071	T	8	0	0.00	0	45.2%	Yes	ND
PTX06-1080	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1081	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1114	T	2	2	0.00	0	0.0%	No	N/A
PTX07-1O01	S	6	5	0.55	1	50.0%	No	NT
PTX07-1O02	T	3	0	0.00	0	0.0%	Yes	ND
PTX07-1O03	T	7	3	0.31	1	50.0%	No	NT
PTX07-1O06	T	10	0	0.00	0	46.4%	Yes	ND
PTX07-1P02	T	6	0	0.00	0	42.3%	Yes	ND
PTX07-1P03	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P06	S	10	0	0.00	0	46.4%	Yes	ND
PTX07-1R03	T	8	0	0.00	0	45.2%	Yes	ND
PTX08-1001	T	7	1	2.03	-6	76.4%	No	NT
PTX08-1002	S	7	4	1.53	4	66.7%	No	NT
PTX08-1010	T	14	0	0.00	0	47.8%	Yes	ND
PTX-BEG3	T	13	11	0.44	25	92.7%	No	PI
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE								
PTX01-1001	T	25	0	0.00	0	49.1%	Yes	ND
PTX01-1002	T	25	0	0.00	0	49.1%	Yes	ND
PTX01-1008	T	13	0	0.00	0	47.6%	Yes	ND
PTX04-1001	T	6	0	0.00	0	42.3%	Yes	ND
PTX04-1002	T	12	7	0.58	-2	52.7%	No	S
PTX06-1013	T	10	10	0.19	19	94.6%	No	PI
PTX06-1023	T	12	12	0.23	-10	72.7%	No	S
PTX06-1048A	T	15	0	0.00	0	48.0%	Yes	ND
PTX06-1049	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1050	S	10	10	0.38	29	99.5%	No	I
PTX06-1069	T	11	1	0.14	-4	59.0%	No	S
PTX06-1071	T	8	0	0.00	0	45.2%	Yes	ND
PTX06-1080	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1081	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1114	T	2	1	0.00	0	0.0%	No	N/A
PTX07-1O01	S	6	6	0.24	1	50.0%	No	NT
PTX07-1O02	T	3	3	0.00	0	0.0%	No	N/A
PTX07-1O03	T	7	7	0.13	-9	88.1%	No	S
PTX07-1O06	T	10	2	1.04	9	75.8%	No	NT
PTX07-1P02	T	6	5	0.79	-13	99.2%	No	D
PTX07-1P03	T	4	4	0.20	-6	95.8%	No	D
PTX07-1P06	S	10	10	0.84	-33	99.9%	No	D
PTX07-1R03	T	8	1	0.17	1	50.0%	No	NT
PTX08-1001	T	7	3	0.99	1	50.0%	No	NT
PTX08-1002	S	7	7	0.70	-11	93.2%	No	PD
PTX08-1010	T	14	2	0.50	-3	54.3%	No	S
PTX-BEG3	T	13	0	0.00	0	47.6%	Yes	ND
PERCHLORATE								
PTX01-1001	T	24	16	1.63	16	64.4%	No	NT

Project: Pantex North **User Name:** MV

Location: North/Playa 1 **State:** Texas

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
PERCHLORATE								
PTX01-1002	T	24	2	0.40	-25	72.2%	No	S
PTX01-1008	T	13	0	0.00	0	47.6%	Yes	ND
PTX04-1001	T	6	0	0.00	0	42.3%	Yes	ND
PTX04-1002	T	16	0	0.00	0	48.2%	Yes	ND
PTX06-1013	T	9	0	0.00	0	46.0%	Yes	ND
PTX06-1023	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1048A	T	13	1	0.54	-12	74.5%	No	S
PTX06-1049	T	9	0	0.00	0	46.0%	Yes	ND
PTX06-1050	S	7	0	0.00	0	43.7%	Yes	ND
PTX06-1069	T	11	0	0.00	0	46.9%	Yes	ND
PTX06-1071	T	8	0	0.00	0	45.2%	Yes	ND
PTX06-1080	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1081	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1114	T	2	0	0.00	0	0.0%	Yes	ND
PTX07-1O01	S	6	0	0.00	0	42.3%	Yes	ND
PTX07-1O02	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1O03	T	7	0	0.00	0	43.7%	Yes	ND
PTX07-1O06	T	9	0	0.00	0	46.0%	Yes	ND
PTX07-1P02	T	7	0	0.00	0	43.7%	Yes	ND
PTX07-1P03	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P06	S	9	0	0.00	0	46.0%	Yes	ND
PTX07-1R03	T	8	0	0.00	0	45.2%	Yes	ND
PTX08-1001	T	7	7	0.23	9	88.1%	No	NT
PTX08-1002	S	10	0	0.00	0	46.4%	Yes	ND
PTX08-1010	T	14	0	0.00	0	47.8%	Yes	ND
PTX-BEG3	T	12	0	0.00	0	47.3%	Yes	ND
TRICHLOROETHYLENE (TCE)								
PTX01-1001	T	25	15	1.10	65	93.2%	No	PI
PTX01-1002	T	25	0	0.00	0	49.1%	Yes	ND
PTX01-1008	T	14	7	1.46	-43	99.0%	No	D
PTX04-1001	T	7	7	0.26	-2	55.7%	No	S
PTX04-1002	T	14	13	0.38	-67	100.0%	No	D
PTX06-1013	T	10	0	0.00	0	46.4%	Yes	ND
PTX06-1023	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1048A	T	15	14	0.43	-55	99.7%	No	D
PTX06-1049	T	11	1	0.53	8	70.3%	No	NT
PTX06-1050	S	10	0	0.00	0	46.4%	Yes	ND
PTX06-1069	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1071	T	8	0	0.00	0	45.2%	Yes	ND
PTX06-1080	T	12	0	0.00	0	47.3%	Yes	ND
PTX06-1081	T	12	10	0.17	21	91.3%	No	PI
PTX06-1114	T	2	0	0.00	0	0.0%	Yes	ND
PTX07-1O01	S	5	1	0.10	-4	75.8%	No	S
PTX07-1O02	T	4	4	0.11	6	95.8%	No	I
PTX07-1O03	T	7	0	0.00	0	43.7%	Yes	ND
PTX07-1O06	T	9	5	0.28	4	61.9%	No	NT
PTX07-1P02	T	7	0	0.00	0	43.7%	Yes	ND
PTX07-1P03	T	4	0	0.00	0	37.5%	Yes	ND
PTX07-1P06	S	10	0	0.00	0	46.4%	Yes	ND

Project: Pantex North

User Name: MV

Location: North/Playa 1

State: Texas

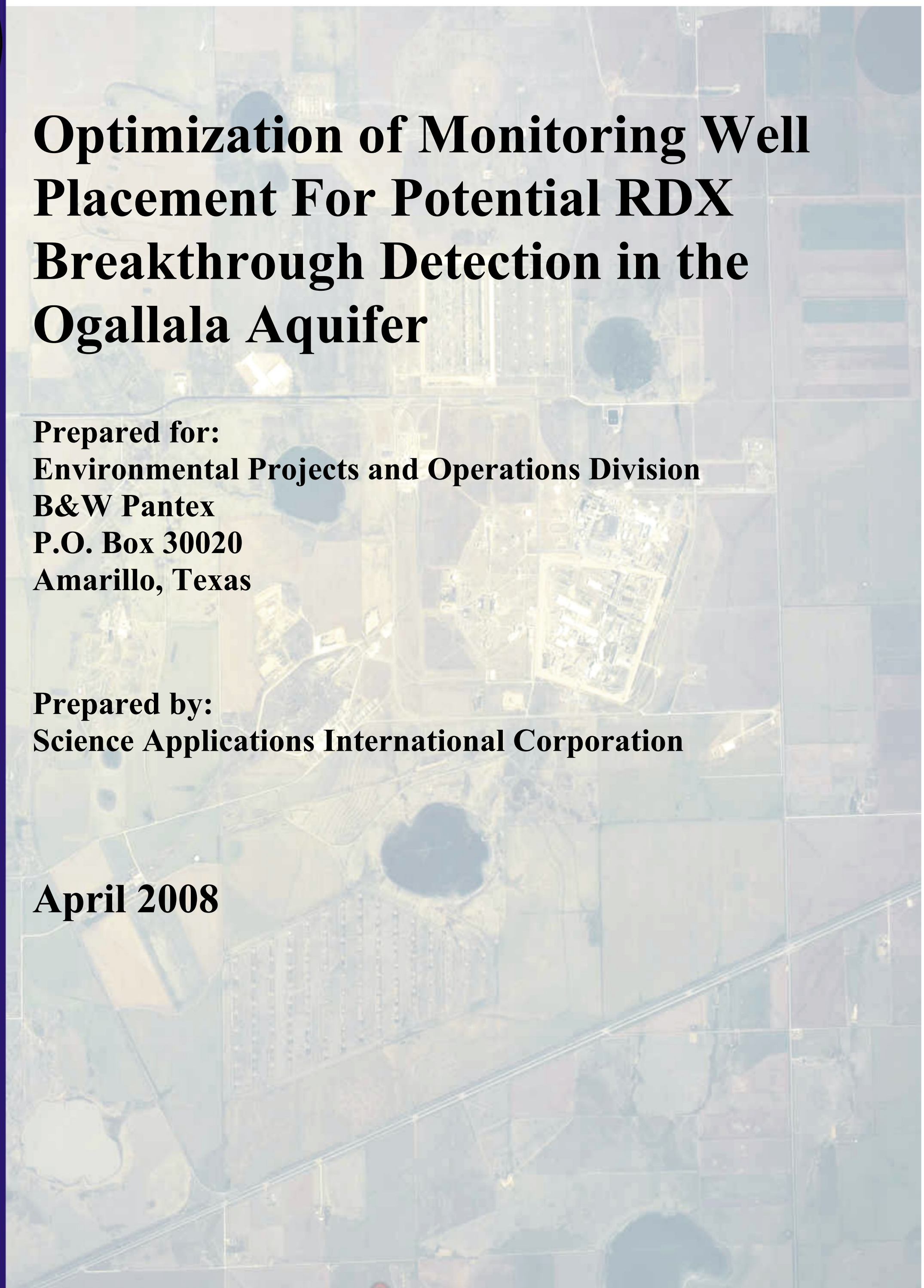
Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
TRICHLOROETHYLENE (TCE)								
PTX07-1R03	T	8	0	0.00	0	45.2%	Yes	ND
PTX08-1001	T	7	0	0.00	0	43.7%	Yes	ND
PTX08-1002	S	6	0	0.00	0	42.3%	Yes	ND
PTX08-1010	T	14	2	0.15	23	88.3%	No	NT
PTX-BEG3	T	13	0	0.00	0	47.6%	Yes	ND

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)- Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

U.S. Department of Energy/ National Nuclear Security Administration

PANTEX PLANT



Optimization of Monitoring Well Placement For Potential RDX Breakthrough Detection in the Ogallala Aquifer

Prepared for:
Environmental Projects and Operations Division
B&W Pantex
P.O. Box 30020
Amarillo, Texas

Prepared by:
Science Applications International Corporation

April 2008

SAIC®
From Science to Solutions

Optimization of Monitoring Well Placement for Breakthrough Detection in the Ogallala Aquifer

Environmental Projects and Operations Division
B&W Pantex
P.O. Box 30020
Amarillo, TX 79120

Prepared By:

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Twinsburg, OH 44087

April 2008

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ACRONYMNS AND ABBREVIATIONS

2-D	two-dimensional
3-D	three-dimensional
ArgusONE	Argus Open Numerical Environments
bgs	below ground surface
B&W Pantex	Babcock & Wilcox Technical Services Pantex, LLC
CMS/FS	Corrective Measures Study/Feasibility Study
DOE	Department of Energy
FGZ	fine-grained zone
ft/d	feet per day
ft/ft	feet horizontally/feet vertically
GAM	Groundwater Availability Model
GSLIB	Geostatistical Software Library
GUI	graphical user interface
meters	meter
ppb	parts per billion
ppm	parts per million
PTC	Princeton Transport Code
TTU	Texas Tech University
TWDB	Texas Water Development Board

EXECUTIVE SUMMARY

The Babcock and Wilcox Technical Services Pantex, LLC (B&W Pantex) Environmental Projects and Operations Division is assessing the need for additional monitoring wells to be installed at several locations around the Pantex Plant for early detection of potential groundwater impacts to the Ogallala Aquifer. This effort focuses on the area east of the Plant, where modeling predicted contaminants might migrate beneath the perched groundwater from discharges south of the Plant (BWXT Pantex/SAIC, 2007). The objective of this effort is to identify best locations for up to three new Ogallala Aquifer monitoring wells, using the PlumeFinder technology, and incorporating the results of previous modeling. Due to its widespread occurrence in perched groundwater and relatively high mobility, RDX (a high explosive) was modeled to determine the best locations for the wells. Although source strength and location are not directly measured, insight can be gleaned from the corrective measures study / feasibility study (CMS/FS) (BWXT Pantex/SAIC, 2007) modeling efforts.

The Ogallala Aquifer beneath the impacted perched groundwater is not accessible for investigation, because of the concern that drilling through the perched groundwater may create pathways allowing the spread of contamination. As a result, irreducible uncertainty stemming from a lack of field data is present in the area of interest. The uncertainty specifically pertains to the hydraulic conductivity, potentiometric surface, and the elevation of the redbeds marking the base of the aquifer.

Modeling is combined with optimal estimation techniques to address this uncertainty. Specifically, geostatistical representations of the Ogallala Aquifer hydraulic conductivity fields are coupled with flow and transport simulations to determine the areas of greatest uncertainty in potential RDX plume location. This approach, known as the "PlumeFinder," is technology which integrates groundwater flow and transport simulation, geostatistical simulation, Monte Carlo simulation, and Kalman filter analysis to optimize monitoring well locations. In the analysis presented here, plume location (plume fringe) is defined as the 1 ppb isopleth contour for RDX and investigated over a 50-year simulation period. The areas of greatest uncertainty in the 1 ppb isopleth location then become candidates for new well locations, which in turn reduce the uncertainty in plume delineation by the maximum amount possible. To locate the leading edge of the RDX plume, both the retardation of RDX and potential biodegradation were ignored. This results in a conservative estimate (shortest travel time) to the fringe of the eastern perched groundwater while identifying the best location for early detection monitoring well placement. The actual travel time for RDX to migrate within the Ogallala Aquifer, if it occurs, is expected to be longer than simulated in this analysis.

The following procedure is used to implement the PlumeFinder technology:

- Gather available information on the groundwater flow and transport properties of the aquifer.
- Gather available information on the current chemistry of the aquifer.
- Use a preliminary groundwater flow and transport model to characterize the movement of groundwater and dissolved contaminants in the aquifer.
- Apply the PlumeFinder technology to baseline the maximum measure of uncertainty from a suspected source area based on the knowledge of the groundwater flow and contaminant transport properties.
- Apply the PlumeFinder technology to assess the maximum measure of uncertainty from a suspected source area based on the knowledge of the groundwater flow and contaminant transport

properties and the existing monitoring well network. This step quantifies the value of the existing monitoring well network as compared to no monitoring wells.

- Use the PlumeFinder technology to generate the next best monitoring well location to gather subsurface information given what is currently known. Constrain the possible locations of future monitoring wells to locations outside the area of impacted perched groundwater.
- Assess the value in the proposed monitoring well with respect to the reduction in the uncertainty in the extent of contamination.
- Update the PlumeFinder observation database with the expected concentration at the new monitoring well location, and repeat the analysis (for up to three wells in the current analysis) to select the next best location for plume fringe location.

The PlumeFinder technology currently requires Princeton Transport Code (PTC) to be used as the numerical code for the flow and transport model. Consequently, to conduct this analysis, a two-dimensional (2-D) model of the Ogallala Aquifer was developed using PTC. This PTC Ogallala Aquifer model was developed by integrating historical information, previous modeling efforts, geostatistical codes, and current field data. Previous models developed for this area include the Pantex BIOF&T3D model and the Pantex Ogallala Aquifer model, both documented in BWXT/SAIC 2007. The latter was a local refinement of the Northern Ogallala Groundwater Availability Model (GAM) (Dutton, Reedy, and Mace, 2001; Dutton 2004). The domain of interest for the PTC model was selected to be an area of approximately 9 square miles (12,000 feet by 24,000 feet) including the southeastern portion of Pantex Plant and areas south and east.

Only sporadic, non-trending, and very low-level (parts per billion [ppb]) detections of RDX have been observed in Ogallala Aquifer monitoring wells. However, RDX detections in the parts per million (ppm) range are routinely observed in perched groundwater above the Ogallala Aquifer. Groundwater simulations show RDX may impact the Ogallala Aquifer in the future (BWXT/SAIC 2007), and the proposed monitoring wells are in response to this potential issue.

Delineation of potential future plumes can be improved by adding three new monitoring wells at locations determined using the PlumeFinder technology in combination with previous modeling results. Installation of new wells, in concert with the existing Ogallala Aquifer monitoring wells, increases the certainty of early plume detection. A new well located using PlumeFinder reduces the maximum measure of uncertainty of plume delineation beyond the fringe of the perched aquifer by 72 %. Two additional wells beyond the eastern extent of perched groundwater provide early detection of potential contamination originating along the fringe of perched groundwater. Since the majority of the projected plume is beneath the perched aquifer, most of the uncertainty in its extent resides there. If the total uncertainty reduction is computed (within and beyond the perched groundwater extent) then the reduction in uncertainty achieved with the addition of a new well located by PlumeFinder is only 16%. This demonstrates the contribution of irreducible uncertainty which results from employing safe investigative practices by imposing the constraint that no wells be drilled through the perched groundwater to investigate a hypothetical plume.

The following specific recommendations are provided upon installation of the additional monitoring wells:

- Assess the groundwater flow field by collecting a complete set of potentiometric surface data to reduce uncertainty in current groundwater flow directions.
- Update the conceptual site model as appropriate (e.g. base of Ogallala Aquifer, lithology, and hydraulic properties).

- Collect analytical data, test for the occurrence of RDX in the Ogallala Aquifer, and assess trends or patterns; compare this with existing information on the sporadic detection of RDX in the Ogallala Aquifer.
- Collect monitored natural attenuation parameters to assess natural degradation rates for RDX with time.
- Compare to previous water table maps, chemical information and expected degradation rates from the CMS/FS. If information is similar (i.e. quasi-stable) then continue long-term monitoring; if not then update the preliminary groundwater model and revise PlumeFinder results to ensure well locations remain adequate for early RDX detection.

1.0 INTRODUCTION

1.1 BACKGROUND

In 2002, Pantex Plant initiated a comprehensive site investigation and groundwater modeling program to evaluate the extent and potential movement of groundwater and contaminants beneath the Plant. RDX, a high explosive, is one of the most ubiquitous contaminants detected in soils and perched groundwater beneath Pantex Plant. The perched groundwater occurs above the fine-grained zone (FGZ), a series of fining-upward sequences capped by clay layers several feet thick. Near the southern and eastern extent of perched groundwater, site investigation data noted a decrease in clay content and higher permeability of the upper surface of the FGZ. Consistent with the field observations, modeling results showed the potential for low-level RDX impacts to the Ogallala Aquifer in these areas. Due to the concern of spreading RDX contamination by drilling through contaminated perched groundwater and into the Ogallala Aquifer, numerical models were developed to estimate the rate and direction of potential RDX migration.

The detection monitoring capabilities of the existing Ogallala Aquifer monitoring well network can be improved by the installation of additional wells in appropriate locations. To determine the best locations to enhance the detection monitoring network, Pantex Plant requires a tool that links a groundwater flow and transport model and geostatistical techniques to optimize placement of new wells south and east of the Plant. As part of this task, SAIC developed a model to encompass the southeastern and eastern portions of the site and offsite areas, and incorporated an optimization tool to determine the best monitoring well placement.

1.2 OBJECTIVE AND TASK DEFINITION

The objective of this effort is to identify best locations for up to three new Ogallala Aquifer monitoring wells using the PlumeFinder technology and incorporating predictions from previous modeling efforts such as the Baseline Human Health Risk Assessment (BWXT Pantex/SAIC, 2006) and CMS/FS (BWXT Pantex/SAIC, 2007). Two potential source areas, one to the south of Pantex Plant and another distributed along the eastern extent of perched groundwater saturation, are evaluated because they are the most likely areas for contaminant breakthrough from the overlying and impacted perched groundwater. These areas were selected based upon site investigation data and prior modeling. The potential source to the south represents the most likely area of breakthrough based upon the current understanding of site conditions and the modeling predictions presented in the CMS/FS. The potential source along the eastern extent of perched groundwater represents the next most likely area of contaminant breakthrough, again, based upon the current understanding of site conditions. Based upon site investigation data, the confining unit underlying perched groundwater is more transmissive along the fringe of perched groundwater than within its interior. So the fringe of perched groundwater is considered a likely area for contamination to migrate to the Ogallala Aquifer. In addition, a constraint is imposed in this analysis that proposed wells not be drilled through perched groundwater.

The best locations are determined by completing a combination of a PlumeFinder assessment of RDX migration from the potential areas of impact to the Ogallala Aquifer and evaluations of well location using results from the CMS/FS modeling.

The outcomes of this task include determining the effectiveness of the current Ogallala Aquifer monitoring well network in the southeastern and eastern Plant areas and recommending placement of three additional monitoring wells. To accomplish these objectives, existing information and modeling results are reviewed to assess where RDX may potentially be migrating to the Ogallala Aquifer. The information required to predict a plume includes:

- Groundwater flow directions and rates, measured and simulated
- Source strength and timing, simulated
- Regulatory / risk-based criteria for plume detection
- Reactions (such as biological) that act to reduce the plume size, measured and simulated

The source locations under consideration are estimated to be in the locations where the FGZ becomes more permeable and groundwater transitions from predominantly horizontal to vertical flow. In this region, vertical flow occurs from the perched groundwater through the FGZ to the underlying unsaturated Ogallala Formation and Ogallala Aquifer. Although source strength and location are not well-defined via direct measurement, knowledge exists from previous site investigations and modeling efforts. The hydrogeologic conditions in the Ogallala Aquifer are also uncertain, specifically the hydraulic conductivity beneath the perched groundwater and the pumping rates from nearby irrigation wells. To address the uncertainty, geostatistical representations of the aquifer hydraulic conductivity are coupled with flow and transport simulations, and the simulation results are used to assess the areas of greatest uncertainty in potential RDX plume fringe location. These areas then became candidates for new well locations that reduce the uncertainty of the groundwater plume fringe location by the maximum amount possible.

1.3 DOCUMENT OUTLINE

Section 1 provides an introduction to the effort and work to be accomplished. Section 2 provides an overview of the methodology and modeling approach employed, including a summary of concepts and tools used in this analysis. Section 3 provides detailed information about the model developed and results of the simulations and associated optimization. Section 4 presents the report summary and conclusions. Finally, Section 5 provides a list of references used in this study.

2.0 METHODOLOGY

2.1 APPROACH

The overall approach to determine the best locations for new wells to enhance the detection monitoring network includes:

1. Develop an understanding of flow and transport conditions in the Ogallala Aquifer beneath the perched groundwater from physical consistency with observed conditions elsewhere.

2. Use the Plume Finder Technology to optimize the early warning detection well network.

The first step was largely completed through recent work at Pantex Plant in support of other Environmental Restoration Program objectives. An extensive hydrogeologic investigation has been completed, and the data collected was used to develop a conceptual model for the site. The results of flow and transport models developed from this framework enhance the understanding of the hydrogeology and provide physically-based estimates of aquifer conditions and properties beneath the perched groundwater. The second step uses the best optimization tools currently available to directly incorporate the results of previous work into the design of the well network. These optimization tools are further described in this chapter.

2.2 OPTIMIZATION

Optimization tools are used to guide decisions that are defensible by integrating physics-based simulation models, models based on measured data and observations, and direct incorporation of uncertainty through geostatistics. Simulation models provide a mathematical statement of current and expected future conditions in the subsurface based on the physics of groundwater flow and contaminant transport, but these models are limited by the amount of data available to calibrate the models. By combining the physics and data models, optimization tools provide optimal estimates based on knowledge gained from both the physical simulator and the data. The information content from the different models and associated uncertainty with each is fused through the use of signal processing or formal optimization algorithms. For this project, the uncertainty in predicted plume fringe location is quantified, and the optimum monitoring well locations provide the maximum reduction in this uncertainty.

Optimization tools are extremely useful when limited data are available. For example, this occurs beneath the perched groundwater where investigations have been limited because of the potential for cross contamination to the Ogallala Aquifer as a result of drilling through the FGZ. In this case, optimization tools quantify the uncertainty of a monitoring well network and help determine if our understanding of the subsurface is supported by available data.

2.3 PLUMEFINDER

The PlumeFinder is an optimization tool that identifies the optimal locations (i.e., those locations that reduce the uncertainty in contaminant plume location the most) for new monitoring wells. PlumeFinder works by identifying (before sampling) the next sampling location in 2-D (two-dimensional) or 3-D (three-dimensional) space that, when sampled, minimizes the uncertainty of the plume boundary location after the sample has been taken. Sampling activity is prioritized because a new sampling location is proposed only if it provides the maximum amount of information when solving the plume location challenge. Output from the PlumeFinder evaluation consists of a rank-ordered list of sample locations for new monitoring wells that minimize the uncertainty in delineating the plume boundary. The PlumeFinder optimization software is based on well-accepted mathematical and statistical concepts and was developed under the direction of Dr. George Pinder at the Research Center for Groundwater Remediation Design at the University of Vermont, USA (McGrath and Pinder, 1996). It has been extended by Larry Deschaine as part of his PhD work at the Chalmers University of Technology, Sweden.

The PlumeFinder works by modeling the information content provided by new sampling locations and quantifies the "maximum measure of uncertainty" in the plume boundary. The procedure is as follows:

1. Build a preliminary flow and transport model for the site. This initial model need not be perfect and does not need rigorous site knowledge to be effective.
2. Generate PlumeFinder statistics.
    a. Geostatistics are used to generate 500 aquifer realizations from observed variations of hydraulic conductivity in the aquifer.
    b. Each aquifer realization is simulated (for a period of 50 years in the current analysis) with the model to create a modeled plume in the aquifer.
    c. Kalman filtering is used to combine the modeled plume realizations with observed data and estimate the uncertainty in plume delineation.
    d. A rank-ordered list of monitoring well locations is created based on their maximum measures of uncertainty.
3. Collect data and add to observation database.
    a. For existing monitoring wells, measured concentration and, if available, hydraulic conductivity, data are included. If measured concentrations are non-detect, a value of one-half the detection limit is assumed.
    b. For future monitoring wells, concentration data is assumed using a value of one-half the plume fringe threshold.
4. Impose the additional constraints; in this case a constraint is imposed that the well not be placed within the extent of perched groundwater.
5. Quantify the confidence in the knowledge of the plume location from the existing Ogallala Aquifer monitoring wells and proposed new monitoring well.

For the transport modeling used in the PlumeFinder analysis presented here a unit source was used, the plume fringe was defined as 1/1000 of the unit source, and RDX concentrations at proposed new monitoring well locations were set at ½ of the plume fringe value (1 part per billion [ppb]). Modeling of the recommended alternative in the CMS/FS (BWXT Pantex/SAIC, 2007) indicated a maximum predicted RDX concentration of 4 ug/l in the Ogallala Aquifer. With the RDX contaminant plume fringe defined as the 0.774 ug/l isocontour, the maximum ratio of plume fringe concentration to potential source in the Ogallala Aquifer is approximately 1/5. No measurements of RDX in the Ogallala Aquifer have been made in the predicted area of breakthrough. Perched groundwater concentrations above this area are on the order of 1 to 4 parts per million (ppm). Therefore, a source to strength ratio of 1000:1 was applied and no retardation or biodecay was applied during the 50-year transport simulation. While conservative, this methodology identified the most likely area of plume migration and the uncertainty with this migration beyond the extent of perched groundwater. The region of uncertainty in a focused area beyond the perched groundwater became the location for the first monitoring well.

2.4 MODELING

Numerous challenges exist in developing a modeling approach for this problem. Historical data describing the timing and volume of wastewater releases to the ditches are limited, so the transport of compounds through the upper unsaturated zone to perched groundwater is not well understood. Limited direct observation data are available to determine the timing and mass flux of releases from perched groundwater to the Ogallala Aquifer, including specific flow and transport mechanisms and rates, hydraulic conductivity, and natural attenuation processes in the Ogallala Aquifer. In addition, current and historical withdrawals from the irrigation and water supply wells local to the site are not known with great certainty because the flows are not typically measured at the wellhead nor are detailed operational records kept. These uncertainties are well documented in the Pantex CMS/FS Modeling Report (BWXT/SAIC 2007). In spite of these uncertainties, a method for determining for the best locations for monitoring the potential breakthrough of RDX plumes is needed. The PlumeFinder optimization tool is helpful in developing superior investigation strategies for plume delineation when compared to standard Monte Carlo simulation techniques which merely provide upper and lower bounds on confidence. PlumeFinder uses Monte Carlo and Latin Hypercube techniques and assesses the noise in the concentration signal, compares it on a nodal and model-wide basis to the value of the concentrations samples, and uses Kalman filtering to fuse this information and arrive at the optimal estimate of the plume location.

To implement the PlumeFinder optimization tool, information was obtained and assessed from four primary sources:

- The *Groundwater RCRA Facility Investigation Report* (Stoller, 2004)
- Analytical data available for monitoring wells proximate to the area of interest (from the Pantex Integrated Environmental Database)
- The site-wide BIOF&T3D groundwater flow and contaminant transport model (BWXT/SAIC, 2007)
- The Pantex MODFLOW-SURFACT Ogallala Aquifer model (BWXT/SAIC 2007), which was a local refinement of the Northern Ogallala GAM (Dutton, Reedy, and Mace, 2001; Dutton 2004)

The following tools were used to facilitate this approach:

- Argus Open Numerical Environments (ArgusONE) Modeling Environment – model independent graphical user interface
- Princeton Transport Code (PTC) – finite element flow and transport code
- GSLIB – Geostatistical Software Library
- PlumeFinder – tool that integrates all of the above through optimization algorithms

The PlumeFinder technology currently requires the Princeton Transport Code (PTC) for numerical flow and transport because PlumeFinder includes links to PTC within the ArgusONE modeling environment. Therefore, a 2-D model of the Ogallala Aquifer was first developed using PTC. The PTC Ogallala Aquifer model was developed by integrating historical information, previous modeling efforts, geostatistical codes (GSLIB), and current field data. Previous models developed for this area include the Pantex CMS/FS BIOF&T3D model (BWXT/SAIC 2007) and the Pantex Ogallala Aquifer model (BWXT/SAIC 2007).

The domain of interest includes areas south and east of Pantex (along the fringe of perched groundwater saturation) where (1) investigation data indicate the FGZ becomes more permeable, and therefore introduce likely points of breakthrough to the underlying Ogallala Aquifer and (2) previous modeling results predicted low level impacts to the Ogallala Aquifer.

A transport simulation time of 50 years was selected for the evaluation to support development of the early detection monitoring network.

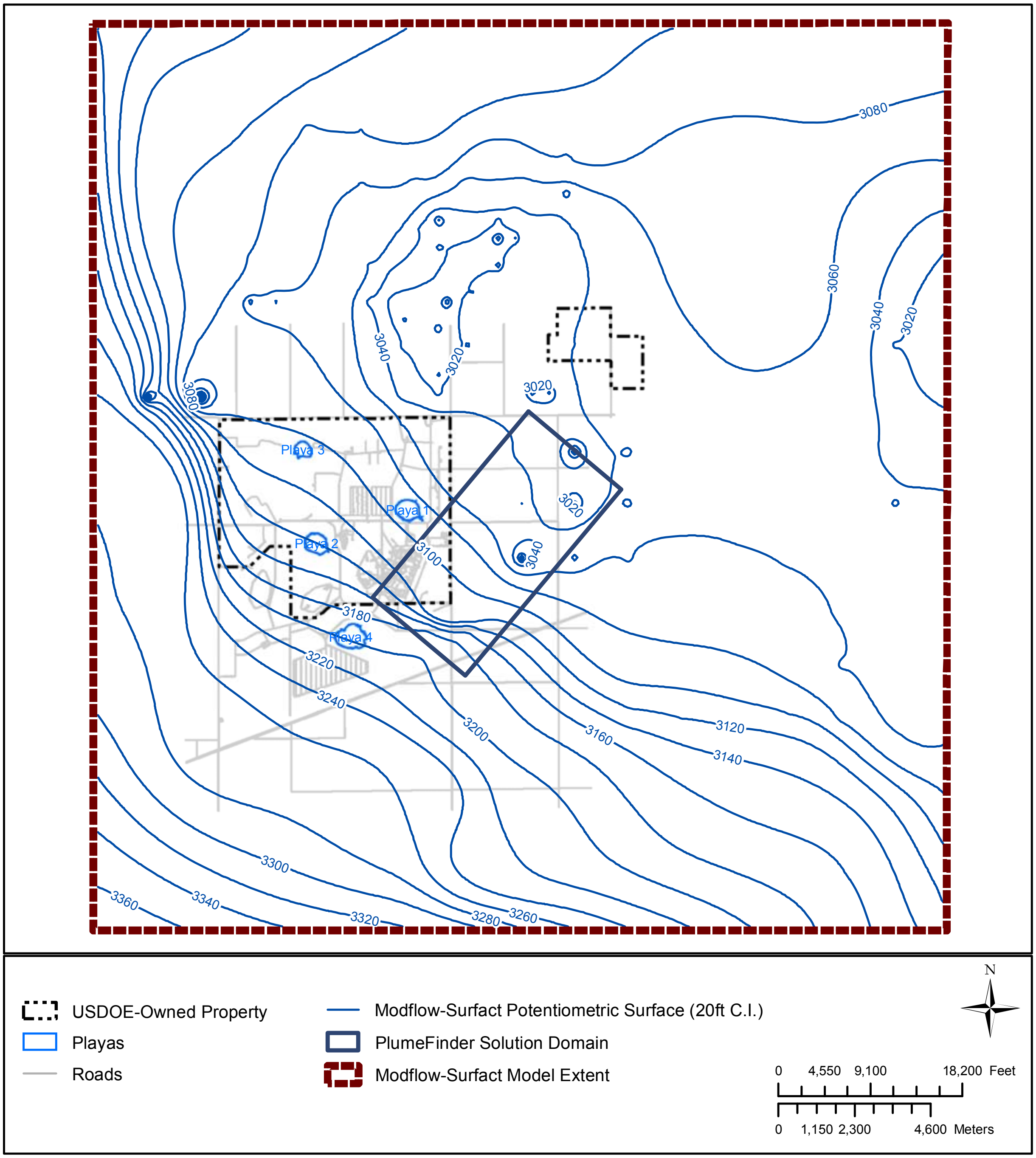


Figure 2-1. MODFLOW-SURFACT and PTC/PlumeFinder Model Domains

PlumeFinder differs from standard groundwater flow and transport modeling because in addition to flow and transport, the "information content" is modeled and the worth of new monitoring well data is computed (McGrath & Pinder, 1996). This contrasts the typical approach which simply computes the expected residual mass of RDX. The following example illustrates the PlumeFinder concept.

Given all the unknowns in the above problem statement, if one were to give this problem to 500 different analysts, one could reasonably expect 500 different answers if conventional modeling techniques were used. Each analyst would be free to choose their own interpretation of required information such as historical pumping rates and locations, hydraulic conductivity, and transport process and attenuation parameters. There would be a finite probability that any of the 500 analysts could be correct, but there would be no way to tell which analyst provided the best results using conventional modeling techniques. This is both disconcerting and untenable for decision makers.

Using the PlumeFinder technology, hundreds of different aquifers can be simulated – each with the same probability of being correct. The results from all these simulations are combined, and the areas that have the most uncertainty in the plume concentration are chosen as the best areas to investigate. This approach provides a scientifically-based decision that considers the unknowns.

2.5 MODEL CODE AND GRAPHICAL USER INTERFACE

The PlumeFinder technology includes links to the PTC (Pinder, George, F. 1997) numerical flow and transport code. PTC is a 3-D, finite element, saturated flow and single component transport model. PTC has been used for over 20 years, and has been used at major Superfund sites. The PTC model can be accessed through the ArgusONE graphical user interface (GUI) that allows for visualization of models through plug-in extensions. These tools are the interface for the PlumeFinder technology.

PTC is a very robust, accurate, and fast numerical flow and transport solver. This robustness and solution speed is critically important when conducting PlumeFinder integrated modeling and statistical investigations, because 1,500 separate aquifer realizations and subsequent flow and transport simulations are needed to solve the particular optimization challenge presented here. Future modeling needs are also considered satisfied by PTC and the ArgusONE GUI because the possibility of plume migration management exists.

The GSLIB (Deutsch and Journel, 1992) was selected for generating aquifer realizations based on observed variations in hydraulic conductivity data. GSLIB is the industry-standard for geostatistical analysis and the source code is publicly available.

3.0 ANALYSIS AND RESULTS

3.1 MODEL DEVELOPMENT

A summary of the hydrogeology and current studies of the Ogallala Aquifer are included in the sections below.

3.1.1 Hydrogeology

Pantex is situated on the High Plains of the Texas Panhandle. One of the major aquifer systems, the Ogallala Aquifer has more water being pumped from it than any other aquifer in Texas. The Ogallala Formation in which the Aquifer is seated consists of alluvial sands, silt, clay, gravel, and several caliche horizons. An unconfined aquifer in the sands and gravels of the lower Ogallala is the principal source of groundwater in the High Plains region, and is a primary source of potable water for Pantex and the City of Amarillo. In the vicinity of Pantex, this aquifer lies approximately 107 to 130 meters (350 to 425 feet) below ground surface (bgs). The base of the Ogallala is an irregular surface that represents the pre-Ogallala topography, which was influenced by the dissolution of underlying Permian salts and erosion. Consequently, the depth to the base of the Ogallala Formation varies across the Plant from approximately 122 meters (400 feet) below the southwest corner of the Plant to nearly 244m (800 feet) below the northeast corner of the facility. The thickness of the Ogallala Formation in the vicinity of Pantex ranges from approximately 99 to 220 meters (325 to 725 feet), increasing from southwest to northeast. Figure 3-1 shows the water table of the Ogallala Aquifer near Pantex as measured in December 2007.

Regionally, the Ogallala Aquifer water table slopes from northwest to southeast, generally following the regional topographic surface. In the vicinity of Pantex, however, the water table slopes from southwest to northeast, as shown in Figure 3-1, in response to extensive pumping from the City of Amarillo Carson County well field north of Pantex. Figure 3-1 also indicates an area of no saturation in the aquifer on the eastern side of the Texas Tech University (TTU) property. As water levels in the aquifer continue to decline, this area of no saturation will expand.

Groundwater in the Ogallala Aquifer is recharged from downward percolation of water, either from the surface of the High Plains or from the overlying perched groundwater zones. The distribution of recharge is poorly known, with estimates ranging from less than 0.01 inches per year to several feet per year. Higher recharge rates occur where the Ogallala Formation occurs at the surface and where surface water runoff is focused, such as beneath drainage ditches and playas. Lower rates occur for uplands (areas between the ditches and playas). A good summary of the recharge rates is presented in the Subsurface Modeling Report (BWXT/SAIC 2004 and 2007). For this effort, recharge rates were specified based on the MODFLOW-SURFACT model of the Ogallala Aquifer presented in the CMS/FS (BWXT/SAIC 2007).

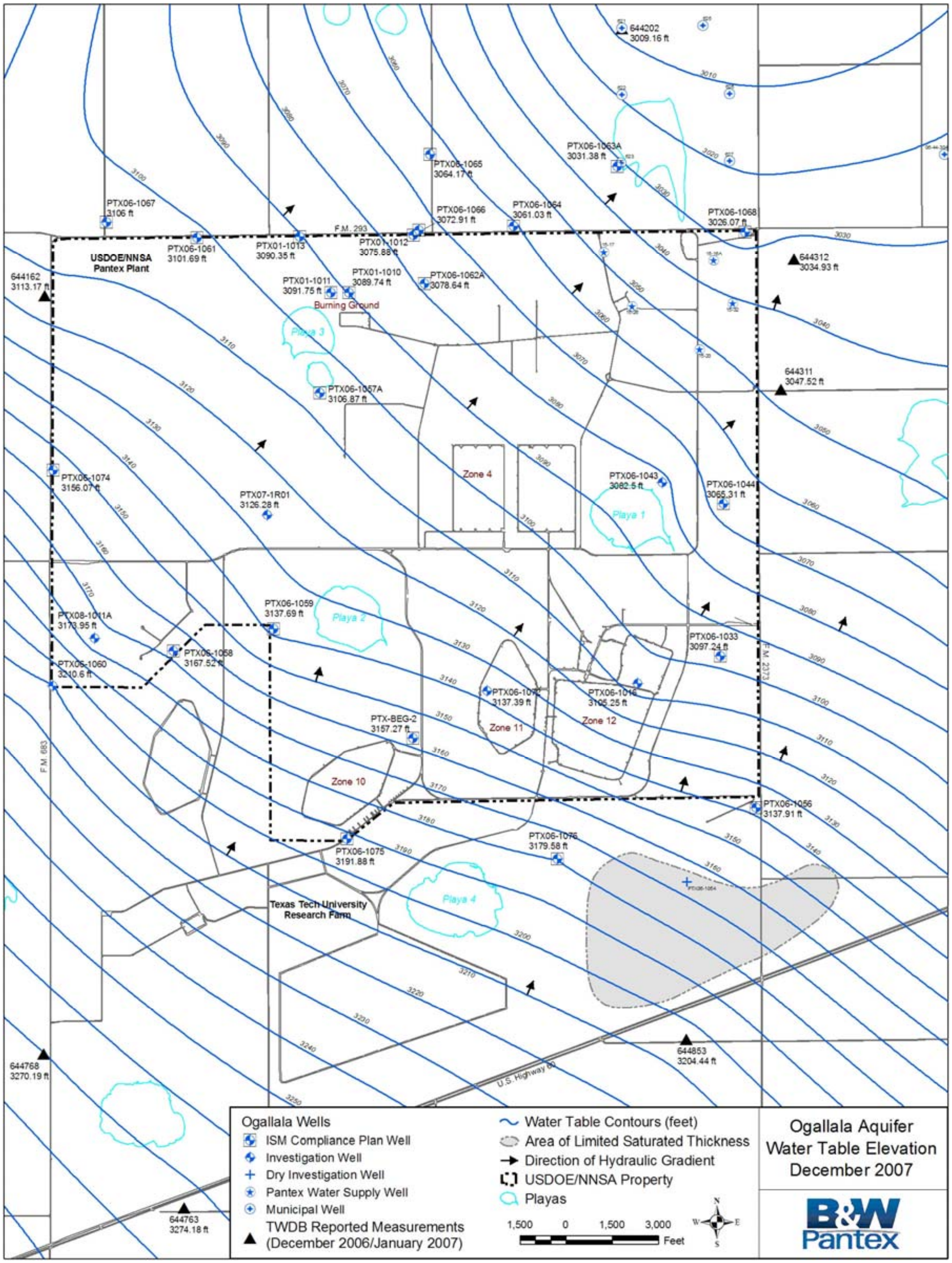


Figure 3-1. Ogallala Aquifer Water Table, December 2007

Few site-specific measurements of hydraulic conductivity have been completed in the Ogallala Aquifer at Pantex. As a result, information from regional studies has been used to supplement the site-specific hydraulic conductivity data. Of particular interest in the Bureau of Economic Geology study (Dutton, Reedy, and Mace, 2001) were the tests compiled from Mullican (1997) and from the groundwater database maintained by the Texas Water Development Board (TWDB). Mullican (1997) obtained information on 70 aquifer tests which included high-quality specific-capacity tests. Mullican (1997) were also able to cull data from an additional 1,271 specific-capacity tests in the TWDB groundwater database. To estimate transmissivity and hydraulic conductivity from specific capacity, they used an analytical technique developed by Theis (1963). Hydraulic conductivity was determined by dividing transmissivity by the saturated thickness exposed to the well bore.

Based on results from the data compilation and specific-capacity analysis, the hydraulic conductivity for the Ogallala Aquifer was found to be log-normally distributed (Figure 3-2) with a geometric mean of approximately 14.8 feet per day (ft/d) and a standard deviation that spans from 5 to 44 ft/d. The upper range of the standard deviation (i.e., 44 ft/d) is three times the geometric mean of approximately 14.8 ft/d, indicating variability in hydraulic conductivity. Because of this variability, uncertainty in hydraulic conductivity was evaluated using geostatistical methods to develop 500 equally plausible representations of the Ogallala Aquifer within the Ogallala Aquifer flow model.

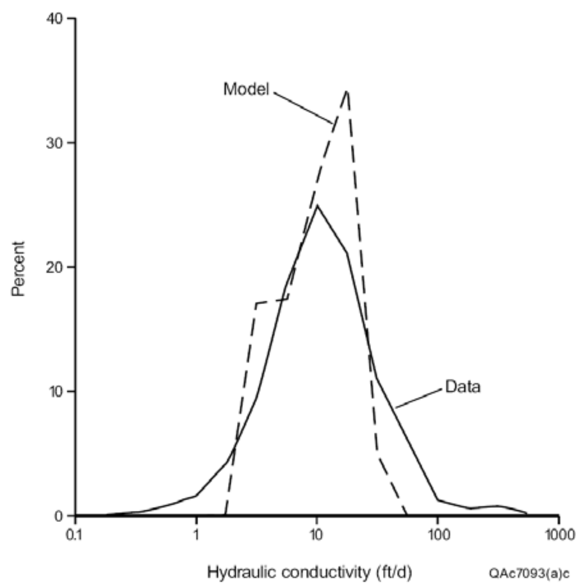


Figure 3-2. Bureau of Economic Geology Finding of Lognormal Distribution for Hydraulic Conductivity in the Ogallala Aquifer (after Dutton et al, 2000).

The greatest source of uncertainty in assessing transport is the uncertainty in hydraulic conductivity (Smith and Schwartz, 1981). To illustrate that hydraulic conductivity is the most sensitive parameter for determining plume location, the sensitivity of average groundwater velocity to gradient, porosity, and hydraulic conductivity is evaluated (within the range of values expected at the Plant). Considering Darcy's Law (v=ki/n; where v = velocity, k = hydraulic conductivity, i = hydraulic gradient, and n = porosity), sensitivity to changes in the gradient or porosity changes within the range of measured values at the Plant are relatively small compared to sensitivity to the anticipated range in hydraulic conductivity.

For example, the gradient ranges from 0.003 feet horizontally/feet vertically (ft/ft) beyond the northeast corner of the Plant to 0.012 ft/ft in the vicinity of Zone 12 in the 2007 water table shown in Figure 3-1. The porosity, n, has been measured in a number of samples collected at the Plant and ranges from approximately 29% to 42% based on samples collected from above the water table (SAIC, 2000). Specific yield values can be used to estimate porosity (although they typically underestimate porosity slightly). Specific yield values from 41 test holes scattered throughout the region averaged about 16% (SAIC, 2000). Porosity values published in the literature range from 25% to 35% for the sandy-gravelly sediments (Fetter, 1988) that comprise the Ogallala Aquifer.

Using a constant hydraulic conductivity of 5 ft/d for illustrative purposes, the increase in velocity for the gradient change is by a factor of 4.0 and the decrease in velocity for the porosity change is by a factor of .381. Velocities shown below are in ft/d:

Gradient Change (using the lower end of the porosity range)

$v = 5(.003)/.16$	$v = 5(.0012)/.16$
$v = .094$	$v = .375$

Porosity Change (using the mid-point of the gradient range)

$v = 5(.0075)/.16$	$v = 5(.0075)/.42$
$v = .234$	$v = .089$

The change in velocity from varying hydraulic conductivity by the upper and lower end of the standard deviation range, we see an increase in velocity by a factor of 8.8.

Hydraulic Conductivity Change (using the lower end of the porosity range and the mid-point of the gradient range)

$v = 5(.0075)/.16$	$v = 44(.0075)/.16$
$v = .150$	$v = 1.320$

This example illustrates that the greatest variation is from the hydraulic conductivity field and hence, why it is chosen as the parameter to capture using geostatistics in the PlumeFinder analysis. This example also corresponds with the results by Smith and Schwartz, (1981) that the greatest source of uncertainty is hydraulic conductivity. The remaining transport parameters are as follows:

- Retardation factor: none specified. Retardation refers to the relative velocity of the center of the transport plume to the advective groundwater flow. Neglecting retardation permits the advective portion of the simulated RDX plume to migrate with the same velocity as the groundwater.
- Dispersivity: Dx=50 ft, Dy=5 ft and Dz = 5 ft. Dispersivity refers to the process of the plume spreading in all directions from its centerline. The dispersivity parameters are taken directly from the model reported in the Corrective Measures Study/Feasibility Study (CMS/FS). Smaller values will produce a narrower, focused plume and larger values will produce wider, more disperse plumes with lower peaks values.
- Molecular diffusion: none specified. The process of molecular diffusion (Brownian motion) describes how a concentration of a chemical such as RDX would diffuse from areas of higher concentrations to areas of lower concentrations. This is a slow process, and the dispersion due to the movement outweighs this effect for the Ogallala Aquifer flow system. A non-zero value would results in a practically negligible addition to the dispersive plume front.

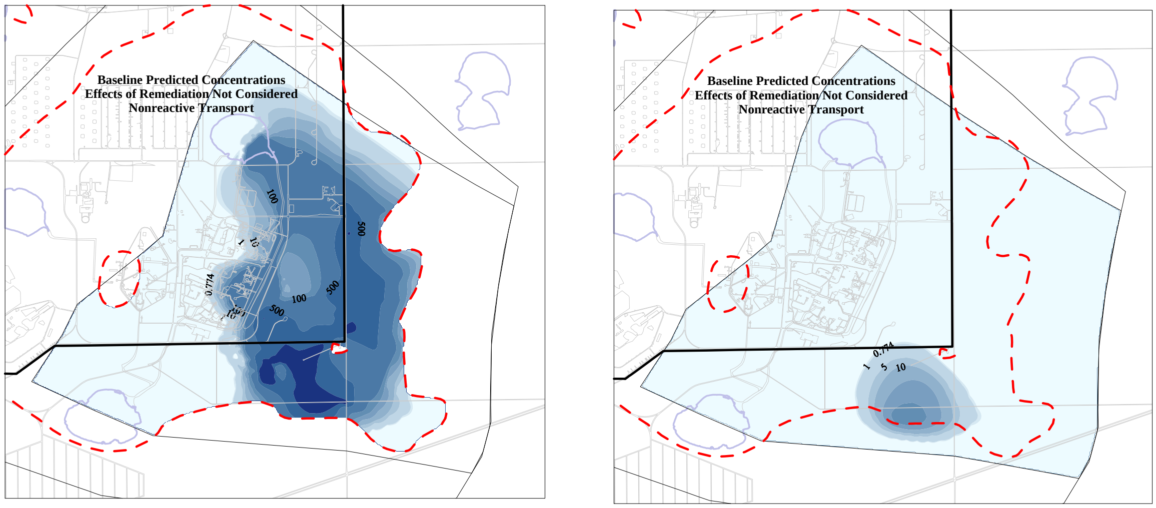
- Biological decay: none specified. The biological decay processes destroy contaminants such as RDX. Neglecting biodegradation allows the simulated RDX to migrate the furthest.
- Porosity: 0.25%. Porosity is the open area of the soils where the water flows. All other parameters being equal and given a fixed flux, higher values of porosity produce slower plume migration and lower values result in faster plume migrations.
- Source strength: constant unit source. In the southeastern portion of the Plant where RDX is projected to migrate from the perched groundwater to the Ogallala Aquifer at detectable concentrations based on CMS/FS modeling a continuous constant unit source is specified. Since the flux through the source area is realization-specific, each simulated aquifer will generate a unique source flux. A second hypothetical source along the eastern fringe of the perched extent is not directly simulated in the PlumeFinder analysis but is evaluated separately.
- Base hydraulic conductivity: specified from the CMS/FS MODFLOW-SURFACT Ogallala Aquifer model (BWXT/SAIC 2007b). This is the base conductivity field used for the geostatistical realizations. It is used directly only in the deterministic case, and varied geostatistically to generate 500 stochastic realizations of the Ogallala Aquifer. The base hydraulic conductivity is not used directly the PlumeFinder fringe calculations.

Finally, variograms from several studies (Clark, 1979; McCuen and Snyder, 1986) show that hydraulic conductivity in the Ogallala Aquifer is spatially correlated. Spatial correlation infers that points that are closer together are more similar to each other than points that are further apart. Fitting a spherical theoretical variogram (Dutton, Reedy, and Mace, 2001) to the experimental variogram resulted in a nugget of 0.12 $[\log(ft/d)]^2$, a sill of 0.22 $[\log(ft/d)]^2$, and a range of 140,000 feet. The range suggests that hydraulic conductivity is spatially correlated within 140,000 feet (26 miles) in the Ogallala Aquifer. The distance correlation is the range (length) beyond which a conductivity measurement no longer has value in predicting local conductivities.

3.1.2 Water Quality

Past operational and waste handling procedures have resulted in contamination of the perched groundwater beneath the Plant. Groundwater quality in the Ogallala Aquifer is characterized by groundwater samples collected from monitoring wells installed in the aquifer. Although non-trending sporadic detections of constituents occur in the Ogallala Aquifer at low, non-actionable concentrations below regulatory screening levels, no constituents of concern have been identified in the Ogallala Aquifer based on the current monitoring network.

Modeling conducted as part of the Baseline Human Health Risk Assessment and CMS/FS indicates the potential for contaminants in perched groundwater, particularly RDX, to impact the Ogallala Aquifer in the future (BWXT/SAIC 2006 and BWXT/SAIC 2007). Figure 3-3, taken from the Baseline Human Health Risk Assessment Report, shows modeled concentrations of RDX in the perched groundwater and Ogallala Aquifer after 20 years of transport in the absence of corrective actions. The figure on the left shows that the highest concentrations of RDX in perched groundwater occur south of Pantex Plant beneath TTU property with high concentrations of RDX also found along the eastern boundary of Pantex. The figure on the right shows modeled impacts to the Ogallala Aquifer occur near the southern extent of perched groundwater, beneath the area containing the highest RDX concentrations in perched groundwater. This area was identified as the source area for the PlumeFinder modeling.



a) RDX predicted in Perched Groundwater at T=20 years

b) RDX predicted in the Ogallala Aquifer at T=20 years

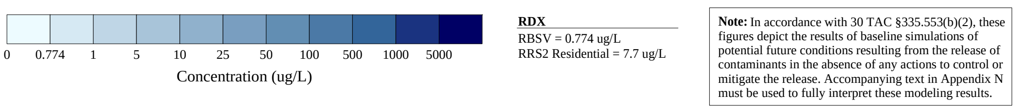


Figure 3-3. Modeled RDX Concentrations in the Perched Groundwater and Ogallala Aquifer

A second potential source area along the eastern extent of perched groundwater is also considered, although it is not directly included as a source in the PlumeFinder analysis. No impacts exceeding risk based levels to the Ogallala Aquifer were predicted in this area, but the area is considered a potential source because of the high RDX concentrations in perched groundwater coupled with a slightly more permeable FGZ along the fringe of perched groundwater.

RDX is projected to migrate from the perched groundwater to the Ogallala Aquifer. Before entering the Ogallala Aquifer, the RDX must vertically traverse the unsaturated zone between the FGZ and the Ogallala Aquifer water table. In the southeast area this distance is much less than along the eastern extent of saturation. The FGZ is also simulated as slightly less permeable along the eastern extent in the CMS/FS models compared to the southern fringe of perched groundwater. Increased travel time simulated through a thicker unsaturated zone and slightly lower FGZ permeability mitigates predicted impacts to the Ogallala Aquifer hence less impact to the Ogallala Aquifer is expected along the eastern fringe of perched groundwater. However, given the lack of direct data in the Ogallala Aquifer in this area it is prudent to locate monitoring wells capable of detecting RDX migration here.

3.1.3 Previous Models

Few regional aquifers have been as extensively studied as the Ogallala Aquifer. Models of groundwater flow have been important tools for managing the groundwater resource and evaluating future changes in water level and saturated thickness. At least 15 numerical groundwater flow models have been developed for different parts of the aquifer. Most recently, studies were completed by the Bureau of Economic Geology at the University of Texas on withdrawal projections in the Ogallala Aquifer in the Panhandle Water Planning Area (Dutton, Reedy, and Mace, 2001; Dutton 2004). The studies predicted that by 2050, major areas of the aquifer will have less than 50 feet of remaining saturated thickness and parts of the aquifer in various counties in the Panhandle Water Planning Area may be dry.

Two recent site-specific models have been developed which include the Ogallala Aquifer in the area-of-interest for this study. The motivation for developing these models was to support decision-making that protects the Ogallala and Amarillo well field. Specifically, these are the Pantex CMS/FS BIOF&T3D model and the Pantex MODFLOW-SURFACT Ogallala Aquifer model (BWXT/SAIC 2007).

Ideally, the CMS/FS BIOF&T3D model (BWXT/SAIC 2007) would be integrated with PlumeFinder technology to optimize the proposed well locations. However, execution of one simulation with this model requires approximately 7 to 20 days using computers available in 2007. As part of this study, over 1,500 final simulations were completed during the PlumeFinder analysis. This includes computing flow and transport over a 50-year period, using different – though equally plausible – aquifer conductivity realizations. Years of computational time would be required using the fully 3-D, variable saturated, coupled transient flow and transport model with all the site complexity.

Use of the CMS/FS BIOF&T3D model in a PlumeFinder analysis presented a significant computational hurdle. Therefore, the MODFLOW-SURFACT Ogallala Aquifer model was used to set up a PTC flow and transport model, and then this PTC flow and transport model was applied to the PlumeFinder analysis.

3.1.4 PlumeFinder / Princeton Transport Code (PTC) Model

The first step in the PlumeFinder analysis was to develop the PTC Ogallala Aquifer groundwater flow and transport model from the MODFLOW-SURFACT Ogallala Aquifer model (BWXT/SAIC 2007). The MODFLOW-SURFACT model contains the most recent updates of aquifer properties (including bottom elevation of the Ogallala Aquifer, the hydraulic conductivity and water table information) in the area of interest local to the Plant. It acceptably simulates flow under both steady-state conditions (using reduced pumping rates as described in BWXT/SAIC 2007) and transient conditions. The steady state version was selected for conversion to PTC for computational efficiency. The CMS/FS modeling conducted with the BIOF&T3D model included comparisons of RDX transport results using a declining, transient water table and a steady-state water table for the Ogallala Aquifer. The simulations produced nearly identical results, so the use of the steady-state model is not expected to significantly affect the outcome of the PlumeFinder analysis.

The MODFLOW-SURFACT Ogallala Aquifer steady-state model was used as-is in developing the PTC Ogallala Aquifer model, with the two minor refinements to include a finer grid and modify of two wells. In the final steady-state Ogallala Aquifer model, each model grid cell was 844.8 feet (257.5 meters) wide in the east-west direction and 897.6 feet (273.6 meters) wide in the north-south direction. In the transient Ogallala Aquifer model that was used for predicting future flow conditions, a finer grid cell size was used: 211.2 feet (64.4 meters) in the east-west direction and 224.4 feet (68.4 meters) in the north-south direction. The latter grid resolution was needed to assist in subsequent contaminant transport calculations in PTC, so the withdrawal rates from the steady-state Ogallala Aquifer model were substituted into the finer transient Ogallala Aquifer model grid to obtain the steady-state head solution in the more finely discretized model. During this process, two wells were modified with respect to those included in the final steady-state model. First, one Pantex production was excluded; this well was active c.1994 (i.e., consistent with the time period represented by the steady-state model) but is not active today. Second, one irrigation well that was inadvertently omitted from the final steady-state model was added. This irrigation well lies north of the Amarillo well field, and has insignificant impact on this or previous analyses.

To focus the PlumeFinder calculations, simulations were conducted with the steady-state Ogallala Aquifer model to guide the selection of the PTC model extent. Two unit sources were included. One was an areal source placed in the potential areas of RDX breakthrough to the Ogallala Aquifer predicted by the BIOF&T3D model (BWXT/SAIC 2007) and another was a distributed line source along the eastern fringe of perched groundwater. Transport parameters for RDX were specified consistent with those used in the BIOF&T3D model, with the following notable exceptions:

- Biodegradation is assumed not to occur.
- Retardation is assumed not to occur.
- The source strength in the Ogallala Aquifer is assumed 1000 times greater than the plume fringe (1 ppb) for RDX.

The assumptions are more conservative (result in larger predicted plume extent) than those included (biodegradation & retardation) or simulated (peak concentrations of RDX in the Ogallala Aquifer) from the CMS. For instance, a biodecay rate of 25 years and a retardation factor of approximately 1.7 were assumed in the CMS. This conservatism ensures the PTC model extent is sufficiently large to encompass all realizations produced for the PlumeFinder evaluation. Transport was simulated until the plume produced by both simulated source areas reached steady-state. The source areas and the resulting steady-state plume are depicted in Figure 3-4.

Withdrawals from the Amarillo production wells (generally north and northeast of Pantex) and the local area irrigation wells create cones of depression in the Ogallala Aquifer water table (Figure 3-4) that provide an outer bound for contaminant migration. Consequently, the PTC model domain was specified to extend just beyond this depression, as shown in Figure 3-4. The PTC model domain is substantially smaller than the MODFLOW-SURFACT model domain. This smaller model domain permits the 500 PTC models (i.e. the individual realizations generated after geostatistically varying the hydraulic conductivity) to be executed in about 5 minutes, or less than 1 second per run. The PTC model and the PlumeFinder solution domain cover approximately 9 square miles (12,000 feet by 24,000 feet) including the southeastern portion of the Plant area and the likely points of breakthrough to the south and east.

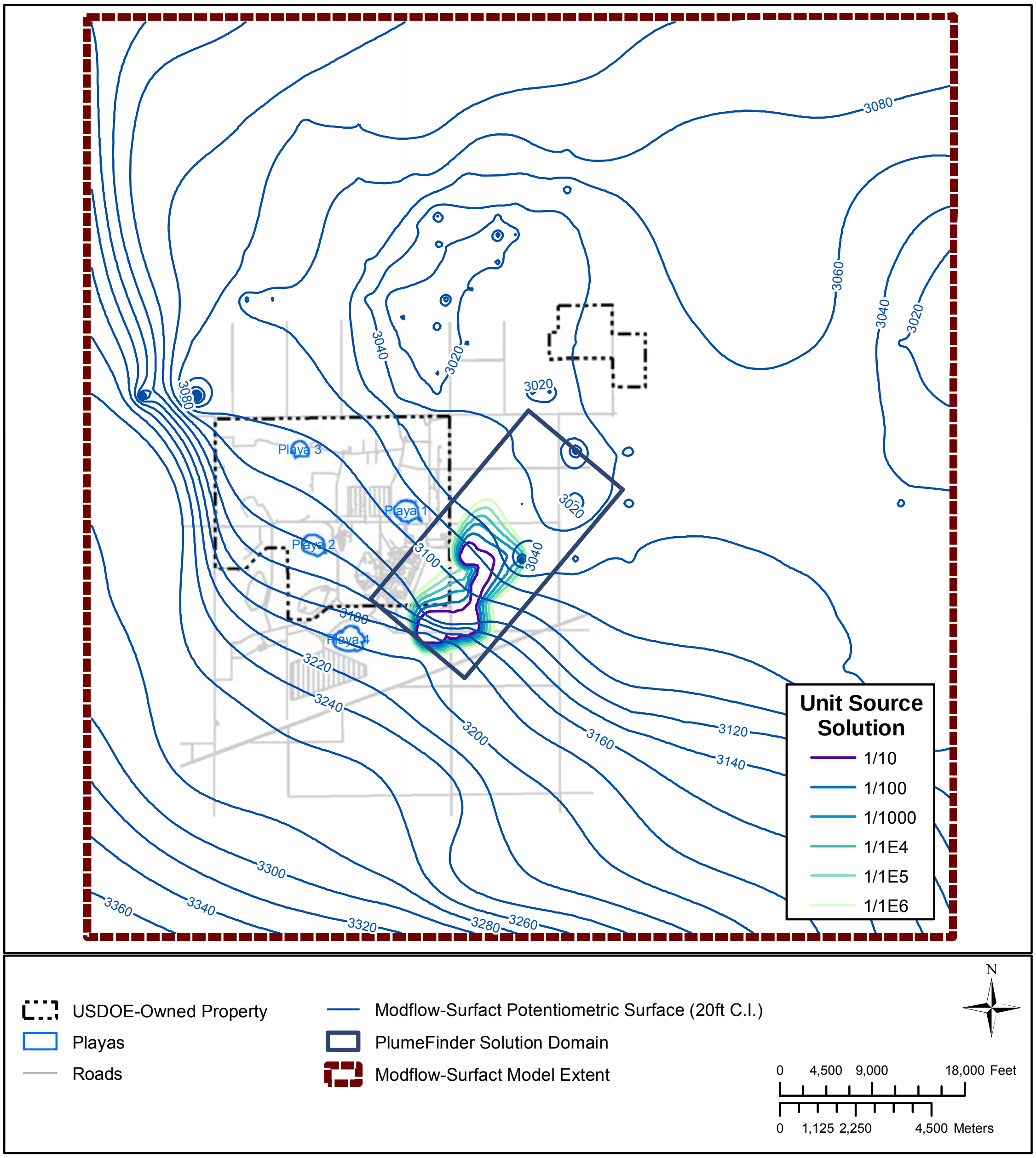


Figure 3-4. Model Domains and Steady-State Plume

Simulations were also conducted with the MODFLOW-SURFACT model to assess the sensitivity of contaminant transport to the pumping rate of irrigation wells immediately east of Pantex Plant, nearest the areas of potential breakthrough. Future pumping rates at the wells are unknown; therefore, the wells impart uncertainty on the transport directions in the area of interest. Transport and particle tracking were conducted to assess the sensitivity of results to the pumping rate of the well closest to the potential breakthrough areas. Three sensitivity simulations were conducted with pumping rate reductions of 50%, 75%, and 87.5% for this well. Predicted steady-state heads, steady-state transport results, and particle tracking results for the rate used in the steady-state model are presented in Figure 3-5a. Similar items are presented in Figure 3-5b for a 75% reduction in pumping rate for this well.

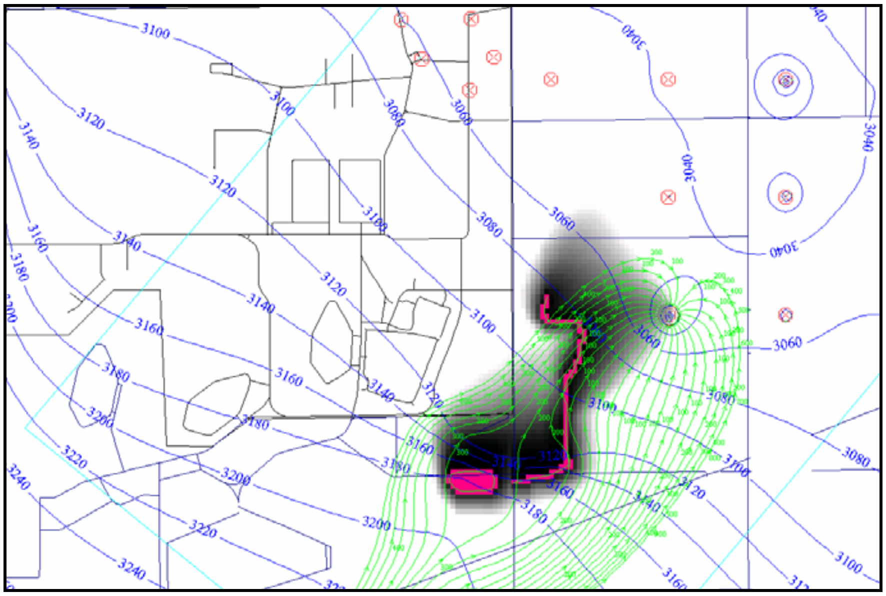


Figure 3-5a. Unchanged Flow Rate at Pumping Well

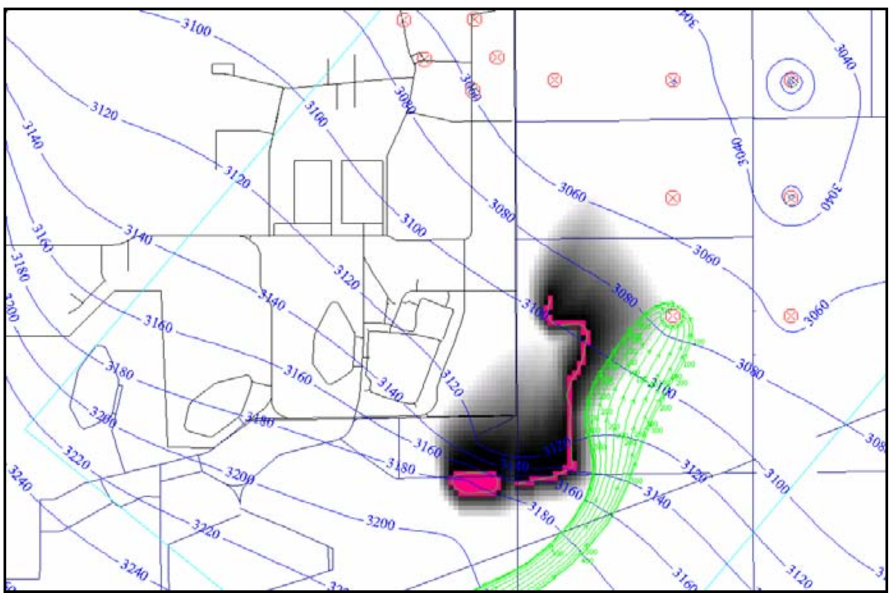


Figure 3-5b. Reduced Flow Rate at Pumping Well

Figure 3-5. Capture Zone and Transport Sensitivity Results

Comparing the two figures, a diminished capture zone for the well can be seen from the particle tracking comparison. However, impacts on the overall extent of the steady-state plume are not dramatic. Based on this comparison, the decision was made to represent all pumping wells with constant head boundary conditions in the PTC model rather than specify a constant flow rate in each. The constant head boundary condition allows the PTC model to calculate a variable flow rate at each well so that a constant water level is maintained in the cell. Note that much of the RDX release may be captured by a single pumping well. This is plausible but other alternatives cannot be discounted since there is a high degree of uncertainty due to the lack of direct field measurements in this area. Installation of the monitoring wells proposed from this analysis would add direct field measurements for this region and reduce the uncertainty.

After establishing the PTC model domain, aquifer properties including hydraulic conductivity, recharge, aquifer top and bottom elevations, and porosity were transferred directly from the MODFLOW-SURFACT model to the PTC model via the ArgusONE numerical modeling GUI. South of the southeast edge of Pantex, a dry area in the Ogallala Aquifer has been observed at one monitoring well. The area is simulated in the MODFLOW-SURFACT model as a partially saturated area, using the value of recharge as the flow in the cell to avoid the dry cell condition. In some areas, the aquifer thickness was less than one foot. Initial testing of the PTC model revealed that realizations with some classes of hydraulic conductivity fields caused the PTC model to fail due to stability limitations in areas with minimal saturated thickness. In these problematic iterations the water table “fell” below the aquifer bottom, causing the hydraulic conductivity in the numerical matrix to go negative and the solver to crash. To prevent these model convergence issues, a confined aquifer configuration was used in the PTC model, and the simulated aquifer thickness was held constant at its initial conditions. This solved the thin aquifer condition and allowed the saturated flow model to be used without requiring a computationally intensive variably saturated flow model or removing the thinner portions of the model domain out of the model. (Removing areas with minimal aquifer thickness was not preferred because the potential RDX source is in these areas.)

The heads from the drawdown of the pumping wells in the steady-state MODFLOW-SURFACT model were transferred into the PTC model and specified as constant head boundary conditions, with specified head values based on the steady-state flow solution. The PTC model boundaries were specified using constant head boundary conditions, again with head values based on the steady-state flow solution. Steady-state flow was then simulated in the PTC model and compared to the MODFLOW-SURFACT model, as seen in Figure 3-6. The comparison shows only minor differences in simulated heads between the two models in the areas of the well fields and at the boundaries with somewhat greater differences underneath the southeastern breakthrough area. The differences can be attributed directly to the combination of both different grid sizes used to solve the model domain, specifically in the area of the wells, and the simplification to apply the approximation of a constant aquifer thickness. The results for the final set of 500 realizations (hydraulic conductivity, head, and concentration) are provided on the attached compact disc.

Figure 3-7 shows the source used in the PTC model and applied to the associated PlumeFinder modeling. This source is placed in the potential area of RDX breakthrough to the Ogallala Aquifer predicted by the BIOF&T3D model (BWXT/SAIC 2007). A unit source strength of 1 ppm was assumed, and the fate and transport solution was calculated with a duration of 50 years. The Plume fringe was defined as the 1 ppb isocontour, and thus the ratio of source concentration to fringe concentration was 1000:1. Neither biodegradation nor retardation was included as a transport process. As a result, the conservative assumptions increased the predicted RDX migration along the likely pathway of the plume and identified the area where RDX from the southern source (breakthrough area) would first migrate beyond the perched groundwater extent.

This PTC model mesh used in the PlumeFinder is shown in Figure 3-8. The dense node arrangement associated with the source ensures accuracy in this critically important region of the model domain and limits numerical dispersion of the transport solution.

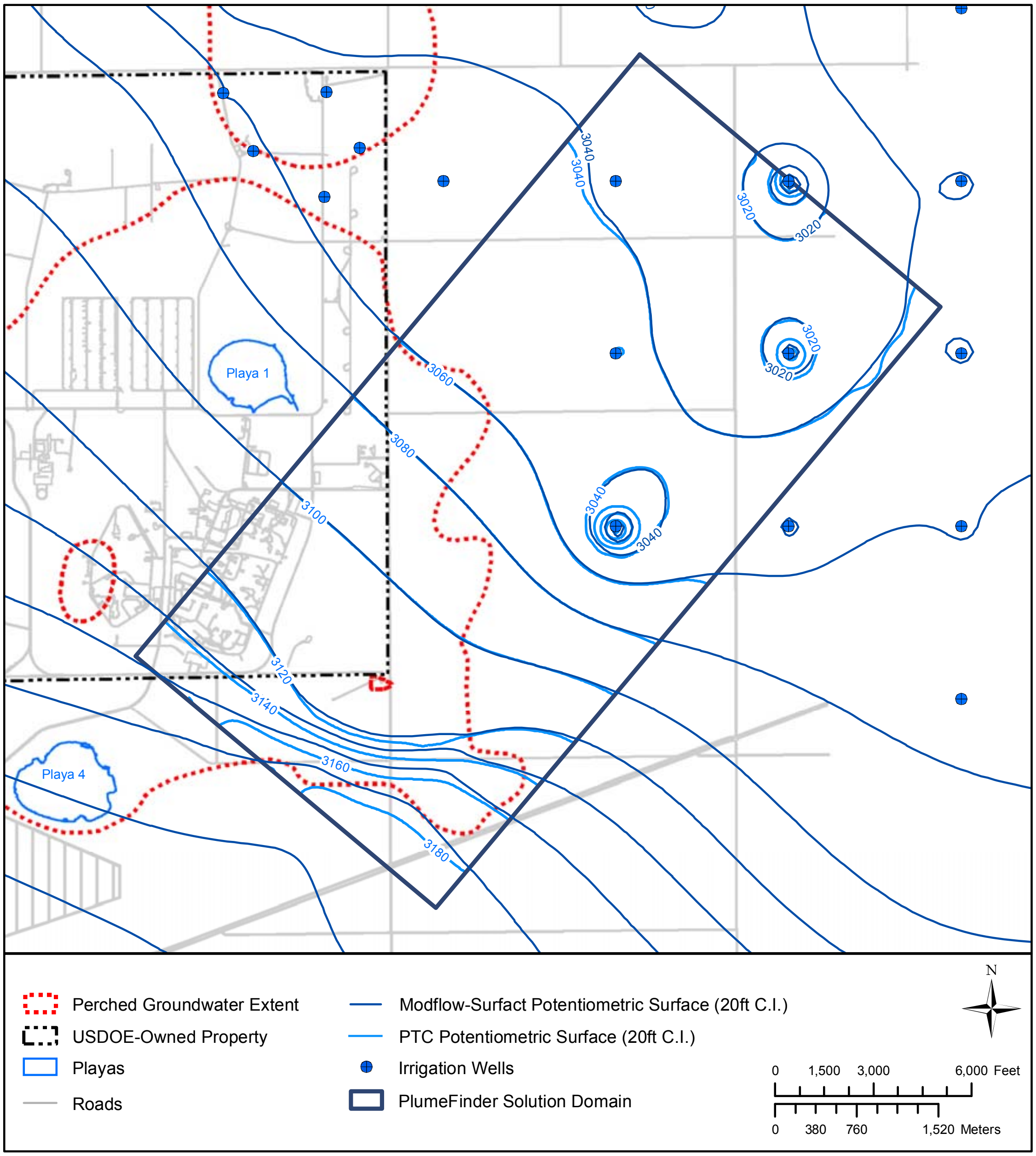


Figure 3-6. Potentiometric Surfaces Defined in PTC Model and Modflow-Surfact Model

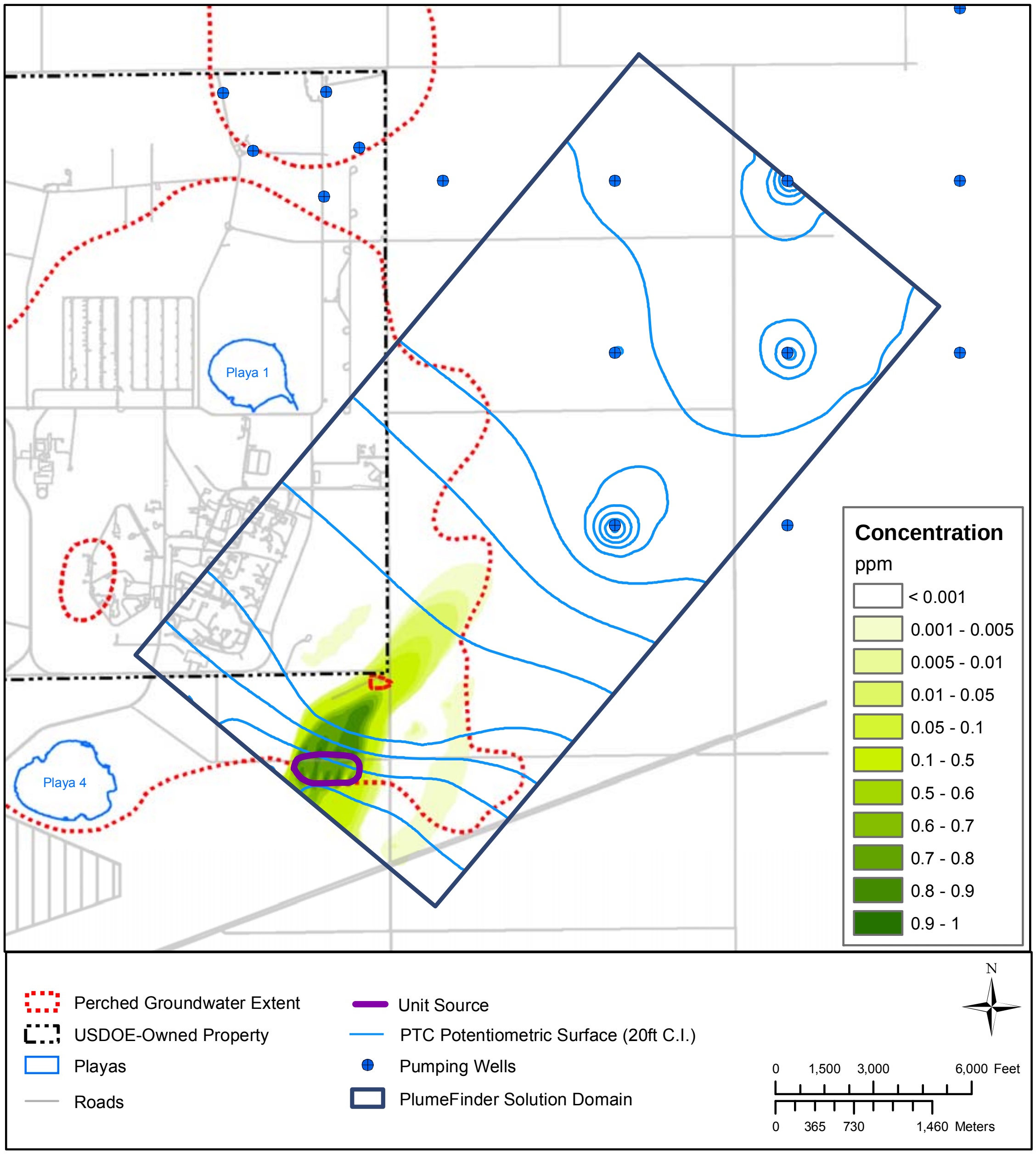


Figure 3-7. Contaminant Source and 50 year Deterministic Transport Plume in PTC Model

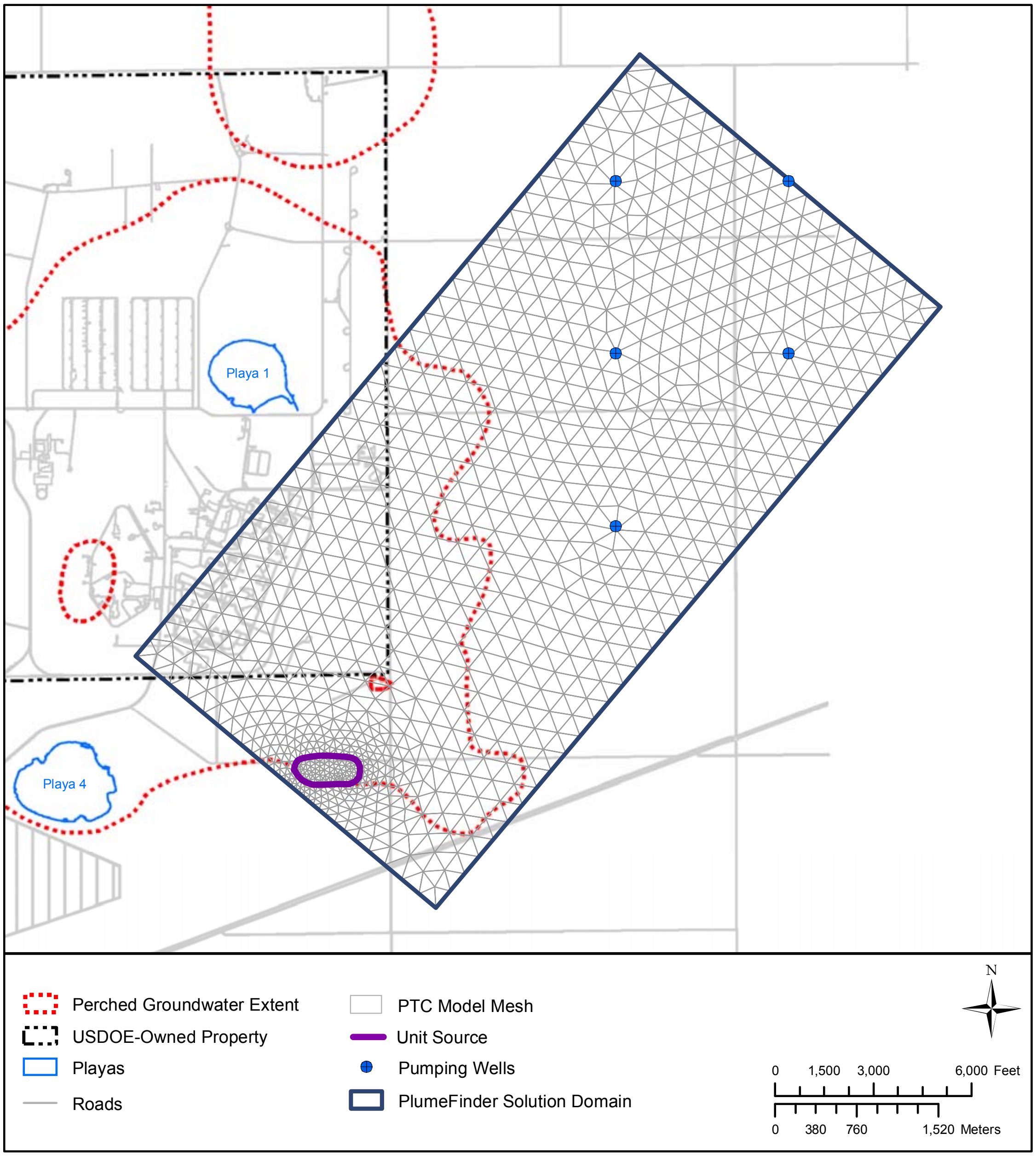


Figure 3-8. PlumeFinder Computational Mesh in PTC Model

3.1.5 Additional Considerations

Hydraulic conductivity: Hydraulic conductivity is assumed to be locally isotropic; that is, the same in the x and y directions within each element. However, because of uncertainty associated with the hydraulic conductivity and the limited amount of available test data, geostatistics were used to create 500 likely aquifers and the combined results analyzed to provide recommended locations for new monitoring wells. The variogram for the entire Ogallala Aquifer was used as discussed above. The extent the variogram may differ from local conditions is unknown. The variogram provides the best available information from which to base the hydraulic conductivity realizations.

Groundwater flow direction: With the exception of a few monitoring wells, the actual flow patterns beneath the perched groundwater are unknown from direct measurement. The inferred flow directions represent the best estimate from measurements recorded in the Ogallala Aquifer monitoring wells.

Potential Source Locations to the Ogallala Aquifer: The potential source of RDX to the Ogallala Aquifer is inferred. RDX has not been directly measured at any consistent value at any location in the Ogallala Aquifer. RDX is consistently detected in the perched groundwater at values in the mg/l range. The assumed sources used in the PlumeFinder analysis and accompanying qualitative assessment are the best estimates of where RDX could migrate into the Ogallala Aquifer, based upon both site investigation data and previous modeling results.

Fifty-year monitoring design period: Fifty years was chosen as a period from which to evaluate the plume fringe uncertainty. Uncertainty grows over time. Sporadic and unreplicated detections of RDX complicate the analysis, as it is uncertain whether or not a plume fringe exists in these monitoring locations. Only three Ogallala Aquifer monitoring wells within the PTC model extent still contain groundwater from which to make assessments.

Irrigation wells (pumping wells): The stochastic analysis of the plume fringe location also addresses the uncertainty associated with the pumping rates of irrigation and water supply wells. Simulations conducted with the MODFLOW-SURFACT Ogallala Aquifer model indicate that flow in the Ogallala Aquifer (and therefore contaminant transport) directions are sensitive to the pumping rates of wells east of Pantex near the areas of potential breakthrough. Future pumping rates at the wells are unknown, and the wells are not under Pantex control. These wells therefore impart substantial uncertainty on the transport directions in the area of interest. Because well pumping rates are allowed to vary with the different aquifer realizations, this uncertainty is somewhat addressed in the PlumeFinder analysis.

One last consideration is that the analysis presented here does not incorporate degradation or biological decay of RDX in the transport calculations. Degradation rates, usually expressed in terms of a first-order kinetic reaction rate, for RDX are well documented in the literature but have not been measured in the Ogallala Aquifer. Because biological reactions are redox-zone specific, the biochemistry is important in assessing the transport of material in the subsurface and will therefore be important in early detection of a plume fringe. As described in the *CMS/FS Modeling Report* (BWXT/SAIC 2007), the degradation rate of RDX is an irreducible uncertainty that can only be addressed over time as information on the redox zones and degradation rates in the Ogallala Aquifer groundwater.

A principled groundwater flow and transport model helps overcome data limitations through accurate representation of the underlying physics. However, a deterministic solution may not capture the variety of possibilities that exist to effectively manage potential migration of RDX. The PlumeFinder technology incorporates the major elements of the uncertainty, and provides a mechanism to support management decisions following a systematic and proven approach. Below are the results of the analysis.

3.2 PLUMEFINDER ANALYSIS AND RESULTS

The objective of this analysis is to identify best locations for up to three new Ogallala Aquifer monitoring wells using the PlumeFinder technology and incorporating predictions from previous modeling efforts. PlumeFinder optimally locates wells to better delineate the boundary of a contaminant plume. As noted earlier, PlumeFinder integrates the PTC model, the model GUI (Argus ONE), and geostatistical software into a computer system for guiding the investigation of contaminated aquifers. As discussed in the previous section, PlumeFinder is based on the idea that the best means of delineating a contaminant plume boundary is to place wells in such a manner as to minimize the uncertainty of the boundary location.

The threshold level that defines the RDX plume boundary is $1/1000^{th}$ of the assumed unit source strength of 1 mg/l. This assumed unit source and plume fringe threshold are conservative. The recommended alternative in the CMS/FS (BWXT Pantex/SAIC, 2007) indicated a maximum predicted RDX concentration of 4 ug/l in the Ogallala Aquifer and a plume fringe defined by the 0.774 ug/l isocontour. An approximately 1/5 ratio produces an area of plume fringe uncertainty much smaller than if a lesser ratio of 1:1000 is used. Despite conservative assumptions in the PlumeFinder analysis, the likelihood that RDX will migrate from the source area to a point beyond the extent of perched groundwater in the east is low in this 50-year design period.

The GSLIB code was used to geostatistically vary the hydraulic conductivity field and generate multiple realizations of the Ogallala Aquifer. The hydraulic conductivity variogram from the Northern Ogallala GAM (Dutton, et al., 2001) was used as input into the model. Because pumping wells are simulated as constant head boundaries, the flow into them varied depending on the geostatistical representation of the aquifer hydraulic conductivity. The analysis consisted of generating 500 aquifer realizations, executing flow and transport simulations for each, and repeating this for each PlumeFinder investigation scenario. Three scenarios were evaluated: no wells, the existing monitoring well network, and one optimally located monitoring well. This resulted in 500 separate flow and transport simulations for each scenario, totaling 1500 simulations. The mathematics underlying PlumeFinder, specifically the Kalman filtering aspect, are explained in Appendix A. The flow and transport mathematics are provided in the PTC textbook and manuals (Pinder, 1997 & 2002). The applied geostatistics are described in the Geostatistical Software Library and User's Guide (Deutsch and Journel, 1992).

3.2.1 <u>Baseline Uncertainty (No Monitoring Wells)</u>

As a first step, the PlumeFinder investigation was executed without monitoring well information to provide a baseline for evaluating the existing well network. The results of the base case can be seen in Figure 3-9. In this figure, darker colors depict greater uncertainty and lighter colors depict higher confidence. The best location to place a well is in the area of maximum uncertainty outside the perched groundwater extent. The value for uncertainty (shown in the legend of Figure 3-9) is a measure of the uncertainty in the value of the RDX concentration in the groundwater when compared to the plume fringe value. The volume underneath the measure of uncertainty value has been normalized to 100%.

- <u>Uncertainty beneath the Perched Groundwater</u> – Most of the plume migration and uncertainty associated with fringe location occurs beneath the perched groundwater, an area for the most part precluded from investigation in the Ogallala Aquifer for reasons of cross-contamination concerns.

- <u>Uncertainty beyond the Extent of Perched Groundwater</u> – Two areas of plume fringe uncertainty occur beyond the extent of perched groundwater saturation, one to the south of the Plant, and one to the east.

- In the area to the south observations show the Ogallala Aquifer to be dry in at least some locations. Investigations in this area are prudent, and B&W Pantex is already planning on further investigations to characterize the Ogallala in this area.
- The area to the east represents the most likely location where RDX could migrate from beneath the perched groundwater extent. The PlumeFinder technology is used to identify the best monitoring well location in this area to the east of perched groundwater saturation.

3.2.2 Uncertainty in Current Monitoring Well Network

Figure 3-10 shows the results when the information for the existing three Ogallala Aquifer wells (within the PTC model domain) is added. An assumed concentration of half the plume fringe value (1 ppb) was specified at the three existing well locations. By inspection, information is most lacking in the southeast near the extent of perching groundwater. This finding is consistent with the known uncertainties in the conceptual site model. This analysis shows that the current monitoring well network in the Ogallala Aquifer only reduced the uncertainty in the plume fringe location by 8%.

The reduction in uncertainty is low for several reasons. First and foremost, to avoid the potential for cross contamination, there are only a limited number of monitoring wells (three) installed downgradient of the source area. All are installed through localized areas within the current extent of the perched groundwater where the FGZ projected above the perched groundwater table. PTX06-1033 is outside the area impacted by the source assumed here and has no effect on reducing uncertainty. PTX06-1032 is in an area of low uncertainty with respect to plume delineation and accounts for a minor reduction in uncertainty. PTX06-1056 is directly downgradient of the source area and accounts for nearly all the reduction in uncertainty from the existing Ogallala Aquifer monitoring well network. PTX06-1054, south of the source area, contains insufficient water for sampling and was therefore not included in the PlumeFinder analysis. There are no existing monitoring wells east of the perched groundwater extent capable of characterizing the Ogallala Aquifer near a potential secondary source in that area.

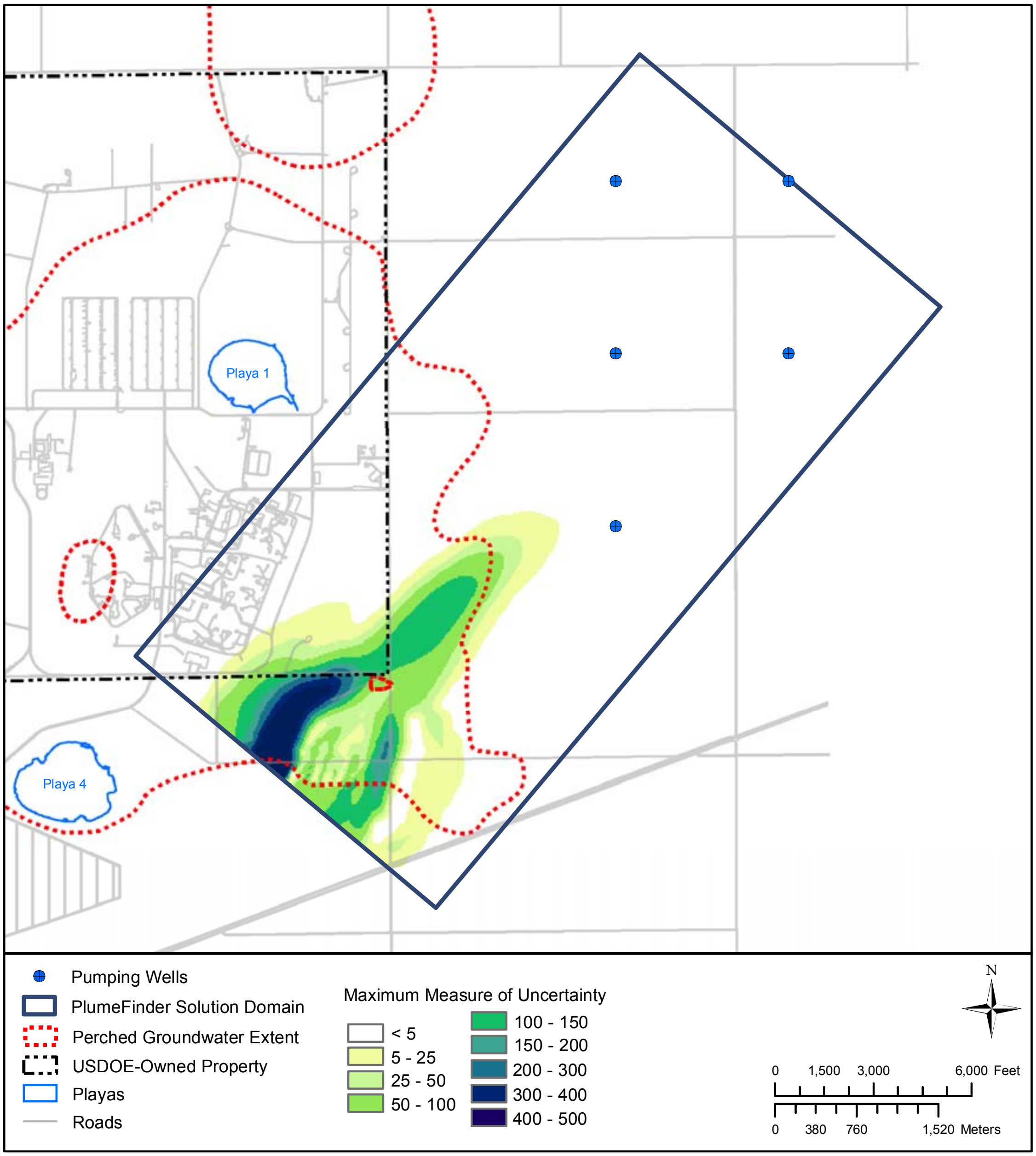


Figure 3-9. PlumeFinder Rendering of Baseline Uncertainty

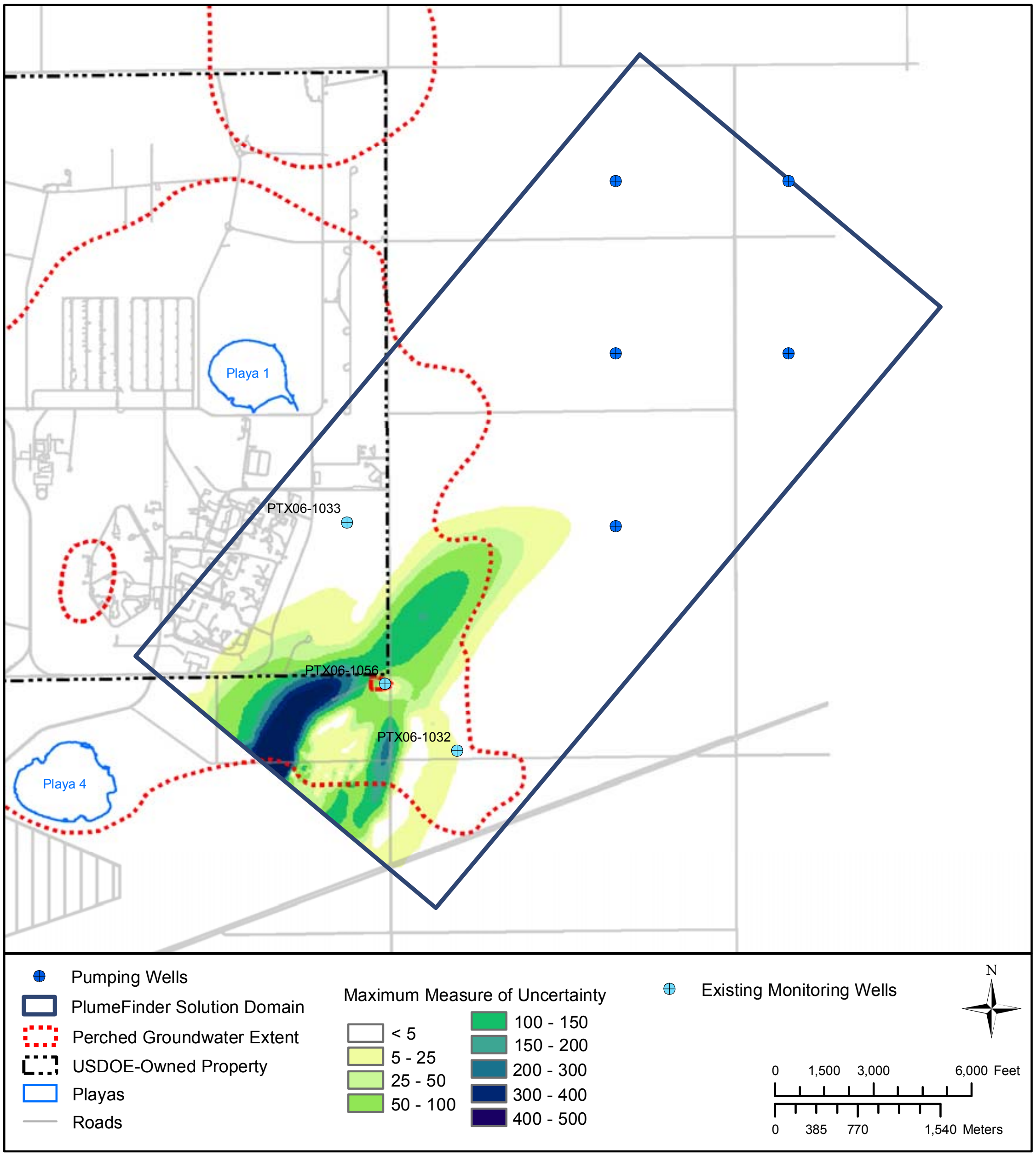


Figure 3-10. PlumeFinder Rendering of Uncertainty with Existing Pantex Monitoring Wells

3.2.3 Uncertainty with Proposed New Monitoring Wells

A proposed new well is added in the optimal location (i.e., at the location of the maximum value of uncertainty from Figure 3-10) that is to the east of the perched groundwater extent. This location can be seen in Figure 3-11. Assuming the new well detects the plume fringe, Figure 3-11 shows its projected effectiveness in decreasing the uncertainty in plume delineation if installed. This represents a 72% reduction in the volumetric uncertainty beyond the extent of perching from the current case (which assumed the Pantex monitoring well network). Overall, the total uncertainty reduction is 16% when considering the entire volume (below perched, south of Plant, and east of Plant).

The majority of the remaining uncertainty exists beneath perched groundwater and constitutes irreducible uncertainty due to the constraint that wells not be drilled through areas of perched groundwater containing RDX. As such, it is more desirable to place two additional wells slightly downgradient of the extent of perched groundwater rather than to drill through the perched groundwater to install monitoring wells. The locations of these well are shown on Figure 3-12. They are placed based on insight from the CMS/FS and associated BIOF&T3D modeling. They are not placed by the PlumeFinder analysis. The purpose of these two wells is early warning detection of RDX from the eastern portion of the perched groundwater, as opposed to farther field plume detection from the potential RDX source area beneath perched groundwater. They are located as preliminary investigation wells to gather subsurface information in these areas. PF-2 is where the extent of perched groundwater extends the least when compared to the surrounding area to assess the potential for downward migration (see Figure 3-3a) , and PF-3 is at the point where there is a decreasing area of RDX in the perched groundwater (also Figure 3-3a). These placements are motivated by an understanding of the physics of the 3-D flow and transport system. They are not positioned simply by placing them between potential receptors, for example. Installation of these wells will provide key observation data to better understand the flow and transport properties in this area and to assist in making informed decisions regarding potential RDX migration.

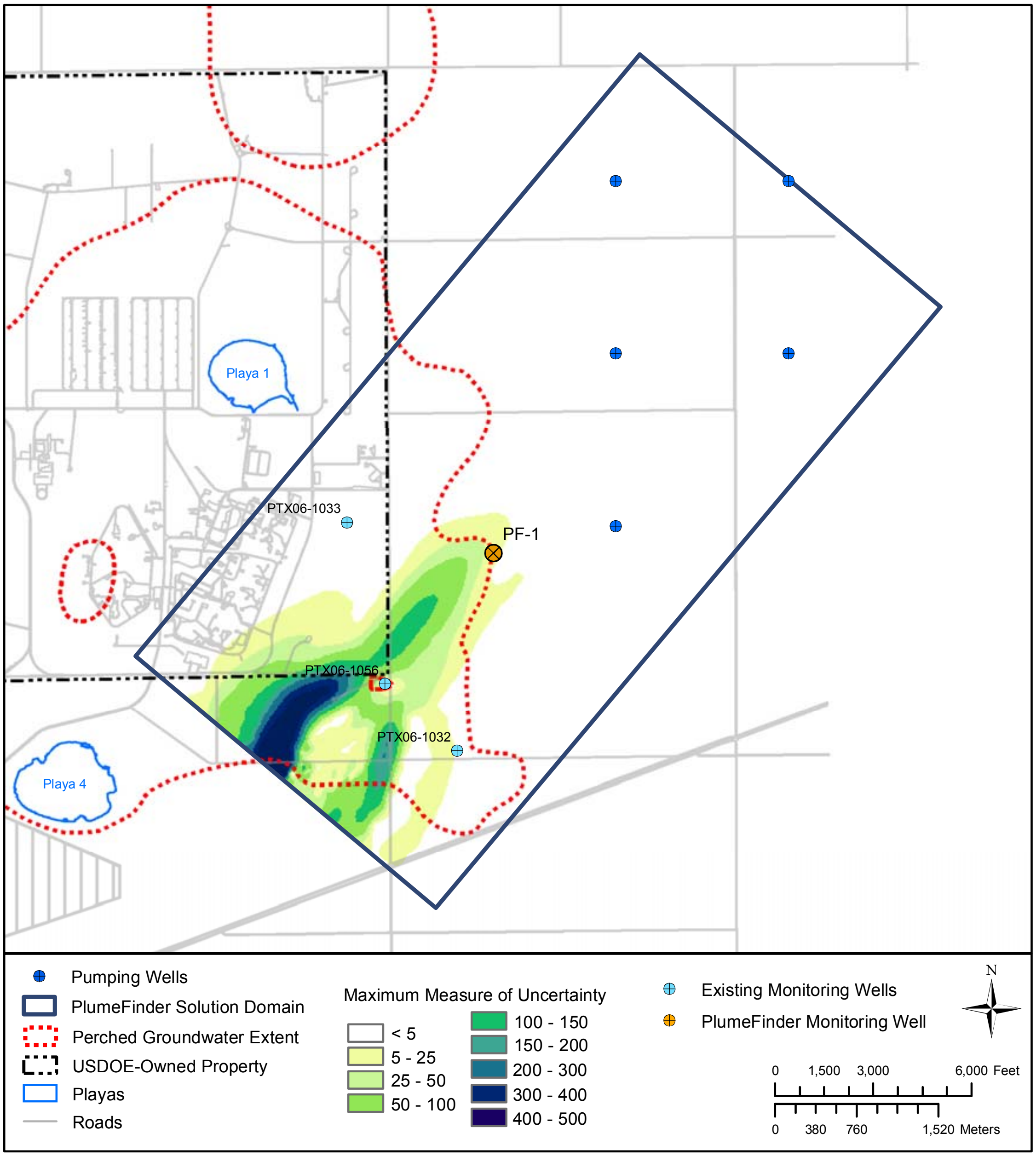


Figure 3-11. PlumeFinder Rendering of Uncertainty with First New Well Installed

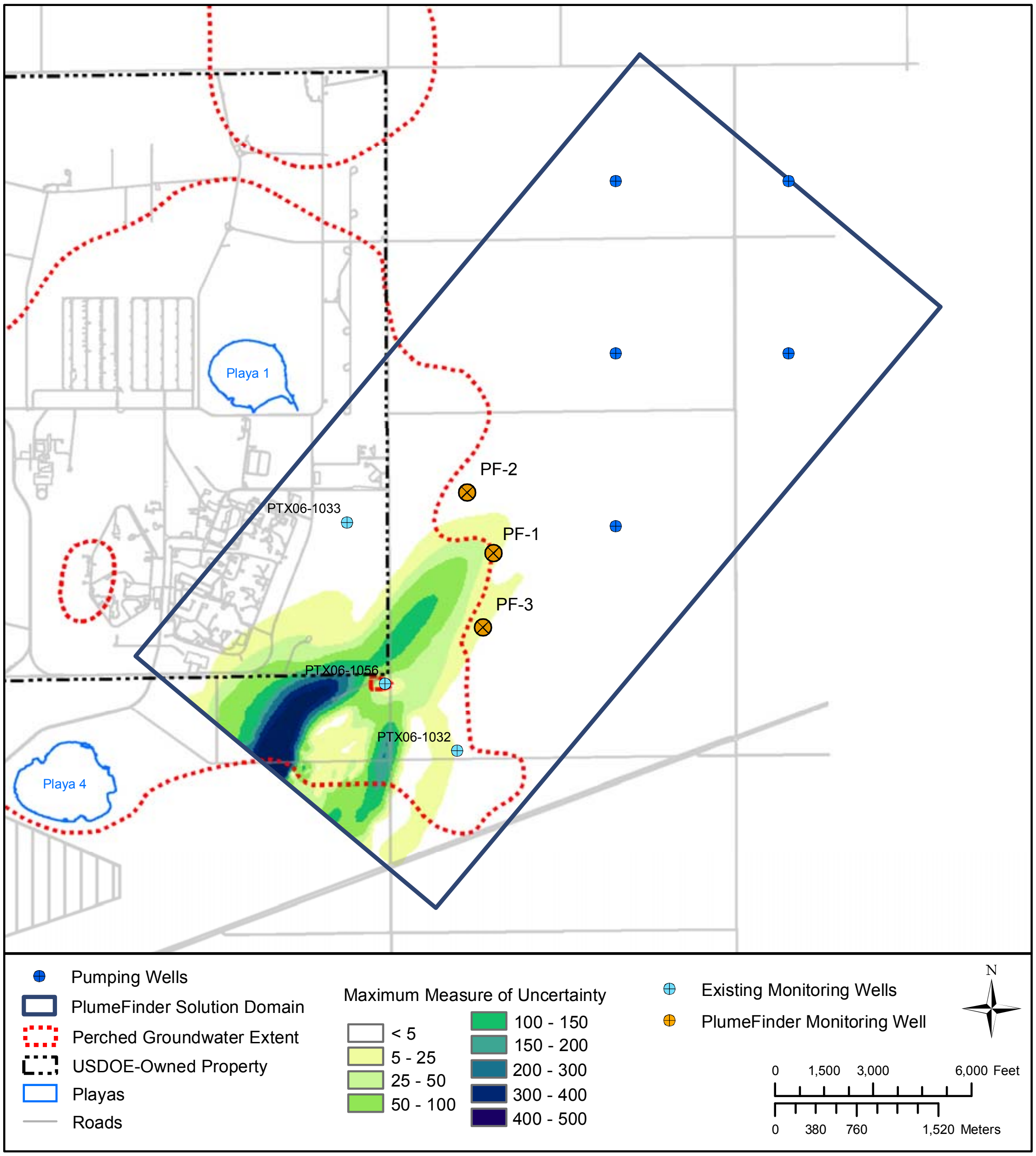


Figure 3-12. PlumeFinder Rendering of Uncertainty with Second and Third New Wells Installed

3.2.4 Summary of PlumeFinder Results

The first monitoring well, PF-1, details the effect of uncertainty from a potential RDX source area in the southeastern portion of the Plant derived from contamination in the overlying perched groundwater. Proposed wells PF-2 and PF-3 additionally help to provide early warning detection at the fringe of perched groundwater, and are based on professional judgment since the reduction in uncertainty computed from the PlumeFinder analysis indicated minimal value beyond the one monitoring well for reducing uncertainty from the potential source in the southeast. These three locations are based on the optimization performed with PlumeFinder combined with understanding the 3-D flow and transport physics to provide early warning detection for RDX derived from vertical flow near the extent of perched groundwater. Important points to consider are:

1) The fluxes from the perched groundwater vary with location and over time as the perched groundwater slowly drains into the Ogallala Aquifer.

2) Remediation is underway which is designed to minimize the risk that RDX enters the Ogallala Aquifer.

3) Placement of groundwater monitoring wells directly adjacent to the perceived extent of perched groundwater might cause a failure to identify RDX migrating to the Ogallala Aquifer due to the lack of direct observations in this area.

4) Placement of monitoring wells too far from the perched groundwater extent reduces their usefulness as an early warning system.

5) Currently, there are no Ogallala Aquifer monitoring wells east of the perched groundwater extent (second source); and therefore, there is no way to determine if the Ogallala Aquifer has been impacted in this area. Modeling results from the risk assessment and CMS/FS indicate only very low (ppb range) potential impacts in this area.

Hence, the proposed monitoring well network provides a balance of these complexities and the one well (PF-1) is optimal for detecting plume fringes from a potential source in the southeast area within a 50-year time period. The other two wells, PF-2 and PF-3, are good locations to assess migration of RDX along the eastern fringe of perched groundwater. For the monitoring well network to be workable, the well screens must be long enough to account for the documented and projected decline in the Ogallala Aquifer water table.

Note that in this analysis precise knowledge of the flow and transport system is not necessary, but is very helpful in making good decisions about well placement. The PlumeFinder assesses the ability of a monitoring location to provide information valuable to determining where the plume fringe resides. The conclusions for the PlumeFinder analysis for RDX in the Ogallala Aquifer are as follows:

- The existing monitoring network was established by installing monitoring wells through the FGZ. Although this was done using safe installation criteria, the existing network has limited value for RDX detection beneath the perched groundwater. It demonstrates the amount of irreducible uncertainty to safely investigate beneath the perched groundwater.

- Better delineation of the plume fringe can be achieved by adding three new wells outside the eastern extent of perched groundwater. The wells, however, do little to reduce the uncertainty in RDX plume fringe delineation beneath the perched groundwater.

- A periodic review of the flow directions and a regular sampling regimen, including both target and monitored natural attenuation parameters, is warranted.

- This analysis can be updated pending installation of the three proposed wells, collection of water table data, hydraulic conductivity, and RDX concentrations, if warranted.

4.0 SUMMARY

4.1 RESULTS OF WELL PLACEMENT OPTIMIZATION

A significant benefit in understanding the potential plume migration, as well as plume fringe delineation, can be gained by this analysis. Adding three new monitoring wells provides for a solid increase in understanding the groundwater flow and transport in this eastern area – an area currently devoid of Ogallala Aquifer monitoring wells. It also shows the irreducible uncertainty in knowledge of plume migration beneath the perched groundwater when safe investigation practices limit the amount of available data. The locations for three new monitoring wells are shown in Figure 4-1. PF-1 has been established using the PlumeFinder technology while PF-2 and PF-3 are recommended based on previous modeling efforts and site investigation data. With the high cost of monitoring well installation and sampling in the Ogallala Aquifer, it is prudent to collect additional subsurface characterization data before more new wells are installed beyond the three recommended. Additional valuable information includes verifying the presence or absence of RDX in the aquifer, determining the flow direction variation with time, and determining natural attenuation parameters over time and distance. This data will reduce the uncertainty in the information used to locate additional wells, if needed. A summary of the volume under the measure of uncertainty for RDX is presented in Table 4-1. The corresponding percentage reduction in far field plume fringe uncertainty from the current conditions is shown in parenthesis.

The reduction in uncertainty shown in Table 4-1 indicates that the first proposed monitoring well network has been well designed and reduces the uncertainty in plume location beyond the extent of perched groundwater for RDX by 72%. This translates into a total reduction of uncertainty for the entire plume (to the south and beneath the perched groundwater) of only 16%. Increasing the uncertainty reduction more would require drilling through the perched aquifer, which is not recommended. Hence, this 16% improvement also represents the irreducible uncertainty in understanding the flow and transport system. The installation of the second and third wells is for early warning detection of RDX originating along the eastern fringe of perched groundwater.

- PF-1: This is a dual-purpose monitoring well. This location resolves the greatest portion of uncertainty from the southeastern perched groundwater area and provides early warning detection for RDX emanating from the eastern fringe.

- PF-2 and PF-3: These serve as early detection wells for RDX emanating from the eastern fringe, and are derived from the physics-based understanding of 3-D flow and transport and the conceptual site understanding.

4-1. PlumeFinder RDX Results Summary

PlumeFinder Simulation	Overall Measure of Uncertainty Residual (reduction)
Baseline (No Wells Installed)	100%
Current Conditions (Existing Well Network)	92% (8% reduction)
Add One New Well (improvement from current conditions)	84% (16% reduction)
Add One New Well (improvement from current conditions east of perched groundwater)	28% (72% reduction)

The results of this analysis are significant because they document the baseline condition, quantify the value of the existing well network, and provide insight for optimally refining the well monitoring network. Adequate knowledge of the plume location is important to conducting good site investigations and making good plume management decisions. The PlumeFinder technology used in this study quantifies the plume fringe location even when data is limited and uncertain, so informed decisions can be made to ensure that long term monitoring or remediation activities are optimally located. The PlumeFinder technology applied here provides one new well location recommendation to produce the maximum reduction in plume uncertainty using proven mathematical and geostatistical principles. It also shows and quantifies the residual uncertainty beneath the perched groundwater. Above all, plume management needs to be done in a cost-effective manner with a focus on collecting information with demonstrated value to decision-makers. An improvement in the Ogallala Aquifer monitoring system can be made and the corresponding management risk associated with the decision to commit funds to implement additional wells for that purpose is clarified and quantified as a result of using the PlumeFinder technology.

4.2 RECOMMENDATIONS

The reduction in uncertainty from this analysis is relatively low when compared with other studies, and is driven by the inaccessibility of the areas of highest uncertainty beneath the perched groundwater. Therefore, the following recommendations supplement this analysis:

- A periodic evaluation of flow directions and regular sampling of chemical parameters, including both target and monitored natural attenuation parameters, is needed. The groundwater flow field should be assessed by careful examination of potentiometric data and water chemistry in this area.

- Following installation of the three new Ogallala Aquifer monitoring wells, data gleaned from the new wells should be compared with historical Ogallala Aquifer water table and chemical information, and an assessment of natural attenuation should be performed.

- The new field data should be compared with the current model assumptions, and any updates / refinements implemented, as merited.

- Future new well locations, if warranted, should be assessed using the PlumeFinder technology.

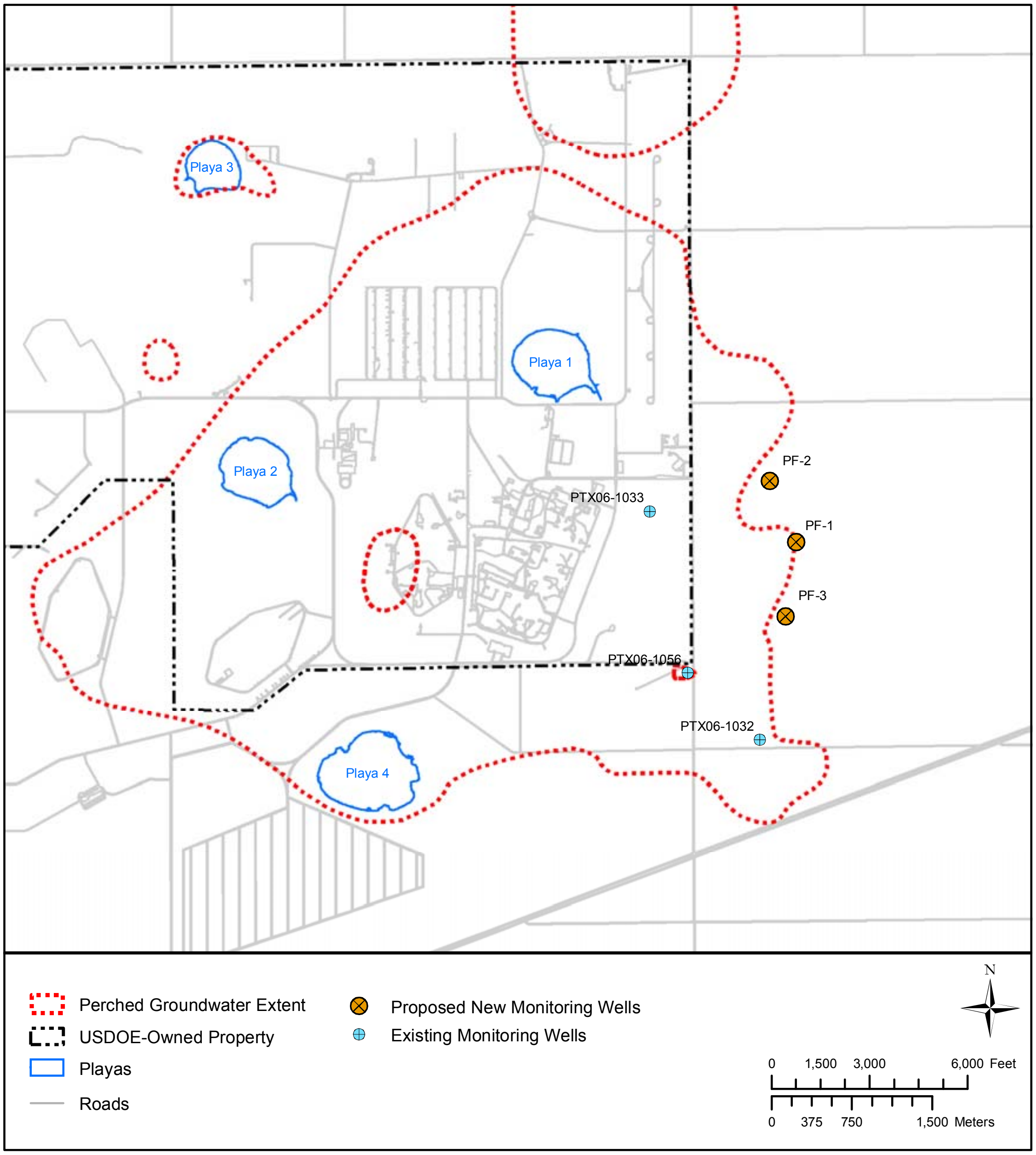


Figure 4-1. Proposed New Well Locations based on PlumeFinder Results

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Appendix A

Kalman Filtering used in the PlumeFinder Analysis

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LIST OF EQUATIONS

1.0 OPTIMAL ESTIMATION VIA KALMAN FILTERING

The goal of optimal estimation is to be able to develop an estimate of the subsurface conditions with respect to flow and transport. This estimate then becomes the state of the system for optimization and decision-making under uncertainty. As discussed in the report, the costs associated in collecting information content about the subsurface results in only sparse knowledge available for analysis. To estimate how the subsurface conditions may vary, geostatistics are used to generate representative realizations. These realizations are used as inputs to the computational fluid dynamic models. This results in a distribution of subsurface conditions, as opposed to a single valued estimate. We now have a quandary: we have predictions of the subsurface condition from models, and we also have data from field surveys. While the role of information theory in this problem is conceptually enlightening, the most important part of this problem is solving the input/output representation of a linear or non-linear system. This generates a probability distribution function for the unknown (e.g., concentration of contaminate in groundwater), and the associated entropy reveals a certain measure of the uncertainty of it. This type of problem falls into the general field of optimum filtering and the stochastic signal extraction from noisy data.

Common parameter estimation in the geo-sciences groundwater modeling community consist primarily of: Bayesian estimators, cokriging estimators, geostatistical inverse methods, Kalman filtering, least squares methods, maximum likelihood methods, and pilot point techniques. McLaughlin and Townley (1996) showed that all these methods are special cases of the Gaussian maximum a posteriori estimator. Additionally, it is shown that using equivalent assumptions, the Kalman filter is equivalent to the least squares estimate, maximum likelihood estimate and the maximum a posteriori estimate. See for example: *Applied Optimal Estimation* (Gelb 1974), *Optimal Estimation with an Introduction to Stochastic Control Theory* (Lewis 1986), *Optimal Control and Estimation* (Stengel 1994). A nice overview of the extended Kalman filter is found in *Stochastic Methods in Subsurface Contaminant Hydrology* (Govindaraju 2002).

The first references found using Kalman filtering in groundwater investigations appeared in 1990s. Techniques have been developed to integrate the information content from both the predictive models and the observed measurements. The technique used in this work was integrating the computational fluid dynamic model (PTC) with a Kalman filter, as it has been demonstrated to provide the best unbiased estimate of the subsurface conditions integrating the uncertainty in the simulator and field data.

2.0 EXTENDED KALMAN FILTERING

The extended Kalman filter is a method to combine the information from samples that are available at discreet time and space with the predictions of a subsurface simulator to provide the minimum error estimate of subsurface conditions.

For extended Kalman filtering to be effective, a stochastic representation of the aquifer is necessary. Stochastic aquifer realizations were conducted using the GSLIB geostatistical package. This approach used the GAMS variogram to generate 500 aquifer realizations; the set of these realizations is called the ensemble. The concept here being that the deterministic representation is difficult to be precisely accurate, so one is always dealing in stochastic nature and uncertainty when developing predictions of subsurface behavior, specifically of the Ogallala Aquifer beneath the Pantex Plant.

The filter used in the analysis is comprised of essentially two parts:

1. The propagation component that specifies how the conditional moments (i.e., hydraulic head, contaminant distribution, flow velocity fields) evolve between times information is available (via sensor measurements). This component performs what a subsurface flow and transport simulator typically perform in conventional groundwater flow and transport projects.

2. The updating component incorporates the new information and specifies how the propagated moments are modified. This component performs the activity typical of a parameter estimation algorithm

The key benefit that the Kalman filter performed is the formal way to integrate the information from the physical PTC simulator and the monitoring well field data. But rather than do these separately, the Kalman filter updates both the mean and the covariance of the model state and associated parameters. Because the conditional statistics are used as the uncertainty measure— as opposed to the spatial variability—the assumption of ergodicity is not required. Ergodicity refers to a stationary random function and its ability to tend towards the stationary mean of its cdf. This concept is used widely in geostatistical analysis. This is an important point. At the scales that are of interest in most flow and transport studies, the conditional hydrobiogeochemical moments are most likely non-stationary and, hence, nonergodic. It should be noted that the updated estimates need not be mass conservative, but the best representation of the mass available given the uncertainty of the information available about the system and its performance.

The Kalman filter is a recursive algorithm. It is a convenient way to fuse the predictions between a subsurface simulator and field data. It estimates the state variables in a linear system by optimally combining the information content of the model and data, incorporating uncertainty. In linear systems, the Kalman filter estimate is the true conditional mean —the truly optimal (minimum variance) estimate. The Kalman filter must be extended to handle non-linear systems, such as most groundwater flow and transport challenges. Linearizing the state equation around the latest parameter estimates to approximate the conditional mean does this. Essentially, this formulation is like a series of linear batch filters. Practice has shown that even with this reduced dimensionality and linearization, the extended Kalman filter will provide an estimate that is close enough to the conditional mean and mode.

To explain this concept, the mathematical explanation that follows is essentially taken from *Stochastic Methods in Subsurface Contaminant Hydrology* (Govindaraju 2002), with insight added to help bring out the value of this approach. The state and parameter equations for a flow and transport simulator were presented above. Here, we focus on the equations of the Kalman filter and the state-parameter moment update equations:

Equation 1. Kalman Filter

$$K(x,t) = P_{xx}(x,x',t)H^T(x',t)[H(x,t)P_{xx}(x,x',t)H^T(x',t) + R(x,x',t)]^{-1}$$

K (x, t) is the Kalman gain matrix. This matrix provides the weighting between the expected values from the simulations and the measured values at the sensor locations.

P_{xx} (x, x’, t) is a first order approximation of the conditional covariance between two variables and two locations, denoted as x and x’ at time t. Conditioning makes the stochastic analyses more site specific for the Pantex Plant / Ogallala Aquifer flow and transport system. The variables are properties typically measured in the field such as hydraulic head, conductivity, chemical concentrations, and the like. The Pantex heads and concentrations were measured in the monitoring wells, and the conductivity information from the local and GAMS modeling studies. The conditional mean of the variable's random field is the minimum variance unbiased estimate of the actual site-specific distribution. The conditional variance measures the uncertainty of this estimate. The conditional covariance relates to the behavior between different variables.

H (x', t) is an operator in space and time. It specifies the relationship between the augmented state vector and the measurements made in the field. The augmented state vector contains the stochastic simulator – the heads, velocities, concentrations, and the uncertain parameters such as conductivities, retardation, biochemical degradation, source strength. The assumptions of these are provided in the main body of the report.

R (x, x', t) is the measurement covariance matrix covariance between two variables and two locations, denoted as x and x' at time t.

The second key equation relates how the augmented state vector [X (x, t)], the vector that contains the stochastic simulator – the heads, velocities, concentrations, and the uncertain parameters (such as conductivities, retardation, biochemical degradation, source strength, etc.) is updated after a measurement is made. Since we are placing a hypothetical monitoring well, we have no direct measurement. We assume it will detect a value of half the plume fringe value, but that neither hydraulic conductivity nor heads are known. This minimizes the possibility biasing the results based on estimates from the regional Ogallala model. After actual monitoring well installation, the concentration, water levels and hydraulic conductivity should be measured.

Equation 2. Augmented State Vector Update

$$\hat{X}^{+}(x,t) = \hat{X}^{-}(x,t) + K(x,t)[Z(x,t) - H(x,t)\hat{X}^{-}(x,t)]$$

$\hat{X}(x,t)$ is the first-order approximation of the conditional mean, given all measurements. The (-) sign indicates the estimate before the new measurement information is given, and the (+) indicates the estimate after the new information is analyzed.

Z (x, t) is the measurement vector. It is equal to H (x, t) X (x, t) + V (x, t). H and X are defined above, and V (x, t) is a measurement error vector, with zero mean, Gaussian white noise. It relates to the fact that when a measurement is made, the uncertainty about the value of the measurement at that point in time is reduced to zero plus the measurement error.

The third key equation relates how the first order approximation of the conditional covariance between two variables and two locations, denoted as x and x' at time t [P_{xx} (x, x', t)] is updated after a measurement is made:

Equation 3. Conditional Covariance Update

$$P_{xx}^{+}(x,x',t) = P_{xx}^{-}(x,x',t) - K(x,t)H(x,t)P_{xx}^{-}(x,x',t)$$

The Kalman filter performs as follows:

- Equation 1 defines the Kalman filter.

- Equation 2 states that the best linear unbiased estimate (minimum variance) of the augmented state vector [$\hat{X}^{+}(x,t)$] is a linear combination of the model prediction [$\hat{X}^{-}(x,t)$] and the field measurement [Z (x, t)]. This is how the predictive model information and field measurements are used in concert to provide the best estimate of the subsurface conditions. In general, subsurface simulators are coded to conserve mass. By adding the information content of the field data, the mass conservation is not guaranteed. This is, however, the best estimate of the subsurface conditions when the information is imperfect. It has a correction for the field data reliability, for if the measurements are unreliable, the measurement covariance matrix [R (x, x', t)] will be large. Because this term appears as an inverse in the Kalman gain matrix, K (x, t) will be small. Because K (x, t) weighs the observations, the best estimate will be close to the model estimate. If the measurements are of high accuracy, then this equation ensures that the estimate is consistent with the observed field data. This functionality allows for optimization of allowable measurement error: do you collect a lot of data with low fidelity? A few highly accurate data points or some combination of both is an optimal investigation design question. For this investigation, only formal monitoring wells are considered.

- Equation 3 is the heart of the optimal sampling design approach. The first order approximation [P_{xx} (x, x', t)] of the updated conditional covariance between two variables and two locations, denoted as x and x' at time t, does not depend on any new observations. Note that all the terms rely on knowledge we currently have – denoted by (-), as opposed to (+). This equation is linearized around the most recently updated estimate of X (x, t), the augmented state vector – which depends on measurements to date but not the future. This provides insight to how the Kalman filter will behave and its accuracy before any new samples are taken. Because this equation is the difference between two positive definite matrices, the difference most also be positive definite. This says that the value of adding information (taking samples) is quantifiable, and the updated covariance matrix will always be less than or equal to the forecast covariance matrix. Of course, if the measurement covariance matrix [R (x, x', t)] goes to infinity, the second term of this equation will go to zero. This means that the samples have no value, which is consistent with why the matrix goes to infinity (unreliable samples).

These important attributes of the Kalman filter provided great value in finding the best location for a monitoring well in the Ogallala Aquifer just slightly beyond the eastern extent of perched groundwater at Pantex Plant.

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In cooperation with U.S. Department of Energy/National Nuclear Security Administration and Babcock & Wilcox Technical Services Pantex, LLC

Analysis of Vertical Flow during Ambient and Pumped Conditions in Four Monitoring Wells at the Pantex Plant, Carson County, Texas, July–September 2008

By Gregory P. Stanton, Jonathan V. Thomas, and Jeffery Stovall

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Conversion Factors and Datums

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre	4,047	square meter (m^2)
	Flow rate	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Transmissivity*	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

*Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [(ft^3/d)/ft^2]ft. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Datums

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Analysis of Vertical Flow during Ambient and Pumped Conditions in Four Monitoring Wells at the Pantex Plant, Carson County, Texas, July–September 2008

By Gregory P. Stanton, Jonathan V. Thomas, and Jeffery Stovall[1]

Abstract

The Pantex Plant is a U.S. Department of Energy/National Nuclear Security Administration (USDOE/NNSA)-owned, contractor-operated facility managed by Babcock & Wilcox Technical Services Pantex, LLC (B&W Pantex) in Carson County, Texas, approximately 17 miles northeast of Amarillo. The U.S. Geological Survey, in cooperation with B&W Pantex through the USDOE/NNSA, made a series of flowmeter measurements and collected other borehole geophysical logs during July–September 2008 to analyze vertical flow in screened intervals of four selected monitoring wells (PTX01-1012, PTX06-1044, PTX06-1056, and PTX06-1068) at the Pantex Plant. Hydraulic properties (transmissivity values) of the section of High Plains (Ogallala) aquifer penetrated by the wells also were computed. Geophysical data were collected under ambient and pumped flow conditions in the four monitoring wells. Unusually large drawdowns occurred at two monitoring wells (PTX06-1044 and PTX06-1056)

[1] Babcock &Wilcox Technical Services Pantex, Amarillo, Texas

while the wells were pumped at relatively low rates. A decision was made to redevelop those wells, and logs were run again after redevelopment in the two monitoring wells.

Logs collected in monitoring well PTX01-1012 during ambient conditions indicate a dynamic environment that probably was affected by pumping of nearby irrigation or public-supply wells. During pumping, downward vertical flow of 0.2 to 2.1 gallons per minute that occurred during ambient conditions was either reversed or reduced. During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed. Estimated total transmissivity for four production zones identified from Flow–B numerical model results taken together was calculated to be about 3,100 feet squared per day.

Logs collected in monitoring well PTX06-1044 during ambient conditions before redevelopment indicate a static environment with no flow. During pumping there was upward vertical flow at rates ranging from 0.1 to about 1.5 gallons per minute. During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed. Estimated total transmissivity before redevelopment for five production zones identified from Flow–B numerical model results, and transmissivity values for each zone, are considered to be in error because of the lack of communication between the well and the aquifer before redevelopment. After redevelopment, logs for well PTX06-1044 during ambient conditions indicate a near-static environment with minimal downward flow. During pumping there was upward vertical flow at rates ranging from 0.5 to about 4.8 gallons per minute. During pumping, a gradual trend of more positive flowmeter values with distance up the well was observed. Estimated total transmissivity after redevelopment for the same five identified production zones taken together was calculated to be about 520 feet squared per day.

Logs collected in monitoring well PTX06-1056 during ambient conditions before redevelopment indicate a static environment with no flow. During pumping there was upward vertical flow at rates ranging from 0.3 to about 1.5 gallons per minute. During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed. Estimated total transmissivity before redevelopment for four production zones identified from Flow–B numerical model results taken together was calculated to be about 450 feet squared per day. After redevelopment, logs collected in monitoring well PTX06-1056 during ambient conditions indicate a near-static environment with no flow except for a very small amount of downward flow near the bottom of the well. During pumping there was upward vertical flow at rates ranging from 0.7 to about 2.9 gallons per minute. Estimated total transmissivity after redevelopment for five production zones identified from Flow–B numerical model results taken together was calculated to be about 330 feet squared per day.

Logs collected in monitoring well PTX06-1068 during ambient conditions indicate a static environment with no flow. During pumping there was upward vertical flow at rates ranging from 0.4 to 4.8 gallons per minute. During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed. Estimated total transmissivity for four production zones identified from Flow–B numerical model results taken together was calculated to be about 200 feet squared per day.

Introduction

The Pantex Plant is a U.S. Department of Energy/National Nuclear Security Administration (USDOE/NNSA)-owned, contractor-operated facility managed by Babcock & Wilcox Technical Services Pantex, LLC (B&W Pantex) in Carson County, Tex., approximately 17 miles northeast of Amarillo. The Pantex Plant was originally constructed by the U.S.

Department of Army for production of conventional ordnance during World War II. The Pantex Plant was deactivated after the war and the property reverted to the War Assets Administration. Texas Technological College (now Texas Tech University [TTU], Lubbock) purchased the installation in 1949. The Army Ordnance Corps reclaimed the site in 1951 for use by the Atomic Energy Commission as a nuclear weapons facility. Today (2009) the mission of the Pantex Plant is to assemble nuclear weapons for the Nation’s stockpile; disassemble nuclear weapons being retired from the stockpile; evaluate, repair, and retrofit nuclear weapons in the stockpile; sanitize components from dismantled nuclear weapons; provide interim storage for plutonium pits from dismantled nuclear weapons; and develop, fabricate, and test chemical explosives and explosive components for nuclear weapons to support USDOE/NNSA initiatives (U.S. Department of Energy, 2009). The U.S. Geological Survey (USGS), in cooperation with B&W Pantex through the USDOE/NNSA, made a series of flowmeter measurements and collected other borehole geophysical logs during July–September 2008 to analyze vertical flow in screened intervals of four selected monitoring wells at the Pantex Plant. Hydraulic properties (transmissivity values) of the section of High Plains (Ogallala) aquifer penetrated by the wells also were computed.

Purpose and Scope

The purpose of this report is to analyze vertical flow during ambient and pumped conditions in four monitoring wells at the Pantex Plant in Carson County, Tex., and to document the methods of collection of electromagnetic (EM) flowmeter data and fluid-resistivity, temperature, and natural gamma logs at the Pantex Plant during July–September 2008. The USDOE/NNSA contractor, B&W Pantex, identified the four wells open to the Ogallala aquifer for the analysis. The wells are constructed of 4-inch-diameter stainless steel casing and range in total depth below land-surface datum (LSD) from 475 to 900 feet. Data were collected at various depths below LSD to assess the distribution of flow in screened intervals and compute transmissivity values for the adjacent section of Ogallala aquifer. Transmissivity values were computed using a numerical flow model developed for analysis of flowmeter data.

Description of Study Site

The Pantex Plant main area of operations is bounded on the north by Farm to Market Road (FM) 293, on the east by FM 2373, and on the west by FM 683 (fig. 1). Recently, USDOE/NNSA purchased 1,526 acres of land east of FM 2373 to provide access for ground-water monitoring and positive control over future land and ground-water use (B&W Pantex, writtten commun., 2008). The Pantex Plant site now consists of a total of 17,559 acres, of which 5,856 acres constitutes a safety and security buffer owned by TTU. TTU leases the safety and security buffer property back to USDOE/NNSA; Texas Tech Research Farm manages the buffer zone as rangeland and farmland.

Hydrogeology

The primary subsurface geologic units at the Pantex Plant are the Triassic-age Dockum Group (sand to clay), the Tertiary-age Ogallala Formation (sand to silty sand), and the Quaternary-age Blackwater Draw Formation (clayey silts) (Holliday, 1989). The uppermost of two water-yielding units (aquifers) in the Ogallala Formation at the study site is perched at depths of approximately 200 to 300 feet below LSD. This unit is underlain by a zone of relatively low permeability, informally referred to as the fine-grained zone, which consists of silts and clays that retard the downward migration of perched water. The perched aquifer flows radially and away from beneath a playa lake designated Playa 1 (fig. 2) and ranges in thickness from less than 1 foot near its lateral extent to more than 50 feet near Playa 1.

Figure 1. Location of the Pantex Plant, Carson County, Texas.

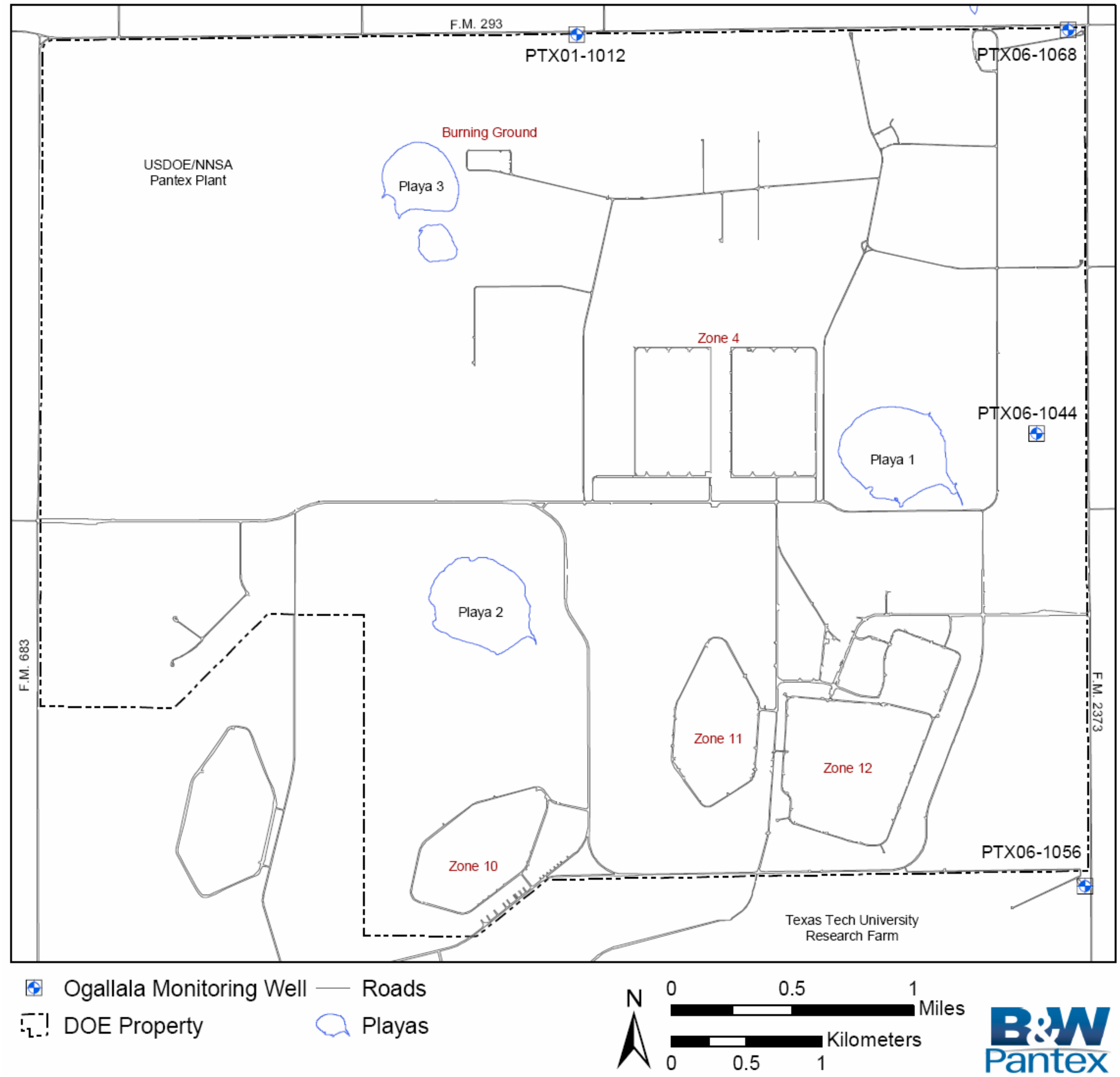

Figure 2. Ogallala aquifer monitoring wells logged with flowmeter at the Pantex Plant, Carson County, Texas.

The second water-yielding unit in the Ogallala Formation, below the fine-grained zone, is the Ogallala aquifer. The Ogallala aquifer is the primary source of drinking and irrigation water for most of the High Plains region in Texas. The Ogallala aquifer generally occurs at depths of approximately 350 to 900 feet below LSD at the study site. Because of regional water-level declines, the upper 150 feet of the aquifer is mostly unsaturated. The water level is about 500 feet below LSD and the saturated part of the aquifer is about 1 to 100 feet thick in the southern part of the Pantex Plant site and about 250 to 400 feet thick in the northern part. The primary flow direction in the Ogallala aquifer at the site is north to northeast.

Acknowledgments

The authors thank Tony Biggs, B&W Pantex, for providing technical information on the wells; and Scott McLaughlin and Ken Nicholson, B&W Pantex, for their many hours setting and operating the pump for the pumping flowmeter measurements.

Methods of Borehole Geophysical Data Collection

The USGS collected borehole geophysical data consisting of vertical flow rates, fluid resistivity/temperature, and natural gamma radiation in the four monitoring wells (PTX01-1012, PTX06-1044, PTX06-1056, and PTX06-1068) (fig. 2; table 1). These data were analyzed to determine the direction and magnitude of vertical flow in the screened intervals and distribution of transmissivity in the adjacent section of the aquifer.

Pertinent information for monitoring wells (well identifier, location, altitude of LSD, total depth, depth to water, total screen length, and number of screened intervals) (table 1) was provided by B&W Pantex. In addition to the logs collected for this study, the Pantex monitoring wells were logged by a contractor at the time of drilling (B&W Pantex, writtten commun., 2008). Among the logs collected at that time were 16- and 64- inch normal resistivity, single-point resistance, spontaneous potential, and natural gamma in wells PTX01-1012, PTX06-1056, and PTX06-1068 and natural gamma and neutron in well PTX06-1044. Selected previously collected logs (normal resistivity and neutron) were digitized for use in this study because only photocopies of the logs were available.

Table 1. Pertinent information for Ogallala aquifer monitoring wells logged at the Pantex Plant, Carson County, Texas, July–September 2008.

USGS site identifier	Pantex well identifier	Location (latitude longitude)	Altitude of land-surface datum (feet above NAVD 88)	Total depth (feet below land-surface datum)	Static depth to water (feet below land-surface datum)	Total screen length (feet)	Number of screened intervals
352111101352301	PTX01-1012	N35 21 11.4 W101 35 22.6	3,572	900	500	380	3
351944101324201	PTX06-1044	N35 19 44 W101 32 42	3,555	613	475	180	2
351806101322901	PTX06-1056	N35 18 06 W101 32 29	3,489	475	393	120	1
352111101323401	PTX06-1068	N35 21 11 W101 32 34	3,519	804	508	325	2

All geophysical probes used in the data collection for this study interfaced to a Century System VI log-acquisition system in the USGS Texas Water Science Center logging unit by way of ¼-inch-diameter four-conductor wireline. The log-acquisition system was interfaced to a personal computer and data storage by way of an Ethernet connection.

Vertical flow rates were measured under ambient and pumped flow conditions in the four monitoring wells. Unusually large drawdowns occurred at two monitoring wells (PTX06-1044 and PTX06-1056) while the wells were pumped at relatively low rates (about 1.5 gallons per minute [gal/min]), which might adversely affect the accuracy of the calculated transmissivity values. Accordingly, a decision was made to redevelop those wells using common methods such as scrubbing the screened interval with tubing-conveyed brushes to loosen fine-grained material in the filter pack and then surging the well to remove the loosened material. Logs were run again after redevelopment during ambient and pumped flow conditions in the two monitoring wells.

B&W Pantex furnished a 3-inch-diameter submersible pump capable of reaching the existing depths to water, which allowed for drawdown at a pumping rate of at least 5 gal/min. The submersible pump was deployed using a Smeal 5T pump hoist rig and 1.5-inch-diameter steel pipe. The pump and hoist rig was operated by B&W Pantex personnel.

Electromagnetic Flowmeter

The EM flowmeter measures the rate and direction of vertical flow in a borehole using the principle of Faraday's Law of Induction. The EM flowmeter probe consists of an electromagnet and two electrodes 180 degrees apart and 90 degrees to the magnetic field inside a hollow cylinder or tube. The voltage induced by a conductor moving at right angles through the magnetic field is directly proportional to the velocity of the conductor (water) through the field (Century Geophysical Corporation, 2006).

Generally, when using the tool to measure low-velocity vertical flow in small-diameter wellbores, rubber diverters are installed around the sensor to direct the water flow through the open tube in the sensor. The diameter of the tube and voltage response is calibrated, and the volume of flow is instantaneously recorded. The direction of vertical water flow is determined by the polarity of the response with upward flow being positive and downward flow being negative.

The flowmeter is placed in the wellbore with a rubber diverter installed to direct the flow through the sensor (fig. 3). Relatively high hydraulic head in a transmissive zone of the aquifer will push the flow from that high-head zone into the wellbore, through the tool in the direction of a transmissive zone of relatively low hydraulic head, to the low-head zone and out of the wellbore.

(A) (B)

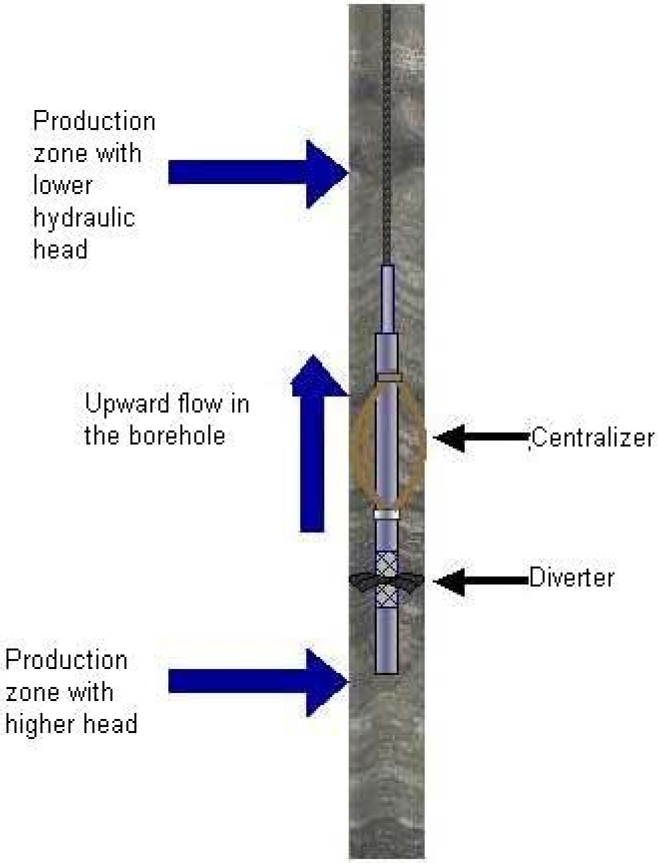

Figure 3. (A) Drawing of flowmeter in borehole showing zones of differing hydraulic head and direction of flow in the borehole, and (B) photograph of Century Model 9721 electromagnetic flowmeter with rubber diverter installed.

Downward flow was calibrated at a rate of 1 gal/min and upward flow was calibrated at a pumped rate in the well, which was between 1.5 and 5 gal/min depending on the well and development status. Flowmeter log data were collected in stationary and trolling conditions for both ambient and pumped conditions. When possible, flowmeter data were collected at the same depths during both ambient and pumped flow conditions.

Fluid Resistivity/Temperature Logs

Fluid resistivity logs provide a record of the capacity of the borehole fluid to conduct electrical current (Keys, 1997). Changes in fluid resistivity are measured by ring electrodes inside a housing that allows borehole fluid to flow through it. The best fluid resistivity logging results are achieved when logging downward into boreholes containing ambient fluid that has had sufficient time to stabilize. Ideally, fluid resistivity logs are the first logs run to record ambient conditions before other probes have passed through the borehole and vertically mixed the borehole fluid. Curve deflections on the fluid resistivity log can indicate horizontal or vertical flow, stratification of borehole fluid, or screen openings in cased wells. Fluid resistivity values also can be used in calculations with other logs.

The fluid resistivity logs collected in this study were converted to fluid conductivity for comparison to specific conductance values of ground water in the area. The fluid conductivity values contained in the logs for this study are the values recorded in the ambient borehole temperature and are not corrected to a standard temperature.

A Century model 8144c multiparameter probe was used to log fluid resistivity and temperature. Calibration of the fluid resistivity logging probes was done with solutions of known conductivity/resistivity in a two-point calibration.

Natural Gamma Logs

Natural gamma logs provide a record of gamma radiation detected at depth in a borehole. Natural gamma radiation can be useful in determining lithologies and contact depths of the strata penetrated by the borehole. Fine-grained sediments that contain abundant clay tend to be more radioactive than quartz-grain sandstones or carbonates (Keys, 1997). The natural gamma log was run in conjunction with the fluid resistivity log and was recorded simultaneously in natural gamma counts per second.

A natural gamma sensor with a sodium iodide detector built into the Century 8144c multiparameter probe was used. The natural gamma probe is calibrated at the factory and does not require calibration in the field. Natural gamma count rates, which commonly will increase in the proximity of clay and shale, could be slightly increased adjacent to any bentonite seals in the wells.

Analysis of Vertical Flow

Flowmeter and fluid resistivity/temperature data were analyzed by (1) plotting the logs with existing pertinent information such as other geophysical logs and casing and well-construction records provided by B&W Pantex, (2) evaluating the flowmeter data to identify potential zones of fluid movement to or from the wellbore and the magnitude and direction of vertical flow, (3) evaluating the flowmeter data with the USGS Flow–B numerical model (Paillet, 2000) to compute total transmissivity and distribution of transmissivity and head (as depth to water) in the screened intervals, and (4) plotting the transmissivity and head values on the logs.

The Flow–B numerical model of Paillet (2000) is a computer program developed for analysis of flowmeter data. The model gives estimates of transmissivities and hydraulic heads of two or more water-producing (flow) zones intersecting a single interval of open borehole under typical field conditions. Zone transmissivity and hydraulic head are obtained by running the model in a series of iterations in which transmissivity and head values are adjusted by trial-and-error to develop a best-fit match between simulated and measured borehole flows. The output data from the numerical model are in appendix 1.

Monitoring Well PTX01-1012

Monitoring well PTX01-1012 was constructed by Stewart Brothers Drilling Company near the northern Pantex Plant property boundary (fig. 2) on April 28, 2000. The well was drilled 7.9 inches in diameter to a total depth of 903 feet below LSD and constructed of schedule 10, 4-inch-diameter stainless steel casing and screened to 900 feet below LSD. The well has slotted screen openings of 0.010 inch in the following intervals: 460–640 feet, 660–720 feet, and 755–895 feet below LSD. Well records indicate that 8-16 sieve-size silica sand filter pack material is in the annular space of the screened intervals, and bentonite seal is in the annular space above each screened interval. Static water level (depth to water) was about 500 feet below LSD on the day of logging.

Data Collected

The USGS collected EM flowmeter, fluid resistivity, temperature, and natural gamma measurements on August 13, 2008. Flowmeter measurements were collected in trolling and stationary modes during ambient and pumped conditions. Thirty-six stationary measurements were collected during ambient conditions, and 32 stationary measurements were collected during pumped conditions. The well was logged during pumped conditions on the same day the well was logged during ambient conditions. The pump was set at about 520 feet below LSD and discharged about 5.5 gal/min at the surface, which created a constant drawdown of about 2 feet.

Flow during Ambient and Pumped Conditions

Logs collected in monitoring well PTX01-1012 during ambient conditions (fig. 4) indicate a dynamic environment that probably was affected by pumping of nearby irrigation or public-supply wells. Downward flow ranging from 0.2 to 2.1 gal/min indicates a lower hydraulic head in the interval below 750 feet below LSD. The highest rate of ambient flow was measured at the stations in the casing between screened intervals (725–750 and 645–655 feet below LSD) that contained a bentonite seal in the annular space. The screened intervals below 650 feet below LSD are losing flow from the wellbore to the aquifer. In contrast, the screened interval above 650 feet below LSD appears to be gaining downward flow from the aquifer into the wellbore. This lower hydraulic head observed below 650 below LSD during ambient conditions probably is caused by nearby pumping.

During pumping, downward vertical flow during ambient conditions was either reversed or reduced. At depths from 700 to 850 feet below LSD, vertical flow that was downward during ambient conditions was reduced, and at depths from 575 to 695 feet below LSD, downward ambient flow was reversed to upward as a result of the pumping.

Ambient and pumped flowmeter values were entered into the Flow–B numerical model, as well as other data such as static water level, drawdown, and well diameter. The flowmeter values were plotted in Flow–B (appendix 1.1) and visually evaluated for fluctuations in the data that might indicate individual flow (production) zones. In well PTX01-1012, the flow zones were defined as originating below the following depths below LSD: 600, 650, 750, and 810 feet. Measurements at depths 650 and 750 feet below LSD correspond to cased intervals (hereinafter referred to as blanks) between the sealed screened intervals and show greater differences between ambient and pumped flowmeter values. Greater differences between ambient and pumped flowmeter values in the blanks probably is a result of a better seal of the flow diverter on the flowmeter to the smooth surface of the casing in the blank section and the bentonite seal in the annular space more efficiently funneling flow through the flowmeter sensor. The static depth to water for each of the production zones was computed:

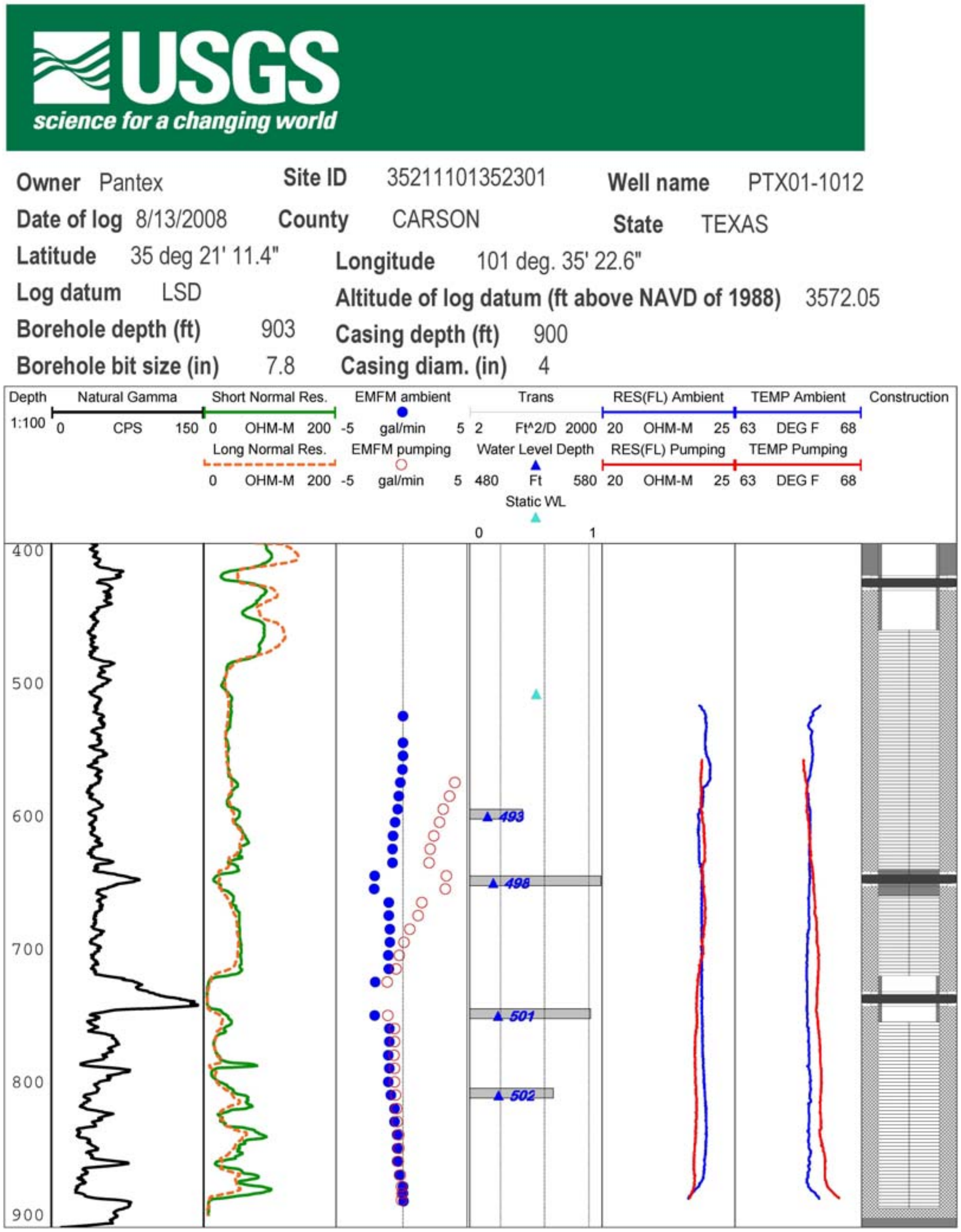

Figure 4. Borehole geophysical logs plotted with calculated transmissivity and well construction in screened intervals of monitoring well PTX01-1012 at the Pantex Plant, Carson County, Texas. [CPS, counts per second; OHM-M, ohm-meters; EMFM, electromagnetic flowmeter; gal/min, gallons per minute; Trans, transmissivity; Ft^2/D, feet squared per day; Ft, foot or feet; RES(FL), fluid resistivity; TEMP, temperature; DEG F, degrees Fahrenheit; WL, depth to water from land-surface datum]

Zone 600–650 feet below LSD, 493 feet.

Zone 650–750 feet below LSD, 498 feet.

Zone 750–810 feet below LSD, 501 feet.

Zone 810–900 feet below LSD, 502 feet.

These calculated depths indicate hydraulic head was several feet lower in the lower three zones than the static head for the entire water column (500 feet below LSD), probably caused by nearby irrigation or public-supply well pumping at times during the flowmeter measurements.

During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed from about 715 to 575 feet below LSD, with fluctuations at the blanks between sealed screened intervals (fig. 4; appendix 1.1).

Estimated total transmissivity was calculated to be about 3,100 feet squared per day (ft^2/d) and is distributed among the production zones as indicated:

Zone 600–650 feet below LSD about 1 percent of the estimated transmissivity (31 ft^2/d).

Zone 650–750 feet below LSD about 60 percent of the estimated transmissivity (1,860 ft^2/d).

Zone 750–810 feet below LSD about 34 percent of the estimated transmissivity (1,054 ft^2/d).

Zone 810–900 feet below LSD about 5 percent of the estimated transmissivity (155 ft^2/d).

The zone of highest transmissivity (650–750 feet below LSD) corresponds with a sand unit at about 650–715 below LSD with reduced gamma counts per second and increased resistivity, which indicate decreased clay content and greater sand content.

Monitoring Well PTX06-1044

Monitoring well PTX06-1044 was constructed by the Water Development Corporation near the eastern Pantex Plant property boundary (fig. 2) during August 13–27, 1999. The well was drilled 7.9 inches in diameter to a total depth of 622 feet below LSD and constructed of schedule 10, 4-inch-diameter stainless steel casing and screened to 613 feet below LSD. The well has slotted screen openings of 0.020 inch in the following intervals: 393–493 and 533–613 feet below LSD. Well records indicate that 8-16 sieve-size silica sand filter pack material is in the annular space at 373–622 feet below LSD. Static water level was about 475 to 479 feet below LSD on the days of logging.

Data Collected

The USGS collected EM flowmeter, fluid resistivity, temperature, and natural gamma measurements on July 25, August 11, and September 24, 2008. Ambient logs were collected July 25, 2008, and pumping logs were collected August 11, 2008, because muddy conditions delayed access to the well. Ambient measurements were rechecked on August 11, 2008, to confirm ambient conditions had not changed. Flowmeter measurements were collected in trolling and stationary modes during ambient and pumped conditions. Fourteen stationary measurements were collected during ambient conditions on July 25, 2008, and 11 stationary measurements were collected while pumping 1.5 gal/min on August 11, 2008.

The pump was set at about 511 feet below LSD. The unusually low well yield of 1.5 gal/min resulted in 30 feet of drawdown. To improve well yield and reduce drawdown, the well screens were cleaned, and the well was redeveloped by B&W Pantex and subsequently logged again by the USGS with an EM flowmeter on September 24, 2008. After redevelopment, the pump was set at about 500 feet below LSD. Thirteen stationary measurements were collected during ambient conditions, and 11 stationary measurements were collected while pumping 5 gal/min. The drawdown observed while pumping 5 gal/min after redevelopment was about 17 feet, considerably less than the 30 feet of drawdown before redevelopment while pumping 1.5 gal/min.

Flow during Ambient and Pumped Flow Conditions before Redevelopment

Logs collected in monitoring well PTX06-1044 during ambient conditions before redevelopment July 25, 2008 (fig. 5), indicate a static environment with no flow. This lack of flow during ambient conditions indicates generally uniform hydraulic heads throughout the screened intervals; however in this case, results obtained after redevelopment indicate that screened intervals were not allowing adequate flow to enter the wellbore during ambient conditions before redevelopment.

During pumping there was upward vertical flow at rates ranging from 0.1 to about 1.5 gal/min. Upward vertical flow occurred at 590 to 542 below LSD, with most of the flow entering the well at depths below 570 feet below LSD.

Ambient and pumped flowmeter values were entered into the Flow–B numerical model, as well as other data such as static water level, drawdown, and well diameter. The flowmeter values were plotted in Flow–B (appendix 1.2) and visually evaluated for fluctuations in the data that might indicate individual flow zones. To discretize the numerical model with consistent flow zones, the flowmeter logs collected after redevelopment were ultimately used for the selection of flow zones, which facilitated a detailed analysis of the flow distribution. The flow zones were defined as originating below the following depths below LSD: 495, 530, 555, 570, and 590 feet. The depth to static water level for each zone was about 475 feet below LSD, about the same as depth to the static water level for the entire water column (475–479 feet below LSD).

During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed from about 590 to 542 feet below LSD (fig. 5; appendix 1.2).

Estimated total transmissivity before redevelopment was calculated to be about 95 ft^2/d and is distributed among the production zones as indicated:

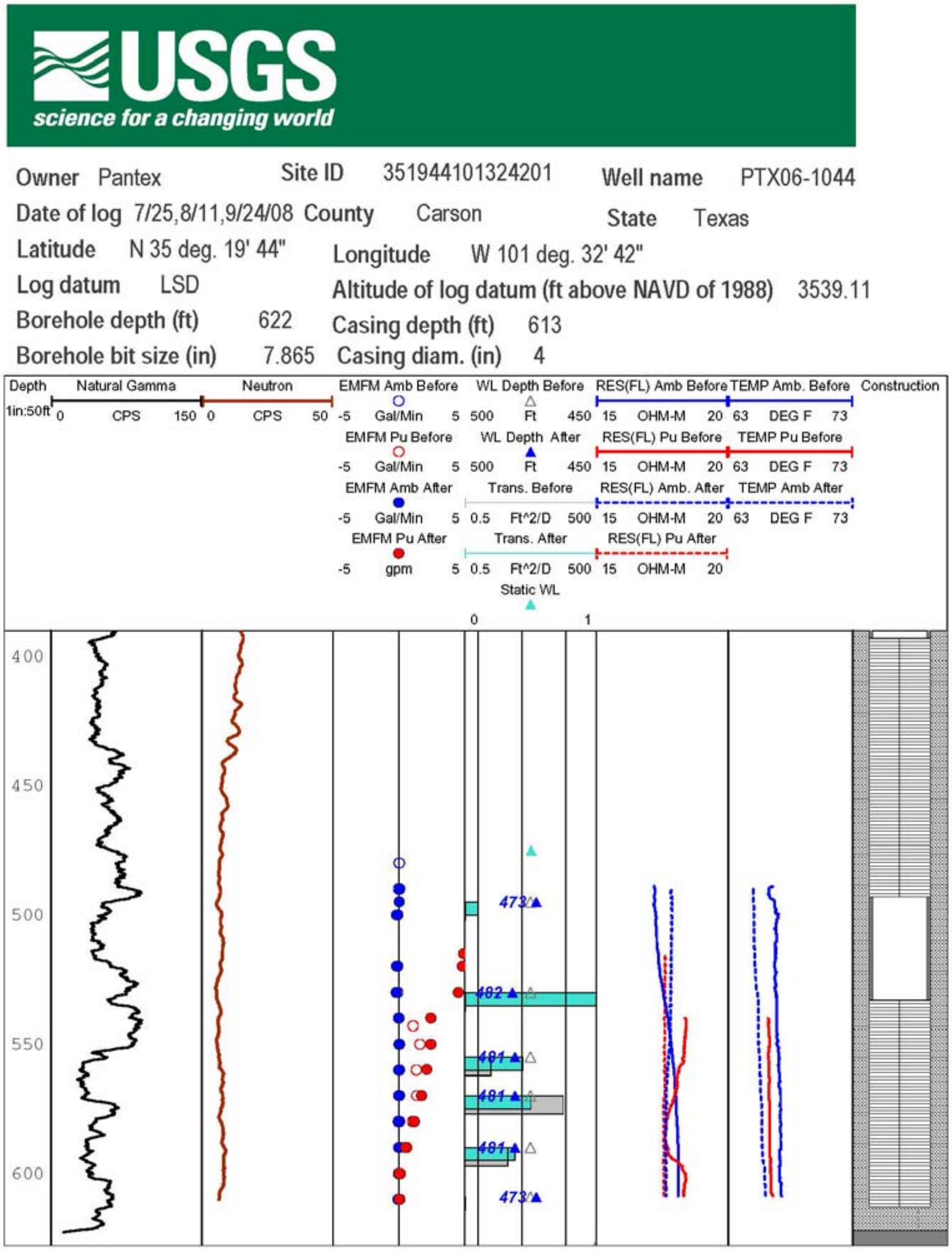

Figure 5. Borehole geophysical logs plotted with calculated transmissivity and well construction in screened intervals of monitoring well PTX06-1044 at the Pantex Plant, Carson County, Texas. [CPS, counts per second; OHM-M, ohm-meters; EMFM, electromagnetic flowmeter; Amb, ambient; Pu, pumping; Before, before redevelopment; After, after redevelopment; Gal/min, gallons per minute; Trans, transmissivity; Ft^2/D, feet squared per day; Ft, foot or feet; RES(FL), fluid resistivity; TEMP, temperature; DEG F, degrees Fahrenheit; WL, depth to water from land-surface datum]

Zone 495–530 feet below LSD none of the estimated transmissivity.

Zone 530–555 feet below LSD about 0.5 percent of the estimated transmissivity (less than 1 ft^2/d).

Zone 555–570 feet below LSD about 2 percent of the estimated transmissivity (2 ft^2/d).

Zone 570–590 feet below LSD about 92.5 percent of the estimated transmissivity (88 ft^2/d).

Zone 590–609 feet below LSD about 5 percent of the estimated transmissivity (5 ft^2/d).

The zone of highest transmissivity (570–590 feet below LSD) corresponds with a sand unit 577–603 feet below LSD. However, these transmissivity values are considered to be in error because of the lack of communication between the well and the aquifer before redevelopment. The hydraulic properties listed here are for documentation of results only.

Flow during Ambient and Pumped Flow Conditions after Redevelopment

Logs collected in monitoring well PTX06-1044 during ambient conditions after redevelopment September 24, 2008 (fig. 5; appendix 1.3), indicate a near-static environment with minimal downward flow (-0.17 gal/min) from about 495 to 530 feet below LSD. This very low downward flow during ambient conditions indicates lower hydraulic head (compared to static water level) at the bottom of the zone (530 feet below LSD). No flow is apparent elsewhere in the well, indicating essentially uniform hydraulic head throughout the screened intervals; however, the lower hydraulic head at 530 feet below LSD must be maintained to the bottommost zone of production to prevent upward flow from occurring.

During pumping there was upward vertical flow at rates ranging from 0.5 to about 4.8 gal/min. Upward vertical flow occurred at 590 to 514 feet below LSD, with most of the flow entering the well at depths between 529 and 539 feet below LSD.

Ambient and pumped flowmeter values were entered into the Flow–B numerical model (appendix 1.3), as well as other data such as static water level, drawdown, and well diameter, as before redevelopment. The flow zones defined were the same as those defined before redevelopment, originating below the following depths below LSD: 495, 530, 555, 570, and 590 feet. The static depth to water for each of the production zones was computed:

Zone 495–530 feet below LSD, 473 feet.

Zone 530–555 feet below LSD, 482 feet.

Zone 555–570 feet below LSD, 481 feet.

Zone 570–590 feet below LSD, 481 feet.

Zone 590–609 feet below LSD, 481 feet.

These calculated depths indicate hydraulic head was 8 to 9 feet lower in the zones of production from 530 to 609 feet below LSD than the hydraulic head for the entire water column, probably caused by nearby wells pumping at times during the flowmeter measurements.

During pumping, a gradual trend of more positive flowmeter values (upward flow of 0.5 to 2.4 gal/min) with distance up the well was observed from about 590 to 540 feet below LSD. A large increase in upward flow occurred between 540 and 530 feet below LSD indicating the most productive zone between those depths (fig. 5; appendix 1.3).

Estimated total transmissivity after redevelopment was calculated to be about 520 ft^2/d and is distributed among the production zones as indicated:

Zone 495–530 feet below LSD less than 1 percent of the estimated transmissivity (1 ft^2/d).

Zone 530–555 feet below LSD about 93.5 percent of the estimated transmissivity (486 ft^2/d).

Zone 555–570 feet below LSD about 2 percent of the estimated transmissivity (10 ft^2/d).

Zone 570–590 feet below LSD about 3 percent of the estimated transmissivity (16 ft^2/d).

Zone 590–609 feet below LSD about 1 percent of the estimated transmissivity (7 ft^2/d).

The zone of highest transmissivity (530–555 feet below LSD) corresponds with a thin sand unit with somewhat higher natural gamma counts, which indicates moderate clay content, less sand content, and likely lower permeability than other units. The noted increase in flow entering the well at depths between 529 and 539 feet below LSD (fig. 5) could be attributed to the blank section of casing improving the seal of the flowmeter diverter thus forcing more fluid to enter the sensor in that range. If this is the case, the large computed percentage of flow in the zone 530–555 feet below LSD likely is more indicative of the transmissivity of the entire lower screened section below 530 feet below LSD.

Monitoring Well PTX06-1056

Monitoring well PTX06-1056 was constructed by Stewart Brothers Drilling near the southeastern corner of the Pantex Plant property boundary (fig.2) on May 15, 2000. The well was drilled 7.9 inches in diameter to a total depth of 500 feet below LSD and constructed of schedule 10, 4-inch-diameter stainless steel casing and screened to 475 feet below LSD. The well has slotted screen openings of 0.020 inch in the interval 350–470 feet below LSD. Well records indicate that 8-16 sieve-size silica sand filter pack material is in the annular space at 328–622 feet below LSD. Static water level was about 392 to 393 feet below LSD on the days of logging.

Data Collected

The USGS collected EM flowmeter, fluid resistivity, temperature, and natural gamma measurements on July 23, August 14, and September 23–24, 2008. Ambient logs were collected July 23, 2008, and pumping logs were collected August 14, 2008, because muddy conditions delayed access to the well. Ambient measurements were rechecked on August 14, 2008, to confirm ambient conditions had not changed. Flowmeter measurements were collected in trolling and stationary modes during ambient and pumped conditions. Sixteen stationary measurements were collected during ambient conditions on July 23, 2008, and 11 stationary measurements were collected while pumping 1.5 gal/min on August 14, 2008 (appendix 1.4; fig. 6).

The pump was set at about 403 feet below LSD. The unusually low well yield of 1.5 gal/min resulted in a constant drawdown of about 7.6 feet. To improve well yield and reduce drawdown, the well screen was cleaned, and the well was redeveloped by B&W Pantex and subsequently logged again by the USGS with an EM flowmeter on September 23, 2008. After redevelopment, the pump was set at about 412 feet below LSD. Sixteen stationary measurements were collected during ambient conditions, and 12 stationary measurements were collected while pumping 3 gal/min (appendix 1.5; fig. 6). The drawdown observed while pumping 3 gal/min after redevelopment was about 13.5 feet, substantially larger than the 7.6 feet of drawdown before redevelopment while pumping 1.5 gal/min.

Flow during Ambient and Pumped Flow Conditions before Redevelopment

Logs collected in monitoring well PTX06-1056 during ambient conditions before redevelopment July 23, 2008 (fig. 6), indicate a static environment with no flow. The lack of flow during ambient conditions generally indicates uniform hydraulic heads throughout the screened interval.

During pumping there was upward vertical flow at rates ranging from 0.3 to about 1.5 gal/min. Upward vertical flow occurred at 423 to 456 below LSD, with most of the flow entering the well at depths below 450 feet below LSD.

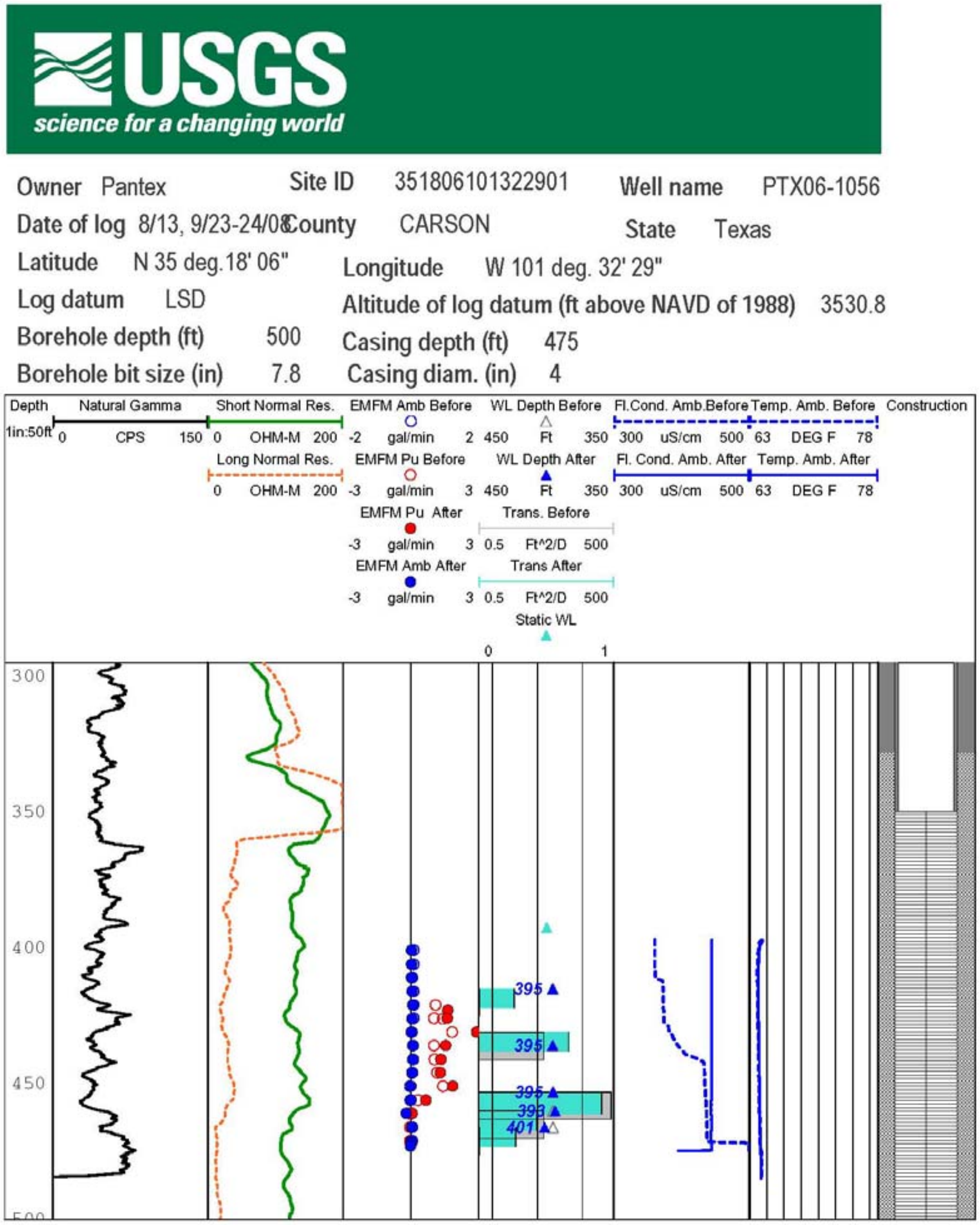

Figure 6. Borehole geophysical logs plotted with calculated transmissivity and well construction in screened interval of monitoring well PTX06-1056 at the Pantex Plant, Carson County, Texas. [CPS, counts per second; OHM-M, ohm-meters; EMFM, electromagnetic flowmeter; Amb, ambient; Pu, pumping; Before, before redevelopment; After, after redevelopment; Gal/min, gallons per minute; Trans, transmissivity; Ft^2/D, feet squared per day; Ft, foot or feet; Fl. Cond., Fluid Conductivity at well; uS/cm, microsiemens per centimeter; Temp, temperature; DEG F, degrees Fahrenheit; WL, depth to water from land-surface datum]

Ambient and pumped flowmeter values were entered into the Flow–B numerical model, as well as other data such as static water level, drawdown, and well diameter. The flowmeter values were plotted in Flow–B (appendix 1.4) and were visually evaluated for fluctuations that might indicate individual flow zones. To discretize the numerical model with consistent flow zones, the flowmeter logs collected after redevelopment were ultimately used for the selection of flow zones, which facilitated a detailed analysis of the flow distribution. The flow zones were defined as originating below the following depths below LSD: 415, 431, 453, and 460 feet. The static depths to water for the production zones were the same as the static depth to water for the entire water column (about 392 feet below LSD).

During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed from about 455 to 432 feet below LSD. The upward flow results from an apparent increase in flow below 450 feet below LSD and remains relatively constant through the uppermost measurement at 423 feet below LSD (fig. 6; appendix 1.4). Increased upward flows are observed at 431 and 451 feet below LSD, depths in the well that could correspond to decreased inside diameter at the threaded connections of screen sections, which likely improve the diverter seal on the flowmeter sensor to the casing.

Estimated total transmissivity before redevelopment was calculated to be about 450 ft^2/d and is distributed among the production zones as indicated:

Zone 415–431 feet below LSD none of the estimated transmissivity.

Zone 431–453 feet below LSD about 2.5 percent of the estimated transmissivity (13 ft^2/d).

Zone 453–460 feet below LSD about 95 percent of the estimated transmissivity (427 ft^2/d).

Zone 460–466 feet below LSD about 2.5 percent of the estimated transmissivity (13 ft^2/d).

The zone of highest transmissivity (453–460 feet below LSD) corresponds with a sand unit 443–460 feet below LSD with somewhat decreased natural gamma counts (fig. 6), which indicates less clay content and more sand content.

Flow during Ambient and Pumped Flow Conditions after Redevelopment

Logs collected in monitoring well PTX06-1056 during ambient conditions after redevelopment September 23, 2008 (fig. 6; appendix 1.5) indicate a near-static environment with no flow from about 401 to 456 feet below LSD. This lack of flow during ambient conditions indicates generally uniform hydraulic heads throughout the section of screened interval above 456 feet below LSD. A very small amount of downward flow occurred during ambient conditions at 461 feet below LSD, which indicates lower hydraulic head at the bottom of the zone (466 feet below LSD).

During pumping there was upward vertical flow at rates ranging from 0.7 to about 2.9 gal/min. Upward vertical flow occurred at 456 to 423 below LSD, with most of the flow entering the well at depths between 456 and 451 feet below LSD.

Ambient and pumped flowmeter values were entered into the Flow–B numerical model (appendix 1.5), as well as other data such as static water level, drawdown, and well diameter, as before redevelopment. The flow zones were defined as originating below the following depths below LSD: 415, 431, 453, 460, and 466 feet. The static depth to water for each of the production zones was computed:

Zone 415–431 feet below LSD, 395 feet.
Zone 431–453 feet below LSD, 395 feet.
Zone 453–460 feet below LSD, 395 feet.
Zone 460–466 feet below LSD, 393 feet.
Zone 466–475 feet below LSD, 401 feet.

These calculated depths indicate a 2- to 3-foot decrease in hydraulic head in the zones 415–460 feet below LSD and about an 8-foot decrease in hydraulic head in the zone 466–475 feet below LSD relative to the hydraulic head for the entire water column (392–393 feet below LSD). Similar to the other wells, the head decreases likely are caused by nearby irrigation or supply wells pumping during the flowmeter measurements.

During pumping, a sharp increase in positive flowmeter values (upward flow) ranging from 0.7 to 1.85 gal/min occurred from about 456 to 451 feet below LSD and indicates a zone of dominant inflow. This upward flow continues up the well, decreases in magnitude somewhat from 446 to 436 feet below LSD, then increases again between 436 and 431 feet below LSD indicating another productive zone between those depths (fig. 6; appendix 1.5).

Estimated total transmissivity after redevelopment was calculated to be about 330 ft^2/d—slightly lower than before redevelopment (450 ft^2/d)—and is distributed among the production zones as indicated:

Zone 415–431 feet below LSD about 1 percent of the estimated transmissivity (3 ft^2/d).

Zone 431–453 feet below LSD about 15 percent of the estimated transmissivity (50 ft^2/d).

Zone 453–460 feet below LSD about 80 percent of the estimated transmissivity (264 ft^2/d).

Zone 460–466 feet below LSD about 3 percent of the estimated transmissivity (10 ft^2/d).

Zone 466–475 feet below LSD about 1 percent of the estimated transmissivity (3 ft^2/d).

The zone of highest transmissivity (453–460 feet below LSD) corresponds with a sand unit 443–460 feet below LSD with somewhat decreased natural gamma counts (fig. 6), which indicates less clay content and more sand content. Redevelopment resulted in the percentage of total transmissivity accounted for by this zone to decrease from 95 to 85 percent. The percentage of transmissivity of the zone accounting for the second-highest percentage of transmissivity (431–

453 feet below LSD) increased from about 2.5 percent of the total transmissivity (about 13 ft^2/d) before redevelopment to about 15 percent of the total transmissivity (about 50 ft^2/d) after redevelopment. This redistribution of transmissivity is related not only to the redevelopment but also to the amount of stress on the well. Drawdown in this well increased from 7.6 feet while pumping at 1.5 gal/min before redevelopment to 13.5 feet while pumping at 3 gal/min. The larger pumping stress caused a redistribution of flow that resulted in more drawdown, which caused the model to calculate a lower total transmissivity.

Monitoring Well PTX06-1068

Monitoring well PTX06-1068 was constructed by Layne Christensen near the northeast corner of the Pantex property boundary (fig. 2) during May 1–5, 2001. The well was drilled 8 inches in diameter to a total depth of 805 feet below LSD and constructed of schedule 10, 4-inch diameter stainless steel casing and screened to 804 feet below LSD. The well has slotted screen openings of 0.010 inch in the following intervals: 454–754 and 774–799 feet below LSD. Well records indicate that 10-20 sieve-size silica sand filter pack material is in the annular space of the screened intervals, and bentonite seal is in the annular space above each screened interval. Static water level was about 508 feet below LSD on the days of logging.

Data Collected

The USGS collected EM flowmeter, fluid resistivity, temperature, and natural gamma measurements on July 23, 2008, and August 12, 2008. Flowmeter measurements were collected in trolling and stationary modes during ambient and pumped conditions. Thirty stationary measurements were collected during ambient conditions, and 27 stationary measurements were collected during pumped conditions. The well was logged during pumped conditions on August

12, 2008, because muddy conditions delayed access to the well. The pump was set at about 531 feet below LSD and discharged about 4.5 gal/min at the surface, which created a constant drawdown of about 10 feet.

Flow during Ambient and Pumped Conditions

Logs collected in monitoring well PTX06-1068 on July 23, 2008, during ambient conditions indicate a static environment with no flow (fig. 7; appendix 1.6). The lack of flow during ambient conditions indicates generally uniform hydraulic heads throughout the screened interval with no influence from nearby pumping wells.

During pumping there was upward vertical flow at rates ranging from 0.4 to 4.8 gal/min. Ambient and pumped flowmeter values were entered into the Flow–B numerical model, as well as other data such as static water level, drawdown, and well diameter. The flowmeter values were plotted in Flow–B (appendix 1.6) and were visually evaluated for fluctuations in the data that might indicate individual flow zones. In this well, the flow zones were defined as originating below the following depths below LSD: 565, 650, 775, and 789 feet. Measurements at depths of 775 and 789 feet below LSD correspond to measurements collected at blank intervals at the threaded parts of screened intervals and show the greatest relative difference between ambient and pumped flowmeter values. This is probably a result of a better seal of the flow diverter on the flowmeter to the smooth surface of the casing blank section and more efficient funneling of flow through the flowmeter sensor. The static depths to water for the production zones were the same as static depth to water for the entire water column (about 508 feet below LSD).

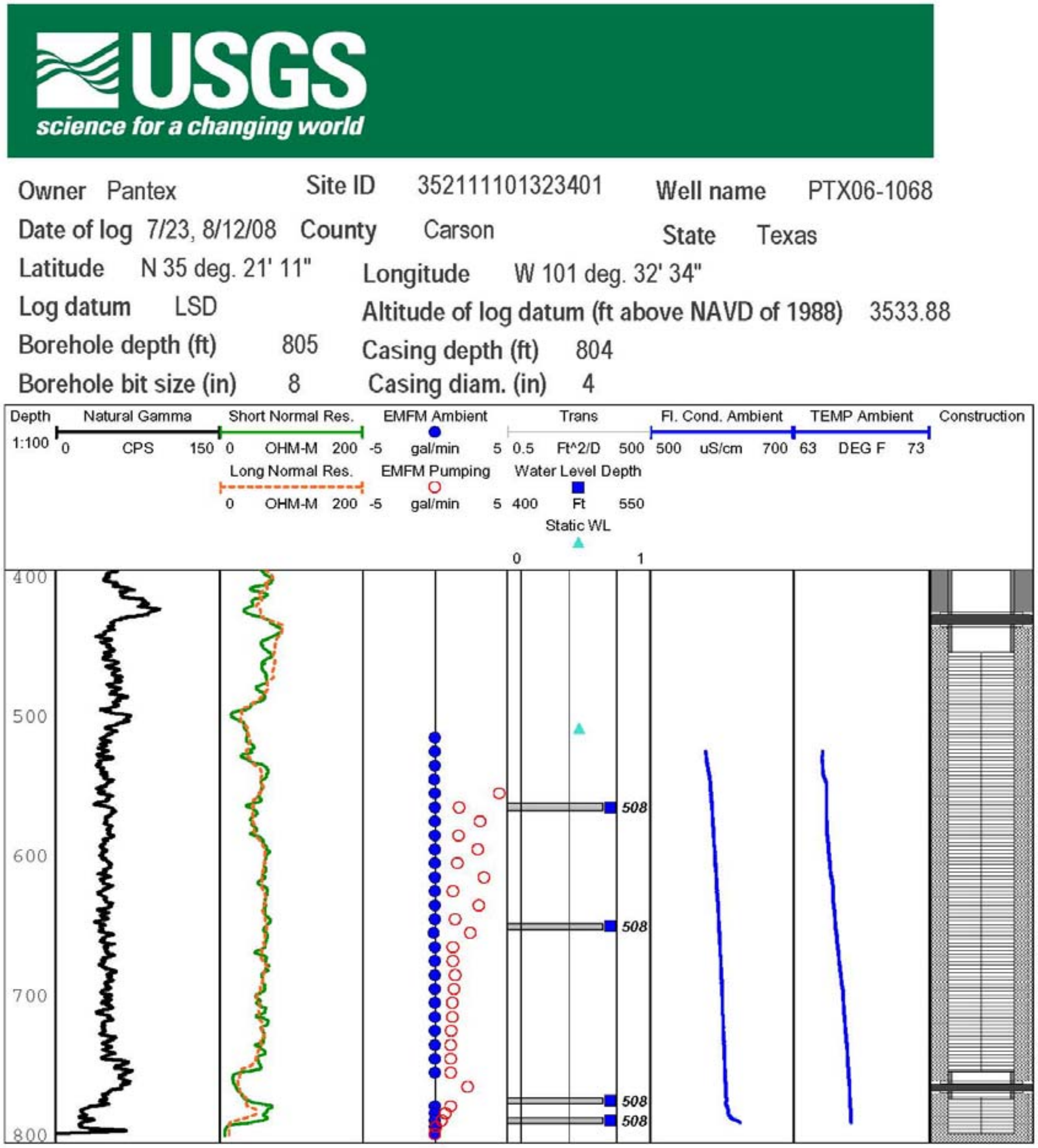

Figure 7. Borehole geophysical logs plotted with calculated transmissivity and well construction in screened interval of monitoring well PTX06-1068 at the Pantex Plant, Carson County, Texas. [CPS, counts per second; Res., resistivity; OHM-M, ohm-meters; EMFM, electromagnetic flowmeter; gal/min, gallons per minute; Trans, transmissivity; Ft^2/D, feet squared per day; Ft, foot or feet; Fl. Cond., fluid conductivity at well temperature; uS/cm, microsiemens per centimeter; Temp, temperature; DEG F, degrees Fahrenheit; WL, depth to water from land-surface datum]

During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed from about 789 to 765 feet below LSD, with the highest values at the blanks between sealed screened intervals (fig. 7; appendix 1.6). Flowmeter values between 555 and 655 feet below LSD appear to alternate between relatively high and low flow values with highest values every 20 feet. This likely is an artifact of well construction. The screen sections have a threaded connection every 20 feet, and there is a better seal with the diverter in the threaded (smaller diameter) part of the screen sections. The higher flowmeter values were used in the numerical model.

Estimated total transmissivity was calculated to be about 200 ft^2/d and is evenly distributed among the production zones as indicated:

Zone 565–650 feet below LSD about 25 percent of the estimated transmissivity (50 ft^2/d).

Zone 650–775 feet below LSD about 25 percent of the estimated transmissivity (50 ft^2/d).

Zone 775–789 feet below LSD about 25 percent of the estimated transmissivity (50 ft^2/d).

Zone 789–804 feet below LSD about 25 percent of the estimated transmissivity (50 ft^2/d).

Summary

The Pantex Plant is a U.S. Department of Energy/National Nuclear Security Administration (USDOE/NNSA)-owned, contractor-operated facility managed by Babcock & Wilcox Technical Services Pantex, LLC (B&W Pantex) in Carson County, Tex., approximately 17 miles northeast of Amarillo. The U.S. Geological Survey (USGS), in cooperation with B&W Pantex through the USDOE/NNSA, made a series of flowmeter measurements and collected other borehole geophysical logs during July–September 2008 to analyze vertical flow in screened intervals of four selected monitoring wells at the Pantex Plant. Hydraulic properties (transmissivity values) of the section of High Plains (Ogallala) aquifer penetrated by the wells also were computed.

The USGS collected borehole geophysical data consisting of vertical flow rates, fluid resistivity/temperature, and natural gamma radiation in the four monitoring wells (PTX01-1012, PTX06-1044, PTX06-1056, and PTX06-1068). Vertical flow rates were measured under ambient and pumped flow conditions in the four monitoring wells. Unusually large drawdowns occurred at two monitoring wells (PTX06-1044 and PTX06-1056) while the wells were pumped at relatively low rates (about 1.5 gal/min), which might adversely affect the accuracy of the calculated transmissivity values. Accordingly, a decision was made to redevelop those wells. Logs were run again after redevelopment during ambient and pumped flow conditions in the two monitoring wells.

Flowmeter and fluid resistivity/temperature data were analyzed by (1) plotting the logs with existing pertinent information such as other geophysical logs and casing and well-construction records provided by B&W Pantex, (2) evaluating the flowmeter data to identify potential zones of fluid movement to or from the wellbore and the magnitude and direction of vertical flow, (3) evaluating the flowmeter data with the USGS Flow–B numerical model to compute total transmissivity and distribution of transmissivity and head (as depth to water) in the screened intervals, and (4) plotting the transmissivity and head values on the logs.

Logs collected in monitoring well PTX01-1012 during ambient conditions indicate a dynamic environment that probably was affected by pumping of nearby irrigation or public-supply wells. Downward flow ranged from 0.2 to 2.1 gal/min. During pumping, downward vertical flow that occurred during ambient conditions was either reversed or reduced. The flow (production) zones in the well were defined from Flow–B numerical model results as originating below the following depths below LSD: 600, 650, 750, and 810 feet. During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed from about 715 to 575 feet below LSD. Estimated total transmissivity for the four identified production zones taken together was calculated to be about 3,100 ft^2/d. The zone of highest transmissivity (1,860 ft^2/d) corresponds with a sand unit at about 650–715 below LSD.

Logs collected in monitoring well PTX06-1044 during ambient conditions before redevelopment indicate a static environment with no flow. During pumping there was upward vertical flow at rates ranging from 0.1 to about 1.5 gal/min. The flow zones in the well were defined from Flow–B numerical model results as originating below the following depths below LSD: 495, 530, 555, 570, and 590 feet. During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed from about 590 to 542 feet below LSD. Estimated total transmissivity before redevelopment for the five identified production zones taken together was calculated to be about 95 ft^2/d; but this and associated transmissivity values for the individual zones are considered to be in error because of the lack of communication between the well and the aquifer before redevelopment.

Logs collected in monitoring well PTX06-1044 during ambient conditions after redevelopment indicate a near-static environment with minimal downward flow (-0.17 gal/min). During pumping there was upward vertical flow at rates ranging from 0.5 to about 4.8 gal/min. The flow zones defined from Flow–B numerical model results were the same as those defined before redevelopment. During pumping, a gradual trend of more positive flowmeter values (upward flow of 0.5 to 2.4 gal/min) with distance up the well was observed from about 590 to 540 feet below LSD. A large increase in upward flow occurred between 540 and 530 feet below LSD indicating the most productive zone between those depths. Estimated total transmissivity after redevelopment for the five identified production zones taken together was calculated to be about 520 ft^2/d. The zone of highest transmissivity (486 ft^2/d) corresponds with a thin sand unit.

Logs collected in monitoring well PTX06-1056 during ambient conditions before redevelopment indicate a static environment with no flow. During pumping there was upward vertical flow at rates ranging from 0.3 to about 1.5 gal/min. The flow zones in the well were defined from Flow–B numerical model results as originating below the following depths below LSD: 415, 431, 453, and 460 feet. During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed from about 455 to 432 feet below LSD. Estimated total transmissivity before redevelopment for the four identified production zones taken together was calculated to be about 450 ft^2/d. The zone of highest transmissivity (427 ft^2/d) corresponds with a sand unit 443–460 feet below LSD.

Logs collected in monitoring well PTX06-1056 during ambient conditions after redevelopment indicate a near-static environment with no flow from about 401 to 456 feet below LSD. A very small amount of downward flow occurred during ambient conditions at 461 feet below LSD. During pumping there was upward vertical flow at rates ranging from 0.7 to about 2.9 gal/min. The flow zones in the well were defined from Flow–B numerical model results as originating below the following depths below LSD: 415, 431, 453, 460, and 466 feet. During pumping, a sharp increase in positive flowmeter values (upward flow) ranging from 0.7 to 1.85 gal/min occurred from about 456 to 451 feet below LSD and indicates a zone of dominant inflow. Estimated total transmissivity after redevelopment for the five identified production zones taken together was calculated to be about 330 ft^2/d. The zone of highest transmissivity (264 ft^2/d) corresponds with a sand unit 443–460 feet below LSD.

Logs collected in monitoring well PTX06-1068 during ambient conditions indicate a static environment with no flow. During pumping there was upward vertical flow at rates ranging from 0.4 to 4.8 gal/min. The flow zones in the well were defined from Flow–B numerical model results as originating below the following depths below LSD: 565, 650, 775, and 789 feet. During pumping, a gradual trend of more positive flowmeter values (upward flow) with distance up the well was observed from about 789 to 765 feet below LSD. Estimated total transmissivity for the four identified production zones taken together was calculated to be about 200 ft^2/d and is evenly distributed among the selected zones.

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Paillet, F.L., 2000, A field technique for estimating aquifer parameters using flow log data: Ground Water, v. 38, no. 4, p. 510–521.

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Appendix 1 – Flowmeter Analyses of Monitoring Wells with Flow–B

Numerical Model Input and Results

1.1 Monitoring Well PTX01-1012

FLOW-B INPUT AND PLOTS

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Wellname: **PTX011012**
Ogallala

REQUIRED INPUT:

Elevation of Measuring Point [FT]	
Number of fractures [-]	4
Well Diameter [IN]	4
Drawdown [FT]	2
Step Factor [-]	100
Total Transmissivity [FT^2/day]	3100
Depth to Ambient Water Level [FT]	499.09
Depth at bottom of Plot [FT]	900
Depth at top of Plot [FT]	499

PLOT LOGS

RUN FWRAP

LOAD/PLOT RESULTS

FRACTURES:	Depth [FT]	Flow above fracture Ambient [GPM]	Flow above fracture Pumped [GPM]	Zone Tfactor [-]	Zone H [FT]
4	600.000	0.000	4.000	0.010	0.000
3	650.000	-0.700	3.300	0.600	-4.500
2	750.000	-2.114	-1.040	0.340	-8.000
1	810.000	-0.886	-0.420	0.050	-8.500
				1.000	

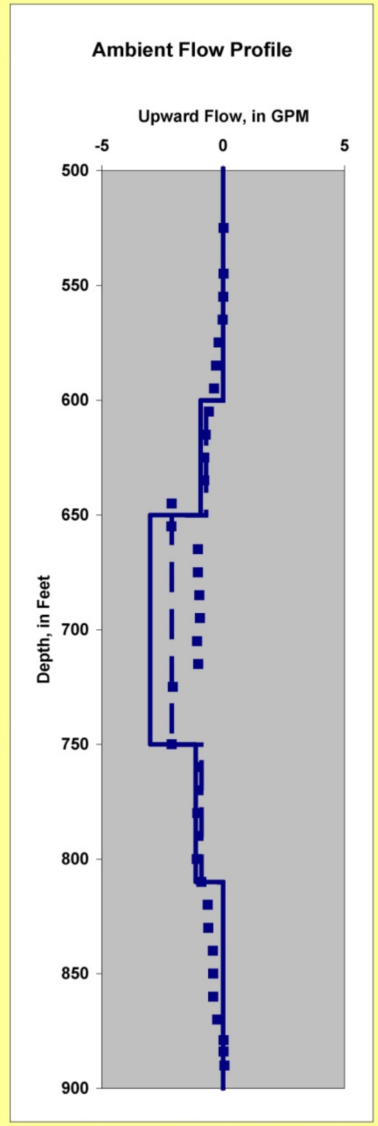
Elev, Ambient WL [FT] = -499.09 Elev, Pumped WL [FT] = -501.09

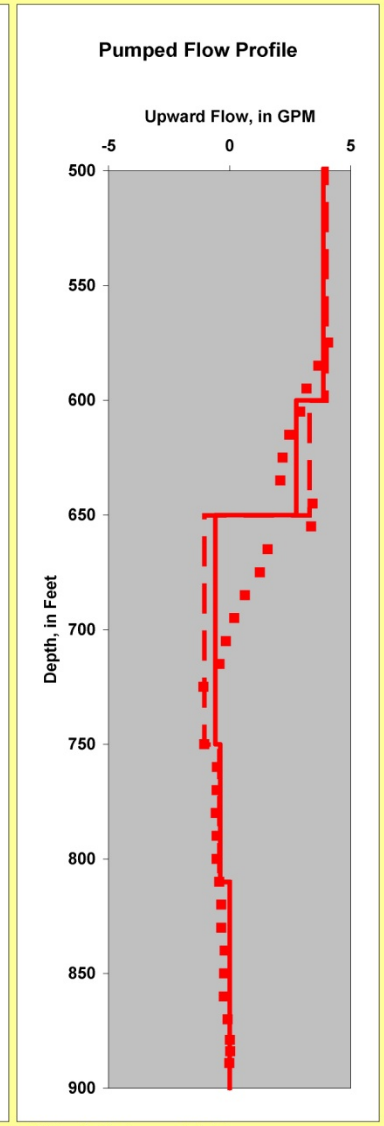
SIMULATION OUTPUT FROM FWRAP (DO NOT CHANGE)

SSE [GPM^2]	1.41776
Ambient WL [FT]	-7.84500
Pumped WL [FT]	-6.57290

RMS Error [GPM] = 0.59534864

FRACTURES:	Depth [FT]	Ambient Flow above [GPM]	Pumped Flow above [GPM]	Zone T [FT^2/day]	Water Level [FT]	Elevation of Water Level [FT]
4	600.000	0.000	3.865	31.000	493.245	-493.245
3	650.000	-0.930	2.755	1860.000	497.745	-497.745
2	750.000	-3.000	-0.585	1054.000	501.245	-501.245
1	810.0000	-1.1224	-0.3815	155.0000	501.7450	-501.74500
0						





Dashed line indicates measured flow. Solid line indicates modeled flow.

1.2 Monitoring Well PTX06-1044 before Redevelopment

FLOW-B INPUT AND PLOTS

USGS science for a changing world

Wellname: **PTX061044** **Ogallala**

REQUIRED INPUT:

Elevation of Measuring Point [FT]	
Number of fractures [-]	6
Well Diameter [IN]	4
Drawdown [FT]	30
Step Factor [-]	90
Total Transmissivity [FT^2/day]	95
Depth to Ambient Water Level [FT]	475
Depth at bottom of Plot [FT]	620
Depth at top of Plot [FT]	450

PLOT LOGS

RUN FWR/

LOAD/PLOT RESULTS

FRACTURES:	Depth [FT]	Flow above fracture Ambient [GPM]	Flow above fracture Pumped [GPM]	Zone Tfactor [-]	Zone H [FT]
6	495.000	0.021	1.600	0.000	0.000
5	530.000	-0.080	1.600	0.005	0.000
4	555.000	0.021	1.600	0.020	0.000
3	570.000	0.036	1.370	0.925	0.000
2	590.000	0.022	0.600	0.050	0.000
1	609.000	-0.020	0.060	0.000	0.000

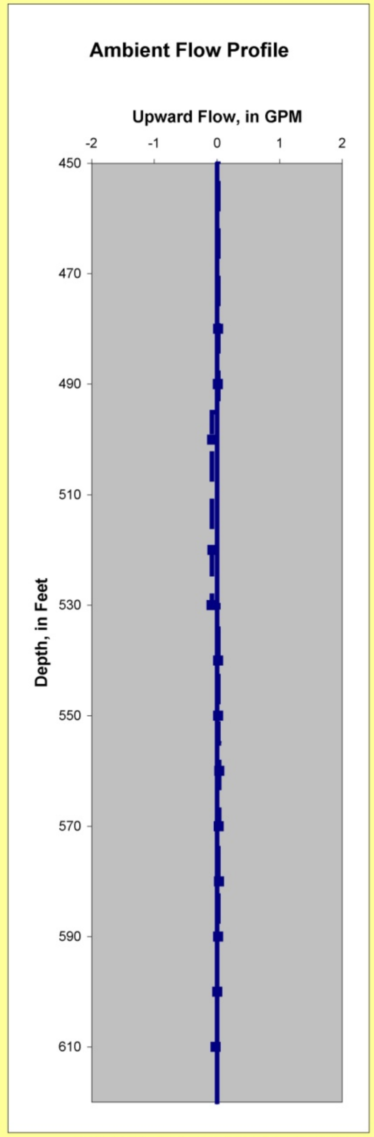
Elev, Ambient WL [FT] = -475.00 Elev, Pumped WL [FT] = -505.00

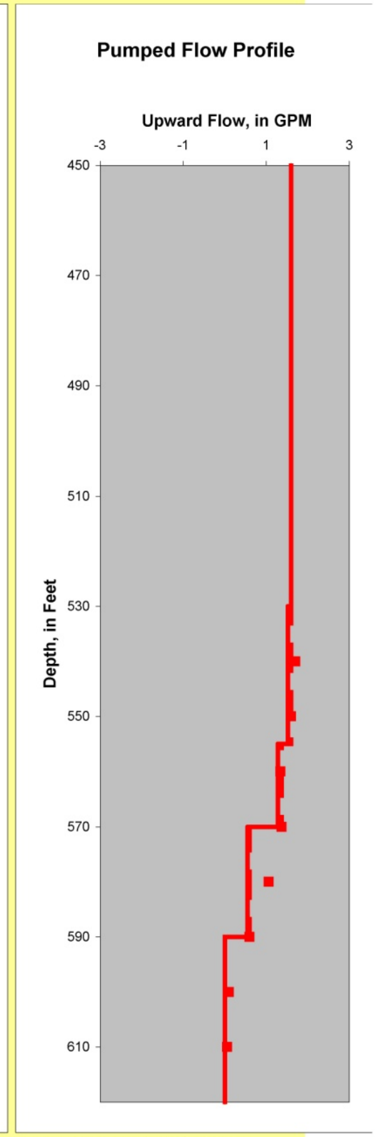
SIMULATION OUTPUT FROM FWRAP (DO NOT CHANGE)

SSE [GPM^2]	0.02971
Ambient WL [FT]	-30.00000
Pumped WL [FT]	0.00000

RMS Error [GPM] = 0.07036726

FRACTURES:	Depth [FT]	Ambient Flow above [GPM]	Pumped Flow above [GPM]	Zone T [FT^2/day]	Water Level [FT]	Elevation of Water Level [FT]
6	495.000	0.000	1.597	0.000	475.000	-475.000
5	530.000	0.000	1.597	0.475	475.000	-475.000
4	555.000	0.000	1.526	1.900	475.000	-475.000
3	570.0000	0.0000	1.2788	87.8750	475.0000	-475.00000
2	590.0000	0.0000	0.5471	4.7500	475.0000	-475.00000
1	609.0000	0.0000	0.0000	0.0000	475.0000	-475.00000
0						





Dashed line indicates measured flow. Solid line indicates modeled flow.

1.3 Monitoring Well PTX06-1044 after Redevelopment

FLOW-B INPUT AND PLOTS

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Wellname: PTX061044 Post Redevelopment Ogallala

REQUIRED INPUT:

Elevation of Measuring Point [FT]	
Number of fractures [-]	6
Well Diameter [IN]	4
Drawdown [FT]	17.2
Step Factor [-]	90
Total Transmissivity [FT^2/day]	520
Depth to Ambient Water Level [FT]	482
Depth at bottom of Plot [FT]	620
Depth at top of Plot [FT]	470

PLOT LOGS

RUN FWRA

LOAD/PLOT RESULTS

FRACTURES:	Depth [FT]	Flow above fracture: Ambient [GPM]	Flow above fracture: Pumped [GPM]	Zone Tfactor [-]	Zone H [FT]
6	495.000	0.019	5.000	0.002	0.000
5	530.000	-0.172	4.800	0.935	-9.000
4	555.000	0.040	2.400	0.020	-8.000
3	570.000	0.036	1.700	0.030	-8.000
2	590.000	0.022	0.600	0.013	-8.000
1	609.000	0.000	0.020	0.000	0.000

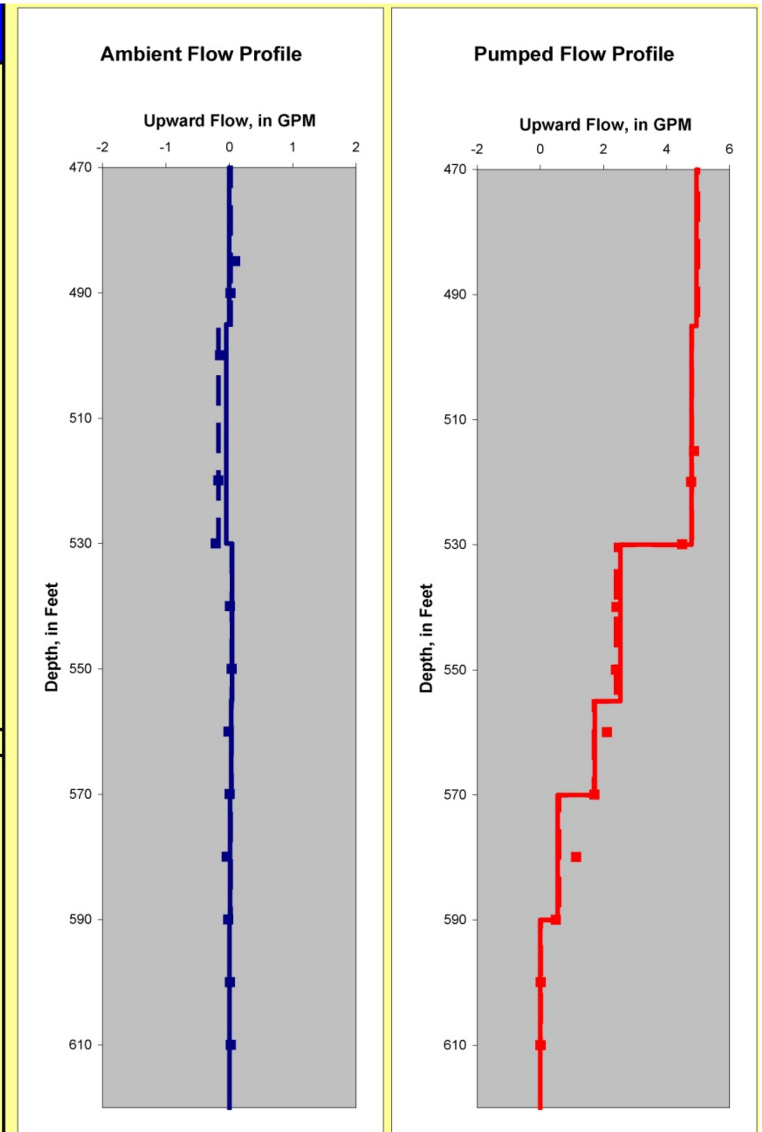
Elev, Ambient WL [FT] = -482.00 Elev, Pumped WL [FT] = -499.20

SIMULATION OUTPUT FROM FWRAP (DO NOT CHANGE)

SSE [GPM^2]	0.04151
Ambient WL [FT]	-26.11900
Pumped WL [FT]	-8.30373

RMS Error [GPM] = 0.08317363

FRACTURES:	Depth [FT]	Ambient Flow above [GPM]	Pumped Flow above [GPM]	Zone T [FT^2/day]	Water Level [FT]	Elevation of Water Level [FT]
6	495.000	0.000	4.952	1.040	473.081	-473.081
5	530.000	-0.049	4.798	486.200	482.081	-482.081
4	555.000	0.043	2.542	10.400	481.081	-481.081
3	570.0000	0.0289	1.7254	15.6000	481.0810	-481.08099
2	590.0000	0.0092	0.5511	6.7600	481.0810	-481.08099
1	609.0000	0.0000	0.0000	0.0000	473.0810	-473.08099
0						



Dashed line indicates measured flow. Solid line indicates modeled flow.

1.4 Monitoring Well PTX06-1056 before Redevelopment

FLOW-B INPUT AND PLOTS

USGS science for a changing world

Wellname: **PTX061056**
Ogallala

REQUIRED INPUT:

Elevation of Measuring Point [FT]	
Number of fractures [-]	5
Well Diameter [IN]	4
Drawdown [FT]	7.58
Step Factor [-]	100
Total Transmissivity [FT^2/day]	450
Depth to Ambient Water Level [FT]	392.5
Depth at bottom of Plot [FT]	480
Depth at top of Plot [FT]	410

PLOT LOGS

RUN FWRAP

LOAD/PLOT RESULTS

FRACTURES:	Depth [FT]	Flow above fracture Ambient [GPM]	Flow above fracture Pumped [GPM]	Zone Tfactor [-]	Zone H [FT]
5	415.000	0.000	1.500	0.000	0.000
4	431.000	0.000	1.500	0.030	0.000
3	453.000	0.000	1.300	0.950	0.000
2	460.000	0.000	0.300	0.030	0.000
1	466.000	0.000	0.000	0.000	0.000

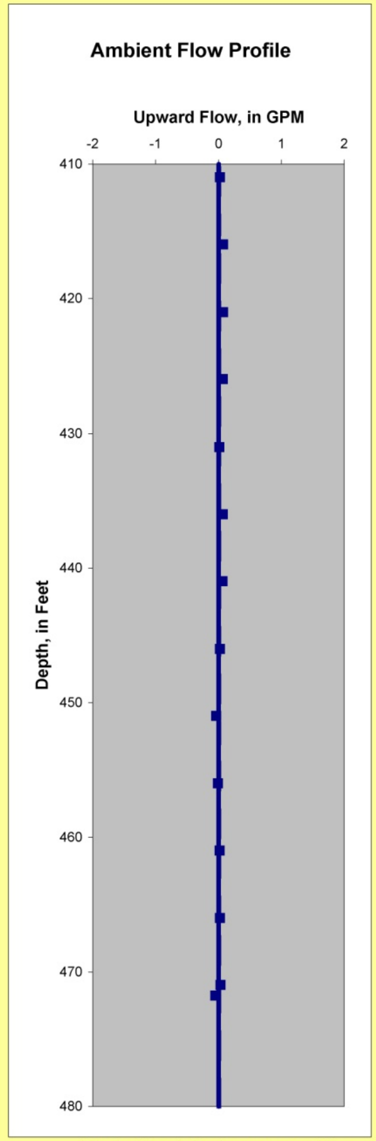
Elev, Ambient WL [FT] = -392.50 Elev, Pumped WL [FT] = -400.08

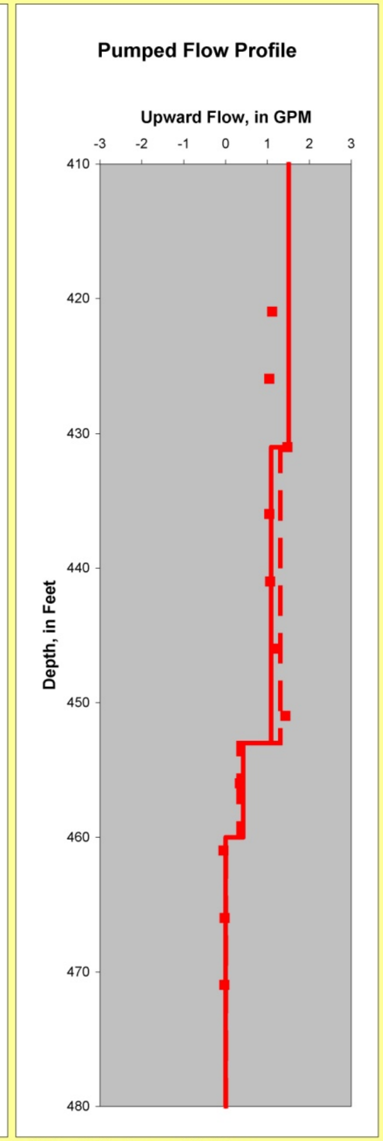
SIMULATION OUTPUT FROM FWRAP (DO NOT CHANGE)

SSE [GPM^2]	0.05982
Ambient WL [FT]	-7.58000
Pumped WL [FT]	0.00000

RMS Error [GPM] = 0.10938085

FRACTURES:	Depth [FT]	Ambient Flow above [GPM]	Pumped Flow above [GPM]	Zone T [FT^2/day]	Water Level [FT]	Elevation of Water Level [FT]
5	415.000	0.000	1.506	0.000	392.500	-392.500
4	431.000	0.000	1.506	13.500	392.500	-392.500
3	453.000	0.000	1.087	427.500	392.500	-392.500
2	460.0000	0.0000	0.4195	13.5000	392.5000	-392.50000
1	466.0000	0.0000	0.0000	0.0000	392.5000	-392.50000
0						





Dashed line indicates measured flow. Solid line indicates modeled flow.

1.5 Monitoring Well PTX06-1056 after Redevelopment

FLOW-B INPUT AND PLOTS USGS science for a changing world

Wellname: PTX061056 Post Redevelopment Ogallala

REQUIRED INPUT:

Elevation of Measuring Point [FT]	
Number of fractures [-]	5
Well Diameter [IN]	4
Drawdown [FT]	13.5
Step Factor [-]	120
Total Transmissivity [FT^2/day]	330
Depth to Ambient Water Level [FT]	395.02
Depth at bottom of Plot [FT]	480
Depth at top of Plot [FT]	410

PLOT LOGS

RUN FWRAP

LOAD/PLOT RESULTS

FRACTURES:	Depth [FT]	Flow above fracture Ambient [GPM]	Flow above fracture Pumped [GPM]	Zone Tfactor [-]	Zone H [FT]
5	415.000	0.000	3.000	0.010	0.000
4	431.000	0.000	2.900	0.150	0.000
3	453.000	0.000	1.500	0.800	0.500
2	460.000	0.000	0.600	0.030	2.000
1	466.000	-0.198	0.046	0.010	-6.000

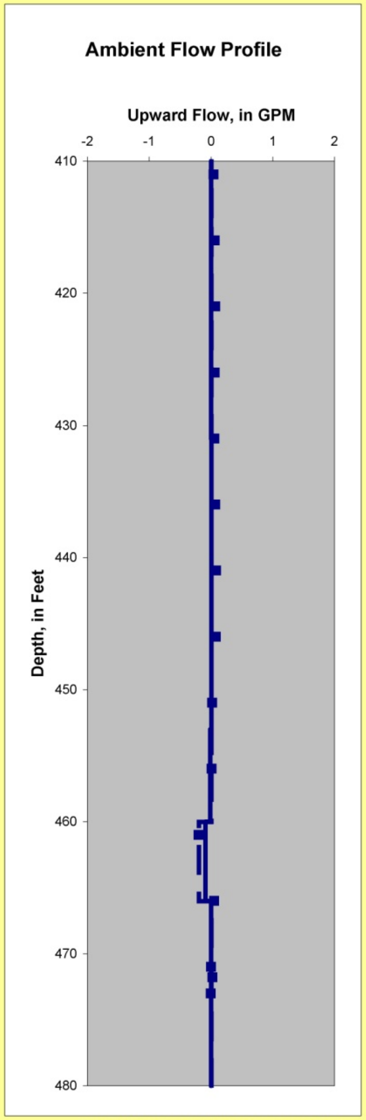
Elev, Ambient WL [FT] = -395.02 Elev, Pumped WL [FT] = -408.52

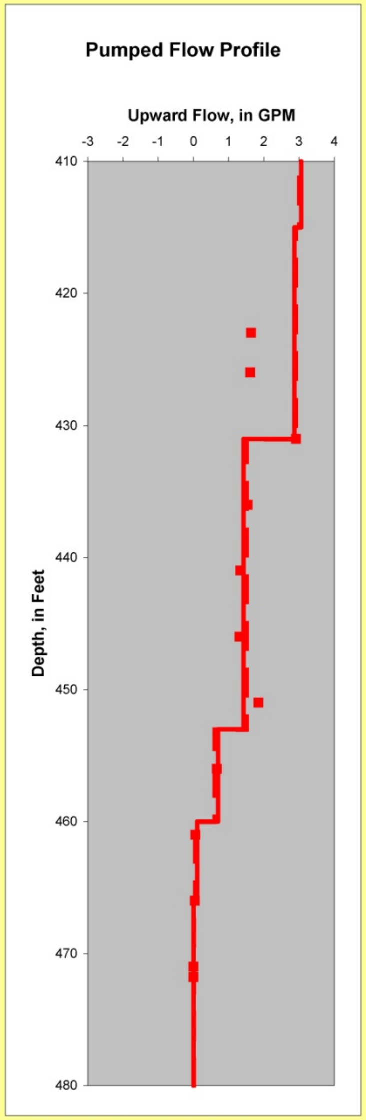
SIMULATION OUTPUT FROM FWRAP (DO NOT CHANGE)

SSE [GPM^2]	0.03670
Ambient WL [FT]	-13.10000
Pumped WL [FT]	0.07177

RMS Error [GPM] = 0.08567051

FRACTURES:	Depth [FT]	Ambient Flow above [GPM]	Pumped Flow above [GPM]	Zone T [FT^2/day]	Water Level [FT]	Elevation of Water Level [FT]
5	415.000	0.000	3.064	3.300	395.420	-395.420
4	431.000	0.001	2.870	49.500	395.420	-395.420
3	453.000	0.009	1.424	264.000	394.920	-394.920
2	460.0000	-0.0137	0.7020	9.9000	393.4200	-393.42001
1	466.0000	-0.0899	0.1052	3.3000	401.4200	-401.42001
0						





Dashed line indicates measured flow. Solid line indicates modeled flow.

1.6 Monitoring Well PTX06-1068

FLOW-B INPUT AND PLOTS

USGS science for a changing world

Wellname: PTX061068 Ogallala

REQUIRED INPUT:

Elevation of Measuring Point [FT]	
Number of fractures [-]	4
Well Diameter [IN]	4
Drawdown [FT]	10
Step Factor [-]	70
Total Transmissivity [FT^2/day]	200
Depth to Ambient Water Level [FT]	508
Depth at bottom of Plot [FT]	800
Depth at top of Plot [FT]	500

PLOT LOGS

RUN FWRAP

LOAD/PLOT RESULTS

FRACTURES:	Depth [FT]	Flow above fracture Ambient [GPM]	Pumped [GPM]	Zone Tfactor [-]	Zone H [FT]
4	565.000	0.000	4.450	0.250	0.000
3	650.000	0.000	3.300	0.250	0.000
2	775.000	0.000	2.200	0.250	0.000
1	789.000	0.000	0.500	0.250	0.000

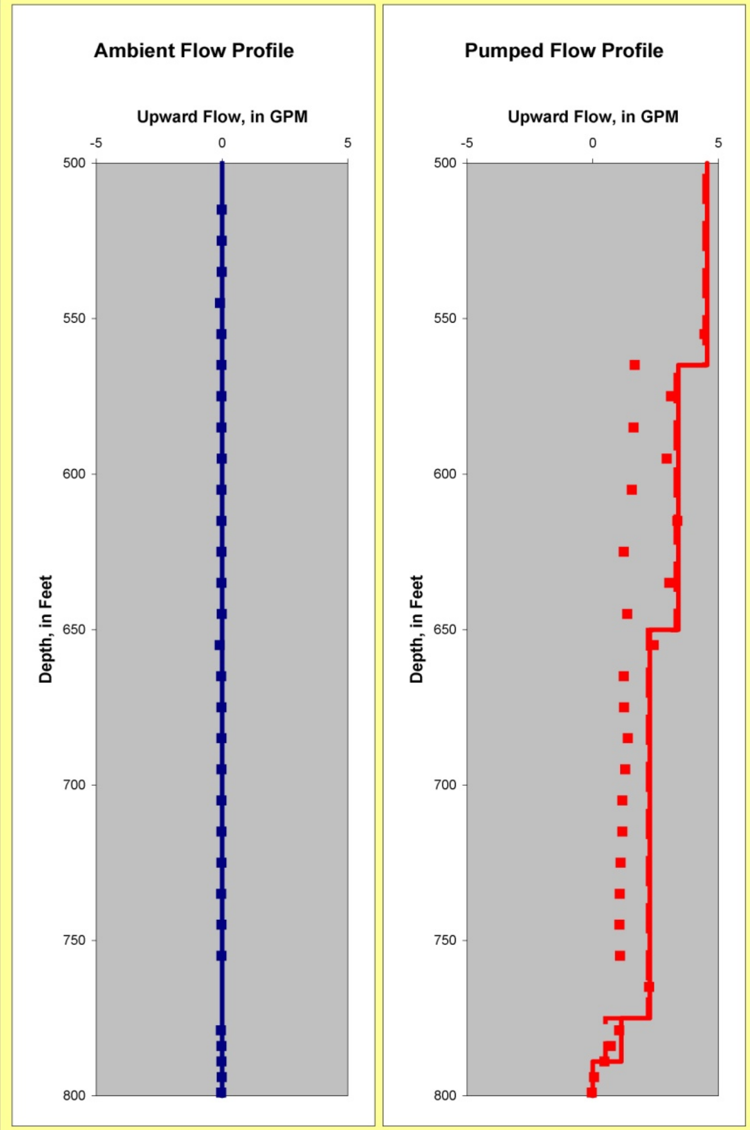
Elev, Ambient WL [FT] = -508.00 Elev, Pumped WL [FT] = -518.00

SIMULATION OUTPUT FROM FWRAP (DO NOT CHANGE)

SSE [GPM^2]	0.43271
Ambient WL [FT]	-10.00000
Pumped WL [FT]	0.00000

RMS Error [GPM] = 0.32890367

FRACTURES:	Depth [FT]	Ambient Flow above [GPM]	Pumped Flow above [GPM]	Zone T [FT^2/day]	Water Level [FT]	Elevation of Water Level [FT]
4	565.000	0.000	4.547	50.000	508.000	-508.000
3	650.000	0.000	3.411	50.000	508.000	-508.000
2	775.000	0.000	2.274	50.000	508.000	-508.000
1	789.0000	0.0000	1.1368	50.0000	508.0000	-508.00000
0						



Dashed line indicates measured flow. Solid line indicates modeled flow.

APPENDIX C

Chromium in Perched Groundwater Wells

C.1. INTRODUCTION

Total chromium has been observed at concentrations above background in many of the perched groundwater monitoring wells constructed with stainless steel screens. Analysis of metals data in perched groundwater shows that a statistical relationship exists among the constituents found in stainless steel (specifically, chromium, manganese, molybdenum, and nickel) at wells with stainless steel screens. The correlation among chromium, manganese, molybdenum, and nickel concentrations indicates measured concentrations of these constituents do not relate to groundwater contamination, but rather to sample contamination contributed by stainless steel well construction materials. Although these wells may not be suitable for monitoring of total chromium and other constituents found in stainless steel (i.e., manganese, molybdenum, and nickel), the presence of chromium in the samples does not preclude the wells from providing representative samples for other constituents.

This appendix presents a summary of conclusions presented in the Baseline Human Health Risk Assessment (BHHRA) Report (BWXT Pantex, 2006) and Groundwater RFIR (Stoller, 2004) regarding water sample contamination caused by stainless steel well construction materials. In the BHHRA, a statistical analysis of metals data in perched groundwater was conducted to determine the relationship of stainless steel corrosion products in groundwater to well casing material. For the Groundwater RFIR, well screen corrosion was visually confirmed by downhole video in nine perched groundwater wells; analytical data for chromium, manganese, and nickel acquired from those wells were removed from the RFIR dataset and the rationale for removing those data was presented. Based on the statistical analysis and visual evidence, analytical data for chromium, manganese, molybdenum, and nickel from stainless steel wells were not included in the Baseline HHRA evaluation for perched groundwater.

C.2. CHEMICAL CHARACTERISTICS OF STAINLESS STEEL WELLS

Many studies have confirmed that groundwater quality data can be biased by the presence of well construction materials in the sample as a result of leaching, desorption, or volatization (USGS, 1997). According to EPA, when constituents are leached from well materials, “constituents that are not indicative of formation water quality may be detected in samples collected from the well” (1989). These “false positives” only indicate that the sample has been affected by the well casing material.

Because well screen materials have a large surface area exposed to groundwater, the screen is the part of a well most susceptible to corrosion and leaching of its constituents. In a ranking of well screen materials by potential to leach inorganic constituents, the USGS lists stainless steel among the most leaching of potential well construction materials even though stainless steel generally has high corrosion resistance (1997). Stainless steel type 316, the type used in most stainless steel wells at Pantex, is composed of 30 to 37 percent chromium, manganese, molybdenum, and nickel (USGS, 1997).

C.3. CHROMIUM IN PERCHED GROUNDWATER

Based on historical information and soil and groundwater sampling, two separate source areas of hexavalent chromium in Zone 12 South have impacted perched groundwater. The two plumes commingle southeast of Zone 12 and extend offsite beneath Texas Tech property south of Pantex. Chromium has been detected in samples from many stainless steel wells located either upgradient or far away from these plumes. These detections do not indicate the presence of chromium contamination in perched groundwater at these locations, but are related to corrosion of stainless steel well screens as shown by the statistical evaluation presented in the BHHRA. Further, it is not plausible that a widespread chromium plume could result from well casing corrosion because well casings do not contain sufficient mass of chromium.

As an example, consider an aquifer of 20-ft saturated thickness and porosity of 0.25 containing a circular (1,000-ft radius) plume of chromium with a uniform concentration of 1 mg/L. The mass of chromium in this volume of groundwater is about 980 lb (445 kg). By comparison, a 20-ft length of 4-inch stainless steel monitoring well casing weighs about 220 lb (100 kg) based on screen weight of 11 lb/ft and contains at most 40 lb (18 kg) of chromium. Therefore, at least 25 well screens would need to be completely dissolved in the groundwater to create the small plume in the aquifer. This rather extreme example illustrates that apparent water quality impacts caused by well screen corrosion affect only the water contained within the well bore and cannot measurably affect water quality in the aquifer away from the well.

As presented in Section I.3.1 of the BHHRA, the majority of chromium, manganese, molybdenum, and nickel action level exceedances occur at well locations with stainless steel screens, while no hexavalent chromium exceedances occur at stainless steel wells. The presence of elevated concentrations of total chromium without corresponding hexavalent chromium coupled with the high occurrence of exceedance among the other corrosion constituents suggests that corrosion of the stainless steel screens is likely the cause. A statistical correlation analysis supports this hypothesis. For this analysis, total and hexavalent chromium results for 3 stainless steel wells located downgradient of known total chromium and hexavalent chromium source areas were removed. Among non-stainless steel wells where corrosion would not be expected to occur, poor relationships between the corrosion constituents (chromium, manganese, molybdenum, and nickel) are observed. In addition, the statistically significant correlation between total chromium and hexavalent chromium indicates the observed chromium detections can be attributed to a source. Conversely, the relationship between the corrosion constituents from wells with stainless steel screens showed statistically significant correlations. These results among wells with stainless steel screens coupled with the poor correlation between total chromium and hexavalent chromium would suggest that the presence of the corrosion constituents is not indicative of source contamination.

C.4. SUMMARY AND CONCLUSIONS

In the BHHRA, metals data acquired for chromium, manganese, molybdenum, and nickel in wells constructed with stainless steel screens were removed from the groundwater datasets because measured concentrations of these constituents are only localized occurrences associated with wells exhibiting corrosion. Removal of this data is consistent with the data evaluation in the Groundwater RFIR and is supported by visual observations (by downhole video) of corroded well screens, the observed extent of chromium in perched groundwater from known source areas, statistical evaluations of total and hexavalent chromium, manganese, molybdenum, and nickel in perched monitoring wells, and published data from EPA and USGS. In addition, a simple calculation of the mass of chromium in a stainless steel well screen shows that well corrosion cannot measurably affect water quality in the aquifer away from the well.

Wells constructed with stainless steel screens may not be suitable for monitoring of total chromium and other constituents found in stainless steel (i.e., manganese, molybdenum, and nickel), but these wells can provide representative samples for other constituents. Aside from chromium, none of the other constituents found in stainless steel were identified as constituents of concern in perched groundwater. Chromium impacts to perched groundwater are associated with releases of hexavalent, not total, chromium, and a separate analytical method is used to quantify concentrations of hexavalent chromium. Therefore, it is recommended that the presence of chromium and other constituents found in stainless steel at elevated concentrations not be used in the determination of the need for well replacement without other information indicating that a particular well can no longer provide representative samples of perched groundwater quality, such as visual evidence of well screen deterioration obtained from downhole video or hydraulic data from slug or pump tests.

C.5. REFERENCES

BWXT Pantex, 2006. Baseline Human Health Risk Assessment Report for Zones 10, 11, and 12, Fire Training Area, Ditches and Playas, Independent Sites, and Groundwater. Prepared for Pantex Plant, Amarillo, Texas.

Stoller, 2004. Groundwater RCRA Facility Investigation Report. Prepared for Pantex Plant, Amarillo, Texas.

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USGS (W.W. Lapham, F.D. Wilde, and M.T. Koterba), 1997. Guidelines and Standard Procedures for Studies of Ground-Water Quality: Selection and Installation of Wells, and Supporting Documentation. U.S. Geological Survey Water-Resources Investigations Report 96-4233.

APPENDIX D

<u>Table of Wells and Coordinates</u>

Monitoring Wells and Coordinates

Well ID	Easting	Northing	Well ID	Easting	Northing
Ogallala Wells					
PTX01-1010	630576.88	3771397.26	PTX06-1064	635900.45	3773557.90
PTX01-1011	629986.45	3771397.29	PTX06-1068	643403.70	3773360.30
PTX01-1012	632664.21	3773264.13	PTX06-1072	635047.45	3758434.63
PTX01-1013	628976.89	3773218.25	PTX06-1076	637327.32	3752978.41
PTX06-1032	645981.41	3752592.58	PTX06-1137A	647901.00	3758634.00
PTX06-1033	642614.48	3759581.41	PTX06-1138	646435.00	3760502.00
PTX06-1043	640711.00	3765225.21	PTX06-1139	646920.00	3756375.00
PTX06-1044	642706.18	3764538.54	PTX06-1140A	646959.05	3762805.39
PTX06-1056	643767.03	3754642.87	PTX06-1141	633445.46	3766872.54
PTX06-1057A	629630.04	3768142.23	PTX06-1143	639245.28	3770497.08
PTX06-1058	624894.00	3759747.11	PTX06-1144	640250.00	3773335.00
PTX06-1061	625651.61	3773186.59	PTX07-1R01	627914.28	3764159.91
PTX06-1062A	633017.18	3771685.22	PTX-BEG2	632652.49	3756906.56
Perched Wells					
1114-MW4	636151.93	3757809.40	PTX06-1089	646637.32	3760258.95
OW-WR-38	640645.32	3765201.69	PTX06-1090	647727.51	3757684.39
PTX01-1001	630592.95	3769641.90	PTX06-1091	646554.01	3756363.40
PTX01-1002	628496.92	3769596.99	PTX06-1093	645529.01	3759922.32
PTX01-1004	630729.82	3770768.71	PTX06-1094	643813.77	3751494.55
PTX01-1008	629942.97	3770782.89	PTX06-1095A	640634.87	3755598.65
PTX01-1009	630594.67	3769018.50	PTX06-1096A	630823.57	3766548.35
PTX04-1001	641458.10	3772334.66	PTX06-1097	633104.35	3765068.63
PTX04-1002	641818.01	3772165.27	PTX06-1098	640266.14	3753628.43
PTX06-1002A	641161.56	3759984.00	PTX06-1100	640285.97	3753579.52
PTX06-1003	641498.93	3758711.05	PTX06-1101	640383.57	3753437.09
PTX06-1005	640545.44	3756139.87	PTX06-1102	642751.09	3754532.94
PTX06-1006	637450.19	3757599.75	PTX06-1103	641228.13	3752946.88
PTX06-1007	637679.37	3759513.00	PTX06-1118	641644.92	3752736.07
PTX06-1008	639441.93	3759325.25	PTX06-1119	642646.10	3752739.01
PTX06-1010	639886.62	3758067.00	PTX06-1120	643152.43	3752735.03
PTX06-1011	639178.93	3757219.75	PTX06-1121	643645.57	3752750.09
PTX06-1012	634640.91	3755068.80	PTX06-1122	640677.35	3752308.74
PTX06-1013	643710.38	3764075.09	PTX06-1123	642051.96	3752319.94
PTX06-1014	643758.88	3755125.71	PTX06-1124	642877.91	3752327.45
PTX06-1015	643765.00	3753617.00	PTX06-1125	643377.53	3752331.14
PTX06-1023	642773.84	3764603.10	PTX06-1126	635034.72	3755562.85
PTX06-1030	644670.42	3755008.03	PTX06-1127	635901.90	3755432.03
PTX06-1031	644674.92	3753348.03	PTX06-1130	644270.36	3759745.02
PTX06-1034	646555.62	3752434.98	PTX06-1131	629371.66	3754232.94
PTX06-1035	633027.45	3755092.64	PTX06-1133	645285.00	3751284.00
PTX06-1036	638615.43	3752455.56	PTX06-1134	635211.37	3754129.45
PTX06-1037	641549.25	3752194.06	PTX06-1135	638343.76	3753631.93
PTX06-1038	643802.04	3760426.35	PTX06-1136	634860.00	3766768.00
PTX06-1039A	643807.47	3759272.56	PTX06-1146	645978.91	3757691.87
PTX06-1040	643811.23	3758262.93	PTX06-1147	645431.85	3753953.21
PTX06-1041	643803.61	3757622.78	PTX06-1148	636465.02	3754720.72
PTX06-1042	643812.20	3755779.88	PTX06-1149	635896.51	3754720.72
PTX06-1045	642697.65	3752300.00	PTX06-1150	635234.30	3754720.72
PTX06-1046	643802.63	3752292.55	PTX07-1O01	638532.53	3767695.22

Well ID	Easting	Northing	Well ID	Easting	Northing
PTX06-1047A	643817.46	3752004.39	PTX07-1O02	639106.56	3768117.46
PTX06-1048A	642103.43	3766957.63	PTX07-1O03	639046.64	3767462.56
PTX06-1049	633343.53	3763376.96	PTX07-1O06	638814.40	3768536.81
PTX06-1050	636746.04	3766622.06	PTX07-1P02	637817.70	3763019.08
PTX06-1051	640332.91	3752279.10	PTX07-1P05	637136.13	3762886.83
PTX06-1052	639100.91	3753957.66	PTX07-1Q01	629274.83	3755836.12
PTX06-1053	636576.74	3753672.06	PTX07-1Q02	628876.97	3756408.66
PTX06-1055	633521.90	3767254.87	PTX07-1Q03	630542.61	3757408.87
PTX06-1069	646317.00	3762879.60	PTX07-1R03	627664.39	3764501.80
PTX06-1071	642601.46	3773219.43	PTX08-1001	638950.13	3762969.23
PTX06-1073A	634963.34	3758072.00	PTX08-1002	640878.64	3763005.65
PTX06-1077A	637201.80	3760689.50	PTX08-1003	635385.36	3760136.56
PTX06-1080	638901.00	3772643.95	PTX08-1005	635316.66	3756346.19
PTX06-1081	641222.41	3770912.33	PTX08-1006	636400.41	3756761.86
PTX06-1082	653856.27	3780321.59	PTX08-1007	638898.35	3758429.95
PTX06-1083	658643.46	3779777.76	PTX08-1008	637485.10	3755695.51
PTX06-1085	629059.82	3760418.31	PTX08-1009	638866.95	3755275.01
PTX06-1086	631411.81	3759843.32	PTX08-1010	641401.47	3773206.74
PTX06-1088	639902.10	3757059.42	PTX10-1013	639664.44	3759944.21

APPENDIX E

Modified Compliance Plan Attachment B Well Specifications

COMPLIANCE PLAN ATTACHMENT B
MODIFIED WELL DESIGN AND CONSTRUCTION SPECIFICATIONS

The following well design and construction specifications should be used as guidance when designing a groundwater Compliance Monitoring Program (Section XI.C.) or a Corrective Action Program (Section XI.D.). This guidance is provided to establish minimum well design and construction specifications for the Compliance Plan.

1. Well drilling methods that minimize potential adverse effects on the quality of water samples withdrawn from the well and that minimize or eliminate the introduction of foreign fluids into the borehole must be utilized.

2. All wells shall be constructed such that the wells can be routinely sampled with a pump, bailer, or alternate sampling device. Piping associated with recovery wells should be fitted with sample ports or an acceptable alternative sampling method to facilitate sampling of the recovered groundwater on a well by well basis.

3. Above the saturated zone the well casing may be two (2)-inch diameter or larger schedule 40 or 80 polyvinyl chloride (PVC) rigid pipe or stainless steel or polytetrafluoroethylene (PTFE or "teflon") or an approved alternate material. The PVC casing must bear the National Sanitation Foundation logo for potable water applications (NSF-pw). Solvent cementing compounds shall not be used to bond joints and all connections shall be flush-threaded. In and below the saturated zone, the well casing shall be stainless steel or PTFE.

   PVC or fiberglass reinforced resin may be used as an alternate well casing material in and below the saturated zone provided that it yields samples for groundwater quality analysis that are unaffected by the well casing material.

4. Any well that has deteriorated due to incompatibility of the casing material with the groundwater contaminants or due to any other factors must be replaced if the well material interferes with the evaluation of groundwater against expected conditions.

5. Well casings and screens shall be steam cleaned prior to installation to remove all oils, greases, and waxes. Well casings and screens made of fluorocarbon resins shall be cleaned by detergent washing.

6. Screen lengths exceeding ten (10) feet may be installed in groundwater recovery or injection wells to optimize the groundwater remediation process in accordance with standard engineering practice. Monitoring well screen length shall be installed as noted below:
   - Perched – screen across the entire saturated thickness (less than 40 ft in most cases).
   - Ogallala – screen across the entire saturated interval with blank casing segments set across less transmissive zones and between each screen interval. The uppermost screen interval will be based on the anticipated rate of decline in the water table, but will be no greater than 40 feet. Subsequent screen intervals up to 40 feet will be continued to enable sampling near the top of the water table for 30 years after installation. Blank casing segments separating the screen intervals will be 15 feet long. Screening of the lower portion of the aquifer will be determined by evaluation of lithologies and geophysical logs.

7. The intake portion of a well shall be designed and constructed so as to allow sufficient water flow into the well for sampling purposes and minimize the passage of formation materials into the well during pumping. The intake portion of a well shall consist of commercially manufactured stainless steel or PTFE screen or approved alternate material. The annular space between the screen and the borehole shall be filled with clean siliceous granular material (i.e., filter pack) that has a proper size gradation to provide mechanical retention of the formation sand and silt. The well screen slot size shall be compatible with the filter pack size as determined by sieve analysis data. The filter pack should extend no more than three (3) feet above the well screen. A silt trap, no greater than one (1) foot in length, may be added to the bottom of the well screen to collect any silt that may enter the well. The bottom of the well casing shall be capped with PTFE or stainless steel or approved alternate material.

Groundwater recovery and injection wells shall be designed in accordance with standard engineering practice to ensure adequate well production and accommodate ancillary equipment. Silt traps exceeding one (1) foot may be utilized to accommodate ancillary equipment. Well heads shall be fitted with mechanical wellseals, or equivalent, to prevent entry of surface water or debris.

8. A minimum of two (2) feet of pellet or granular bentonite shall immediately overlie the filter pack in the annular space between the well casing and borehole. Where the saturated zone extends above the filter pack, pellet or granular bentonite shall be used to seal the annulus. The bentonite shall be allowed to settle and hydrate for a sufficient amount of time prior to placement of grout in the annular space. Above the minimum two (2)-foot thick bentonite seal, the annular space shall be sealed with a cement/bentonite grout mixture. The grout shall be placed in the annular space by means of a tremie pipe or pressure grouting methods equivalent to tremie grouting standards.

   The cement/bentonite grout mixture or TCEQ approved alternative grout mixture shall fill the annular space to within two (2) feet of the surface. A suitable amount of time shall be allowed for settling to occur. The annular space shall be sealed with concrete, blending into a cement apron at the surface that extends at least two (2) feet from the outer edge of the monitor well for above-ground completions. Alternative annular-space seal material may be proposed with justification and must be approved by the executive director prior to installation.

   In cases where flush-to-ground completions are unavoidable, a protective structure such as a utility vault or meter box should be installed around the well casing and the concrete pad design should prevent infiltration of water into the vault. In addition, the following requirements must also be met 1) the well/cap juncture is watertight; 2) the bond between the cement surface seal and the protective structure is watertight; and 3) the protective structure with a steel lid or manhole cover has a rubber seal or gasket.

9. Water added as a drilling fluid to a well shall contain no bacteriological or chemical constituents that could interfere with the formation or with the chemical constituents being monitored. For groundwater recovery and injection wells, drilling fluids containing freshwater and treatment agents may be utilized in accordance with standard engineering practice to facilitate proper well installation. In these cases, the water and agents added should be chemically analyzed to evaluate their potential impact on in-situ water quality and to assess the potential for formation damage. All such additives shall be removed to the extent practicable during well development.

10. Upon completion of installation of a well, the well must be developed to remove any fluids used during well drilling and to remove fines from the formation to provide a particulate-free discharge to the extent achievable by accepted completion methods and by commercially available well screens. Development shall be accomplished by reversing flow direction, surging the well or by air lift procedures. No fluids other than formation water shall be added during development of a well unless the aquifer to be screened is a low-yielding water-bearing aquifer. In these cases, the water to be added should be chemically analyzed to evaluate its potential impact on in-situ water quality, and to assess the potential for formation damage.

    For recovery and injection wells, well development methods may be utilized in accordance with standard engineering practice to remove fines and maximize well efficiency and specific capacity. Addition of freshwater and treatment agents may be utilized during well development or re-development to remove drilling fluids, inorganic scale or bacterial slime. In these cases, the water and agents added should be chemically analyzed to evaluate their potential impact on in-situ water quality and to assess the potential for formation damage. All such additives shall be removed to the extent practicable during well development.

11. Each well shall be secured and/or designed to maintain the integrity of the well borehole and groundwater.

12. The above-ground portion of the well must be protected by bumper guards and/or metal outer casing protection when wells are located in traffic areas or outside the secured plant area.

13. Copies of drilling and construction details demonstrating compliance with the items of this provision shall be kept on site. This record shall include the following information:

. name/number of well (well designation);
. intended use of the well(sampling, recovery, etc.);
. date/time of construction;
. drilling method and drilling fluid used;
. well location (± 0.5 ft.);
. bore hole diameter and well casing diameter;
. well depth (± 0.1 ft.);
. drilling and lithologic logs;
. depth to first saturated zone;
. casing materials;
. screen materials and design;
. casing and screen joint type;
. screen slot size/length;
. filter pack material/size;
. filter pack volume (how many bags, buckets, etc.);
. filter pack placement method;
. sealant materials;
. sealant volume (how many bags, buckets, etc.);
. sealant placement method;
. surface seal design/construction;
. well development procedure;
. type of protective well cap;
. ground surface elevation (± 0.01 ft. MSL);
. top of casing elevation (± 0.01 ft. MSL); and,
. detailed drawing of well (include dimensions).

14. Construction or plugging and abandonment of each well shall be completed in accordance with the requirements of 16 TAC Chapter 76 and must be reported/certified to the TCEQ that such proper construction or plugging and abandonment has occurred following installation or plugging and abandonment. Well completion logs for each newly installed or replaced well shall be included with the report. The certification shall be prepared by a qualified geologist or geotechnical engineer. Each well certification shall be accompanied by a certification report, including an accurate log of the soil boring, which thoroughly describes and depicts the location, elevations, material specifications, construction details, and soil conditions encountered in the boring for the well. A copy of the certification and certification report shall be kept on-site, and a second copy shall be submitted to the executive director.

15. The well number must be clearly marked and maintained on each well at the site.

16. The elevation of the top of each well casing must be measured in feet above mean sea level to the nearest 0.01 foot.

17. Wells must be replaced at any time the well integrity or materials of construction or well placement no longer enable the well to yield samples representative of groundwater quality.

18. Soil test borings shall be plugged and wells removed from service with a cement/bentonite grout mixture so as to prevent the preferential migration of fluids in the area of the borehole. Certification of each plugging shall be reported in accordance with Provision 14. The plugging of wells shall be in accordance with 16 TAC Chapter 76 dealing with Well Drilling, Completion, Capping and Plugging.

19. A well's screened interval shall be appropriately designed and installed to meet the well's specific objective (i.e., either DNAPL, LNAPL, both, or other objective of the well). All wells designed to detect, monitor, or recover DNAPL must be drilled to intercept the bottom confining layer of the aquifer. The screened interval to detect DNAPL should extend from the top of the lower confining layer to above the portion of

the aquifer saturated with DNAPL. The screened interval for all wells designed to detect, monitor, or recover LNAPL must extend high enough into the vadose zone to provide for fluctuations in the seasonal water table. In addition, the sandpacks for the recovery or monitoring well's screened interval shall be coarser than surrounding media to ensure the movement of NAPL to the well.

APPENDIX F

Well Construction Diagrams and
Approach to Construction of New Ogallala Aquifer Wells

F. WELL CONSTRUCTION DIAGRAMS AND APPROACH TO CONSTRUCTION OF NEW OGALLALA AQUIFER WELLS

Seven new wells are proposed in the Ogallala Aquifer as early detection wells near perched groundwater contamination and for uncertainty management. This section provides the diagrams and information for proposed well installations.

F.1. OGALLALA AQUIFER DRILLING AND WELL INSTALLATION DECISION PROCESS

Ogallala aquifer monitoring well drilling will progress in steps. An Air Rotary Casing Hammer (ARCH) drilling rig will initially be used to bore through the Blackwater Draw and upper Ogallala Formations to the FGZ, generally about 260 to 290 feet bgs. An 8-inch carbon steel conductor casing will then be set and permanently cemented from the FGZ to ground surface. The Portland cement used to grout the conductor casing will be allowed to cure a minimum of 24 hours before drilling operations continue. Mud rotary drilling then will be used to complete the borehole. This method includes a containment system that will hold all drilling fluids and cuttings until the well is completed. All grout will be segregated from this system. The borehole will be advanced to the Permian redbeds. At completion of drilling activities, a series of geophysical surveys will be run in the borehole. The geophysical logging suite will consist of natural gamma, spontaneous-potential, and resistivity. A video survey may also be completed on the Ogallala aquifer monitoring well. This survey will be completed after the well is developed and at the end of the drilling program in order to ensure clarity of the well. At the conclusion of logging activities and following evaluation of the geophysical and lithological logs by the field geologist, 5-inch, Schedule 10, Type 316, stainless steel screen and casing will be used to construct the well. This procedure will be used for any other Ogallala aquifer monitoring wells that may be installed during the project. Drilling activities are described in more detail below.

During all drilling operations, the lithology of the soil and rock cuttings will be described and logged on standard field forms. Lithologic descriptions will conform to USCS criteria. Munsell soil and rock color charts will be used to facilitate uniform naming of soil/rock colors. Additionally, the on-site geologist may conduct field sieve analysis of soil samples collected from selected intervals using a core barrel or split-spoon type sampler.

After installation of the conductor casing, drilling will continue with mud rotary methods through the Ogallala and Dockum Formations to the Permian redbeds. The Triassic/Permian contact beneath the site is often difficult to identify based solely on drill cuttings. It is necessary to penetrate the Permian formation at least ten feet in order to identify the correct natural gamma and resistivity curves on a geophysical log. Therefore, drilling will terminate when the field geologist has identified the contact based on lithology, penetration-rate, and inferred data from the nearest existing wells. This will occur at about ten to fifteen feet into the Permian formation.

The well will be constructed using a 5-inch, Schedule 10, Type 316 stainless steel riser and screen with a sump up to 5 feet in length. Well materials will either be pre-cleaned and packaged for environmental use by the manufacturer, or steam-cleaned at the decontamination pad prior to installation. Sand will be used to fill the bottom 10 to 15 feet of the over-drilled hole beneath the well. The bottom of the well screen will be set as close as possible to the Triassic/Permian contact. The top of the well screen will be set about five feet above the saturated interval of the Ogallala aquifer. A sand filter pack will be placed around the screened interval in the annulus between the well and borehole. The filter pack will extend from total depth of the well to at least three feet above the well screen. A five-foot thick bentonite seal will be placed in the annulus on top of the sand pack. The remaining annular space will be filled with Volclay or equivalent grout to the surface.

The surface completion of the Ogallala aquifer monitoring well will be constructed similarly to existing wells. Unauthorized access to the well will be restricted with a temporary cover until the permanent wellhead is constructed. The wellhead will consist of a 10-inch steel protective casing with a locking cover installed over the well and centered in a concrete pad. The concrete pad will have 25 square feet of surface area measuring 5 feet by 5 feet. The pad will be 8 inches thick with 6 inches below ground. Four 3-inch steel bollards will be placed exactly vertical within the concrete pad and equidistant from the edges of the pad and each other. The concrete pad and bollards will be oriented parallel to adjacent roads and/or fences. The wellhead will be painted to match existing wellheads. A brass plate stamped with the well number will be set in the surface of the pad to serve as the survey marker.

F.2. MULTIPLE WELL SCREEN INTERVAL DETERMINATION

The primary method for determination of the depth intervals for the different screen lengths and intervening blank casing sections is the interpretation of the geophysical logs. While there usually is sufficient and detailed information available from the field notes (provided in final form as lithologic logs), there can be a lag time for specific sediment intervals to be transported to the surface via the drilling mud/water solution. This lag time results in depth intervals for the various geologic strata (gravels, sands, clays) in the geologic field note descriptions being off slightly from those shown on the geophysical logs. Sometimes the discrepancy can be 20 feet or more. Therefore, the geophysical logs are used as the primary guidance for well construction.

Examination of well logs from two previously installed wells show clayey intervals that were "blanked-off" from the screened sections. Some of the clay intervals were not noted on the lithologic logs, but in general all significant sand and/or gravel zones were noted. These sediments are usually easier to identify when drilling with mud-rotary methods. The geophysical logs also help identify prominent sandy/gravelly zones.

Field methods utilized for well completion will be as described above for lithologic descriptions followed by conducting the geophysical logging as soon as the drill stem is removed from the borehole. Following the logging, a printout is made in the field and the geologist compares it to the notes made during drilling to determine the approximate lag time between observed depths of sediments and their actual depths. Once the entire saturated interval has been evaluated, a determination will be made if there are significant clayey layers that should be eliminated, or "blanked-off" from the screened section. Equally important is well construction that ensures screened intervals "capture" significant sand/gravel layers that may be preferentially transmissive zones. This information will be provided to the Pantex technical representative and upon agreement, conveyed to the drilling subcontractor and well construction started. The time interval between geophysical logging completion and well construction start-up should be as soon as possible (1 hour preferred) to prevent borehole collapse.

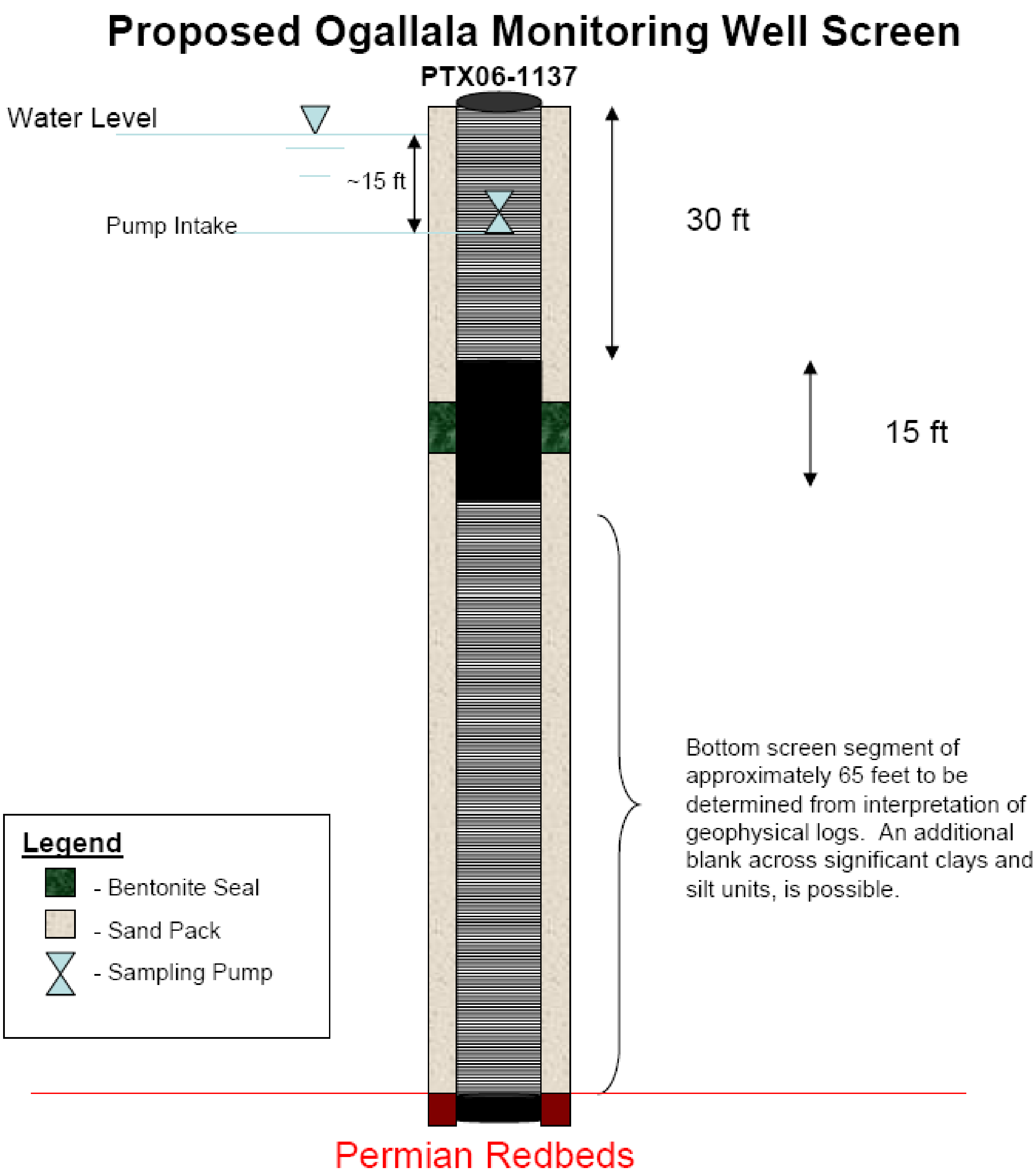
Table F-1. Proposed Screen Segments for New Ogallala Wells

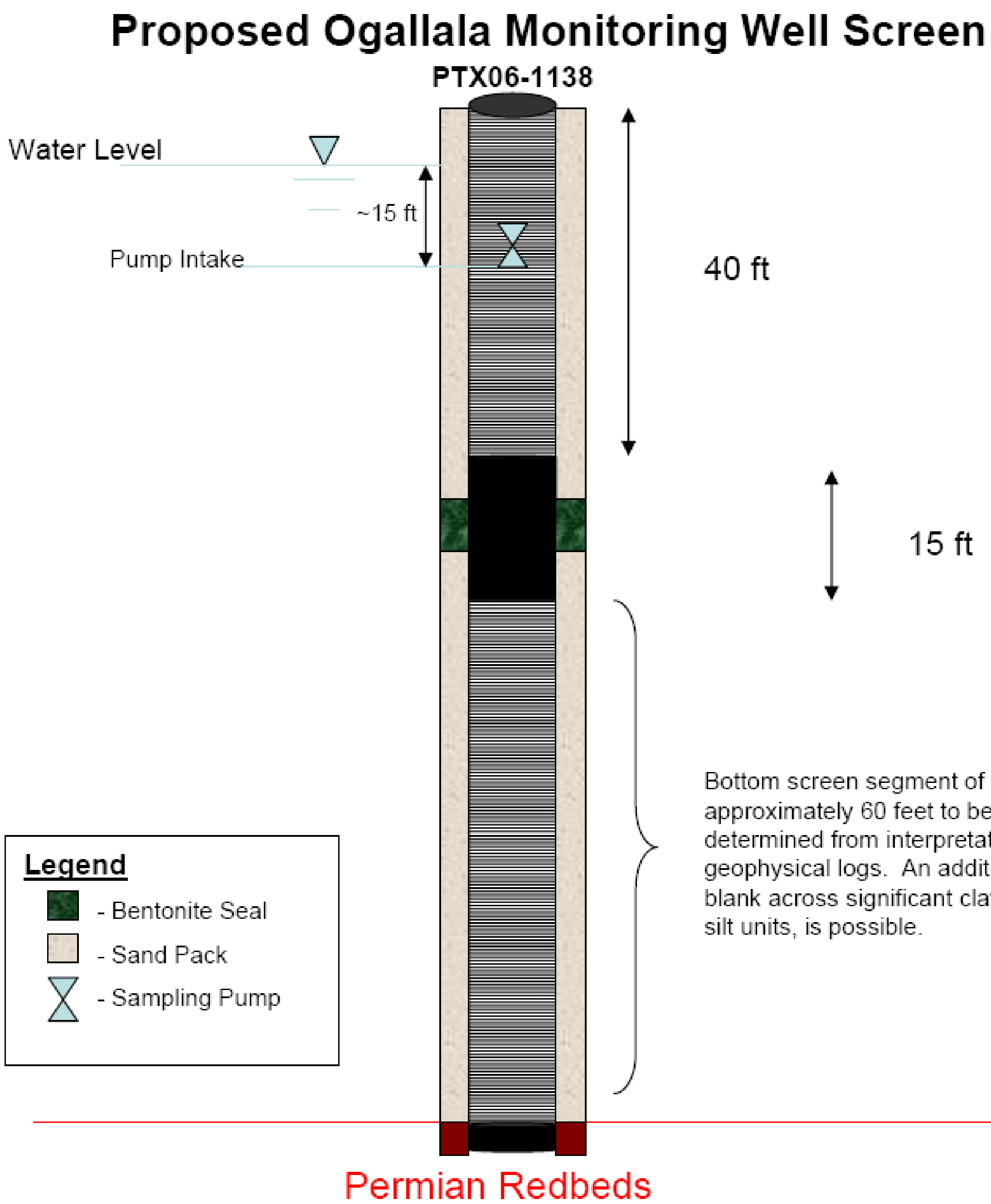
Well ID	Projected Saturated Thickness (ft)	Observed Rate of Decline (ft/yr)	Estimated 30-yr Decline[1] (ft)	First Screen Segment[2] (ft)	Second Screen Segment (ft)	No. of 15-ft Blank Segments	Bottom Screen Segment (ft)
PTX06-1137	105	0.9	27	30	N/A	1	63
PTX06-1138	107	1.1	33	40	N/A	1	59
PTX06-1139	70	0.7	21	30	N/A	1	34
PTX06-1140	145	1.2	36	40	30	2	49
PTX06-1141	282	1.2	36	40	40	2	176
PTX06-1143	272	2	60	40	40	2	172
PTX06-1144	315	2	60	40	40	2	215

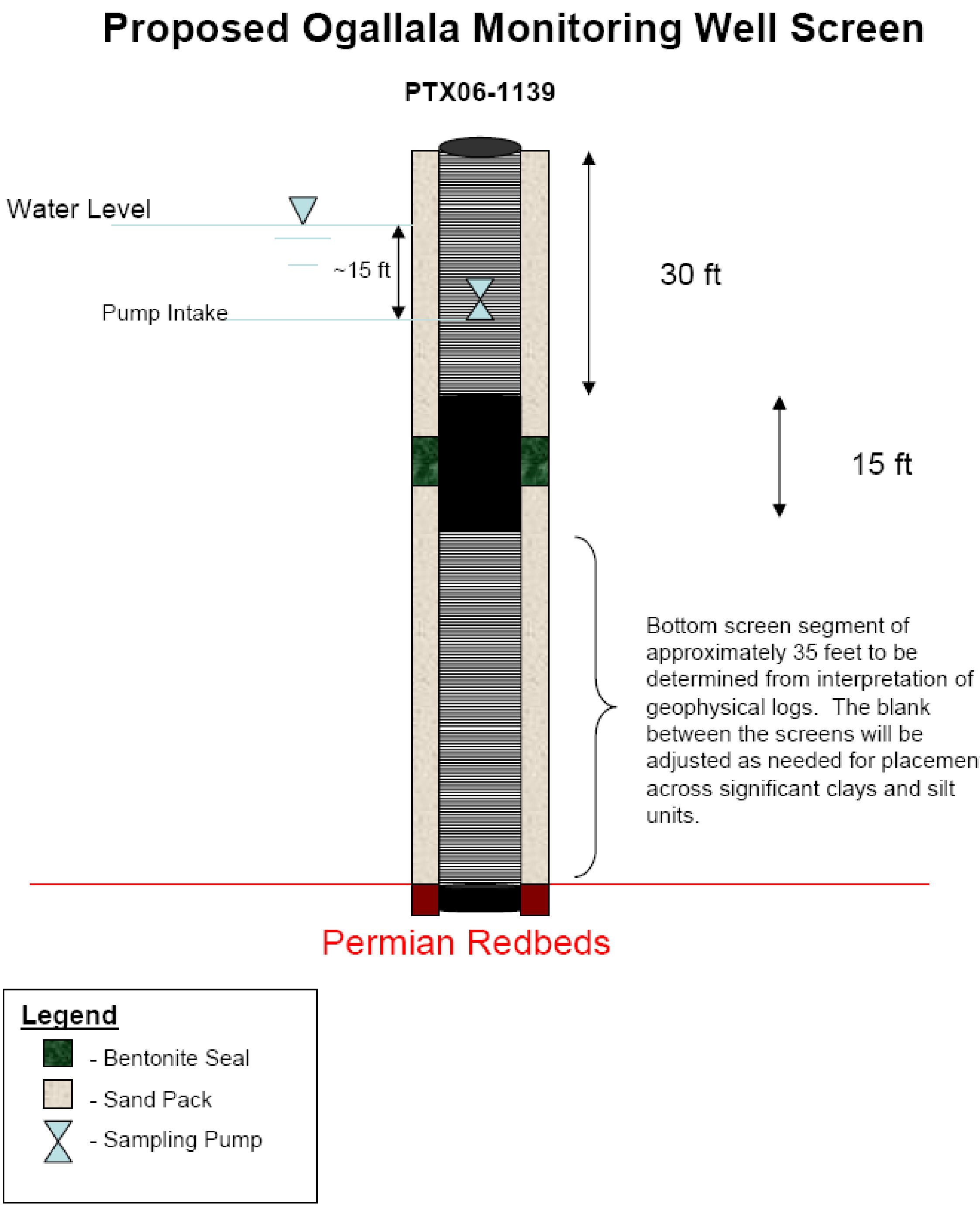
[1] Based on review of trends for the annual rate of water level decline in nearby Ogallala Aquifer monitoring wells.

[2] Accounts for screen above the top of water (between 3 and 10 feet); length of this segment limited to no more than 40 feet.

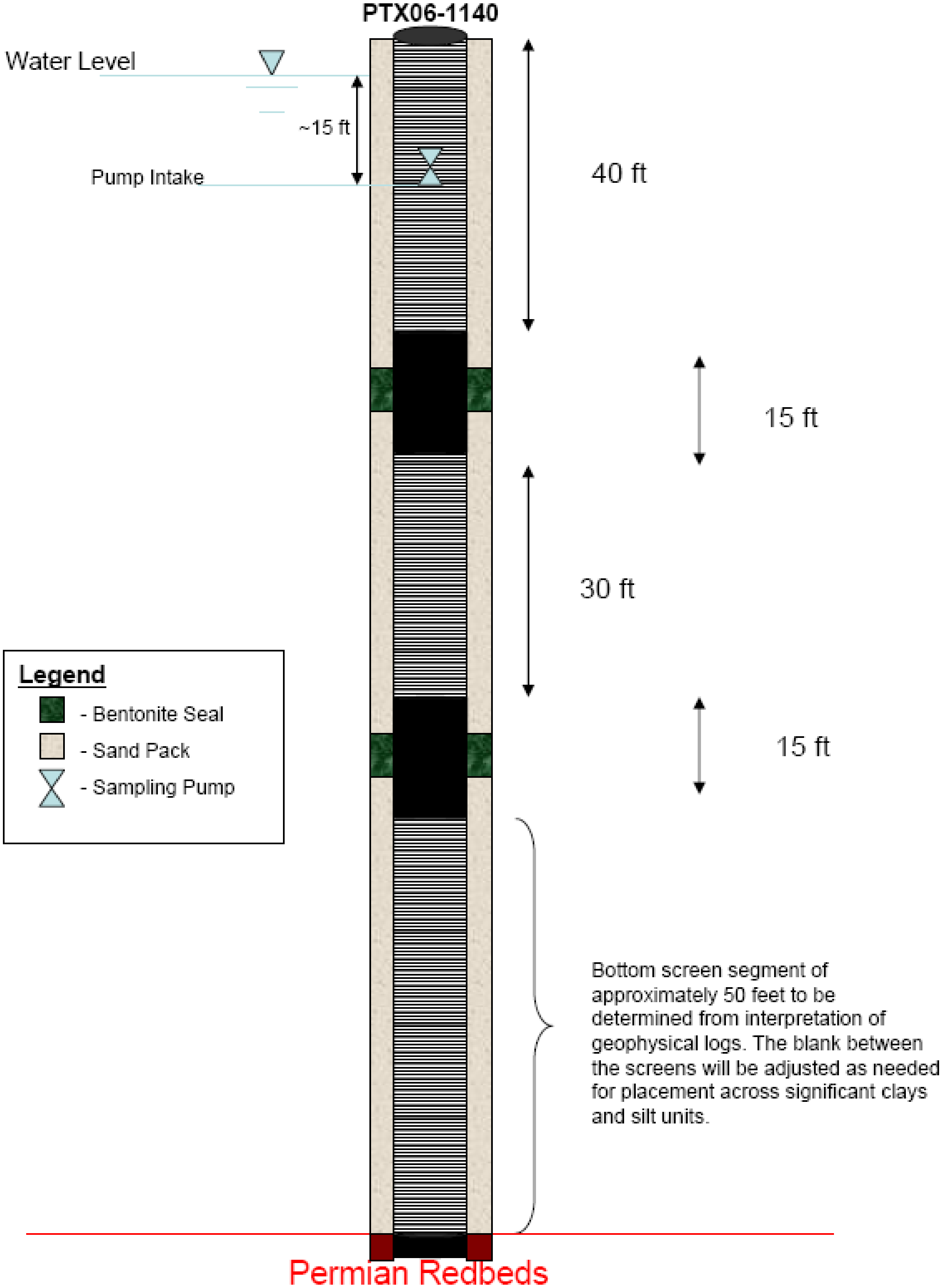
F.3. PROPOSED WELL CONSTRUCTION DIAGRAMS



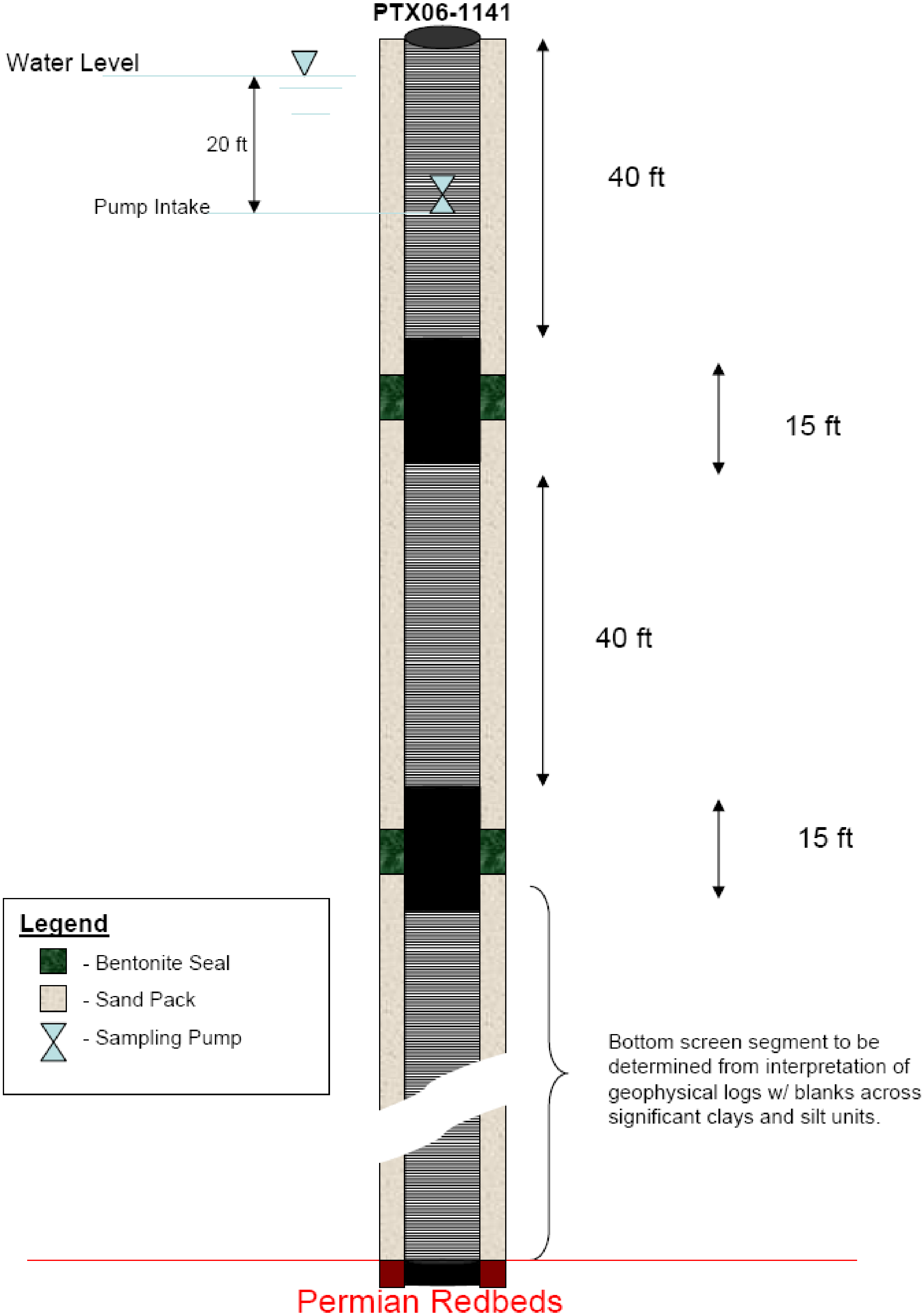

Proposed Ogallala Monitoring Well Screen
PTX06-1138
Water Level
~15 ft
Pump Intake
40 ft
15 ft
Bottom screen segment of approximately 60 feet to be determined from interpretation of geophysical logs. An additional blank across significant clays and silt units, is possible.
Legend
- Bentonite Seal
- Sand Pack
- Sampling Pump
Permian Redbeds

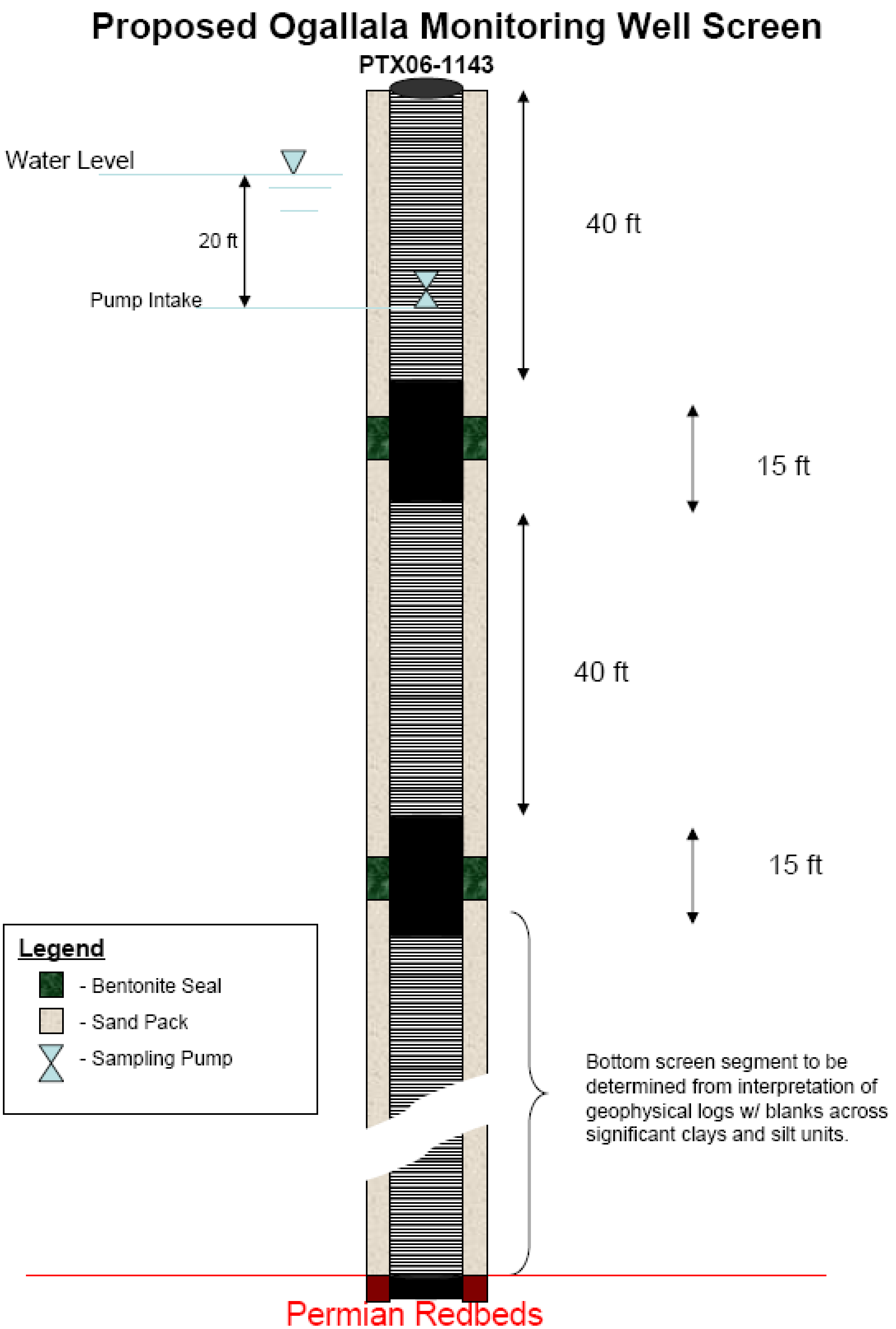

Proposed Ogallala Monitoring Well Screen
PTX06-1139
Water Level
~15 ft
Pump Intake
30 ft
15 ft
Bottom screen segment of approximately 35 feet to be determined from interpretation of geophysical logs. The blank between the screens will be adjusted as needed for placement across significant clays and silt units.
Permian Redbeds
Legend
- Bentonite Seal
- Sand Pack
- Sampling Pump

Proposed Ogallala Monitoring Well Screen

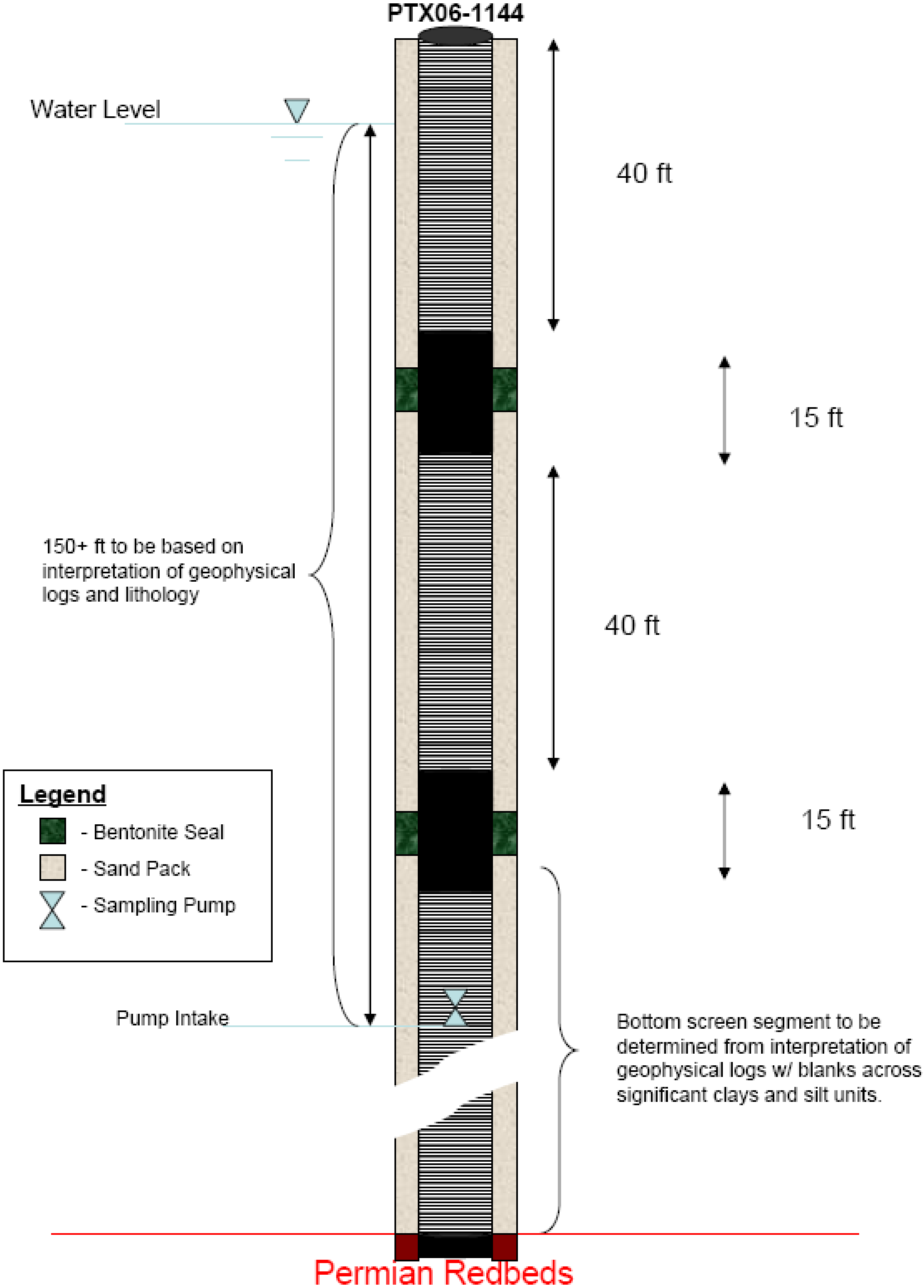


Proposed Ogallala Monitoring Well Screen




Proposed Ogallala Monitoring Well Screen
PTX06-1143
Water Level
20 ft
Pump Intake
40 ft
15 ft
40 ft
15 ft
Legend
- Bentonite Seal
- Sand Pack
- Sampling Pump
Bottom screen segment to be determined from interpretation of geophysical logs w/ blanks across significant clays and silt units.
Permian Redbeds

Proposed Ogallala Monitoring Well Screen



F.4. WELL CONSTRUCTION DIAGRAMS

BEGＭPTX-02

Contractor:

Contract #:

OPTIX #:

Included Documents

___Drilling Log
  ___Draft
  ___Final

_X_Installation Log

___Lithologic Logs
  ___Draft
  ___Final

___Geophysical Logs
  ___Neutron
  ___Gamma
  ___e-log
  ___Bond Log
  ___Deviation log

_X_State Well Report

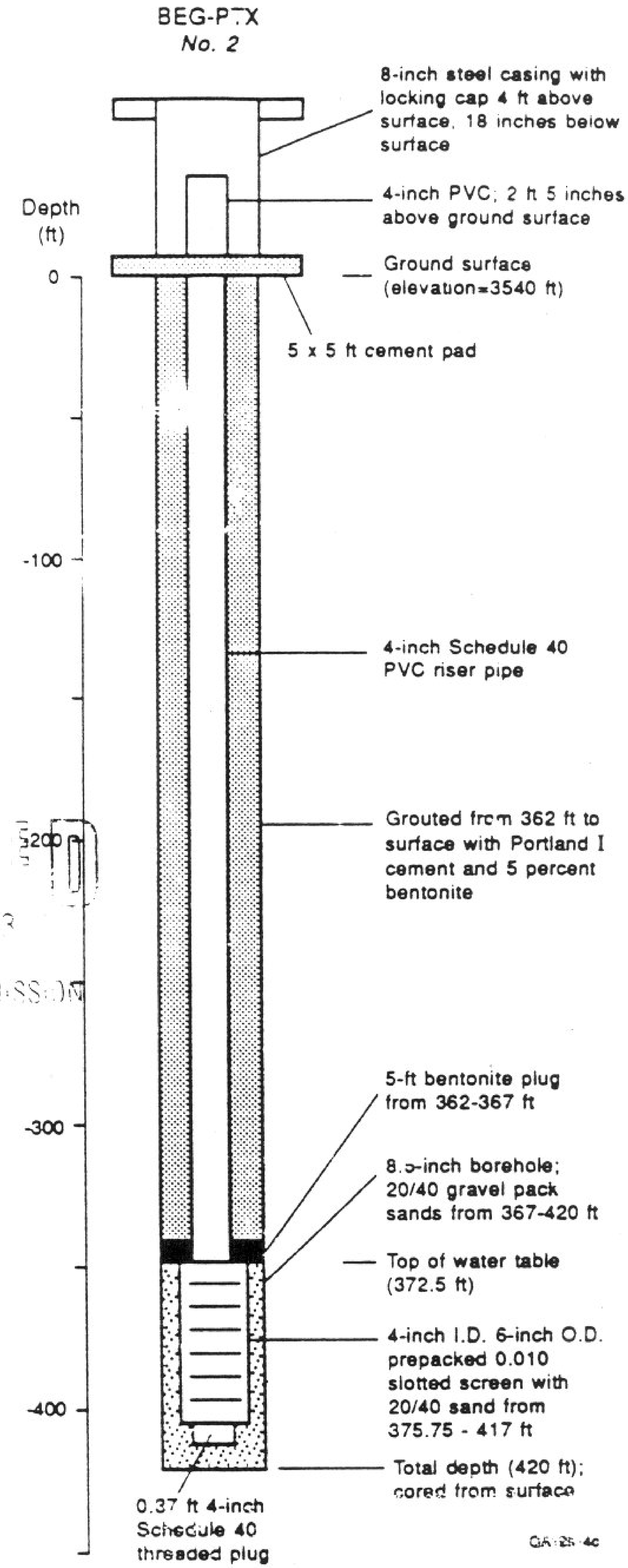


Figure 8. Schematic diagram of BEG-PTX No. 2.

Send original copy by certified mail to: Texas Water Commission, P.O. Box 13087, Austin, Texas 78711

Please use black ink.

ATTENTION OWNER: *Confidentiality Privilege Notice on Reverse Side*

State of Texas WELL REPORT

BEG PTX-#2

D.I.M.

Texas Water Well Drillers Board
P.O. Box 13087
Austin, Texas 78711

1) **OWNER** U.S. Department of Energy (Name) **ADDRESS** P.O. Box 30030 Hwy 60 & FM 2373 (Street or RFD) Amarillo (City) TX (State) 79120 (Zip)

2) **LOCATION OF WELL:** Pantex Plant Reservation
County Carson, in Zone 10 miles in east (NE, SW, etc.) direction from Batch Plant (Town)

Driller must complete the legal description below with distance and direction from two intersecting section or survey lines, or he must locate and identify the well on an official Quarter- or Half-Scale Texas County General Highway Map and attach the map to this form.

☐ **LEGAL DESCRIPTION:**
Section No. ______ Block No. ______ Township ______ Abstract No. ______ Survey Name ______
Distance and direction from two intersecting section or survey lines ______

☒ **SEE ATTACHED MAP**

3) **TYPE OF WORK (Check):** ☒ New Well ☐ Deepening ☐ Reconditioning ☐ Plugging

4) **PROPOSED USE (Check):** ☐ Domestic ☐ Industrial ☒ Monitor ☐ Public Supply ☐ Irrigation ☐ Test Well ☐ Injection ☐ De-Watering

5) **DRILLING METHOD (Check):** ☐ Driven ☐ Mud Rotary ☐ Air Hammer ☐ Jetted ☐ Bored ☐ Air Rotary ☐ Cable Tool ☒ Other Auger

6) **WELL LOG:**
Date Drilling:
Started 02-12 1992
Completed 02-15 1992

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
8.5	Surface	420.00

7) **BOREHOLE COMPLETION:**
☐ Open Hole ☐ Straight Wall ☐ Underreamed
☒ Gravel Packed ☐ Other
If Gravel Packed give interval . . . from 367 ft. to 420 ft.

From (ft.)	To (ft.)	Description and color of formation material
		See attached boring log for No. 2

(Use reverse side if necessary)

8) **CASING, BLANK PIPE, AND WELL SCREEN DATA:**

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casting Screen
4	N	PVC Casing	+2.5	367	Sch 40
4	N	PVC Screen	367	417	0.010

RECEIVED MAR 1 1993 TEXAS WATER COMMISSION

9) **CEMENTING DATA** [Rule 287.44(1)]
Cemented from 0 ft. to 362 ft. No. of Sacks Used 145
______ ft. to ______ ft. No. of Sacks Used ______
Method used Tremie Pipe
Cemented by David Fendley

10) **SURFACE COMPLETION**
☒ Specified Surface Slab Installed [Rule 287.44(2)(A)]
☐ Specified Steel Sleeve Installed [Rule 287.44(3)(A)]
☐ Pitless Adapter Used [Rule 287.44(3)(B)]
☐ Approved Alternative Procedure Used [Rule 287.71]

11) **WATER LEVEL:** N/A
Static level ______ ft. below land surface Date ______
Artesian flow ______ gpm. Date ______

12) **PACKERS:** Type Depth
Bentonite Pellets 362' to 367'

13) **TYPE PUMP:** N/A
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ______
Depth to pump bowls, cylinder, jet, etc., ______ ft.

14) **WELL TESTS:** N/A
Type Test: ☐ Pump ☐ Bailer ☐ Jetted ☐ Estimated
Yield: ______ gpm with ______ ft. drawdown after ______ hrs.

15) **WATER QUALITY:**
Did you knowingly penetrate any strata which contained undesirable constituents?
☐ Yes ☒ No If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ______ Depth of strata ______
Was a chemical analysis made? ☐ Yes ☐ No

I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief. I understand that failure to complete items 1 thru 15 will result in the log(s) being returned for completion and resubmittal.

COMPANY NAME Fugro Geosciences, Inc. (Type or print) **WELL DRILLER'S LICENSE NO.** 02791-M

ADDRESS 6105 Rookin (Street or RFD) Houston (City) Texas (State) 77074 (Zip)

(Signed) [signature] (Licensed Well Driller) David Fendley (Signed) ______ (Registered Driller Trainee)

Please attach electric log, chemical analysis, and other pertinent information, if available.

For TWC use only: Well No. ______ Located on map ______

WWD-012 (Rev. 05-18-90)

TEXAS WATER COMMISSION COPY

PTX01-1010

Contractor: S.M. Stoller

Contract #: 3350-105

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

_X_Installation Log

_X_Lithologic Logs
    ___Draft
    _X_Final

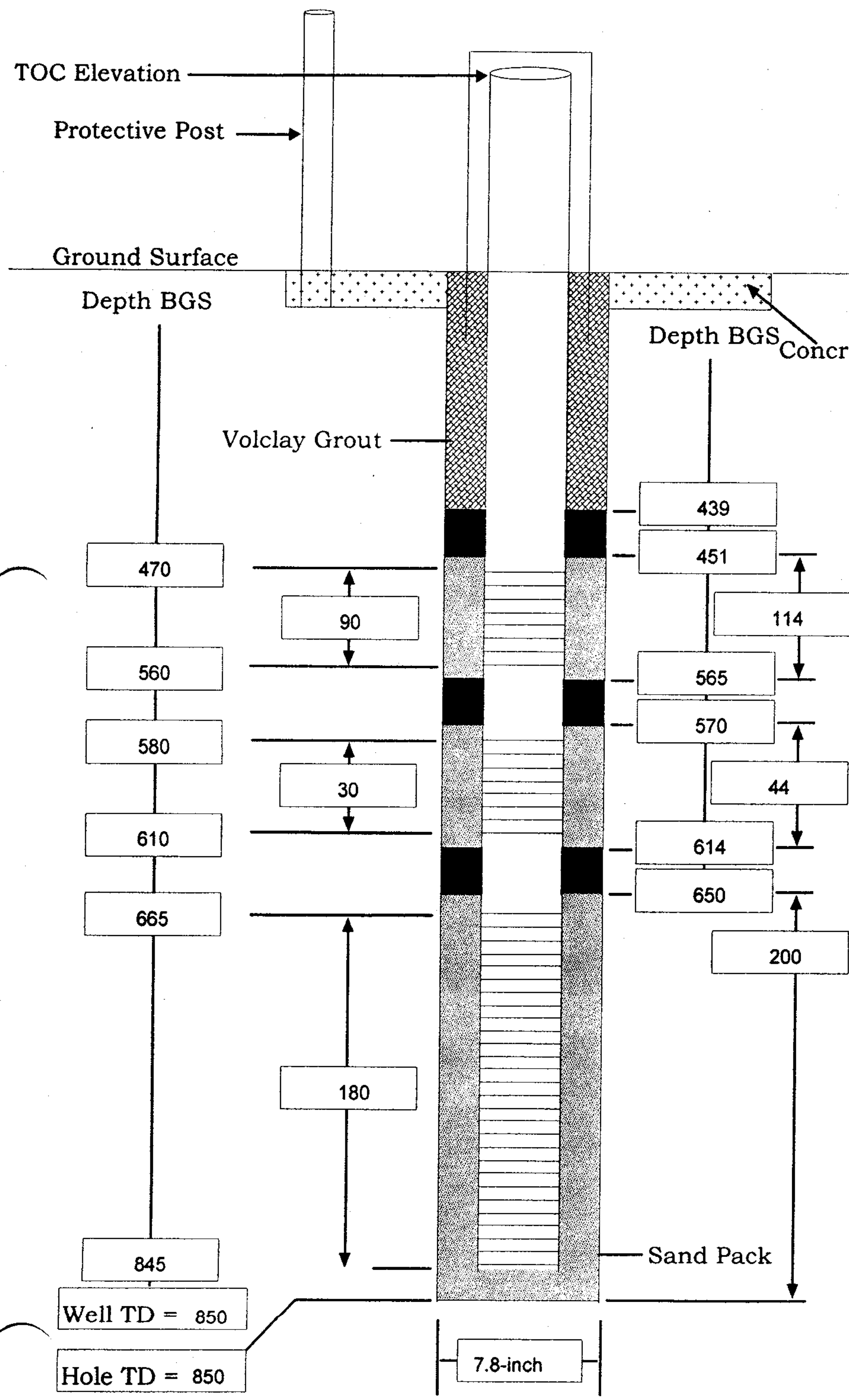
___Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

Monitor Well Installation Diagram

Project: Pantex GW RFI
Location: North of Burning Grounds
Contractor: Stewart Brothers Drilling Co.
Driller: M.King
Well Coordinates: N-3771397.26 / E-630576.88
TOC Elevation: 3576.15
Surface Elevation: 3574.01

Monitor Well No: PTX01-1010
Date Constructed: 4-2-00
Observed by: J.Ford
Sheet 1 of 1



Protective Casing
Material: Steel
Diameter: 10-inch with 8-inch to 267'

Surface Pad
Composition & Size: 5'x5'x8"

Riser Pipe
Type: Schedule 10, Type 304 Stainless Steel
Diameter: 4-inch

Grout
Composition: Volclay Grout (Bentonite)

Seal
Type: 0.25-inch pellets (Bentonite)

Filter Pack
Type: Silica Sand
Source: Colorado Silica Sand
Gradation: 8-16

Screen
Type: Schedule 10, Type 304 Stainless Steel
Diameter: 4-inch
Slot Size: 0.010-inch

Sump
Type: Schedule 10, Type 304 Stainless Steel
Bottom Cap Y / N

PTX01-1010

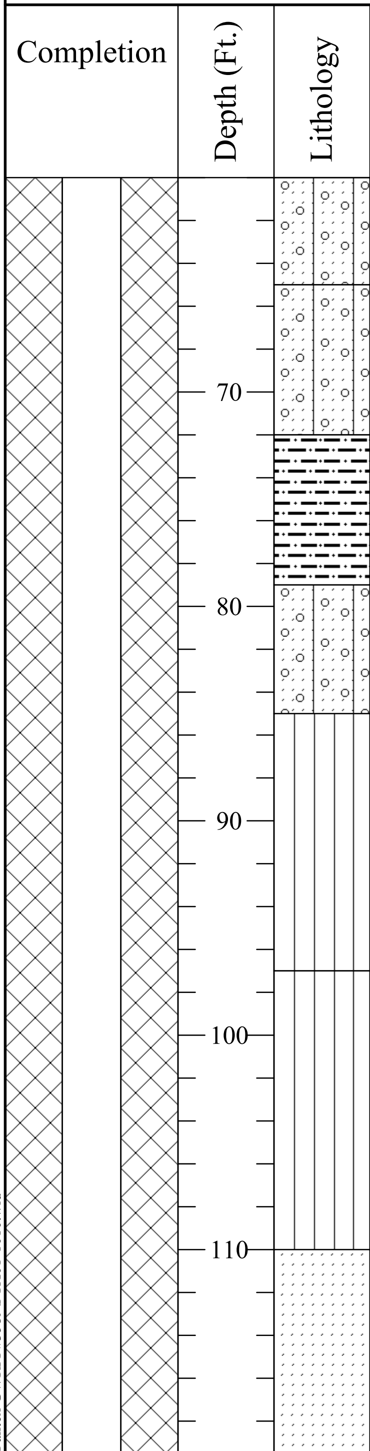
Pantex GW RFI	Pantex Plant (Burning Grounds)	Amarillo, Texas

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML	0-2' SILT, clayey, brown, soft, dry to moist, Topsoil		
	10, 20		CL	2-30' CLAY, silty, reddish yellow to yellowish red (5YR 6/6 to 5/6), very stiff, moist, trace MnO2, caliche nodules <1/4"		
	30, 40, 50		ML	30-57 SILT, clayey, sandy, reddish yellow (7.5YR 6/6), low plasticity, fine grained, hard, damp, trace caliche lenses and MnO2 50' color change to strong brown (7.5YR 6/6), increase in caliche stringers		
			SM	57-65' SAND, silty, w/ clay, yellowish red (5YR 5/6), v fine grain, subrnded, dense, dry, w/ caliche nodes & thin lenses		

PTX01-1010

Pantex GW RFI	**Pantex Plant (Burning Grounds)**		**Amarillo, Texas**
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'



USCS	Description	Sample	Sample Number
SM			
SM	65-72' CALICHE layer with silty sand (as above) numerous nodules and broken pieces to 2"		
RX	72-79' CALICHE CAPROCK, pinkish white (5YR 8/2), thick caliche layer, very dense, dry		
SM	79-85' SAND, silty, pink (7.5YR 7/4), fine to very fine grain, medium dense, dry		
ML	85-97' SILT, sandy, light brown (7.5YR 6/4), loose to medium dense, dry		
ML	97-110' SILT, sandy, pink (7.5YR 7/4), dry, siltyer with depth		
SP	110-125' SAND, trace silt, brownish yellow (10YR 6/8), 90% fine grain, subangular, poorly graded, loose to medium dense, dry; cemented sand at 120'; coarsening to medium grain at 125'		

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PTX01-1010

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP			
	130		ML	125-133' SILT, sandy, 65% silt, light brown (7.5YR 6/4), medium dense, dry, moderately cemented sandstone pebbles		
	140, 150		SP	133-160' SAND, trace silt with depth, reddish yellow (7.5YR 6/4), fine to very fine grain, subangular, poorly graded, loose, dry to damp		
	160, 170		SP	160-182' SAND, light yellowish brown (10YR 6/4), fine to medium grain with trace coarse grain, subangular, poorly graded, loose, dry, some thin cemented layers		

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PTX01-1010

Pantex GW RFI	Pantex Plant (Burning Grounds)	Amarillo, Texas

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP			
	190		SM	182-195' SAND, slightly silty, brownish yellow (10YR 6/6), fine to very fine grain, medium dense with well cemented layers of sandstone, dry		
	200		SW	195-210' SAND, light yellowish brown (10YR 6/4), 10% very fine 70% fine to medium 10% coarse grain, subangular, well graded, medium dense, dry		
	210, 220		SP	210-222' SAND, light yellowish brown (10YR 6/4), 85% fine grain, subangular, poorly graded, medium dense to dense, dry to damp		
	230		SM	222-231' SAND, silty, 80-85% sand, strong brown (7.5YR 5/6), nonplastic, very fine to fine grain trace medium, subangular, poorly graded, medium dense, damp to moist		
			SW	231-245' SAND, light yellowish brown (10YR 6/4), 60% fine to medium 20% very fine 20% coarse with some very coarse and small peagravel (flattened), subrounded, well graded, medium dense, dry		

PTX01-1010

Pantex GW RFI	Pantex Plant (Burning Grounds)	Amarillo, Texas

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SW			
			SW	245-248' SAND, gravelly (10-15%), dark brown (10YR 4/3) to yellowish brown (10YR 5/4), very fine to coarse, subrounded, well graded, dry; "silver dollar" gravel, big and flat		
	250		SM	248-250' SAND, silty, clayey, 40% silts and clays, yellowish red (5YR 5/6), well sorted sand, moist		
			SM	250-258' SILT, clayey, sandy, reddish yellow (5YR 6/6), low plasticity, medium dense, moist, calcic granules		
	260		SM-ML	258-260' SILT, very sandy, reddish yellow (5YR 6/6), nonplastic, fine grained sand, medium dense, moist to damp		
			CL	267-267.5' CLAY, silty, sandy, light brown (7.5YR 6/4), medium plastic, stiff, damp		PTX01-1010-2-0266 VOC, HE
	270		SM	267.5-271.5' SAND, silty, lt yellowish brn (10YR 6/4), fine grain some med, rnded, dense, moist, v thin hvy mineral laminations, clay lense 269-270'; BEGIN CORE SAMPLING		PTX01-1010-2-0269 Permeability Analysis PTX01-1010-2-0271 VOC, HE
			CL	271.5-273.5' CLAY, silty, yellowish brn-brn (10YR 5/4 - 7.5YR 5/4), med plastic, v stiff, moist		PTX01-1010-2-0272 Permeability Analysis
			SC	273.5-275.5' SAND, clayey, w/ silt, brn-lt brn (7.5YR 5/4 - 6/4), fine grain, rnded-well rnded, dense, damp; w/ MnO2 specks		PTX01-1010-2-275.5 Permeability Analysis
			CL	275.5-277.5' CLAY, sandy, silty, brn (7.5YR 5/4), v stiff, moist		
	280		SM	277.5-285' SAND, silty, lt brn (7.5YR 6/4), v fine grain, rnded, dense, dry-dmp		PTX01-1010-2-281.5 Permeability Analysis
			SM-ML	285-287' SAND, silty to SILT, sandy, lt brn (7.5YR 6/4 - 5/4), v fine grain, hard-dense, dry, w/ cemented nodes/siltstone, v dense		PTX01-1010-2-287.5 Permeability/Gradation
	290		SM	287-305' SAND, silty, reddish yellow (7.5YR 6/6), v fine grain, rnded, dense, dmp		PTX01-1010-2-299.5 Permeability/Gradation

PTX01-1010

Pantex GW RFI		Pantex Plant (Burning Grounds)	Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SM	295' ocassional cemented nodules (white) up to 1/4" - 1/2"		
	310		SM	305-320' SAND, silty, light brown (7.5YR 6/4) to light reddish brown (5YR 6/4), very fine to fine grain size, subrounded to well rounded, dense to very dense, with some pinkish white (5YR 8/2) cemented nodules (sand grains) up to 1/2" diameter	■	PTX01-1010-2-0309 Permeability/Gradation
				315' increase in cemented nodules to 10% - 15%	■	PTX01-1010-2-0316 Permeability/Gradation
	320		SM	320-328' SAND, silty, light reddish brown (5YR 6/4), fine to medium, subrounded to well rounded, primarily quartz grains, very dense to hard, dry to damp		
	330		SP	328-336' SAND, silty to SAND, light reddish brown (5YR 6/4), fine to medium grain size, subrounded to well rounded, very dense to hard, dry to damp; with pinkish white (5YR 8/2) cemented sand grain nodules throughout		
			SM-ML	336-340' SAND, silty to SILT, sandy, light reddish brown (5YR 6/4), very fine grained, rounded, dense, damp; END OF CORING		
	340				■	PTX01-1010-2-339.5 Permeability/Gradation
	350		SM	340-375' SAND, silty, reddish brown (5YR 6/4), very fine to fine grained		

PTX01-1010

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	370		SM			
	380		SM	375-440' SAND, silty, brown (7.5YR 5/4), fine grained, rounded, dense		
	390					
	400					
	410					

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PTX01-1010

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	430		SM			
	440		CL	440-455' CLAY, silty, with sand, brown (7.5YR 5/4) to (10YR 5/3)		
	450					
	460		SP	455-540' SAND, light brown (7.5YR 6/4), fine to medium grain		
	470					

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PTX01-1010

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	490		SP			
	500					
	510					
	520		SP			
	530					

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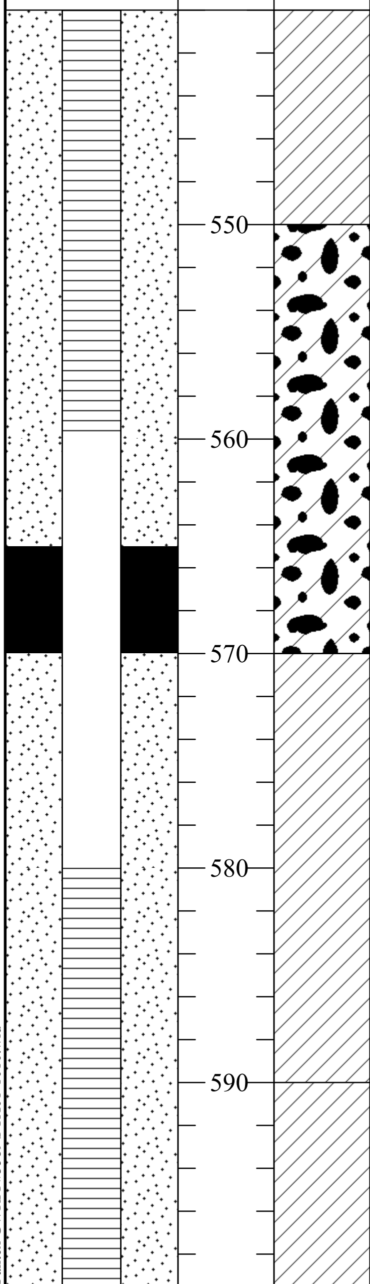
S.M. STOLLER CORPORATION

PTX01-1010

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'



Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			CL	540-550' CLAY, silty, yellowish brown (10YR 5/6), stiff		
			GC	550-570' SAND, yellowish brown (10YR 5/6), very coarse with some pea-gravel, clayey		
			CL	570-590' CLAY, silty, yellowish brown (10YR 5/6)		
			CL	590-630' CLAY, silty, yellowish brown (10YR 5/6)		

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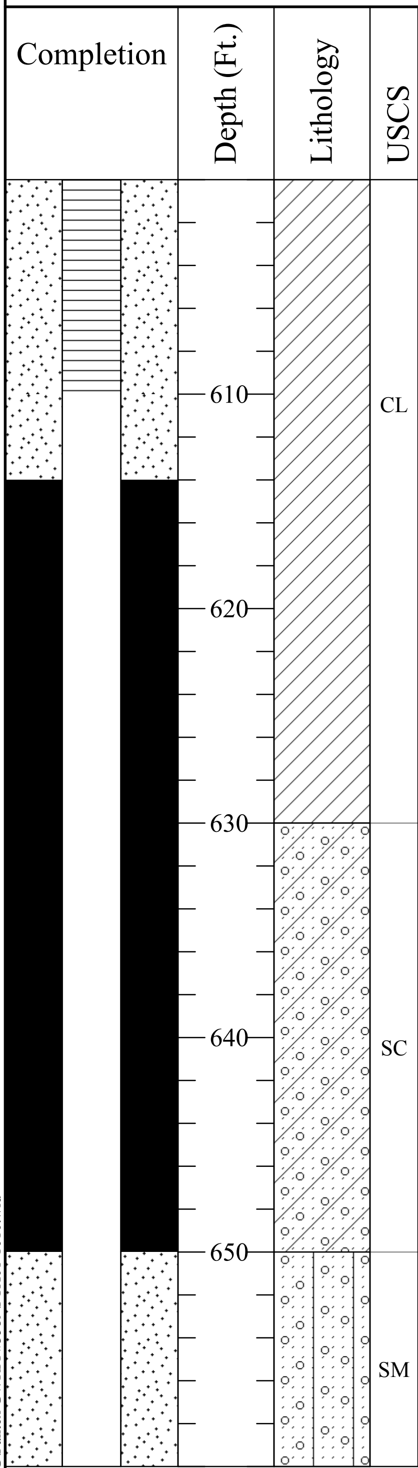
PTX01-1010

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'



Description	Sample	Sample Number
630-650' SAND, some clay, fine to medium grain		
650-720' SAND, silty, light brown, firm		

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S.M. STOLLER CORPORATION

PTX01-1010

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	670					
	680					
			SM			
	690					
	700					
	710					

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PTX01-1010

Pantex GW RFI		Pantex Plant (Burning Grounds)	Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

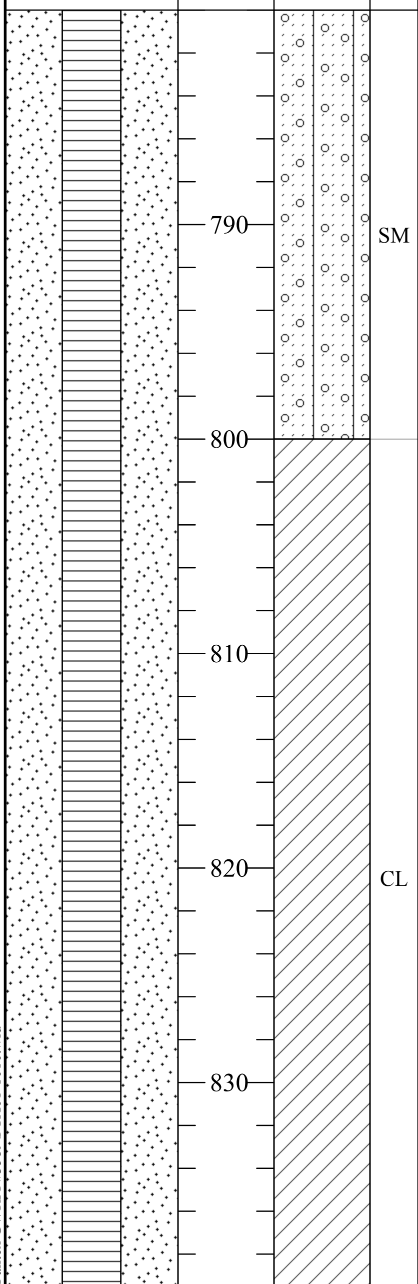
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	720-740		SC	720-740' SAND, with clay, reddish brown (2.5YR 4/4), fine to medium grain		
	740-760		SP	740-760' SAND, reddish brown (5YR 4/4), fine grained		
	760-780		SC	760-780' CLAY, sandy to SAND, clayey, reddish brown (5YR 5/4), fine grained		

Depth scale marks: 730, 740, 750, 760, 770

PTX01-1010

Pantex GW RFI	Pantex Plant (Burning Grounds)		Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SM	780-800' SAND, fine grained		
			CL	800-842' CLAY, brown (7.5YR 5/3)		



PTX01-1010

Pantex GW RFI		Pantex Plant (Burning Grounds)	Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J. Ford/R. Rupp/B. King	Northing: 3771397.26	Easting: 630576.88
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	850' BGS
Dates Drilled:	03/13/00 - 04/04/00	Depth to Water:	479.4' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3574.01'	TOC Elevation:	3576.15'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			CL			
	850		CL	842-850' CLAY, dark reddish brown (2.5YR 3/4), stiff		
	860					
	870					
	880					
	890					

Total Depth of Borehole 850' BGS
Fine Grain Zone 260' BGS
Red Beds 842' BGS

Borehole continuously cored from 265' to 340' using a 3-inch split barrel sampler prior to mud rotary drilling.

Well Completion Details:
Borehole Diameter 12 3/4" from surface to 267' BGS
8 5/8" steel conductor casing cemented from surface to 267' BGS
Borehole Diameter 7 7/8" from 267' to 850' BGS
4-inch, Schedule 10, Type 304, Stainless Steel Casing and Screen Installed
5' Sump (845' - 850'); 180' Screen (665' - 845'); 55' Casing (610' - 665'); 30' Screen (580' - 610'); 20' Casing (560' - 580'); 90' Screen (470' - 560'); 472' Casing (+2' - 470'); Filter Pack, 8/16 Colorado Silica Sand at screen intervals (650' - 850'), (570' - 614'), (451' - 565'); Bentonite Seals (614' - 650'), (565' - 570'), (439' - 451'); Bentonite Grout (Surface - 439'); Concrete Pad (5'X5'X8") with 4 bollards, 10-inch steel Protective Casing with locking cover.

COLOG Division of Layne Christensen Company
17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

ELECTRIC LOG

COM: SM STOLLER
WELL: PTX01-1010
FLD: PANTEX
ST: TX COUNTY:CARSON

COMPANY: SM STOLLER
WELL: PTX01-1010
FIELD: PANTEX
STATE: TX COUNTY: CARSON
LOCATION:
SEC TWP RGE

OTHER SERVICES:

PERMANENT DATUM: Ground Surface ELEVATION: NA
LOG MEAS. FROM: Ground Surface 0.0 FT ABOVE PERM. DATUM
DRILL MEAS. FROM: Ground Surface

DATE ACQUIRED	3/30/00	3/30/00		
RUN NUMBER	1	1		
LOG TYPE	Gamma	Electric		
DEPTH-DRILLER	850'			
DEPTH-LOGGER	851'			
BTM LOGGED INTERVAL	846'	850'		
TOP LOGGED INTERVAL	Surface	267'		
RECORDED BY	Davis			
WITNESSED BY	Ford			
FLUID LEVEL	70'			
FLUID TYPE	Mud			
Rm at TEMP	N/A			
TIME SINCE CIRC.	N/A			
PROBE TYPE, S/N	RABPF 2171	EPF1567		
MODULE TYPE, S/N	UM 1524	UM 1524		
LOGGING SPEED	15 ft/min	15 ft/min		
A.S.D.E.	0.9'	0.9'		
SAMPLE INTERVAL	0.1'	0.1'		
SOURCE S/N	None	None		

BOREHOLE RECORD

BIT SIZE	FROM	TO
10"	Surface	267'
8"	267	850'

CASING RECORD

SIZE/WGT	FROM	TO
Sump	845'	850'
Screen	470'	845'
Riser	Surface	470'

COMMENTS:

Drill Type: ARCH 0-267'
Mud Rotary 267-850'

8 5/8" Conductor Casing Set Surface to 267'

COMMENTS:

4" Type 304 Stainless Steel Casing & Screen
Screen Slot 0.010

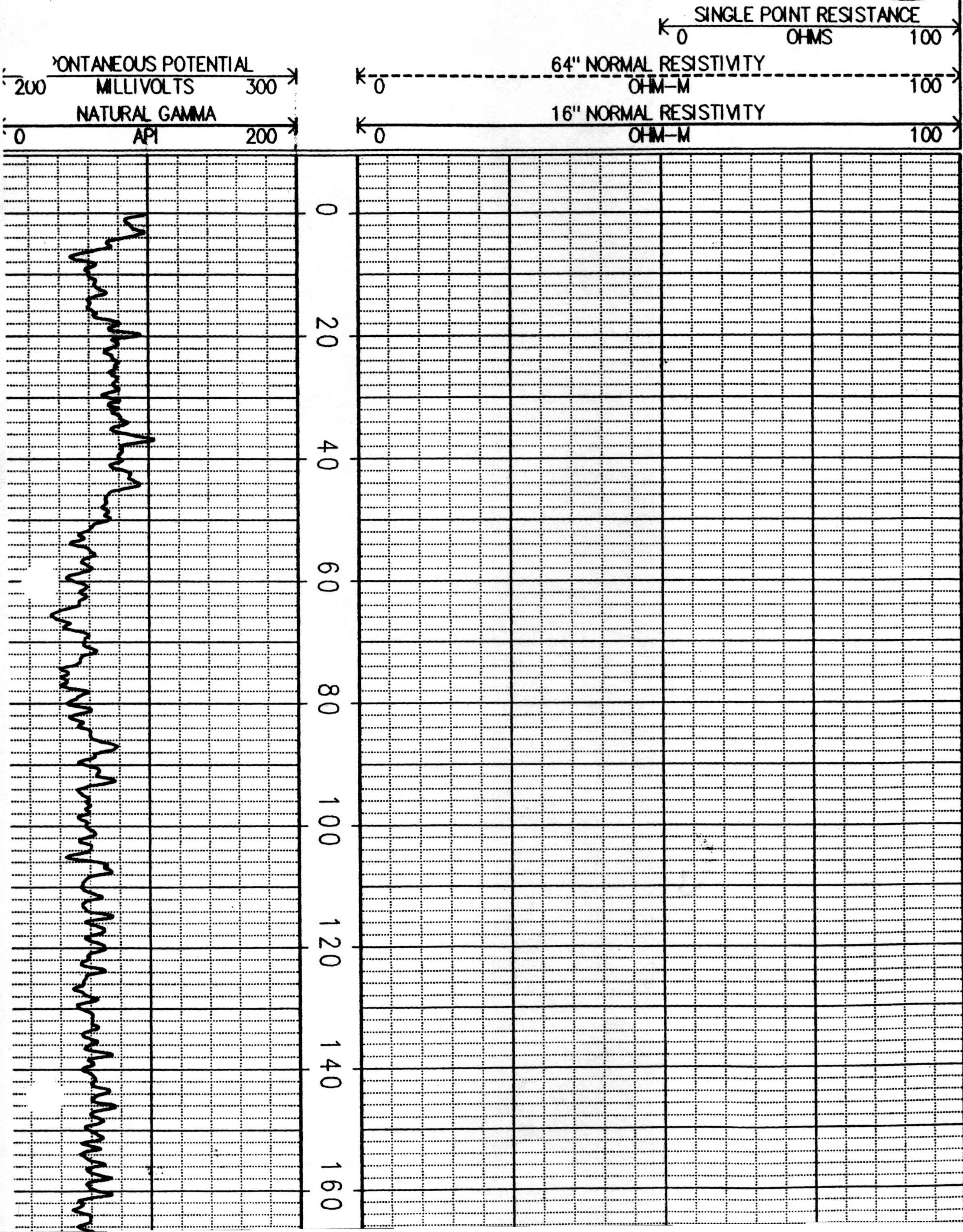
Borehole Logged Open Hole from 267-850'

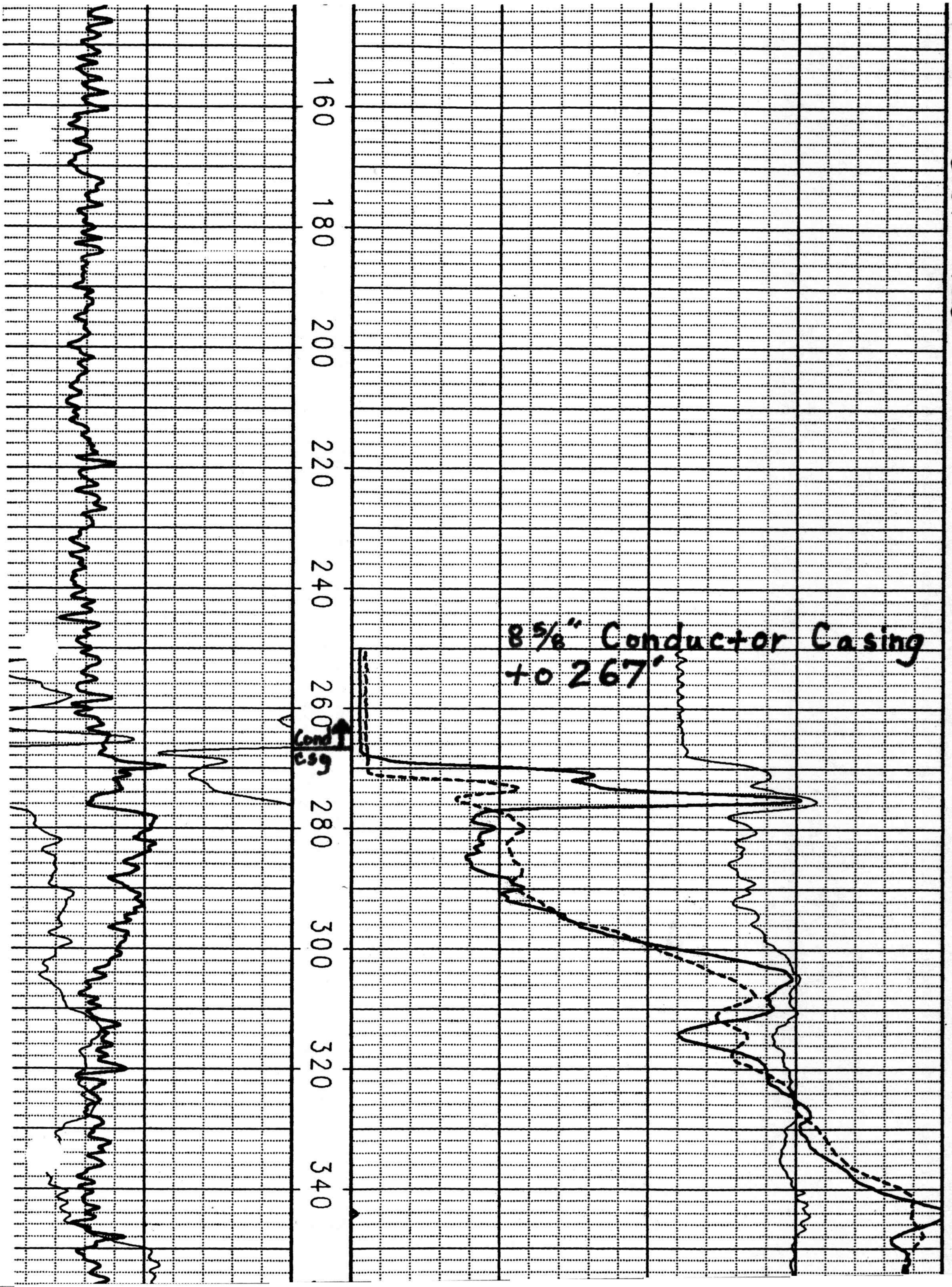
NA - NOT AVAILABLE, N/A - NOT APPLICABLE

DIGITAL FILES: 1010.dat, 1010.HDP, 1010.PLP

SM STOLLER, PTX01-1010, 3/30/00

COLOG




160
180
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220
240
260
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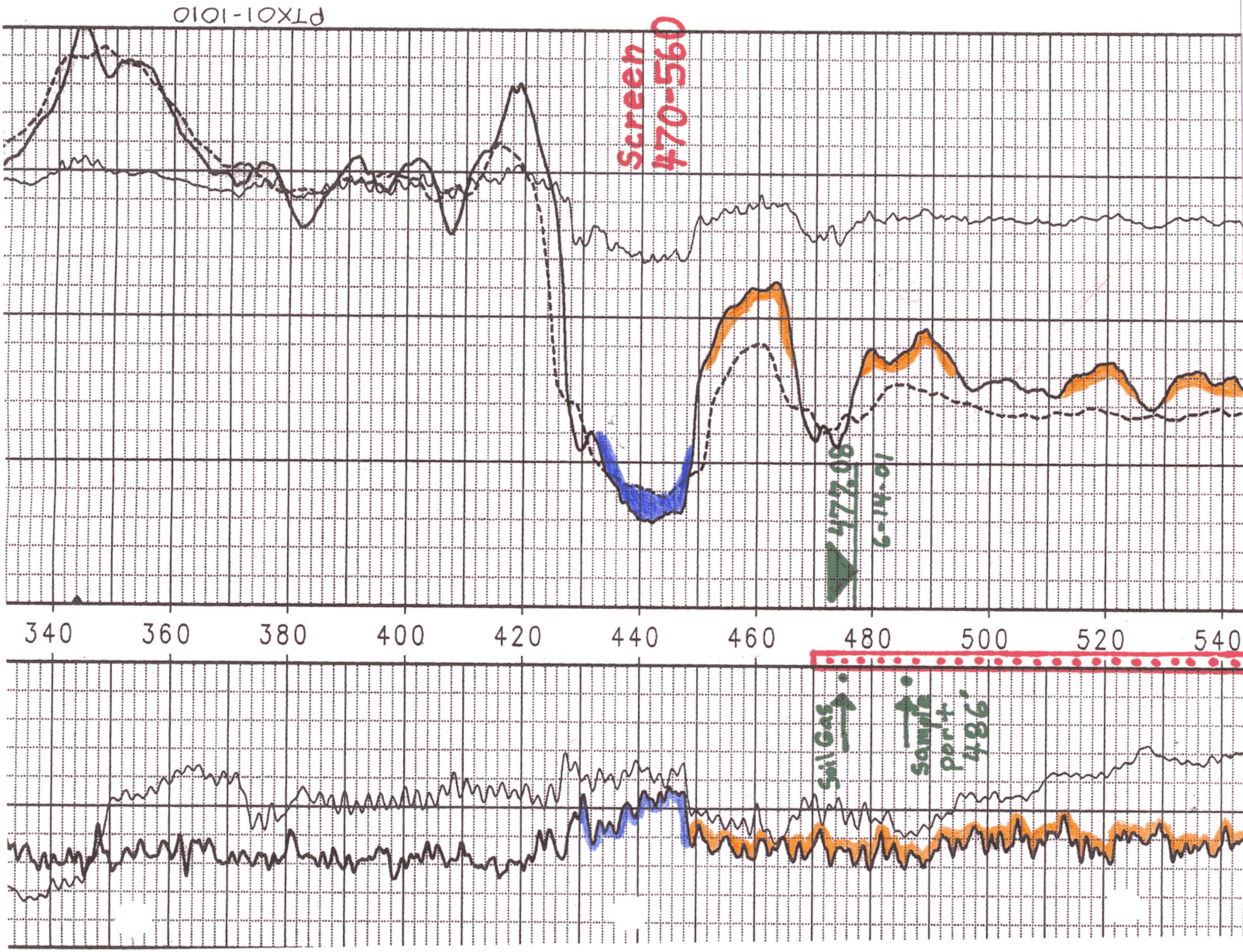
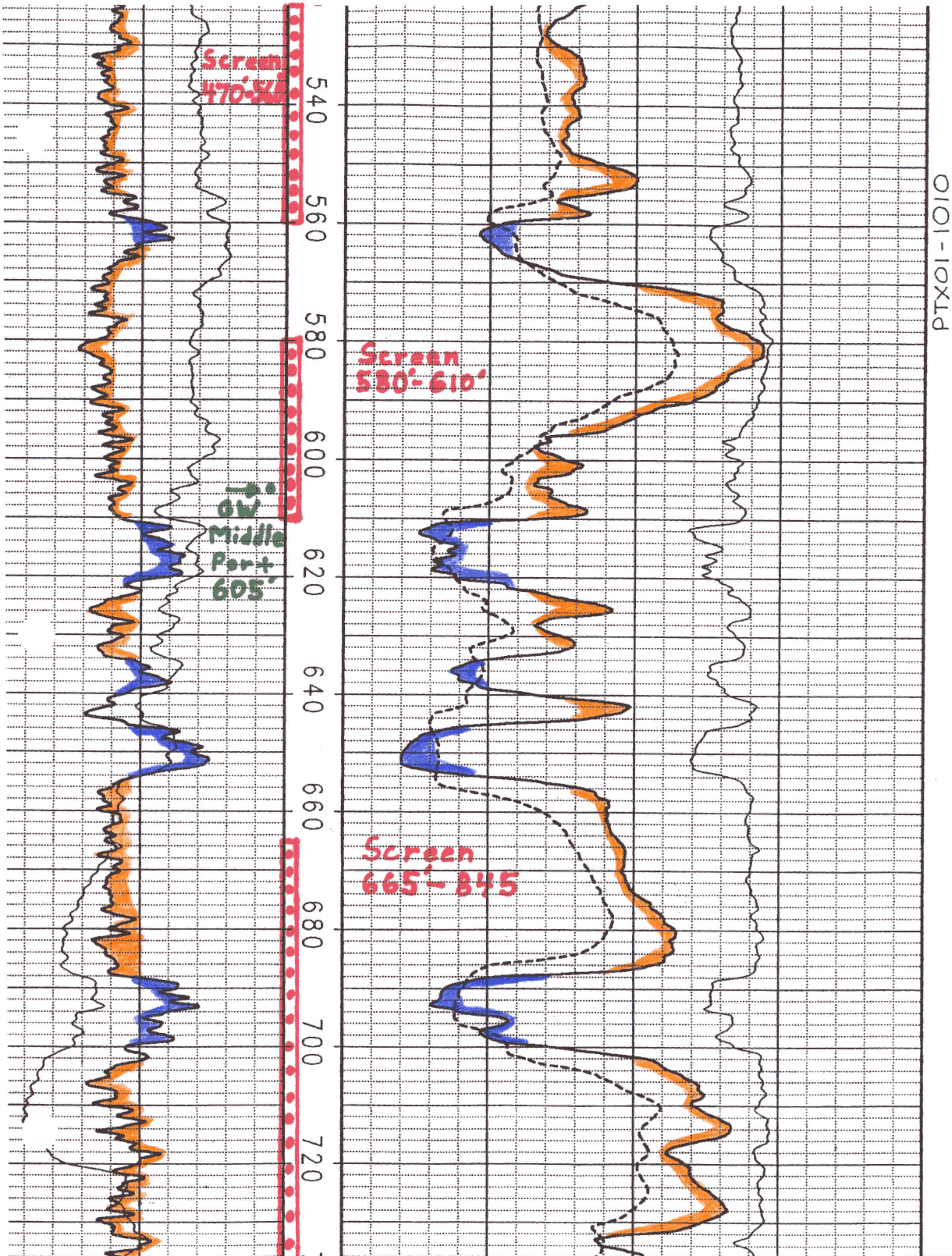
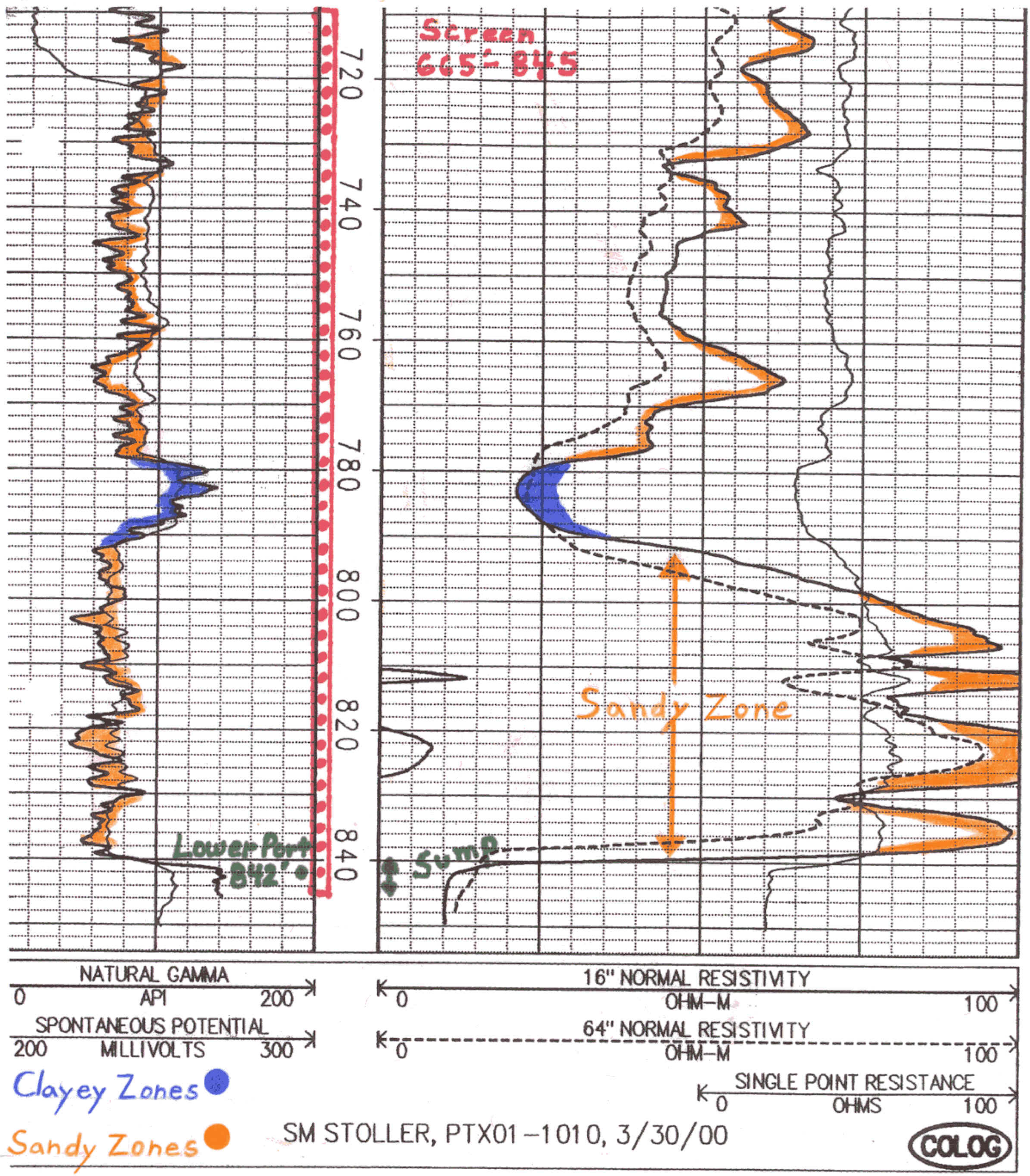
320
340
Cond Csg
8 5/8" Conductor Casing
to 267'

PTX01-1010

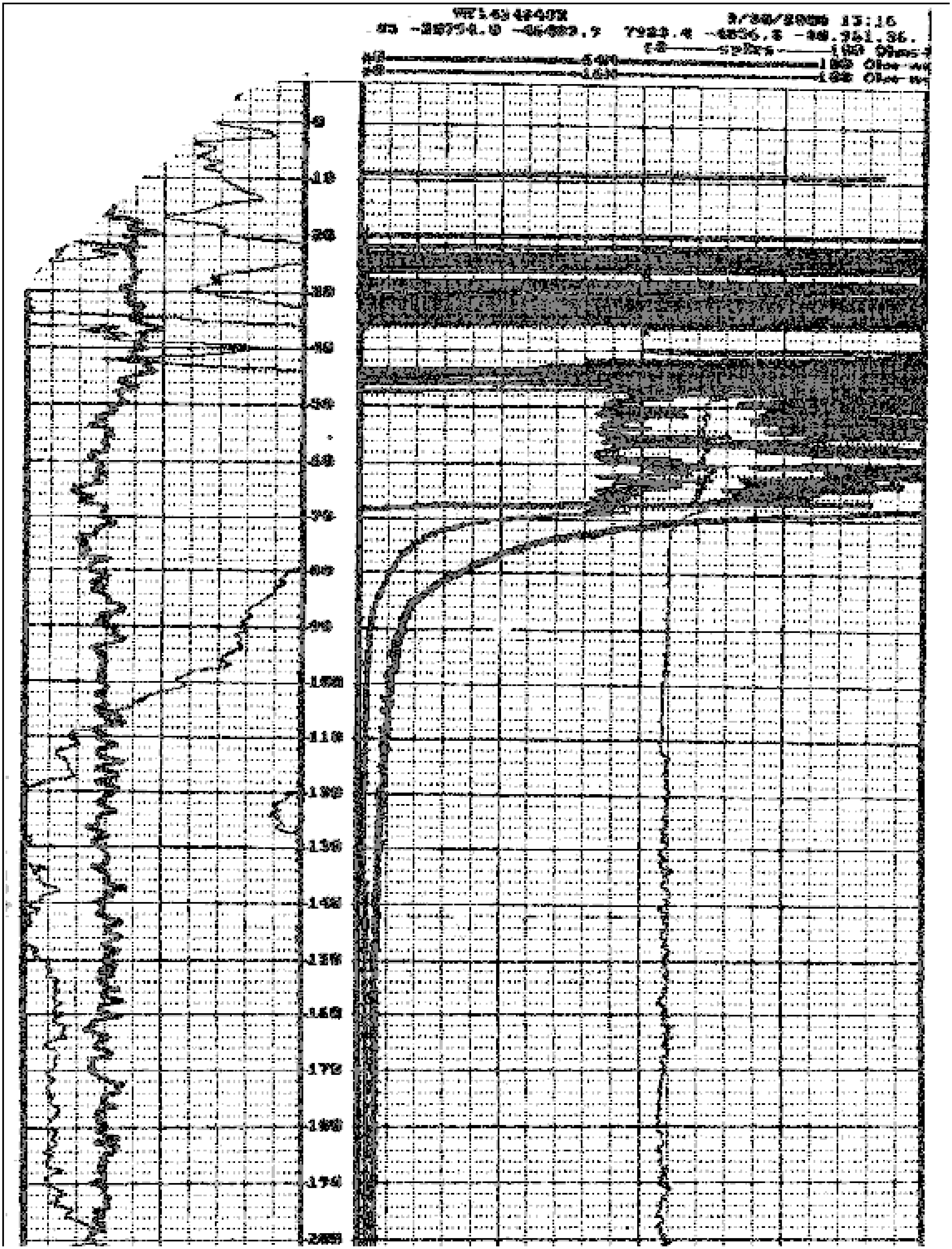

PTX01-1010
Screen
470-560
477.08
6-14-01
340
360
380
400
420
440
460
480
500
520
540
Soil Gas
Sample
port
486'



PTXO1-0101
Screen 470'-560'
Screen 580'-610'
OW Middle Port 605'
Screen 665'-845
540
560
580
600
620
640
660
680
700
720



Screen
665'-845
720
740
760
780
800
820
840
Lower Port
842'
Sump
Sandy Zone
NATURAL GAMMA
0 API 200
SPONTANEOUS POTENTIAL
200 MILLIVOLTS 300
16" NORMAL RESISTIVITY
0 OHM-M 100
64" NORMAL RESISTIVITY
0 OHM-M 100
SINGLE POINT RESISTANCE
0 OHMS 100
Clayey Zones
Sandy Zones
SM STOLLER, PTX01-1010, 3/30/00
COLOG



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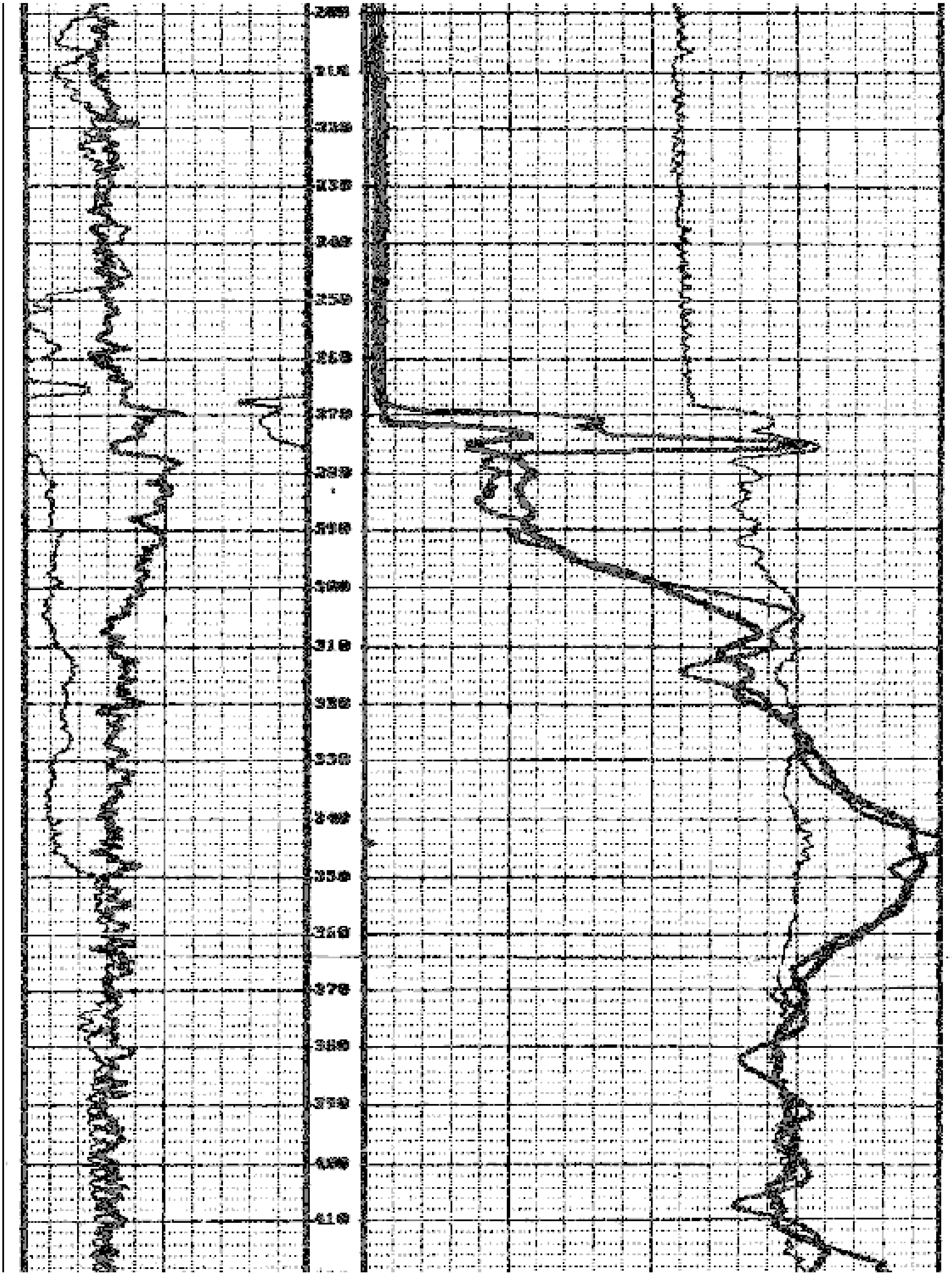
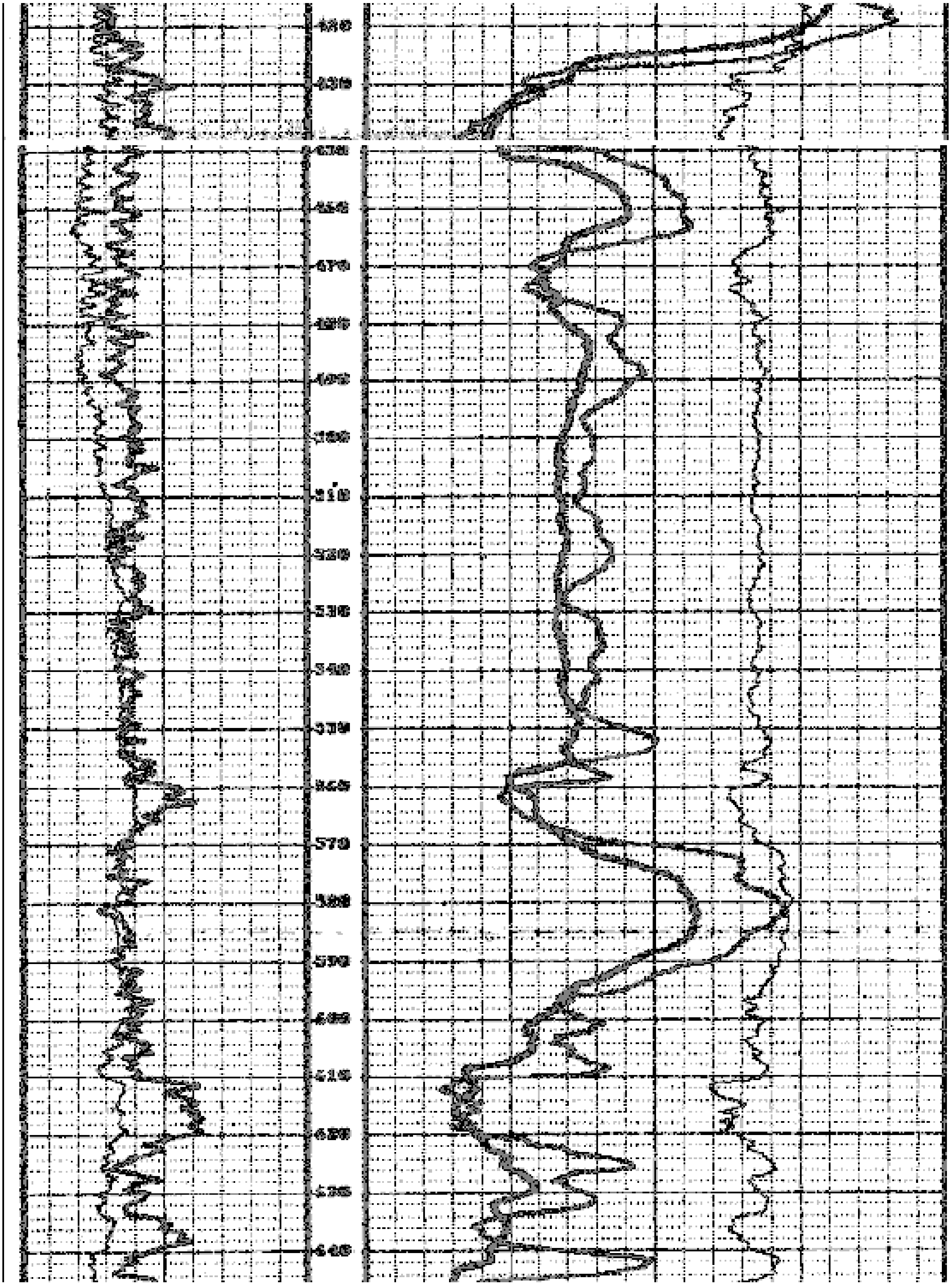
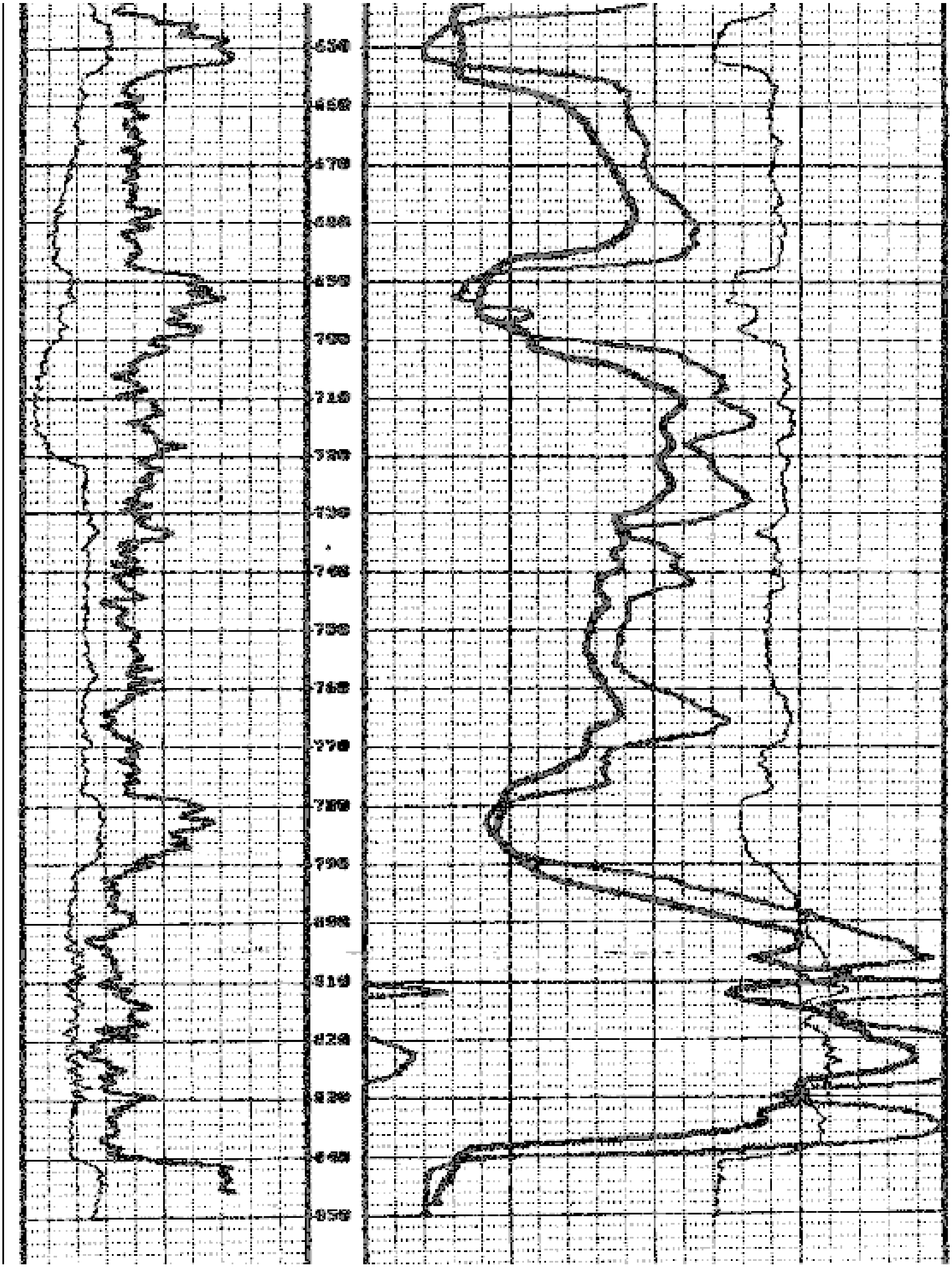




510
570


650
660
670
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[illegible] 3/[illegible]/2000 14:34
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[illegible] 2F [illegible] 1[illegible] Ohm[illegible]
[illegible] [illegible] 1[illegible] Ohm[illegible]

PTX01-1010

Form No. 98-DOM-01

Panhandle Ground Water Conservation District No. 3

Application For Water Well Registration

WELL NUMBER ____________________
APPLICATION DATE ____________________
RECEIVED BY ____________________
COMPLETION DATE ____________________

1. Well Owner **U.S. Department of Energy - Pantex Plant**

   Address **P.O. Box 30020 Amarillo, Texas 79120**

   Phone **(806) 477-3183**

2. Well Location: **Carson** County

   NW1/4 NE1/4 SW1/4 SE1/4 Section 51 Block M-4 Survey **J.H. Gibson**
   (Circle One that Applies)

   4 miles N S and **17** miles E W of the town of **Amarillo, Texas**

   ______ measured yards from N or S, (property) or (section) line, and

   ______ measured yards from E or W, (property) or (section) line
   (Circle all that apply)

   Latitude____________________ Longitude____________________ (if known)

   Easting 630717.7 Northing 3769642.9

3. Well Description: **PTX01-1010**

   Anticipated Drill Date 1-20-00 Driller Peterson Drilling

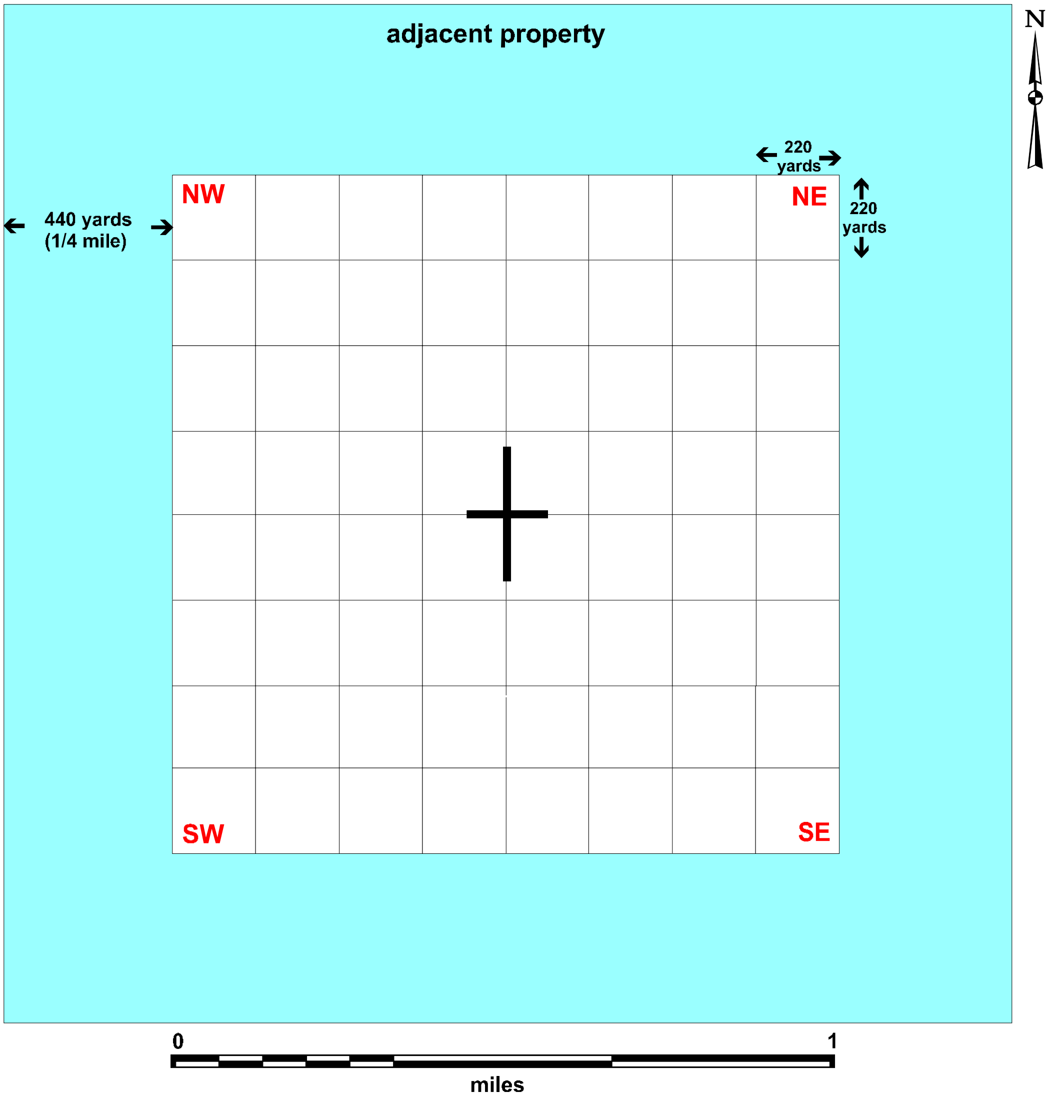
   Casing Size 4"

   Pump Size Sample Pump

4. Well Use: Domestic Stock Watering Other Monitoring Well

–

5. Locate well by marking dot inside a circle within the grid to show proposed well location. Grid represents one section or one square mile.



I agree that this well will be drilled within ten (10) yards of the location specified and not elsewhere, and that I will furnish the Board of Directors the completed well log immediately upon completion of this well and prior to the production of water. I hereby certify that I have read the foregoing statements, and that all data therein contained are true and correct to the best of my knowledge and belief.

This notice given by:

____

(Signature of Owner or Agent) Title

I, hereby, certify that this application has been verified and is in compliance with the Rules of the District.

_________________________________ _______________

District Manager Date

PTX01-1011

aka:

Contractor: S.M. Stoller
Contract #: 3350-105
Contractor's Project #:
Drilled date: 04/26/2000

OPTIX #:
Last Update: 07/28/2004 (add missing pages/better pages from Stoller data)

Standard Included Documents

(Others may also be included)

Drilling/Boring Log

___ Draft
___ Final

_X__ Installation Log/Diagram

Lithologic Logs

___ Draft Visual Classification of Soils (handwritten)
_X_ Final Visual Classification of Soils (computerized)

Geophysical Logs

___ Neutron
___ Gamma
___ Compensated Density
___ e-Log
___ Bond Log
___ Deviation Log

___State Well Report
___State Plugging Report

Monitor Well Installation Diagram

Project: Pantex GW RFI

Location: North of Burning Grounds

Contractor: Stewart Brothers Drilling Co.

Driller: M.King

Well Coordinates: N-3771397.29 / E-629986.45

TOC Elevation: 3575.07

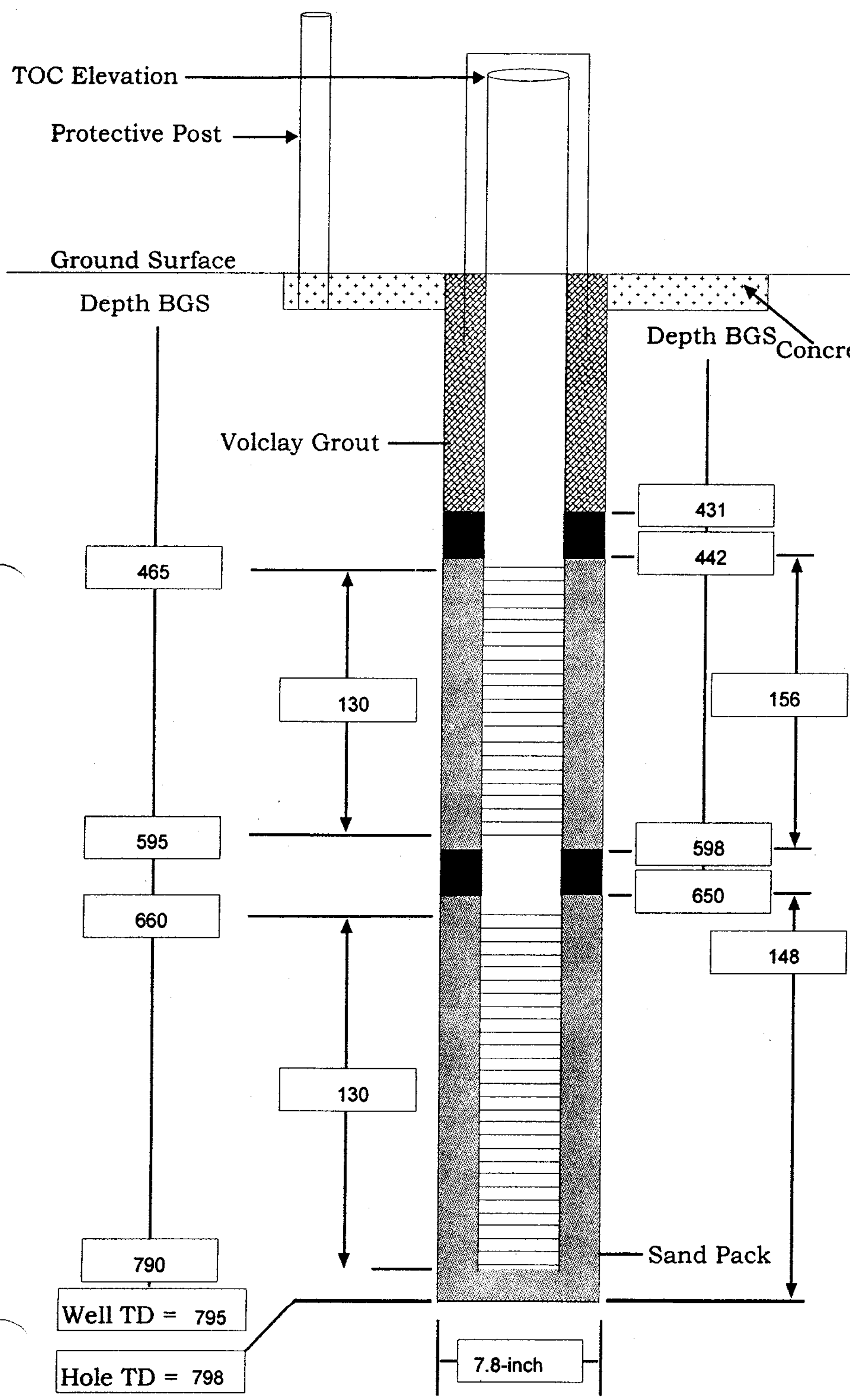
Surface Elevation: 3572.81

Monitor Well No: PTX01-1011

Date Constructed: 4-26-00

Observed by: J.Ford

Sheet 1 of 1



Protective Casing

Material: Steel

Diameter: 10-inch with 8-inch to 267'

Surface Pad

Composition & Size: 5'x5'x8"

Riser Pipe

Type: Schedule 10, Type 304 Stainless Steel

Diameter: 4-inch

Grout

Composition: Volclay Grout (Bentonite)

Seal

Type: 0.25-inch pellets (Bentonite)

Filter Pack

Type: Silica Sand

Source: Colorado Silica Sand

Gradation: 8-16

Screen

Type: Schedule 10, Type 304 Stainless Steel

Diameter: 4-inch

Slot Size: 0.010-inch

Sump

Type: Schedule 10, Type 304 Stainless Steel

Bottom Cap Y / N

PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	0-5		ML	0-5' SILT, clayey, brown (10YR 4/3), soft, moist, Topsoil		
	10, 20		ML-CL	5-25' SILT, clayey to CLAY, silty, yellowish red (5YR 5/6), stiff, with caliche nodules and lenses		
	30, 40		ML	25-45' SILT, clayey, reddish yellow (7.5YR 7/6), low plasticity, medium stiff, dry, with caliche stringers and MnO2 specks		
	50		ML	45-60' SILT, sandy, clayey, reddish yellow (7.5YR 6/6), low plasticity, very fine sand, medium stiff, dry, with MnO2 and caliche nodules (1-2 mm) throughout		

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S.M. STOLLER CORPORATION

PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
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Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SM	60-63' CALICHE layer, pink (5YR 8/3), very dense		
			SM-SC	63-78' SAND, silty, with clay, yellowish red (5YR 5/6 - 5/8), fine and medium grain, rounded, moderately dense, damp		
			RX	78-84' CALICHE layer, pinkish white (5YR 8/2), hard		
			SM	84-105' SAND, silty, pink (5YR 7/4), fine and medium grain, dense, dry, with caliche nodules and lenses		
			SM	105-110' SAND, silty, fine grained, dense, dry, interbedded with caliche and cemented sand lenses		
			SP	110-125' SAND, very pale brown (10YR 8/4), fine to medium, subrounded to well rounded, loose, dry		

PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
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Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP			
	130		SP-SM	125-135' SAND, to silty SAND, pink (7.5YR 7/4), very fine to fine grained, loose, dry		
	140, 150		SP	135-160' SAND, yellow (10YR 7/6), very fine to fine, subrounded to rounded, loose, dry; thin, dense, sandstone beds		
	160		SP	160-164' SAND, very pale brown (10YR 7/4), very fine to fine, with trace medium, subrounded to rounded, loose, dry		
	170		SP-SM	164-176' SAND to silty SAND, light brown (7.5YR 6/4), fine to medium, subrounded to rounded, loose, dry		
			SP	176-215' SAND, very pale brown (10YR 7/4) to light yellowish brown (10YR 6/4), fine grained, loose, dry; same as above but		

PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
				with some thin, very dense sandstone lenses		
	190					
			SP			
	200					
	210					
			SP-SM	215-220' SAND to silty SAND, light brown (7.5YR 6/4), very fine to medium, subrounded to well rounded, loose, damp; trace sandstone and caliche lenses		
	220			220-233' SAND, very pale brown (10YR 7/4), fine to medium grain, subangular to rounded, loose to very dense on sandstone lenses, dry		
			SP			
				230' color change to strong brown (7.5YR 5/6)		
	230					
			SP-SW	233-241' SAND, light yellowish brown (10YR 6/4), very fine to medium with coarse grain, subangular to rounded, moderately dense, dry		

PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP	241-246' SAND and SANDSTONE lenses, very pale brown (10YR 7/4), subrounded, moderately dense to very dense, dry		
			SP-SM	246-248' SAND to silty SAND, light brown (7.5YR 6/4), fine to medium grain, moderately dense, damp		
			SM	248-250' SAND, silty, with some clay, brown (7.5YR 5/4), fine to medium grained, moderately dense, moist		
	250		SM	250-253' SAND, silty to SAND, clayey, silty, brown (7.5YR 5/4), fine to coarse, moderately dense, moist		
			GM	253-259' GRAVEL, sandy, with silt and clay, fine to coarse gravel, angular to flat and rounded; fine to coarse sand; dense		
	260		SM-ML	259-262' SAND,silty to SILT, sandy, light reddish brown (5YR 6/4), fine grain, damp		
			ML-CL	262-267' SILT, sandy, clayey, to CLAY, silty, reddish brown (5YR 5/4), clay content increases with depth, dense, damp to dry, fine grain sand, trace caliche nodules in siltstone-like material		
	270		CL	267-275' CLAY, increasing as above		
	280		SM-ML	275-285' SILT, sandy, light reddish brown (5YR 6/4), fine grained sand		
	290		SM	285-295' SAND, silty, reddish brown (5YR 5/4), very fine to fine grained		
			CL	295-299' CLAY, sandy, yellowish brown (10YR 5/6), stiff		

PTX01-1011

Pantex GW RFI	Pantex Plant (Burning Grounds)	Amarillo, Texas	
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	310, 320		SP-SM	299-330' SAND to silty SAND, reddish brown (5YR 5/4), fine grained with some pea-sized angular pebbles; with some thin (<6") yellow-brown clay lenses		
	330, 340, 350		SP	330-370' SAND, brown (7.5YR 5/4), fine grained with medium, same as above		

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PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP			
	370		SM	370-385' SAND, silty, light reddish brown (5YR 6/4), fine with medium grain size		
	380					
	390		SP	385-445' SAND, light brown (7.5YR 6/4), fine grained with trace medium		
	400			405' Same, light brown (7.5YR 6/3)		
	410			420' Same, light reddish brown (5YR 6/4)		

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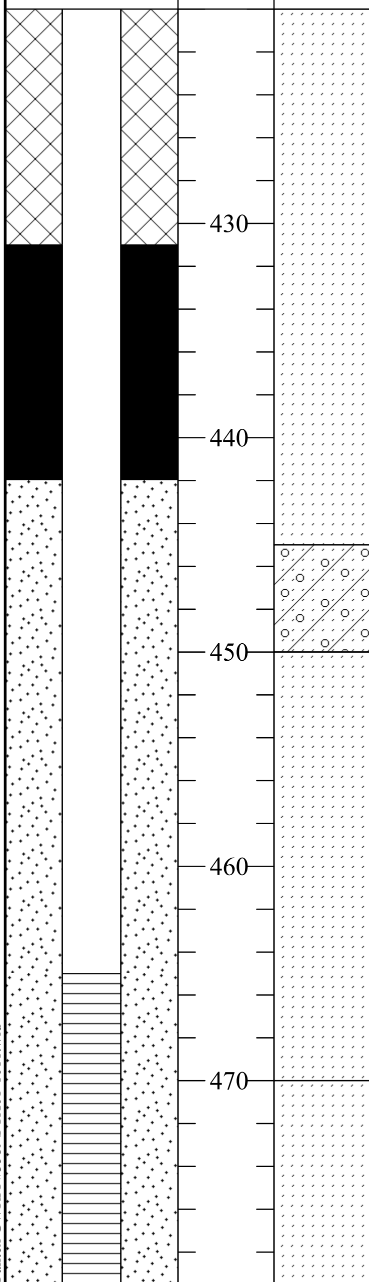
S.M. STOLLER CORPORATION

PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'



Depth (Ft.)	USCS	Description	Sample	Sample Number
430	SP			
440				
445	SC	445-450' SAND, clayey, pale brown (10YR 6/3), fine grained		
450	SP-SM	450-470' SAND, some silt, reddish brown (5YR 5/4), fine grained with trace medium and caliche nodules		
460				
470	SP	470-512' SAND, pale brown (10YR 6/3), fine to medium grained, rounded to well rounded		

PTX01-1011

Pantex GW RFI	Pantex Plant (Burning Grounds)		Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	490					
			SP	493' same as above		
	500					
	510					
			SP	512-540' SAND, light brown (7.YR 6/4), fine grained, well rounded		
	520					
	530					

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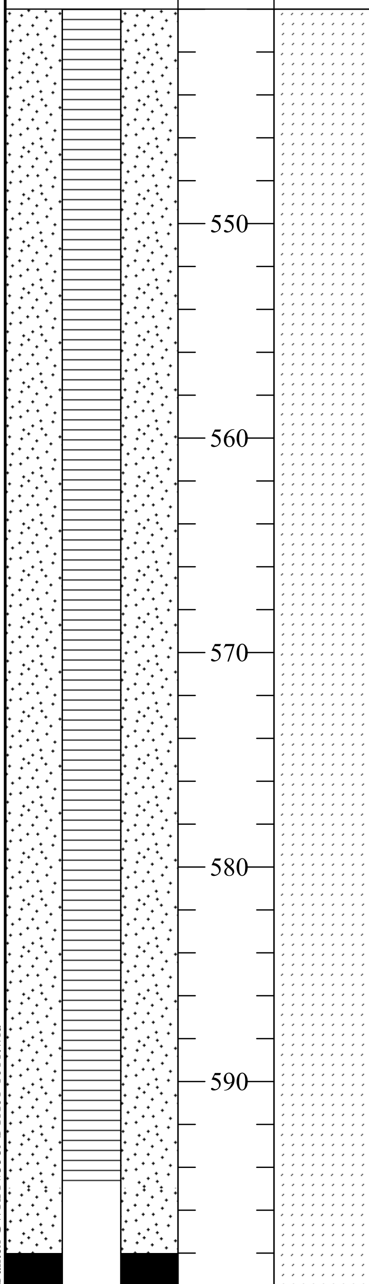
PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	550, 560, 570, 580, 590		SP	540-600' SAND, light yellowish brown (10YR 6/4), fine to medium grained, with silty sand layers		



PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	600–610		CL	600-610' CLAY, yellow brown (10YR 5/6), high plasticity, stiff		
	610–645 (620, 630, 640)		SP-SM	610-645' SAND to silty SAND, light yellowish brown (10YR 6/4), poorly graded		
	645–655 (650)		CL	645-655' CLAY, silty, brown (10YR 5/3), low plasticity, stiff		
	655–		SP	655-680' SAND, very pale brown (10YR 7/3), very fine to medium grain size		

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PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	670		SP			
	680			680-705' SAND to silty SAND, light yellowish brown (10YR 6/4), fine grained		
	690		SP-SM			
	700					
				705-745' SAND, light brown, very fine grained		
	710		SP			

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PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	730					
	740		SP			
			CL	745-750' CLAY, trace to some silt, red (2.5YR 5/6), low to medium plasticity, stiff		
	750					
	760		SC	750-775' SAND, clayey, light gray (10YR 7/1) to red (2.5YR 4/5), dense to stiff, interbedded sands and clays,		
	770					
			SM	775-786' SAND, silty, clayey, pink (5YR 7/4), very fine to fine grain, subangular sand, dense, white calcic nodes and thin inclusions		

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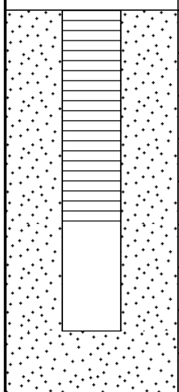
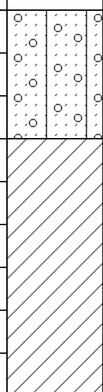
PTX01-1011

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / T.Hall	Northing: 3771397.29	Easting: 629986.45
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	798' BGS
Dates Drilled:	03/15/00 - 04/26/00	Depth to Water:	475.45' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.81'	TOC Elevation:	3575.07'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	790		CL	786-798' CLAY, red (2.5YR 4/6), very stiff to hard red bed formation		
	800 810 820 830			Total Depth of Borehole 798' BGS Fine Grain Zone 262' BGS Red Beds 786' BGS Well Completion Details: Borehole Diameter 12 3/4" from surface to 270' BGS 8 5/8" steel conductor casing set from surface to 270' BGS Borehole Diameter 7 7/8" from 270' to 798' BGS 4-inch, Schedule 10, Type 304, Stainless Steel Casing and 10 Slot Screen 5' Sump (790' - 795'); 130' Screen (660' - 790'); 65' Casing (595' - 660'); 130' Screen (465' - 595'); 467' Casing (+2' - 465'); Filter Pack, 8/16 Colorado Silica Sand at the screen intervals (650' - 798'), (442' - 598'); Bentonite Seals ((598' - 650'), (431' - 442'); Bentonite Grout (Surface - 431'); Concrete Pad (5'X5'X8") with 4 bollards, 10-inch steel Protective Casing with locking cover.		

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COLOG Division of Layne Christensen Company

17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

ELECTRIC LOG

COM: SM STOLLER
WELL: PTX01-1011
FLD: PANTEX
ST: TX COUNTY: CARSON

COMPANY: SM STOLLER
WELL: PTX01-1011
FIELD: PANTEX
STATE: TX COUNTY: CARSON

LOCATION:

SEC TWP RGE

OTHER SERVICES:

PERMANENT DATUM: Ground Surface ELEVATION: NA
LOG MEAS. FROM: Ground Surface 0.0 FT ABOVE PERM. DATUM
DRILL MEAS. FROM: Ground Surface

DATE ACQUIRED	4/26/00	4/26/00		
RUN NUMBER	1	1		
LOG TYPE	Gamma	Electric		
DEPTH-DRILLER	798'			
DEPTH-LOGGER	796'			
BTM LOGGED INTERVAL	790'	795'		
TOP LOGGED INTERVAL	Surface	272'		
RECORDED BY	Davis			
WITNESSED BY	Ford			
FLUID LEVEL	Surface			
FLUID TYPE	Mud			
Rm at TEMP	N/A			
TIME SINCE CIRC.	N/A			
PROBE TYPE, S/N	RABPF 2171	EPF1567		
MODULE TYPE, S/N	UM 1524	UM 1524		
LOGGING SPEED	15 ft/min	15 ft/min		
A.S.D.E.	0.8'	0.8'		
SAMPLE INTERVAL	0.1'	0.1'		
SOUR[illegible]IZE, S/N	None	None		

BOREHOLE RECORD		
BIT SIZE	FROM	TO
10"	Surface	267'
8"	267'	798'

CASING RECORD		
SIZE/WGT	FROM	TO
Sump	790'	795'
Screen/Blank	465'	790'
Riser	Surface	466'

COMMENTS:
Drill Type:
Arch 0-267'
Mud Rotary 267-798'

8 5/8" Conductor Casing
set Surface to 267'

NA - NOT AVAILABLE, N/A - NOT APPLICABLE

COMMENTS:
4" Type 304 Sch 10 Stainless Steel
Casing & Screen
Screen Slot 0.010

Borehole Logged Open Hole 272-TD'

DIGITAL FILES: 1011.dat, 1011.HDP, 1011.PLP

SM STOLLER, PTX01-1011, 4/26/00

COLOG

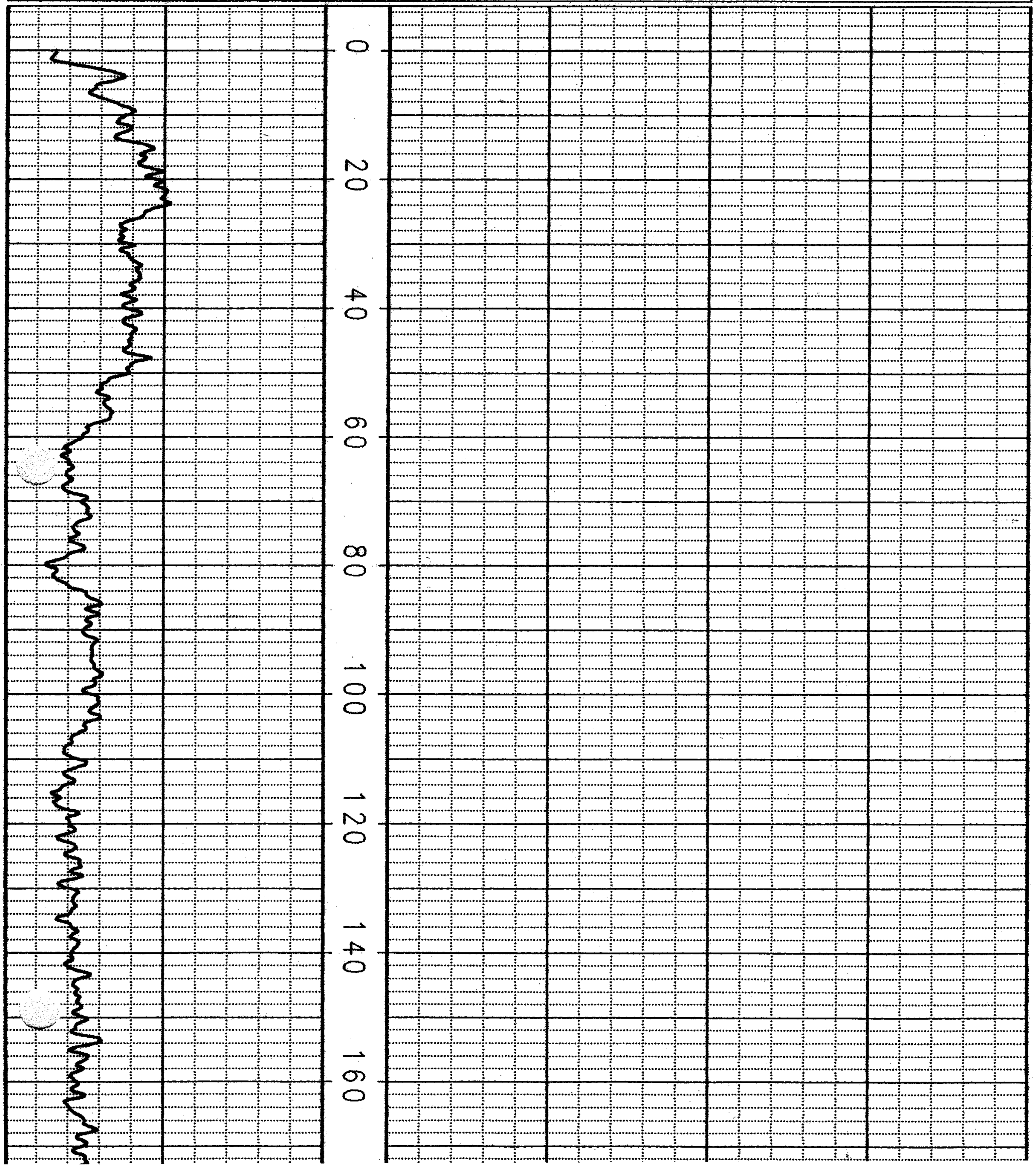
SINGLE POINT RESISTANCE
0 OHMS 100

SPONTANEOUS POTENTIAL
00 MILLIVOLTS -200

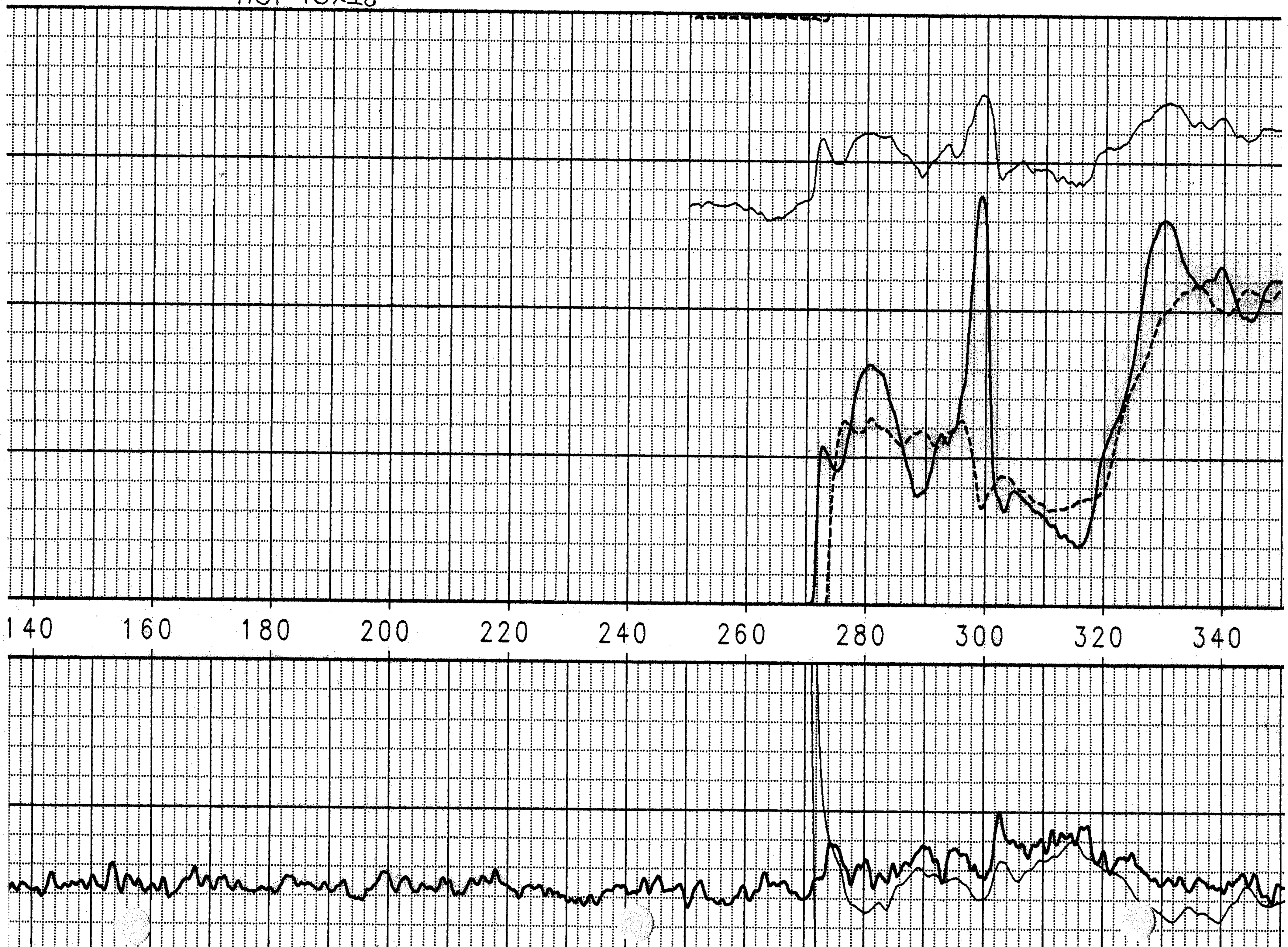
NATURAL GAMMA
0 API 200

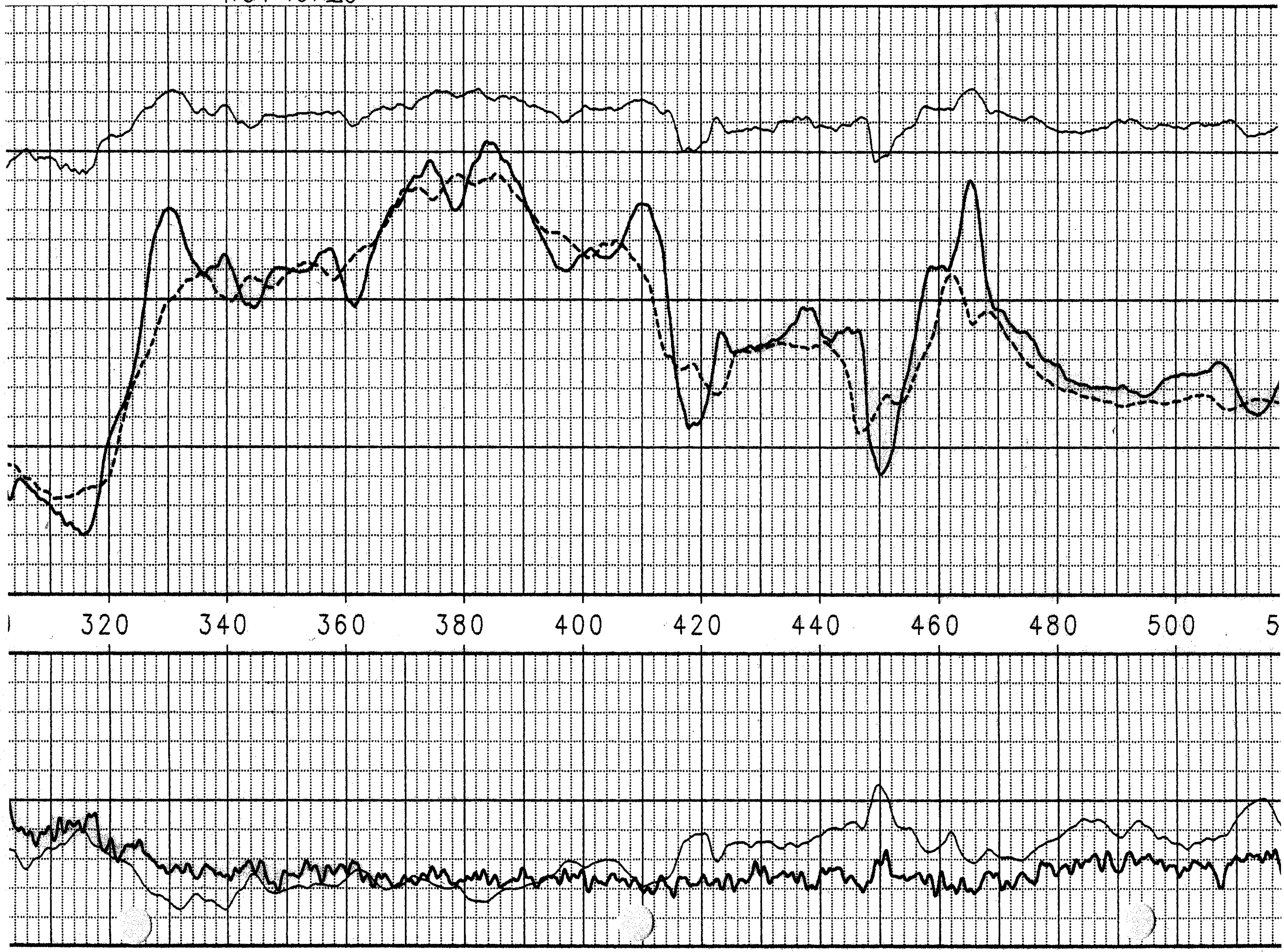
64" NORMAL RESISTIVITY
0 OHM-M 100

16" NORMAL RESISTIVITY
0 OHM-M 100



PTX01-1011

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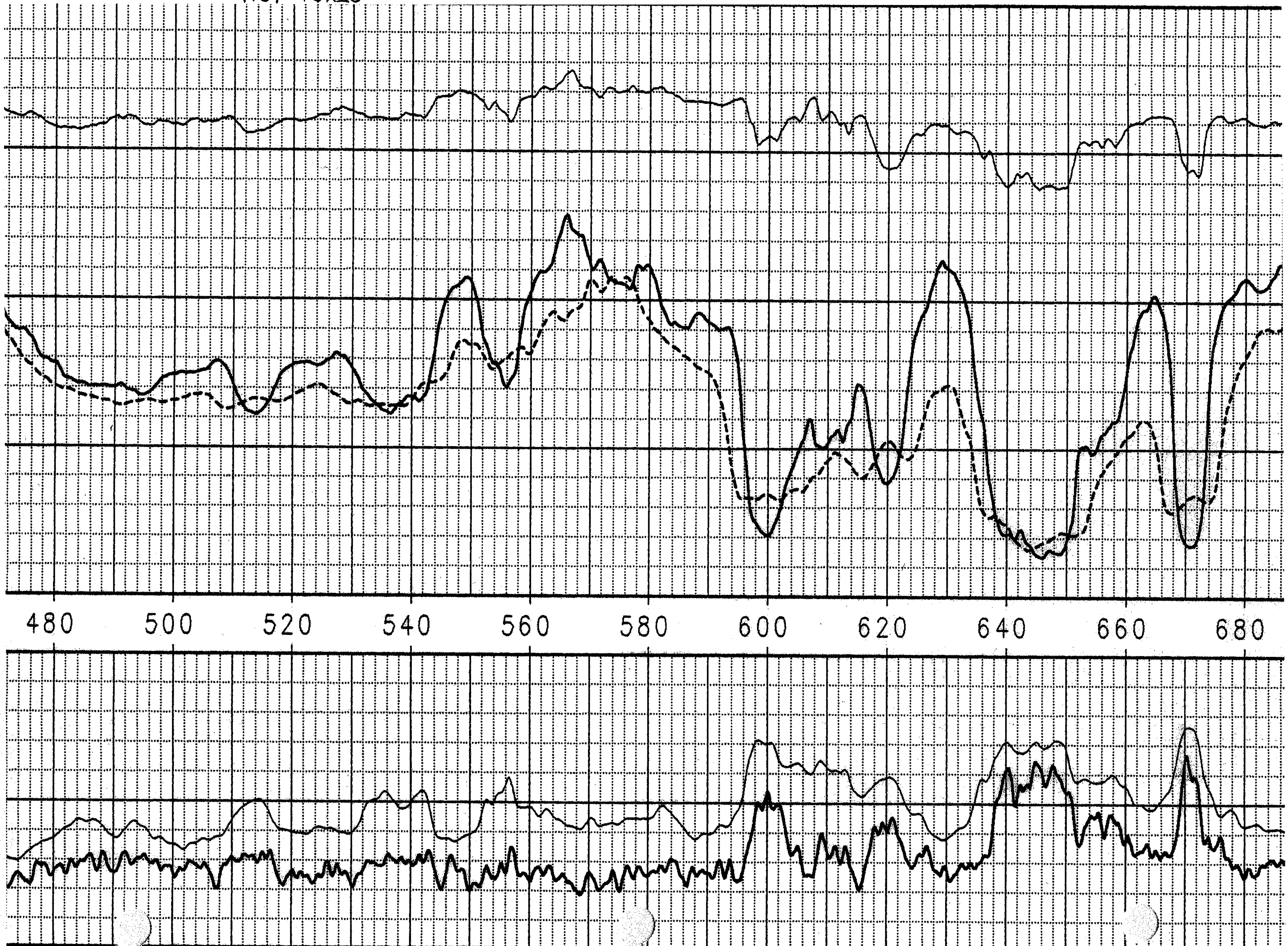
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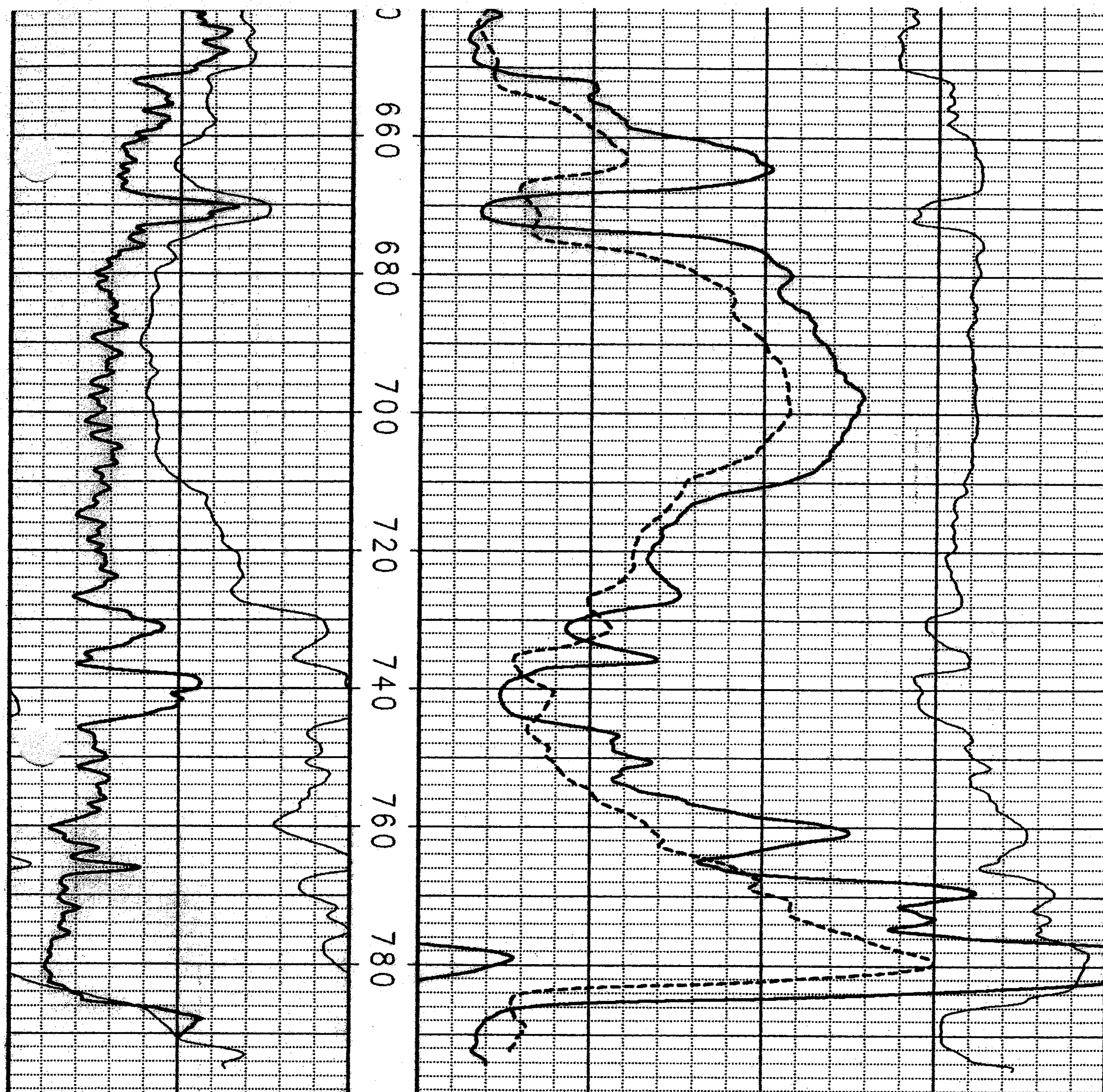


NATURAL GAMMA
0 API 200

SPONTANEOUS POTENTIAL
-300 MILLIVOLTS -200

16" NORMAL RESISTIVITY
0 OHM-M 100

64" NORMAL RESISTIVITY
0 OHM-M 100

SINGLE POINT RESISTANCE
0 OHMS 100

SM STOLLER, PTX01-1011, 4/26/00

COLOG

PTX01-1012

Contractor: S.M. Stoller

Contract #: 3350-105

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

_X_Installation Log

_X_Lithologic Logs
    ___Draft
    _X_Final

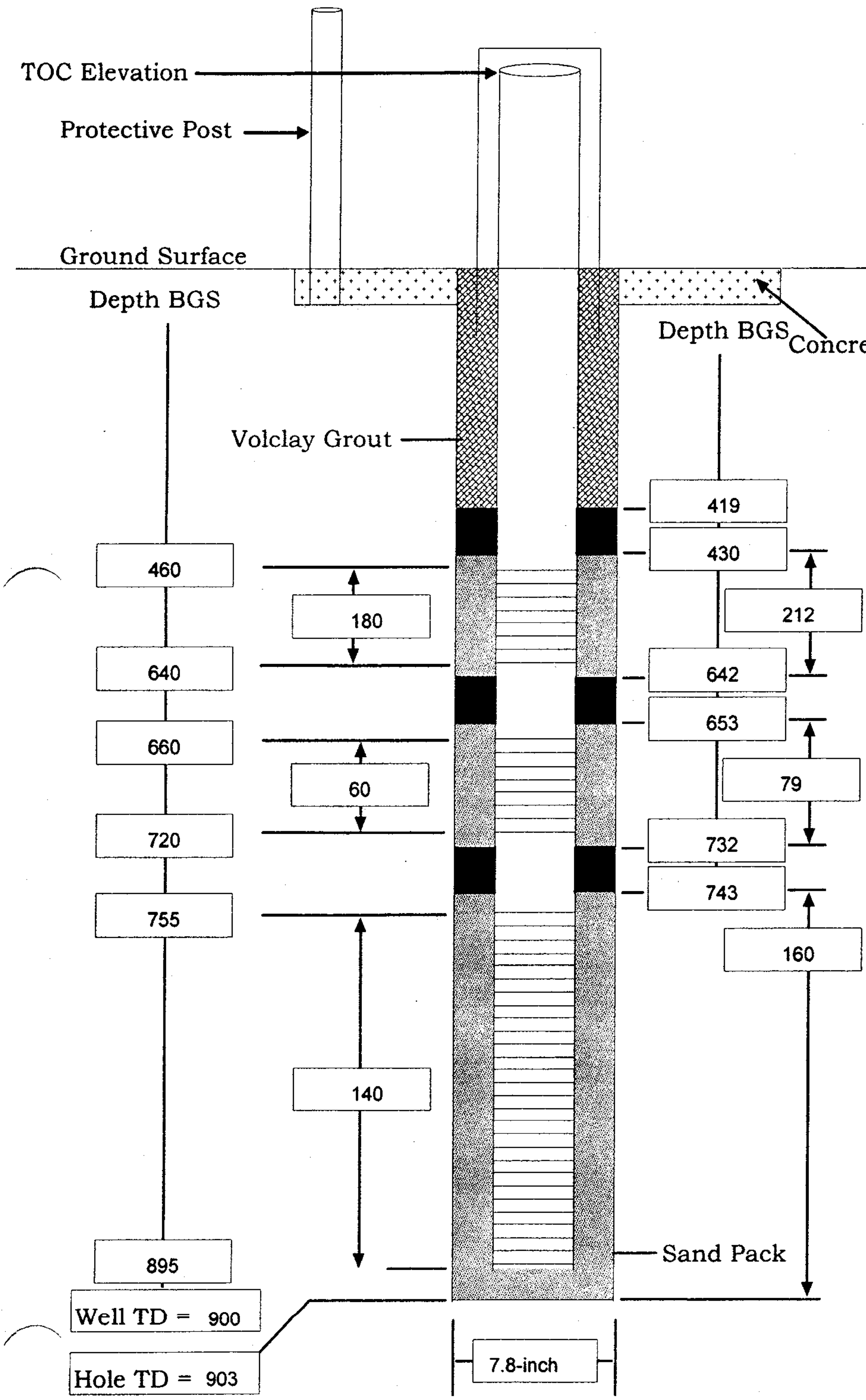
___Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

Monitor Well Installation Diagram

Project: Pantex GW RFI
Location: NE of Burning Grounds, North Plant Boundary
Contractor: Stewart Brothers Drilling Co.
: M.King
Well Coordinates: N-3773264.13 / E-632664.21
TOC Elevation: 3574.34
Surface Elevation: 3572.05

Monitor Well No: PTX01-1012
Date Constructed: 4-28-00
Observed by: J.Ford
Sheet 1 of 1



Protective Casing
Material: Steel
Diameter: 10-inch with 8-inch to 255'

Surface Pad
Composition & Size: 5'x5'x8"

Riser Pipe
Type: Sch.10, Type 304 300-460'; Sch 5 Type 316 Stainless Steel 0-300'
Diameter: 4-inch

Grout
Composition: Volclay Grout (Bentonite)

Seal
Type: 0.25-inch pellets (Bentonite)

Filter Pack
Type: Silica Sand
Source: Colorado Silica Sand
Gradation: 8-16

Screen
Type: Schedule 10, Type 304 Stainless Steel
Diameter: 4-inch
Slot Size: 0.010-inch

Sump
Type: Schedule 10, Type 304 Stainless Steel
Bottom Cap Y / N

PTX01-1012

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML	0-5' SILT, sandy, trace clay, reddish brown (5YR 4/3), non-low plasticity, very fine sand, some fine, soft, damp to moist; Topsoil		
	10		ML	5-17' SILT, clayey, sandy, light reddish brown (5YR 6/4), low plasticity, increasing clay with depth, soft to medium stiff, damp to slightly moist, significant caliche and trace manganese		
	20			17-57' CLAY, silty, sandy, yellowish red (5YR 5/6), low to medium plasticity, medium stiff, damp, increasing manganese, decreasing caliche as stringers and nodes;		
	30		CL			
	40			40' laminar caliche, slight increase in sand, very fine grain		
	50			50' Soft, 25% sand, sand % increasing		
	60		CL	57-65' CLAY, sandy, 65% clay, 35% sand, yellowish red (5YR 5/8), low plasticity, sand grains fine to very fine, soft, damp, caliche as coarse grain granules to small pebbles		
	70		SC	65-75' SAND, clayey, 60% sand 40% clay, reddish yellow (5YR 7/6) to red (2.5YR 5/8) at 75', sand increasing with depth, rounded to subrounded, poorly graded, loose, dry to damp, increasing caliche		
			RX	75-80' CALICHE CAPROCK, red (2.5YR 5/8) sand at 60%, clay at 40%, caliche to 1 1/2" diameter, loose and slightly damp		
	80		SC	80-95' SAND, clayey, with 10% silt, pink (5YR 8/2), CaCO3 in small nodules to 30%, loose, slightly damp		

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S.M. STOLLER CORPORATION

PTX01-1012

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SC			
			SC	95-100' SAND, clayey (20%), pink (5YR 7/4), fine to medium grain sands, CaCO3 nodules to 25%, loose, damp		
	100		SC	100-130' SAND, clayey, as above, pink (5YR 7/4), hit sandstone lense, nodules to 1/2" daimeter, loose, damp		
	110					
	120			120' Same as above		
	130		SC	130-150' SAND, slightly clayey some fines, very pale brown (10YR 7/3), fine to medium grain sand, loose, slightly damp		
	140			140' Same as above		
	150		SP	150-180' SAND, very pale brown (10YR 8/3), fine to medium grain sand, subrounded, graded, loose, slightly damp		
	160			160' Same as above		
	170					

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S.M. STOLLER CORPORATION

PTX01-1012

Pantex GW RFI	Pantex Plant (Burning Grounds)		Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'

Depth (Ft.)	USCS	Description	Sample Number
180-185	SP	180-185' SAND, very pale brown (10YR 8/3), content same as above, very loose, slightly dry	
185-200 (190)	SP	185-200' SAND, very pale brown (10YR 7/4), fine to medium grain, graded, loose, slightly moist	
200-225 (200, 210, 220)	SP	200-225' SAND, trace gravel, light yellow brown (10YR 6/4), very fine grain, loose, damp, with sandstone nodules to 2" diameter 215' SAND as above, sandstone lense with nodules to 1/4" diameter 220' Sandstone decrease	
225-240 (230, 240)	SW	225-240' SAND, some gravel < 10%, very pale brown to yellow (10YR 7/5), fine to very coarse grain sand, well graded, subangular to subrounded, loose, damp	
240-242	SW	240-242' SAND, with gravel (50%), coarse grain, angular, well graded, moist	
242-245	CL	242-245' CLAY, light brown (7.5 YR 6/3), slightly plastic, stiff, dry, with CaCO3	
245-251 (250)	CL	245-251' CLAY, trace sand, light reddish brown (5YR 6/3), plastic, stiff, dry, with CaCO3	PTX01-1012-2-250.5 Permeability Analysis
251-270 (260)	CL	251-270' CLAY, light reddish brown (5YR 6/3), plastic, stiff, dry, FGZ Split Spoon Sample 100% Recovery	PTX01-1012-1-252.5 HE, VOC

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PTX01-1012

Pantex GW RFI		Pantex Plant (Burning Grounds)	Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	280, 290		SM	270-300' SAND, silty, some clay, brown (7.5YR 5/4), fine grained, caliche nodules and cemented sand nodules throughout		PTX01-1012-2-0282 VOC
	300		SP	300-310' SAND, strong brown (7.5YR 5/5) fine to medium grain, graded		
	310		SP	310-320' SAND, as above, with 20% caliche		
	320, 330		SM	320-340' CALICHE, pinkish white (7.5YR 8/2)		
	340, 350		SM	340-370' Caliche as above, with some (20%) SP sand in cuttings		

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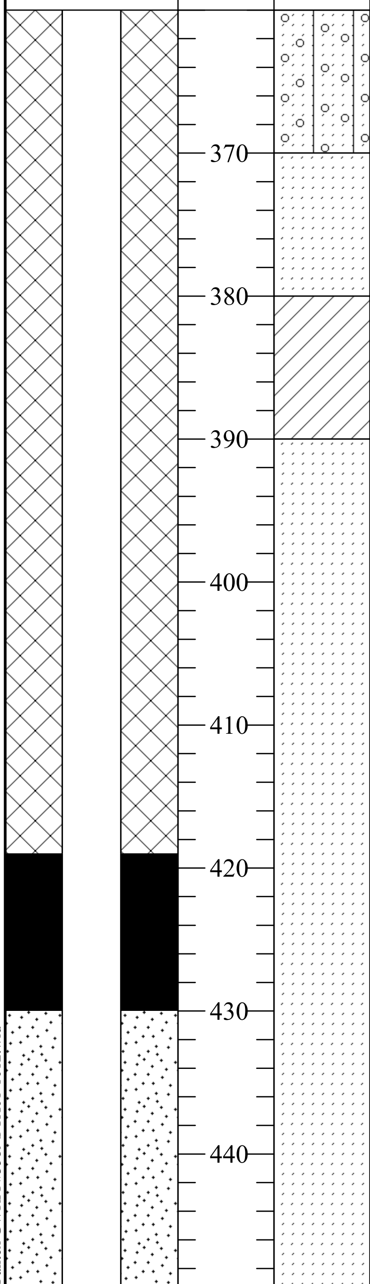
PTX01-1012

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'

Completion | Depth (Ft.) | Lithology | USCS | Description | Sample | Sample Number



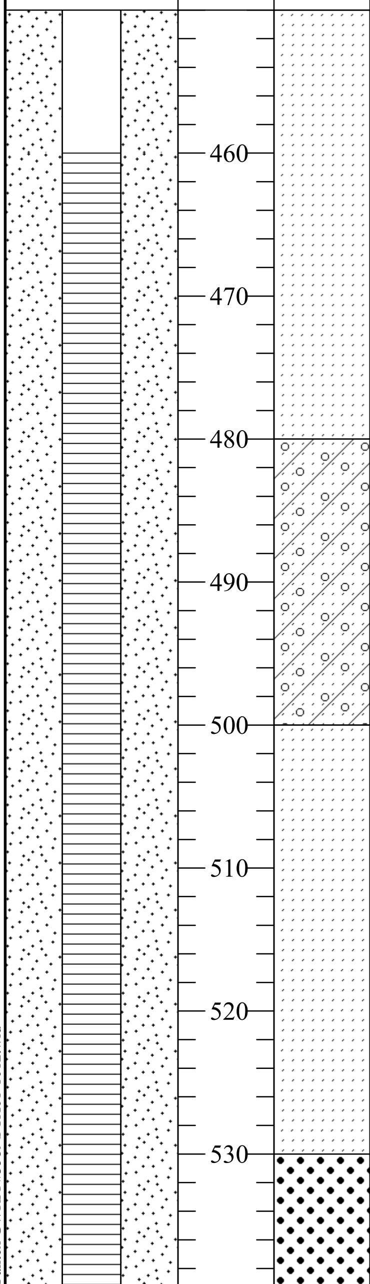
Depth	USCS	Description
(above 370)	SM	
370-380	SM	370-380' SAND, slightly silty, light brown (7.5YR 6/4), fine to medium grain, graded
380-390	CL	380-390' CLAY, with silt and fine sand, brown, medium plasticity, stiff
390-450	SP	390-450' SAND, light brown (7.5YR 6/3), very fine to medium grain, graded

PTX01-1012

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'

Completion | Depth (Ft.) | Lithology | USCS | Description | Sample | Sample Number



USCS	Description	Sample	Sample Number
SP	450-480' SAND, light brown (7.5YR 6/3), fine to medium grain, subangular, graded to well graded, sand is 30% SiO2		
SC	480-500' SAND, clayey, brown (7.5YR 5/4), 60% clay 40% sand		
SP	500-530' SAND, pink (7.5YR 7/4), fine to coarse grain, subangular to subrounded, graded		
SW	530-575' SAND, light brown (7.5YR 6/4), fine to very coarse grain, subangular to subrounded, well graded		

PTX01-1012

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	550, 560, 570		SW			
			SW	575-580' SAND, light brown (7.5YR 6/4), coarse grain sands and gravels, well graded		
	580, 590		SP	580-595' SAND, fine to medium grain		
	600, 610		SW	595-615' SAND, gravelly, light brown (7.5YR 6/4), coarse grain sands and gravels, well graded		
	620		GW	615-655' SAND, well graded fine gravels to very coarse sands		

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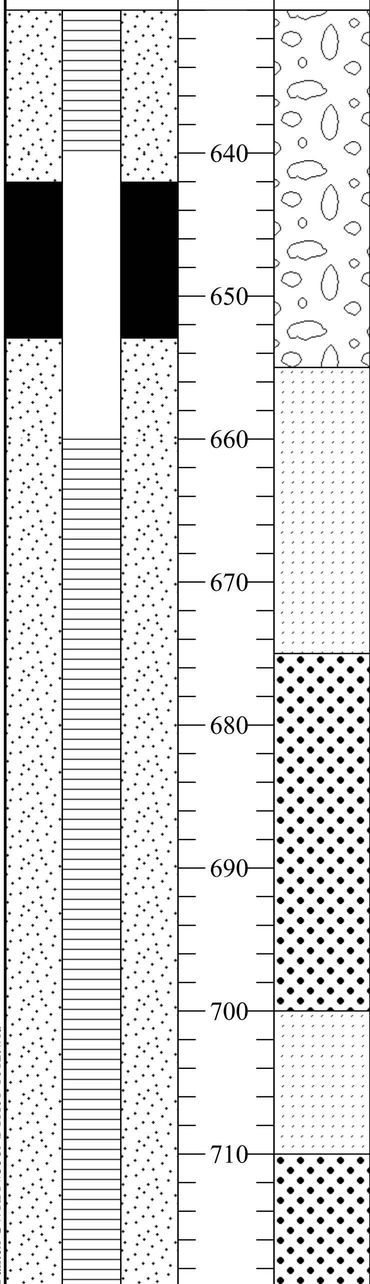
S.M. STOLLER CORPORATION

PTX01-1012

Pantex GW RFI	Pantex Plant (Burning Grounds)	Amarillo, Texas

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'



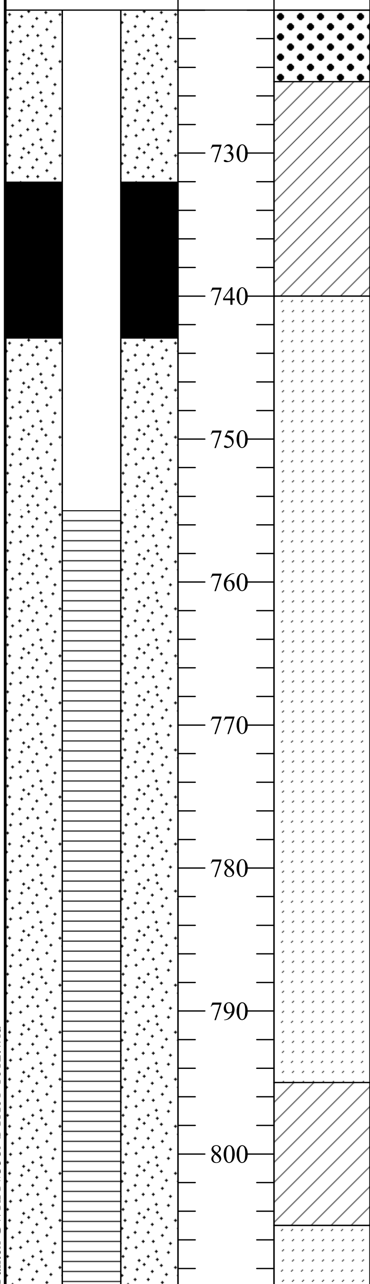
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			GW			
			SP	655-675' SAND, light brown (7.5YR 6/4), fine to medium grain		
			SW	675-700' SAND, gravelly, pink (5YR 7/3), fine to medium grain, subangular, well graded, with 20% small gravel		
			SP	700-710' SAND, light brown (7.5YR 6/4), fine to medium grain, subrounded to rounded		
			SW	710-725' SAND, light brown (7.5YR 6/4), fine to medium with coarse grain, subrounded to well rounded		

PTX01-1012

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'

Completion | Depth (Ft.) | Lithology



USCS	Description	Sample	Sample Number
SW			
CL	725-740' CLAY, sandy, light brownish gray (10YR 6/2)		
SP	740-790' SAND, very pale brown (10YR 7/3), fine grained, well rounded		
CL	795-805' CLAY, dark reddish brown (2.5 YR 3/4), stiff		
SP	805-820' SAND, white (10YR 8/2), fine grained		

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S.M. STOLLER CORPORATION

PTX01-1012

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP			
	820		CH	820-830' CLAY, with silt and very fine sand, dark reddish brown (2.5 YR 3/4), high plasticity, stiff		
	830		SP	830-860' SAND, white (10YR 8/2), fine grain, clay lense at 845'		
	840					
	850					
	860		SC	860-870' SAND, clayey/CLAY, sandy, red (2.5YR 4/6)		
	870		SP	870-890' SAND, white (10YR 8/2), fine grain		
	880					
	890		CH	892-903' CLAY, dark reddish brown (2.5YR 3/4), high plasticity, stiff-very stiff		

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PTX01-1012

Pantex GW RFI		Pantex Plant (Burning Grounds)	Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	J.Ford / R.Rupp / T.Hall	Northing: 3773264.13	Easting: 632664.21
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	903' BGS
Dates Drilled:	04/13/00 - 04/30/00	Depth to Water:	494.6' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3572.05'	TOC Elevation:	3574.34'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			CH			
	910 920 930 940 950 960 970 980			Total Depth of Borehole 903' BGS Fine Grain Zone 251' BGS Red Beds 890' BGS Well Completion Details: Borehole Diameter 12 3/4" from surface to 255' BGS 8 5/8" steel surface conductor casing set from surface to 255' Borehole Diameter 7 7/8" from 255' to 903' BGS 4-inch, Schedule 10, Type 304 and Schedule 5, Type 316 Stainless Steel Casings used in construction of the well along with 4-inch, Type 304 Stainless Steel, 10 Slot Screen. 5' Sump (895' - 900'); 140' Screen (755' - 895'); 35' Casing (720' - 755'); 60' Screen (660' - 720'); 20' Casing (640' - 660'); 180' Screen (460' - 640'); 462' Casing (+2' - 460'); Filter Pack, #8/16 Colorado Silica Sand at Screened Intervals (743' - 903'), (653' - 732'), (430' - 642'); Bentonite Seals ((732' - 743'), (642' - 653'), (419' - 430'); Bentonite Grout (Surface - 419'); Concrete Pad (5'X5'X8") with 4 bollards, 10-inch steel Protective Casing with locking cover.		

COLOG

COLOG Division of Layne Christensen Company
17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

ELECTRIC LOG

COM: SM STOLLER
WELL: PTX01-1012
FLD: PANTEX
ST: TX COUNTY:CARSON

COMPANY: SM STOLLER
WELL: PTX01-1012
FIELD: PANTEX
STATE: TX COUNTY: CARSON

LOCATION: NA

SEC TWP RGE

OTHER SERVICES:

PERMANENT DATUM: Ground Surface ELEVATION: NA
LOG MEAS. FROM: Ground Surface 0.0 FT ABOVE PERM. DATUM
DRILL MEAS. FROM: Ground Surface

DATE ACQUIRED	4/28/00	4/28/00		
RUN NUMBER	1	1		
LOG TYPE	Gamma	Electric		
DEPTH-DRILLER	905'			
DEPTH-LOGGER	904'			
BTM LOGGED INTERVAL	899'	903'		
TOP LOGGED INTERVAL	Surface	250'		
RECORDED BY	Davis			
WITNESSED BY	Ford			
FLUID LEVEL	Surface			
FLUID TYPE	Mud			
Rm at TEMP	N/A			
TIME SINCE CIRC.	N/A			
PROBE TYPE, S/N	RABPF 2171	EPF1567		
MODULE TYPE, S/N	UM 1524	UM 1524		
LOGGING SPEED	15 ft/min	15 ft/min		
A.S.D.E.	0.9'	0.9'		
SAMPLE INTERVAL	0.1'	0.1'		
SOUR[illegible]ZE, S/N	None	None		

BOREHOLE RECORD

BIT SIZE	FROM	TO
10"	Surface	250'
8"	250'	TD

CASING RECORD

SIZE/WGT	FROM	TO
Sump	895'	900'
Screen/Blank	460'	895'
Riser	Surface	460'

COMMENTS:

Drill Type:
Arch 0-255'
Mud Rotary 250-905'

8 5/8" Conductor Casing
Set Surface to 250'

COMMENTS:

4" Type 304 Sch 10 Stainless Steel
Casing & Screen 300-900'
Screen Slot 0.010

4" Type 316 Sch 5 Stainless Steel
Casing Surface-300', MHC Supplied

Borehole Logged Open Hole 300-TD'

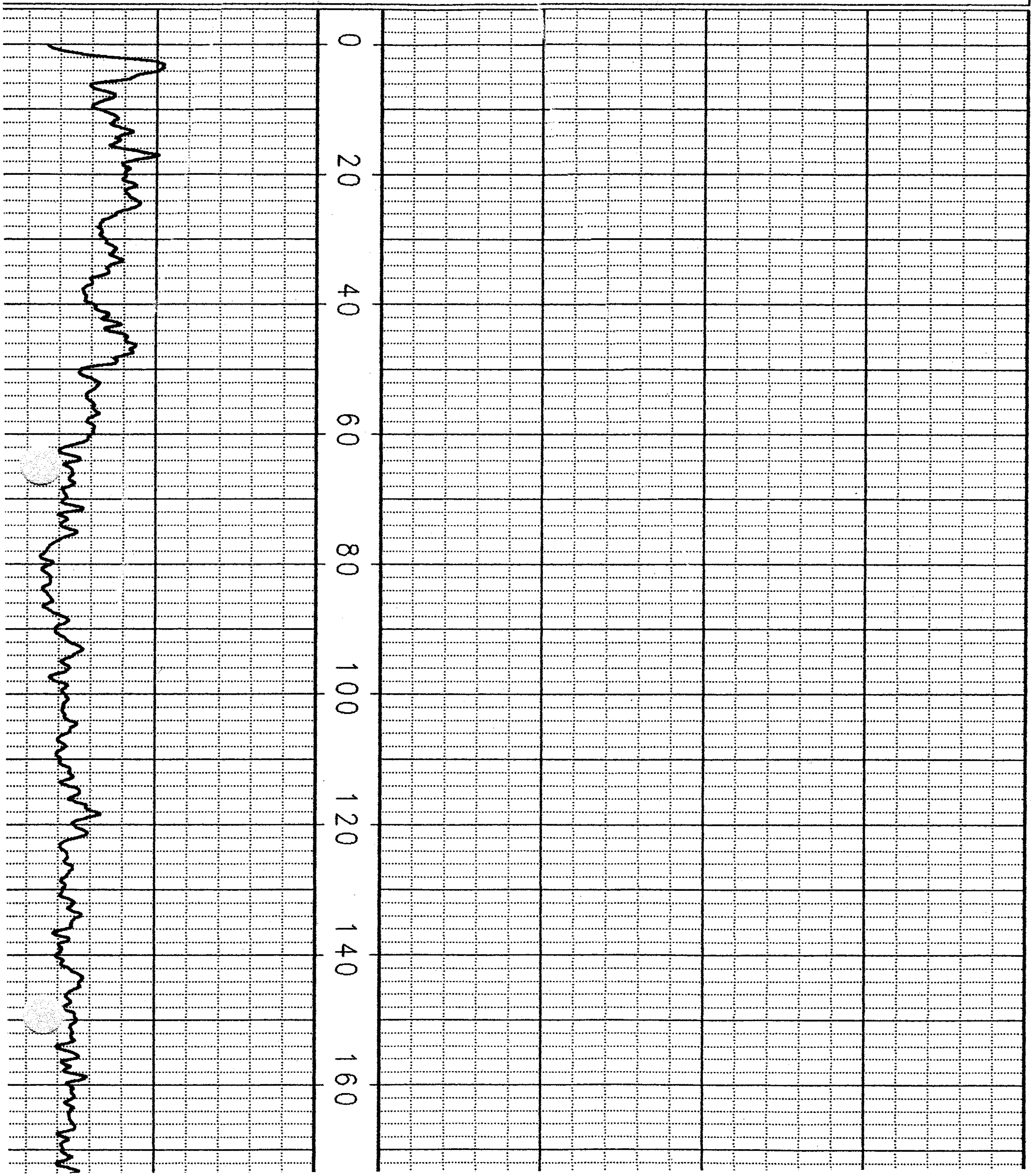
NA - NOT AVAILABLE, N/A - NOT APPLICABLE

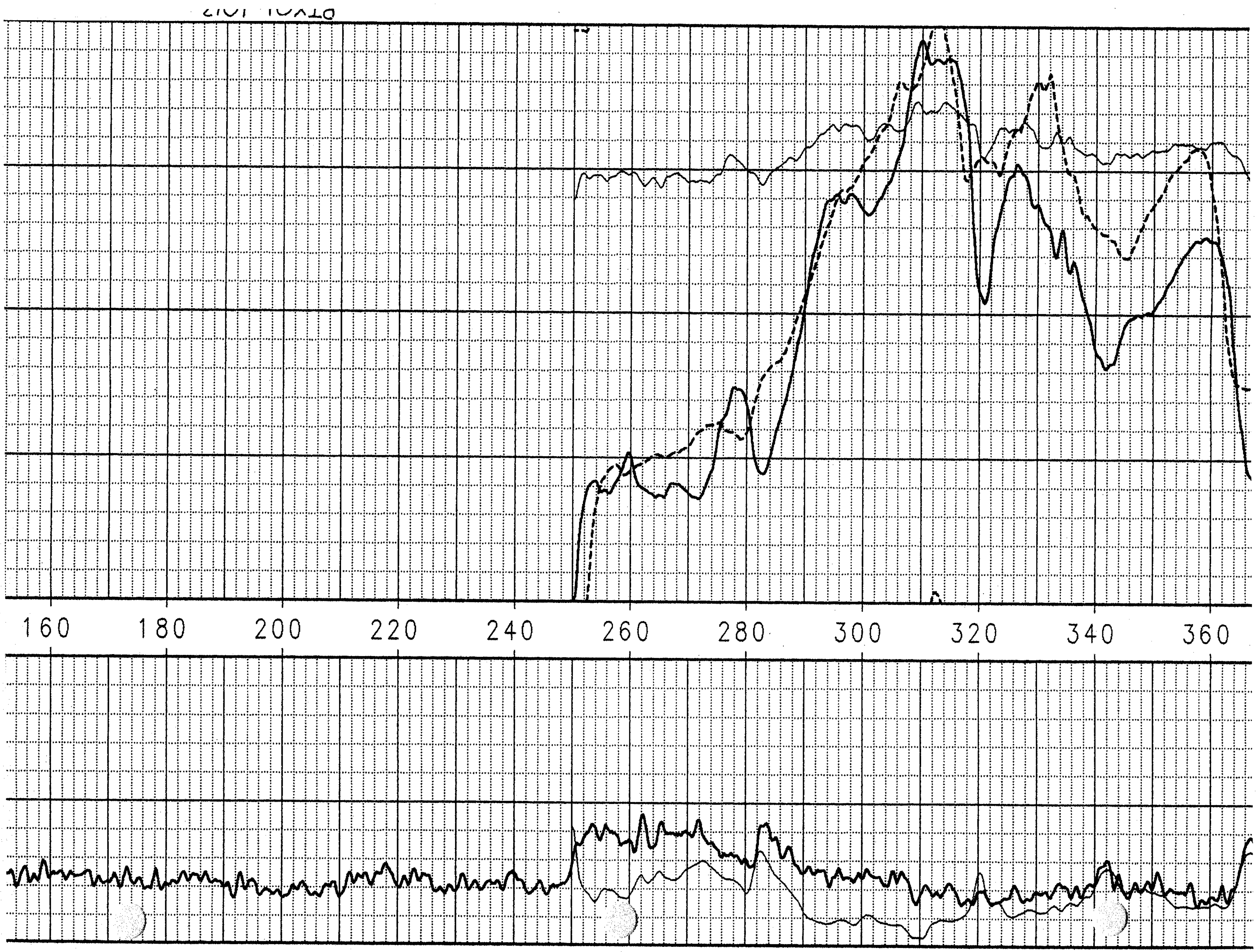
DIGITAL FILES: 1012,dat, 1012.HDP, 1012.PLP

SM STOLLER, PTX01-1012, 4/28/00

COLOG

	SINGLE POINT RESISTANCE — 0 OHMS 100
SPONTANEOUS POTENTIAL — -200 MILLIVOLTS -100	64" NORMAL RESISTIVITY — 0 OHM-M 100
NATURAL GAMMA — 0 API 200	16" NORMAL RESISTIVITY — 0 OHM-M 100

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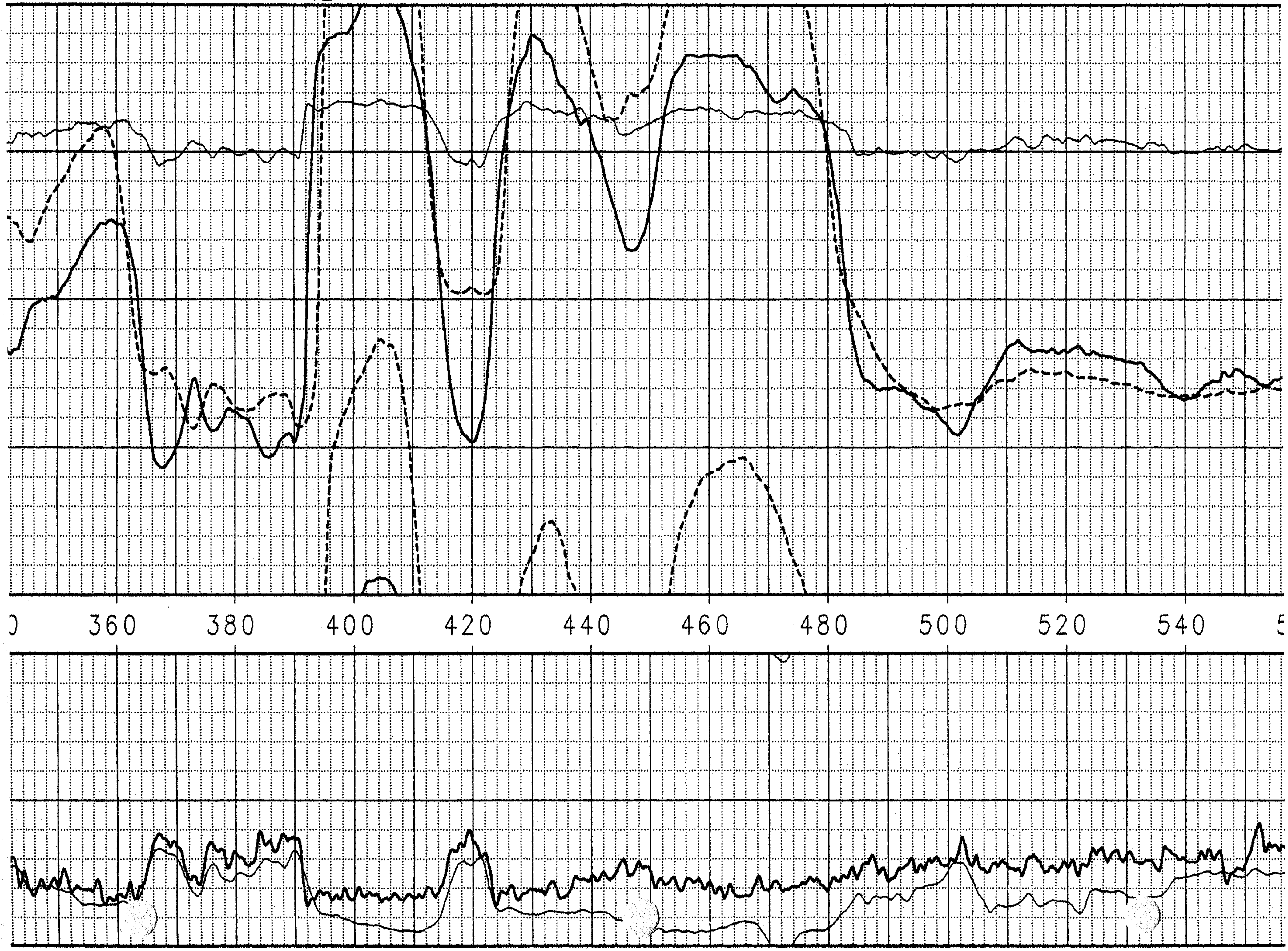
340
360

PTX01-1017



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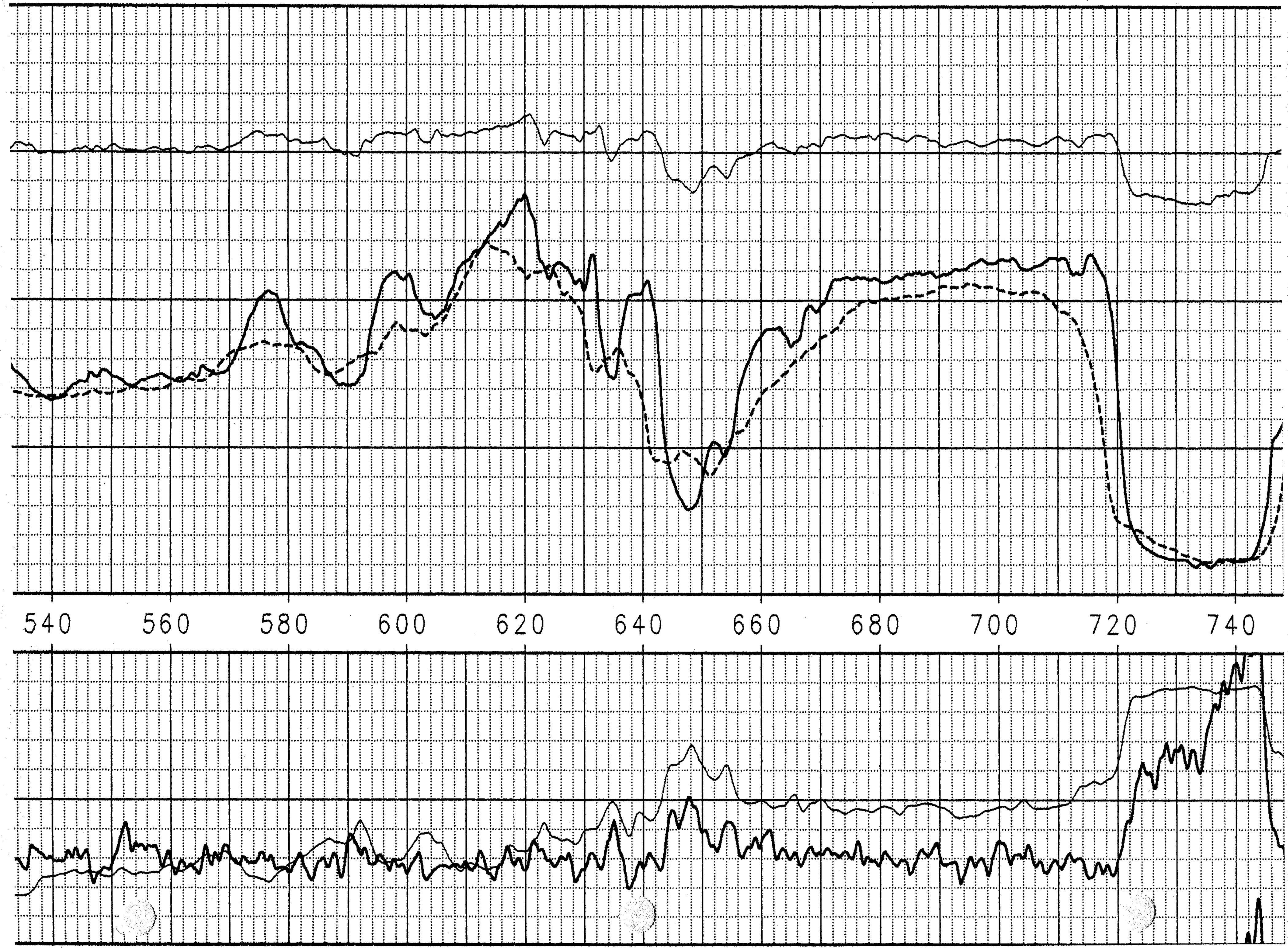
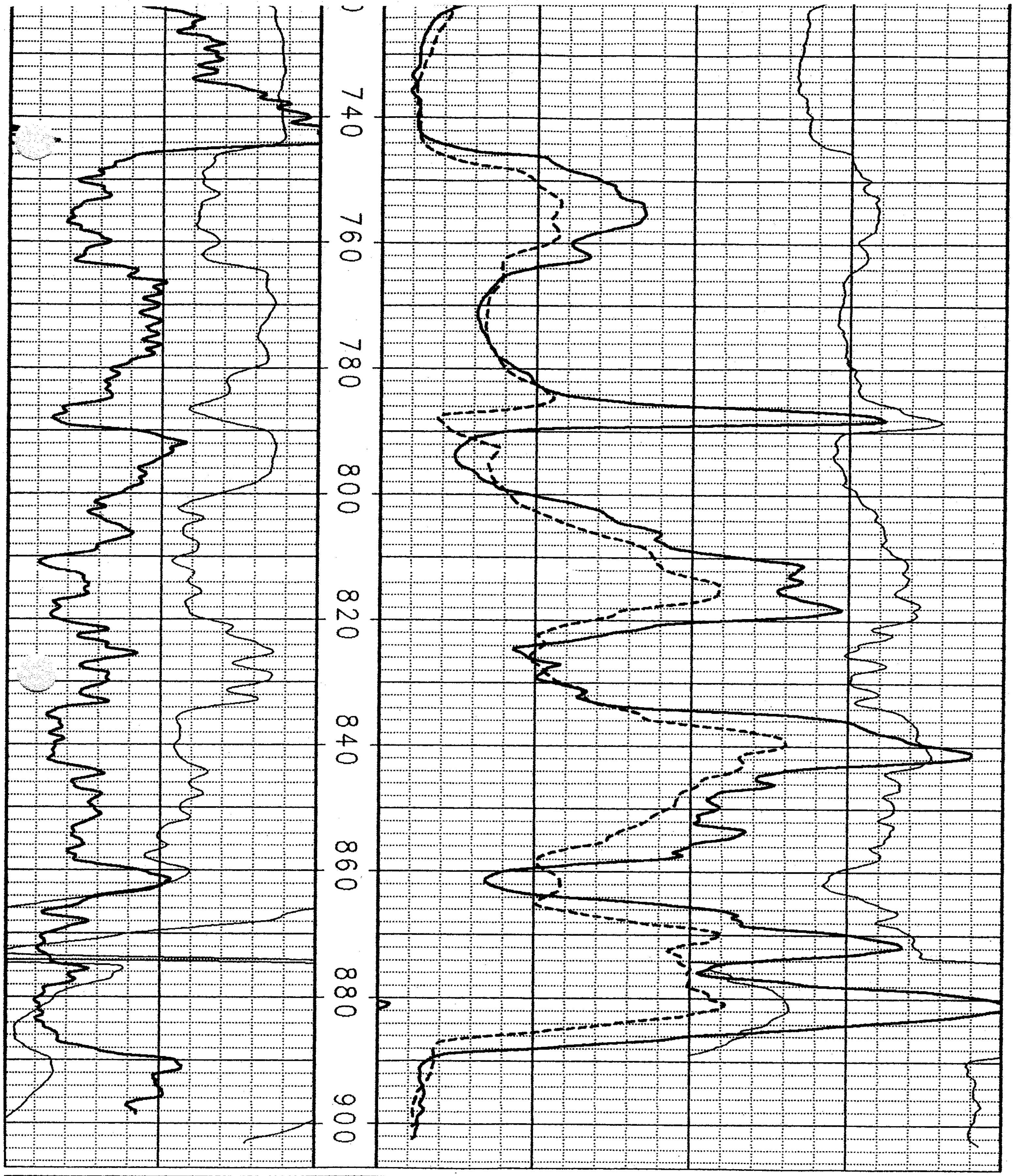




NATURAL GAMMA
API 200
SPONTANEOUS POTENTIAL
-200 MILLIVOLTS -100

16" NORMAL RESISTIVITY
0 OHM-M 100
64" NORMAL RESISTIVITY
0 OHM-M 100
SINGLE POINT RESISTANCE
0 OHMS 100

SM STOLLER, PTX01-1012, 4/28/00

PTX01-1013

Contractor: S.M. Stoller

Contract #: 3350-105

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

_X_Installation Log

_X_Lithologic Logs
    ___Draft
    _X_Final

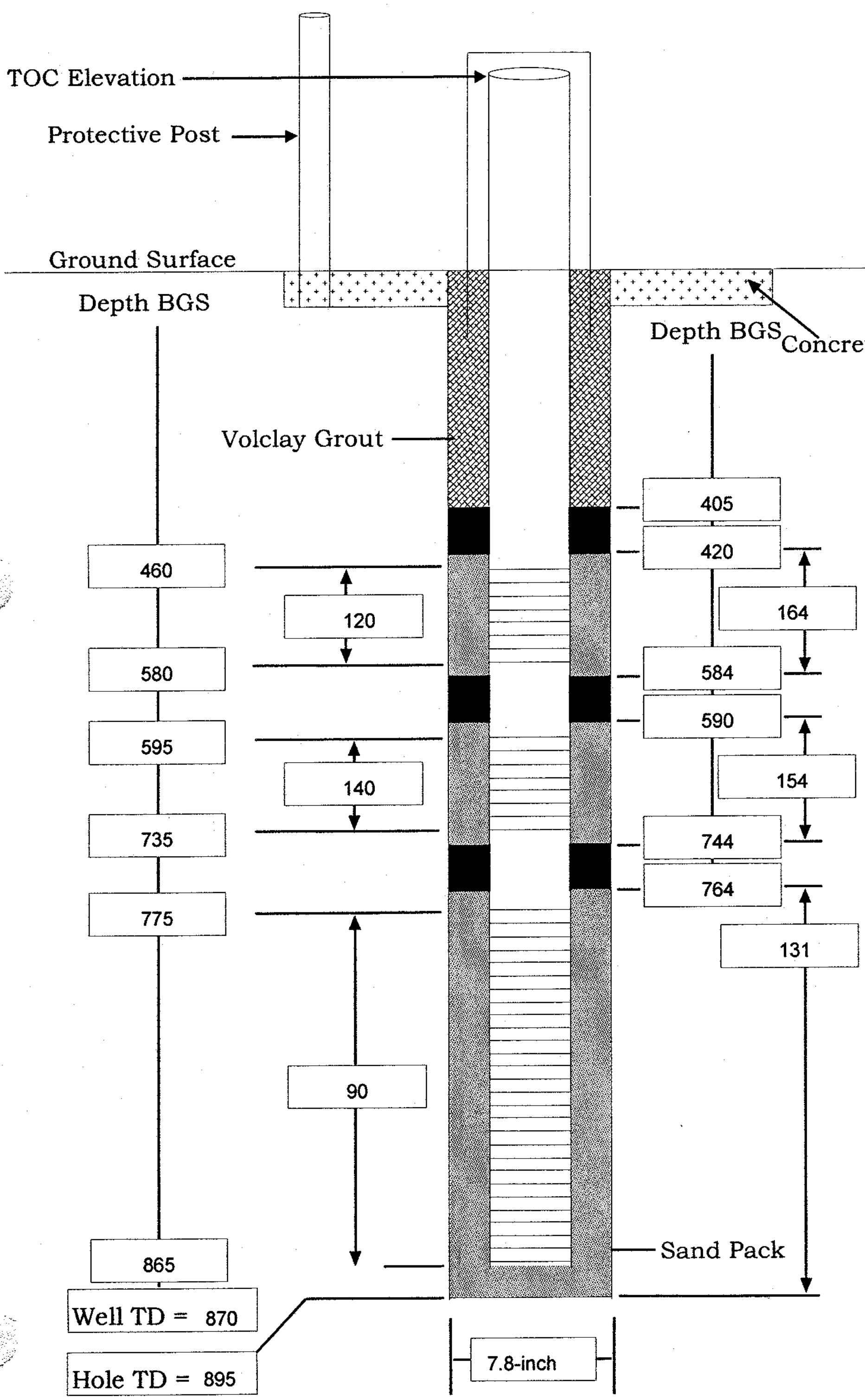
___Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

Monitor Well Installation Diagram

Project: Pantex GW RFI
Location: NW of Burning Grounds, North Plant Boundary
Contractor: Stewart Brothers Drilling Co.
Driller: M.King
Well Coordinates: N-3773218.25 / E-628976.89
TOC Elevation: 3584.10
Surface Elevation: 3582.04

Monitor Well No: PTX01-1013
Date Constructed: 5-12-00
Observed by: R.Rupp
Sheet 1 of 1



Protective Casing
Material Steel
Diameter 10-inch with 8-inch to 310'

Surface Pad
Composition & Size 5'x5'x8"

Riser Pipe
Type Schedule 10, Type 304 Stainless Steel
Diameter 4-inch

Grout
Composition Volclay Grout (Bentonite)

Seal
Type 0.25-inch pellets (Bentonite)

Filter Pack
Type Silica Sand
Source Colorado Silica Sand
Gradation 8-16

Screen
Type Schedule 10, Type 304 Stainless Steel
Diameter 4-inch
Slot Size 0.010-inch

Sump
Type Schedule 10, Type 304 Stainless Steel
Bottom Cap Y / N

footer: ph E:\projects\Pantexcovs\pantex.apr Layout2 (6.6.2000)

PTX01-1013

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	0-5		SM	0-5' SILT, clayey, sandy, reddish brown (5YR 5/4), damp, topsoil		
	5-20		CL	5-20' CLAY, silty, sandy, light reddish brown (5YR 6/4), very fine sand, medium plasticity, medium stiff, dry to damp		
	20-30		ML	20-30' SILT, sandy, trace clay, pink (5YR 7/4), nonplastic, medium stiff, dry, strong CaCO3 throughout		
	30-50		CL	30-50' CLAY, sandy, yellowish red (5YR 7/6), medium plastic, very fine grain rounded sand, medium stiff, dry		
	50-70		ML	50-70' SILT, sandy, gravelly, reddish yellow (5YR 7/6), nonplastic, stiff, dry, highly cemented caliche nodules up to 1/2" throughout		
	70-90		ML	70-90' CALICHE horizon, pinkish white to pink with depth (5YR 8/2 - 7/3), well developed calcrete, sub 1" angular "gravel" fragments and rock-flour, increasing sand with depth		

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S.M. STOLLER CORPORATION

PTX01-1013

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	90–100		SM	90-100' SAND, silty, reddish yellow (5YR 6/6), fine to very fine grain, subrounded to subangular, medium dense, dry		
	100–140		SP	100-140' SAND, pink (7.5YR 7/4), fine to medium grain some very fine, subangular, graded, loose, dry 105-115' well cemented sandstone as broken nodules 125' weakly cemented sandstone 130-140' cemented sandstone nodules and somewhat silty sand		
	140–150		SP	140-150' SAND, pink (7.5YR 7/4), very fine to fine grain, subangular, poorly graded, loose, dry		
	150–160		SM	150-160' SAND, silty, light reddish brown (5YR 6/4), fine to medium grain, subrounded, loose, damp		
	160–		SP	160-220' SAND, reddish yellow (7.5YR 7/6) to light brown (7.5YR 6/4), fine to medium grain, trace coarse grain, poorly graded, loose, dry		

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PTX01-1013

Pantex GW RFI	Pantex Plant (Burning Grounds)	Amarillo, Texas

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'

Depth (Ft.)	USCS	Description	Sample Number
185-220	SP		
220-230	SM	220-230' SAND, silty, light brown (7.5YR 6/4), fine to medium grain, trace coarse, subrounded, medium dense, damp	
230-240	SW	230-240' SAND, gravelly (flattened angular pea-gravel), very pale brown (10YR 7/3), very fine to coarse grain, subangular	
240-245	SW	240-245' SAND, gravelly, brown (7.5YR 5/4), very fine to coarse grain, subangular, clayey @ 245', moist	
245-245.5	GM	245-245.5' GRAVEL, slty sndy, +1" - < 2", rnded-subang	PTX01-1013-2-0245 Sieve Analysis
245.5-247	ML	245.5-247' SILT sndy lt redsh brn (5YR 6/4) vfn snd med dns mst	PTX01-1013-2-245.5 VOC
247-247.5		247-247.5' SILTSTONE, trace subrounded flattened gravel, pink (5YR 7/3), very fine grain, dense, dry	PTX01-1013-2-0246 Permeability Analysis; PTX01-1013-2-246.5 HE, VOC
247.5-255	CL	247.5-255' CLAY, silty, sandy, light reddish brown (5YR 6/4), very fine sand, medium stiff, moist, dryer with depth	
255-260	SC	255-260' SAND, clayey, trace gravel, light brown (7.5YR 6/4), 90% very fine 10% fine grain, subangular, poorly graded, medium dense, dry; stiff 1/8" clayballs; angular pea-gravel	
260-270	SC	260-270' SAND, 30% clay, reddish yellow (5YR 6/6), low plasticity, 70% very fine grain, some fine and medium, poorly	

Depth scale: 190, 200, 210, 220, 230, 240, 250, 260

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PTX01-1013

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
				graded, medium dense, dry		
	280		CL	270-285' CLAY, sandy, 60% clay, 40% sand, reddish brown (5YR 5/4), medium plastic, very fine grain, some fine, medium stiff, damp to moist with depth		
	290		SW	285-295' SAND, very pale brown (10YR 7/4), 60% medium, 30% fine, 10% very fine, trace coarse grain, subangular, well graded, loose, dry		
	300		SP	295-310' SAND, light reddish brown (5YR 6/4), 80% very fine grain, some fine grain, trace medium, subangular, poorly graded, loose, dry, with very coarse sand to pea-gravel size, rounded, cemented sand nodes		
	310, 320, 330		SM	310-340' SAND, silty, 60% sand, 40% silt, very pale brown (10YR 7/3), with pale yellow (5Y 7/3) mottling and white caliche nodes and pebbly grains, very fine to fine grain sand, subrounded grains, medium dense to loose, damp		PTX01-1013-2-0332 VOC
	340		SM	340-350' SAND, slightly silty, light gray (10YR 7/2), fine to medium grain sand, subrounded, dense, caliche is 50% of content		
	350		SM	350-390' SAND, silty, light brownish gray (10YR 6/2), fine to medium grain sands, subrounded, slightly graded, some caliche (30%) decreasing in content		

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S.M. STOLLER CORPORATION

PTX01-1013

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	370		SM			
	380					
	390		SC	390-400' SAND, clayey (30%), pale yellow (2.5YR 7/4), very fine to fine grain sand, subrounded, medium loose		
	400		SC	400-440' SAND, clayey (30%), light reddish brown (5YR 6/3), very fine to fine grain sands		
	410					
	420					
	430			430' same as above		
	440		SM	440-470' SAND, silty, light yellowish brown (2.5YR 6/4), very fine to fine grain sands, loose		

PTX01-1013

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	460		SM			
	470–480		SM	470-490' SAND, slightly silty, reddish yellow (7.5YR 7/5), fine grain sand, subrounded, abundant SiO2, loose		
	490–530		SP	490-570' SAND, brownish yellow (10YR 6/6), fine to medium grain sand, subrounded, slightly graded, loose		

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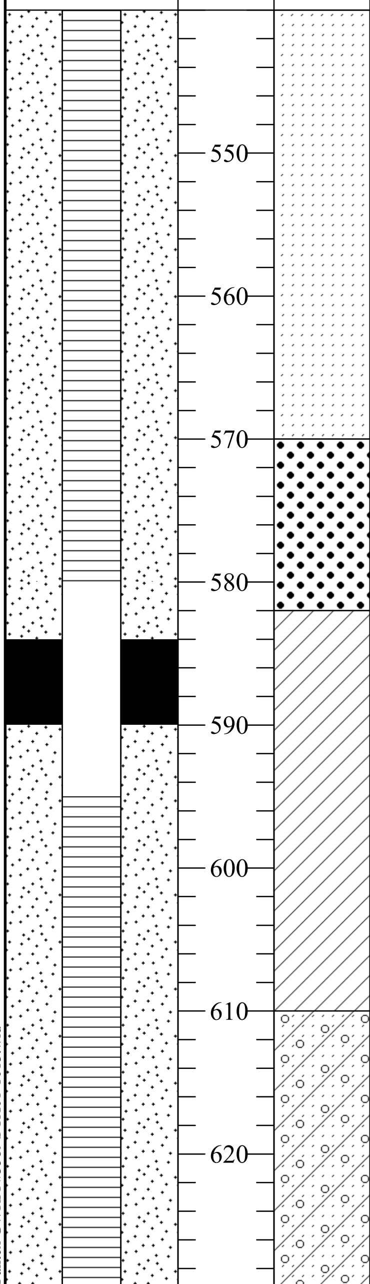
PTX01-1013

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'



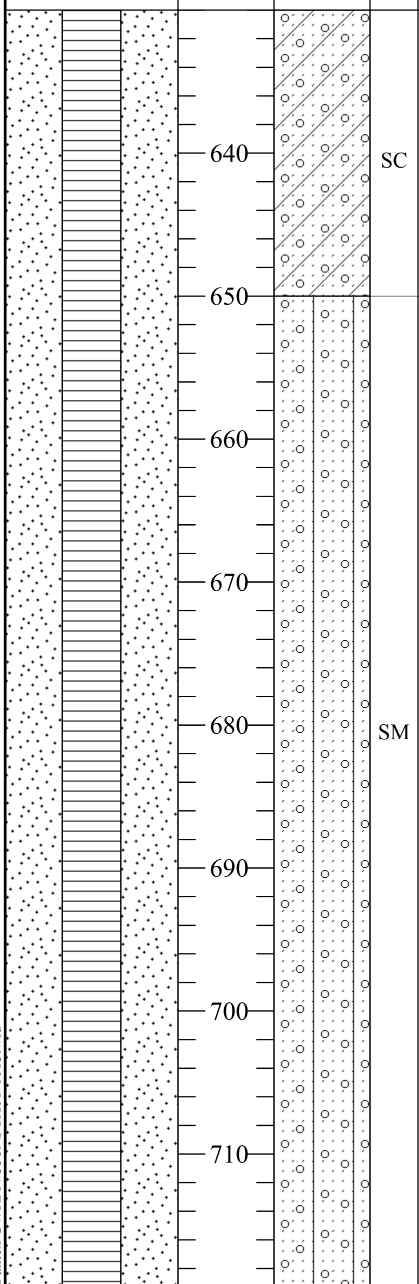
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP			
	570		SW	570-582' SAND, gravelly (small), light yellowish brown to brownish yellow (10YR 6/4 - 6/6), medium to coarse grain, subangular, well graded, loose		
	582		CL	582-610' CLAY, very pale brown (10 YR 7/3), stiff		
	610		SC	610-650' SAND, clayey, light yellowish brown (10YR 6/4), fine to medium grain, medium loose		

PTX01-1013

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	640		SC			
	650			650-750' SAND, slightly silty, very pale brown (10YR 7/3), very fine to fine grain, medium loose		
	660					
	670			675' same as above		
	680		SM			
	690					
	700					
	710					



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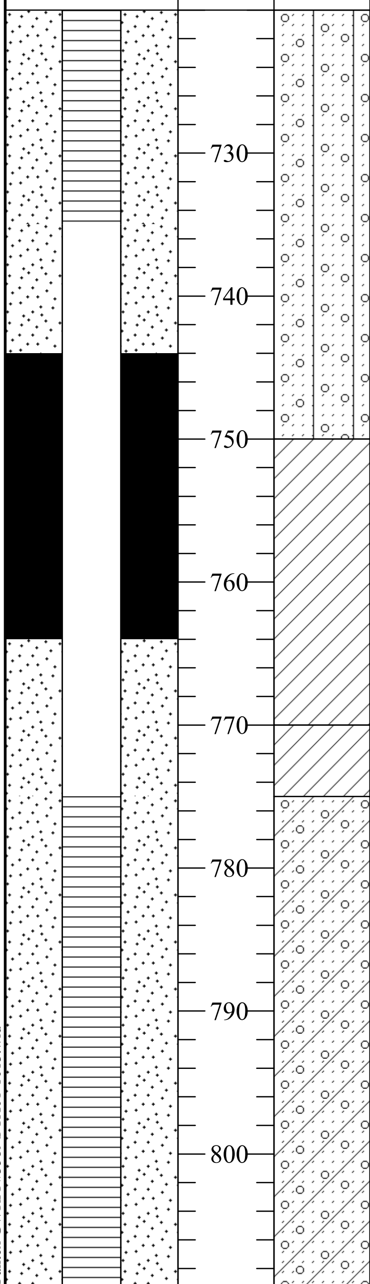
PTX01-1013

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number



USCS	Description
SM	
CL	750-770' CLAY, slightly sandy, reddish yellow (5YR 6/6), slightly plastic, medium stiff
CL	770-775' CLAY, slightly silty, light reddish brown (2.5YR 6/4), slightly plastic, medium stiff
SC	775-840' SAND, clayey, pink (5YR 7/4), very fine grain, medium loose, slightly plastic

PTX01-1013

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	820, 830		SC			
	840		CL	840-850' CLAY, slightly silty, reddish brown (2.5YR 5/4), medium stiff		
	850, 860		SC	850-863' SAND, clayey, pink (5YR, 7/3), very fine grain, slightly plastic, medium dense		
	870, 880, 890		CL	863-895' CLAY, weak red to red (10R 5/4 - 5/6), medium plastic, medium stiff 890' same as above		

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PTX01-1013

Pantex GW RFI | **Pantex Plant (Burning Grounds)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R.Rupp / T.Hall	Northing: 3773218.25	Easting: 628976.89
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	895 BGS'
Dates Drilled:	04/17/00 - 05/13/00	Depth to Water:	485.3' BTOC 05/25/00
Borehole Type:	12.75" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3582.04'	TOC Elevation:	3584.10'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	910 920 930 940 950 960 970 980			Total Depth of Borehole 895' BGS Fine Grain Zone 247' BGS Red Beds 863' BGS Well Completion Details: Borehole Diameter 12 3/4" from surface to 310' 8 5/8" steel conductor casing installed from surface to 310' Borehole Diameter 7 7/8" from 310' to 895' 4-inch, Schedule 10, Type 304, Stainless Steel Casing and 10 Slot Screen 5' Sump (865' - 870'); 90' Screen (775' - 865'); 40' Casing (735' - 775'); 140' Screen (595' - 735'); 15' Casing (580' - 595'); 120' Screen (460' - 580'); 462' Casing (+2' - 460'); Filter Pack, #8/16 Colorado Silica Sand at screen intervals (764' - 895'), (590' - 744'), (420' - 584'); Bentonite Seals (744' - 764'), (584' - 590'), (405' - 420'); Bentonite Grout Surface - 405'); Concrete Pad (5'X5'X8") with 4 bollards, 10-inch steel Protective Casing with locking cover.		

COLOG Division of Layne Christensen Company

17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

ELECTRIC LOG

COM: SM STOLLER
WELL: PTX01-1013
FLD: PANTEX
ST: TX COUNTY: CARSON

COMPANY: SM STOLLER
WELL: PTX01-1013
FIELD: PANTEX
STATE: TX COUNTY: CARSON

LOCATION: NA

SEC TWP RGE

OTHER SERVICES:

PERMANENT DATUM: Ground Surface ELEVATION: NA
LOG MEAS. FROM: Ground Surface 0.0 FT ABOVE PERM. DATUM
DRILL MEAS. FROM: Ground Surface

DATE ACQUIRED	5/12/00	5/12/00		
RUN NUMBER	1	1		
LOG TYPE	Gamma	Electric		
DEPTH-DRILLER	895'			
DEPTH-LOGGER	894'			
BTM LOGGED INTERVAL	888'	893'		
TOP LOGGED INTERVAL	Surface	310'		
RECORDED BY	Nelson			
WITNESSED BY	Rupp			
FLUID LEVEL	Surface			
FLUID TYPE	Mud			
Rm at TEMP	NA			
TIME SINCE CIRC.	1 1/2 hours			
PROBE TYPE, S/N	RABPF, 2019	EPF, 1567		
MODULE TYPE, S/N	UM-1524	UM-1524		
LOGGING SPEED	20 ft/min	20 ft/min		
A.S.D.E.	0.1'	0.1'		
SAMPLE INTERVAL	0.1'	0.1'		
SOL. SIZE, S/N	N/A	N/A		

BOREHOLE RECORD			CASING RECORD		
BIT SIZE	FROM	TO	SIZE/WGT	FROM	TO
10"	Surface	310'	Sump	865'	870'
8"	310'	895'	Screen/Blank	460'	865'
			Riser	Surface	460'

COMMENTS:

Drill Type:
Arch 0-310'
Mud Rotary 310-895'

8 5/8" Conductor Casing
Surface to 310'

NA - NOT AVAILABLE, N/A - NOT APPLICABLE

COMMENTS:

4" Type 304 Sch 10 Stainless Steel
Casing & Screen
Screen Slot 0.010

Borehole Logged Open Hole 310-TD'

DIGITAL FILES: 1013.DAT, 1013.PLP, 1013.HDP

SM STOLLER, PTX01-1013, 5/12/00

COLOG

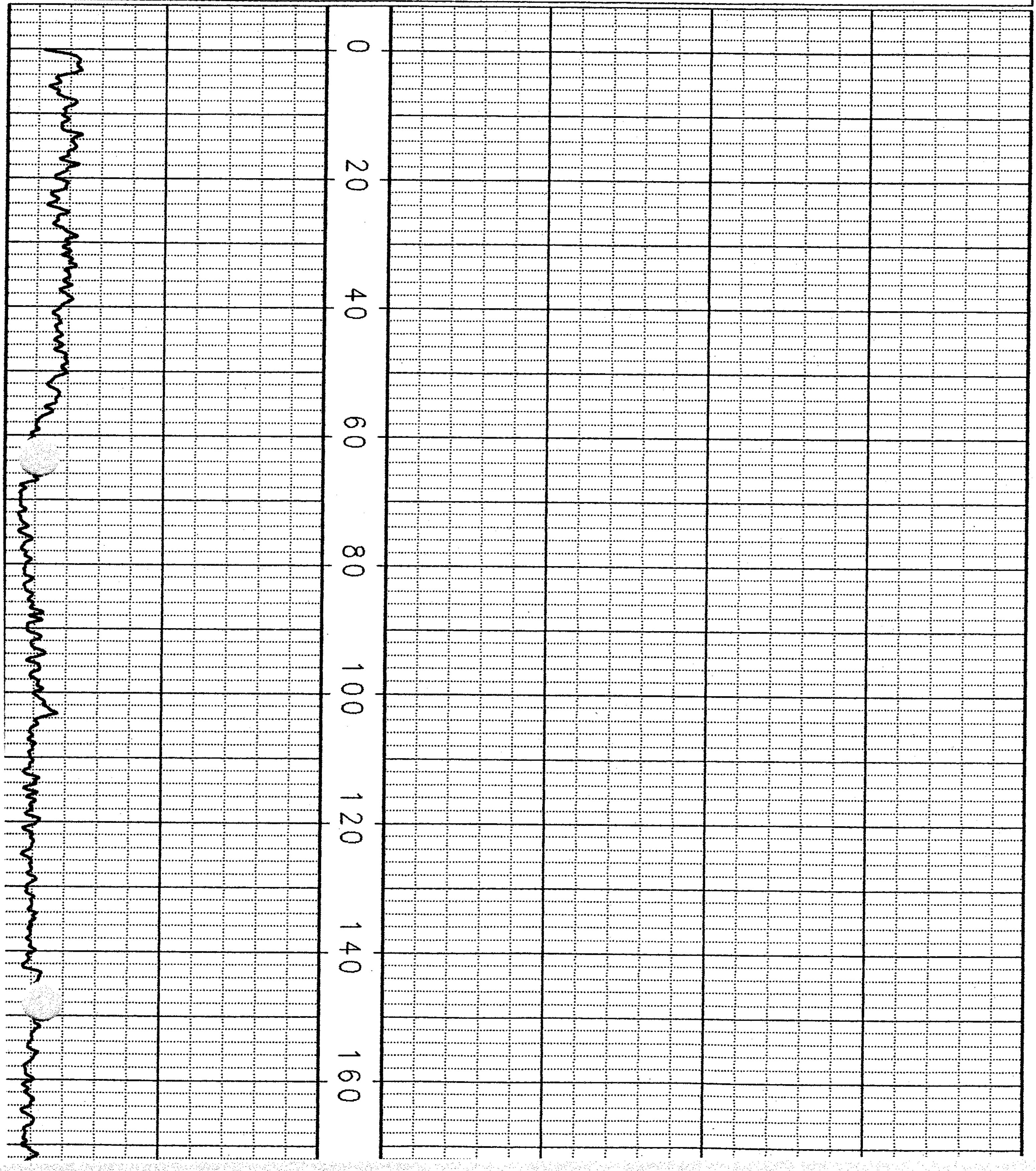
SINGLE POINT RESISTANCE
0 OHMS 100

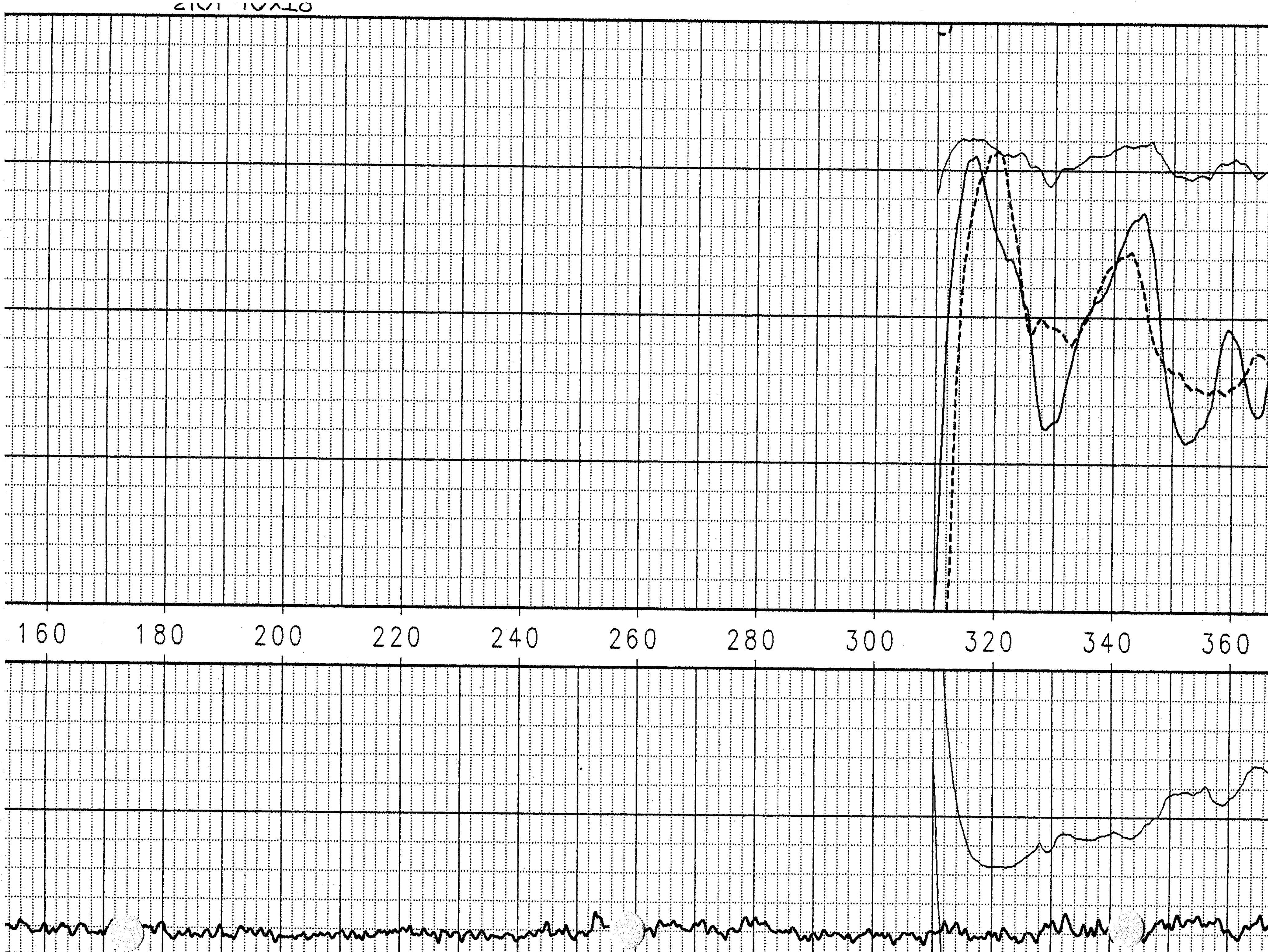
SPONTANEOUS POTENTIAL
50 MILLIVOLTS 150

64" NORMAL RESISTIVITY
0 OHM-M 100

NATURAL GAMMA
0 API 400

16" NORMAL RESISTIVITY
0 OHM-M 100

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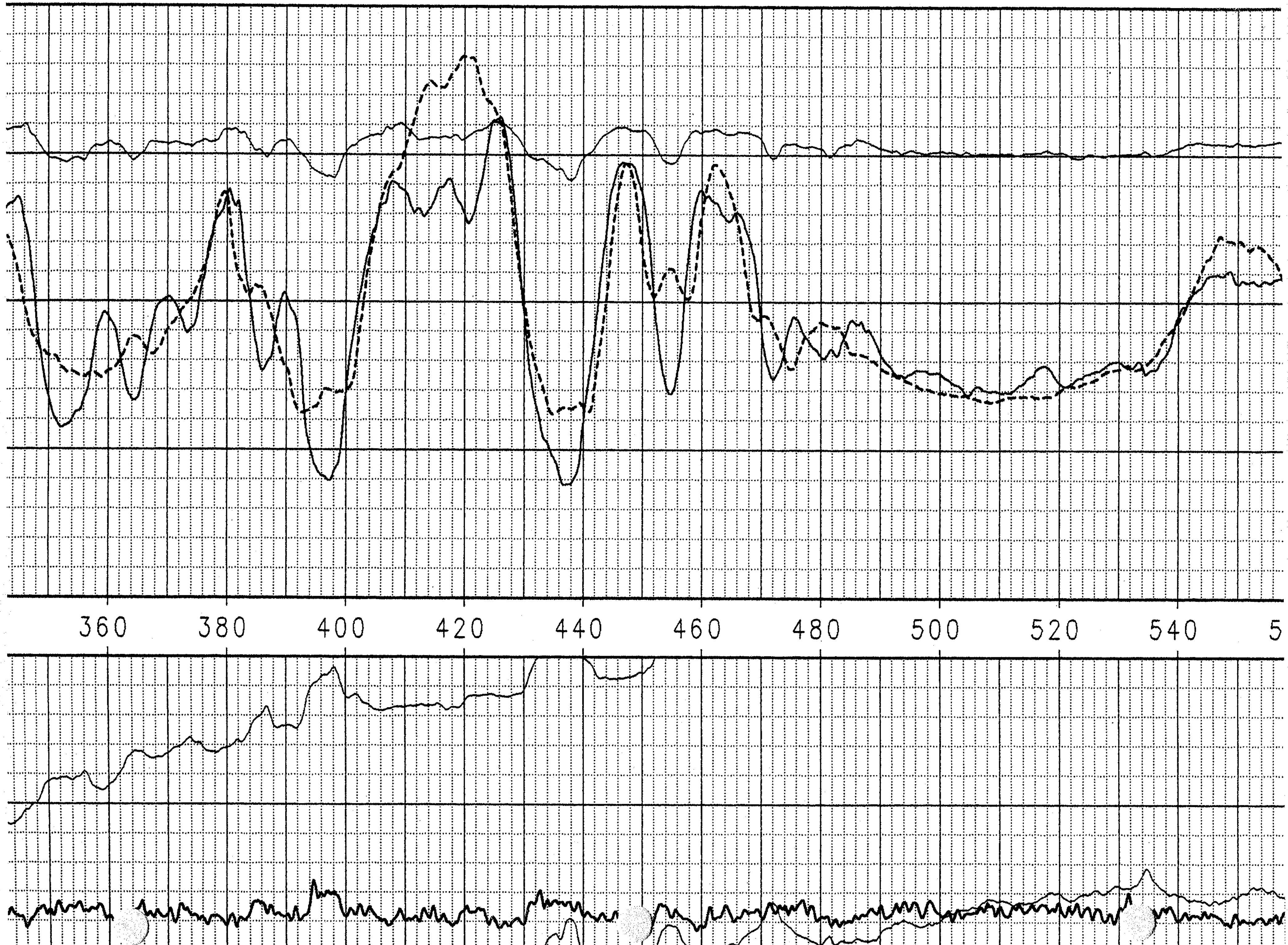
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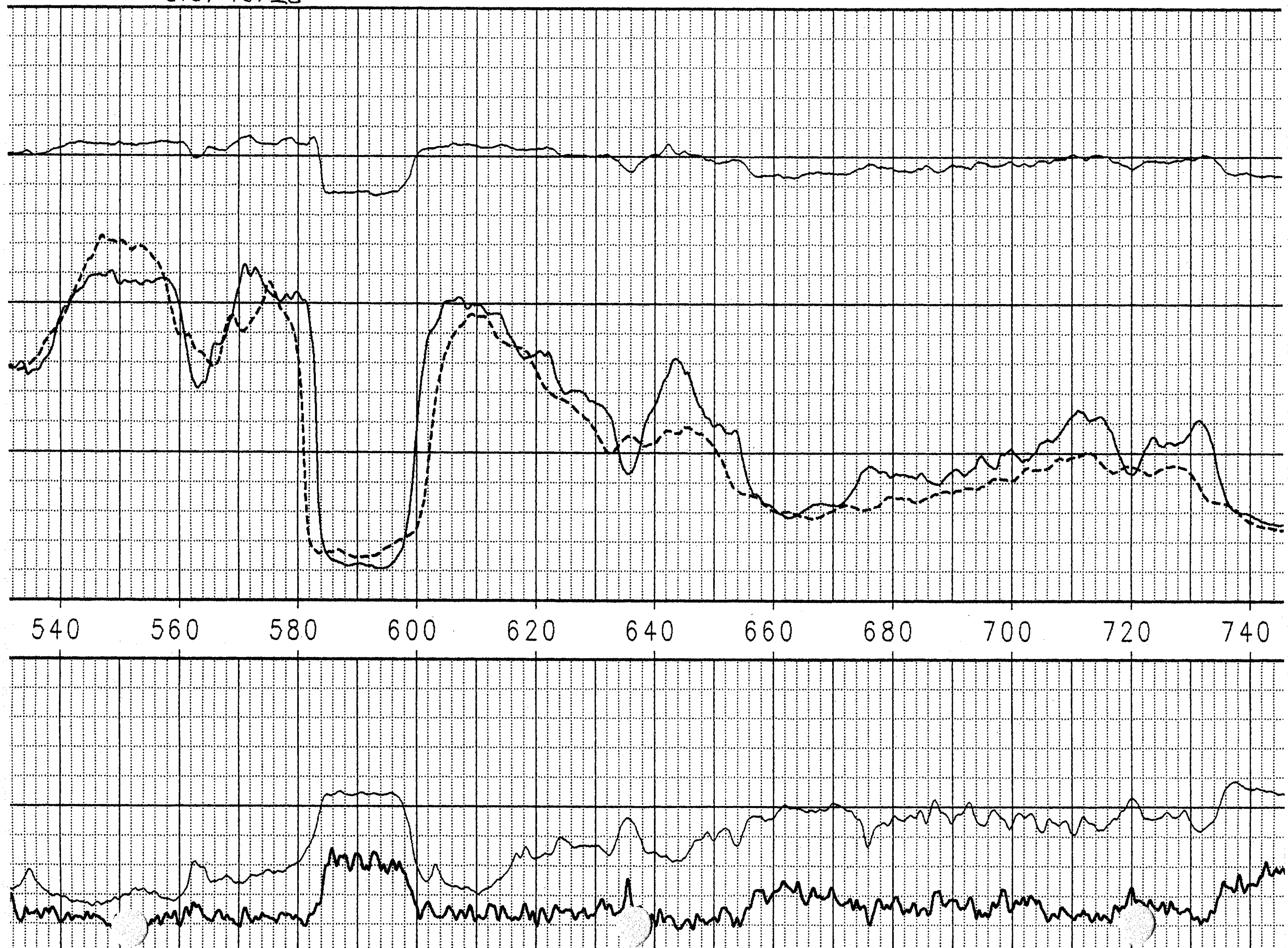
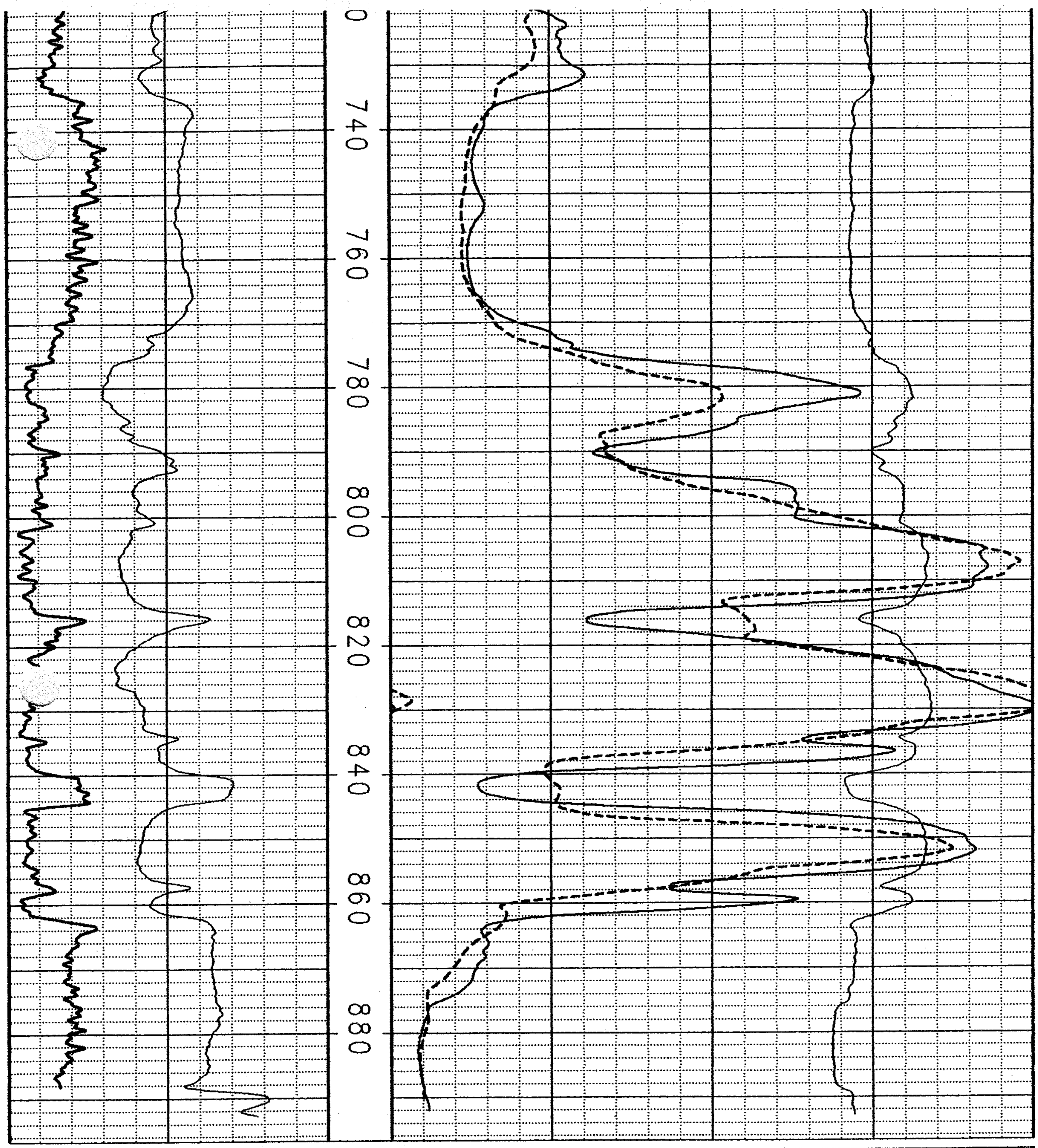
DTX01-1012





NATURAL GAMMA	16" NORMAL RESISTIVITY	
0 API 400	0 OHM-M 100	
SPONTANEOUS POTENTIAL	64" NORMAL RESISTIVITY	
MILLIVOLTS 150	0 OHM-M 100	
		SINGLE POINT RESISTANCE
		0 OHMS 100

SM STOLLER, PTX01-1013, 5/12/00

COLOG

PTX06-1033

Contractor: E^2M

Contract #: 03003

OPTIX #:

Included Documents

_X_Drilling Log
    _X_Draft
    ___Final

_X_Installation Log

___Lithologic Logs
    ___Draft
    ___Final

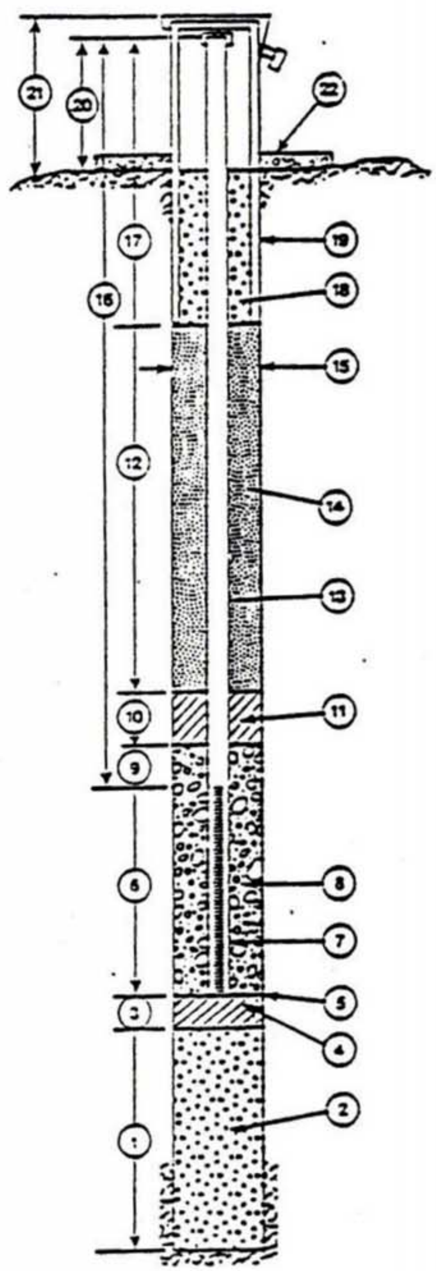
___Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

_X_State Well Report

	MONITORING WELL INSTALLATION LOG	BOREHOLE/WELL NUMBER: PTX06-1033

PROJECT NUMBER 9621
PROJECT NAME ZONE 12 GW EXPANSION STUDY
INSTALLATION TEAM WATER DEVELOPMENT CORP

GROUND SURFACE ELEVATION ______
TOP OF WELL CASING ELEVATION ______
START DATE 9.5.96 TIME 1015
END DATE 9.12.96 TIME 1140



1. ELEV/DEPTH OF BOREHOLE 556 FEET.
2. TYPE OF LOWER BACKFILL 5 FEET.
3. ELEV/DEPTH OF BOTTOM OF BOTTOM SEAL (IF INSTALLED) NA FEET.
4. TYPE OF BOTTOM SEAL NA.
5. ELEV/DEPTH TO TOP OF BOTTOM SEAL NA FEET.
6. ELEV/BOTTOM DEPTH OF WELL SCREEN 546 FEET. BOTTOM OF SUMP = 551'
7. TYPE OF SCREEN MATERIAL STAINLESS STEEL. DIAMETER OF SCREEN 4". SLOT SIZE OF SCREEN 2 SLOT.
8. TYPE OF PACK AROUND WELL POINT OR SCREEN 10/20 SAND.
9. ELEV/DEPTH TO TOP OF WELL POINT OR SCREEN 406 FEET.
10. ELEV/DEPTH TO BOTTOM OF TOP OF SEAL (IF INSTALLED) 381 FEET.
11. TYPE OF UPPER SEAL 3/8" BENTONITE CHIPS
12. ELEV/DEPTH TO TOP OF TOP SEAL (IF INSTALLED) 364 FEET.
13. TYPE OF RISER PIPE MATERIAL STAINLESS STEEL
DIAMETER OF RISER PIPE 4".
14. TYPE OF UPPER BACKFILL CEMENT/BENTONITE GROUT
* 15. BOREHOLE DIAMETER ~~8~~ 7 7/8" ~~FEET~~.
16. TOTAL LENGTH OF RISER PIPE 406'.
17. ELEV/DEPTH TO BOTTOM OF UPPER SEAL/PROTECTIVE CASING ______.
18. TYPE OF UPPER SEAL ______.
19. TYPE OF WELL COVER ______.
DIAMETER OF WELL COVER ______.
20. ELEV/HEIGHT OF WELL CASING ABOVE GROUND ______ FEET.
21. PROTECTIVE CASING? YES NO (CIRCLE ONE)
ELEV/HEIGHT ABOVE GROUND ______ FEET.
LOCKING CAP? YES NO (CIRCLE ONE)
22. CONCRETE CAP? YES NO (CIRCLE ONE)

Data Verified ______ Date ______
Data Reviewed by ______ Date ______

* 8" PERMANENT STEEL CASING INSTALLED IN A 12" BOREHOLE FROM GROUND LEVEL TO 283.73 bgl. CASING GROUTED W/ CEMENT/BENTONITE GROUT

Log of Boring No.	Project Number	Location
PTX06. 1033	9621	ZONE 12 / PANTEX

Logged by: V. CRNICH | Checked by: | Date Started: 9.5.96 | Date Completed: 9.12.96

Drilling Co. WATER DEVELOPMENT CORP | Bit Diameter: 10 7/8; 7 5/8 | Total Depth: 556

Driller: R. CRINER | Sampler:

Drilling Method: AIR ROTARY w/ CASING HAMMER[1] | Depth to water: First: * ; Final: —

Drilling Equipment: SPEEDSTAR | Elevation: Grnd: | TOC:

Borehole Backfill or Well Completion Data: [1] AIR ROTARY TO 282'; MUD ROTARY TO TOTAL DEPTH
* WL OF PERCHED AQUIFER = 259.65' bgl

Depth (feet)	LITHOLOGIC DESCRIPTION	Lithology USCS	Sample	Blow Counts	Recovery	PPM	REMARKS
0	CLAY - TOPSOIL, MEDIUM PLASTICITY, MOIST, MED STIFF, DARK BROWN (10YR3/3); INTERBEDDED SAND.	CL					
	SANDY CLAY - 70% CLAY, 30% SAND; LOW PLASTICITY; MED STIFF, DRY; DARK GRAYISH BROWN (10YR 4/2); AT 5' PINKISH GRAY (7.5YR 7/2) INTERBEDDED CALICHE.	CL					
	- REDDISH YELLOW (7.5YR 6/6); DAMP, INTERBEDDED CALICHE						
25							
	- DRY; SOFT TO MEDIUM STIFF; INTERBEDDED CALICHE						
	- 80% CLAY, 20% SAND; LOW TO MEDIUM PLASTICITY; PINKISH GRAY (7.5YR 7/2), INTERBEDDED CALICHE						
	- 70% CLAY; 30% SAND, STRONG BROWN (7.5YR 5/8); INTERBEDDED CALICHE						
50	- REDDISH YELLOW (5YR 7/6); INTERBEDDED CALICHE						
	- 60% CLAY; 40% SAND; DAMP; YELLOWISH RED (5YR5/8); INTERBEDDED CALICHE						
75	SILTY SAND - 90% SAND, 10% SILT; VERY FINE TO FINE GRAINED; LOOSE TO MEDIUM DENSE; DRY; PINK (5YR 7/4); INTERBEDDED CALICHE	SM					
	- LIGHT REDDISH BROWN (5YR 6/4)						
	- MEDIUM DENSE; DAMP; SUBROUNDED SAND; YELLOW (10YR 7/6); INTERBEDDED CALICHE						
	- DRY; DECREASE IN CALICHE						
100	SAND - VERY FINE TO FINE GRAINED; LOOSE; DAMP; SUBROUNDED; YELLOW (10YR 7/6)	SP					
	- INTERBEDDED FINE GRAINED GRAVEL; DRY						
	- INTERBEDDED FINE TO COARSE GRAINED GRAVEL						
125							

Log of Boring No.	Project Number	Location
PTX06-1033	9621	ZONE 12 / PANTEX

Logged by: V. CRNICH	Checked by:	Date Started: 9.5.96	Date Completed: 9.12.96
Drilling Co. WATER DEVELOPMENT CORP.		Bit Diameter: 7 5/8, 10 5/8	Total Depth: 556.0
Driller: R. CRINER		Sampler:	
Drilling Method: ARCH (0-282') MUD ROTARY (282-TD)		Depth to water: First: *	Final:
Drilling Equipment: SPEEDSTAR		Elevation: Grnd:	TOC:

Borehole Backfill or Well Completion Data
* WL OF PERCHED AQUIFER = 259.65' bgl

Depth (feet)	LITHOLOGIC DESCRIPTION	Lithology USCS	Sample	Blow Counts	Recovery	PPM	REMARKS
25	SAND - VERY FINE TO FINE GRAINED, LOOSE, DRY, SUBROUNDED, YELLOW (10YR 7/6); INTERBEDDED FINE TO COARSE GRAINED GRAVEL	SP					
	- SLIGHTLY SILTY (<5%); DAMP						
	SILTY SAND - 90% SAND, 10% SILT; VERY FINE TO FINE GRAINED; LOOSE TO MEDIUM DENSE; DAMP, REDDISH YELLOW (7.5YR 7/6)	SM					
	- MEDIUM DENSE						
50							
	- DAMP TO DRY; YELLOW (10YR 7/6); MINOR AMOUNTS OF GRAVEL (<5%)						
	- ZONES OF PARTIALLY CEMENTED SAND						
	- NO GRAVEL OBSERVED						
7c							
	SAND - VERY FINE TO FINE GRAINED, MEDIUM DENSE; DAMP, YELLOW (10YR 7/6); SLIGHTLY SILTY (<5%)	SP					
	- DRY TO DAMP						
00	- MEDIUM DENSE TO DENSE, INTERBEDDED CALICHE						
	SILTY SAND - 90% SAND, 10% SILT; VERY FINE TO FINE GRAINED; DENSE; DAMP, REDDISH YELLOW (7.5YR 6/6)	SM					
	CLAYEY SAND - 80% SAND, 20% CLAY; VERY FINE TO FINE GRAINED; DENSE; DAMP; REDDISH YELLOW (7.5YR 6/6) SMALL ZONES OF PARTIALLY CEMENTED SAND.	SC					
	- 90% SAND, 10% CLAY; DENSE; DAMP						
25	- MINOR AMOUNTS OF CLAY LENSES (SM ZONES OF INTERBEDDED CLAY)						
	SAND - VERY FINE TO MEDIUM GRAINED; RARE AMOUNTS OF COARSE GRAINED SAND; SUBROUNDED; DENSE, DAMP; BROWNISH YELLOW (10YR 6/6)	SP					
	GRAVEL - FINE GRAINED; DENSE; SUBROUNDED; INTERBEDDED VERY FINE TO MEDIUM GRAINED DAMP SAND.	GP					
	SAND - FINE TO MEDIUM GRAINED, SUBROUNDED, DENSE TO VERY DENSE; VERY PALE BROWN (10YR 7/4); CLEAN; DRY	SP					
	- DAMP TO MOIST; VERY FINE TO MEDIUM GRAINED; INTERBEDDED GRAVELS; YELLOW (10YR 7/6)						
0	- DAMP; NO GRAVEL; SLIGHTLY SILTY						

Log of Boring No. PTX06-1033

Project Number: 9621

Location: ZONE 12/PANTEX

Logged by: J. CZNICH | Checked by: | Date Started: 9.5.96 | Date Completed: 9.12.96

Drilling Co.: WATER DEVELOPMENT CORP. | Bit Diameter: 10 5/8 7 5/8 | Total Depth: 556

Driller: R. CRINER | Sampler:

Drilling Method: REC. AH (0-282') MUD ROTARY (282-TD) | Depth to water: First: * | Final:

Drilling Equipment: SPEEDSTAR | Elevation: Grnd: | TOC:

Borehole Backfill or Well Completion Data:
* WL OF PERCHED AQUIFER = 259.65' bgl

Depth (feet)	LITHOLOGIC DESCRIPTION	Lithology USCS	Sample	Blow Counts	Recovery	PPM	REMARKS
250	SAND - DAMP, SLIGHTLY SILTY; VERY FINE TO MEDIUM GRAINED; YELLOW (10YR 7/6)	SW					
	- DAMP TO MOIST; BROWN (7.5YR 5/4)						
	CLAYEY SAND - 90% SAND, 10% CLAY; DENSE; DAMP; FINE TO MEDIUM GRAINED; BROWN (7.5YR 5/4)	SC					
	SILTY SAND - 80% SAND, 20% SILT; FINE TO MEDIUM GRAINED; MOIST; DENSE; BROWNISH YELLOW (10YR 6/6)	SM					
	- SLIGHTLY CLAYEY, MOIST						
	SAND - FINE TO COARSE GRAINED; SUBROUNDED, DENSE; MOIST; SLIGHTLY SILTY (<5%)	SW					
275	- VERY MOIST; FINE TO MEDIUM GRAINED						
	SILTY, CLAYEY SAND - 80% SAND, 10% CLAY, 10% SILT; FINE TO MEDIUM GRAINED; DAMP TO MOIST; YELLOWISH BROWN (10YR 5/4)	SC SM					TD'D 12" CASING AT 282' bgl SET 8" PERMANENT CASING TO 283.73' bgl
	SANDY, SILTY CLAY - 70% CLAY, 15% SAND, 15% SILT; MEDIUM PLASTICITY; BROWNISH YELLOW (10YR 6/6); MED STIFF (FIRM)	CL					
	CLAYEY GRAVEL - 60% GRAVEL, 40% CLAY; FINE GRAINED GRAVEL, BROWNISH YELLOW (10YR 6/6)	GC					
	SANDY CLAY - 80% CLAY, 20% SAND; INTERBEDDED GRAVEL LAYERS, BROWNISH YELLOW (10YR 6/6); VERY FINE TO FINE GRAINED SAND, SAND CONTENT INCREASES AT 295' (~40%)	CL					
	CLAYEY GRAVEL - 60% GRAVEL, 40% CLAY; FINE GRAINED GRAVEL; BROWNISH YELLOW CLAY (10YR 6/6) SLIGHTLY SANDY (COARSE SAND <5%)	GC					
300	SILTY SAND - 80% SAND, 20% SILT; SLIGHTLY CLAYEY; VERY FINE - FINE GRAINED; RARE COARSE GRAINS; BROWNISH YELLOW (10YR 6/6); INTERBEDDED FINE GRAINED GRAVEL AT 300'	SM					
	SANDY CLAY - 70% CLAY, 30% SAND, BROWNISH YELLOW (10YR 6/6) FINE TO COARSE GRAINED SAND	CL					
	- MEDIUM TO COARSE GRAINED SAND (30-40%); LIGHT BROWN (7.5YR 6/4); SLIGHTLY SILTY						
	CLAYEY SAND - 60% SAND, 40% CLAY, VERY FINE TO COARSE GRAINED SAND (80% VERY FINE TO FINE); VERY PALE BROWN TO LIGHT BROWN (10YR 7/3 7.5YR 6/4)	SC					
325							
	SILTY SAND - 70% SAND, 30% SILT; VERY FINE TO FINE GRAINED SAND, SLIGHTLY CLAYEY (<10%); LIGHT BROWN (7.5YR 6/4)	SM					
350	- CLAY PERCENTAGE DECREASES						
	- INTERBEDDED GRAVEL						
375							

Log of Boring No. PTX06-1033 | Project Number 9621 | Location ZONE 12

Logged by: V. CRNICH | Checked by: | Date Started: 9.5.96 | Date Completed: 9.12.96

Drilling Co. WATER DEVELOPMENT CORP | Bit Diameter: 7 5/8 | Total Depth: 556

Driller R. CRANER | Sampler:

Drilling Method: ARCH (0-282) MUD ROTARY (282-TD) | Depth to water: First: * | Final:

Drilling Equipment SPEEDSTAR | Elevation: Grnd: | TOC:

Borehole Backfill or Well Completion Data.
* W.L OF PERCHED AQUIFER = 259.65 bgl

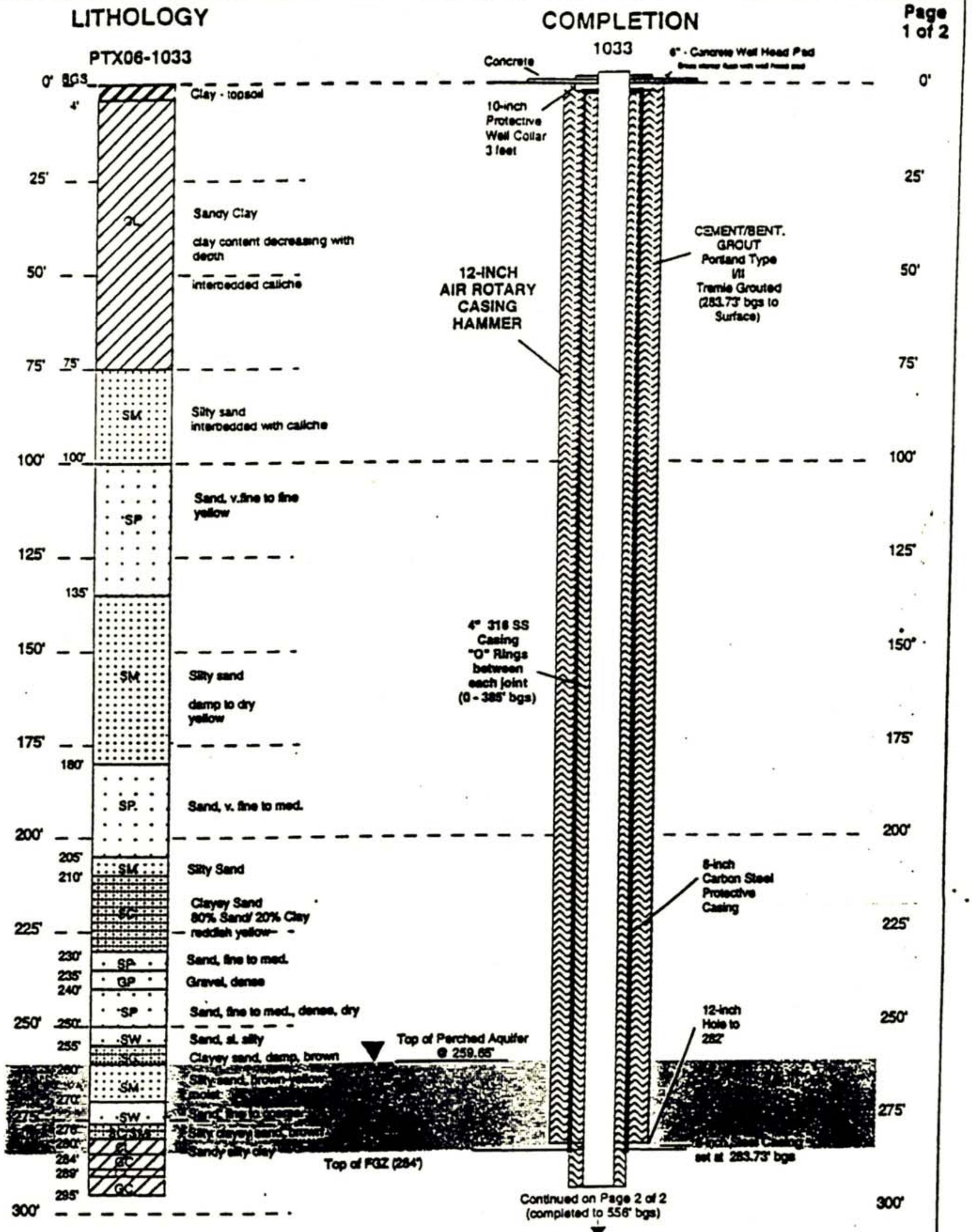
Depth (feet)	LITHOLOGIC DESCRIPTION	Lithology USCS	Sample	Blow Counts	Recovery	PPM	REMARKS
375	SILTY SAND - 70% SAND, 30% SILT; VERY FINE TO FINE GRAINED; SLIGHTLY; LIGHT BROWN (7.5YR6/4); INTERBEDDED GRAVEL	SM					
	- INTERBEDDED CALICHE; VERY PALE BROWN (10YR7/4)						
	- INCREASE IN SAND CONTENT (90%)						
·00							
25	- SLIGHTLY CLAYEY; INTERBEDDED CALICHE AND FINE GRAINED GRAVEL						
	- INCREASE IN CLAY CONTENT; RARE COARSE GRAINED SAND (<5%); VERY-FINE TO FINE GRAINED; VERY PALE BROWN (10YR7/4) TO BROWNISH YELLOW (10YR6/8)						
50	- 90% SAND, 10% SILT; INTERBEDDED CALICHE,						
	- INCREASE IN PERCENTAGE OF COARSE GRAINED SAND (20%); SUBANGULAR TO SUBROUNDED; LIGHT BROWN (7.5YR6/4)						
	GRAVEL - FINE GRAINED GRAVEL INTERBEDDED WITH VERY FINE TO FINE GRAINED SILTY SAND AND COARSE GRAINED SAND; CALICHE NODULES, GRAVEL IS SUBROUNDED	GP					
5	- INTERBEDDED WITH LIGHT BROWN AND WHITE (5YR8/2) SILTY SAND AND DARK YELLOW SANDY CLAY (10YR6/8); SUBROUNDED - RARE SUBANGULAR GRAINS						
	- SILTY, CLAYEY MATRIX						
	SANDY GRAVEL - 80% GRAVEL, 20% SAND; FINE GRAINED GRAVEL, COARSE GRAINED SAND; SUBROUNDED TO SUBANGULAR; WHITE CLAYEY MATRIX; ABUNDANT QUARTZ	GC					
0	- INTERBEDDED SANDY CLAY, RED (2.5YR5/6)						

Log of Boring No.	Project Number	Location
PTX06-1033	9621	ZONE 12

Logged by: V. CRNICH	Checked by:	Date Started: 9.5.96	Date Completed: 9.12.96
Drilling Co. WATER DEVELOPMENT CORP		Bit Diameter: 7 5/8	Total Depth: 556
Driller R. CRINER		Sampler:	
Drilling Method: ARCH (0-282); MUD ROTARY (282-TD)		Depth to water: First: *	Final:
Drilling Equipment SPEEDSTAR		Elevation: Grnd:	TOC:

Borehole Backfill or Well Completion Data.
* WL IN PERCHED AQUIFER = 259.65 bgl

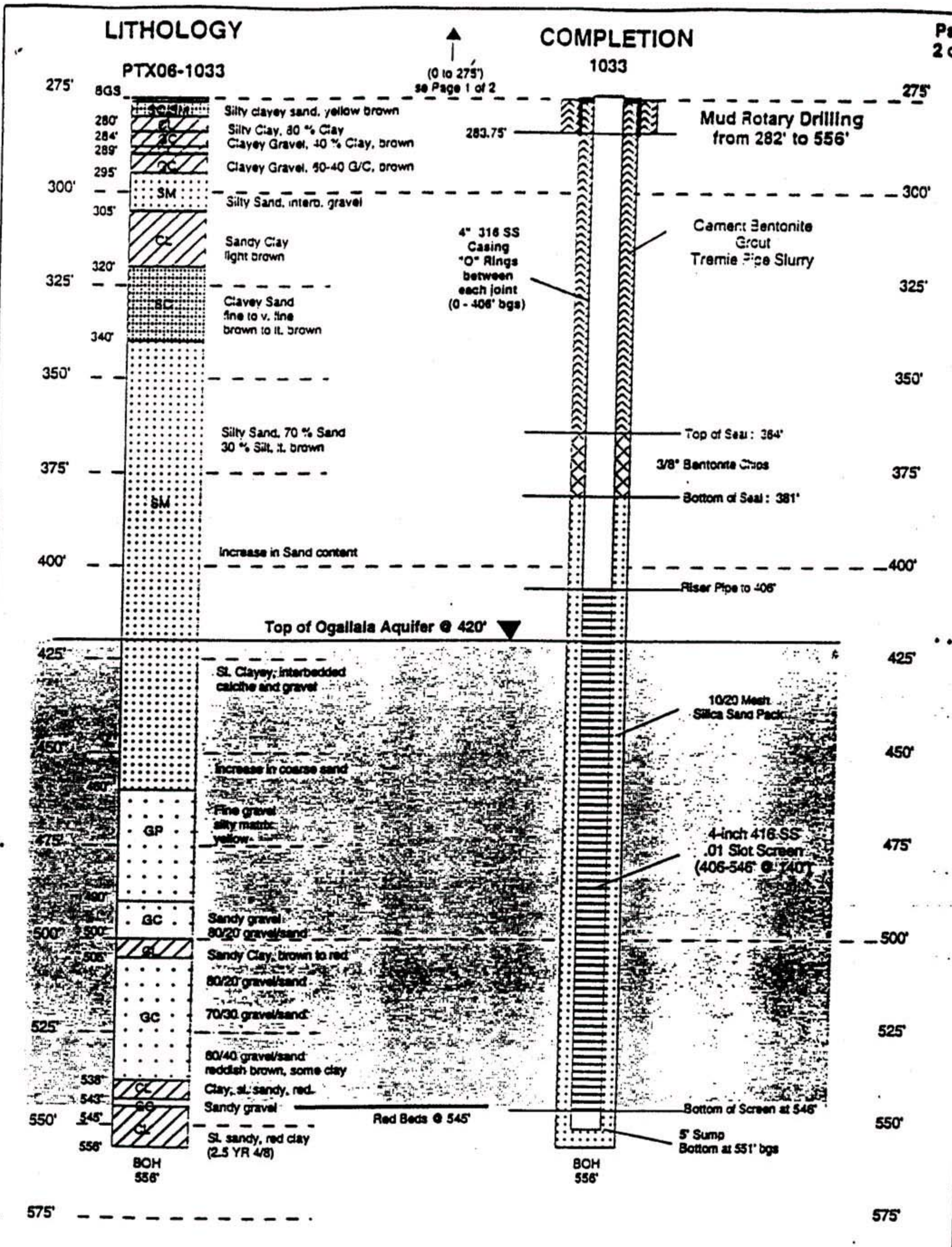
Depth (feet)	LITHOLOGIC DESCRIPTION	Lithology USCS	Sample	Blow Counts	Recovery	PPM	REMARKS
500	SANDY CLAY - 80% CLAY, 20% SAND; LIGHT BROWN (7.5YR 6/4) TO RED (2.5YR 5/6)	CL					
	SANDY GRAVEL - 80% GRAVEL, 20% SAND, FINE GRAINED GRAVEL, COARSE GRAINED SAND, CLAYEY MATRIX	GC					
	- 70% GRAVEL, 30% SAND; FINE GRAINED GRAVEL, MEDIUM TO COARSE GRAINED SAND; MOIST, UNSORTED; LIGHT BROWN CLAY MATRIX (7.5YR 6/4), SUBROUNDED TO SUBANGULAR; DRILLING BECOMES HARDER AT 519' (DENSE)						
525	- 60% GRAVEL, 40% SAND; INTERBEDDED CLAY COLOR RANGES FROM LIGHT BROWN 7.5YR 6/4, LIGHT REDDISH BROWN 5YR 6/4, YELLOWISH RED 5YR 5/8 AND WHITE (5YR 8/1)						
	CLAY - SLIGHTLY SANDY, MEDIUM STIFF (BASED ON DRILLING); RED (2.5YR 4/8)	CL					
	SANDY GRAVEL - 60% GRAVEL, 40% SAND; FINE GRAINED GRAVEL, COARSE GRAINED SAND; SLIGHTLY CLAYEY MATRIX LIGHT BROWN 7.5YR 6/4	GC					
	CLAY - SLIGHTLY SANDY, MED STIFF - STIFF (BASED ON DRILLING) RED (2.5YR 4/8)	CL					
550	TOTAL DEPTH = 556'						
575							



Continued on Page 2 of 2
(completed to 556' bgs)

Pertinent Well Data:
Start Date: 9/06/96
Finish Date: 9/12/96
Location: Pantex E. of Zone 12
Amarillo, Texas
Drilling Company:
Driller: R. Criner
Method: Comb. ARCH/Mud Rotary
Depth to Water: 259.65'(P.A.); 420' Ogallala
Elevation: 3540.60' (V-Notch on Well Head)
Elevation: 3538.28' (Brass Plate in Concrete Pad)
10" Hole Depth: 0'
12" Hole Depth: 282'
7-5/8" Mud Rot: 274', (T.D.= 556')
On-Site Geologist:
Project Manager:
Easting (x): 642614.48
Northing(y): 3759581.41
Special Note: X,Y,Coordinates represent exact location of the Brass Plate in well head concrete pad

Title: PTX06-1033 (Ogallala Monitoring Well) Lithologic & Completion Schematics (PAGE 1 of 2)	Drawn By: DTB Date: 12-05-96 Project No.: 003003



Pertinent Well Data:
Start Date: 9/05/96
Finish Date: 9/12/96
Location: Pantex E. of Zone 12
Amarillo, Texas
Drilling Company:
Driller: R. Criner
Method: Comb. ARCH/Mud Rotary
Depth to Water: 259.65'(P.A.): 420' Ogallala
Elevation: 3540.60' (V-Notch on Well Head)
Elevation: 3538.28' (Brass Plate in Concrete Pad)
10" Hole Depth: 0'
12" Hole Depth: 282'
7-5/8" Mud Rot: 274', (T.D.= 556')
Easting (x): 642814.48
Northing(y): 3759581.41
On-Site Geologist:
Project Manager:
Contract No.:
Special Note: X,Y,Coordinates represent exact location of the Brass Plate in well head concrete pad

Title: PTX06-1033 (Ogallala Monitoring Well)
Lithologic & Completion Schematics
(PAGE 2 of 2)

Drawn By: DTB
Date: 12-05-96
Project No.: 003003

PTX06-1043

Contractor: ETAS

Contract #: 1552-003-184

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

_X_Installation Log

___Lithologic Logs
    ___Draft
    ___Final

_X_Geophysical Logs
    _X_Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

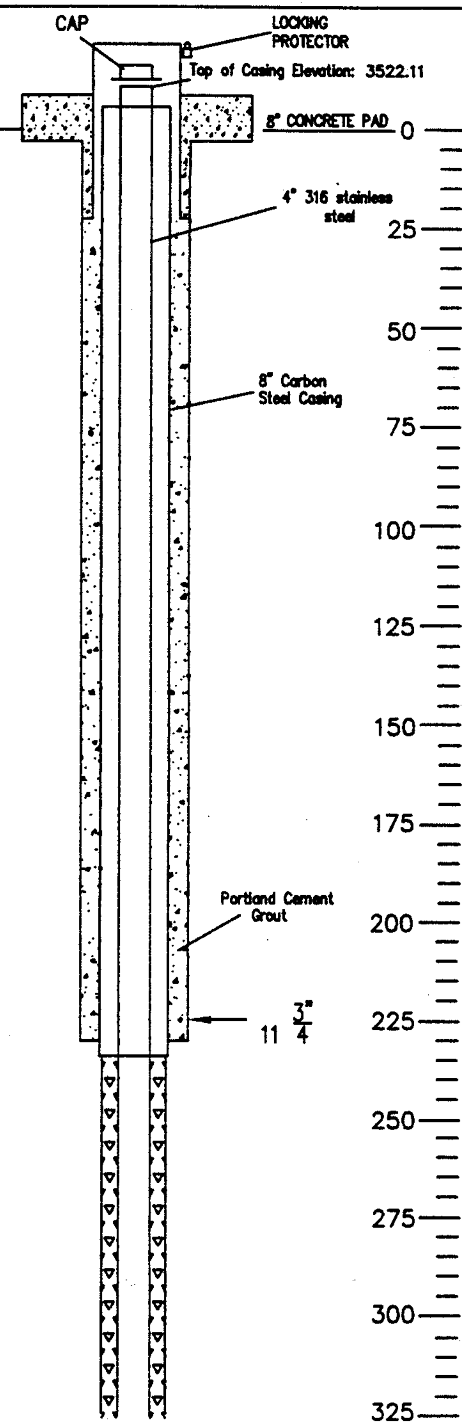
___State Well Report

PTX06-1043 WELL LOG

DEPTH (FEET)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	SPLIT SPOON SAMPLE INTERVAL
		Northing (X) : 3765226.15 Easting (Y) : 640711.10	
0		GROUND SURFACE ELEVATION: 3519.05	
0–6'	CH	Topsoil.	
6'–70'	CL	Clay 7.5yr 7/2 pinkishgray. Silty w/caliche inclusions to 50 ft., becoming sandy with depth. Dry.	
70'–222'	SM	Sand 7.5yr 7/3. Very fine grain with fine mica, poorly sorted, slightly moist with gravel @ 190 ft. Becoming very moist to wet @200 ft.	205'–206'
222'–325	FGZ	Clay 7.5 yr 5/3. Silty, dense and dry.	230'–231.5'

Con't on page 2

WELL COMPLETION DETAIL



TASK ORDER NO. 1552-003 PROJECT 184

ETAS CORPORATION

LOCATION: NE OF PLAYA1
DATE STARTED: 8/11/99
DATE COMPLETED: 8/20/99 DATE PLUGGED: N/A
DRILLING METHOD CASING HAMMER/AIR ROTARY/MUD ROTARY
DRILLED BY WATER DEVELOPMENT CORP. WEDDLE/THATCHER/PHILLIPS
LOGGED BY HENDRICKS/SCHLAG/HALL
CHECKED BY SCHLAG
DRAWN BY: ETAS

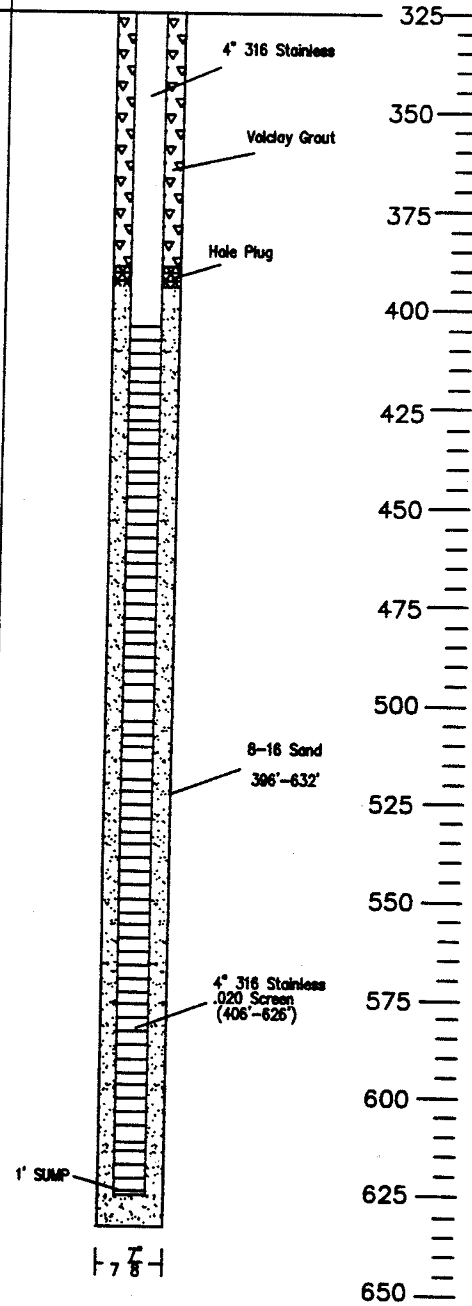
PTX06-1043 WELL LOG CONTINUED

DEPTH (FEET)	GRAPHIC LOG	CONTINUED FROM PAGE 1	SPLIT SPOON SAMPLE INTERVAL
325–378'	FGZ	Continued from page 1	
378'–622'	SP	Sand 2.5yr 7/2-8/3 pale red to pink. Silty with medium to course grain, very silty/calyey with hard dense layer from 555'-565'. Courser sand near 580'.	
622'–650	Red beds	Sandstone/siltstone reddish brown Very dense, hard.	

Depth scale: 325, 350, 375, 400, 425, 450 ▼, 475, 500, 525, 550, 575, 600, 625, 650

TD @632' ▼ Water Table @ (24hrs)

WELL COMPLETION DETAIL



TASK ORDER NO. 1552-003 PROJECT 184

ETAS CORPORATION

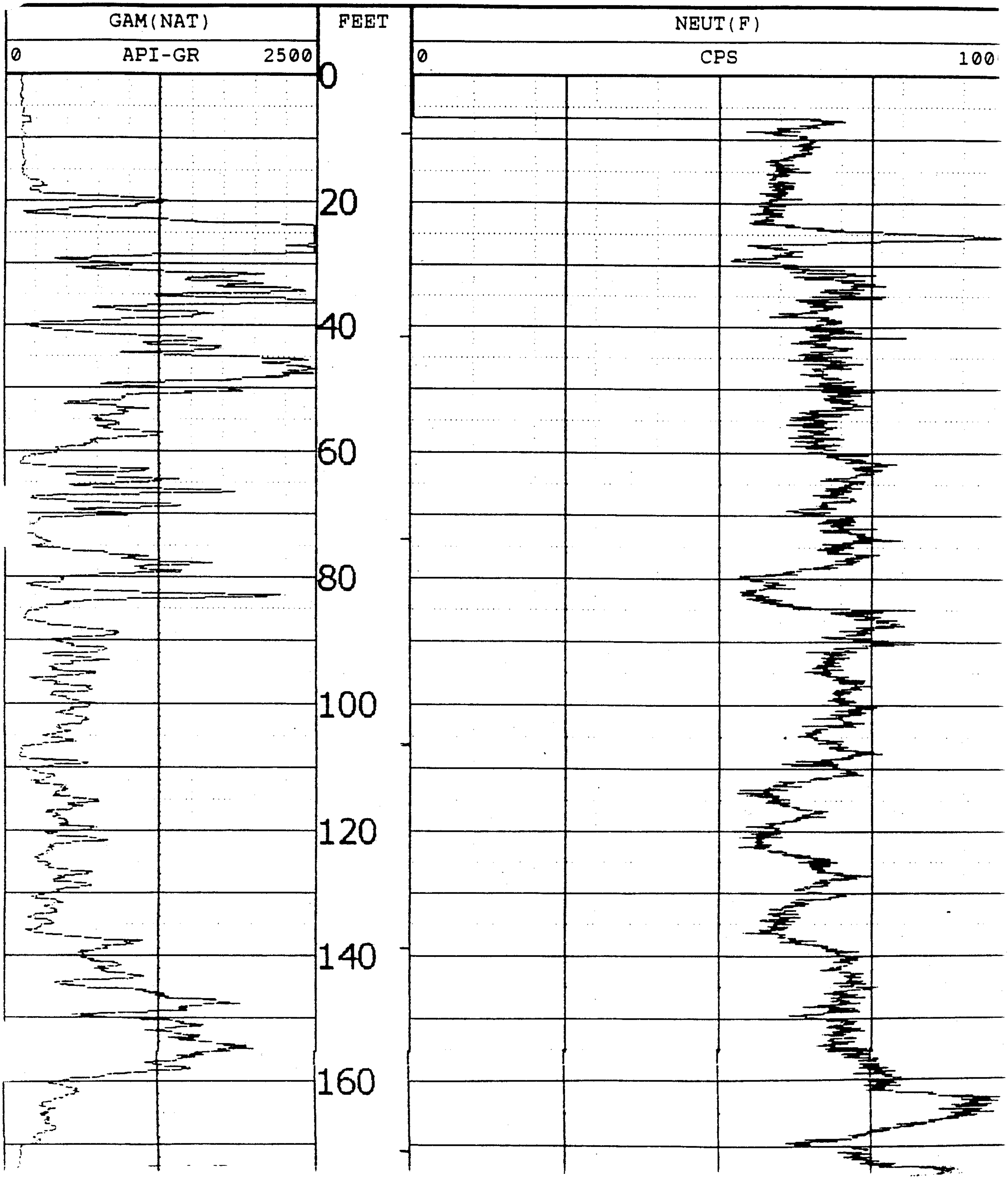
LOCATION: EAST OF PLAYA1
DATE STARTED: 8/13/99
DATE COMPLETED: 8/27/99 DATE PLUGGED: N/A
DRILLING METHOD CASING HAMMER/AIR ROTARY/MUD ROTARY
DRILLED BY WATER DEVELOPMENT CORP. THATCHER/ANDERSON
LOGGED BY HENDRICKS/HALL
CHECKED BY SCHLAG
DRAWN BY: ETAS

CGC

Century Geophysical Corp

PTX-06-1043

COMPANY	: ETAS			OTHER SERVICES:	
WELL	: PTX-06-1043				
LOCATION/FIELD	: Pantex				
COUNTY	: Carson				
STATE	: TX				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 08/31/99	PERMANENT DATUM	:		
DEPTH DRILLER	: 622			KB	:
LOG BOTTOM	: 629.00	LOG MEASURED FROM:	T.O.C.	DF	:
LOG TOP	: -0.50	DRL MEASURED FROM:	G.L.	GL	:
CASING DIAMETER	: 6	LOGGING UNIT	: 9607		
CASING TYPE	: S.S.	FIELD OFFICE	: TULSA		
CASING THICKNESS:	.2	RECORDED BY	: Federwisch		
BIT SIZE	: 9.825	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 8	RM	: 0	TYPE	: 9072A
MATRIX DENSITY	: 2.71	RM TEMPERATURE	: 0		
NEUTRON MATRIX	: sandstone	MATRIX DELTA T	: 54		
				THRESH:	20000



GAM(NAT)
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API-GR
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FEET
NEUT(F)
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CPS
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20
40
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100
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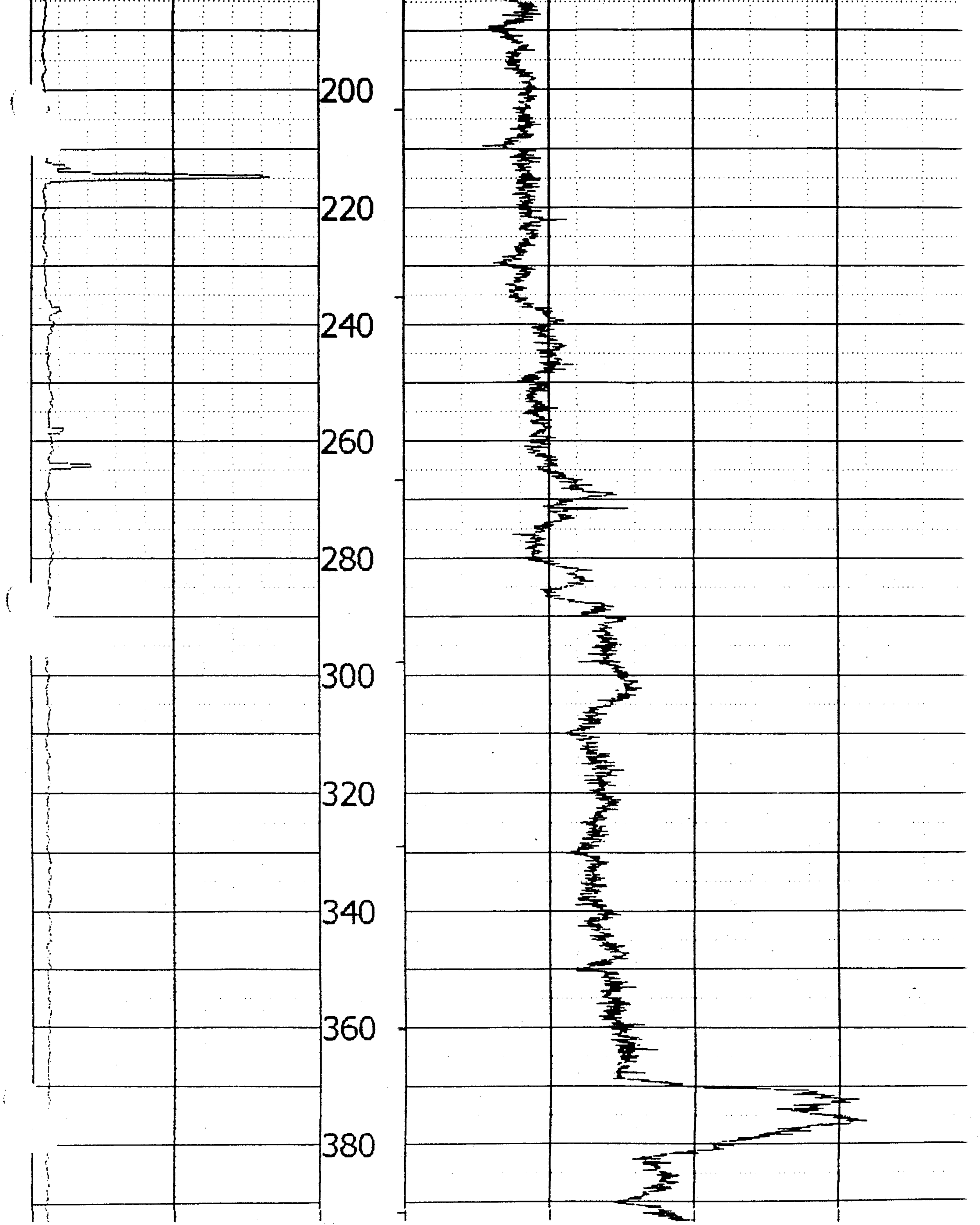

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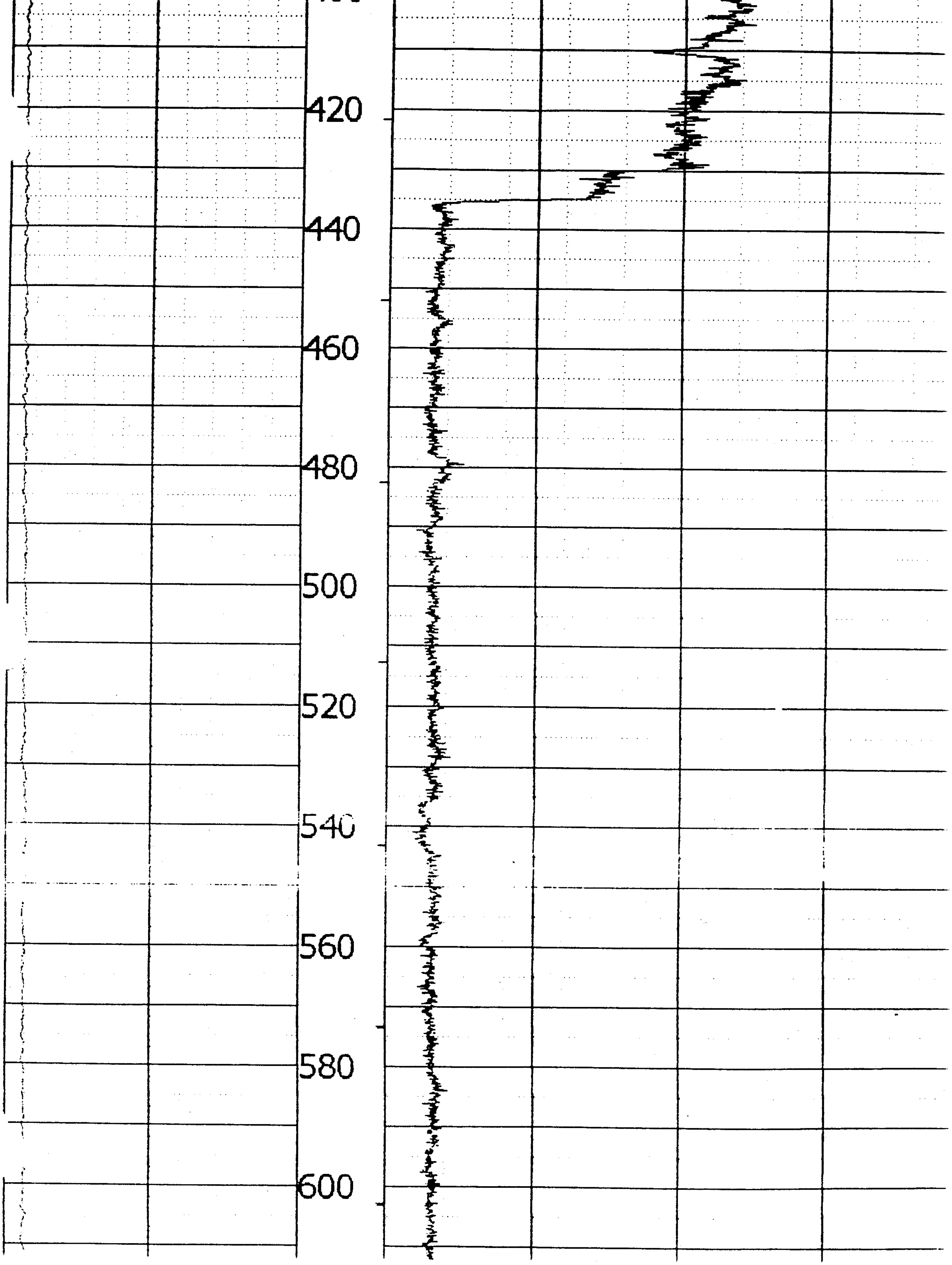
420
440
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500
520
540
560
580
600

0 API-GR 2500	FEET	0 CPS 100
GAM(NAT)		NEUT(F)

TOOL CALIBRATION PTX-06-1043 08/31/99 10:34
TOOL 9072A
SERIAL NUMBER 306

	DATE	TIME	SENSOR	STANDARD	RESPONS
1	Jun07,99	16:21:56	GAM(NAT)	Default [API-GR]	Default [CPS]
	Jun07,99	16:21:56	GAM(NAT)	Default [API-GR]	Default [CPS]
2	Jun07,99	16:21:56	VOLTAGE	Default [MV]	Default [CPS]
	Jun07,99	16:21:56	VOLTAGE	Default [MV]	Default [CPS]
3	Jun07,99	16:21:56	CURRENT	Default [UA]	Default [CPS]
	Jun07,99	16:21:56	CURRENT	Default [UA]	Default [CPS]
4	Jun07,99	16:21:56	NEUT(N)	10520.000 [CPS]	
5	Jun07,99	16:21:56	NEUT(F)	397.000 [CPS]	

PTX06-1044

Contractor: ETAS

Contract #: 1552-003-184

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

_X_Installation Log

___Lithologic Logs
    ___Draft
    ___Final

_X_Geophysical Logs
    _X_Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

PTX06-1044 WELL LOG

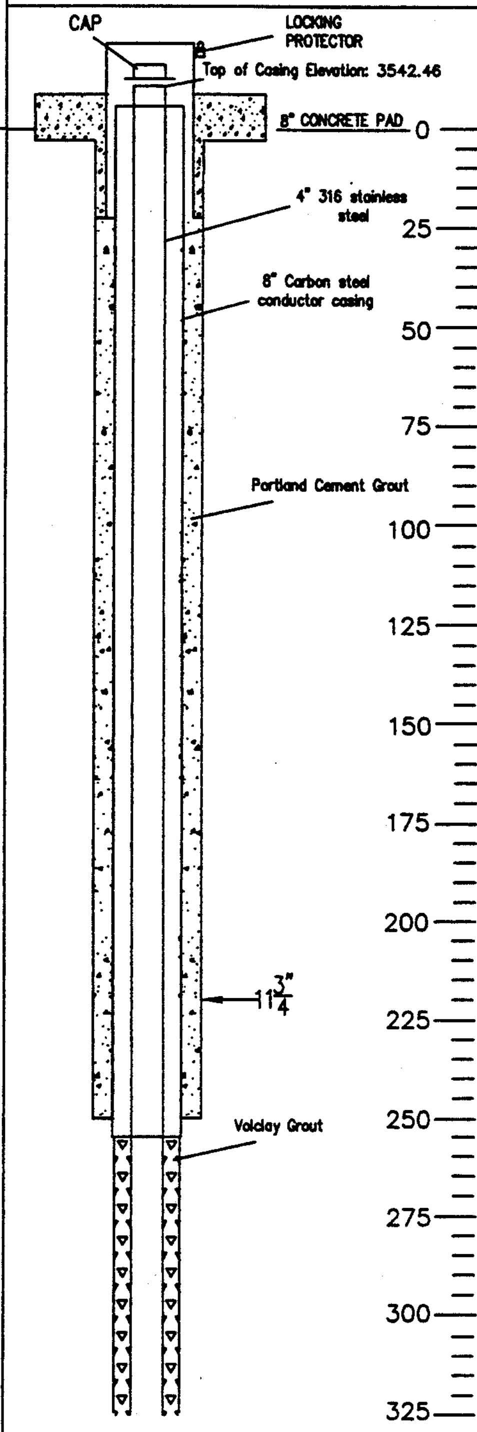
Northing (X) : 3764539.39
Easting (Y) : 642706.19

GROUND SURFACE ELEVATION: 3539.11

DEPTH (FEET)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	SPLIT SPOON SAMPLE INTERVAL
0–6'	CH	Topsoil.	
6'–60'	CL	Clay 7.5yr 6/4–8/3 lightpink. Silty w/caliche inclusions and nodules < 1/2" dia. Dry. to slightly moist.	
60'–140	SM	Sand 7.5yr 7/4. Silty, very fine grain. Dry.	
140–250	SP	Sand 10yr 7/3. Silty, fine grain with up to 20% gravel, sub-angular, dry.	
250–325	FGZ	Clay 7.5 yr 7/3. Silty with caliche inclusions. Hard and dry.	250'–251.5' Cored 255–320

Con't on page 2

WELL COMPLETION DETAIL



TASK ORDER NO. 1552-003 PROJECT 184

ETAS CORPORATION

LOCATION: EAST OF PLAYA1
DATE STARTED: 8/13/99
DATE COMPLETED: 8/27/99 DATE PLUGGED: N/A
DRILLING METHOD CASING HAMMER/AIR ROTARY/MUD ROTARY
DRILLED BY WATER DEVELOPMENT CORP. WEDDLE/THATCHER
LOGGED BY HENDRICKS/HALL
CHECKED BY SCHLAG
DRAWN BY: ETAS

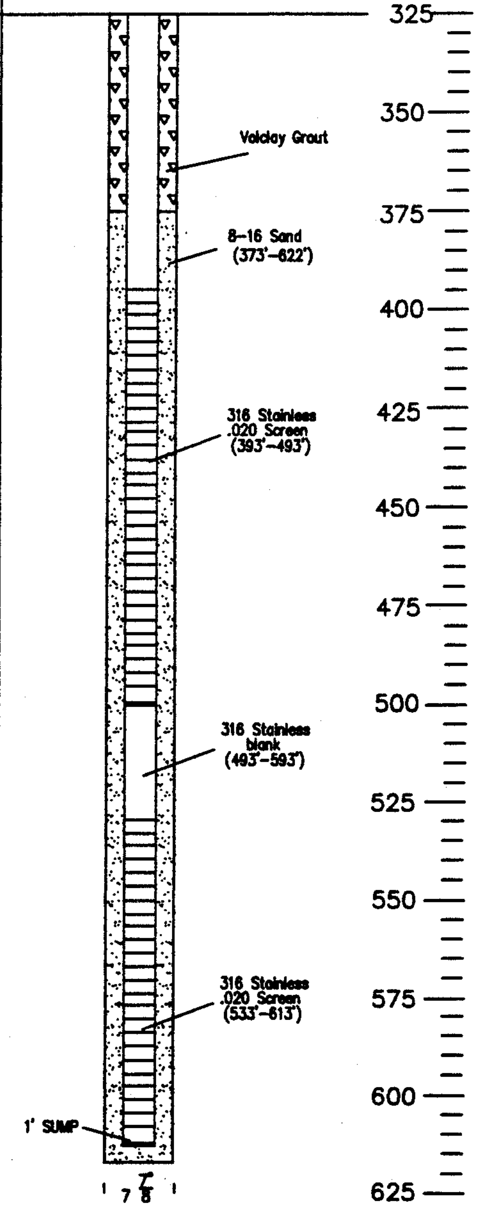
PTX06-1044 WELL LOG CONTINUED

DEPTH (FEET)	GRAPHIC LOG	CONTINUED FROM PAGE 1	SPLIT SPOON SAMPLE INTERVAL
325–385'	FGZ	Continued from page 1	
385'–440'	SP	Sand 7.5yr 6/3 light brown. Fine grain to coarse, silty in places.	
440'–600	ML	Silty clay, Sand 7.5yr 5/3 brown. Very fine grain sand/silt. Samll gravel very clayey in places.	
600–613	SP	Gravelly Sand	
613–650	Red beds	Sandstone/siltstone reddishbrown Very dense, hard.	

Depth scale: 325, 350, 375, 385', 400, 425, 440', 450, 475, 500, 525, 550, 575, 600, 613, 625, 650

TD @622' ▼ Water Table @ (24hrs)

WELL COMPLETION DETAIL



TASK ORDER NO. 1552-003 PROJECT 184

ETAS CORPORATION

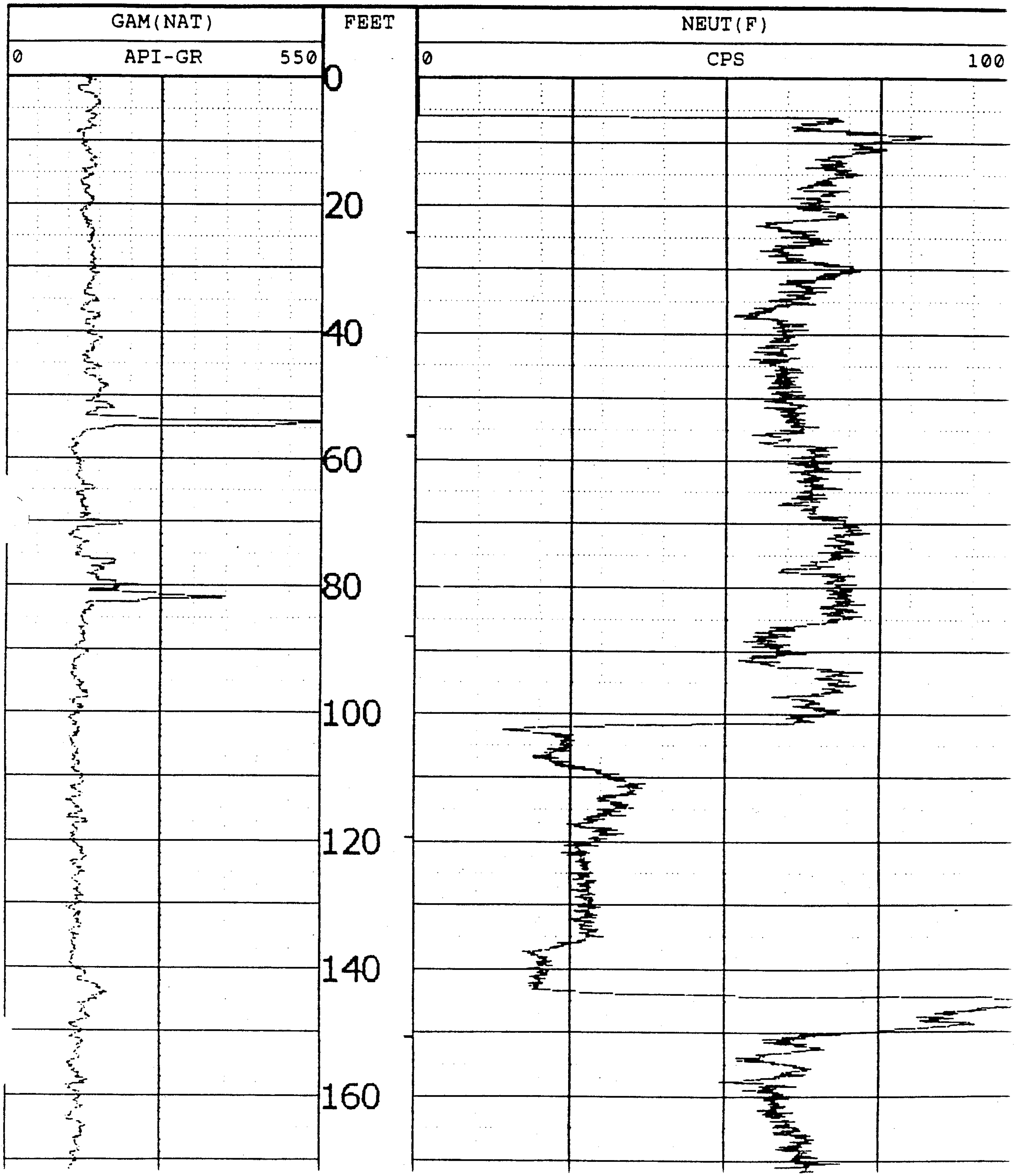
LOCATION: EAST OF PLAYA1
DATE STARTED: 8/13/99
DATE COMPLETED: 8/27/99 DATE PLUGGED: N/A
DRILLING METHOD CASING HAMMER/AIR ROTARY/MUD ROTARY
DRILLED BY WATER DEVELOPMENT CORP. THATCHER/ANDERSON
LOGGED BY HENDRICKS/HALL
CHECKED BY SCHLAG
DRAWN BY: ETAS PAGE 2 OF 2

CGC

Century
GEOPHYSICAL CORP

PTX-06-1044

COMPANY	: ETAS			OTHER SERVICES:	
WELL	: PTX-06-1044				
LOCATION/FIELD	: Pantex				
COUNTY	: Carson				
STATE	: TX				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 08/31/99	PERMANENT DATUM	:		
DEPTH DRILLER	: 614			KB	:
LOG BOTTOM	: 619.30	LOG MEASURED FROM:	T.O.C.	DF	:
LOG TOP	: -1.20	DRL MEASURED FROM:	G.L.	GL	:
CASING DIAMETER	: 5	LOGGING UNIT	: 9607		
CASING TYPE	: S.Steel	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .2	RECORDED BY	: Federwisch		
BIT SIZE	: 9.825	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 8	RM	: 0	TYPE	: 9072A
MATRIX DENSITY	: 2.71	RM TEMPERATURE	: 0		
NEUTRON MATRIX	: sandstone	MATRIX DELTA T	: 54		
				THRESH:	20000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CPS
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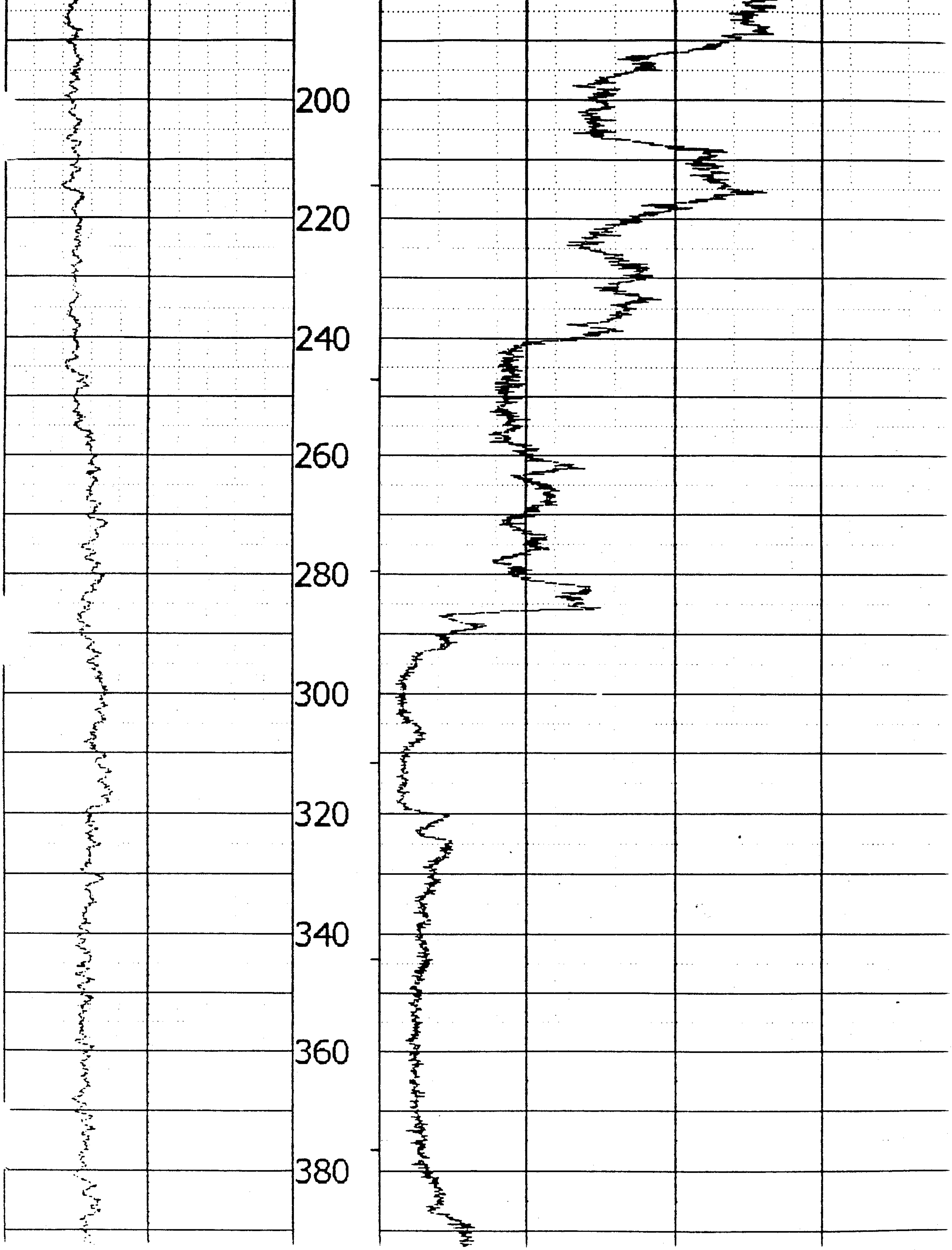
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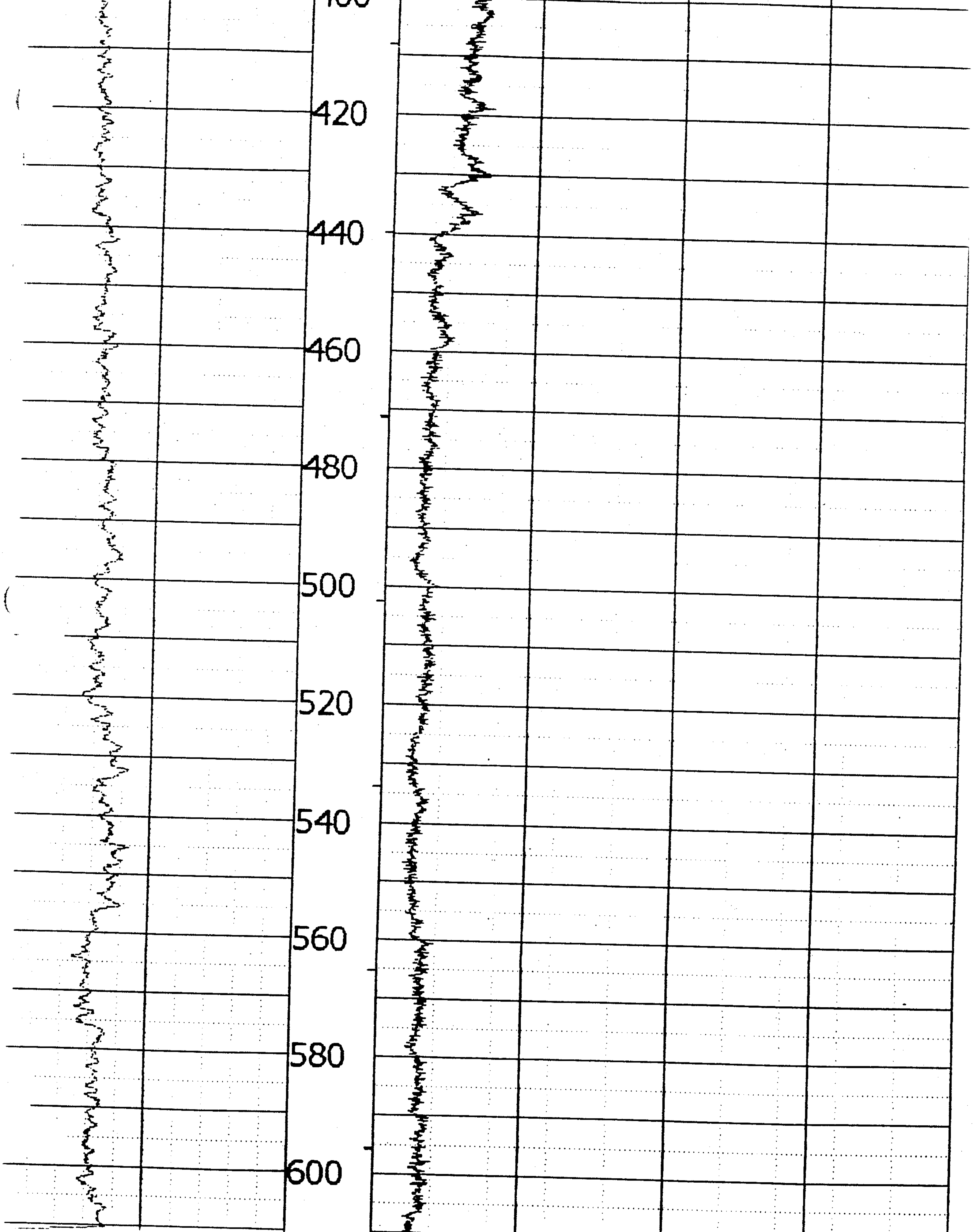
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0 API-GR 550		0 CPS 100(

TOOL CALIBRATION PTX-06-1044 08/31/99 14:24
TOOL 9072A
SERIAL NUMBER 306

	DATE	TIME	SENSOR	STANDARD	RESPONS
1	Jun07,99	16:21:56	GAM(NAT)	Default [API-GR]	Default [CPS]
	Jun07,99	16:21:56	GAM(NAT)	Default [API-GR]	Default [CPS]
2	Jun07,99	16:21:56	VOLTAGE	Default [MV]	Default [CPS]
	Jun07,99	16:21:56	VOLTAGE	Default [MV]	Default [CPS]
3	Jun07,99	16:21:56	CURRENT	Default [UA]	Default [CPS]
	Jun07,99	16:21:56	CURRENT	Default [UA]	Default [CPS]
4	Jun07,99	16:21:56	NEUT(N)	10520.000 [CPS]	
5	Jun07,99	16:21:56	NEUT(F)	397.000 [CPS]	

PTX06-1056

Contractor: S.M. Stoller Corporation

Contract #: 3589 Project 102

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

_X_Installation Log

_X_Lithologic Logs
    ___Draft
    _X_Final

___Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

PTX06-1056

Pantex GW RFI | **Pantex Plant (Texas Tech, Southeast of Zone 12 along FM 2373)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp/T. Hall	Northing: 3754642.87	Easting: 643767.03
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	500' BGS
Dates Drilled:	05/09/00 - 05/15/00	Depth to Water:	394.15' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3530.65'	TOC Elevation:	3532.80'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	0-5		CL	0-5' CLAY, sandy, dark reddish brown (5YR 3/4) low plasticity, very fine subrounded sand, stiff and damp		
	5-44 (10, 20, 30, 40)		CL	5-44' CLAY, silty, sandy, 70% clay 20% silt 10% sand, light reddish brown (5YR 6/4) to reddish yellow (5YR 6/6), low plasticity, very fine sand, stiff, damp, caliche streaks and nodes, some manganese staining		
	44-62 (50)		SM	44-62' SAND, slightly silty, trace clay, reddish yellow (7.5YR 6/5), loose, dry, 20% CaCO3		

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S.M. STOLLER CORPORATION

PTX06-1056

Pantex GW RFI | **Pantex Plant (Texas Tech, Southeast of Zone 12 along FM 2373)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp/T. Hall	Northing: 3754642.87	Easting: 643767.03
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	500' BGS
Dates Drilled:	05/09/00 - 05/15/00	Depth to Water:	394.15' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3530.65'	TOC Elevation:	3532.80'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SM			
	70		RX	62-72' CALICHE CAPROCK, pinkish white (7.5YR 8/2) slightly silty sand with caliche nodules to 1/2" diameter		
	80		CL	72-90' CLAY, sandy, 70% clay, 20% sand, 10% caliche nodes, brown (7.5YR 5/4), sand is very fine to fine grain, medium stiff, dry		
	90		SP	90-95' SAND, reddish yellow (7.5YR 6/6), very fine to medium grain, subrounded, medium dense, dry, with weakly cemented sandstone nodules to 1" diameter		
	100		SM	95-105' SAND, silty, pinkish white (7.5YR 8/2), very fine to fine grain		
	110		SM	105-115' SAND, silty, pink (7.5YR 8/3), with dense sandstone nodules, some CaCO3		
			SP	115-125' SAND, pink (7.5YR 7/4), very fine to medium grain, subrounded, slightly graded, medium loose, dry		

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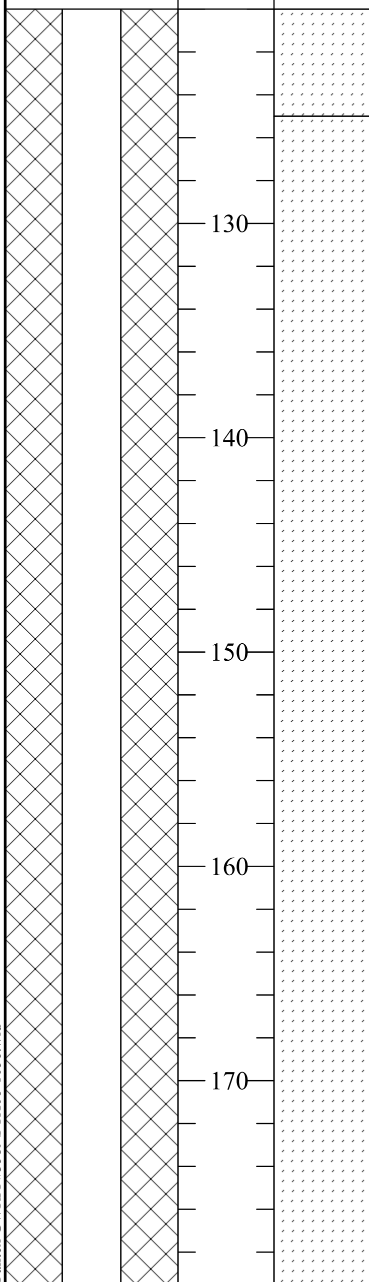
PTX06-1056

Pantex GW RFI | **Pantex Plant (Texas Tech, Southeast of Zone 12 along FM 2373)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp/T. Hall	Northing: 3754642.87	Easting: 643767.03
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	500' BGS
Dates Drilled:	05/09/00 - 05/15/00	Depth to Water:	394.15' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3530.65'	TOC Elevation:	3532.80'



Depth (Ft.)	USCS	Description	Sample	Sample Number
	SP			
130		125-210' SAND, light brown (7.5YR 6/4), sands are moderately well cemented in thin layers, especially from 150-210 which has very coarse grain to pea-gravel size nodes and fragments of calcic cemented sands		
140	SP			
150				
160	SP			
170				

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S.M. STOLLER CORPORATION

PTX06-1056

Pantex GW RFI | **Pantex Plant (Texas Tech, Southeast of Zone 12 along FM 2373)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp/T. Hall	Northing: 3754642.87	Easting: 643767.03
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	500' BGS
Dates Drilled:	05/09/00 - 05/15/00	Depth to Water:	394.15' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3530.65'	TOC Elevation:	3532.80'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	190					
			SP			
	200					
	210		SW	210-215' SAND, gravelly, very pale brown (10YR 7/3), fine to coarse grain, well graded, dense, slightly moist		
			SW	215-220' SAND, very pale brown (10YR 7/3), fine to coarse grain as above with very little gravel, dense, dry to slightly damp		
	220		SW	220-225' SAND, gravelly, very pale brown (10YR 7/3), fine to coarse grain, well graded, dense, dry to slightly damp		
			SP	225-232' SAND, slightly silty, brownish yellow (10YR 6/5), very fine to medium grain sands, dense, damp		
	230					
			CL	232-235' CLAY, brown (7.5YR 5/4), stiff with trace CaCO3		
			SW	235-240' SAND, gravelly, very pale brown (10YR 7/4), fine to coarse grain, subangular, well graded, dense, dry, gravel with numerous fresh surfaces		

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S.M. STOLLER CORPORATION

PTX06-1056

Pantex GW RFI | **Pantex Plant (Texas Tech, Southeast of Zone 12 along FM 2373)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp/T. Hall	Northing: 3754642.87	Easting: 643767.03
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	500' BGS
Dates Drilled:	05/09/00 - 05/15/00	Depth to Water:	394.15' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3530.65'	TOC Elevation:	3532.80'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			GW	240-245' GRAVEL, sandy, well compacted, very dense, dry, drive casing refusal from 0330 to 0710		
	250		SW	245-255' SAND, light yellowish brown (10YR 6/4), very fine to very coarse sand, grain size decreasing with depth, subangular, very well graded, dense, dry		
			CL	255-257' CLAY, gravelly, 70% clay, 30% pea-gravel, light yellowish brown (2.5YR 6/3) to light olive brown (2.5YR 5/3), medium plastic, stiff, damp, gravel flattened and rounded, some angular from above		
	260		CL	257-265' CLAY, sandy, 50/50 mix, yellowish brown (10YR 5/4), low plasticity, fine to coarse sand, subangular, stiff, damp to moist		
			SC	265-270' SAND, clayey, 80% sand 20% clay, yellowish brown (10YR 5/4), nonplastic, medium to fine grain, subangular to subrounded, dense, moist		PTX06-1056-2-0265 Sieve Analysis
	270		SW	270-274' SAND, gravelly, 90% sand 10% rounded gravel to 1" diameter, very pale brown (10YR 6/3), fine to very coarse sand, subrounded to rounded, well graded, medium dense, damp to moist		PTX06-1056-2-0270 Sieve Analysis
			SC	274-280' SAND, clayey, silty, 60% sand 20% clay, 20% silt, brown (7.5YR 5/4), nonplastic, fine to medium grain, some coarse, subangular, dense, damp to moist		PTX06-1056-2-0275 HE Analysis PTX06-1056-2-0276 Permeability Analysis
	280		ML	280-281' SILT, sandy, clayey, 80% silt, 15% sand, 5% clay, brown (7.5YR 5/4), low plasticity, very fine sand, stiff, damp		
			SM	281-285' SAND, silty, 65% sand 35% silt, light brown (7.5YR 6/4), very fine to fine grain sand, trace medium grain, subangular, dense, damp, silt decreasing with depth; 100% core recovery 281-285'		PTX06-1056-2-0284 Capillary Moisture Permeability Analysis
	290		SM-ML	285-301' SAND, trace silt, light brown (7.5YR 6/4), very fine to fine grain sand with trace medium grain, subangular, dense, damp; to SILT, sandy, 70% silt, 30% sand, light reddish brown (5YR 6/4) to pink (5YR 7/4), sand size very fine to fine with trace coarse grain, subangular to subrounded, stiff, damp; 100% core recovery 285-301'		PTX06-1056-2-0288 Permeability Analysis PTX06-1056-2-291.5 Permeability Analysis PTX06-1056-2-0296 Permeability Analysis PTX06-1056-2-299.5 Capillary Moisture

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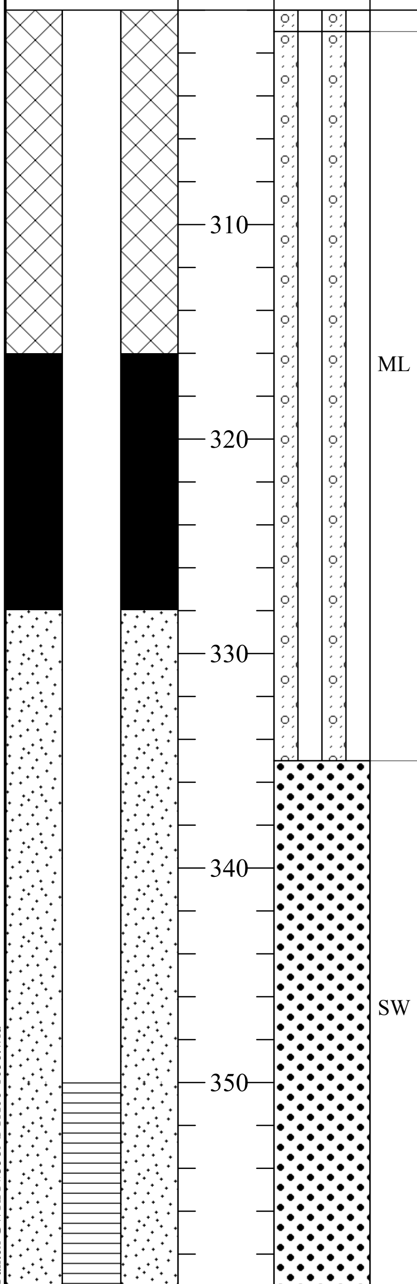
PTX06-1056

Pantex GW RFI	Pantex Plant (Texas Tech, Southeast of Zone 12 along FM 2373)		Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp/T. Hall	Northing: 3754642.87	Easting: 643767.03
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	500' BGS
Dates Drilled:	05/09/00 - 05/15/00	Depth to Water:	394.15' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3530.65'	TOC Elevation:	3532.80'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	310, 320, 330		ML	301-335' SILT, sandy, light brown (7.5YR 6/4), fine to medium grain, subangular sand		PTX06-1056-2-0300 Permeability Analysis
	340, 350		SW	335-360' SAND, gravelly, trace clay, brownish yellow (10YR 6/6), fine to very coarse subangular sand and up to 1/4-inch angular, broken gravel		



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PTX06-1056

Pantex GW RFI | **Pantex Plant (Texas Tech, Southeast of Zone 12 along FM 2373)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp/T. Hall	Northing: 3754642.87	Easting: 643767.03
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	500' BGS
Dates Drilled:	05/09/00 - 05/15/00	Depth to Water:	394.15' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3530.65'	TOC Elevation:	3532.80'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	370 380		CL	360-385' CLAY, sandy, pale brown (10YR 6/3), fine grain subangular, sand increasing with depth		
	390 400		SC	385-405' SAND, clayey to CLAY, sandy, reddish brown (2.5YR, 5/4), very fine to fine grain sand, some medium grain, subangular, possibly interbedded sands and clays		
	410		SP	405-420' SAND, white (5YR 8/1), very fine grain, dense, cemented sandstone nodules		

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S.M. STOLLER CORPORATION

PTX06-1056

Pantex GW RFI **Pantex Plant (Texas Tech, Southeast of Zone 12 along FM 2373)** **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp/T. Hall	Northing: 3754642.87	Easting: 643767.03
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	500' BGS
Dates Drilled:	05/09/00 - 05/15/00	Depth to Water:	394.15' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3530.65'	TOC Elevation:	3532.80'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			CL	420-430' Clay, red (2.5YR 4/6), interbedded with pinkish gray very fine grain cemented sandstone		
	430, 440, 450		SC	430-455' SAND, clayey to CLAY, sandy, red brown to tan and light brown (2.5YR 5/4 to 7.5YR 6/3), very fine sandstone interbedded with sandy clay		
			SC	455-460' SAND, silty, to CLAY, slightly silty, 80% sand 20% clay, pinkish white sand (5YR 8/2) and red clay (2.5YR 5/6)		
	460		CL-SM	460-470' CLAY, red (2.5YR5/6), with 25% pinkish white (5YR 8/2) silty sand, interbedded silty sand and clay		
	470		CL	470-481' CLAY, red (2.5YR 5/6) very stiff clay, no interbedded white sand		

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PTX06-1056

Pantex GW RFI | **Pantex Plant (Texas Tech, Southeast of Zone 12 along FM 2373)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp/T. Hall	Northing: 3754642.87	Easting: 643767.03
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	500' BGS
Dates Drilled:	05/09/00 - 05/15/00	Depth to Water:	394.15' BTOC 05/25/00
Borehole Type:	12 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3530.65'	TOC Elevation:	3532.80'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SC	481-485' SAND, silty, pinkish white (5YR 8/2), with some interbedded, red (2.5YR 5/6), stiff, clay		
	490		CL	485-495' CLAY, weak red (10R 5/3), mottled with pinkish white (5YR 8/2) silty sand, sand increasing with depth		
			CL	495-500' CLAY, pale red (10R 6/3) slightly silty clay with pinkish white (5YR 8/2) silty sand to 40% in content		
	500					
	510					
	520					
	530					

Total Borehole Depth 500'
Fine Grain Zone 274'

No Perched Aquifer Groundwater was encountered. Depth to Ogallalla Groundwater is 394.15' BTOC, as measured on 05/25/00.

Well Completion Details:
Borehole Diameter is 12 3/4" from surface to 281' BGS. An 8 5/8" conductor casing was cemented from surface to 281' BGS, using ARCH methods. Mud Rotary drilling was used to complete a 7 7/8" borehole from 281' to 500' BGS. Continuous core with 100% recovery was collected from the borehole from 281' to 301'. 260 feet of 4-inch Schedule 5, Type 316, stainless steel casing (Pantex supplied), 100 feet of 4-inch Schedule 10, Type 304, stainless steel casing and 120 feet of 4-inch, Type 304, stainless steel screen were used in well construction. 5' Sump (470 - 475'); 120' screen, 0.010" Factory Slot (350 - 470'); 352' Casing (+2 - 350'); Filter Pack, 8/16 Colorado Silica Sand, thickness above screen 22' (328 - 500'); Bentonite Seal, pellet thickness above sand 12" (316 - 328'); Bentonite Grout (Surface - 316'); Concrete Pad (5'X5'X8") with 4 bollards; Steel Protective Casing (10.75") with locking cover.

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COLOG Division of Layne Christensen Company
17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

ELECTRIC LOG

COM: SM STOLLER
WELL: PTX06-1056
FLD: PANTEX
ST: TX COUNTY: CARSON

COMPANY: SM STOLLER
WELL: PTX06-1056
FIELD: PANTEX
STATE: TX COUNTY: CARSON

LOCATION: NA

SEC TWP RGE

OTHER SERVICES:

PERMANENT DATUM: Ground Surface ELEVATION: NA
LOG MEAS. FROM: Ground Surface 0.0 FT ABOVE PERM. DATUM
DRILL MEAS. FROM: Ground Surface

DATE ACQUIRED	5/15/00	5/15/00		
RUN NUMBER	1	1		
LOG TYPE	Gamma	Electric		
DEPTH-DRILLER	502'			
DEPTH-LOGGER	502.8'			
BTM LOGGED INTERVAL	498'	502'		
TOP LOGGED INTERVAL	Surface	281'		
RECORDED BY	Nelson			
WITNESSED BY	Rupp			
FLUID LEVEL	Surface			
FLUID TYPE	Mud			
Rm at TEMP	NA			
TIME SINCE CIRC.	1 hour			
PROBE TYPE, S/N	RABPF 2019	EPF 1567		
MODULE TYPE, S/N	UM 1524	UM 1524		
LOGGING SPEED	20 ft/min	20 ft/min		
A.S.D.E.	0.0'	0.0'		
SAMPLE INTERVAL	0.1'	0.1'		
SOURCE SIZE, S/N	N/A	N/A		

BOREHOLE RECORD			CASING RECORD		
BIT SIZE	FROM	TO	SIZE/WGT	FROM	TO
10"	Surface	281'	Sump	470'	475'
8"	281'	TD	Screen	350'	470'
			Riser	Surface	350'

COMMENTS:

Drill Type:
Arch 0-281'
Mud Rotary 281-502'

8 5/8" Conductor Casing
set Surface to 281'

NA - NOT AVAILABLE, N/A - NOT APPLICABLE

COMMENTS:

4" Type 304 Sch 10 Stainless Steel
Casing & Screen 260-475'
Screen Slot 0.010

4" Type 316 Sch 5 Stainless Steel
Casing Surface-260', MHC Supplied

Borehole Logged Open Hole 281-TD'

DIGITAL FILES: 1056.RB0, 1056.RB1, ELEC.PLP, ELEC.HDP

SM STOLLER, PTX06-1056 (2nd run), 5/15/00

COLOG

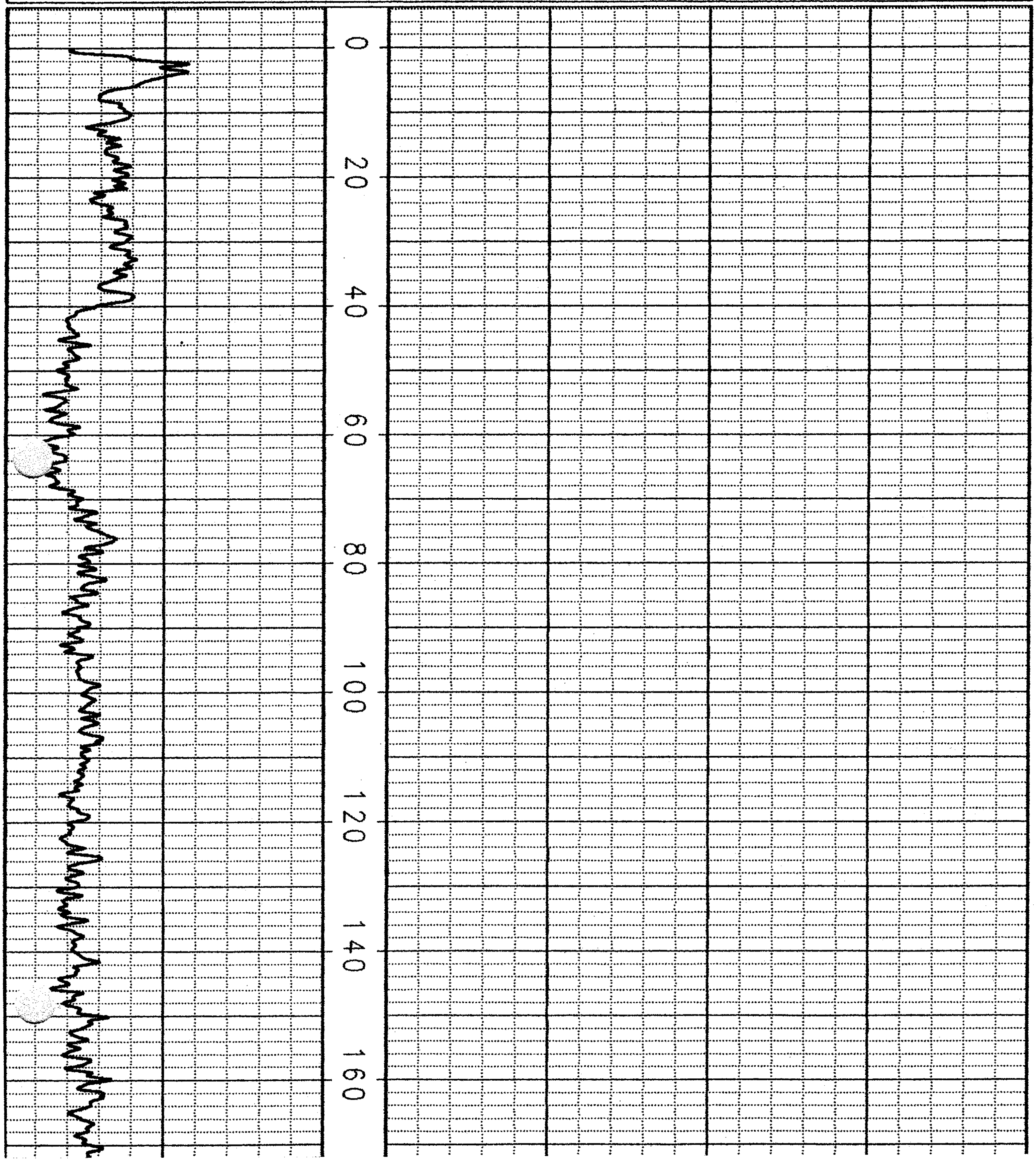
SINGLE POINT RESISTANCE
10 OHMS 60

SPONTANEOUS POTENTIAL
-100 MILLIVOLTS 0

64" NORMAL RESISTIVITY
0 OHM-M 100

NATURAL GAMMA
0 API 200

16" NORMAL RESISTIVITY
0 OHM-M 100



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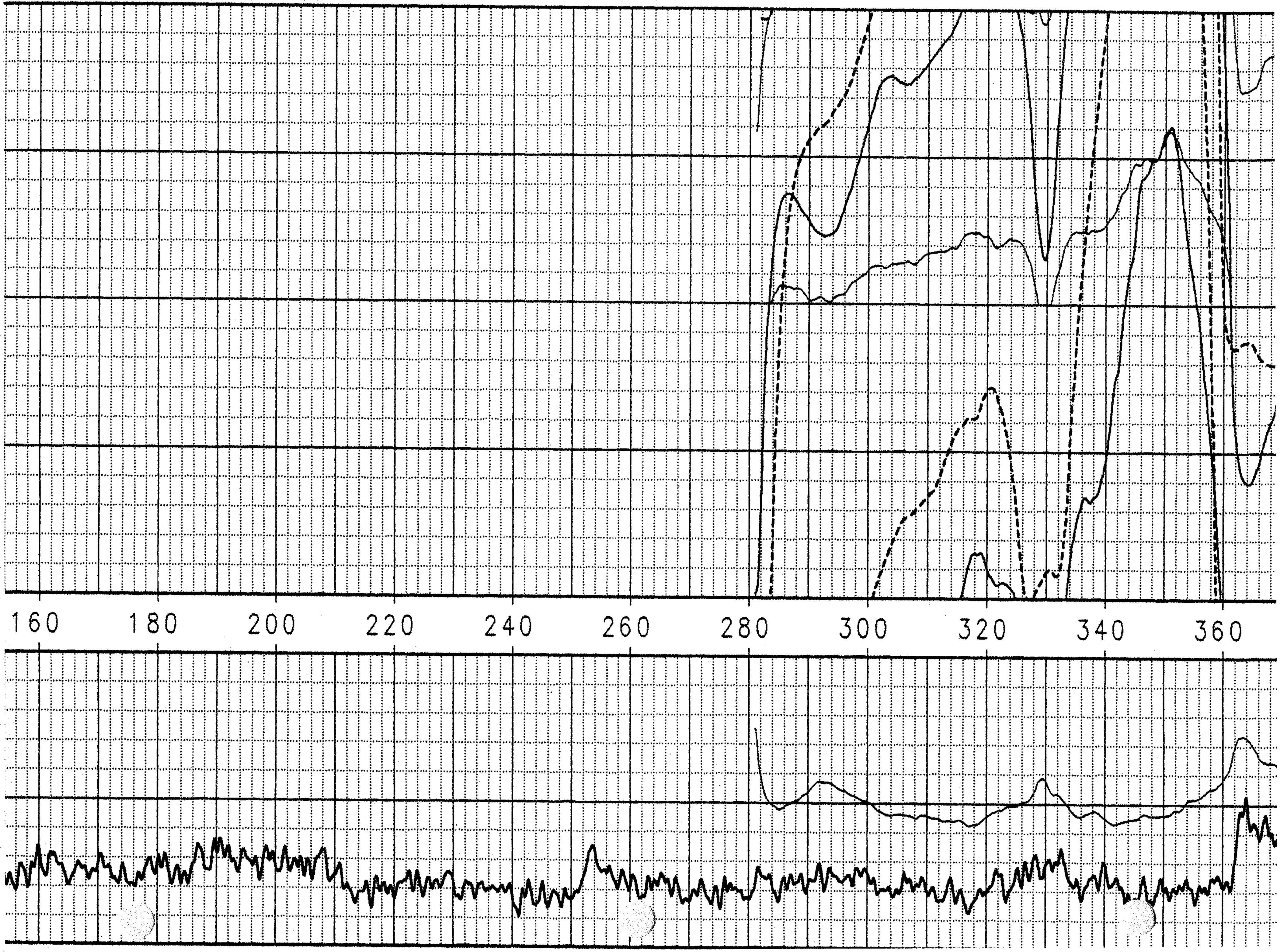
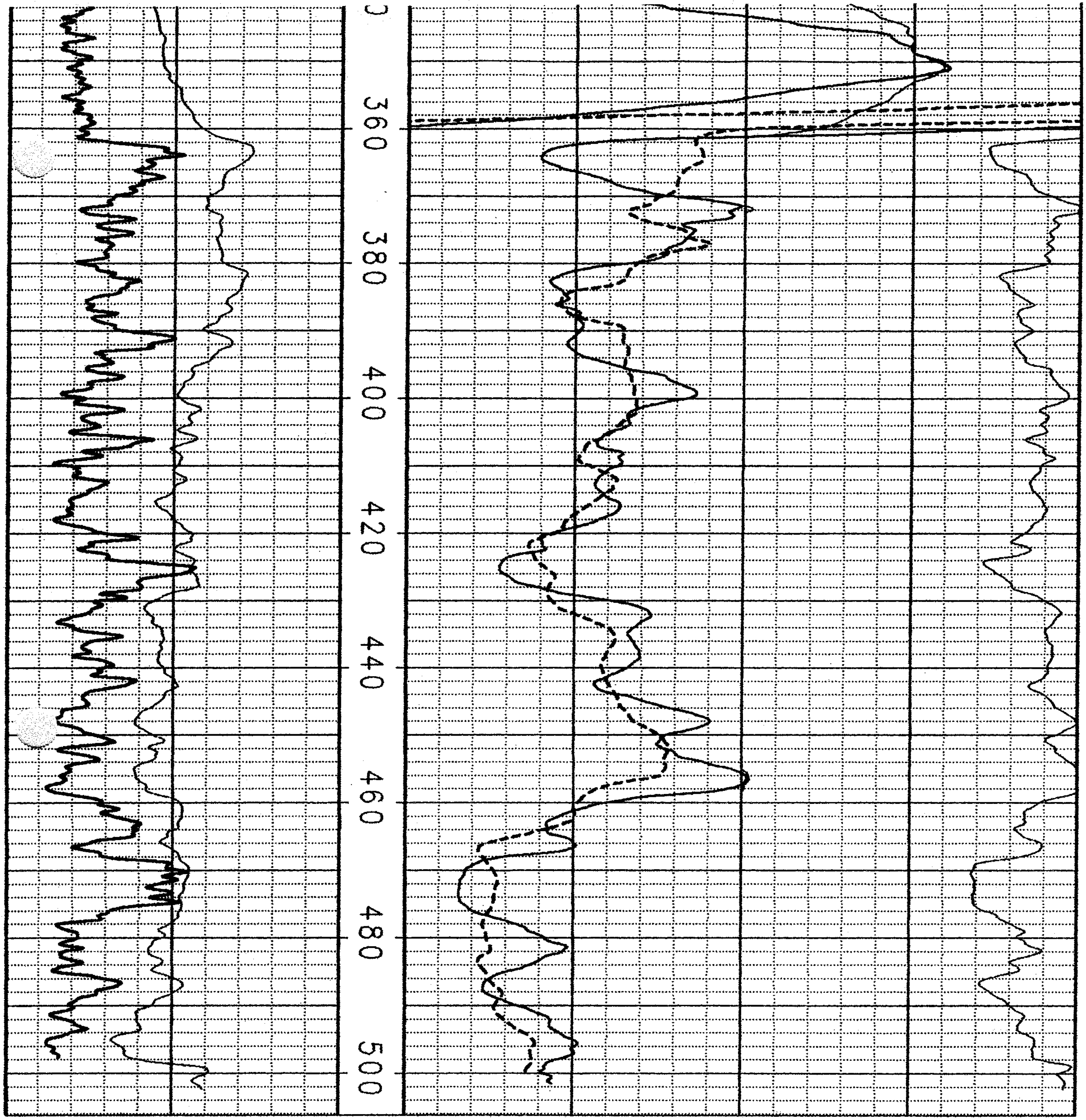




NATURAL GAMMA
0 API 200

SPONTANEOUS POTENTIAL
-100 MILLIVOLTS 0

16" NORMAL RESISTIVITY
0 OHM-M 100

64" NORMAL RESISTIVITY
0 OHM-M 100

SINGLE POINT RESISTANCE
10 OHMS 60

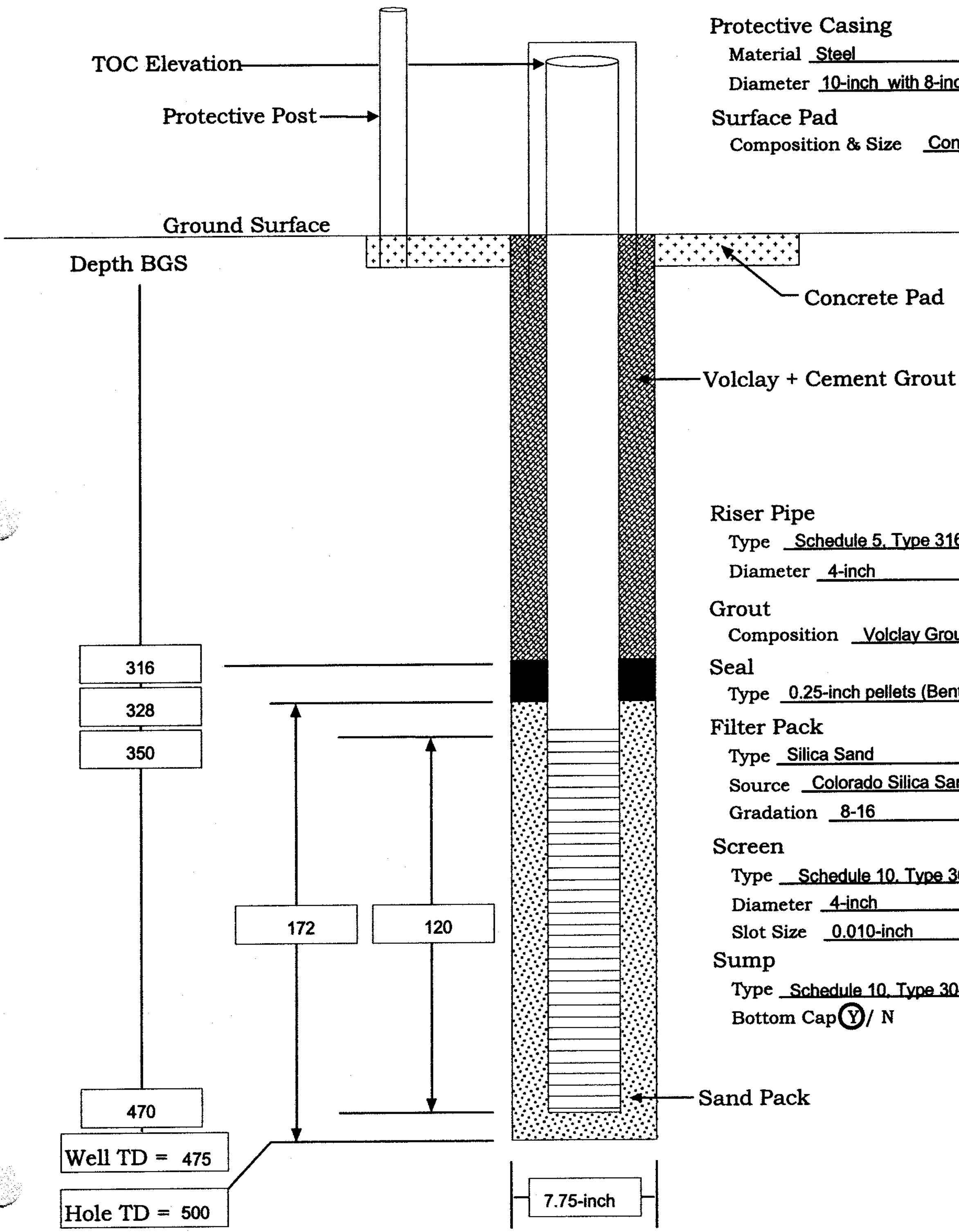
SM STOLLER, PTX06-1056 (2nd run), 5/15/00

COLOG

Monitor Well Installation Diagram

Project: Pantex GW RFI
Location: Texas Tech
Contractor: Stewart Brothers Drilling Co.
Driller: M.King
Well Coordinates: N-3754642.87 / E-643767.03
TOC Elevation: 3532.80
Surface Elevation: 3530.65

Monitor Well No: PTX06-1056
Date Constructed: 5-15-00
Observed by: R.Rupp
Sheet 1 of 1



Protective Casing
Material: Steel
Diameter: 10-inch with 8-inch steel to 281'

Surface Pad
Composition & Size: Concrete 5'x5'x8"

Riser Pipe
Type: Schedule 5, Type 316 Stainless Steel
Diameter: 4-inch

Grout
Composition: Volclay Grout (Bentonite)

Seal
Type: 0.25-inch pellets (Bentonite)

Filter Pack
Type: Silica Sand
Source: Colorado Silica Sand
Gradation: 8-16

Screen
Type: Schedule 10, Type 304 Stainless Steel
Diameter: 4-inch
Slot Size: 0.010-inch

Sump
Type: Schedule 10, Type 304 Stainless Steel
Bottom Cap Y / N

PTX06-1057

Contractor: S.M. Stoller Corporation

Contract #: 3615

OPTIX #:

Included Documents

___Drilling Log
 ___Draft
 ___Final

___Installation Log

_X_Lithologic Logs
 _X_Draft
 _X_Final

___Geophysical Logs
 ___Neutron
 ___Gamma
 ___e-log
 ___Bond Log
 ___Deviation log

___State Well Report

PTX06-1057A

Pantex Burning Grounds Soil Gas | **Pantex Plant (South of Playa 3)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
			ML	0-1.5' TOPSOIL, dark brown		
			CL	1.5-5' CLAY, with silt to 20%, reddish brown (5YR 4/3), hard, dry		
			CL	5-10' CLAY, with silt and minor caliche, reddish brown (5YR 4/3), hard, dry		
	10		CL	10-15' CLAY, with silt to 20% and caliche stringers, reddish brown (5YR 4/3), hard, dry		
			CL	15-20' CLAY, with silt to 40% and caliche stringers, reddish brown (5YR 4/4), hard, dry @ 17' 1 ft. caliche bed		
	20		CL	20-25' CLAY, with silt to 20%, reddish brown (5YR 5/4), hard, dry to damp		
			CL	25-30' CLAY, with silt to 20%, reddish brown (5YR 4/4), hard, dry to damp		
	30		CL	30-35' CLAY, with silt, reddish brown (5YR 5/4) to pinkish white (5YR 8/2), hard, dry		
			CL	35-40' CLAY, with silt and caliche beds/nodules, reddish brown (5YR 5/4), hard, dry		
	40		ML	40-45' SILT, with clay to 20% and caliche stringers and nodules, reddish brown (5YR 5/4), hard, damp		
			ML	45-50' SILT, with clay to 20%, yellowish red (5YR 4/6) to pinkish white (5YR 8/2), dry, no hard caliche pieces		
	50		ML	50-55' SILT, with clay to 30% and caliche stringers and nodules, yellowish red (5YR 4/6), dry to damp		
			ML	55-60' SILT, with clay, yellowish red (5YR 4/6), hard, dry @ 57' caliche bed estimated 6-8-inches thick		

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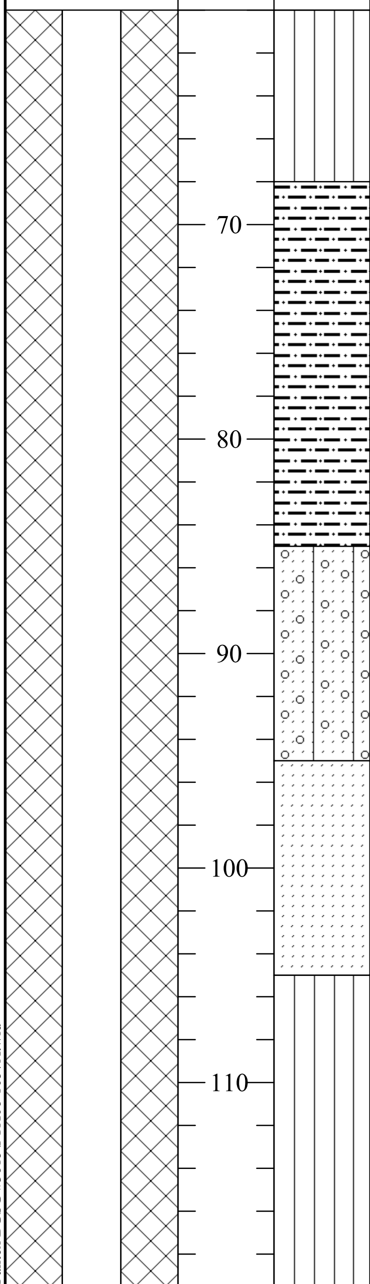
PTX06-1057A

Pantex Burning Grounds Soil Gas	Pantex Plant (South of Playa 3)		Amarillo, Texas
Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'



Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
			ML	60-68' SILT, with clay to 30%, light reddish brown (5YR 6/4), hard, damp; caliche bed, nodules to 1/2"		
			CAP RX	68-85' CALICHE CAPROCK, white (5YR 8/1-8/2), hard, dry		
			SM	85-95' SAND, silty, with caliche nodules, pink (5YR 8/3)		
			SP	95-105' SAND, light brown (7.5YR 6/4), fine to medium grain, subrounded to rounded grains, poorly graded, loose to medium dense, dry		
			ML	105-120' SILT, with <10% fine sand, light reddish brown (5YR 6/4), low to nonplastic, soft to medium stiff, dry to damp		

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Pantex Burning Grounds Soil Gas | **Pantex Plant (South of Playa 3)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
	130, 140		SP	120-145' SAND, light yellowish brown (10YR 6/4), very fine and fine grain with trace medium grain, subangular, poorly graded, loose, dry @ 140' becoming silty, silt increasing with depth		
	150		ML	145-160' SILT, sandy, 70% silt 30% sand, strong brown (7.5YR 5/6), nonplastic, fine grain sand, subrounded, soft, damp		
	160, 170		SP	160-200' SAND, light yellowish brown (10YR 6/4), 90% fine to medium grain size, subrounded to rounded, poorly graded, medium dense, dry, scattered fragments of moderately well cemented sandstone @ 180' 95% very fine grain		

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Pantex Burning Grounds Soil Gas | **Pantex Plant (South of Playa 3)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
	190		SP			
	200		ML	200-220' SILT, sandy, 60% silt 40% sand, brownish yellow (10YR 6/6), nonplastic, very fine grain sand, soft to medium stiff, damp, increasing silt with depth		
	210					
	220		SP	220-230' SAND, light yellowish brown (10YR 6/4), 70% fine grain 30% medium grain, subrounded, poorly graded, loose, dry to damp		
	230		SM	230-235' SAND, silty, 70% sand <30% silt, very pale brown (10YR 7/3), very fine grain, some fine grain, subrounded, poorly graded, loose, damp		
			SP	235-255' SAND, light yellowish brown (10YR 6/4), medium to coarse sand with some fine grain, subangular, poorly graded, loose, damp		

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Pantex Burning Grounds Soil Gas | **Pantex Plant (South of Playa 3)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
	250		SP			
	260		CL	255-263' CLAY, silty, sandy, 60% clay 20% silt 20% sand, yellowish brown (10YR 5/6) to strong brown (7.5YR 4/6), medium plasticity, very fine sand, medium stiff to stiff, moist Top FGZ at 255', 8-inch steel conductor casing set with cement to 265' BGS, begin continuous coring at 263'		
			CL	263-268' CLAY, silty, 50% clay 40% silt 10% sand, dark reddish brown (2.5YR 5/4), medium plastic, fine grain sand, subangular, poorly graded, moist, @ 263' 1.2' bentonite plug		263-268': 5.0 ft.; 100%
	270		CL	268-273' same as above		268-273': 5.0 ft.; 100%
			CL	273-278' same as above		273-278': 5.0 ft.; 100%
	280		ML	278-283' SILT, sandy, 70% silt, 20% sand, 10% clay, light reddish brown (5YR 6/4), very fine grain, subangular, poorly graded sand, moist, caliche nodules common in lower 3 feet		278-283': 5.0 ft.; 100%
			ML	283-288' same as above		283-288': 5.0 ft.; 100%
	290		ML	288-293' SILT, sandy, 70% silt 20% sand 10% clay, reddish yellow (7.5YR 6/6), very fine grain, subangular, well sorted sand, stiff, some caliche		288-293': 5.0 ft.; 100%
			ML	293-294.4' same as above		
			SP	294.4-298' SAND, strong brown (7.5YR 5/6), fine grain, subangular, poorly graded, moist; 3" sandstone at bottom of core		293-298': 5.0 ft.; 100%
			SM	298-303' SAND, silty, 90% sand 10% silt, strong brown		

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Pantex Burning Grounds Soil Gas | **Pantex Plant (South of Playa 3)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
			SM	(7.5YR 5/6), very fine grain, subrounded, well sorted, moist		298-303': 5.0 ft.; 100%
			SM	303-307' same as above @ 306-307' no recovery		303-308': 4.0 ft.; 80%
	310		CL	307-308' CLAY, silty, 60% clay 30% silt 10% sand, dark yellowish brown (10YR 4/4), fine grain, subrounded, well sorted		308-313': 4.0 ft.; 80%
			SP	308-311' SAND, light brown (7.5YR 6/3), very fine grain, subrounded, well sorted, loose, moist		
			CL	311-312' CLAY, silty, 70% clay 20% silt 10% sand, light brown, (7.5YR 6/4), stiff, moist		313-318': 5.0 ft.; 100%
			SP	312-313' no recovery due to large fragment of sandstone		
			CL	313-315' CLAY, dark brown (7.5YR 4/4), stiff, moist		
	320		SM	315-323' SAND, silty, 50% sand 40% silt 10% clay, strong brown (7.5YR 5/8), very fine to medium grain, subrounded, well sorted, moist		318-323': 5.0 ft.; 100%
			SM	323-328' SAND, with 40% silt 10% clay, reddish yellow (7.5YR 6/6), fine grained, subrnded, poorly graded, dense, moist		323-328': 5.0 ft.; 100%
	330		SM	328-332' SAND, with 40% silt and clay, strong brown (7.5YR 5/8), fine grained, subrounded, sorted, dense, moist, 4 ft. run		328-332': 4.0 ft.; 100%
			SM	332-336' SAND, with 40% silt and clay, light brown (7.5YR 6/3), very fine grained with some fine grain, subrounded, poorly graded, dense, moist, no odor, areas are partially lithified		332-337': 5.0 ft.; 100%
	340		SM	336-341' SAND, with 40% silt and clay, light brown (7.5YR 6/3), very fine grained with some fine grains, subrounded, poorly graded, loose, moist, 1 ft. core loss		337-341': 3.0 ft.; 75%
			SM	341-346' no recovery		341-346': 0.0 ft.; 0%
	350		SM	346-352' SAND, 40% silt and clay, light brown (7.5YR 6/4), very fine and fine grained, subrounded, poorly graded, dense, with lithified areas @ 351-352' 1 ft. core loss		346-352': 5.0 ft.; 100%
			SM	352-357' SAND, with 30-40% silt and clay, light brown (7.5YR 6/4), fine grain, subrounded, dense, hard, partially lithified, with <2% caliche nodules to 1/8-inch diameter		352-357': 5.0 ft.; 100%
			SM	357-362' SAND, with silt and clay to 30%, light brown (7.5YR 6/4), fine grain, subrounded, dense, hard, partially lithified, with		357-362': 5.0 ft.; 100%

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Pantex Burning Grounds Soil Gas **Pantex Plant (South of Playa 3)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Depth (Ft.)	USCS	Description	Sample	% Recovery/ Sample No.
	SM	3-5% caliche nodules to 1/4-inch		
	SM	362-367' SAND, with silt and clay to 30%, light brown (7.5YR 6/4), fine and very fine grain, subrounded, dense, hard, partially lithified, with 5% caliche nodules to 1/2-inch giving a nomatoblastic appearance		362-367': 5.0 ft.; 100%
370	SM	367-372' same as above		367-372': 5.0 ft.; 100%
	SM	372-377' SAND, as above, light brown (7.5YR 6/4), fine grain, subrounded, dense, hard, partially lithified		372-377': 5.0 ft.; 100%
380	SM	377-382' SAND, with 10-20% silt, light brown (7.5YR 6/4), fine grained, subrounded, dense, hard, partially lithified, caliche nodes @ 377-378' 1 ft. core loss		377-382': 4.0 ft.; 80%
	SM	382-387' SAND, with 10-15% silt, light brown (7.5YR 6/4), fine grain, subrounded, with caliche nodes		382-387': 5.0 ft.; 100%
390	SM	387-392' same as above		387-392': 5.0 ft.; 100%
	SM	392-397' same as above		392-397': 5.0 ft.; 100%
400	SM	397-402' same as above, more lithified, less fines		397-402': 5.0 ft.; 100%
	SM	402-407' same as above, increasing caliche nodules		402-407': 5.0 ft.; 100% PTX06-1072A-2-0405 Permeability
410	SM	407-412' no recovery, spring malfunction in core shoe prevented core entry to barrel		407-412': 0.0 ft.; 0%
	SM	412-417' same as above with increasing caliche nodules, fairly well lithified		412-417': 5.0 ft.; 100%
	SM	417-422' same as above		417-422': 5.0 ft.; 100%

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Pantex Burning Grounds Soil Gas | **Pantex Plant (South of Playa 3)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
			SM			
			SM	422-427' same as above		422-427': 5.0 ft.; 100%
			SM	427-428' same as above, less lithified		
	430		SP	428-432' SAND, reddish brown (5YR 5/4), very fine grain, subrounded, poorly graded, loose, moist @ 428-429' no recovery		427-432': 4.0 ft.; 80%
			SM	432-437' SAND, silty, 90% sand 10% silt, yellowish red (7.5YR 5/8), very fine grain, subrounded, dense, moist, fairly well lithified		432-437': 5.0 ft.; 100%
	440		SM	437-442' same as above @ 440-442' much looser, 441-442' no recovery		437-442': 4.0 ft.; 80%
			SM	442-443.5' CALICHE, hard and dry		
			SM	443.5-447' SAND, 10% silt, light gray (5YR 7/1), very fine grain, subangular to subrounded, poorly graded, moist Water Level 446' BGS on 10/10/00		442-447': 5.0 ft.; 100%
			SM	447-448.5' no recovery		
	450		SM	448.5-451.5' SAND, 10% silt, strong brown (7.5YR 5/6), very fine grain, subangular to subrounded, well sorted		447-452': 3.0 ft.; 60%
			SM	451.5-452' no recovery		
			SM	452-457' SAND, 15% silt, strong brown (7.5YR 5/6), very fine grain, subangular to subrounded, well sorted, moist, fairly well lithified, some caliche zones		452-457': 5.0 ft.; 100%
			SM	457-457.2' same as above but loose		
	460		SM	457.2-462' no recovery		457-462': 0.2 ft.; 4%
			SM	462-462.5' SAND, silty, as above		
			SM	462.5-467' no recovery		462-467': 0.5 ft.; 10%
	470		SM	467-472' SAND, 15% silt, strong brown (7.5YR 5/6), very fine grain, subrounded, poorly graded, moist, variably lithified from moderately to non-, some caliche stringers		467-472': 3.0 ft.; 60%
			SM	472-477' no recovery		472-477': 0.0 ft.; 0%
			SM	477-482' SAND, 10-15% silt, strong brown (7.5YR 5/6), very fine grain, poorly graded, dense,		477-482': 5.0 ft.; 100%

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Pantex Burning Grounds Soil Gas | **Pantex Plant (South of Playa 3)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

USCS	Description	Sample	% Recovery/ Sample No.
SM	@ 479' caliche bed, 6" thick, partially lithified, hard	■	PTX06-1057A-2-0481 Permeability
SM	482-484' SAND, as above, becoming much more clayey, (7.5YR 5/6), dense, lithified		482-487': 5.0 ft.; 100%
CL	484-487' CALICHE/CLAY, with sand to 20%, pale olive (5Y 6/3), low plasticity, shears	■	PTX06-1057A-2-0486 Permeability
ML	487-492' CLAY and CALICHE, pale olive (5Y 6/3) to white (5Y 8/1), layers of sandy clay, fat clay (bentonite?) and hard caliche, shears, hard, dense		487-492': 5.0 ft.; 100%
ML	492-497' CALICHE and bentonite as above, bentonite may be sheared caliche zones, caliche may be a soft limestone		492-497': 3.0 ft.; 60%
SM	497-502' no recovery		497-502': 0.0 ft.; 0%
SM	502-504.5' SAND, 20% silt, reddish gray (5YR 5/2), v fine grain, subrnded-rnded, poorly graded, loose, moist, less lithified		502-507': 5.0 ft.; 100%
CL	504.5-505' CLAY, limey, light gray (7.5YR N7/), hard, dense, dry, strong FeO vertical staining		
SM	505-507' SAND, silty, 90% sand 10% silt, reddish yellow (7.5YR 6/6), v fine grain, subrnded, med sorted, loose, moist		
SP	507-508' SAND, light brown (7.5YR 6/4), fine to medium grain, loose; with limestone mottling/clay		507-512': 5.0 ft.; 100%
SP	508-512' SAND, light brown (7.5YR 6/4), fine to medium grain sands, subrounded, loose		
SP	512-517' SAND, strong brown (7.5YR 4/6), fine to medium grain sands, subrounded, slightly dense, no recovery 516.25-517'		512-517': 4.3 ft.; 86%
SP	517-522' SAND, strong brown (7.5YR 5/6), fine to medium grain, subangular, poorly graded, medium dense, slightly damp to damp @ 517.5-517.75' mottling of limestone @ 519-519.5' less resistant, medium dense, slightly damp		517-522': 5.0 ft.; 100%
SP	522-527' SAND, light brown (7.5YR 6/4), fine to medium grain with 10% coarse grain, graded, medium dense, damp		522-527': 5.0 ft.; 100%
SP	527-532' SAND, strong brown (7.5YR 5/6), 80% fine grain 20% very fine grain, subrounded, poorly graded, medium dense, saturated, core is within the saturated zone of Ogallala Aquifer		527-532': 4.5 ft.; 90%
SP	532-537' SAND, strong brown (7.5YR 4/6), 80% fine grain 20% very fine, subrounded, poorly graded, dense, saturated		532-537': 4.8 ft.; 96%
SP	537-542' SAND, as above, 0.2' recovery		537-542': 0.2 ft.; 4%

Depth (Ft.): 490, 500, 510, 520, 530

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Pantex Burning Grounds Soil Gas | **Pantex Plant (South of Playa 3)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Depth (Ft.)	USCS	Description	% Recovery/ Sample No.
	SP		
	SM	542-547' SAND, silty, 25% silt, brown (7.5YR 5/4), nonplastic, very fine and fine grain, subrounded, poorly graded, dense to very dense, saturated	PTX06-1057A-2-0543 Permeability 542-547': 4.8 ft.; 96%
550	SM	547-551' SAND, silty, as above	547-552': 4.7 ft.; 94%
	CL	551-553' CLAY, sandy, yellowish red (5YR 4/6), medium plastic, very fine sand, stiff to hard, damp to moist	
	SM	553-557' no recovery	552-557': 1.1 ft.; 22%
560	SM	557-562' SAND, silty, 80% sand 20% silt, strong brown (7.5YR 4/6), fine to very fine grain, subrounded, medium dense, saturated	557-562': 3.0 ft.; 60%
	SM	562-565' SAND, silty, as above	562-567': 5.0 ft.; 100%
570	SM	565-572' SANDSTONE, predominately light brown (7.5YR 6/3) with light gray (7.5YR 7/2), fine grain, subangular, medium to well cemented with silty calcic matrix, dense to very dense, moist to saturated	567-572': 5.0 ft.; 100%
	SM	572-577' SAND, silty, 80-90% sand, 10+% silt, brown (7.5YR 5/4), fine to very fine grain, subrounded, medium dense, saturated	572-577': 5.0 ft.; 100%
	SM	577-580' same as above, well indurated	577-582': 3.0 ft.; 60%
580–590	SP	580-602' SAND, yellowish brown (10YR 5/4), fine grain, subrounded, poorly graded, loose, saturated @ 580-582' no recovery @ 582-587' 2.8 ft. recovery @ 587-592' SAND, as above, with scattered subrounded, calcic nodes, up to 1/4-inch diameter @ 592-597' SAND, as above, 3.3' recovery, poor recovery due to loose sand washing out @ 597-602' SAND, as above, but more calcic, medium dense to dense, scattered caliche nodes, trace silt, 4.6' recovery	582-587': 2.8 ft.; 56% PTX06-1057A-2-0587 Permeability 587-592': 3.4 ft.; 68% 592-597': 3.3 ft.; 66% 597-602': 4.6 ft.; 92%

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Pantex Burning Grounds Soil Gas **Pantex Plant (South of Playa 3)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
			SP			
	610		SM	602-617' SAND, silty, 70% sand about 30% silt, yellowish brown (10YR 5/4), fine grain, poorly graded, medium dense, saturated @ 602-607' 4.8' recovery @ 607-612' SAND, as above, 4.4' recovery @ 612-617' SAND, as above, becoming loose, 4.9' recovery		602-607': 4.8 ft.; 96% 607-612': 4.4 ft.; 88% 612-617': 4.9 ft.; 98%
	620		SP	617-622' SAND, loose, saturated, very poor recovery (0.6 ft.) possibly due to decreasing silt and sand washing out		617-622': 0.6 ft.; 12%
			SP	622-627' no recovery, borehole is taking water, possibly coarse sand, driller reports no significant change in penetration		622-627': 0.0 ft.; 0%
	630		GM	627-632' GRAVEL, clayey, with well cemented sand, coarse fluvial sediment, 1 ft. recovery		627-632': 1.0 ft.; 20%
			GW	632-637' no recovery		632-637': 0.0 ft.; 0%
	640		GW	637-642' no recovery		637-642': 0.0 ft.; 0%
			GW	642-647' no recovery		642-647': 0.0 ft.; 0%
	650		GW	647-652' no recovery		647-652': 0.0 ft.; 0%
			SC	652-657' SAND, clayey, with 1" diameter gravel, light reddish brown (5YR 6/3), dense, 1 ft. recovery appears to be from shoe end		652-657': 1.0 ft.; 20%
			SP	657-662' SANDSTONE, with cobbles to 4" in diameter, very pale brown (10YR 8/3), lithified, 1 ft. recovery		657-662': 1.0 ft.; 20%

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Pantex Burning Grounds Soil Gas | **Pantex Plant (South of Playa 3)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
			SP			
			SP	662-663' SAND, very pale brown (10YR 7/3), very fine to medium grain, slightly loose		662-667': 5.0 ft.; 100%
			CL	663-664' CLAY, light gray (10YR 7/1), plastic, dense, slightly damp, covered with fine to medium grain sand		
			CL	664-667' CLAY, yellowish brown (10YR 5/5), plastic, dense, slightly moist		
	670		SP	667-669' SANDSTONE, yellowish red (5YR 5/6), fine to very fine with 30% medium grains, partially lithified, MnO3 staining		667-672': 1.5 ft.; 30%
			SP	669-672' no core recovered		
			SP	672-673.5' SANDSTONE, with some clay, yellowish red (5YR 5/6), fine to medium grain, dense to lithified @ 673-673.5' sandstone is moderately weak from dissolution		672-677': 1.4 ft.; 28%
	680		SP	673.5-682' no recovery		677-682': 0.0 ft.; 0%
			SP	682-687' SANDSTONE, reddish yellow (7.5YR 6/4), fine to medium grain, medium dense, lithified from 682-682.5', Mn03 mottling in center of core, 1.5 ft. recovery @ 687' hard, very well cemented at contact		682-687': 1.5 ft.; 30%
			CL	687-689' CLAY, sandy, 25% sand, dark brown (7.5YR 4/3), medium plastic, stiff to very stiff, damp to moist		687-692': 5.4 ft.; 100%
	690 700 710		CL	689-714' CLAY, gray to dark gray (7.5YR N5/-N4/), high plasticity, hard, moist, commonly broken every 0.2-0.4 ft. with limonite staining in fractures @ 693-695' and 697-698' becoming sandy clay to clayey sand, sandy portions are light olive brown (2.5Y 5/6) color due to limonite staining, very fine to fine grain sand @ 699' calcic layer, 0.2 ft. thick, microcrystalline, light gray @ 703.5-707' sand to clayey sand, grayish brown (10YR 5/2), very fine to fine grain, medium dense, moist, limonitic, calcic, large calcic clast at 706', indurated at 707' @ 707-712' clay becoming increasingly weakly calcic and muddy, limonite throughout @ 712-714' as above, yellowish brown	■	PTX06-1057A-2-0691 Permeability 692-697': 5.4 ft.; 100% 697-702': 3.2 ft.; 64% 702-707': 5.0 ft.; 100% 707-712': 5.2 ft.; 100%
			SP	714-717' SAND, sandstone clast 0.2' at 714' then no recovery - loose sand?		712-717': 1.9 ft.; 38%
			SC	717-722' SANDSTONE, yellowish brown (10YR 5/6), fine sand and sandy clay intervals, core loss related to fine loose		717-722': 1.8 ft.; 36%

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PTX06-1057A

Pantex Burning Grounds Soil Gas **Pantex Plant (South of Playa 3)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
			SC	sand washing out in the center of the run from about 717.6-721.4'		
			SC	722-727' SAND, clayey, yellowish brown (10YR 5/4), fine grain sand, subrounded, loose, saturated; 1 ft. recovery 722-727'		722-727': 1.0 ft.; 20%
	730		SC	727-732' SAND, silty clayey, 70% sand 25% silt 5% clay, yellowish brown (10YR 4/6), nonplastic, very fine grain, poorly graded, medium dense, moist		727-732': 5.3 ft.; 100%
			SC	732-737' SAND, as above, decreasing silt/clay, saturated		732-737': 2.3 ft.; 46% PTX06-1057A-2-0735 Permeability
	740		SM	737-742' SAND, silty, dark brown (7.5YR 4/4) to dark yellowish brown (10YR 4/4), nonplastic, very fine grain 80%, fine grain 20%, trace medium grain, poorly graded, medium dense to dense, saturated		737-742': 5.4 ft.; 100%
			SC	742-747' SAND, clayey to CLAY, sandy, yellowish brown (10YR 5/6), very fine sand, strong clacic mottling throughout, well indurated, moist to saturated		742-747': 5.0 ft.; 100%
	750		CL	747-752' CLAY, sandy as above, with angular pebbles, less mottling, becoming reddish brown (5YR 4/4) at 750'		747-752': 4.0 ft.; 80%
			CL	752-759' CLAYSTONE, pebbly, red (2.5YR 4/8), hard, white and yellow mottling at 753',754', and 757', calcic hairline veining from 757-759'		752-757': 5.3 ft.; 100%
	760		CL	759-765.5' CLAYSTONE, grading to strong brown (7.5YR 5/6), continued calcic infilling of fractures		757-762': 5.0 ft.; 100% 762-767': 5.0 ft.; 100%
			MUD STN	765.5-767.5' CLAY/MUDSTONE, pale yellow (2.5Y 7/2)		
	770		CL	767.5-772' CLAY, red (2.5YR 4/6), high plasticity, very stiff to hard, dry to moist, pale yellow mottling in irregular fractures, trace fine and very fine sand		767-772': 5.2 ft.; 100%
			CL	772-777' CLAY, red (2.5YR 4/6), clay, highly plastic, pale yellow mottling throughout, some calcic deposits along fractures, hard, damp		772-777': 5.0 ft.; 100%
			CL	777-782' CLAY, red (2.5YR 4/6), highly plastic, as above, no significant mottling or calcic deposits, hard, damp		777-782': 5.0 ft.; 100%

PTX06-1057A

Pantex Burning Grounds Soil Gas	Pantex Plant (South of Playa 3)		Amarillo, Texas
Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Hall/Hull/Rupp	Northing: 3768142.23	Easting: 629630.04
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	798' BGS
Dates Drilled:	08/10/00 - 08/17/00	Depth to Water:	446' BGS 10/10/00
Borehole Type:	12"ARCH/4"WL Core/8"Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3562.39'	TOC Elevation:	3565.48'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	% Recovery/ Sample No.
			CL	782' Total Depth Cored		
	790		CL	782-798' CLAY, as above, drilled with tricone bit while reaming		
	800 810 820 830			Total Depth of Borehole 798' BGS Cored Interval: 265-782' BGS Fine Grain Zone 255' BGS Redbeds 752' BGS Well Completion Details: Borehole Diameter: 12" surface to 265' 7 7/8" 265-798' 8 5/8" steel conductor casing set with cement from surface to 265' Total Depth of Well 758' BGS 4-inch, Type 316 stainless steel casing and 10-slot screen 5' sump (753-758'), 330' screen (423-753'), 425' casing (+2-423') Filter pack (390-798') Bentonite seal (385-390') Bentonite grout (surface-385') Cement seal (0-2') Concrete pad (5'x5'x8') with 4 bollards Protective casing, 10-inch steel with locking cover		

PTX06-1057A

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil GAS	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8/10/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/10/00
ENGINEER/GEOLOGIST: Steve Bruskowa	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Air -		PAGE: 1 OF 22

COPY

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS PID
0				0-1.5' Dark brown Soil			
				1.5-5' - Clay w/silt, silt to 20%, 5YR 4/3 hard, Dry,	CL		1.1 ppm
				5-10 - Clay w/ silt, minor caliche, 5YR 4/3 hard dry.	CL		1.4 ppm static charge?
10				10-15' - Clay w/ silt to 20%, caliche stringers 5YR 4/3 hard dry.	CL		0.8 ppm
				15-20 Clay w/ silt to 40%, caliche stringers, 5YR 4/4 hard dry. 1' caliche bed @ 17'	CL		0.3 ppm
				20-25 - Clay w/silt to 20%, 5YR 5/4 dry to damp hard. reddish brown.	CL		0.0 ppm
				25-30 - Clay w/ silt to 20% 5YR 4/4 dry to damp hard.	CL		0.0 ppm
30				30-35' Clay w/ silt, 5YR 4/4 reddish brown to 5YR 8/2 Pinkish white, Dry & hard	CL		0.0 ppm
				35-40 clay w/silt 5YR 5/4 w/caliche beds/Nodules. Dry & hard	CL		0.0 ppm
40				40-45 Silt w/ clay to 20% 5YR 5/4 w/caliche stringers & Nodules - Damp, hard.	ML		0.0 ppm
				45-50' Silt w/clay to 20% 5YR 4/6 to 5YR 8/2 No hard caliche pieces, Dry,	ML		0.0 ppm
50				50-55 - Silt w/clay to 30% 5YR 4/6 w/ caliche stringers & Nodules Dry to Damp	ML		0.0 ppm
				55-60 Silt w/clay - caliche bed @ 57' Bed 6-8" thick (estimated) 5YR 4/6 Hard, dry	ML		0.0 ppm
60							

: Drilling w/ 14" tricone
Layne - D. Gordon, R. Thompson

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gas	
NG NUMBER: PTX06-1057A	COORDINATES:	DATE: 8/10/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/10/00
ENGINEER/GEOLOGIST: S. Brinkman	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Air w/ Tri-cone bit 14"		PAGE: 2 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS PID
60	Grab ↓		60-65'	- Silt, clay to 30%, Caliche bed, chunks to 1/2" 5YR 6/4 lite reddish brown, Damp, hard	ML		0.0 ppm
		68'		- Caliche Cap Rock starts white, 5YR 8/1 to 8/2 hard, dry			
70							
80				80' Still in caprock,			
				85' SM - (5YR 8/3) pink silty sand w/ caliche nods -			90' @ 1845
90				90' SM same as above			
95				95-105 SAND, light brown (7.5YR 6/4), fine to medium grained, subrounded to rounded grains, poorly graded, loose to medium dense, dry	SP		
100							
105				105-120 SILT, with some fine sand (<10%); light reddish brown (5YR 6/4), low to nonplastic, soft to medium stiff, dry to damp	ML		
110							
120							

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil GAS	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8-10-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 08-10-00
ENGINEER/GEOLOGIST: R. RUPP	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: ARCH Schramm/ODEX 11 5/8" LAYNE		PAGE: 3 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
				120-145 SAND, light yellowish brown (10 YR 6/4), very fine and fine grain with trace medium grain, subangular, poorly graded, dry, loose,	SP		
130							
140				@ 140' becoming silty, silt increasing with depth.			
145				145-160 SILT, sandy, 70% silt, 30% sand Strong brown (7.5YR 5/6), nonplastic, fine grained sand, subrounded, soft, damp.	ML		150' @ 2145
150							
160				160-200 SAND, light yellowish brown (10 YR 6/4), 90% fine to medium grain size, subrounded to rounded, poorly graded, medium dense, dry. scattered fragments of moderately well cemented sandstone.	SP		
170							
				@ 180' grain size is 95% very fine grain			
180							180' @ 2300

Broken Hose

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Pantex Burning Grounds Soil GAS	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8-11-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8-10-00
ENGINEER/GEOLOGIST: R. RUPP	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: ARCH; Layne, Dean Walton, Schramm/ODEX		PAGE: 4 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
				160-200 Sand see above description.	SP		
190							
200				200—220 SILT, sandy 60% silt & 40% sand, increasing silt with depth, Brownish yellow (10YR 6/6), nonplastic, very fine sand, soft to medium stiff, damp.	ML		200' @ 2400 8-10-00
210							210' @ 0055 8-11-00
220				220-230 SAND, light yellowish brown (10YR 6/4) 70% fine grain 30% medium grain subrounded, poorly graded, loose, dry to damp.	SP		220' @ 0142
230				230-235 SAND, SILTY, 70% sand 30% silt <30% silt trace very pale brown (10YR 7/3) very fine grain, some fine grain, subrounded, poorly graded, loose, damp	SM		
235				235-255 SAND, light yellowish brown (10 yr 6/4), medium to coarse sand with some fine grained. —continued→	SP		
240							

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VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Pantex Burning Grounds Soil Gas	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8-11-00 - 8/13/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8-10-00
ENGINEER/GEOLOGIST: R. RUPP	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: ARCH, Layne, Dean Walton, Schramm/ODEX		PAGE: 5 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
				235-255 continued. subangular, poorly graded, loose, damp	SP		
250							
255				255- CLAY, SILTY, sandy 60% clay, 20% silt, 20% sand yellowish brown (10YR 5/6) to strong brown (7.5YR 4/6), medium plasticity, very fine sand, medium stiff to stiff, moist but does not appear it would make significant water.	CL		265' @ 0430
270				Top FEZ @ 255'			
				263-268 1.2' Bentonite Plug	CL		
				264-268 - siltyclay, 40% silt, 50% clay, 10% sand, dk reddish brown 2.5YR 5/4, med. plast., fn gr sand, moist, subang., well srtd. poorly graded.			
280							
285				268-273' SAA			
				273-278' SAA			PID
				278-283' Sandy silt, 20% sand, 10% clay 70% silt, light reddish brown 5YR 6/4, moist, sand v. fn gr, subang, med srtd, poorly graded. Caliche nodules common in lower 2'.	ML		0.0ppm
290				283-288 SAA			0.0 ppm

VISUAL CLASSIFICATION OF SOILS

...ECT NUMBER: 3615	PROJECT NAME: BGSG	
...ING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8/13/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/10/00
ENGINEER/GEOLOGIST: C. Hull	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: ODEX CORE - LAYNE		PAGE: 6 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
290 300 310 315				288-293 Sandy silt, reddish yellow 7.5YR 6/6 20% sand, 10% clay, 70% silt, stiff, sands v fngr, subang, well srtd, some caliche. 293-294.4 SAA 294.4-298 Sand, strong brown 7.5YR 5/6 fngr, subangl., well srtd, poorly graded. moist. Sandstone 3" @ bottom of core 298-303 Silty sand, strong brown 7.5YR 5/6 10% silt, 90% sand, v. fngr, subrnded, well srtd, moist. 303-306 SAA 306-307 No recovery 307-308 ~~Silty clay~~ - dk yellowish brown, 10YR 4/4, moist, sand 10%, silt 30% clay 60%. sand fngr, ~~subrounded~~, well srtd. 308-311 - Sand, light brw, 7.5YR 6/3 v. fn gr, subrdd, well srtd, loose, moist 311-312 - Siltyclay - 20% silt, 10% sand, 70% clay, light brw, 7.5YR 6/4, moist, stiff, 312-313 No recovery due to large fragment of sandstone. 313-318 - Sand, v fn gr, well srtd, subrdd, light brw 313-315 - Clay, 7.5YR 4/4 dk brown, moist, stiff 315-316 - Sand, 50% sand, 10% clay, 40% silt, v fn to med gr, subrnd, poorly srtd, strong brw 7.5YR 5/8.	ML SP SM CL SP CL SP CL SP		0.0 ppm 0.0 ppm 0.0 ppm 0.0 ppm 0.0 ppm 0.0 ppm

NC

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSG		
BORING NUMBER: PTX06-1057A	COORDINATES:		DATE: 8/13/00
ELEVATION:	GWL: Depth	Date/Time	DATE STARTED: 8/10/00
ENGINEER/GEOLOGIST: C. Hull	Depth	Date/Time	DATE COMPLETED:
DRILLING METHODS: ODEX Core - LAYNE			PAGE: 7 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	Core Scan REMARKS PID
315				318-323 silty sand, 50% sand, 40% silt 10% clay, strong brw, 7.5YR 5/8 v. fn to med gr, subrnd, poorly srtd moist	SP		0.0 ppm
320				Curt Hull Relieved by S. Brinkman ABO 8/13/00			
	core		100%	323-327.7 Sand, w/40% silt & 10% clay Fine grained. 7.5YR 6/6 subrounded, Poorly Graded moist, dense. No odor.	SM		0.0 ppm
330			100%	328-332.0 Sand w/40% silt & clay Fine grained 7.5YR 6/8 subrounded; sorted moist, dense 4' run only!	SM		0.0 ppm
335			100%	332-336 - Sand w/40% silt & clay Very Fine Grained w/ fine grains no med/coarse 7.5YR 6/3 subrounded, Poorly Graded, moist, Dense no odor - areas are partially lithified.	SM		0.0 ppm
340			1' missing	- 337-340 - Sand w/40% silt & clay Very fine grained w/ Fine Grains no larger Grains 7.5 YR 6/3 subrounded, Poorly Grad. - moist Loose.	SM		0.0 ppm
345			0%	341-345 - No Recovery			

S. Brinkman & Alex W. @ 1900

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gas	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8/14/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: C. Brinkman	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Core		PAGE: 8 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS Pid Scan
345							
350			100%	346-350 → Sand, 40% fine, silt & clay, very fine grained and fine grained poorly graded 7.5YR 6/4 subrounded, dense w/ lithified areas.	SM		0.0 ppm
			0%	→ Core driven 6' to be sure it was full			
			100%	352-356 - Sand - fine Gr. w/ silt & clay 30-40% 7.5YR 6/4 sub rounded dense & hard - partially lithified w/ <2% caliche nodules to 1/8" dia	SM		0.0 ppm
360			100%	357-361 Sand fine G. w/ silt & clay to 30% 7.5YR 6/4 sub rounded dense, hard, partially lithified w/ caliche nodules to 1/4" 3-5%.	SM		0.0 ppm
365			100%	362-366 - Sand w/ silt & clay to 30% fine & very fine Gr. 7.5YR 6/4 subrounded dense, hard, partially lithified, w/ caliche nodules to 1/2" 5% giving a nonmetoblastic appearance.	SM		0.0 ppm
370			100%	367-371 - Same as above	SM		0.0 ppm
375			100%	372-376 Same as previously noted. partially lithified sand - fine Gr. sub round 7.5YR 6/4 dense, hard	SM		0.0 ppm

No.

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gas	
BORING NUMBER: PX06-1057A	COORDINATES:	DATE: 8/14/60
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: S. Brinkman	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Core Rig		PAGE: 9 OF 22

DEPTH ( ) 375	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
			100%	Prev. Page —			0.0 ppm
			0	-377-No recovery			
			100%	378-381 - Sand Fine Grained 10-20% silt 7.5YR 6/4 sub round hard, dense, partially Lith. - Cal [illegible] nods	SM		0.0 ppm
			100%	382-386 Sand Fine Gr 10-15% silt 7.5yr 6/4 sub rounded w caliche nodules - As prev. noted.	SM		0.0 ppm
			100%	387-391 - SAME.	SM		0.0 ppm
			100%	392-396 SAME.	SM		0.0 ppm
400			100%	397-402' - SAME More Lithified less Fines	SW		0.0 ppm
405				402-407 SAA - increasing caliche nodules	SW		0.0 ppm

NO.

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSG	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8/14/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: C Hull	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: ODEX Core Leyne		PAGE: 10 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
405				407-412 No recovery, spring malfunction in core shoe prevented core entry to barrel.	SW		
410				412-417 SAA w/ increasing caliche nodules, fairly well lith.	SW		0.0 ppm
				417-422 SAA	SW		0.0 ppm
15				422-427 SAA	SW		0.0 ppm
420							
425				427-428 SAA, less lithified	SW		0.0 ppm
				428-432 Sand, reddish brown 5YR 5/4, v. f.n gr, subrounded, well sorted poorly graded, loose, moist.	SP		
430				528-529 No recovery			
435				432-437 silty sand, 10% silt, 90% sand 7.5YR 5/6, v. f.n gr, subrounded, moist stiff, fairly well lithified	SW		0.0 ppm

ES:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSG	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8/14/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: C. Hull	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: ODEX Core Leyne		PAGE: 11 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
435				437-442 Top2' SAA,			0.0ppm
				440-442 Somesand but much looser			
				441.2 Norecovery			
445				442-443.5 Caliche, hard, dry, stiff			0.0 ppm
				443.5-447 Sand, 10% silt, light gray 5YR 7/1, sand is v. fn gr, subang to subrounded, wellsrtd, poorly graded, moist			0.0ppm
450				447 Mud pump down			
				447-448.5 No recovery			0.0ppm
				448.5-451.5 Sand, 10% silt, 7.5YR 5/6 strong brown v.fn gr, subang to subrdd, well srt.			0.0ppm
				4~~51~~.5-452 No recovery			
455				452-457 Sand, 15% Silt, 7.5YR 5/6 strong brown, v. fn gr, subang to subrd, well srted, moist fairly well lithified, some caliche zones			0.0ppm
				457-457.2 SAA, but loose			0.0ppm
460				457.2-462 No recovery.			0.0ppm
				462.- 462.5 SAA			
				462.5-467 No recovery			
				- 5' missing -			
465				C. Hull offsite @ 1800 - SBrinkman			
			60%	467-471 - Sand, 15% silt 7YR 5/6 very fine gr, subrounded, poorly graded, moist - Variably lithified from moderately to non. some caliche stringers	SW		0.0 ppm

ES:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Ground soil gas	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8/15/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: S. Brinkman	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Core		PAGE: 12 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
470				prev. Page -			
475	see prev. page			E-95 Log correction (end of C. Hall shift)			
				47			
480			100%	477 - 481.9 - SAND - w/10-15% silt very fine Gr. w/ caliche bed @ 479' 6" thick Partially Lith., Hard, dense, 7.5YR 5/6. poorly Graded	SW		0.0 ppm
485			100%	482 - ~~482.9~~ - 484 - Sand as above becoming much more clayey SW → CL 7.5YR 5/6 Hard, Dense, Lithified	SW CL		0.0ppm
				484 - 486.9 - Caliche/clay w/ sand to 20% 5Y 6/3 Pale olive, Shears, Low Plasticity	CL		
490			100%	487 - 491.9 - Clay & Caliche, ~~Bedded~~ Layers of Sandy clay, Fat clay (Bentonite?) & Hard Caliche 5Y 6/3 To 5Y 8/1 olive to white, shears, Hard, dense,	ML		0.0ppm
495			60%	492 - 496.9 - As above Caliche & bentonite Bentonite maybe sheared caliche zones Caliche maybe a soft limestone.	ML		0.0ppm
				496.9 - 497 No recovery END BRINKMAN SHIFT			
500				497 - 502 No recovery			

ES:

12

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSG	
BORING NUMBER: PTX06-1057 A	COORDINATES:	DATE: 8/15/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: C. Hull	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: ODEX CORE / LAYNE		PAGE: 13 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
500				502-507.5 Sand, reddish gray, 5YR 5/2, 20% silt, v. fn gr, subrd to rnded, med srtd, poor grading moist., not as litified, loose	SM		0.0 ppm
				507.5'-508 Limey clay, lt. grey 7.5YR N7/ hard, dense, dry, strong FeO vert. stain.	ML		
505				506 507 Sand, 10% silt, 90% sand, reddish yellow 7.5YR 6/6, v. fn gr, subrnd., med srtd, loose, ~~than sand~~ moist.	SM		
510				~~507-510' light brown [7.5YR6/4] v. fine to fine~~ grain sands. loose, Moist	ML		
		507-512	5' rec.	~~511-51~~ 507-508' light brown [7.5YR6/4] fine to med. grain sand w/ lmst. mottling/clay loose	SP		0.0 ppm
				509-512' light brown [7.5YR6/4] fine to med grain sands, subrounded. loose			
515		512-516	4.25 recov.	512.1 - 516.25' - strong brown [7.5YR5/6] fine to med grain sands. sub-rounded med. sli. dense,	SP		0.0 ppm
520			5' rec	517-522'	SP		
				517-518 (SP) strong brown [7.5YR5/6] fine to med grain sand poorly graded, sand is sub-angular unit is mod. dense and sl. damp to damp. Mottling of lmst @ 517.5 - 517.75'			
525				518.1-522' Same sand as above - less resistant @ 519-519.5. mod dense and sli. damp			
			5' rec	522.1-527 (SP) light brown [7.5YR6/4] fine to med grain w/ 10% coarse grain sand, graded, Mod. dense & damp			
530							

NOTES:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: PANTEX Burning Grounds Soil GAS	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 08/15/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 08/10/00
ENGINEER/GEOLOGIST: R. RUPP	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: CORE		PAGE: 14 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	PID LITHOLOGY	REMARKS DEPTH Time
530		527-532	4.5' Recovery	527-532 SAND, strong brown (7.5YR 5/6) 80% fine grain 20% very fine grain, subrounded poorly graded, medium dense, SATURATED CORE IS within the saturated zone of Ogallala Aquifer	SP	0.0 ppm	532' @ 2015
535		532-537	4.8'	532-537 SAND, strong brown (7.5YR 4/6) 80% of fine grain 20% very fine, subrounded poorly graded, dense, saturated	SP	0.0 ppm	537' @ 2042
		537-542	0.2'	537-542 SAND AS ABOVE MOST core lost AND unrecoverable.	SP	0.0 ppm	542' @ 2120
		542-547	4.8'	542-547 Sand, silty, 25% silt, Brown (7.5YR 5/4), nonplastic, very fine and fine grain, subrounded, poorly graded dense to very dense, saturated	SM	0.0 ppm	547' @ 2154
545	WATER MEASURED 9/18/00		445.5				
		547-552	4.7'	547-552 - Sand, silty as above	SM		552' @ 2237
550				551-553 CLAY, SANDY, yellowish red (5YR 4/6) medium plasticity, very fine sand stiff to hard, damp to moist	CL		
		~~552-557~~	~~1.2'~~ 1.1'	552-557 Recovery 1.1' from 552'-553' (lost 553'-557') Recovered core is sandy clay as above.		0.0 ppm	557' @ 2324
555							
		557-562'	3.0'	557-562 Sand, silty 80% sand 20% silt strong Brown (7.5YR 4/6) fine to very fine grain subrounded, medium dense Saturated	SM	0.0 ppm	562' @ 2345
560							

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME:	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8/16/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/10/00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: BB 80 Core Drill		PAGE: 15 OF 22

DEPTH ( ) 560	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY (FT)	DESCRIPTION	USCS SYMBOL	PID ~~LITHOLOGY~~	REMARKS DEPTH TIME
				562-565 Sand, Silty as above	SM		
	562-	567	5.0'			0.0ppm	567' @ ~~2345~~ 0035
565				565-592 Sandstone light gray (7.5YR 7/2) fine grained, subangular, medium to well cemented with silty calcic matrix dense to very dense, moist to saturated color predominantly light brown (7.5YR 6/3)	SM		
	567-	572	5.0'			0.0ppm	572 @ 0100
570							
	572-	577	5.0'	572-' Sand, silty, 80-90% sand 10%+ silt, brown (7.5YR 5/4) fine to very fine grain, subrounded, medium dense, saturated.	SM	0.0ppm	577' @ 0136
575							
	577-	582	3.0'	577-580 as above, well indurated, lost core 580-582	SM	0.0ppm	582 @ 0200
580				580-602 Sand yellowish brown (10YR 5/4) fine grained subrounded, poorly graded loose, saturated	SP		
	582	587	2.8'			0.0ppm	587 @ 0245
585							
	587	592	3.4'	587-592 Sand as above with scattered calcic nodes, subrounded up to 1/4" diameter	SP	0.0ppm	592 @ 0320
590							

NOTES:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Pantex Burning Grounds Soil Gas	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8/16/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/10/00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: BB 80 Core Drill		PAGE: 16 OF 22

DEPTH ( ) 590	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY (FT)	DESCRIPTION	USCS SYMBOL	PID	REMARKS Depth Time
	592	597	3.3'	592-597 Sand as above recovery is poor due to loose sand washing out	SP	0.0ppm	597' @ 0350
595	597	602	4.6'	597-602 Sand as above but more calcic, medium dense to dense scattered calcite nodes, trace silt	SP	0.0ppm	602 @ 0420
600	602-	607	4.8'	602- Sand yellowish brown (10YR 5/4) silty, 70% sand ± 30% silt, fine grain subrounded, poorly graded, medium dense saturated	SM	0.0ppm	607 @ 0450
605	607-	612	4.4'	607-612 Sand as above	SM	0.0ppm	612' @ 0520
610	612-	617	4.9'	612-617 Silty Sand as above becoming loose	SM	0.0	617 @ 0543
615	617-	622	0.6'	617-622 Very poor recovery possibly due to dense silt and sand washing out. ??. Recovered material is as above loose, saturated	SM/SP	0.0	622 @ 0605
620							

NOTES:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8/16/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/10/00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: BB 80 Core Drill		PAGE: 17 OF 22

DEPTH ( ) 620	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY (FT.)	DESCRIPTION	USCS SYMBOL	PID ppm LITHOLOGY	REMARKS Depth Time
	622	627	0.0'	622-627 NO Recovery, hole is TAKING WATER, possibly coarse sand. Driller reports no significant change in drill penetration.	?	—	627' @ 0636
625							
	627-	632	1.0'	627-632 Coarse fluvial sediment GRAVEL, clayey with well cemented sand	GM		632' @ 0700
630						0.0ppm	637'
	632-	637	No rec.	—			
635							
640	637	642	No rec	—			
645	642	647	No rec	—			0950 081600 647'
650	647	652	No rec.	—			

NOTES:

VISUAL CLASSIFICATION OF SOILS

[PROJ]ECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas (Pantex)	
[BOR]ING NUMBER: PTX06-1057A	COORDINATES:	DATE: 081600
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 081600
ENGINEER/GEOLOGIST: T. Hall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: BB80 core rig		PAGE: 18 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	PID LITHOLOGY	REMARKS
		~~652~~					
665	652	~~652~~ 657	~~657~~ one foot recovery	652' - 657' one foot recovery - appears to be from shoe end (SC) light reddish brown [5YR6/3] Sandy clay, dense, w/ 1" diam gravel		0.0ppm	
	~~652~~	657 ~~657~~	662 1' rec	657-662 one foot recovery. lithified ssl. very pale brown [10YR 8/2] w/ cobble to 4" diam			
	~~6662~~	~~657~~	~~No rec.~~	~~1/4" thick lithified ssl. dense~~			
665	662	667	5' rec	662-63' very pale brown [10YR 7/3] v fine to med. grain sand. sl. loose	CH	0.0ppm	
				663-64' light gray [10YR 7/1] clay covered w/ fine to med grain sand plastic - dense sli. damp			
670			1.5 PAH	664-667 - Yellowish brown [10YR 5/3] clay - plastic & dense sli. moist			
	667	672	2' rec	667 - 669 Yellowish red [5YR5/6] lithified (partially) ssl. w/ MnO4 staining v. fine to fine w/ 30% med grain sands in ssl. dense	SP	0.0ppm	
675	672	677	1.4' PAH	672-673.5 Yellowish red [5YR5/6] ssl. w/ some clay - dense to lithified - Sands are fine to med grain w/ some dissolution from water @ 673 - 673.5 ssl. is mod. weak			
680	677	682	No rec				

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas (Pantex)	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 081600
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 081000
ENGINEER/GEOLOGIST: THall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: BB-80 Core rig		PAGE: 19 OF 22

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	PID ~~LITHOLOGY~~	REMARKS Depth Time
	682	687	1.5' rec	682-683.5 reddish ~~brown~~ yellow [7.5YR 6/4] Sandstone - mod dense, lithified from 682-682.5. fine to med grain w/ MnO4 mottling in the center of core	SR	0.0 ppm	
685				Sandstone to 687 hard very well cemented @ contact			
	687	692	5.4'	687-689 Clay sandy, dark brown (7.5YR 4/3) 25% sand, medium plastic, stiff to very stiff damp to moist.	CL	0.0	692' @ 2015
690				689-~~TR~~ CLAY GRAY TO DARK GRAY 7.5 YR (N5/- N4/) high plasticity HARD, MOIST, commonly broken every .2-.4 feet with limonite staining in fractures.	OH/CL		
	692-	697	5.4'	Becoming sandy clay to sand clayey from 693-695 and 697-698 sandy portion light olive brown (2.5Y 5/6) very fine to fine grain sand, color due to limonite staining.		0.0	697' @ 2100
695							
	697-	702	3.2'	@ 699 large calcic nodule 0.2' dia. cut by core microcrystalline, light gray		0.0	702 @ 2140
700							
	702-	707	5.0'	703.5-707 Sand to clayey sand grayish brown (10 YR 5/2) very fine to fine grain, medium dense, moist limonitic, calcic and indurated @ 707 large calcic clast @ 706'	SC/CL	0.0	707 @ 2230
705							
	707-	712'	5.2'	707-712 Clay becoming increasingly calcic (weak) and muddy, limonite throughout	CL	0.0	712 @ 2300
710							

NOTES:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSC	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8-16-00/8/17/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8-10-00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: BB 80 Core Rig		PAGE: 20 OF 22

DEPTH ( ) 710	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY (ft)	DESCRIPTION	USCS SYMBOL	PID ~~LITHOLOGY~~	REMARKS Depth Time
715	712 -	717	1.9'	712-714 clay as above but yellowish brown 714-! Sand, sandstone clast 0.2' @ 714 then no recovery. - loose sand?	SP	0.0	717 @ 2329
	717 -	722	1.8'	717-722 Sandstone yellowish brown (10YR 5/6) fine sand and sandy clay intervals - core loss related to fine loose sand washing out of the center of the core from about 717.6 - 721.4	SP/CL	0.0	722 @ 2400
725	722 -	727	1.0'	722-727 only clayey ~~sand~~ recovered yellowish brown (10YR 5/4) fine grained sand, subrounded, loose, saturated	SC	0.0	727 @ 0032
730	727 -	732	5.3'	727- Sand, silty, clayey 70% sand 25% silt, 5% clay dark yellowish brown (10YR 4/6) very fine grain, nonplastic poorly graded, medium dense, moist	SM/SC	0.0	732 @ 0130
735	732	737	2.3'	732-737 Sand as above but decreasing silt/clay, saturated.		0.0	737 @ 0210
740	737	742	5.4'	737- Sand, silty dark brown (7.5YR 4/4) to dark yellowish brown (10YR 4/4) very fine grain 80% fine grain 20% Trace medium grain nonplastic, poorly graded, medium dense to dense, saturated -	SM	0.0	742 @ 0251

NOTES:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSG	
BORING NUMBER: PTR06-1057A	COORDINATES:	DATE: 8·17·00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8·10·00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: BB 80 Cone Rig		PAGE: 21 OF 22

DEPTH ( ) 740	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	PID ppm LITHOLOGY	REMARKS Depth Time
	742-	747	5.0'	742-747 clay sandy to sand clayey yellowish brown (10YR 5/6) very fine sand strong calcic mottling throughout, well indurated, moist to saturated	CL/SC	0.0	747 @ 0330
745							
	747-	752	4.0'	747-752 Clay as above with pebbles, angular and less mottling. becoming reddish brown (5YR 4/4) @ 750'	CL	0.0	752 @ 0416
750							
	752	757	5.3	752-759 claystone, pebbly, hard Red (2.5 YR 4/8) white and yellow mottling @ 753, 754, 757, calcic veining hairline 757-759		0.0	757 @ 0515
755							
	757	762	5.0'	759- grading to strong brown (7.5YR 5/6) continued calcic infilling of fractures.		0.0	762 @ 0600
760				@ 765.5 about ~~2.0~~ 2.0' of pale yellow			
	762	767	5.0	(2.5Y 7/2) clay mudstone.		0.0	767 @ 0659
765				767.5 – Clay, Red (2.5YR 4/6) high plasticity, very stiff to hard, dry to moist, pale yellow mottling and irregular fractures, trace			
	767	772	5.2'	fine and very fine sand. possible top of Permian Quartermaster Fm.		0.0	772 @ ~~0815~~ 0809
770							

NOTES:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSC	
BORING NUMBER: PTX06-1057A	COORDINATES:	DATE: 8.17.00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8.10.00
ENGINEER/GEOLOGIST: T Hall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: BB 80 Core Rig		PAGE: 22 OF 22

DEPTH ( ) 770	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY (Ft.)	DESCRIPTION	USCS SYMBOL	PID ppm LITHOLOGY	REMARKS Depth	Time
	772	777	5'	772-777' CL red [2.5YR4/6] Clay-highly plastic, pale yellow mottling throughout. Some calcic deposits along fractures. hard - unit is damp			777	0902
775								
780	777	782	5'	777-782' CL red [2.5YR4/6] Clay - highly plastic - Same as above No noteworthy traces of yellow mottling or calcic deposits. Dense & damp			782	1000
785								

NOTES: TD@ 782'

PTX06-1058

Contractor: S.M. Stoller Corporation

Contract #: 3615

OPTIX #:

Included Documents

___Drilling Log
 ___Draft
 ___Final

___Installation Log

_X_Lithologic Logs
 _X_Draft
 _X_Final

___Geophysical Logs
 ___Neutron
 ___Gamma
 ___e-log
 ___Bond Log
 ___Deviation log

___State Well Report

PTX06-1058

COPY

VISUAL CLASSIFICATION OF SOILS

[PROJ]ECT NUMBER: 3615	PROJECT NAME: BGSG		
[BORI]NG NUMBER: PTX06-1058 ~~OW-1~~	COORDINATES:		DATE: 8/12/00
ELEVATION:	GWL: Depth	Date/Time	DATE STARTED: 8/12/00
ENGINEER/GEOLOGIST: Hull	Depth	Date/Time	DATE COMPLETED: 8/12/00
DRILLING METHODS: Air Rotary w/ 14" tricone			PAGE: 1 OF ~~2~~ 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
				0-5' DK brown silty clay, 20% silt, minor sand, 5YR 4/3, hard, dry minor caliche.	CL		
10				0-10' Sandy silt, 25% sand, ~~brw~~ yell-red, 5YR 5/6, hard, dry, sand is fine gr, rounded.	ML		
				10-15' Sandysilt, 25-30% sand, yellowish red 5YR 5/6, hard, dry, sand is fine gr rounded, minor caliche.	ML		
20				15-20' Sandy silt - 25-30% sand, yellowish red, 5YR 5/6, hard, minor moisture, sand is fine gr, subangl.	ML		
30				20-25' silty sand, 30% silt, strong brown 7.5YR 5/6, hard, minor moisture, sand is fine gr, subangl. med-well srtd. more caliche	SM		
				25-30' sand, brownish yellow, 10YR 6/6, ~~hard,~~ minor moisture, loose, fine gr, subang, well srtd.	~~SW~~ SP		
40				30-35' Silty sand, 25% silt, yellowish red 5YR 5/6, hard, damp, sand is fine gr, subrnded, med-srtd, some caliche.	SM		
				35-40' Silty sand, 20% silt, yellowish red 5YR 5/6, hard, damp, sand is fn gr subrnded, med-srtd,	SM		
				40-45 Silty sand, 15% silt, reddish yellow 7.5YR 6/6 loose, damp, sand is ~~md~~ crs gr subrnd to subang, poorly srtd,	SM		
50				45-50 Sandy silt, 15% sand, yellowish red, 5YR 5/6, hard, damp, sand is fn gr, subang, med-srtd.	ML		
				50-55 sandy silt, 15% sand, yellowish brw 10YR 5/6, loose, damp, sand is fn gr, subang. med srtd.	ML		
60				55-60 silty clay, 20% silt, brown, 7.5YR 5/4, hard, damp	CL		

NOTE: [Ja]yne - Schramm w/ 14" tricone
D. Gordon: helper

VISUAL CLASSIFICATION OF SOILS

...ECT NUMBER: 3615	PROJECT NAME: BGSG		
...ING NUMBER: OW-1	COORDINATES:		DATE: 8/12/00
ELEVATION: PTX06-1058	GWL: Depth	Date/Time	DATE STARTED: 8/12/00
ENGINEER/GEOLOGIST: Hull	Depth	Date/Time	DATE COMPLETED: 8/12/00
DRILLING METHODS: Air Rotary w/ 14" tricone			PAGE: 2 OF ~~8~~ 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
				60-65' Silty sand, silt 10%, red 2.5YR 4/8, hard, damp, sand is med-fn gr, subang, med srtd.	SM		
70				65-70' Sand, red 2.5YR 4/8, hard, damp. Sand is fn gr, subang, well srtd.	~~SW~~	SP	
				70-75' Sand, red, 2.5YR 4/8, med-hard, damp, sand is ~~med~~ fn gr, subang, well srtd.	~~SW~~ SP		
				75-80' Silty sand, red, 2.5YR 5/8, med-hard, damp sand is fn gr, subang med srtd.			
				80-85 Sand, reddish yellow 5YR 6/6, loose, fn to med gr, subang to subrd med srtd, numerous caliche nodules.	~~SW~~ SP		
90				85-90 Sand + caliche, reddish yellow, 5YR 6/6, loose, fn to med gr, subang to subrdd, med srtd. Caliche nodules large white v. hard.	~~SW~~ SP		
95				~~TD @ 90' in Caliche Caprock~~			Schramm w/ odex
100				95-120 SILT, clayey, sandy 50% silt, 30% clay, 20% sand, Light reddish brown (5YR 6/4), medium plastic, very fine sand, some fine grain, subrounded grains, very stiff to hard, dry, generally finer grain with depth.	ML		
110							
120							

NO Schramm w/ 14" tricone - Layne
D. Gordon & helper

VISUAL CLASSIFICATION OF SOILS

[PROJ]ECT NUMBER: 3615	PROJECT NAME: Pantex Burning Grounds Soil Gas	
[BOR]ING NUMBER: PTX06-1058	COORDINATES:	DATE: 08/13/00
[E]LEVATION:	GWL: Depth Date/Time	DATE STARTED: 08/12/00
ENGINEER/GEOLOGIST: R. Rupp / T Hall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: ARCH w/ odex		PAGE: 3 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
130				120–135 Sand, silty, 70% sand 30% silt, reddish yellow (5YR 6/6) non plastic, very fine to fine grain, subrounded, poorly graded, medium dense, dry to damp.	SM		
135, 14[0]				135-147 Sand, light brown (7.5YR 6/4) fine to medium grain, trace very fine, subangular/subrounded, poorly graded, loose, dry	SP		
147, 150				147-153 Clay, silty, sandy 40% clay 30% silt 30% sand yellowish red (5YR 4/6) low plasticity, fine subangular sand, medium stiff, damp to moist	CL		
153, 155	splitspoon #1		1.75'	153 – (SM) very pale brown [10YR 7/3] Very Silty Sand. 80% silt - 20% v. fine to fine grain sand	SM		
160				155' Clay light brown [7.5YR 6/4] sli. sandy clay. Dense and sli. damp	CL		
165				165' same clay as above			
170							
175'				175' same Clay as above. Sli. damp			
180							

NOT[E]: Dyne - Schramm w/ odex from 85' down   Splitspoon #1 153-155' 1.75' recovery

VISUAL CLASSIFICATION OF SOILS

ECT NUMBER: 3615	PROJECT NAME: Pantex Burning Grounds Soil Gas	
NG NUMBER: PTX06-1058	COORDINATES:	DATE: 8-13-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8-12-00
ENGINEER/GEOLOGIST: R. Rupp/T Hall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: ARCH		PAGE: 4 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
				continued clay - moist, plugging return			
190				Clay, silty, reddish brown (5YR 5/4) medium to high plasticity very stiff, moist a regular fine grained zone	CL		
197				197-200 Sand, clayey	SC		
200				200' (CL) same as above	CL		
210				210' (SP) very pale brown [10YR 7/4] v. fine sand, sli. damp to damp, loose	SP		1430 081400
220				220' same as above			
225				225' (SP) very pale brown [10YR 6/4] v. fine grain sand. sst. lense w/ nods to ½" diam. unit is sli. damp and loose			
230				230' same (SP) v. fine sand - dry to v. sli. damp & loose			
240				240' (SP) very pale brown [10YR 7/4] v. fine sands v. sli. silty. dry & loose			

NOT.: 8½" tri-cone from 185 - 196'
196' - down w/ oxdex

VISUAL CLASSIFICATION OF SOILS

…ECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas (Pantex)	
…NG NUMBER: PTX06-1058	COORDINATES:	DATE: 081400
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 081200
ENGINEER/GEOLOGIST: THall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Air Rotary w/ Odex		PAGE: 5 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
				240-250 Sand, pale brown (10YR 6/3) very fine to medium grain, subangular to subrounded, graded, loose dry	SP		
250 252	PTX06-1058-2-0252 8/14/00 @ 2345 VOC + methanol preser. sieve analysis			@ 252 Sand, light yellowish brown (10YR 6/4) very fine to medium grain, subangular, graded loose, damp.	SP		
				@ 255 ~~silt, sandy~~ Sand silty, 20% silt, very pale brown (10YR 7/3) very fine to medium grain, subangular to subrounded graded, loose, dry	SM		
260				260-265 Sand, gravelly, trace silt light yellowish brown (10YR 6/4), very fine to coarse grain, subrounded, well graded medium dense, ~~moist~~ dry to damp, gravel is flattened decreasing silt with depth	SW		
265 270				265-275 Sand, gravelly, some clay yellowish brown (10YR 5/6) very fine to coarse sand, subangular, gravel up to ½ inch diameter rounded, broken moist	~~SW~~ GC		
				275-277 Sand brownish yellow (10YR 6/6) fine to medium grain, subangular, poorly graded, trace pea gravel, moist	SP		
280				277-280 Sand, clayey, gravelly, dark yellowish brown (10YR 4/4) fine to medium grain, medium dense, moist	SC		
				280-290' Sand, silty, light yellowish brown (10YR 6/4) fine to med. grain, subrounded medium dense, ~~damp~~ dry siltier w/ depth	SM		
290				290-295 Sand, light yellowish brown (10YR 6/4) fine grain, subrounded, poorly graded medium dense dry to damp	SP		
				295- Silt, sandy very pale brown (10YR 7/3) very fine to fine grain sand, hard, dry	ML		
300							

TH

2 attempts to drive a split spoon sampler @ 295' resulted with no recovery sampler looked to penetrate about 6 inches but only slough material was recovered on the second attempt. 200 plus blows of the hammer. Will set conductor casing @ 295' in hard silt

VISUAL CLASSIFICATION OF SOILS

…ECT NUMBER: 3615	PROJECT NAME: PANTEX Burning Grounds Soil GAS	
…NG NUMBER: PTX06-1058	COORDINATES:	DATE: 8-23-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/12/00
ENGINEER/GEOLOGIST: R. RUPP	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: MUD ROTARY		PAGE: 6 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
300				START MUD ROTARY @ 295' - cutting returns ARE going right through strainer NO mud (bentonite) is being used - straight water cuttings settle in bottom of discharge pipe			
310				@ 310' SAND, yellowish brown (10YR 5/6) very fine to fine grain, subrounded, poorly graded,	SP		
320							
330							
340				@ 340' Sand, yellowish brown (10YR 5/4) fine grain, subrounded, poorly graded	SP		340' @ 1858
350				348' Becoming clayey with increasing clay to 370' as indicated by E-log & gamma. 370'-390' decreasing clay/silt	CL		
360				NO recovery			

…S:

VISUAL CLASSIFICATION OF SOILS

..JECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas (Pantex)	
..ING NUMBER: PTX06-1058	COORDINATES:	DATE: 082300
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 081200
ENGINEER/GEOLOGIST: Hall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Mud Rotary/layne		PAGE: 7 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
365				trace coarse grain sands — 365-390' (SP) very pale brown [10YR8/4] Poorly graded sands. fine to med grains. Catching samples in 5gal. bucket. hard to tell exact interval	SP		2200 082300
370							
3..							
390				390' 390'-420' geophysical log indicates sand, silty, possible shale			0425 082400
395	?? ▽ ←	ESTIMATED for well construction					
400	▼	400' BGS measured flow 9/7/00		NO recovery			
410							
415				415' Driller reports that the drilling fluid turned a white color for awhile and it felt like drilling gravel. - probable caliche horizon being penetrated or sandstone.			0600 082400
420							

VISUAL CLASSIFICATION OF SOILS

[PRO]JECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas (Pantex)	
[BO]RING NUMBER: PTX06-1058	COORDINATES:	DATE: 082400 8-24-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 081200
ENGINEER/GEOLOGIST: T. Hall R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Mud Rotary / Layne		PAGE: 8 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
420				@ 420' Sand. light brown (2.5YR 6/4) fine to very fine grained, subrounded, SP poorly graded - 90% clear quartz grains no trace of silt or clay - mud fluid viscosity is low.			
430							430' @ 0700
				420-455 per geophysical log to is sand/sandstone sequence.			
450							455' @ 1050
455					SP		
460				460-480 per Geophysical log. ~~465-485~~ Sand, lithic multicolored clear qtz, yellow, brown			465' @ 1107
465				fine to very coarse grain, angular to subrounded, grains. well graded qtz 90%, 5% mafic, 5% other Rock Frag	SW		
470				@ 475 Rx fragments significantly larger and more angular - looks like crushed rx with trace reddish shale fragments	GW/GP		
480							

NO[TES]:

VISUAL CLASSIFICATION OF SOILS

JECT NUMBER: 3615	PROJECT NAME: PB6SG	
RING NUMBER: PTX06-1058	COORDINATES:	DATE: 8-24-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8-12-00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Mud		PAGE: 9 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
480							
485				485 - ! Clay coarse material drops out and yellow brown silty sandy clay is predominant drilling fluid viscosity has approximately doubled			485' @ 1145
490							
493							
510				510' clay, sandy or Sand clayey fine or medium sand in clayey drilling fluid.			
515				515 - very fine to fine sand - white and yellow, possible gypsum in coarse sand			515 @ 1315
518							
520				525 ~~525~~ GRAVEL coarse and very coarse as above 465-485' IT IS possible this gravel is from above sequence.			
530				530' Drilling fluid turns yellowish brown cuttings are white very fine silty clay with yellows and trace red-brown clayey shale ~~flakes~~ flecks, also scattered muscovite			530' @ 1405
535							
540				c 535 white to pale yellow very fine sand and silty clay - Short zone - about 1 foot thick estimated.			

NOTES:

VISUAL CLASSIFICATION OF SOILS

NUMBER: 3615	PROJECT NAME: BGSC	
G NUMBER: PTX06-1058	COORDINATES:	DATE: 8-24-00
VATION:	GWL: Depth Date/Time	DATE STARTED: 8-12-00
NGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Mud		PAGE: 10 OF 10

DEPTH ( ) 540	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
				@538 clayey silt / siltstone / claystone Red (2.5YR 4/8) drilling mud turning redbrown			538 @ 1433
546							
550				546' TD in Red (2.5YR 4/8) Permian Redbeds, Quartermaster Fm. Clay, silty, very stiff, with white to pale yellow clay fragments (probably reduction mottling)			546 @ 1710
560							
565							
568 ← ON							
570							
580							
590							
600							

NO

PTX06-1058

Pantex Burning Grounds Soil Gas **Pantex Plant (Zone 8)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	C. Hull/R. Rupp/T. Hall	Northing: 3759747.11	Easting: 624894.00
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	546' BGS
Dates Drilled:	08/12/00 - 08/24/00	Depth to Water:	392.9' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3565.15'	TOC Elevation:	3567.25'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			CL	0-5' CLAY, silty, 20% silt, minor sand, reddish brown (5YR 4/3), hard, dry, minor caliche		
	10		ML	5-20' SILT, sandy, 25-30% sand, yellowish red (5YR5/6), fine grain rounded to subangular sand, hard, dry to damp, minor caliche		
	20		SM	20-25' SAND, silty, 30% silt, strong brown (7.5YR 5/6), fine grain, subangular, medium to well sorted sand, dense, minor moisture, more caliche		
			SP	25-30' SAND, brownish yellow (10YR 6/6), fine grain, subangular, well sorted, loose, minor moisture		
	30, 40		SM	30-45' SAND, silty, 20-25% silt, yellowish red (5YR 5/6), fine grain, subrounded, medium sorted, dense, damp, some caliche @ 40-45' 15% silt, reddish yellow (7.5YR 6/6), coarse grain, subrounded to subangular, well sorted, loose, damp		
	50		ML	45-55' SILT, sandy, 15% sand, yellowish red (5YR 5/6) to yellowish brown (10YR 5/6), fine grain, subangular, medium sorted sand, hard to soft with depth, damp		
			CL	55-60' CLAY, silty, 20% silt, brown (7.5YR 5/4), hard, damp		
	60		SM	60-65' SAND, silty, 10% silt, red (2.5YR 4/8), medium to fine grain, subangular, medium sorted, dense, damp		
	70, 80		SP	65-85' SAND, red (2.5YR 4/8) to reddish yellow (5YR 6/6) with depth, fine to medium grain, subangular to subrounded, medium to well sorted, dense to loose with depth, damp @ 80-85' numerous caliche nodules		
			CAP RX	85-90' SAND/CALICHE, reddish yellow (5YR 6/6), fine to medium grain, subangular to subrounded, medium sorted, loose, caliche nodules are large, white, very hard		
	90		ML	90-120' SILT, clayey, sandy, 50% silt, 30% clay, 20% sand, light reddish brown (5YR 6/4), medium plastic, very fine to fine grain sand, finer with depth, subrounded grains, very stiff to		

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PTX06-1058

Pantex Burning Grounds Soil Gas | **Pantex Plant (Zone 8)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	C. Hull/R. Rupp/T. Hall	Northing: 3759747.11	Easting: 624894.00
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	546' BGS
Dates Drilled:	08/12/00 - 08/24/00	Depth to Water:	392.9' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3565.15'	TOC Elevation:	3567.25'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML	hard, dry		
			SM	120-135' SAND, silty, 70% sand 30% silt, reddish yellow (5YR 5/6), non-plastic, very fine to fine subrounded grains, poorly graded, loose, dry to damp		
			SP	135-147' SAND, light brown (7.5YR 6/4), fine to medium grain, trace very fine grain, subangular/subrounded, poorly graded, loose, dry		
			CL	147-153' CLAY, silty, sandy, 40% clay, 30% silt, 30% sand, yellowish red (5YR 4/6), low plasticity, fine grain subangular sand, medium stiff, damp to moist		PTX06-1058-2-0154 Gradation PTX06-1058-2-0154.5 VOC PTX06-1058-2-0155 Permeability
			ML	153-155' SILT, sandy, 80% silt, 20% sand, very pale brown (10YR 7/3), very fine to fine grain sand		
			CL	155-190' CLAY, slightly sandy, light brown (7.5YR 6/4), dense, slightly damp becoming moist with depth		
			CL	190-197' CLAY, silty, reddish brown (5YR 5/4), medium to high plasticity, very stiff, moist		
			SC	197-210' SAND, clayey, light brown (7YR 6/4), dense, damp		

PTX06-1058

Pantex Burning Grounds Soil Gas | **Pantex Plant (Zone 8)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	C. Hull/R. Rupp/T. Hall	Northing: 3759747.11	Easting: 624894.00
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	546' BGS
Dates Drilled:	08/12/00 - 08/24/00	Depth to Water:	392.9' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3565.15'	TOC Elevation:	3567.25'

Depth (Ft.)	USCS	Description	Sample Number
200–210	SC		PTX06-1058-2-0204.5 VOC
210	SP	210-255' SAND, very pale brown (10YR 7/4) to light yellowish brown (10YR 6/4), very fine to medium grain, coarser with depth, subrounded to subangular, graded, loose, dry to damp	
220		@ 225' sandstone lense, nodes to 1/2" diameter	
230			
240		@ 240' slightly silty	
250			PTX06-1058-2-0252 VOC/Gradation
	SM	255-260' SAND, silty, 20% silt, very pale brown (10YR 7/3), very fine to med grain, subang to subrnded, graded, loose, dry	
260	SW	260-265' SAND, gravelly, trace silt, light yellowish brown (10YR 6/4), very fine to coarse grain, subrounded, well graded, medium dense, dry to damp, less silt with depth, gravel flattened	
270	GW	265-275' GRAVEL, sandy, some clay, yellowish brown (10YR 5/6), very fine to coarse grain sand, subangular, gravel up to 1" diameter, rounded, broken, moist	PTX06-1058-2-0272 Gradation
	SP	275-277' SAND, trace peagravel, brownish yellow (10YR 6/6), fine to medium grain, subangular, poorly graded, moist	
280	SC	277-280' SAND, clayey, gravelly, dark yellowish brown (10YR 4/4), fine to medium grain, medium dense, moist	
	SM	280-290' SAND, silty, light yellowish brown (10YR 6/4), fine to med grain, subrnded, med dense, dry, more silt with depth	
290	SP	290-295' SAND, light yellowish brown (10YR 6/4), fine grain, subrounded, poorly graded, medium dense, dry to damp	
	ML	295-300' SILT, sandy, very pale brown (10YR 7/3), very fine to fine grain sand, very hard, dry at 295'	PTX06-1058-2-0295 Gradation

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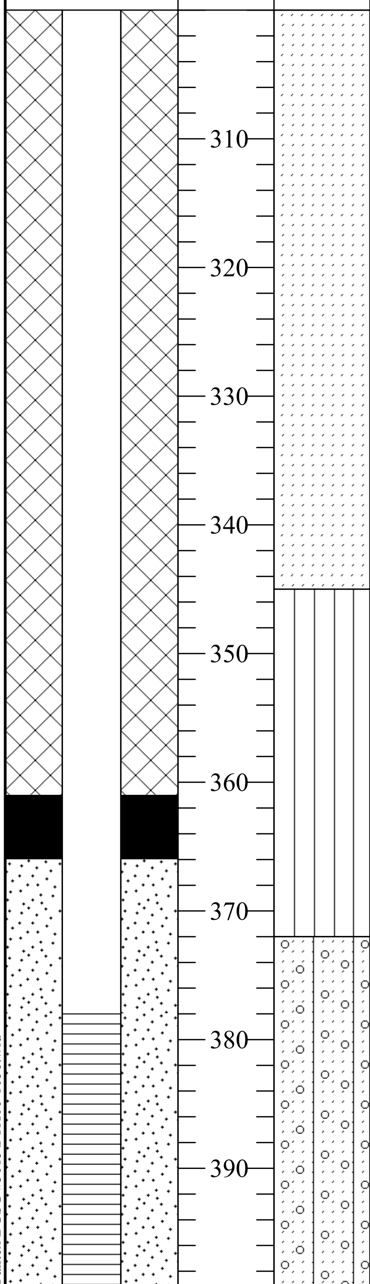
PTX06-1058

Pantex Burning Grounds Soil Gas | **Pantex Plant (Zone 8)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	C. Hull/R. Rupp/T. Hall	Northing: 3759747.11	Easting: 624894.00
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	546' BGS
Dates Drilled:	08/12/00 - 08/24/00	Depth to Water:	392.9' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3565.15'	TOC Elevation:	3567.25'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number



USCS	Description
SP	300-345' SAND, some silt, yellowish brown (10YR 5/4-5/6), very fine to fine grain, subrounded, poorly graded Two attemts to collect split-spoon samples made at 295', more than 200 blows of the hammer each attempt resulted in no recovery Conductor casing set with cement at 295' in very hard silt MUD ROTARY DRILLING BEGINS AT 295 FEET Initial mud chemistry poor
ML	345-372' SILT, sandy, clayey with depth @ 360' SAND, very pale brown (10YR 8/4), fine to medium grain, trace coarse, poorly graded
SM	372-414' SAND, silty with depth Water Level @ 392.9' BGS on 10/10/00

PTX06-1058

Pantex Burning Grounds Soil Gas	Pantex Plant (Zone 8)		Amarillo, Texas
Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	C. Hull/R. Rupp/T. Hall	Northing: 3759747.11	Easting: 624894.00
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	546' BGS
Dates Drilled:	08/12/00 - 08/24/00	Depth to Water:	392.9' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3565.15'	TOC Elevation:	3567.25'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	410		SM			
	420, 430, 440, 450, 460		SP	414-465' SAND, light brown (7.5YR 6/4), fine to very fine grain, subrounded, poorly graded, 90% clear quartz grains, no trace of silt or clay @ 415' drilling fluid turned whitish; driller reported formation felt like gravel; possible caliche or sandstone horizon Mud Viscosity is Low		
	470		GW	465-480' SAND/GRAVEL, trace reddish shale fragments, lithic, multi-colored (clear quartz, yellow, brown), fine to very coarse grain, angular to subrounded, well graded, 90% quartz, 5% mafic, 5% other rock fragments, with depth the rock fragments are significantly larger and more angular		
	480, 490		SH	480-500' SHALE, clayey, silty, sandy, yellow brown, coarse material gone Drilling fluid viscosity has about doubled, lag-time equals about 5 to 10 feet advance		

PTX06-1058

Pantex Burning Grounds Soil Gas | **Pantex Plant (Zone 8)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	C. Hull/R. Rupp/T. Hall	Northing: 3759747.11	Easting: 624894.00
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	546' BGS
Dates Drilled:	08/12/00 - 08/24/00	Depth to Water:	392.9' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3565.15'	TOC Elevation:	3567.25'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SM	500-505' SANDSTONE, silty, fine to medium grain		
			ML	505-510' SILTSTONE, sandy, white and yellow, very fine to fine grain, possible gypsum		
	510		SP	510-520' SAND, gravelly, coarse to very coarse lithic fragments similar to sequence from 430-458' (the gravel material may have originated from above)		
	520		MUD STN	520-525' MUDSTONE, clayey, white, yellow, red-brown, scattered muscovite, drilling fluid yellowish brown		
			SM	525-528' SANDSTONE, silty, white to pale yellow, very fine grain		
	530		CL	528-546' CLAY, silty, red (2.5YR 4/8), very stiff, with white to pale yellow clay fragments from reduction mottling		
	540					
	550			Total Depth of Borehole 546' BGS Fine Grain Zone 295' BGS Well Completion Details: Borehole Diameter: 14" from surface to 85' 12" 85-295' 7 7/8" 295-546' 8 5/8" steel conductor casing set with cement from surface to 295' Total Depth of Well 533' BGS 4-inch, Type 316, stainless steel casing and 10-slot screen 5' sump (528-533'), 150' screen (378-528'), 380' casing (+2-378') Filter pack, 20/40 Colorado Silica Sand (366-546') Bentonite seal (361-366') Bentonite grout (surface-361') Cement seal (0-2') Concrete pad (5'X5'X8") with 4 bollards Protective casing, 10-inch steel with locking cover		
	560					
	570					
	580					
	590					

COLOG Division of Layne Christensen, Co.
17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

GAMMA—ELECTRIC LOG

COM: SM STOLLER
WELL: PTX06-1058
FLD: Pantex
ST: TX COUNTY: Carson

COMPANY: SM STOLLER
WELL: PTX06-1058
FIELD: Pantex
STATE: TX COUNTY: Carson

LOCATION:

OTHER SERVICES:
Deviation

PERMANENT DATUM: G.L. ELEVATION:
LOG MEAS. FROM: G.L. 0.0 FEET ABOVE PERM. DATUM
DRILL MEAS. FROM: G.L.

DATE ACQUIRED	08/24/00	08/24/00		
RUN NUMBER	1	1		
LOG TYPE	Gamma	16,64,SPR,SP		
DEPTH—DRILLER	546 Ft.			
DEPTH—LOGGER	546 Ft.			
BTM LOGGED INTERVAL	546 Ft.	546 Ft.		
TOP LOGGED INTERVAL	4.25 FT.	300 Ft.		
RECORDED BY	MLWhitney			
WITNESSED BY	Ralph Rupp			
FLUID LEVEL	90 Ft.			
FLUID TYPE	Mud			
Rm at TEMP	N/A			
TIME SINCE CIRC.	2 HOURS			
PROBE TYPE, S/N	RAB 2021	EPF 1567		
MODULE TYPE, S/N	UM 1484	UM 1484		
LOGGING SPEED	20			
A.S.D.E.	N/A			
SAMPLE INTERVAL	0.3'			
SOURCE SIZE,	1			

BOREHOLE RECORD		
BIT SIZE	FROM	TO
9.5"	Surface	300 Ft.
7 7/8"	300 Ft.	TD

CASING RECORD		
SIZE/WGT	FROM	TO
8" Steel	Surface	300 Ft.

COMMENTS:

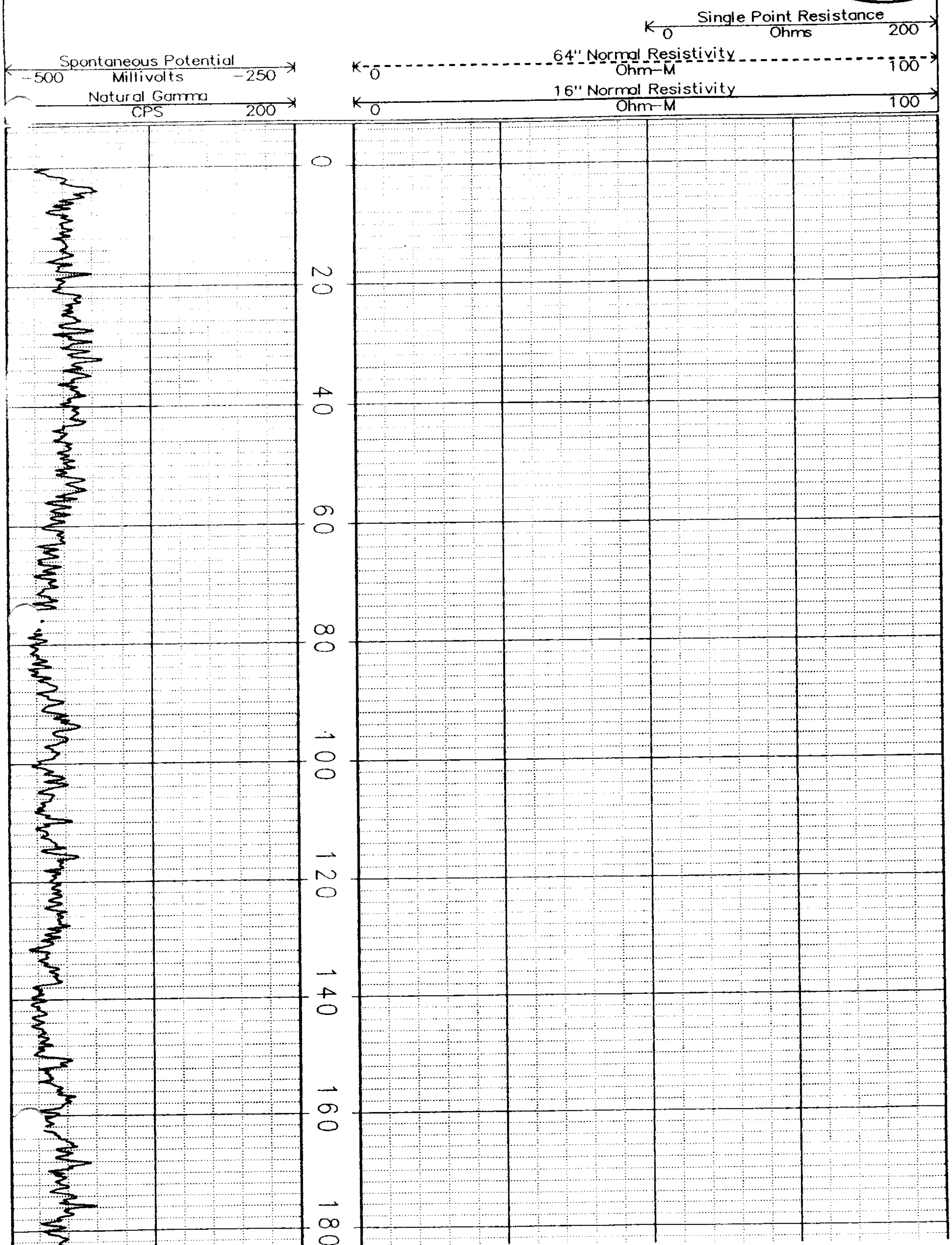
COMMENTS:

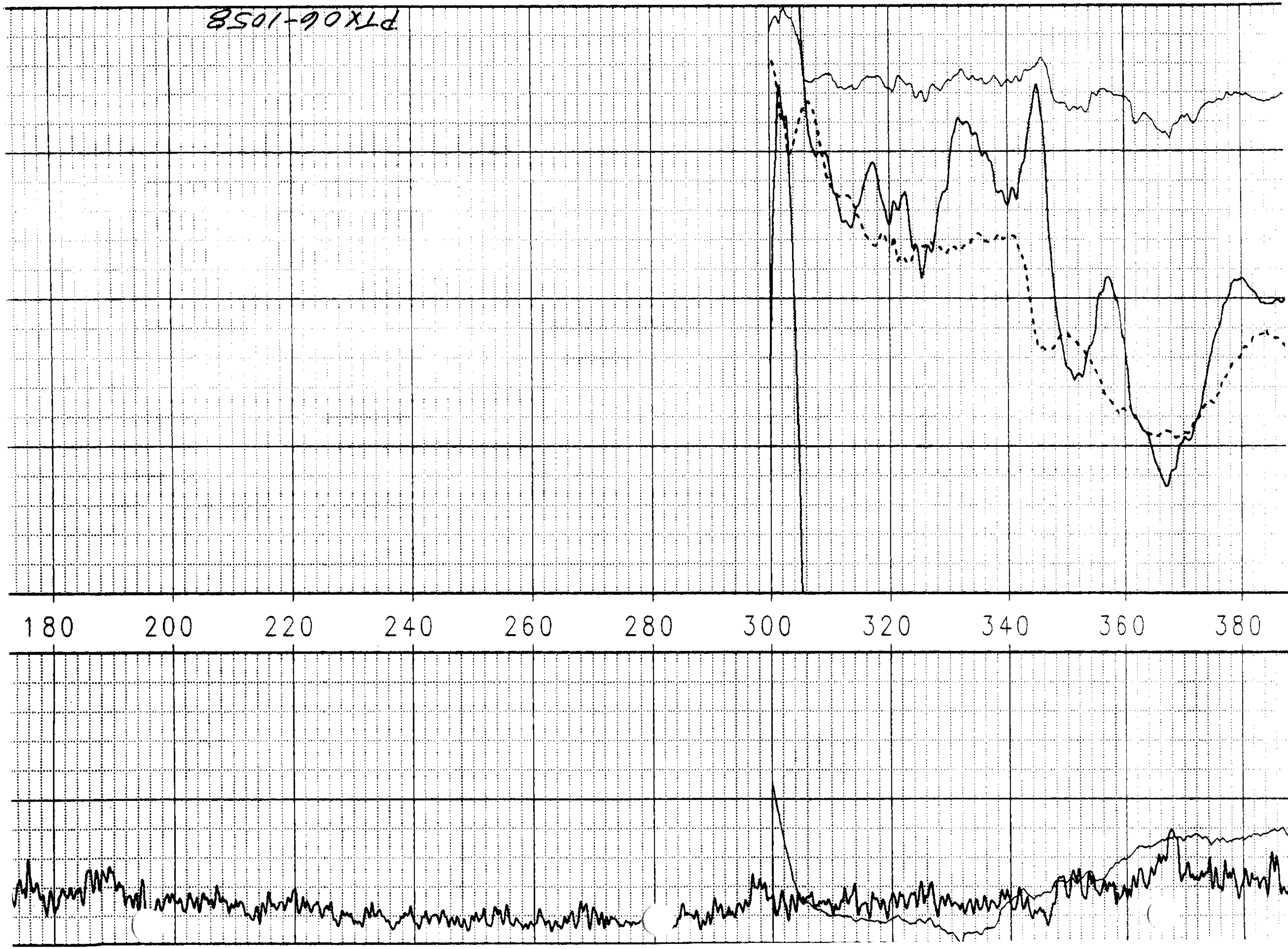
DIGITAL FILES: 1058.FIN; 1058.RPT; 1058.HDP

Well PTX01-1058, Pantex Plant, 08/24/2000 COLOG

Single Point Resistance
0 Ohms 200

Well PTX06-1058, Pantex Plant, 08/24/2000




PTX06-1058
180
200
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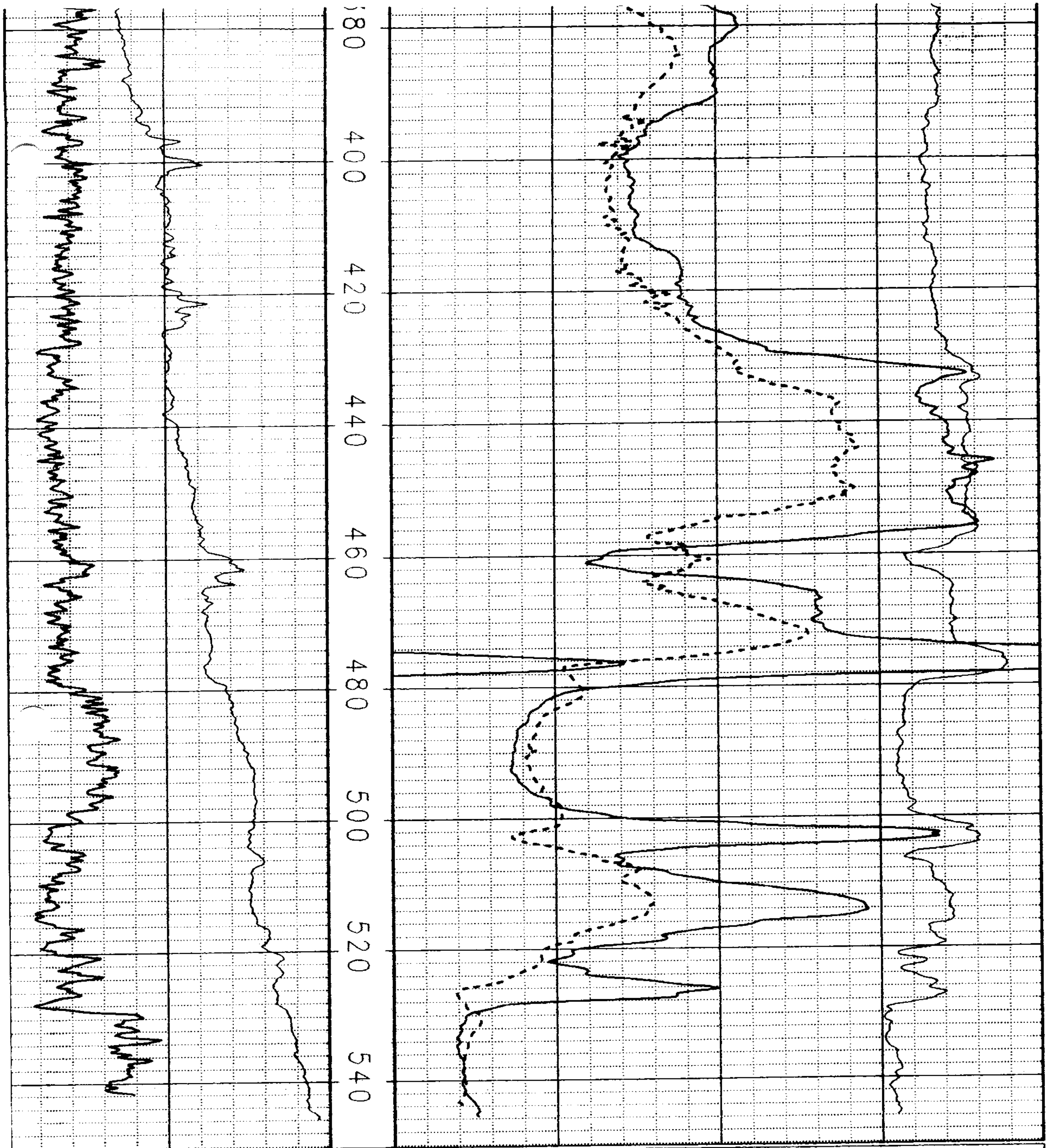
360
380



Natural Gamma
0 CPS 200
Spontaneous Potential
-500 Millivolts -250

16'' Normal Resistivity
0 Ohm-M 100
64'' Normal Resistivity
K-0 Ohm-M 100
Single Point Resistance
0 Ohms 200

Well PTX06-1058, Pantex Plant, 08/24/2000 COLOG

Well PTX01-1058, (Repeat Section) Pantex Plant, 08/24/2000 COLOG

Single Point Resistance
0 Ohms 200

Spontaneous Potential

64'' Normal Resistivity

PTX06-1059

Contractor: S.M. Stoller Corporation

Contract #: 3615

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

___Installation Log

_X_Lithologic Logs
    _X_Draft
    _X_Final

___Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

PTX06-1059

Pantex Burning Grounds Soil Gas **Pantex Plant (West Side Playa 2)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	H. Sutphin/T. Hall/R. Rupp	Northing: 3760459.31	Easting: 628129.98
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	550' BGS
Dates Drilled:	08/29/00 - 09/10/00	Depth to Water:	397.5' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3543.96'	TOC Elevation:	3546.56'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	0		ML	0-20' SILT, clayey, trace fine grain sand, 10% white CO3 nodules, pale red (10R 6/2), medium dry strength, dry Drilling open-hole with Tricone bit		
	20		ML	20-30' SILT, clayey, 15% white CO3 laminae and nodules, yellowish red (5YR 5/6), medium dry strength, dry		
	30		ML	30-40' SILT, clayey, clay about 35%, <5% CO3, reddish brown (5YR 4/4), medium dry strength, dry, flat fragments show interior laminations		
	40		ML	40-50' SILT, clayey, <5% clay, light brown (5YR 5/6), loose, no cohesive chips blown up hole		
	50		ML	50-60' SILT, sandy, 40% fine grain sand, trace clay, pink (5YR 8/4), very loose, dry		
	60		ML	60-70' SILT, clayey, 10% fine grain sand, 5% CO3 fragments <5mm, pink (5YR 8/4), dry @ 62' thin caliche layer, short interval of white chips		
	70		ML	70-80' SILT, 5% CO3 - fines only, very minor recovery, Geophysical log indicates Caliche Caprock 70-74'		
	80		ML	80-90' SILT, 20% sand, 5% caliche nodules, reddish yellow (5YR 4/6), fine and medium grain sand, subrounded, graded, dry, @ 85' becomes more clayey and less sandy Change to ODEX bit with drive casing		
	90		SP	90-100' SAND, 10% clay and silt, fine grained with 5% medium and coarse grain, pink (5YR 7/3), subrounded, poorly graded, dry @ 98' becomes more silty/clayey		

PTX06-1059

Pantex Burning Grounds Soil Gas **Pantex Plant (West Side Playa 2)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	H. Sutphin/T. Hall/R. Rupp	Northing: 3760459.31	Easting: 628129.98
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	550' BGS
Dates Drilled:	08/29/00 - 09/10/00	Depth to Water:	397.5' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3543.96'	TOC Elevation:	3546.56'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML	100-105' SILT, with clay and fine sand to 20%, yellowish red (5YR 5/6), subrounded, damp		
			MUD STN	105-110' MUDSTONE, ground to the above described silt		
	110		ML	110-115' MUDSTONE/CALICHE, 60% mudstone ground to silt/clay, 40% caliche ground to white/pink dust, yellowish red (5YR 5/6) to pinkish white (5YR 8/2), damp to dry		
			ML	115-120' CALICHE, with beds of silt and clay, very hard to fairly soft, difficult to drill		
	120		ML	120-130' SILT, with 40% fine sand, reddish yellow (5YR 6/6), subrounded, poorly graded, dry @ 125' more caliche beds/nodules		
	130		ML	130-140' SILT, with 10% fine sand, reddish yellow (5YR 6/6), subrounded, poorly graded, compact, clay content increasing, drilling very difficult @ 136' clayey silt gumming up ODEX bit		
	140		ML	140-150' SILT, clayey to CLAY, silty, reddish yellow (5YR 6/6), low plasticity, compact, dry to damp		
	150		SM	150-160' SAND, silty, light reddish brown (5YR 6/4), fine grain, dry		PTX06-1059-2-0150 VOC
	160		SM	160-170' SAND, silty, trace gravels <10mm, light reddish brown (5YR 6/4), fine grain, well sorted, damp		
	170		SM	170-180' SAND, silty, trace clay, light reddish brown (5YR 6/4), fine grain, well sorted, low dry strength, damp		
	180		SP	180-190' SAND, minor silt, yellowish brown (10YR 5/4), fine grain, poorly graded, loose, damp		
	190		SP	190-200' SAND, with silt, yellowish red (5YR 5/6), fine grain, poorly graded, loose, damp		

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S.M. STOLLER CORPORATION

PTX06-1059

Pantex Burning Grounds Soil Gas | **Pantex Plant (West Side Playa 2)** | **Amarillo, Texas**

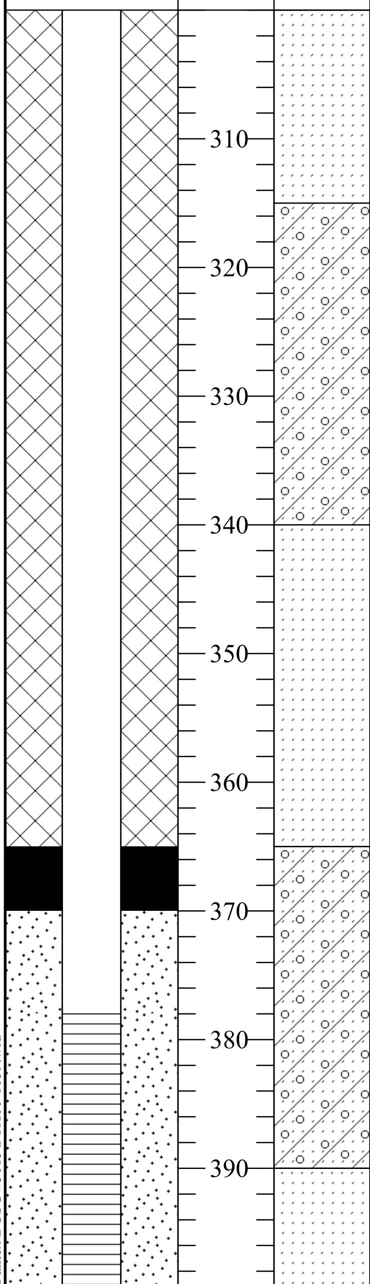
Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	H. Sutphin/T. Hall/R. Rupp	Northing: 3760459.31	Easting: 628129.98
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	550' BGS
Dates Drilled:	08/29/00 - 09/10/00	Depth to Water:	397.5' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3543.96'	TOC Elevation:	3546.56'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SM	200-210' SAND, silty, with gravel up to 3/4" and CO3 cemented sand nodules, very pale orange (10YR 8/2), dry		PTX06-1059-2-0202 VOC
	210		SP	210-220' SAND, with 10% peagravel, very pale brown (10YR 7/4), very fine to medium grain, poorly graded, loose, dry		
	220		SW	220-230' SAND, with 20% gravel to 1/2", light yellowish brown (10YR 6/4), fine to coarse grain, subangular to subrounded, loose, dry		
	230		SW	230-240' SAND, as above with decrease in gravel size, brown (10YR 5/3), angular, loose, dry		
	240		SM	240-250' SAND, silty, 50-50 on content, yellow (10YR 5/8), very fine to fine grain sands, loose, dry		
	250		GW	250-252' GRAVEL, sandy, 60% gravel to 1-inch diameter, 40% coarse grain sand, some fine to medium grain sand, loose, dry		PTX06-1059-2-0250 VOC
	260		SP	252-265' SAND, slightly silty, with gravel to 1-inch diameter, very pale brown (10YR 7/4), subrounded, loose, dry		
			SP	265-270' SAND, with some small gravel, pale brown (10YR 6/3), poorly graded, fine to medium grain, loose, moist		
	270		SM	270-272' SAND, silty, 50-50 sand silt, very pale brown (10YR 8/3), no gravel		
			SM	272-280' SAND, with silt, pinkish white (7.5YR 8/2), ground to rock flour, loose, dry		PTX06-1059-2-0280 VOC
	280		CL	280-290' CLAY, with 10% sand and some small gravel, brown (7.5YR 5/3), fat clay, plastic, very stiff, slightly damp		PTX06-1059-2-0280.5 HE
	290		SP	290-315' SAND, very pale brown (10YR 7/4), very fine to fine grain, rounded, poorly graded		

PTX06-1059

Pantex Burning Grounds Soil Gas **Pantex Plant (West Side Playa 2)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	H. Sutphin/T. Hall/R. Rupp	Northing: 3760459.31	Easting: 628129.98
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	550' BGS
Dates Drilled:	08/29/00 - 09/10/00	Depth to Water:	397.5' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3543.96'	TOC Elevation:	3546.56'



Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP	300-315' SAND, pinkish gray (7.5YR 7/2), very fine grain, subrounded, poorly graded, medium dense, mostly Si02, trace mafic material		
			SC	315-340' SAND, light brown (7.5YR 6/3), fine to medium grain, rounded @ 330' SAND, clayey, gradational change @ 340' CLAY, light brown (7.5YR 6/3), cuttings recovery in sieve not enough for sample collection		
			SP	340-365' SAND, some clay, light brown (10YR 6/3), fine grain, subrounded, contains quartz and mafic materials		
			SC	365-390' SAND to CLAY, clay at 80%, light brown (7.5YR 6/3), some fine grain sand @ 380' sand becomes more well graded, with grain size increasing to 10% coarse grain, subrounded, some mafic material still present		
			SP	390-415' SAND, light brown (7.5YR 6/3), fine to coarse grain, subangular to subrounded, graded to well graded Water Level @ 397.5' BGS on 10/10/00		

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PTX06-1059

Pantex Burning Grounds Soil Gas | **Pantex Plant (West Side Playa 2)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	H. Sutphin/T. Hall/R. Rupp	Northing: 3760459.31	Easting: 628129.98
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	550' BGS
Dates Drilled:	08/29/00 - 09/10/00	Depth to Water:	397.5' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3543.96'	TOC Elevation:	3546.56'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	410		SP	@ 405-415' fine grain sands		
	420, 430		SP	415-440' SAND, light brown (7.5YR 6/3), very fine to fine grain with up to 10% medium grain sand, subangular to subrounded, loose, abundant in SiO2 with only trace mafic material, cuttings recovery poor		
	440, 450, 460, 470, 480		SP	440-490' SAND, fine grain, cuttings recovery poor		
	490		SP	490-500' SAND, light yellowish brown (10yr 6/4), 90% fine grain, 10% very fine grain, subrounded, quartzose sand with trace mafics		

PTX06-1059

Pantex Burning Grounds Soil Gas | **Pantex Plant (West Side Playa 2)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	H. Sutphin/T. Hall/R. Rupp	Northing: 3760459.31	Easting: 628129.98
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	550' BGS
Dates Drilled:	08/29/00 - 09/10/00	Depth to Water:	397.5' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3543.96'	TOC Elevation:	3546.56'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	510		SP	500-510' SAND, coarse to very coarse, 90% clear and yellowish brown quartz with 10% mafics making a multi-colored mix, angular to subangular, drill pipe chatters on table		
	520		SP	510-525' SAND, red, coarse pieces of well cemented, fine grain sandstone with brown mudstone, probable Dockum formation, penetration rate drops, pipe still chattering but not as rough		
	530		MUD STN	525-532' MUDSTONE, brown with multi-colored medium sand (possibly from above) @ 530' penetration rate picking up		
			SH	530-532' SHALE, clayey, red brown		
	540		SP	538-540' SANDSTONE, increasing white and yellow colors in cuttings, fine grain, soft, penetration rate decreases slightly, drilling fluid brown		
	550		SH	540-550' SHALE, clayey, sandy, reddish brown to red (2.5YR 4/4-4/6), quartzose and micaceous fine sand, subrounded grains @ 545' SHALE, clayey, with 30% sand, red (10R 4/6), very fine, rounded, sand grains, hard, possibly a clayey sandy siltstone, penetration rate continues to slow @ 546' Redbeds, as above, with grayish white to pale yellow (2.5YR 7/4) clay reduction mottling @ 547' mottling drops out, some yellows coming in, mud making a gradual change to red color @ 550' TD, drill penetrated 1 ft. very quickly just before TD, probably a soft reduction zone		
	560					
	570					
	580			Total Depth of Borehole 550' BGS Fine Grain Zone 279' BGS Geophysical log indicates top of Redbeds @ 538' BGS		
	590			Well Completion Details: Borehole Diameter: 12" surface to 280' 7 7/8" 280-550'		

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PTX06-1059

Pantex Burning Grounds Soil Gas	Pantex Plant (West Side Playa 2)		Amarillo, Texas
Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	H. Sutphin/T. Hall/R. Rupp	Northing: 3760459.31	Easting: 628129.98
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	550' BGS
Dates Drilled:	08/29/00 - 09/10/00	Depth to Water:	397.5' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3543.96'	TOC Elevation:	3546.56'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	610 620 630 640 650 660 670 680 690			8 5/8" steel conductor casing set with cement 0-280' Total Depth of Well 543' BGS 4-inch, Type 316 stainless steel casing and 10-slot screen 5' sump (538-543'), 160' screen (378-538'), 380' casing (+2-378') Filter pack, 20/40 Colorado Silica Sand (370-550') Bentonite seal (365-370') Bentonite grout (surface-365') Cement seal (0-2') Concrete pad (5'x5'x8") with 4 bollards Protective casing, 10-inch steel with locking cover		

PTX06-1059

VISUAL CLASSIFICATION OF SOILS

...ECT NUMBER: 3615	PROJECT NAME:	
...ING NUMBER: PTX06-1059	COORDINATES:	DATE: 8/29/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/29/00
ENGINEER/GEOLOGIST: H. Sutphin	Depth Date/Time	DATE COMPLETED: 9-10-00
DRILLING METHODS: Air Rotary 11¼ tricone.		PAGE: 1 OF 10

DEPTH (Ft)	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	~~RECOVERY~~ ( ) NM	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
10	Grab		0.	SILT with clay, trace Fg sand, medium dry strength, dry, pale Red (10R 6/2) - 10% white CO3 Nodules.		siltst	
20	Grab		0	SILT, with clay, medium dry strength, dry, moderate Brown (5YR 5/6), 15% white CO3 Laminae & nodules			
30	Grab		0	SILT, Clayey, medium dry strength, dry, <5% CO3 moderate Brown (5YR 4/4), Flat fragments show interior laminations. Clay ~35%			
40	Grab		0	silt, loose, <5% clay, nocohesive chips blown up holes light Brown (5YR 5/6), dry	ML	~~ML~~	All silt particles & dust Blown up hole
50	Grab		0	sandy silt, Fg sand 40%, Trace clay v. loose, dry, Moderate orange pink. (5YR 8/4)	ML		
60	Grab		0	CLAYEY silt with sand, Fg sand 10% Dry - 5% CO3 Fragments <5mm, moderate orange pink.	ML		clay balls in chips

NOTE: 0-60 Feet

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME:	
BORING NUMBER: PTX 06-1059	COORDINATES:	DATE: 8/29/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/29/00
ENGINEER/GEOLOGIST: H Sutphin	Depth Date/Time	DATE COMPLETED: 9-10-00
DRILLING METHODS: Air Rotary 11 1/4 tricone		PAGE: 2 OF 10

DEPTH (Ft)	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( ) PPM	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
			0	68' Thin caliche layer?			Rattle drill stem, short interval of white chips
70	Grab		0.	Silt, 5% CO3 - Fines only	ML		Very minor Recovery
	"			Silt, 20% sand, 5% caliche nodules, 5YR 7/6 reddish yellow, fine & med grained sand, subrounded Graded, dry,	ML		0.0 - change to ODEX
				85' - becomes more clayey & less sandy			
90				90' Sand, fine grained w/10% clay & silt. 5% med & carse grains, 5YR 7/3 pink, dry, subround, Poorly Graded	SP.		0.0
				Becomes more silty/clayey			0.0
100				100' Silt w/ clay & fine sand to 20%. 5YR 5/6 yellowish Red, Damp, subround,	ML		
				105 - Mudstone - Ground into the Above described Silt.	ML		0.0
110				110' Mudstone/caliche - 80% mudstone Ground into silt/clay, 40% caliche ground to white/pink dust - damp/dry yellow red 5YR 5/6 To pink/white 5YR 8/2.	ML		0.0
120	cap rock? ???	interbedded not massive		115 Caliche Cap Rock? w/ beds of Silt & clay Very hard to fairly soft difficult to drill			

60-120

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gas		
BORING NUMBER: PTX06-1059	COORDINATES:		DATE: 8/30/00
ELEVATION:	GWL: Depth	Date/Time	DATE STARTED: 8/29/00
ENGINEER/GEOLOGIST: SRB H. Sutphin	Depth	Date/Time	DATE COMPLETED: 9-10-00
DRILLING METHODS: CDEX			PAGE: 3 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER( )	RECOVERY ( ) OVM	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS PID in ppm
120	Grab			-Silt w/40% fine sand - 5YR 6/6 reddish yellow, dry, subrounded, poorly graded.	ML		0.0
				-125 - more caliche beds / Nodules			
130				-Silt w/10% fine sand 5YR 6/6 reddish yellow dry to damp subrounded, poorly graded, compact	ML		0.0
				- Drilling very difficult - clay content ↑			
				- clayey Silt - gumming of Drill	ML		0.0
				-Silt - clayey to silty clay - 5YR 6/6 low plasticity, compact, dry to damp.	ML/CL		0.0
				-silty clay continues	ML/CL		
150			0	More of the same	ML/CL	SM	0.0 - sample 11:03 for VOCs (1 vial) PTX06-1059-2-150
				silty Fg sand, dry, Light Brown (5YR 5/4)			
160	Grab		0	SILTY FG SAND, well sorted, damp, trace gravels ≤ 10mm Light Brown (5YR 5/4)		SM	
170	Grab	*	3.0	silty Fg sand, trace clay, damp, well sorted, low dry strength, Light Brown (5YR 5/4)		SM	
180	Grab		0	Poorly Graded sand, Fine grained well sorted, minor silt, Damp, Loose, moderate yellowish Brown (10YR 5/4)	SP		

120'-180'

* maybe related to dryness & static charge on the Bags. Empty Bag Reads 5-9 when tip of OVM 1st inserted

sand Damp at 160 feet

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME:	
BORING NUMBER: PTX06-1059	COORDINATES:	DATE: 8-30-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8-29-00
ENGINEER/GEOLOGIST: H. Sutphin	Depth Date/Time	DATE COMPLETED: 9-10-00
DRILLING METHODS: ODEX		PAGE: 8 OF 10

DEPTH (ft)	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( ) ppm	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
190	Grab	—	0	Fine grained sand with silt, damp, well sorted, poorly graded. Light Brown (5YR 5/6), loose.	SP		
	Grab		0.2	Silty sand with Gravel, dry Gravel up to 3/4 inch, with CO3 cemented sand nodules Very pale orange (10YR 8/2)	SM		sample 202-203' PTX06-1059-2-202 Methanol VOC 6:39 pm (1839)
210				210' SP very pale brown [10YR 7/4] v. fine to med grain sand, poorly graded, very small gravel @ 10% content, unit is dry and loose	SP		
220				220' (SW) light yellowish brown [10YR 6/4] fine to coarse grain sands, sub-angular to sub-rounded. gravel to 1/2" diam 20% in content, dry & loose	SW		
230				230' (SW) brown [10YR 5/3] Same as above w/ chng. in color and smaller gravel, angular, unit is dry & loose	SW		
240				240' (SM) yellow [10YR 5/8] Silty sand v. fine to fine grain. 50/50 on content, dry & loose	SM		

180-240

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
BORING NUMBER: PTX06-1059	COORDINATES:	DATE: 083100
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 082900
ENGINEER/GEOLOGIST: T Hall	Depth Date/Time	DATE COMPLETED: 9-10-00
DRILLING METHODS: ARW/odex		PAGE: 5 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
250	Split Spoon #3	250-52'	1'	250-252' SW/GW gravelly sand, sand @ 40% coarse grain, gravel @ 60% to 1/2" diam. Sand is fine to med, loose and dry	SW/GW		250-252 split spoon CH_3OH preserv. ID# 0250 @ 0030
260				260' (SP/SM) very pale brown [10YR7/3] sli. silty sand w/ gravel to 1" diam sub-rounded, loose and dry	SM/SP		
265				265' (SP) pale brown [10YR6/3] poorly graded sands, fine to med grain w/ some small gravel, moist and loose	SP		
270				270' (SM) very pale brown [10YR8/3] silty sand, no gravel. Silt and sand @ 50/50 in content	SM		
280				272' (SM) pinkish white [7.5YR8/2] silt, ground to rock-flour, dry and loose			
				280' (CL) brown [7.5YR5/3] fat clay w/ 10% sand, some small gravel. Clay is plastic, sli. damp and dense	CL		280-282' Sample 280-VOC 280.5 HE 0445
270				290' (SP) very pale brown [10YR7/4] sand very fine to fine grain, rounded, poorly graded. 10%			
300							

: Split Spoon 250-252' 1' recovery, shoe-end CH_3OH pres. Sample taken for VOC @ 0030

Split spoon @ 280-282

Noted: 9-9-00
543' of pipe and sub on site and in hole
250' of pipe on truck (10x25') @ 290'

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
BORING NUMBER: PTX06-1059	COORDINATES:	DATE: 09-09-06
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 082900
ENGINEER/GEOLOGIST: T. Hall	Depth Date/Time	DATE COMPLETED: 9-10-06
DRILLING METHODS: Mudrotary W/ 7⅞" Tri-cone		PAGE: 6 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS time
				290-315' (SP) SAND pinkishgray (7.5YR7/2) v. fine grain sand. poorly graded, mostly SiO_2 grains, sub-rounded, trace mafic material, med. dense			
310							
315				315'-340' (SP) SAND light brown [7.5YR6/3] Sand is fine to med grain and rounded e ≥ 330' graded to an (SC) @ 340' (CL) light brown in color (7.5YR6/3) was in sieve but not enough for sample collection.			2325 – 0015 (9-10)
320							
330							
340				340-365' (SP) SAND light brown (10YR6/3) fine grain sand, sub-rounded to (SC) sandy clay. contains SiO_2 and mafic materials.			0020 – 0125
350							
360							

3:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSG	
BORING NUMBER: PTX06-1059	COORDINATES:	DATE: 091000
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 082900
ENGINEER/GEOLOGIST: T. Hall	Depth Date/Time	DATE COMPLETED: 9-10-00
DRILLING METHODS: Mudrotary w/ 7 7/8" tri-cone		PAGE: 7 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
365				365 – 390' (SC) to (CL) light brown (7.5YR6/3) Some fine grain sands w/ clay @ ≈80%. @ 380' sand became more well graded w/ grain size to coarse ≈10%, sub-rounded. mafic material still present			0135 – 0210
370							
380							
390				390 – 415' 390 – 405 (SP) to (SW) light brown (7.5YR6/3) graded to well graded sands. Sub-angular to sub-rounded. fine to coarse grain sand @ ≈405' drilling slowed down again 405–415' – fine grain sands (SP) No chng. in color			0305 – 0335
400							
410							
415				415' – 440' (SP) SAND light brown (7.5YR6/3) very fine to fine w/ ≤10% medium grain sands. abundant in SiO_2 w/ only trace mafic material.			0340 – 0410
420							

REMARKS:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSG	
BORING NUMBER: PTX06-1059	COORDINATES:	DATE: 091000
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 082900
ENGINEER/GEOLOGIST: T. Hall	Depth Date/Time	DATE COMPLETED: 9-10-00
DRILLING METHODS: Mud Rotary W/ 7 7/8", tri-cone		PAGE: 8 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS time
				sand is sub-angular to subrounded unit is loose. diminished return			
430							
440				440'-465' minimal return fine grain sand (SP) not adequate sample to log			0415 - 0520
450							
460							
465'				465'-490' NO cuttings ~~No return~~			~~0530~~ TR 0545-
470							
480							

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: B6S6		
BORING NUMBER: PTX06-1059	COORDINATES:		DATE: 9-10-00
ELEVATION:	GWL: Depth	Date/Time	DATE STARTED: 8-29-00
ENGINEER/GEOLOGIST: R. Rupp	Depth	Date/Time	DATE COMPLETED: 9-10-00
DRILLING METHODS: mud rotary			PAGE: 9 OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER ( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
490				~~490-500~~ @ 490 circulate and catch cuttings to 500'	SP		0700 9-10-00
493 ov				Sand, fine to very fine, light yellowish brown (10 YR 6/4) 90% fine grained, subrounded, quartzose sand with trace mafics.			
							0930 Start drilling
				500'-510' SAND, coarse to very coarse predominates to 510' when significant fine grain material is evident. Coarse material is 90% clear and yellowish brown quartz with 10% mafic making a multi color mix. Angular to subangular - drill pipe chatters on table	SW		501' @ 0940
510				510' - Coarse fraction drops out still Sand fine grained as above with brown mudstone			
							515' @ 1025
518 ov	0830			Beginning to recover coarse pieces of fine grain sandstone, red, well cemented - probable top of Dockum Formation - penetration rate drops. string still chattering but not as rough. Dockum @ about 510'			
520							
				525' mudstone, brown with multicolored medium sand (possibly from above)			
530				530 penetration picking up			530 @ 1105
				532 quartz increase in red brown shaly clay flakes and sand %			
				538 increasing white and yellow colors in cuttings - ~~[illegible]~~ penetration rate ~~[illegible]~~ decreases slightly - whites and yellows are soft fine grain sandstones? not sure drilling fluid brown			538 @ 1119
540							

Rev 2 ML 7037

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSG		
BORING NUMBER: DTX06-1059	COORDINATES:		DATE: 9-10-00
ELEVATION:	GWL: Depth	Date/Time	DATE STARTED: 8/29/00
ENGINEER/GEOLOGIST: R. Rupp	Depth	Date/Time	DATE COMPLETED: ~~8/29/00~~ Rue 9-10-00
DRILLING METHODS: mud rotary			PAGE: ~~10~~ OF 10

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
540				540 <u>Shale, clayey</u>, reddish brown to red (2.5YR 4/4-4/6) sandy, micaceous fine sand, subrounded, quartzose			1140 @ 540'
542							
550				545 shale clayey sandy, red (10R 4/6) very fine sand, rounded grains hard. penetration rate continues to slow ±30% sand - you could call this a clayey sandy siltstone. Redbeds contact approx. 542'			545' @ 1230
560				@546' Redbeds as above with grayish white to pale yellow (2.5Y 7/4) clay (Reduction mottling)			
				@547 mottling drops out some yellow coming in: mud making a gradual change to red color			547' @ 1302
568	1145						
570				550' TD deep enough for geophysical logging tool. Drill penetrated 1' very quickly just before TD, probably a soft reduction zone.			550' @ 1400
580							
590							
600							

9/11/00 Geophysical Log indicates the Top of Permian Redbeds are approximately 538-540' ~~RWR~~

PTX06-1060

Contractor: S.M. Stoller Corporation

Contract #: 3615

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

___Installation Log

_X_Lithologic Logs
    _X_Draft
    _X_Final

___Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

PTX06-1060

VISUAL CLASSIFICATION OF SOILS

?

P[illegible]CT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gass	
BORING NUMBER: PTX06-1060	COORDINATES:	DATE: 8-27-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/27/00
ENGINEER/GEOLOGIST: S. Brinkman, 4BS	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Air Rotary, 11¼" Tricone		PAGE: 1 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS Pid in PPM
0	Grab			0–2.5 Dark brn organic top soil - rootlets silty sand, clay mix.			0.0
	"			-5' Silt w/clay - Dark brn 7.5YR 3/2, Compact hard dry to slightly damp	ML		
10	"			-Silt w/50% clay Moist lite red-brn 7.5YR 6/4 STIFF, compact Med plastic - difficult to Drill	ML/CL		0.0
				-Same as above less moist			0.0
20	"			-silt/clay Light reddish brown 5YR 5/4, STIFF compact Dry to moist med plast	ML/CL		0.0
30	"	—	—	clayey silt, dry, medium dry strength, greyish Red (10R 4/2).	ML		0.0
40	"	—		clayey silt, trace Fg sand, pale Red, (10R 4/2)	ML		All return as <1mm crumbs
50	Grab		—	silty Fg sand, (5YR 5/6) yellowish red, medium dense, poorly graded sand with silt, non plastic, low dry strength,	SP-SM		0.0
60	Grab	—	—	silty Fg sand Light Brown (5YR 6/4) with clay, trace (1%) carbonate nodules (<2mm), medium dense,	SM		0.0

NOTES: 0-60

VISUAL CLASSIFICATION OF SOILS

PR[illegible]CT NUMBER: 3615	PROJECT NAME:		
BORING NUMBER: PTX06-1060	COORDINATES:		DATE: 8-27-00
ELEVATION:	GWL: Depth	Date/Time	DATE STARTED: 8-27-00
ENGINEER/GEOLOGIST: AB Sutphin	Depth	Date/Time	DATE COMPLETED:
DRILLING METHODS: Air Rotary 11 1/4" Tricone			PAGE: 2 OF 9

DEPTH ( )	SAMPLE TYPE & NO. Grab	BLOWS ON SAMPLER( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS PID in PPM
70	Grab			Silty Clay with 5% sand, Moderate orange pink. (5YR 8/4) medium dry Strength, Fine grained, Dry	SC		70' @ 1200 am PID 0.0
				75' carbonate Nodules (≤ 6mm) blown up hole			
80	[illegible]			silty Fg sand, tr. clay, dry, loose, 2% white CO_3 nodules ≤ 1mm	SM		0.0
90	Grab			Fine grained silty sand, loose, damp, light brown, (5YR 5/6) trace CO_3 Fragments.	SM		PID inoperable
100	Grab			Sand, Fine gravel w/ 15% silt 10% med grains 5YR 6/4 lt. red brn sub round loose, damp Caliche chunks 10%.	SM		0.0
	Grab			105 – Silt, Damp, red, 2.5YR 4/6,	ML		0.0
110	Grab			110 – Silt w/ fine sand to 15%. 5yr 4/6. yellow red - sub rounded, Damp poorly graded, loose	ML		0.0
	grab			115 – As above w/ caliche to 20%	ML		0.0
120				Silt minor fg sand yellowish red 5yr 6/6 damp loose, Caliche pieces to 2%.	ML		0.0

NOTES:

VISUAL CLASSIFICATION OF SOILS

P[illegible]CT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gas -	
BORING NUMBER: PTx06-1060	COORDINATES:	DATE: 8/27/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/27/00
ENGINEER/GEOLOGIST: S. Brinkman	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Air Rotary 11¼" Tri-cone ODEX		PAGE: 3 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS Pid in ppm
120	Grab			Previously described			
				Silt continues			
				Silt, w/10% vfg sand, 5YR 6/6, low plast. Loose, Damp.	ML		0.0
130				-135' silt continues w/ caliche pieces to 2%.	ML		0.0
140				Clay beds - thin -Sand fine grain clay to 10% in beds lite yellow to pale brw 10YR 8/3 5% med grained sub rounded, poorly graded, dry	SP		0.0
				Sand continues w/ caliche beds to 10%.	SP		0.0
150				-150' Very fine sand w/ silt - damp subround 10YR 7/6 yellow poorly graded,	SM		0.0
				-155' Sandstone as above	SM		0.0
160				-160 Sandstone continues 10YR 7/6 fine grained w/ 10% med & silt to 10% sub round, damp, poorly graded	SM		0.0
				-165 silt to vfg sand - 10yr 7/6 subround damp poorly sort.	SM/ML		0.0
170				- Mudstone - Ground into sand&silt 5YR 6/4 Sand - fine to very fine grain, hard, dry, sub round.	ML		0.0
				-175' -Clayey mudstone - soft, moist 5yr 6/4	ML/CL		0.0
				-178' Sandstone - fine to very fine grain, hard, dry yellow 10YR 7/6, sub rounded, poorly graded.	SP.		
180							

NOTES:

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gas	
BORING NUMBER: BTX06-1060	COORDINATES:	DATE: 8/28/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED:
ENGINEER/GEOLOGIST: S. Brinkman	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Air Rotary w/ 11¼" ODEX		PAGE: 4 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS Pid in PPM
180	Grab			- Sandstone - Fine to very fine Grain, silt to 20% med sand to 10% 10YR 7/4 pale brn. sub rounded dry, hard, cemented, contains minor <1% gravel	SP		0.0
190				- Sandstone Med grain w/ 20% coarse, 20% fine & 10% gravel to 2cm. Pale brown 10YR 8/4 sub rounded, well graded, cemented, dry,	SW		0.0
				-195- Increasing Gravel in As above matrix			
200				-200 - 10YR 7/4 As above coarse sandstone Graded, dry, hard, w/ Gravel to 3cm.	SW		0.0
				-205 - Same Sandstone	SW		0.0
210				-210 - Same Sandstone Graded.			
				-214 - hit a limestone? - ground to rock flour - white dust - w/ gravel to 3cm.	LS?		
				-220 - Gravelly Rock flour			
220				-224 Back to SANDSTONE 5% gravel 5% coarse sand, 10% med sand 60% fine 10% very fine & 10% silt/clay yellow 10YR 7/4 sub rounded, dry, hard, well graded.	SW		0.0
230				-226 - silt bed - 7.5YR 7/8 orangish, w/ gravel to 20% and 4cm. Damp, hard -	ML		0.0
				-230 - Sandstone - Graded 10% silt/clay 30% fine Grain 30% med grain 20% coarse & 10% gravel very pale brown 10YR 7/4 sub rounded, cemented, hard dry	SW		0.0
240				-235 - siltstone w/ 35% Fine/very fine sand & 2% gravel 10YR 8/8 orange, damp	ML		0.0

NOTES:

VISUAL CLASSIFICATION OF SOILS

[PROJ]ECT NUMBER: 3607	PROJECT NAME: B6 Soil Gas ?	
BORING NUMBER: PTX06-1060	COORDINATES:	DATE: 8/28/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8/27/00
ENGINEER/GEOLOGIST: A. Sutphin	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Air Rotary 11¼ ODEX		PAGE: 5 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
							PID
240	Grab			sandstone, finer grained, still pale brw (10YR 7/4) with gravel, dry, hard			0.0
250	Grab			poorly graded sand w/ gravel - Fg sand 70%, Cg sand 10%, 20% gravel ≤ 15 mm, v pale orange sand, (10YR 8/2). v. loose, dry			0
260				Damp sand, gravels ≤ 1 inch			
260	Grab			poorly graded sand, Fg sand 65%, Mg sand 25%, 10% gravel ≤ 3/4 inch, Damp, loose			0
270	Grab			poorly graded sand, As Above			
273				273' color change to Moderate brown (5YR 4/4), with silt, minor gravel			
275				275' Top FGZ Fine grained silty sand w/ clay, damp			275 TOP FGZ.
280	Grab			Silt, clayey w/ Fg sand & trace gravel < 5 mm, damp light brown (5YR 5/6)			Low Recovery, clay gumming up ODEX Bit. set Bottom of casing
				290' NO ~~recovery~~ return			
290							
300							

NOTES: 240 -300

VISUAL CLASSIFICATION OF SOILS

…JECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
…ING NUMBER: PTX06-1060	COORDINATES:	DATE: 082700
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 082700
ENGINEER/GEOLOGIST: T. Hall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Mud Rotary		PAGE: 6 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
310							
315				~~No recovery~~ return 315'-340' (SP) SAND very pale brown (10YR7/3) Sli. graded sands. fine to coarse grain, sub-rounded, loose			315' 2230 090500
330							
340				340'-365' (sp) SAND very pale brown (10YR7/3) poorly graded sand. very fine to fine grain, sub-rounded. loose			
350							
360							

NC

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gas (Pantex)	
BORING NUMBER: PTX06-1060	COORDINATES:	DATE: 090600
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 082700
ENGINEER/GEOLOGIST: T. Hall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Mud Rotary		PAGE: 7 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
365				365'-390' No return			
370							
380							
390				390-415'			
400							
410							
415				415-440' SP SAND abundant clear SiO_2			0300 090600
420							

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas (Pantex)	
BORING NUMBER: PTX06-1060	COORDINATES:	DATE: 090600
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 082700
ENGINEER/GEOLOGIST: T. Hall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Mud Rotary		PAGE 8 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
				~~44~~(TV) ≈440 – could be Dockum group drilling mud red [10R 4/8] drilling slow, NO traces of clay yet			
430							
				440'–465' (SM/SC) Sand. (10R 4/8) Silty w/ clay @ 30% probably more clay by density of mud just not good return			440' @ 0430
450							
460				465'-475' 465' @ 0700 shift change and circulate clay (2.5YR 3/6) dark red - sand has dropped out.	CL		
465							
470							
475				475'-485' 475' @ 0840 drilling breaks, penetration quick - advance to 480' and circulate - cuttings are red clay as above but sandy with very fine subangular quartz sand from white, tan, and yellow matrices - variegated sandstone/siltstone	SM		
480							

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: B6SG	
BORING NUMBER: PTX06-1060	COORDINATES:	DATE: 9-6-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 8-27-00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: mud rotary		PAGE: 9 OF 9

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
480							
				@485' penetration rate drops · start drilling slower,			
487				@487' lost circulation			@487' @ 0920 TOTAL LOSS OF circulation
490				@490' circulation recovered penetration rate good .25' in 25 minutes			
				490' - 515' interbedded weak red (10R 4/4) siltstone with gray (10yr 6/1) and (10yr 6/6) brownish yellow clay increasing clays with depth. borehole continues to take on water	ML/CL	490'	@1345 circulation back
510							
515				@517' hole continues to take water and penetration rate greatly slows down. cuttings are decreasing in size with grays and yellows falling out.			515' @ 1410, add pipe to 543'
520							520' @ 1442
				@524' very fine grain sandy siltstone dark red (2.5YR 3/6) out of water stop to get more quartz sand, subangular/subrounded	ML		524 @ 1504
530				530' TD cuttings are clayey silt dark red (10R 3/6) clay recovered from the bit is same color, very plastic, stiff, moist	CH		530 @ 1720
540							

E log indicates top of Permian Redbeds is at 500' BGS. Therefore bottom of screen will be placed at approximately 500' BGS. Discrepancies with lith log may be due to lost circulation problems and Permian Formation not getting significantly harder than Dockum Formation beds until 17 feet into formation.

PTX06-1060

Pantex Burning Grounds Soil Gas **Pantex Plant (Zone 8)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sutphin/Hall/Rupp	Northing: 3758599.72	Easting: 620969.93
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	530' BGS
Dates Drilled:	08/27/00 - 09/06/00	Depth to Water:	357' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3568.74'	TOC Elevation:	3571.51'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML	0-2.5' TOPSOIL, dark brown, organic, rootlets, silt, sand, clay mix		
			ML	2.5-10' SILT, with clay, dark brown (7.5YR 3/2), dense, dry to slightly damp		
	10		ML	10-20' SILT, with clay to 50%, light reddish brown (5YR 6/4), medium plastic, stiff, moist, difficult to drill @ 15' less moist		
	20		ML	20-30' SILT/CLAY, light reddish brown (5YR 5/4), medium plastic, stiff, dry to moist		
	30		ML	30-40' SILT, clayey, greyish red (10R 4/2), medium dry strength, dry		
	40		ML	40-50' SILT, clayey, pale red (10R 6/2), trace fine grain sand		
	50		SM	50-60' SAND, silty, yellowish red (5YR 5/6), non-plastic, fine grain, poorly graded, medium dense, low dry strength		
	60		SM	60-70' SAND, silty, with clay, light brown (5YR 6/4), fine grain, trace (1%) carbonate nodules (<2mm), medium dense		
	70		CL	70-80' CLAY, silty, with 5% sand, moderate orange pink (5YR 8/4), medium dry strength, fine grain sand, dry @ 75' carbonate nodules (<6mm) blown up hole		
	80		SM	80-90' SAND, silty, trace clay, fine grain sand, loose, dry, 2% white C03 nodules <1mm		
	90		SM	90-100' SAND, silty, light brown (5YR 5/6), fine grained, loose, damp, trace CO3 fragments		

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S.M. STOLLER CORPORATION

PTX06-1060

Pantex Burning Grounds Soil Gas | **Pantex Plant (Zone 8)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sutphin/Hall/Rupp	Northing: 3758599.72	Easting: 620969.93
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	530' BGS
Dates Drilled:	08/27/00 - 09/06/00	Depth to Water:	357' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3568.74'	TOC Elevation:	3571.51'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SM	100-105' SAND, with 15% silt, light red brown (5YR 6/4), fine grain, 10% medium grain, subrounded, loose, dry, 10% caliche		
			ML	105-110' SILT, red (2.5YR 4/6), damp		
	110		ML	110-120' SILT, with 15% fine sand, yellowish red (5YR 4/6), subrounded, poorly graded sand, loose, damp @ 115' with caliche to 20%		
	120		ML	120-130' SILT, with minor fine grain sand, reddish yellow (5YR 6/6), loose, damp, caliche pieces to 2%		
	130		ML	130-140' SILT, with 10% very fine grain sand, reddish yellow (5YR 6/6), low plasticity, loose, damp @ 135' caliche pieces to 2%		
	140		SP	140-150' SAND, with 10% clay in thin beds, light yellow to very pale brown (10YR 8/3), fine grain, 5% medium grain, subrounded, poorly graded, dry @ 148' caliche beds to 10%		
	150		SM	150-160' SANDSTONE, silty, yellow (10YR 7/6) very fine grain sand, subrounded, poorly graded, damp		
	160		SM	160-165' SANDSTONE, with silt to 10%, yellow (10YR 7/6), fine grain, 10% med grain, subrounded, poorly graded, damp		
			ML	165-170' SILT to very fine grain sand, yellow (10YR 7/6), subrounded, poorly sorted, damp		
	170		MUD STN	170-178' MUDSTONE, ground into sand and silt, light reddish brown (5YR 6/4), very fine grain to fine grain, subrounded sand, hard, dry, at 175' clayey, soft, moist		
			SP	178-180' SANDSTONE, yellow (10YR 7/6), fine to very fine grain, subrounded, poorly graded, very dense, dry		
	180		SP	180-190' SANDSTONE, silt to 20%, very pale brown (10YR 7/4), fine to very fine grain sand, 10% medium grain, subrounded, cemented, dense, dry, contains minor (<1%) gravel		
	190		SW	190-200' SANDSTONE, very pale brown (10YR 8/4), medium grain with 20% coarse, 20% fine, 10% gravel to 2cm, subrounded, well graded, cemented, dry @ 195' increasing gravel in "as above" matrix		

PTX06-1060

Pantex Burning Grounds Soil Gas | **Pantex Plant (Zone 8)** | **Amarillo, Texas**

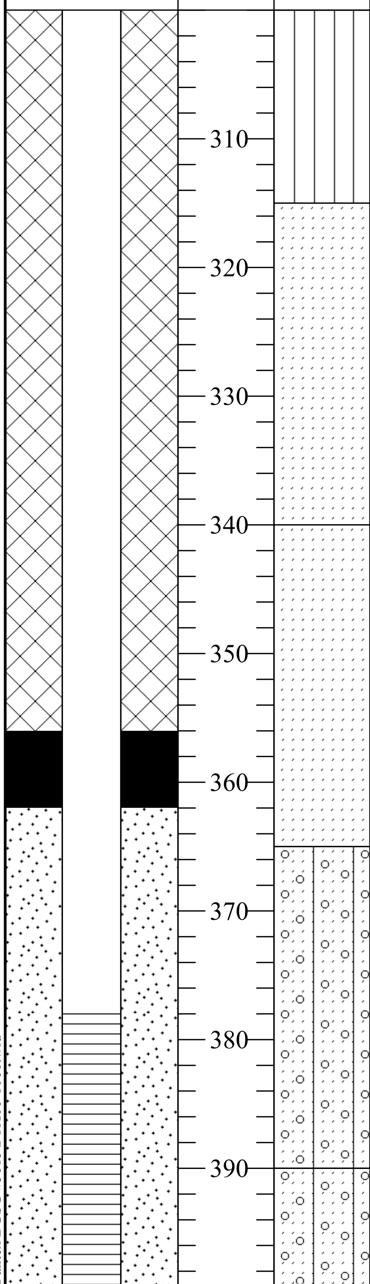
Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sutphin/Hall/Rupp	Northing: 3758599.72	Easting: 620969.93
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	530' BGS
Dates Drilled:	08/27/00 - 09/06/00	Depth to Water:	357' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3568.74'	TOC Elevation:	3571.51'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	210		SW	200-214' SANDSTONE, with gravel to 3cm, very pale brown (10YR 7/4), coarse grain, graded, dense, dry		
	220		LS	214-224' LIMESTONE?, with gravel to 3cm, ground to rock-flour, white dust		
			SW	224-226' SANDSTONE, very pale brown (10YR 7/4), 60% fine grain, 10% medium, 10% very fine, 10% silt/clay, 5% coarse, 5% gravel, subrounded, dense, well graded, dry		
	230		ML	226-230' SILT, with gravel to 20% and 4cm, reddish yellow (7.5YR 7/8), dense, damp		
			SW	230-235' SANDSTONE, very pale brown (10YR 7/4), 30% fine grain, 30% medium, 20% coarse, 10% gravel, 10% silt/clay, subrounded, graded, cemented, dense, dry		
	240		ML	235-240' SILTSTONE, yellow (10YR 8/8), 35% fine to very fine grain sand and 2% gravel, damp		
	250		SP	240-250' SANDSTONE, very pale brown (10YR 7/4), finer grained with gravel, dense, dry		
	260		SP	250-260' SAND, with gravel, fine grain sand 70%, coarse grain sand 10%, 20% gravel <15mm, sand is very pale orange (10YR 8/2), poorly graded, very loose, dry @ 256' sand, gravels <1-inch, damp		
	270		SP	260-273' SAND, fine grain 65%, medium grain 25%, 10% gravel <3/4-inch, poorly graded, loose, damp		
			SM	273-275' SAND, silty, minor gravel, mod brown (5YR 4/4)		
	280		SM	275-280' SAND, silty, with clay, fine grain, damp, Top FGZ, low recovery, clay gumming up ODEX bit, set bottom of conductor casing at 280'		
	290		ML	280-290' SILT, clayey, with fine grain sand and trace gravel <5mm, light brown (5YR 5/6), damp		
			ML	290-315' SILT, poor cuttings recovery		

PTX06-1060

Pantex Burning Grounds Soil Gas | **Pantex Plant (Zone 8)** | **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sutphin/Hall/Rupp	Northing: 3758599.72	Easting: 620969.93
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	530' BGS
Dates Drilled:	08/27/00 - 09/06/00	Depth to Water:	357' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3568.74'	TOC Elevation:	3571.51'



Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML			
			SP	315-340' SAND, very pale brown (10YR 7/3), fine to coarse grain, subrounded, slightly graded, loose		
			SP	340-365' SAND, very pale brown (10YR 7/3), very fine to fine grain, subrounded, poorly graded, loose Water Level at 357' BGS on 10/10/00		
			SM	365-390' SAND, silty, poor cuttings recovery		
			SM	390-415' SAND, silty, poor cuttings recovery		

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PTX06-1060

Pantex Burning Grounds Soil Gas	Pantex Plant (Zone 8)	Amarillo, Texas	
Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sutphin/Hall/Rupp	Northing: 3758599.72	Easting: 620969.93
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	530' BGS
Dates Drilled:	08/27/00 - 09/06/00	Depth to Water:	357' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3568.74'	TOC Elevation:	3571.51'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	410		SM			
	420, 430		SP	415-440' SAND, poorly graded, abundant clear Si02 @ about 440' drilling mud turns red (10R 4/8), no trace of clay		
	440, 450, 460		SC	440-465' SAND, silty with clay at 30%, red (10R 4/8), probably more clay content based on penetration rate and comparative density of formation		
	470		CL	465-475' CLAY, dark red (2.5 YR 3/6), sand has dropped out		
	480		SP ML	475-490' SANDSTONE/SILTSTONE, with red clay from above, variegated white, tan, and yellow matrices, very fine grain, subangular, quartz sand @ 475' drilling break - quick penetration to 480' @ 485' penetration rate drops @ 487' LOST CIRCULATION at 09:20		
	490		CL	490-530' SILTSTONE/CLAY, interbedded, weak red (10R 4/4) siltstone with gray (10YR 6/1) and brownish yellow (10YR 6/6) clay, increasing clays with depth @ 490' circulation recovered at 13:45 (about 4 hours elapsed		

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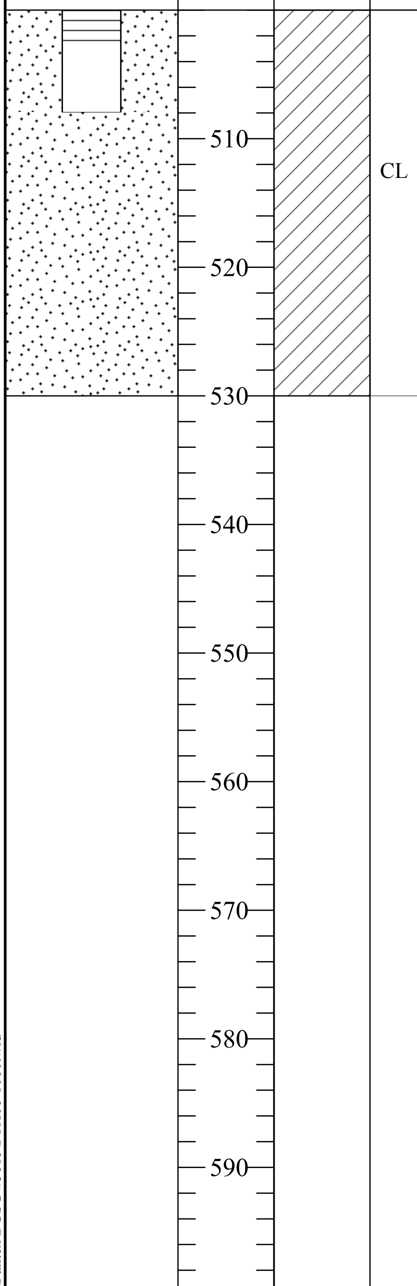
PTX06-1060

Pantex Burning Grounds Soil Gas **Pantex Plant (Zone 8)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sutphin/Hall/Rupp	Northing: 3758599.72	Easting: 620969.93
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	530' BGS
Dates Drilled:	08/27/00 - 09/06/00	Depth to Water:	357' BGS 10/10/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3568.74'	TOC Elevation:	3571.51'

Completion | Depth (Ft.) | Lithology | USCS | Description | Sample | Sample Number



time), borehole continues to take on water

@ 517' Borehole continues to take on water and penetration rate greatly decreases, cuttings are decreasing in size with grays and yellows falling out

@ 524' SILTSTONE, sandy, dark red (2.5YR 3/6) very fine grain, subangular to subrounded, quartzose sand, borehole continues to take water

@ 530' Total Depth Drilled, cuttings are clayey silt, dark red (10R 3/6), clay recovered from the bit is the same color, very plastic, stiff, moist

Total Depth of Borehole 530' BGS
Fine Grain Zone 275' BGS
Geophysical log indicates top of Redbeds at 500' BGS

Well Completion Details:
Borehole Diameter:
12" surface to 280'
7 7/8" 280-530'
8 5/8" steel conductor casing set with cement 0-280'

Total Depth of Well 508' BGS
4-inch, Type 316 stainless steel casing and 10-slot screen
5' sump (503-508'), 125' screen (378-503'), 380' casing (+2-378')
Filter pack, 20/40 Colorado Silica Sand (362-530')
Bentonite seal (356-362')
Bentonite grout (2-356')
Cement seal (0-2')
Concrete pad (5'x5'x8") with 4 bollards
Protective casing, 10-inch steel with locking cover

COLOG Division of Layne Christensen, Co.
17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

GAMMA-ELECTRIC LOG

COM: SM STOLLER
WELL: PTX06-1060
FLD: Pantex
ST: TX COUNTY: Carson

COMPANY: SM STOLLER
WELL: PTX06-1060
FIELD: Pantex
STATE: TX COUNTY: Carson

LOCATION:

OTHER SERVICES:
Deviation

PERMANENT DATUM: G.L. ELEVATION:
LOG MEAS. FROM: G.L. 0.0 FEET ABOVE PERM. DATUM
DRILL MEAS. FROM: G.L.

DATE ACQUIRED	09/06/00	09/06/00		
RUN NUMBER	1	1		
LOG TYPE	Gamma	16,64,SPR,SP		
DEPTH-DRILLER	530 Ft.			
DEPTH-LOGGER	525 Ft.	525 Ft.		
BTM LOGGED INTERVAL	525 Ft.	525 Ft.		
TOP LOGGED INTERVAL	4 Ft.	280 Ft.		
RECORDED BY	MLWhitney			
WITNESSED BY	Raplh Rupp			
FLUID LEVEL				
FLUID TYPE	Mud			
Rm at TEMP	N/A			
TIME SINCE CIRC.	2 Hours			
PROBE TYPE, S/N	RAB 2021	EPF 1567		
MODULE TYPE, S/N	UM 1484	UM 1484		
LOGGING SPEED	20			
A.S.D.E.	N/A			
SAMPLE INTERVAL	0.3'			
SOURCE SIZE, S				

BOREHOLE RECORD			CASING RECORD		
BIT SIZE	FROM	TO	SIZE/WGT	FROM	TO
9.5"	Surface	280 Ft.	8" Steel	Surface	280 Ft.
7 7/8"	280 Ft.	TD			

COMMENTS:

COMMENTS:

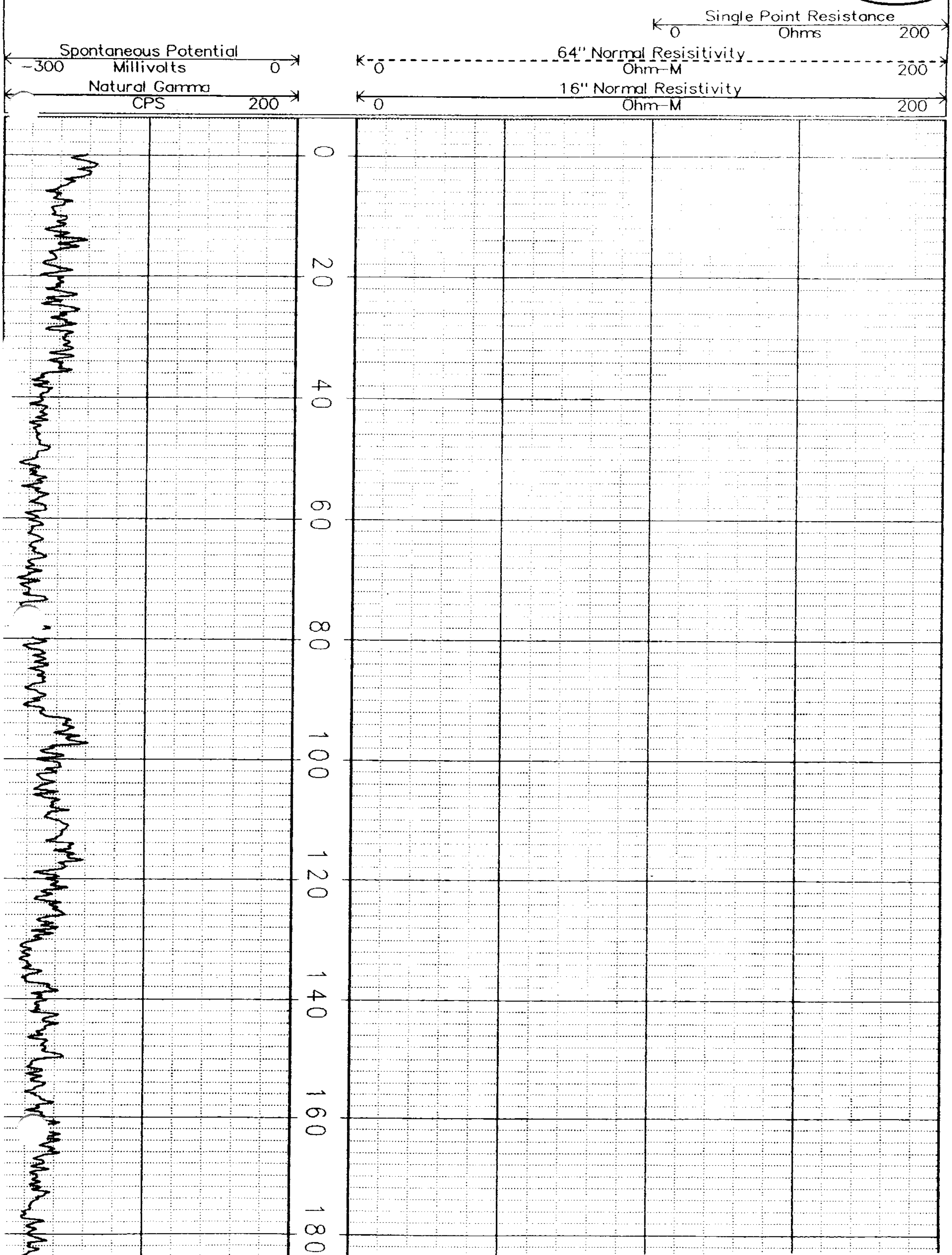
DIGITAL FILES: 1060.FIN; 1060.RPT; 1060.HDP

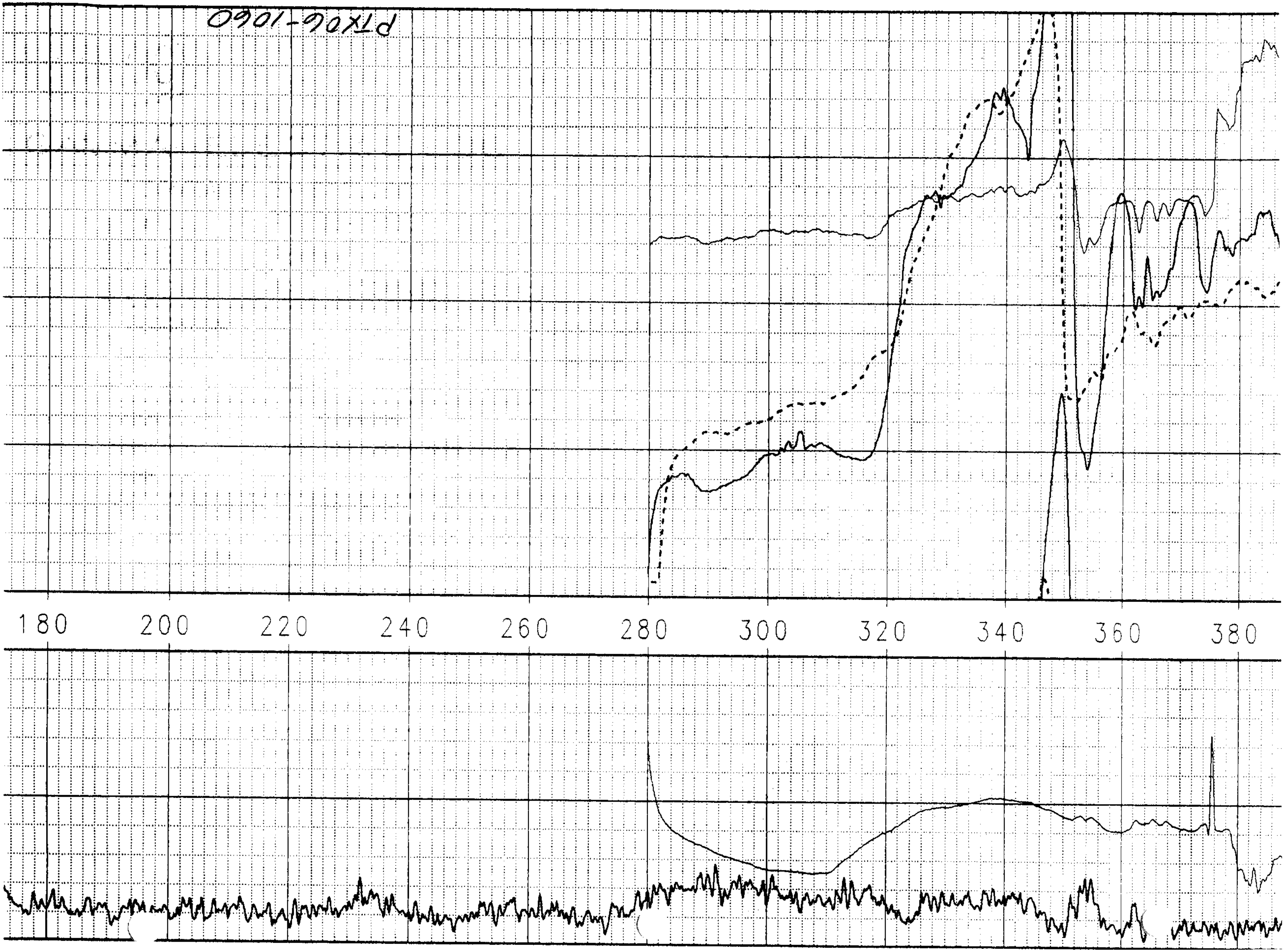
Well PTX06-1060, Pantex Plant, 09/06/2000

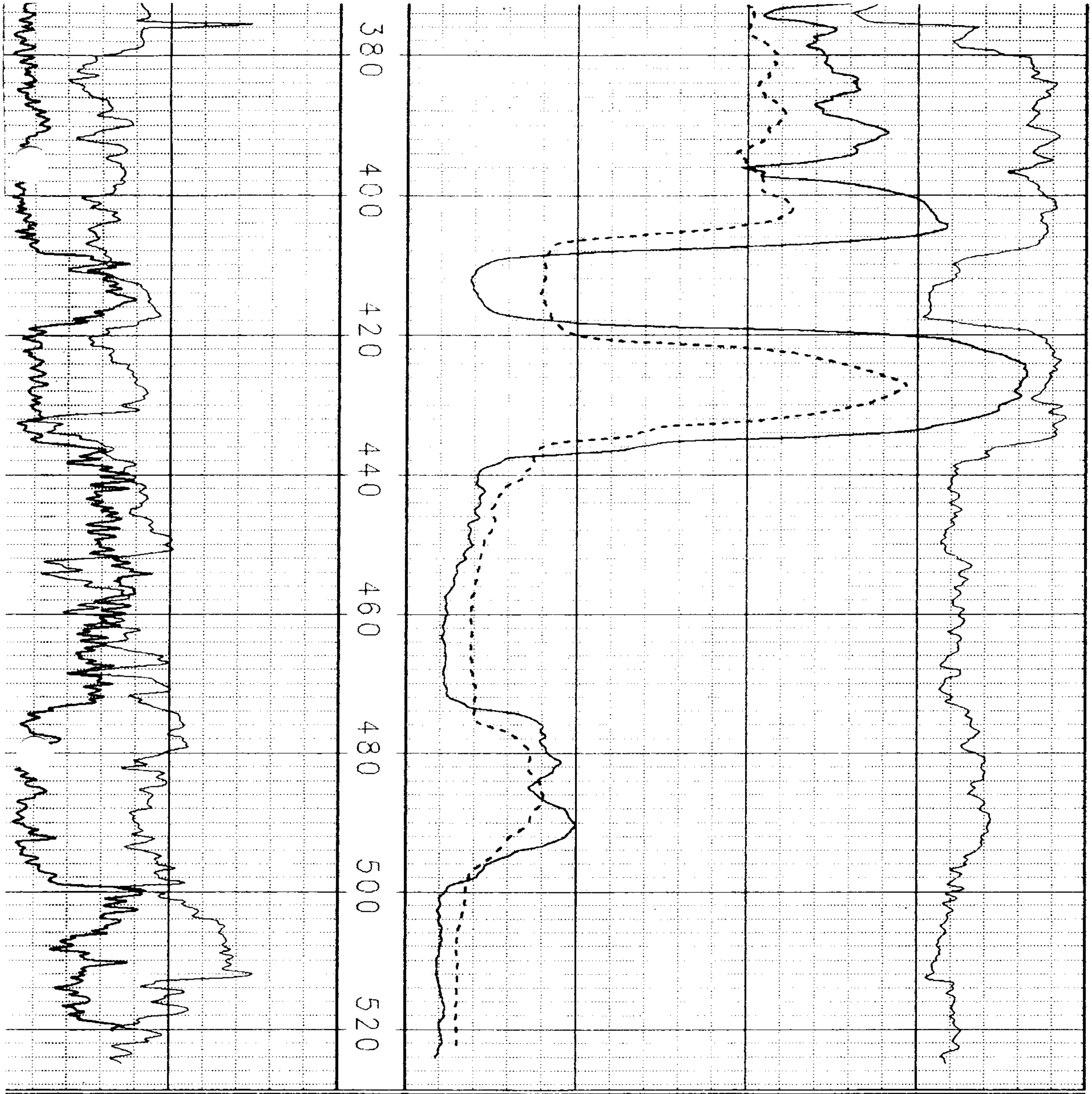
COLOG

Single Point Resistance
0 Ohms 200

Well PTX06-1060, Pantex Plant, 09/06/2000




PTX06-1060
180
200
220
240
260
280
300
320
340
360
380



Natural Gamma
0 CPS 200

Spontaneous Potential
−300 Millivolts 0

16" Normal Resistivity
0 Ohm–M 200

64" Normal Resisitivity
0 Ohm–M 200

Single Point Resistance
0 Ohms 200

Well PTX06–1060, Pantex Plant, 09/06/2000

COLOG

Well PTX06–1060, (Repeat Section) Pantex Plant, 09/06/2000

COLOG

Single Point Resistance
0 Ohms 200

Spontaneous Potential
−150 Millivolts 0

64" Normal Resisitivity
0 Ohm–M 200

Natural Gamma
0 CPS 200

16" Normal Resistivity
0 Ohm–M 200

PTX06-1061

Contractor: S.M. Stoller Corporation

Contract #: 3615

OPTIX #:

Included Documents

___Drilling Log
  ___Draft
  ___Final

___Installation Log

_X_Lithologic Logs
  _X_Draft
  _X_Final

___Geophysical Logs
  ___Neutron
  ___Gamma
  ___e-log
  ___Bond Log
  ___Deviation log

___State Well Report

PTX06-1061

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gas	
[illegible]G NUMBER: PTX06- 1061	COORDINATES:	DATE: 9/9/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9/9/00
ENGINEER/GEOLOGIST: S. Brinkman	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Air Rotary Tricone		PAGE: 1 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS Pid in PPM
0	Grab		1'	Top soil - Dark brown porous, dry, hard, rootlets - Silt, 30% clay, 5YR 3/3 dark reddish brown, dry, hard.	ML		0.0
	"		5'	- Caliche, soft, white, silt 5YR 8/1 white, dry, dusty.	ML		
10	"		10	- Silt w/clay to 30%, 5YR 4/4 reddish brown, low plast. compact, damp	ML		0.0
	"		17	Silt w/caliche to 20% & clay 20%. low plast, compact, damp 5YR 7/4 pink	ML		0.0
20	"		25'	- Silt w/caliche stringers to 10% & clay 10%. 5YR 4/6 yellow Red, dry to slightly damp, hard	ML		0.0
30	"		30'	- Same	ML		0.0
			35'	- Silt, w/caliche 5% and clay 20%. 5YR 4/6 yellow Red, Slightly damp, hard,	ML		0.0
40			40'	- As above - easy drilling -	ML		0.0
			45'	Sand, very fine grained w/ 30% silt & 10% clay 5YR 5/6 yellowish Red, dry, hard, subrounded Graded, w/ 2% caliche	SM		0.0
50			50'	Silt, 10% fine Sand, 20% clay, 5YR 4/4 reddish brown, dry, hard, subrounded poorly Graded	ML		0.0
			55'	Silt - As above w/ caliche to 20%.	ML		0.0
60							

NO[illegible]

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gas	
[illegible] G NUMBER: PTX06-1061	COORDINATES:	DATE: 9/8/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9/8/00
ENGINEER/GEOLOGIST: S. Brinkman	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Air Rotary w/ 11" Tricone		PAGE: 2 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
60			60	- Silt w/ caliche to 30% 7.5YR 7/4 Pink. dry, compact - 10% fine sand, subround.	ML		0.0
			65	- Caliche w/ beds of silt. 60% caliche 40% silt - caliche hard, crystalline, white silt, reddish yellow 5YR 5/6	ML		0.0
70			70	Silt & caliche - interbedded caliche white 5YR 8/1 Hard, crystalline & silt w caliche stringers yellowish red 5YR 5/4, soft, damp.	ML		0.0
			75	- Silt is the same, caliche less to 10%			
80			80	- Sand, fine to very fine w/ silt to 20% Pink 5YR 7/4, subrounded, dry, Poorly Graded caliche 10%	SM		0.0
			85	- Same as above ~~[illegible]~~ 85-90' caliche, ~~100%~~ f-v.e grained sand, pale red (10YR 7/3), dry, sand is loose, caliche unconsolidated frags	SM		0.0
90				90-100' sand, pink (7.5YR 8/4) well-sorted, dry, loose, ≈5% caliche frags @ 90-95'.	SP		0.0
100	VOC + SIEVE SAMPLE @100-102' PTX06-1061-100 @ 17:08			100-102' split spoon sample; sand, pink (5YR 7/4), dry, loose, well-sorted, subang-subrnd, uniform throughout.	SP		0.0
110				102-140' sand, pink (5YR 7/4), fine-v. finegrained, well sorted, dry to damp, uniform throughout, calcareous, color varies somewhat subangular to subrounded grains.	SP		0.0
							0.0
120							0.0

NOT

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BURNING GROUNDS SOIL GAS	
BORING NUMBER: PTX06-1061	COORDINATES:	DATE: 9/11/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9/9/00
ENGINEER/GEOLOGIST: J. SUKUP	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: AIR ROTARY		PAGE: 3 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
120				120-140' sand as above.			
							0.0
130							0.0
							0.0
140				140-150' sand, brownish yellow (10YR 6/6), well sorted, f-vf grained, subangular to subrounded grains, dry to damp, calcareous, loose.	SP		0.0
							0.0
150	PTX06-VOC + SIEVE SAMPLE PTX06-1061-[illegible] 150 @ 10:26	150	100%	150-152' (Sieve sample) sand, v. pale brown (10YR 7/4), f-vf grained, well sorted, subangular-subrounded grains, dry to damp, calcareous, loose.	SP		0.0
							0.0
160				152-200' sand, very pale brown (10YR 7/4) f-vf grained, well sorted, subangular to subrounded grains, dry, calcareous, loose, color varies slightly throughout.	SP		0.0
							0.0
170							0.0
							0.0
180							0.0

NOT

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BURNING GROUNDS SOIL GAS	
NG NUMBER: PTX06-1061	COORDINATES:	DATE: 9/11/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9/9/00
ENGINEER/GEOLOGIST: J. SUKUP	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: AIR ROTARY		PAGE: 4 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS VOCS IN PPM
180				Same as above to 200'.			0.0
							0.0
190							0.0
	VOC AND SIEVE SAMPLE						0.0
200	PTX06-1061-200 @16:23		75%	200-202' sieve+VOC sample: Sand, V. pale brown (10YR7/4), fine-v. fine grained, well sorted, subangular to subrnd grains, ~~scatt~~ caliche galls present, dry, loose.	SP		0.0
							0.0
210							0.0
				202-223' sand, v pale brown (10YR8/3-10YR8/4) f-v f grained, well sorted, subangular to subrounded grains, scattered caliche frags, dry, loose, color varies slightly.			0.0
220	223						0.0
							0.0
230				230' SAND (SC, SP) Sli. clayey sand Brownish yellow (10YR6/6) fine to med grain (damp) sand w/ 20% Clay, some well ~~235' same as above~~ (TR) cemented sst w/	SC/SP		first moisture @ ≈ 230' 2045-091100
235							
240				240' (SW, GW) light gray (10YR7/2)	SW/GW		

N

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: B615	PROJECT NAME: BGSG	
G NUMBER: PTX06-1061	COORDINATES:	DATE: 09-12-00/ 9/19/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 090900
ENGINEER/GEOLOGIST: T. Hall	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Air Rotary		PAGE: 5 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
				well graded sand, sub-rounded w/ smooth surface gravel to 2" diam — frags too. dry	SW/2		
248 / 250	split spoon			248' (CL) yellowish brown (10YR 5/4) still sli. sandy. Only very sli. plastic. sli. damp. dense	FGZ		248' split spoon for HE & VOC 2355 091100
	Drill pipe stuck 9/9/00 STANDBY		TOP	FGZ CALLED ON 9/12/00 by T. HALL @ 248' BGS. Conductor casing installed and cemented on 9/14/00 to 248'. Mud rotary drilling will be used to total depth from 248'.			
260				248-268 Sand, dense yellowish brown (10YR 4/4) fine to very fine grain, trace medium grain subrounded, poorly graded, some trace of cement, sand slightly silty silty.	SP		
268	on @ 1820						268' @ 2036
270				268-280 Clay, sandy pink (~~7.5YR 7/4~~ R&M) very fine sand 20% subrounded, (7.5YR 7/4) low % of cuttings recovered with pretty good mud indicating predominantly clay/silty clay. Bottom of FGZ approximately 280' BGS.	CL		
280				280-30? Sand, light yellowish brown (10YR 6/4) fine grained with 20% very fine subangular, quartz sand. Drilling becomes rapid	SP		
290							289 @ 2147
293	on @ 2112						
300				300' — Silt, sandy @ 300' medium and coarse subangular quartz sand with a lot of clay? or just bentonite probably silt.	ML		300 @ 2312

NOTES: Drilling advance started about 1730 on 9/19/00 w/ mud rotary.
@ 2100 drillers are working up the mud - circulation is mostly water

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
ING NUMBER: PTX06-1061	COORDINATES:	DATE: 9/19/00 - 9/20/00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9/9/00
ENGINEER/GEOLOGIST: R. Riggs	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: mud Rotary		PAGE: 6 OF 15

DEPTH ( ) 300'	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
310				@ 310' pink (7.5YR 7/4) drilling mud with medium to coarse sand, quartz. subangular.	ML		314' @ 2319
318'	on @ 2805						
320							
330				@ 330' Silt, clayey, sandy pink (7.5YR 7/3) fine to medium grain subrounded quartz sand smooth easy drilling with rapid penetration	ML		331' @ 2336
340							339' @ 2350
343	on @ 2325						
350				@ 355 continued silt as above with increasing white caliche and fine grain sand.			
360							

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
NG NUMBER: PTX06-1061	COORDINATES:	DATE: 9-20-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9-9-00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: mud rotary		PAGE: 7 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
360							
							364'@0015
368	on@2400 9/19/00				↑		
370					ML		
380				@385 continued Silt as above sand % increasing slightly, clear quartz, some yellow fine to medium grain, subrounded to subangular penetration rate steady and rapid.	↓		389'@0033
390							
393	on@0020						
400				405–425'			
				@405 increasing sand fine to medium grain as above with decreasing silt and loss of caliche 60% sand 40% silt as close as I can call pink (7.5YR 7/4)	SM/SP		
410							414@0050
418	on@0038						
420							

NC

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
G NUMBER: PTK06-1061	COORDINATES:	DATE: 9-20-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9-9-00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: mud rotary		PAGE: 8 OF 15

DEPTH ( ) 420	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
425				425 — Sand, pink (7.5YR 7/4) color influenced by drilling fluid. fine and very fine grain (50/50) subrounded, poorly sorted, some silt. mud is really loading up - no loss of water.	SM/SP		
430					~~SM~~ SP		
440							439' @ 0112
44	@ 0056						
450				455 Sand, light brown (7.5YR 6/4) fine and very fine with trace medium subrounded, poorly sorted mud too thick to determine silt or clay no significant change in drilling rate some caliche mud still loading up - drillers working to thin it out.	SP		
460							464 @ 0134
468	on @ 0115						
470				470' Sand as above with increasing grain size 10% medium 70% fine 20% very fine.	SP		
480							

NOT

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
BORING NUMBER: PTX06-1061	COORDINATES:	DATE: 9-20-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9-20-00
ENGINEER/GEOLOGIST: R-Rapp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: mud Rotary		PAGE: 9 OF 15

DEPTH ( ) 480	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
					SP		489'@ 0200
490							
493	on @ 0140 Stopped drilling @ 0146						
				@500' Sand as above possible silt increase			
500							
510							514'@ 0228
518	on @ 0218						
520							
530				530' Sand light brown (7.5YR 6/3) 70% very fine 30% fine grain subrounded, subangular possibly silty	SP		
							539'@ 0246
540							

N

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
NG NUMBER: PTX06-1061	COORDINATES:	DATE: 9-20-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9-9-00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: mud Rotary		PAGE: 10 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
540							
543	MR @ 0234						
550							
560				@ 560'-570' Sand clayey light brown (7.5YR 6/4) fine to coarse sand subangular to angular clay about 30%	CL/SC		564' @ 0258
568	MR @ 0250			@ 564' penetration rate slows down for about 5'.			
570				570'-598' Sand/Gravel multi colored fragments fine to very coarse subangular to angular largely quartz w/ 20+% mafics	SW/GW		
580							
							589 @ 0330
590							
593	MR @ 0308						
600				598'-625' Sand, silty clayey fine to medium grain 60% very fine grain 40% light brown (7.5YR 6/4) subangular, silt and clay about 20%	SM		

N

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
[illegible]NG NUMBER: PTX06-1061	COORDINATES:	DATE: 9-20-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9-9-00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: mud Rotary		PAGE: 11 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
600					SM		
610							614' @ 0417
618	on @ 0402						
620				625' Silt, clayey to clay with very fine sand. light brown color of the mud drilling fluid.	ML/CL		
630							
				@ 639' advance the hole was washed clean and Poly-Bore added to drilling fluid to free up the drill string			639' @ 0438 go to get more Drill pipe and water.
640							
643	on @ 0422						0720 – 639' stuck in hole
				639' – 664' return is heavy polymer mix with ~~[illegible]~~ fine sand and silt or clay.			@2103 9/20/00 Rods are free again
650				color is light yellowish brown (10YR 6/4) appears to be a clayey silt interval	ML		
660							

N[illegible]

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: BGSG	
[illegible]G NUMBER: PTX01-1061	COORDINATES:	DATE: 0920
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 090900
ENGINEER/GEOLOGIST: ~~T Hall~~ R. Rapp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: Mud Rotary		PAGE: 12 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
660							
							664' @ 2132 stop & circulate
668	on @	2121		~~Run~~ from 664-689' continues to be clayey sandy silt very fine sand, quartz, rounded clay content estimate low; still significant polymer, no color change; light yellowish brown. drills quick and smooth.	ML		
670							
680							
							689' @ 2217
690							
693	on @	2207		689'-714' continues silt, sandy clayey as above sand size increasing slightly - 90% fine grain	ML		
700							
710							714' @ 2234
714	on @	2224					
720							

NOT[illegible] @ 2230 weather is clear, calm, and getting cold.
20' Drill pipe after 718'.

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil Gas	
BORING NUMBER: PTX06-1061	COORDINATES:	DATE: 09-20-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9-9-00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: mud rotary		PAGE: 13 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
720				714-724 as above silt sandy light yellowish brown fine grain quartz sand some medium grain subangular	ML		
730				724-734 increasing clay slower penetration rate no significant color change - a little darker brown. yellowish brown (10YR 5/6)	CL		734' @ 2301
738	on @	2241					
740				C 745 increasing very fine sand in clay. yellowish brown (10YR 5/6)			
750					CL		754' @ 2349 circulate and work mud
758	on @	2307		760' continued clay or mudstone slow drilling - occasional sand			
760				@ 767 Drilling break penetration rate increases sharply cuttings remain a clay/mudstone yellowish brown (10YR 5/6) with some fine sand - quartz	CL		
770							774' @ 0113
778	on @	0018					
780							

N

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Ground Soil Gas	
BORING NUMBER: PTX06-1061	COORDINATES:	DATE: 9-21-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9-9-00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: mud rotary		PAGE: 14 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
780				780-794 Sand, silty light gray (10YR 7/2) and reddish yellow (5YR 6/6) very fine grain, mix with light yellowish brown (10YR 6/4) mudstone characteristic of lower Dockum Formation	ML		
790							794' @ 0148 wore the mud
798 / 800	on @	0129		@ 800' Sandstone brown (7.5YR 5/4) fine grain subangular quartz	SP		
810				@ 810' more varigated fine grain very fine grain light gray and reddish yellow silty sand	ML		814' @ 0313
818 / 820	on @	0241					
830				@ 830' continued silt sandy as above	ML		834' @ 0345
838 / 840	on @	0323		@ 837' penetration slows to a crawl Lower Dockum Fm. pebbly clay Varigated pebbles in reddish yellow brown clay. To about 841'	CL		

N

pebbles are ~~they~~ very angular to Subrounded

continued clear and cold, light breeze from South

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 3615	PROJECT NAME: Burning Grounds Soil GAS	
BORING NUMBER: PTX06-1061	COORDINATES:	DATE: 9-21-00
ELEVATION:	GWL: Depth Date/Time	DATE STARTED: 9-9-00
ENGINEER/GEOLOGIST: R. Rupp	Depth Date/Time	DATE COMPLETED:
DRILLING METHODS: mud rotary		PAGE: 15 OF 15

DEPTH ( )	SAMPLE TYPE & NO.	BLOWS ON SAMPLER/( )	RECOVERY ( )	DESCRIPTION	USCS SYMBOL	LITHOLOGY	REMARKS
840				@ 841' penetration rate increase			
850				@ 850' coarse to very coarse grain angular, multi colored sandstone grains and distributed very coarse to fine grain 70% quartz trace clayey silt	SW		854' @ 0440
858	on @	0404					
860		"		@ 855 Becoming clayey with sand from above clay is red (2.5YR 5/6) with pale yellow (2.5Y 7/4) reduction mottling.	SC		868' @ 0625
870				@ 858 penetration rate slows significantly			876' @ 0646
				860' Permian Redbed contact			
878	on @	0500		876' TOTAL DEPTH DRILLED	CL		
880				Permian redbeds are claystone clay w/ very fine sand (<10%) red (2.5YR 4/6) to dark red (2.5YR 3/6) with light gray to white reduction mottling hard to very hard, dry			

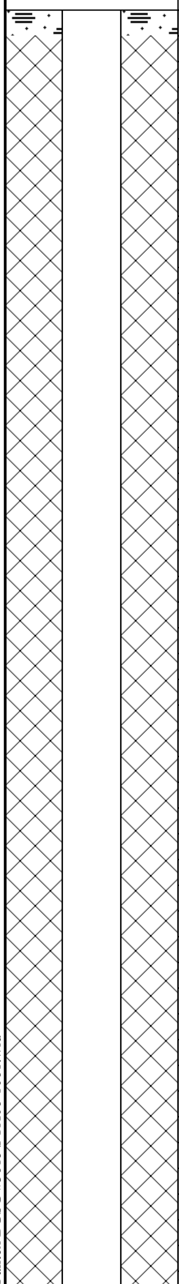
NO

PTX06-1061

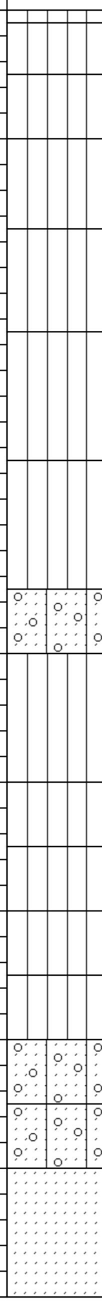
Pantex Burning Grounds Soil Gas **Pantex Plant (Northwest of Burning Grounds)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sukup/Hall/Rupp	Northing: 3773186.59	Easting: 625651.61
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	876' BGS
Dates Drilled:	09/09/00 - 09/21/00	Depth to Water:	480' BGS 10/09/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3588.63'	TOC Elevation:	3591.40'

Completion



Lithology



Depth (Ft.)	USCS	Description	Sample	Sample Number
	ML	0-1' TOPSOIL, dark brown, porous, hard, dry, rootlets		
	ML	1-5' SILT, with 30% clay, dark reddish brown (5YR 3/3), hard, dry		
	ML	5-10' SILT, caliche, white (5YR 8/1), soft, dry, dusty		
10	ML	10-17' SILT, with 30% clay, reddish brown (5YR 4/4), low plasticity, compact, damp		
20	ML	17-25' SILT, with caliche to 20% and clay 20%, pink (5YR 7/4), low plasticity, compact, damp		
30	ML	25-35' SILT, with caliche stringers to 20% and clay 10%, yellowish red (5YR 4/6), hard, dry to slightly damp		
40	ML	35-45' SILT, with caliche 5% and clay 10%, yellowish red (5YR 4/6), hard, slightly damp		
	SM	45-50' SAND, with 30% silt, 10% clay, and 2% caliche, yellowish red (5YR 5/6), very fine grain, subrounded, graded, dense, dry		
50	ML	50-60' SILT, 10% sand, 20% clay, reddish brown (5YR 4/4), fine grain, subrounded, poorly graded sand, hard, dry @ 55-60' with calich to 20%		
60	ML	60-65' SILT, with caliche to 30% and 10% sand, pink (5YR 7/4), fine grain, subrounded sand, compact, dry		
	ML	65-70' CALICHE, with beds of silt, 60% caliche, 40% silt; caliche - hard, crystallized, white; silt - yellowish red (5YR 5/6)		
70	ML	70-75' SILT/CALICHE- interbedded; caliche, white (5YR 8/1), hard, crystalline; silt with caliche stringers reddish brown (5YR 5/4), soft, damp		
	ML	75-80' SILT, same as above; caliche less to 10%		
80	SM	80-85' SAND, with silt to 20% and caliche 10%, pink (5YR 7/4), fine to very fine grain, subrounded, poorly graded, dry		
	SM	85-90' SAND, with caliche, pale red (10YR 7/3), 100% fine to very fine grained, loose, dry, caliche in consolidated fragments		
90	SP	90-100' SAND, pink (7.5YR 8/4), well sorted, loose, dry @ 90-95' 25% caliche fragments		

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S.M. STOLLER CORPORATION

PTX06-1061

Pantex Burning Grounds Soil Gas **Pantex Plant (Northwest of Burning Grounds)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sukup/Hall/Rupp	Northing: 3773186.59	Easting: 625651.61
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	876' BGS
Dates Drilled:	09/09/00 - 09/21/00	Depth to Water:	480' BGS 10/09/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3588.63'	TOC Elevation:	3591.40'

Depth (Ft.)	USCS	Description	Sample Number
100-102	SP	100-102' SAND, pink (5YR 7/4), subangular to subrounded, well sorted, loose, dry, uniform throughout, split-spoon sample	PTX06-1061-2-0100 VOC/Gradation
102-140	SP	102-140' SAND, pink (5YR 7/4), fine to very fine grained, subangular to subrounded, well sorted, dry to damp, calcareous, color varies somewhat	
140-150	SP	140-150' SAND, brownish yellow (10YR 6/6), fine to very fine grained, subangular to subrounded, well sorted, loose, dry to damp, calcareous	
150-152	SP	150-152' SAND, very pale brown (10YR 7/4), fine to very fine grained, subangular to subrounded, well sorted, loose, dry to damp, calcareous; split-spoon sample	PTX06-1061-2-0150 VOC/Gradation
152-200	SP	152-200' SAND, very pale brown (10YR 7/4), fine to very fine grained, subangular to subrounded, well sorted, loose, dry, calcareous, color varies slightly throughout	

Depth scale: 110, 120, 130, 140, 150, 160, 170, 180, 190

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S.M. STOLLER CORPORATION

PTX06-1061

Pantex Burning Grounds Soil Gas **Pantex Plant (Northwest of Burning Grounds)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sukup/Hall/Rupp	Northing: 3773186.59	Easting: 625651.61
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	876' BGS
Dates Drilled:	09/09/00 - 09/21/00	Depth to Water:	480' BGS 10/09/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3588.63'	TOC Elevation:	3591.40'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP	200-202' SAND, very pale brown (10YR 7/4), fine to very fine grained, subangular to subrounded, well sorted, loose, dry, scattered caliche fragments; split-spoon sample		PTX06-1061-2-0200 VOC/Gradation
	210		SP	202-230' SAND, very pale brown (10YR 8/3-8/4), fine to very fine grained, subangular to subrounded,well sorted, loose, dry, scattered caliche fragments, color varies slightly		
	220					
	230		SC	230-240' SAND, with 20% clay, brownish yellow (10YR 6/6), fine to medium grain, damp, some well cemented sandstone		
	240		SW	240-248' SAND, with gravel, light gray (10YR 7/2), subrounded, well graded, smooth surface gravel to 2" in diameter (fragments too), dry		
	250		CL	248-264' CLAY, slightly sandy, yellowish brown (10YR 5/4), only very slightly plastic, dense, slightly damp Top FGZ at 248', conductor casing installed and cemented on 09/14/00 to 248' BGS		PTX06-1061-2-0248 VOC/HE
	260					
			SP	264-270' SAND, slightly silty, dark yellowish brown (10YR 4/4), fine to very fine grain, trace medium grain, subrounded, poorly graded, trace of cement		
	270		CL	270-280' CLAY, sandy, 20% sand, pink (7.5YR 7/4), very fine subrounded sand, low % of cuttings recovered indicating predominantly clay/silty clay		
	280		SP	280-300' SAND, light yellowish brown (10YR 6/4), fine grain with 20% very fine, subangular quartz sand		
	290					

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PTX06-1061

Pantex Burning Grounds Soil Gas **Pantex Plant (Northwest of Burning Grounds)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sukup/Hall/Rupp	Northing: 3773186.59	Easting: 625651.61
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	876' BGS
Dates Drilled:	09/09/00 - 09/21/00	Depth to Water:	480' BGS 10/09/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3588.63'	TOC Elevation:	3591.40'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML	300-310' SILT, sandy, medium and coarse subangular quartz sand		
	310		ML	310-330' SILT, sandy, pink (7.5YR 7/4), medium to coarse subangular quartz sand		
	320					
	330		ML	330-355' SILT, clayey, sandy, pink (7.5YR 7/3), fine to medium grain subrounded quartz sand, smooth easy drilling with rapid penetration		
	340					
	350					
			ML	355-385' SILT, as above with increasing white caliche and fine grain sand		
	360					
	370					
	380					
			ML	385-405' SILT, continued as above, sand % increasing slightly, clear quartz some yellows, fine to medium grain, subrounded to subangular, penetration rate steady and rapid		
	390					

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PTX06-1061

Pantex Burning Grounds Soil Gas **Pantex Plant (Northwest of Burning Grounds)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sukup/Hall/Rupp	Northing: 3773186.59	Easting: 625651.61
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	876' BGS
Dates Drilled:	09/09/00 - 09/21/00	Depth to Water:	480' BGS 10/09/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3588.63'	TOC Elevation:	3591.40'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML			
	410, 420		SM	405-425' SAND, silty, 60% sand, 40% silt, pink (7.5YR 7/4), fine to medium grain, increasing sand decreasing silt and loss of caliche		
	430, 440, 450		SP	425-455' SAND, some silt, pink (7.5YR 7/4), color influenced by drilling fluid, fine and very fine grain sand (50/50), subrounded, poorly graded, mud is really loading up with cuttings, no loss of water		
	460		SP	455-470' SAND, some caliche, light brown (7.5YR 6/4), fine and very fine with trace medium grain, subrounded, poorly graded, mud too thick to determine silt or clay, no significant change in drilling rate, mud still loading up - drillers working to thin it out		
	470, 480, 490		SP	470-500' SAND, as above with increasing grain size - 70% fine, 20% very fine, 10% medium Water Level at 480' BGS on 10/09/00		

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PTX06-1061

Pantex Burning Grounds Soil Gas **Pantex Plant (Northwest of Burning Grounds)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sukup/Hall/Rupp	Northing: 3773186.59	Easting: 625651.61
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	876' BGS
Dates Drilled:	09/09/00 - 09/21/00	Depth to Water:	480' BGS 10/09/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3588.63'	TOC Elevation:	3591.40'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	500-530		SP	500-530' SAND, as above, possible silt increase		
	530-560		SP	530-560' SAND, light brown (7.5YR 6/3), 70% very fine, 30% fine grain, subrounded to subangular, possibly silty		
	560-570		SP	560-570' SAND, clayey, clay about 30%, light brown (7.5YR 6/4), fine to coarse sand, subangular to angular, @ 564' penetration rate slows down for about 5'		
	570-598		SW	570-598' SAND, gravelly, multi-colored fragments, fine to very coarse, subangular to angular, largely quartz with 20+% mafics		
	598-		SM			

Depth scale: 510, 520, 530, 540, 550, 560, 570, 580, 590

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PTX06-1061

Pantex Burning Grounds Soil Gas **Pantex Plant (Northwest of Burning Grounds)** **Amarillo, Texas**

Project Number:	3615	Client:	Mason & Hanger Corporation
Geologist:	Brinkman/Sukup/Hall/Rupp	Northing: 3773186.59	Easting: 625651.61
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	876' BGS
Dates Drilled:	09/09/00 - 09/21/00	Depth to Water:	480' BGS 10/09/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3588.63'	TOC Elevation:	3591.40'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	610, 620		SM	598-625' SAND, silty, clayey, silt and clay about 20%, light brown (7.5YR 6/4), 60% fine to medium grain, 40% very fine grain, subangular		
	630		ML	625-639' SILT, clayey to CLAY, with very fine sand, light brown (color of the drilling fluid)		
	640, 650, 660		ML	639-664' SILT, clayey, sandy, light yellowish brown (10YR 6/4) @ 639' the drill pipe became stuck in the borehole. The hole was washed clean and Poly-Bore was added to the drilling fluid to free the drill pipe. After regaining rotation the drilling fluid has a high polymer content with fine sand and silt/clay.		
	670, 680		ML	664-689' SILT, sandy, clayey, light yellowish brown (10YR 6/4), very fine rounded quartz sand, estimated clay content - low, still significant polymer, drills quick and smooth		
	690		ML	689-714' SILT, sandy, clayey, as above, sand size increasing slightly - 90% fine grain		

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PTX06-1061

Pantex Burning Grounds Soil Gas **Pantex Plant (Northwest of Burning Grounds)** **Amarillo, Texas**

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Geologist:	Brinkman/Sukup/Hall/Rupp	Northing: 3773186.59	Easting: 625651.61
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Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3588.63'	TOC Elevation:	3591.40'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	710		ML			
	720		ML	714-724' SILT, sandy, light yellowish brown, fine grain quartz sand, some medium grain, subangular		
	730		CL	724-734' CLAY, slight color change to yellowish brown (10YR 5/6), increasing clay, slower penetration rate		
	740		CL	734-745' CLAY, yellowish brown (10YR 5/6), increasing very fine sand		
	750		CL	745-760' CLAY or mudstone, continued as above, occassional sand , slow drilling		
	760, 770		CL	760-780' CLAY/mudstone, yellowish brown (10YR 5/6), some fine quartz sand @ 767' drilling break, penetration rate increases sharply		
	780, 790		ML	780-794' SILT, sandy, light gray (10YR 7/2) and reddish yellow (5YR 6/6) very fine grain sand mixed with light yellowish brown (10YR 6/4) mudstone		
			SP	794-800' SANDSTONE, brown (7.5YR 5/4), fine grain subangular quartz		

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PTX06-1061

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Geologist:	Brinkman/Sukup/Hall/Rupp	Northing: 3773186.59	Easting: 625651.61
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	876' BGS
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Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3588.63'	TOC Elevation:	3591.40'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	800–810		ML	800-810' SILT, sandy, fine grain and very fine grain, variegated light gray and reddish yellow		
	810, 820, 830		ML	810-837' SILT, continued as above		
	840		CL	837-841' CLAY, pebbly, variegated pebbles in reddish yellow-brown clay, pebbles are very angular to subrounded, penetration rate slows		
	850		SW	841-855' SANDSTONE, trace clayey silt, multi-colored, grain size distribution very coarse to fine grain, coarse to very coarse grain material is angular, 70% quartz		
	860		SC	855-860' SAND, becoming clayey, with sand from above, clay is red (2.5YR 5/6) with pale yellow (2.5YR 9/4) reduction mottling @ 858' penetration rate slows significantly		
	870		CL	860-876' CLAYSTONE, with very fine sand (<10%), red (2.5YR 4/6) to dark red (2.5YR 3/6) with light gray to white reduction mottling, hard to very hard, dry		
	880, 890			Total Depth of Borehole 876' BGS Fine Grain Zone 248' BGS Redbeds at 860' BGS Well Completion Details: Borehole Diameter: 12" surface to 248' 7 7/8" 248-876' 8 5/8" steel conductor casing set with cement 0-248'		

PTX06-1061

Pantex Burning Grounds Soil Gas **Pantex Plant (Northwest of Burning Grounds)** **Amarillo, Texas**

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Dates Drilled:	09/09/00 - 09/21/00	Depth to Water:	480' BGS 10/09/00
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3588.63'	TOC Elevation:	3591.40'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	910 920 930 940 950 960 970 980 990			Total Depth of Well 865' BGS 4-inch, Type 316 stainless steel casing and 10-slot screen 5' sump (860-865'), 85' screen (775-860'), 40' casing (735-775'), 270' screen (465-735'), 467' casing (+2-465') Filter pack (454-745', 765-876') Bentonite seal (444-454', 745-765') Bentonite grout (2 - 444') Cement seal (0-2') Concrete pad (5'x5'x8") with 4 bollards Protective casing, 10-inch steel with locking cover		

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COLOG Division of Layne Christensen, Co.
17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

GAMMA–ELECTRIC LOG

COM: SM STOLLER
WELL: PTX06-1061
FLD: PANTEX
ST: TX COUNTY: CARSON

COMPANY: SM STOLLER
WELL: PTX06-1061
FIELD: PANTEX
STATE: TX COUNTY: CARSON

LOCATION:

OTHER SERVICES:
DEVIATION

PERMANENT DATUM: G.L. ELEVATION:
LOG MEAS. FROM: G.L. 0.0 FEET ABOVE PERM. DATUM
DRILL MEAS. FROM: G.L.

DATE ACQUIRED	09/21/00	09/212/00		
RUN NUMBER	1	1		
LOG TYPE	GAMMA	16,64,SPR,SP		
DEPTH–DRILLER	876 Ft.			
DEPTH–LOGGER	855 Ft.			
BTM LOGGED INTERVAL	854 Ft.	856 Ft.		
TOP LOGGED INTERVAL	0 Ft.	353 Ft.		
RECORDED BY	MLWhitney			
WITNESSED BY	Ralph Rupp			
FLUID LEVEL				
FLUID TYPE	MUD			
Rm at TEMP	N/A			
TIME SINCE CIRC.	2 Hours			
PROBE TYPE, S/N	2PGA 2278	2PEA 2279		
MODULE TYPE, S/N	MGXII 1077	MGXII 1077		
LOGGING SPEED	18			
A.S.D.E.				
SAMPLE INTERVAL	0.1'			
SOURCE SIZE, S/N				

BOREHOLE RECORD			CASING RECORD		
BIT SIZE	FROM	TO	SIZE/WGT	FROM	TO
9.5"	Surface	280 Ft.	8" Steel	Surface	280 Ft.
7 7/8"	280 Ft.	TD			

COMMENTS:

COMMENTS:

DIGITAL FILES: 1061.fin; 1061.rpt; 1061.hdp

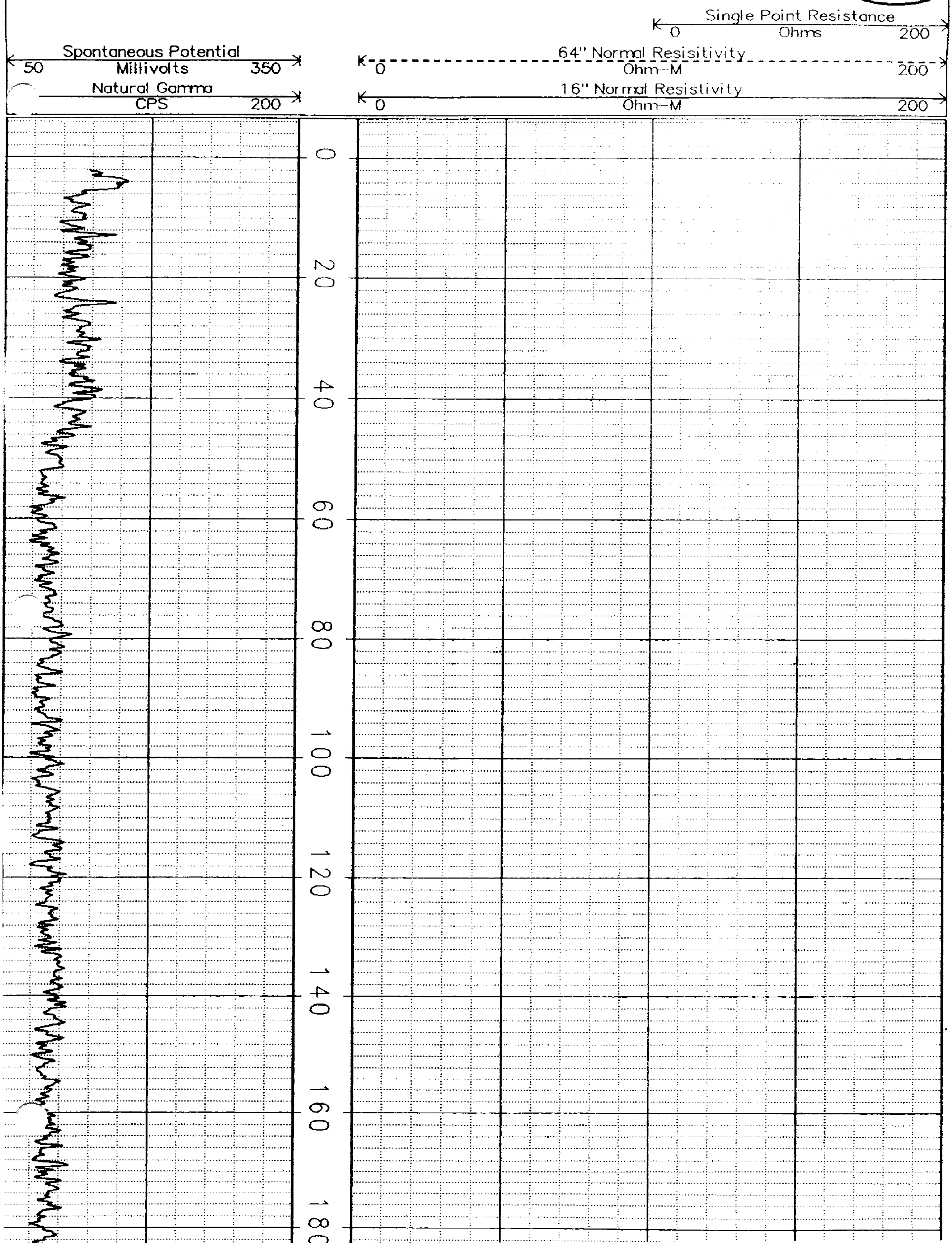
Well PTX06–1061, Pantex Plant, 09/21/2000

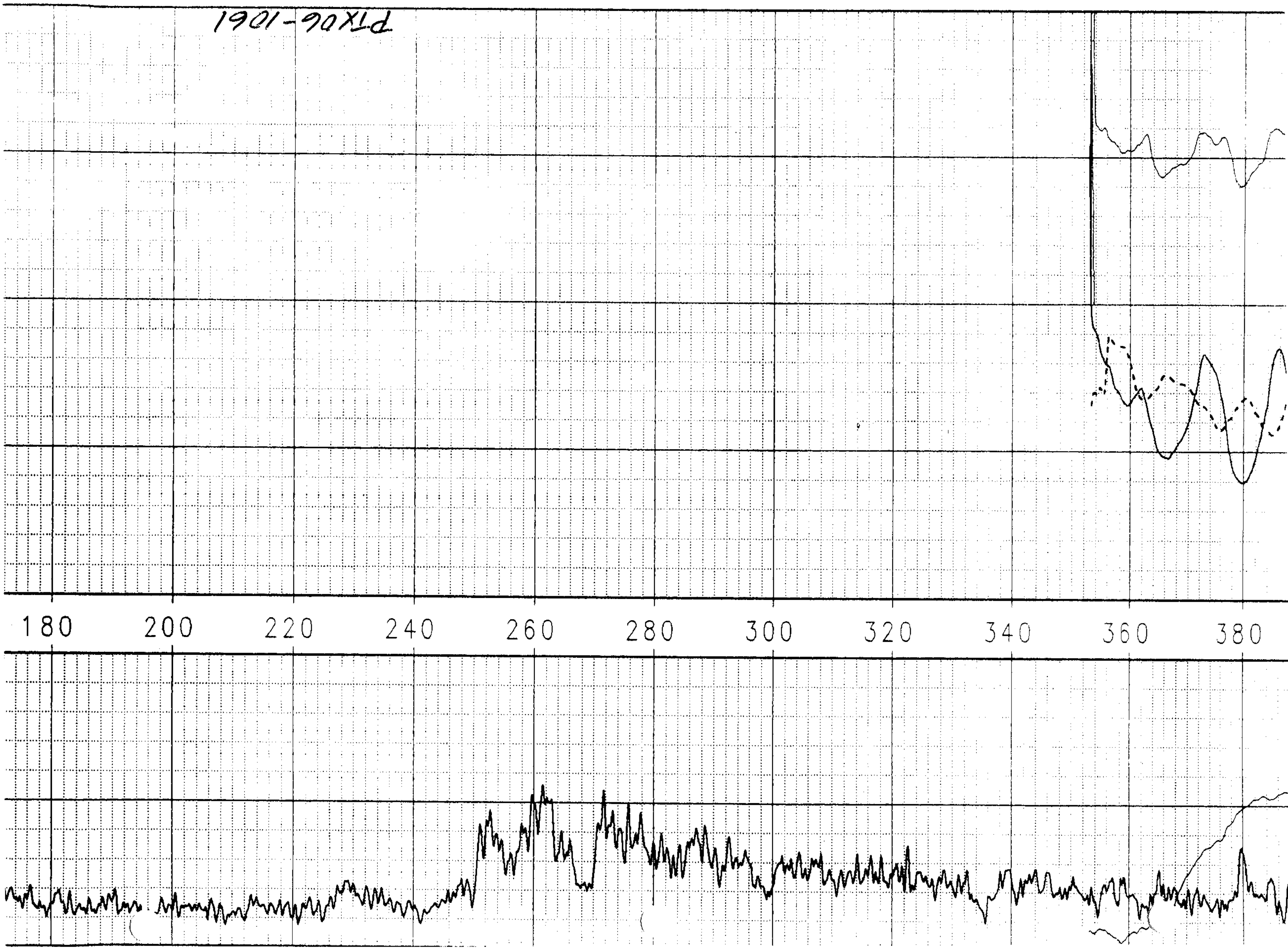
COLOG

Single Point Resistance
0 Ohms 200

Well PTX06–1061, Pantex Plant, 09/21/2000

COLOG




PTX06-1061
180
200
220
240
260
280
300
320
340
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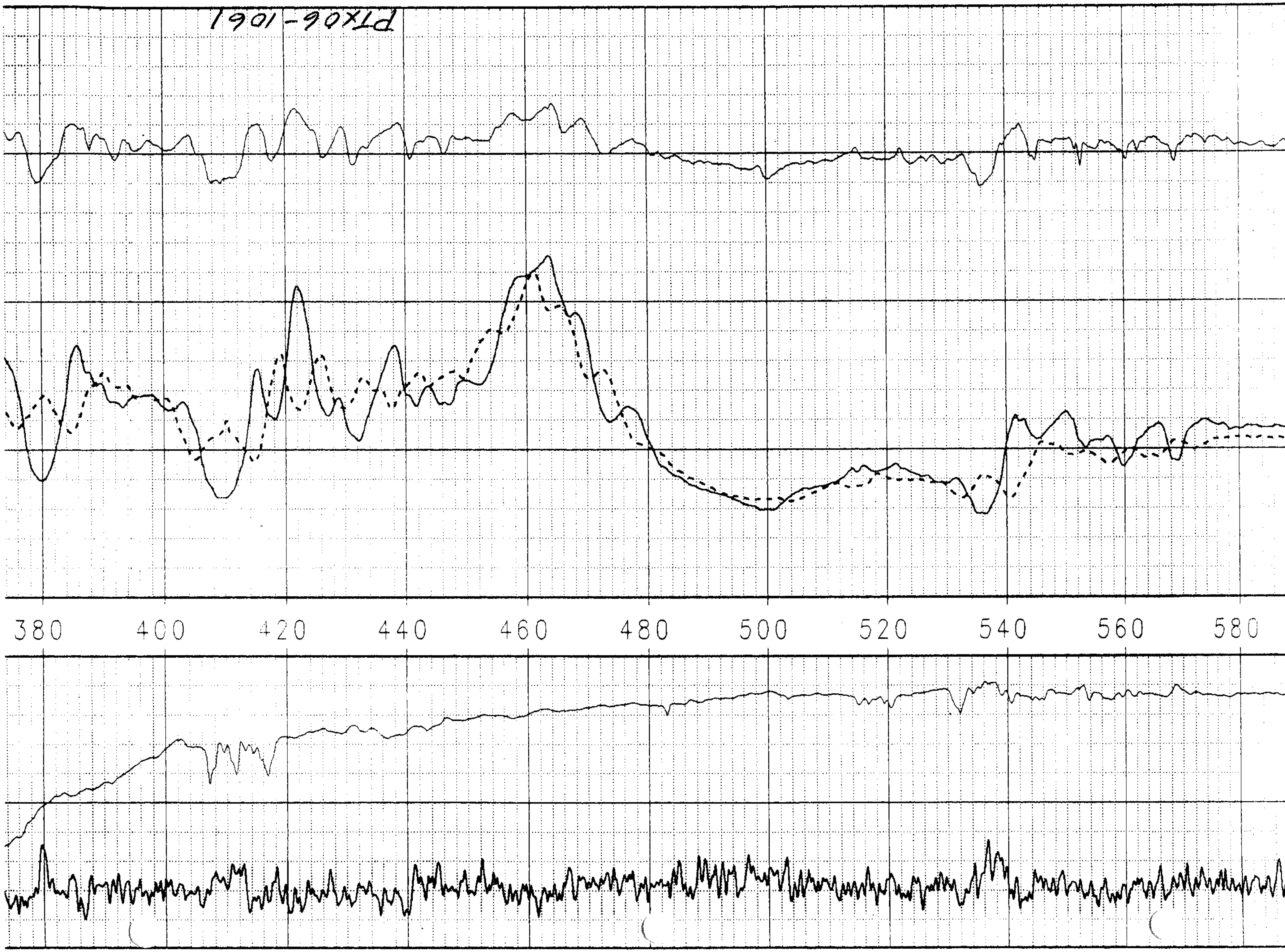
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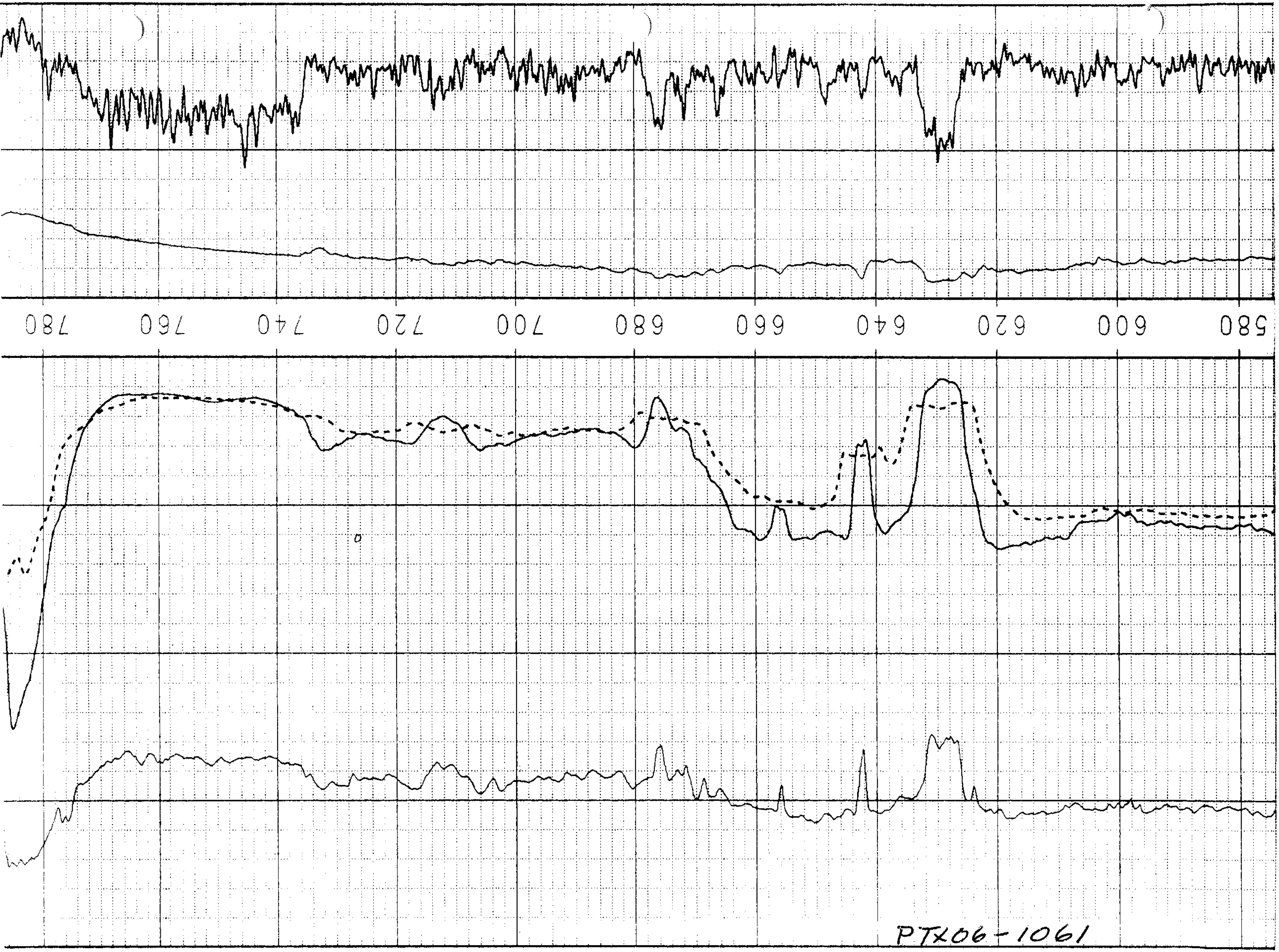
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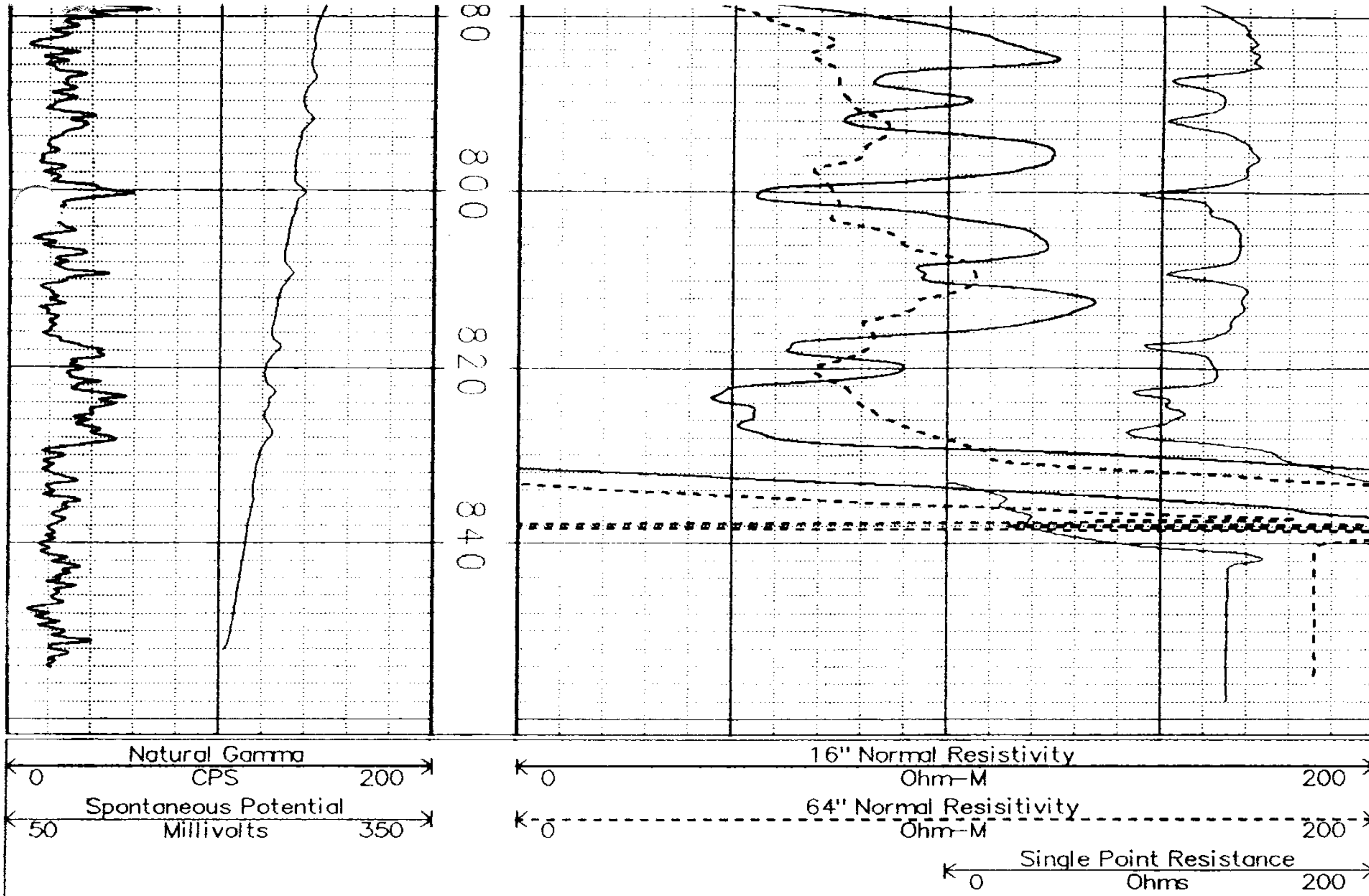
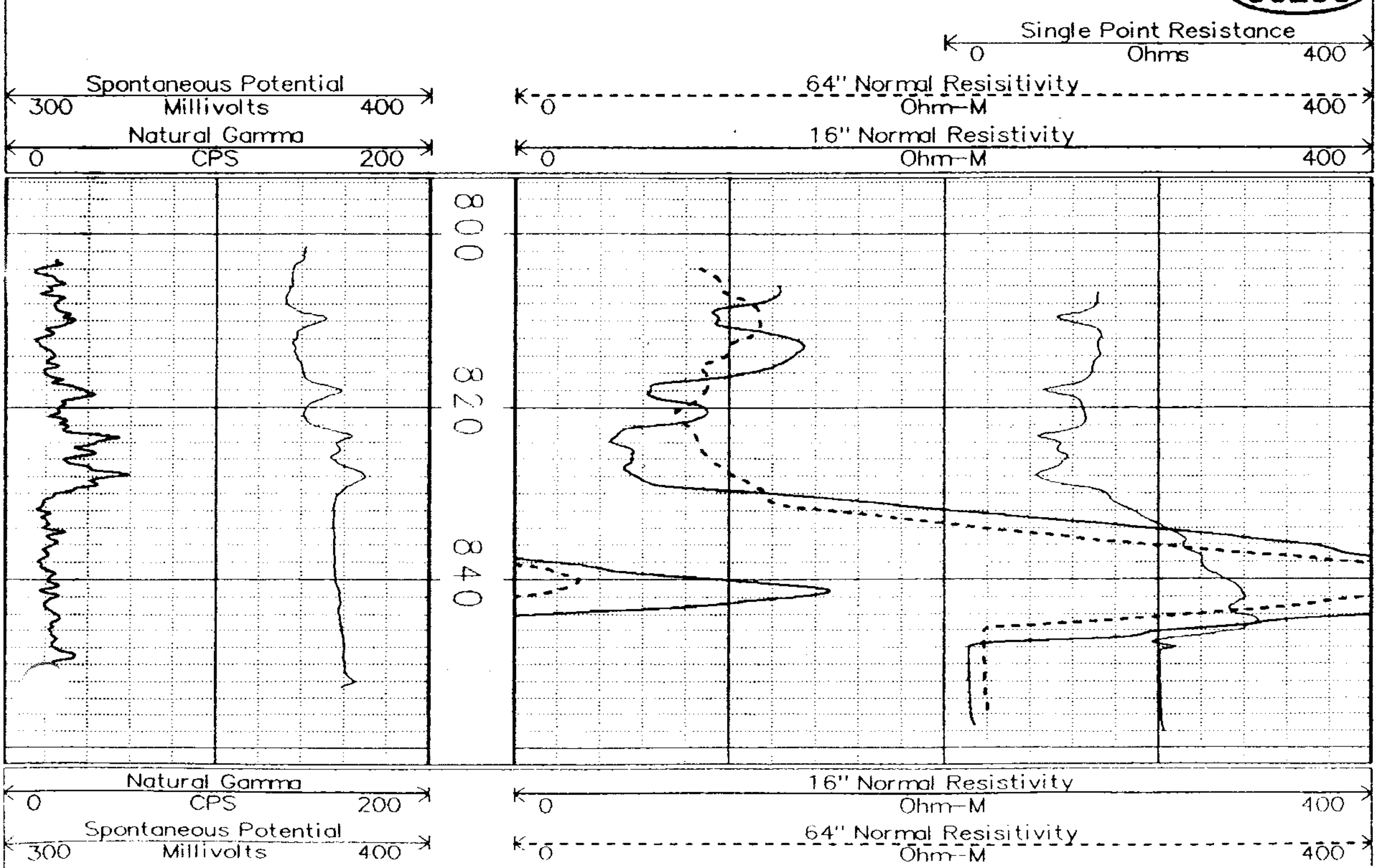


Well PTX06-1061, Pantex Plant, 09/21/2000 COLOG

Well PTX06-1061, (Repeat Section) Pantex Plant, 09/21/2000 COLOG



PTX06-1062A

Contractor: S.M. Stoller Corporation

Contract #: 3615

OPTIX #:

Included Documents

___Drilling Log
　___Draft
　___Final

___Installation Log

_X_Lithologic Logs
　___Draft
　_X_Final

___Geophysical Logs
　___Neutron
　___Gamma
　___e-log
　___Bond Log
　___Deviation log

_X_State Well Report

PTX06-1062A

Pantex Burning Grounds Soil Gas **Pantex Plant (North of Firing Site 1)** **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	J. Ford/P. Fahringer/ R. Rupp	Northing: 3771685.22	Easting: 633017.18
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	905' BGS
Dates Drilled:	04/21/01 - 05/03/01	Depth to Water:	485.5' BTOC 06/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3568.76'	TOC Elevation:	3571.79'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML	0-4' SILT, clayey, with some sand, dark reddish brown (5YR 3/3), low to medium plasticity, hard, damp to moist		
	10, 20		CL-ML	4-22' CLAY, silty and SILT, clayey, reddish brown (5YR 5/4), hard to stiff, dry, with caliche nodules and veins		
	30		CL	22-34' CLAY, silty, light reddish brown (5YR 6/4), medium plasticity, stiff, dry, with caliche nodules to 1/2", MnO2 mottling throughout		
	40		ML	34-51' SILT, clayey, with some fine grained sand, brown (7.5YR 5/4), hard, dry, caliche veinlets and small nodes @ 46-47' SILT, clayey, reddish brown (5YR 6/4), hard, dry, with MnO2 mottling throughout		
	50		SLT STN	51-53.5' CALICHE, pinkish gray (5YR 7/2), hard, dense		
	60		ML	53.5-70' SILT, sandy, clayey, light reddish brown (5YR 6/4), dense, dry		
	70		SLT STN	70-74.5' CALICHE CAPROCK, pinkish white (5YR 8/2), very dense		
	80, 90		SM	74.5-92' SAND, clayey, silty, pink (5YR 7/3), fine grained with medium, subangular to rounded, moderately dense, dry @ 86' as above, pink (5YR 7/4)		
			SM	92-104' SAND to silty sand, light brown (7.5YR 6/4), very fine grained to fine grained, moderately dense, dry, with caliche nodules to 1/4" and cemented sand lenses (thin)		

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S.M. STOLLER CORPORATION

PTX06-1062A

Pantex Burning Grounds Soil Gas **Pantex Plant (North of Firing Site 1)** **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	J. Ford/P. Fahringer/ R. Rupp	Northing: 3771685.22	Easting: 633017.18
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	905' BGS
Dates Drilled:	04/21/01 - 05/03/01	Depth to Water:	485.5' BTOC 06/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3568.76'	TOC Elevation:	3571.79'

Depth (Ft.)	USCS	Description	Sample Number
	SM		
110	SM	104-112' SAND, silty, fine with medium grain, subrounded, dry, some caliche nodules to 1/4"	PTX06-1062-2-0105 HE/VOC Metals
120	SP	112-130' SAND, light yellowish brown (10YR 6/4), very fine to fine grain with some medium, subangular to rounded, poorly graded, loose to medium dense, dry	
130–160	SP	130-168' SAND, brownish yellow (10YR 6/6), fine to very fine grained, subrounded to rounded, poorly graded, loose to dense on thin sandstone lenses, dry	
150		@ 148-150' SAND, as above, fine grained, dry	PTX06-1062-2-0150 HE/VOC Metals
170–180	SM	168-188' SAND to silty sand, very pale brown (10YR 7/4), fine to very fine grained, subrounded to rounded grains, loose to medium dense, dry	
		@ 180-188' as above with dense, thin, sandstone lenses	
190	SM	188-196' SAND, silty, reddish yellow (7.5YR 6/6), very fine to fine grained, subrounded to rounded, medium dense, dry	
	SP	196-214' SAND, very pale brown (10YR 7/4), fine grained	

PTX06-1062A

Pantex Burning Grounds Soil Gas **Pantex Plant (North of Firing Site 1)** **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	J. Ford/P. Fahringer/ R. Rupp	Northing: 3771685.22	Easting: 633017.18
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	905' BGS
Dates Drilled:	04/21/01 - 05/03/01	Depth to Water:	485.5' BTOC 06/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3568.76'	TOC Elevation:	3571.79'

Depth (Ft.)	USCS	Description	Sample	Sample Number
	SP	with some medium grains, rounded, poorly graded, medium dense to dense, dry		
210		@ 210' SAND, yellow (10YR 7/6), fine to medium grain, moderately dense, dry		
	SM	214-221' SAND, silty, brownish yellow (10YR 6/6), very fine to medium grain, subrounded to rounded, loose to moderately dense, damp		
220	SP	221-226' SAND, very pale brown (10YR 7/4), fine to medium grain with trace coarse sand and pebbles, subangular, poorly graded, loose, dry		
230	SW	226-236' SAND, very pale brown (10YR 7/3), fine to coarse grained, with flat pebbles and fine gravel to 1/2", well graded, loose to moderately dense, dry, gravel increasing with depth to 30%. @ 234' gravel to 1 1/4", flat, subangular to rounded		
240	ML	236-240' SILT, sandy, reddish yellow to pink (7.5YR 7/6 to 7/4), very fine grained, hard, dry		
	ML	240-242' SILT, trace sand and some clay (25%), light brown (7.5YR 6/4), medium plasticity, very fine grain, hard-dense, damp, small caliche nodules throughout 1/8 - 1/4", moisture increasing with depth along with clay content		
250	CL-ML	242-247' SILT, clayey to CLAY, silty, brownish yellow (10YR 6/6), medium plasticity, hard to very stiff, damp to slightly moist; conductor casing cemented at 246'	■	PTX06-1062-2-0246 HE/VOC Metals
260	CL	247-280' CLAY, silty, pink (7.5YR 7/4), mixed with some medium grained sand; still fine grain zone		
270				
280	SC	280-317' SAND, clayey, brown to light brown (7.5YR 5/4 - 6/4), coarse to fine grained, poorly sorted		
290				

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PTX06-1062A

Pantex Burning Grounds Soil Gas | **Pantex Plant (North of Firing Site 1)** | **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	J. Ford/P. Fahringer/ R. Rupp	Northing: 3771685.22	Easting: 633017.18
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	905' BGS
Dates Drilled:	04/21/01 - 05/03/01	Depth to Water:	485.5' BTOC 06/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3568.76'	TOC Elevation:	3571.79'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	310		SC			
	320		ML	317-322' CALICHE, clayey, pinkish white (7.5YR 8/2), mixed with 10% fine grained sand		
	330		ML	322-340' SILT, sandy, becoming clayey with depth		
	340, 350, 360, 370		SM	340-380' CALICHE SAND, with silt and 15% shale bits, pinkish gray (7.5YR 7/2), some (<10%) medium grain sand, shale bits are dark red to dark brown (7.5YR 3/3) in color and about 3-5 mm in diameter		
	380, 390		SM	380-410' SAND, silty with caliche, sand 35%, silt/caliche 15%, pinkish gray (7.5YR 6/2), fine grain sand, getting sandier with depth		

PTX06-1062A

Pantex Burning Grounds Soil Gas | **Pantex Plant (North of Firing Site 1)** | **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	J. Ford/P. Fahringer/ R. Rupp	Northing: 3771685.22	Easting: 633017.18
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	905' BGS
Dates Drilled:	04/21/01 - 05/03/01	Depth to Water:	485.5' BTOC 06/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
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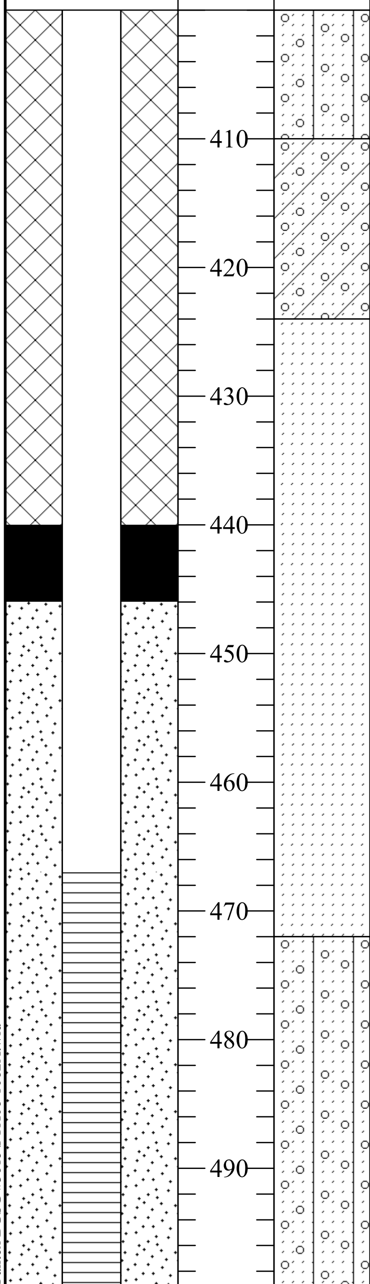

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SM			
	410		SC	410-424' SAND, clayey, silty, 60% sand, 40% clay/silt, light brown (7.5YR 6/3), nonplastic, 80% very fine grain sand, 20% fine grain, subangular, quartzose		
	424		SP	424-472' SAND, trace silt and clay, light brown (7.5YR 6/4), 90% fine grain, subrounded, poorly graded, quartz sand. Some caliche at 437', silty.		
	472		SM	472-510' SAND, silty clayey, 90% sand, 10% silty clay, pale brown (10YR 6/3) fine and medium grain sand, subrounded, poorly graded. Water Level at 485.5' BTOC on June 7, 2001		

PTX06-1062A

Pantex Burning Grounds Soil Gas | **Pantex Plant (North of Firing Site 1)** | **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	J. Ford/P. Fahringer/ R. Rupp	Northing: 3771685.22	Easting: 633017.18
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	905' BGS
Dates Drilled:	04/21/01 - 05/03/01	Depth to Water:	485.5' BTOC 06/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3568.76'	TOC Elevation:	3571.79'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SM			
	510		SP	510-535' SAND, trace silt, pale brown (10YR 6/3), fine to very fine grain, subrounded to rounded, poorly graded, quartz sand.		
	520					
	530					
	540		SM	535-570' SAND, silty, 75% sand, 25% silt, brownish yellow (10YR 6/6), fine grain with some very fine grain, subrounded, poorly graded, quartz sand.		
	550					
	560					
	570		SM	570-585' SAND, silty, 80% sand, 20% silt, light yellowish brown (10YR 6/4), very fine grain, some fine grain, rounded to subrounded, poorly graded.		
	580					
	590		ML	585-595' SILT, sandy, 60% silt, 40% sand, light yellowish brown (10YR 6/4), very fine sand.		
			SP	595-645' SAND, trace silt, light yellowish brown (10YR 6/4), very fine sand, some fine grain, rounded to subrounded, poorly		

PTX06-1062A

Pantex Burning Grounds Soil Gas | **Pantex Plant (North of Firing Site 1)** | **Amarillo, Texas**

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Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3568.76'	TOC Elevation:	3571.79'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	610		SP	graded, grain size increasing with depth, becoming well graded very fine to very coarse grain by 620' with very coarse angular lithic fragments.		
	620, 630, 640		SW			
	650		SP	645-655' SAND, pale brown (10 YR 6/3) very fine to medium grain, subrounded, graded, quartz sand.		
	660		GW	655-667' GRAVEL, sandy, yellowish brown, cuttings are very course angular lithic fragments. Could be a well cemented conglomerate.		
	670, 680, 690		SP	667-693' SAND, pink (7.5YR 7/3) fine (60%) to medium (40%) grain, rounded to subrounded, moderately well sorted, quartz.		
			SP	693-723' SAND, pink (7.5YR 7/3), mostly (75%) fine grain, subrounded, well sorted.		

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PTX06-1062A

Pantex Burning Grounds Soil Gas **Pantex Plant (North of Firing Site 1)** **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	J. Ford/P. Fahringer/ R. Rupp	Northing: 3771685.22	Easting: 633017.18
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	905' BGS
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Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3568.76'	TOC Elevation:	3571.79'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	710, 720		SP			
	730		CL	723-737' CLAY, sandy (25%), silty (10%), very pale yellow (10YR 7/4), clay is plastic, sand is very fine grain, rounded to subrounded, well sorted, quartz.		
	740, 750, 760		SC	737-765' SAND, clayey with <10% silt, very pale yellow (10YR 7/4), fine to very fine grain, rounded, well sorted, quartz lithology with some clay lenses.		
			SP	765-767' SAND, course grained with some fine gravel, angular, mixed lithology.		
	770, 780		CL	767-790' CLAY, sandy, gravelly, silty, light reddish brown (5YR 6/4), mostly clays/silts mixed with sands/gravels, drills harder with depth.		
	790		CL	790-795' CLAY, dark reddish brown (2.5YR 3/4) to red (2.5 YR 4/6), drills hard, little recovery.		
			CL	795-820' CLAY, silty, light brown, clays are plastic, mix with dark red to red brown silts in spots.		

PTX06-1062A

Pantex Burning Grounds Soil Gas | **Pantex Plant (North of Firing Site 1)** | **Amarillo, Texas**

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Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	810		CL			
	820, 830		CL	820-840' CLAY, silty with some (10%) sand, reddish brown (5YR 4/4) when wet, hard to drill.		
	840, 850		CL	840-857' CLAY, silty, red (2.5YR 4/8) to yellowish red (5YR 5/6) highly plastic, stiff.		
	860		CL	857-867' CLAY, gravelly, silty, (5YR 4/6), with quartz gravels.		
	870, 880		Sh Ss Sh Ss Sh Ss	867-890' SHALE and SANDSTONE, shale is yellowish red (5YR 5/6) to red (2.5 YR 5/6), sandstone is white (5YR 8/1) to light gray (5YR 7/1), very fine grain, rounded, soft. 887-890' Gaining red (10YR 4/6) clay and white (5YR 8/1) sandstone flecks.		
	890		CL	890-905' CLAY, red (10YR 4/6), highly plastic, no sand at 905', stiff, some white (5YR 8/1) reduction mottles. Permian contact at about 890'.		

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PTX06-1062A

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Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			CL			

Depth scale: 910, 920, 930, 940, 950, 960, 970, 980, 990

Total Depth of Borehole 905' BGS
Fine Grain Zone 242-276' BGS
Redbeds 890' BGS

Well Completion Details:

Borehole Diameter:
11" from surface to 246'
8" from 246' to 905'

8 5/8" steel conductor casing cemented from surface to 246'

Total Depth of Well 892'
4-inch, Schedule 10, Type 316 Stainless Steel casing and 10-slot Screen

470' Blank (+3-467)
290' Screen (467-757')
40' Blank (757-797')
90' Screen (797-887')
5' Sump (887-892')

3' Cement Seal (0-3')
437' Volclay bentonite grout (3-440')
6' Bentonite seal (440-446')
318' Filter pack, 10/20 Colorado Silica Sand (446-764')
22' Bentonite seal (764-786')
106' Filter pack, 10/20 Colorado Silica Sand (786'-892')
13' Backfill, 10/20 Colorado Silica Sand (892-905')

Surface Completion:
Concrete pad (5'X5'X8") with four bollards and 10-inch steel protective casing with locking cover.

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COLOG Division of Layne Christensen Company

17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

GAMMA-ELECTRIC

COM: S.M. Stoller
WELL: PTX06-1062A
FLD: Pantex Plant
ST: TX COUNTY: Carson

COMPANY: S.M. Stoller
WELL: PTX06-1062A
FIELD: Pantex Plant
STATE: TX COUNTY: Carson

LOCATION:

SEC TWP RGE

OTHER SERVICES:
DEVIATION

PERMANENT DATUM: GL ELEVATION: NA
LOG MEAS. FROM: GL 0.0 FT ABOVE PERM. DATUM
DRILL MEAS. FROM: GL

DATE ACQUIRED	May 02, 2001			
RUN NUMBER	1			
LOG TYPE	GAMMA-ELECTRIC			
DEPTH-DRILLER	905'			
DEPTH-LOGGER	900'			
BTM LOGGED INTERVAL	900'			
TOP LOGGED INTERVAL	GL			
RECORDED BY	T. Staatz			
WITNESSED BY	P. Fahringer			
FLUID LEVEL	NA			
FLUID TYPE	Water			
Rm at TEMP	NA			
TIME SINCE CIRC.	NA			
PROBE TYPE, S/N	2PEA, 2078			
MODULE TYPE, S/N	MGX II 1144			
LOGGING SPEED	15 ft/min			
A.S.D.E.	NA			
SAMPLE INTERVAL	0.5'			
SOURCE SIZE, S	none			

BOREHOLE RECORD			CASING RECORD		
BIT SIZE	FROM	TO	SIZE/WGT	FROM	TO
12 3/4"	GL	246'	8 5/8"	-3'	243'
7 5/8"	243'	TD			

COMMENTS:

COMMENTS:

'A – NOT AVAILABLE, N/A – NOT APPLICABLE

DIGITAL FILES: 1062A, dev.hdp

PANTEX WELL PTX06-1062A 03 MAY 2001 COLOG

Single Point Resistance
50 Ohms 150

PANTEX WELL PTX06-1062A 03 MAY 2001

COLOG

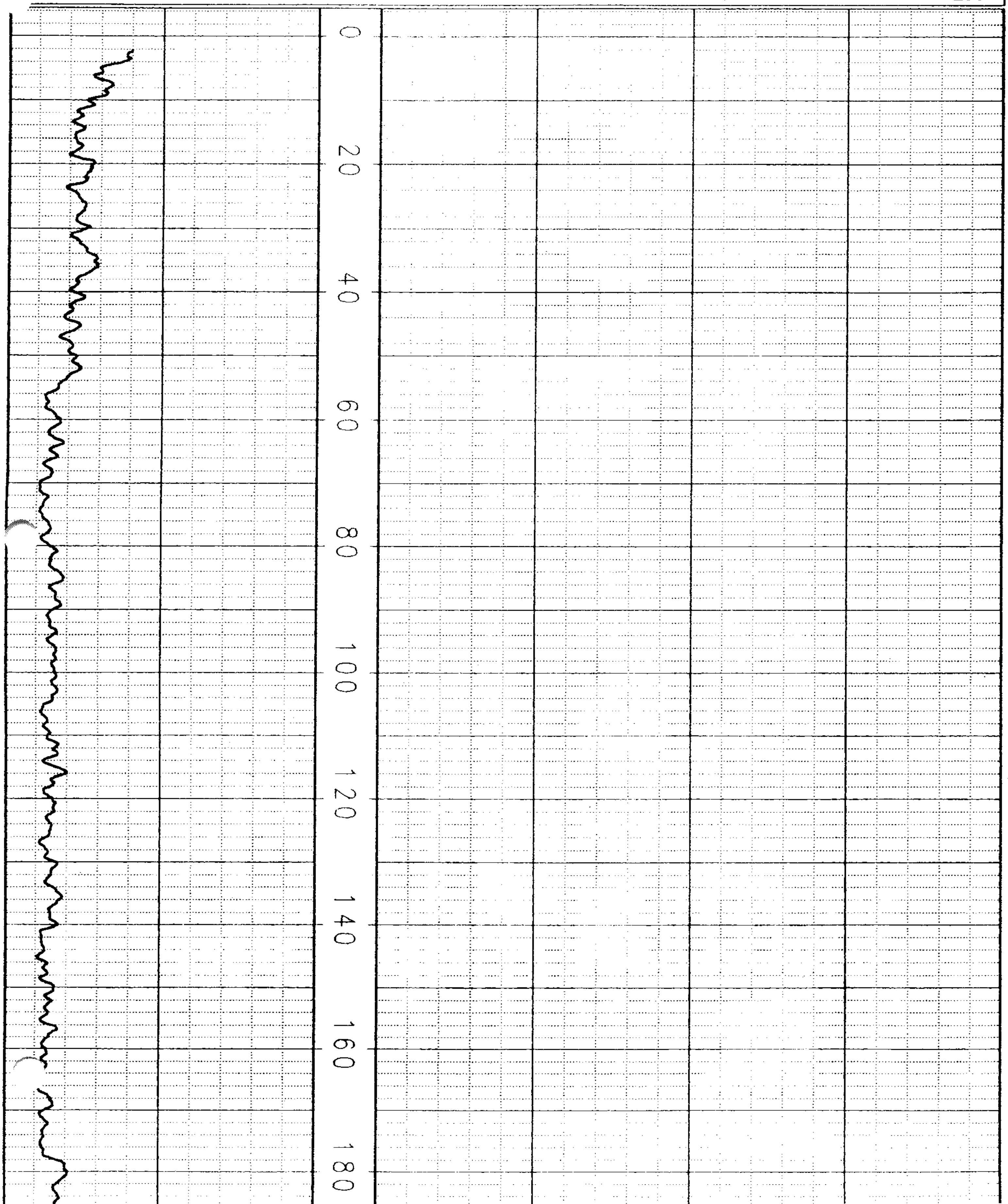
Single Point Resistance
50 Ohms 150

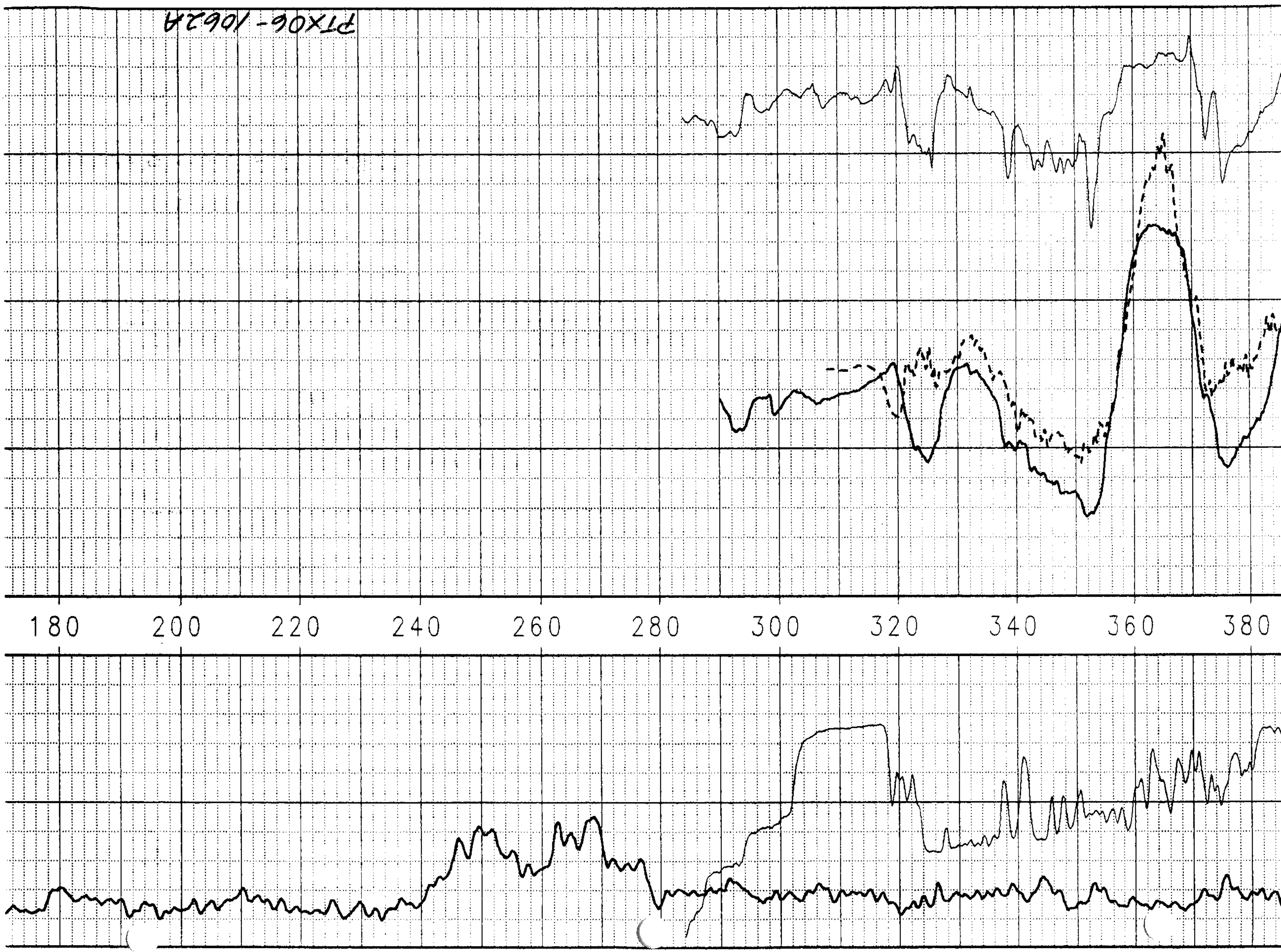
Spontaneous Potential
0 milli Volts 1000

64" Normal Resistivity
0 Ohm-Meters 200

Natural Gamma
0 CPS 200

16" Normal Resistivity
0 Ohm-Meters 200

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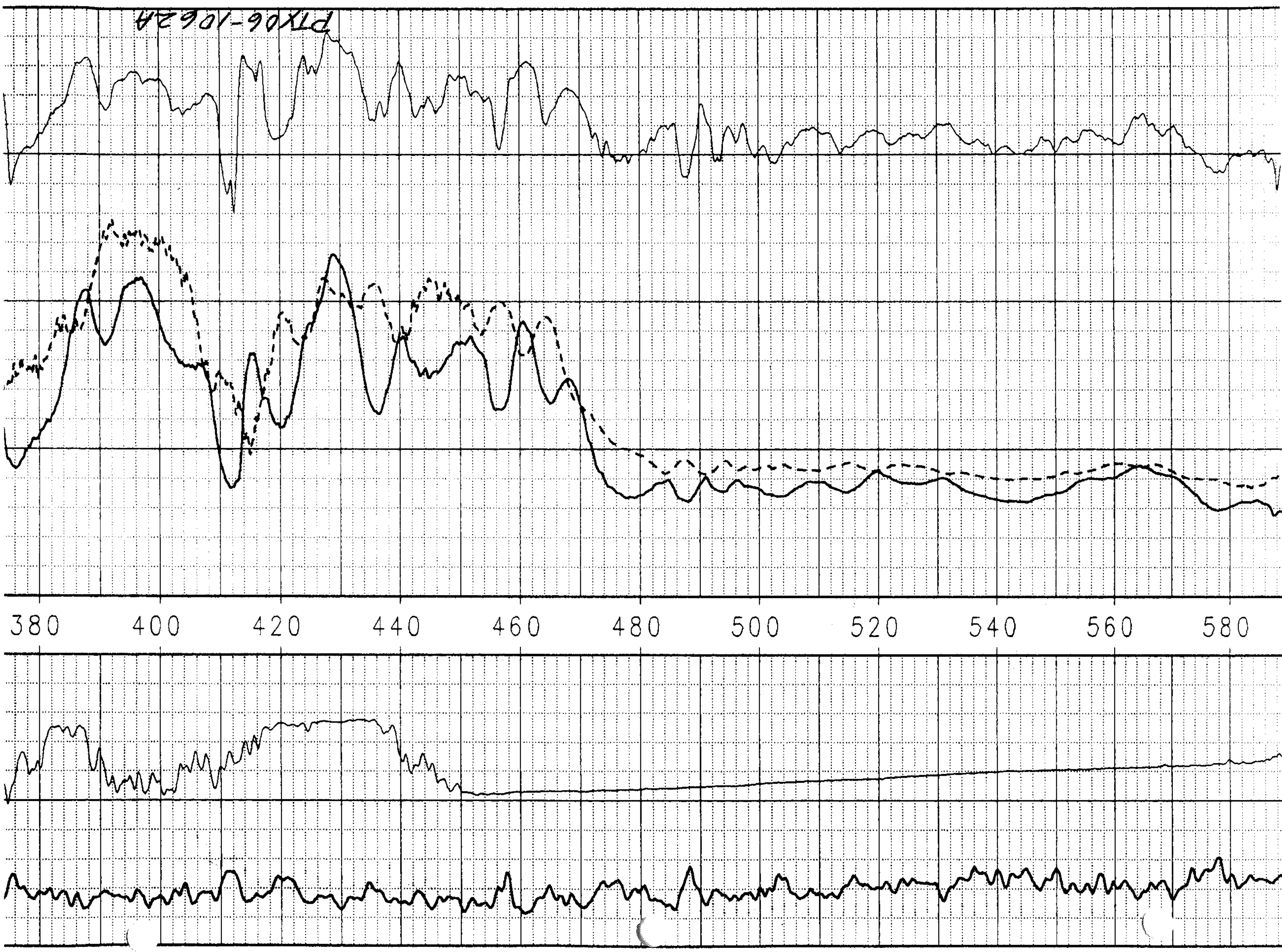

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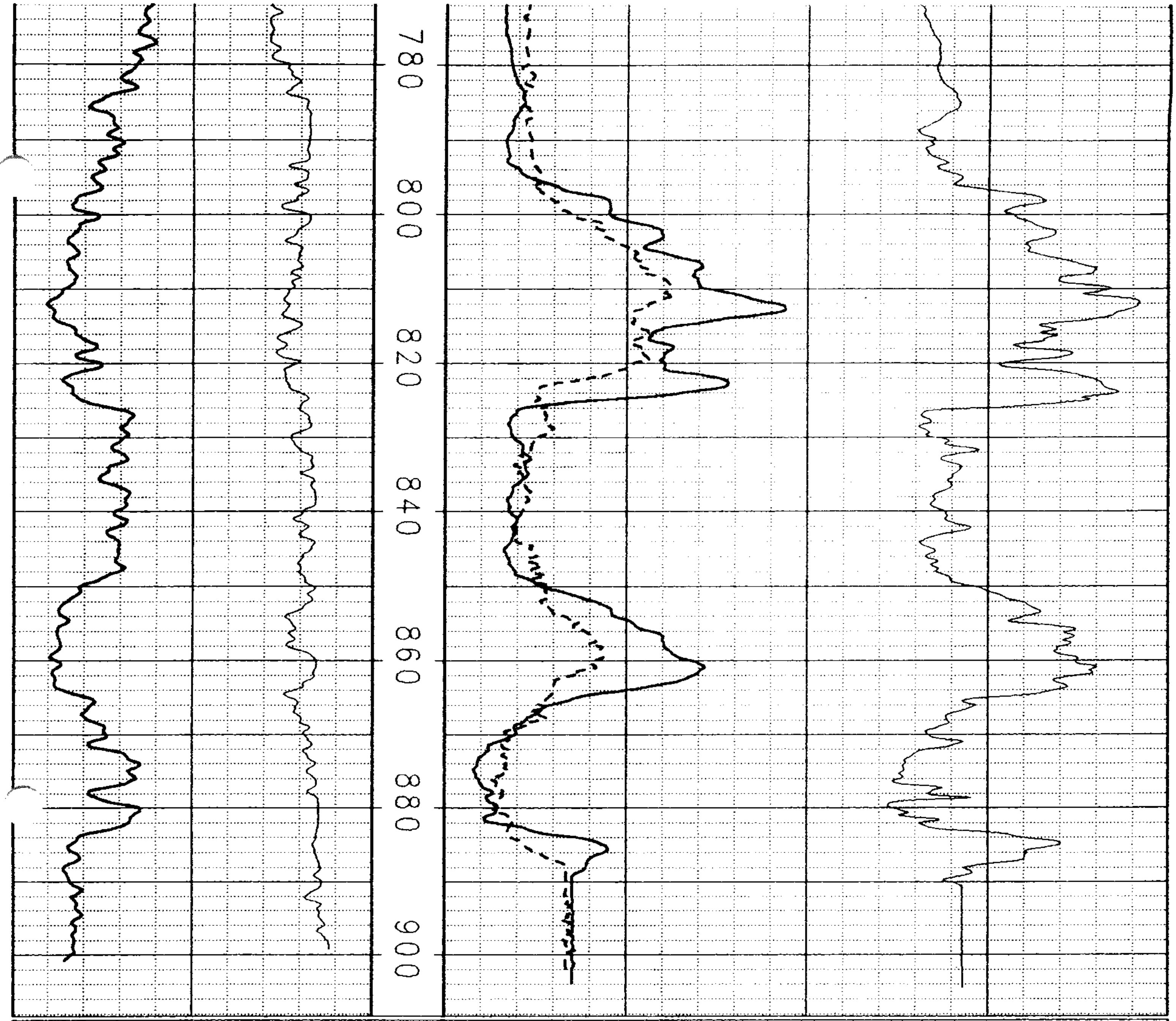


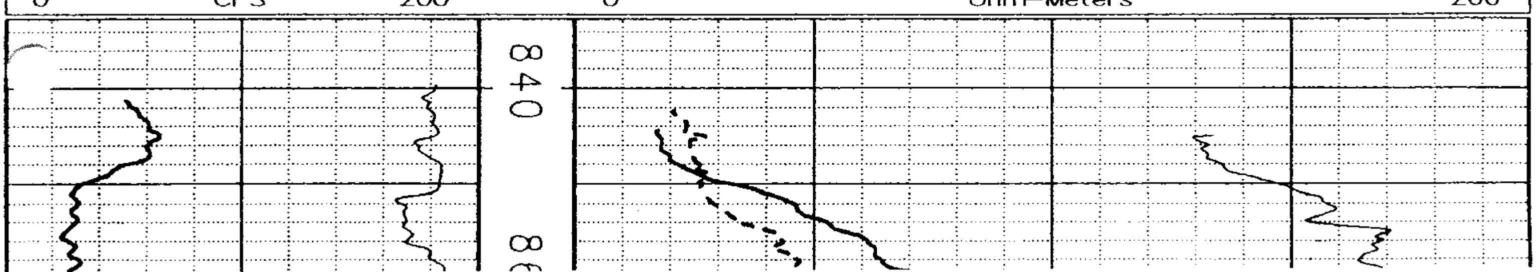
Natural Gamma
0 CPS 200
Spontaneous Potential
0 milli Volts 1000

16" Normal Resistivity
0 Ohm–Meters 200
64" Normal Resistivity
0 Ohm–Meters 200
Single Point Resistance
50 Ohms 150

PANTEX WELL PTX06–1062A 03 MAY 2001 COLOG

PANTEX WELL PTX06–1062A COMPARISON COLOG

Single Point Resistance
50 Ohms 150
Spontaneous Potential
0 milli Volts 1000
64" Normal Resistivity
0 Ohm–Meters 200
Natural Gamma
0 CPS 200
16" Normal Resistivity
0 Ohm–Meters 200



Send original copy by certified return receipt requested mail to: TDLR, P.O. Box 12157, Austin, TX 78711

ATTENTION OWNER: Confidentiality Privilege Notice on reverse side of Well Owner's copy (pink)

PTX06-1062-A

State of Texas WELL REPORT

COPY

water.well@license.state.tx.us

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
512-463-7880

1) OWNER PANTEX U.S.D.O.E. (Name) ADDRESS HWY. 2373 N. HWY. 60 (Street or RFD) AMARILLO (City) TX. (State) 79177 (Zip)

2) ADDRESS OF WELL'S LOCATION: County CARSON HWY. 2373 N. HWY. 60 (Street, RFD or other) AMARILLO (City) TX. (State) 79177 (Zip) Lat. _ _ Long. _ _ Grid # 06-44-1

3) TYPE OF WORK (Check):
☒ New Well ☐ Deepening
☐ Reconditioning ☐ Plugging

(4) PROPOSED USE (Check): ☒ Monitor ☐ Environmental Soil Boring ☐ Domestic
☐ Industrial ☐ Irrigation ☐ Injection ☐ Public Supply ☐ De-watering ☐ Testwell
If Public Supply well, were plans submitted to the TNRCC? ☐ Yes ☐ No

5)

N ↑

6) WELL LOG:
Date Drilling:
Started 4-23 2001
Completed 5-5 2001

DIAMETER OF HOLE

Dia. (in.)	From (ft.)	To (ft.)
10 3/4	Surface	246'
7 7/8	246	905

7) DRILLING METHOD (Check): ☐ Driven
☐ Air Rotary ☐ Mud Rotary ☐ Bored
☒ Air Hammer ☐ Cable Tool ☐ Jetted
☒ Other ODEX DUAL WALL AIR

From (ft.)	To (ft.)	Description and color of formation material
0 -	4 -	TOP SOIL
4 -	22 -	BROWN SILTY CLAY W/CALICHE
22 -	51 -	BROWN SANDY CLAY
51 -	69 -	CALICHE
69 -	91 -	PINK SAND
91 -	112 -	LIGHT BROWN SAND
112 -	230 -	BROWNISH YELLOW FINE SAND
230 -	239 -	BROWN GRAVELLY SAND
239 -	280 -	LIGHT BROWN STIFF CLAY
[illegible]0 -	767 -	BROWN SAND W/GRAVELS
[illegible]7 -	790 -	YELLOW SAND W/GRAVELS
790 -	795 -	REDDISH BROWN CLAY

(Use reverse side of Well Owner's copy, if necessary)

8) Borehole Completion (Check): ☐ Open Hole ☐ Straight Wall
☐ Underreamed ☒ Gravel Packed ☐ Other ____
If Gravel Packed give interval from 446'-467 ft. to 786'-905' ft.
BENTONITE PELLETS 440'-446' – 764'-786'

CASING, BLANK PIPE, AND WELL SCREEN DATA:

Dia. (in.)	New or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft.) From	Setting (ft.) To	Gage Casing Screen
8 5/8	N	STEEL CONDUCTOR	0	246	BLANK
4	N	JOHNSON 316 SS	0	467	BLANK
4	N	JOHNSON 316 SS	467 / 797	757 / 887	0.10
4	N	JOHNSON 316 SS	887	892	BLANK

9) CEMENTING DATA 8 5/8" STEEL – 0 - 246' - 103-SKS CEMENT
Cemented from 0 ft. to 3 ft. No. of sacks used 2
VOLCLAY 3 ft. to 440 ft. No. of sacks used 93
Method used TREMMIE
Cemented by LAYNE-CHRISTENSEN
Distance to septic system field lines or other concentrated contamination ____ ft.
Method of verification of above distance ____

13) ☐ Well plugged within 48 hours

Casing left in well: From (ft)	To (ft)	Cement/bentonite placed in well: From (ft)	To (ft)	Sacks used:

10) SURFACE COMPLETION
☒ Specified Surface Slab Installed 5'X5'X8''
☐ Specified Steel Sleeve Installed
☐ Pitless Adapter Used
☐ Approved Alternative Procedure Used

14) TYPE PUMP:
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ____
Depth to pump bowls, cylinder, jet, etc., ____ ft.

11) WATER LEVEL:
Static level ____ ft. below land surface Date ____
Artesian flow ____ gpm. Date ____

15) WELL TESTS:
Type test ☐ Pump ☐ Bailer ☐ Jetted ☐ Estimated
Yield: ____ gpm with ____ ft. drawdown after ____ hrs.

12) PACKERS: Type Depth

16) WATER QUALITY:
Did you knowingly penetrate any strata which contained undesirable constituents?
☐ Yes ☒ No If yes, submit "REPORT OF UNDESIRABLE WATER"
Type of water? ____ Depth of strata ____
Was a chemical analysis made? ☐ Yes ☒ No

I certify that I drilled this well (or the well was drilled under my direct supervision) and that each and all of the statements herein are true and correct. I understand that failure to complete items 1 thru 16 will result in the log(s) being returned for completion and resubmittal.

COMPANY NAME LAYNE-CHRISTENSEN (Type or print) WELL DRILLER'S LICENSE NO. 2585 WP

ADDRESS 1707 S. 4490 W. (Street or RFD) SALT LAKE CITY (City) UTAH (State) 84104 (Zip)

(Signed) R. L. Burrows (Licensed Well Driller) (Signed) ____ (Registered Driller Apprentice)

Please attach electric log, chemical analysis, and other pertinent information, if available.

TDLR FORM 001WWD (4/98) White - TDLR Yellow - DRILLER Pink - WELL OWNER

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

Section 32.005 of the Texas Water Code, concerning confidential information in the Reporting of Well Logs, reads as follows:

> "Every licensed driller drilling, deepening or otherwise altering a water well within this State shall make and keep a legible and accurate well log in accordance with the department rule on forms prescribed by the department. Not later than the 60th day after the completion or cessation of drilling, deepening, or otherwise altering the well, the licensed driller shall deliver or transmit by certified mail a copy of the well log to the department and to the owner of the well or the person for whom the well was drilled. Each copy of a well log, other than a department copy must include the name, mailing address, and telephone number of the department. The well log shall be recorded at the time of drilling, and must show the depth, thickness, and character of the strata penetrated, the location of water-bearing strata, the depth, size and character of casing installed, and any other information required by department rule. The department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner or person for whom the well was drilled."

The last sentence specifies the means whereby you may, if you wish, assure that logs of your wells will be kept confidential.

PTX06-1062-A

From (ft.)	To (ft.)	Description and color of formation material
795	867	BROWN SILTY CLAY W/SS STR,
867	890	YELLOWISH RED SHALE W/SS
890	905	RED CLAY

Deviation Survey for: S. M. Stoller **Field:** Pantex Plant **Date:** 5/2/2001

Well: PTX06-1062A **Depth Ref.:** GL **Total Deptl** 879.87 **Probe Type, S/N:** SLP

Depth (feet)	Inclination (degrees)	Bearing (degrees)	ClosureLength (line ft.)	ClosureDist. (horiz. ft.)	ClosureDepth (vertical ft.)	Northing (feet)	Easting (feet)	TrueDepth (feet)	Dist.Sum (feet)	NorthSum (feet)	EastSum (feet)
0.00	0.68	350	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50.00	0.76	310	50.00	0.66	50.00	0.43	-0.51	50.00	0.66	0.43	-0.51
100.00	0.75	263	50.00	0.65	50.00	-0.08	-0.65	99.99	1.21	0.35	-1.16
150.00	0.62	110	50.00	0.54	50.00	-0.19	0.51	149.99	0.67	0.16	-0.65
200.00	1.10	200	50.00	0.96	49.99	-0.90	-0.33	199.98	1.23	-0.74	-0.98
250.00	0.37	350	50.00	0.32	50.00	0.32	-0.06	249.98	1.12	-0.42	-1.03
300.00	1.48	352	50.00	1.29	49.98	1.28	-0.18	299.96	1.49	0.86	-1.21
350.00	1.74	355	50.00	1.52	49.98	1.51	-0.13	349.94	2.72	2.37	-1.35
400.00	0.37	347	50.00	0.32	50.00	0.31	-0.07	399.94	3.04	2.68	-1.42
450.00	0.36	345	50.00	0.31	50.00	0.30	-0.08	449.94	3.34	2.99	-1.50
500.00	1.25	86	50.00	1.09	49.99	0.08	1.09	499.92	3.09	3.06	-0.41
550.00	0.95	94	50.00	0.83	49.99	-0.06	0.83	549.92	3.03	3.01	0.42
600.00	1.11	65	50.00	0.97	49.99	0.41	0.88	599.91	3.65	3.41	1.29
650.00	1.15	44	50.00	1.00	49.99	0.72	0.70	649.90	4.59	4.14	1.99
700.00	1.16	19	50.00	1.01	49.99	0.96	0.33	699.89	5.60	5.09	2.32
750.00	1.27	15	50.00	1.11	49.99	1.07	0.29	749.88	6.69	6.16	2.61
800.00	0.85	332	50.00	0.74	49.99	0.65	-0.35	799.87	7.18	6.82	2.26
850.00	0.19	257	50.00	0.17	50.00	-0.04	-0.16	849.87	7.10	6.78	2.10
880.00	0.12	146	30.00	0.06	30.00	-0.05	0.04	879.87	7.06	6.73	2.13

Totals:			
True Depth	DistSum	NorthSum	EastSum
879.87	**7.06**	**6.73**	**2.13**

Definitions

Bearing = Azimuth Degrees from Magnetic North (Raw Data)

ClosureDistance = Horizontal Feet Between Each Station

ClosureDepth = Vertical Feet Between Each Interval

Northing = North/South Component of Horizontal Distance Between Each Station (Negative = South)
(Closure Dist.) x cos(Bearing)

Easting = East/West Component of Horizontal Distance Between Each Station (Negative = West)
(Closure Dist.) x sin(Bearing)

TrueDepth = Vertical Depth from the Surface to This Station

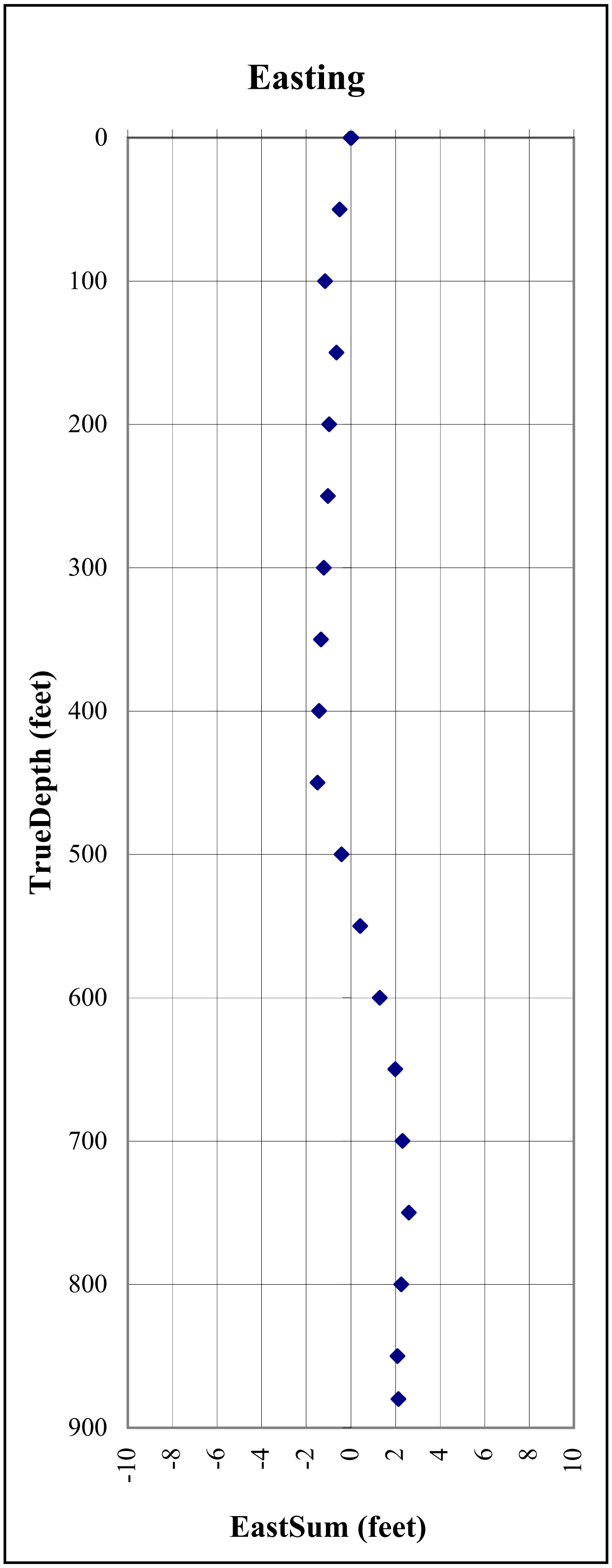
DistanceSum = Horizontal Distance from Wellhead to this Station

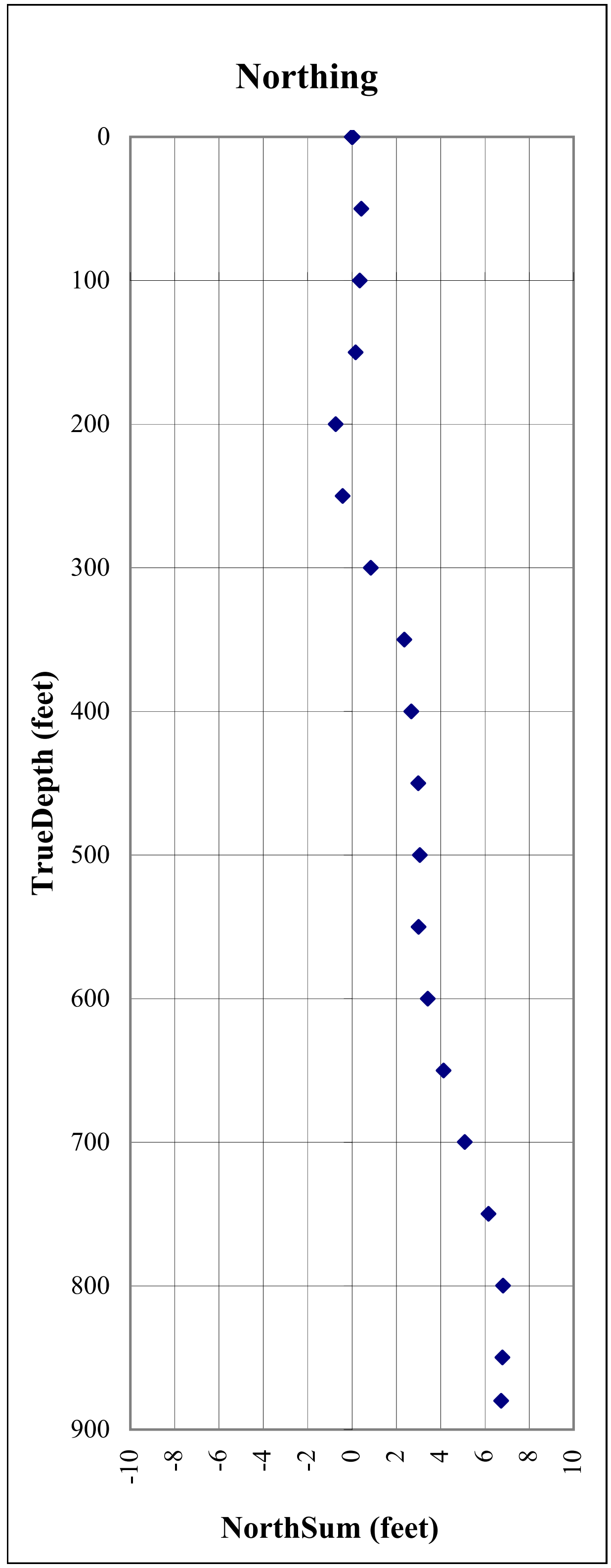
NorthSum = North/South Component of Horizontal Distance from the Wellhead to This Station (Negative = South)
Running Sum of Northing

EastSum = East/West Component of Horizontal Distance from the Wellhead to This Station (Negative = West)
Running Sum of Easting

Deviation Survey for: S. M. Stoller **Field:** Pantex Plant **Date:** 5/2/2001

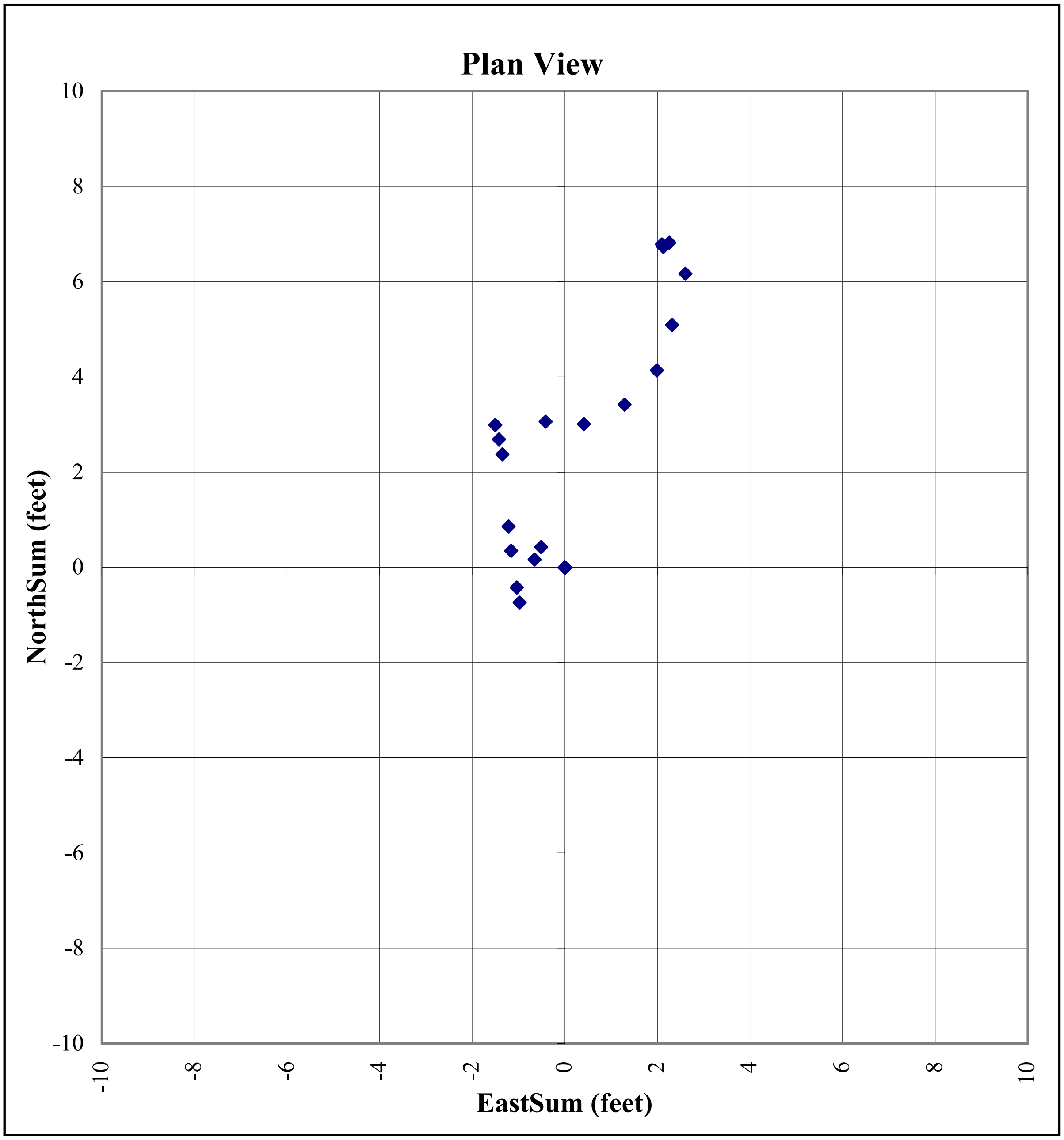
Well: PTX06-1062A **Depth Ref.:** GL **Total Deptl** 879.87 **Probe Type, S/N:** SLP





Orientations are with respect to Magnetic North

Deviation Survey for: S. M. Stoller **Field:** Pantex Plant **Date:** 5/2/2001
Well: PTX06-1062A **Depth Ref.:** GL **Total Deptl** 879.87 **Probe Type, S/N:** SLP



Orientations are with respect to Magnetic North

east	north	depth
0.000	0.000	0.000
-0.508	0.426	49.996
-1.158	0.347	99.991
-0.649	0.161	149.988
-0.978	-0.740	199.979
-1.034	-0.423	249.978
-1.213	0.856	299.961
-1.346	2.369	349.938
-1.418	2.683	399.937
-1.500	2.987	449.936
-0.412	3.063	499.924
0.415	3.005	549.918
1.293	3.414	599.908
1.990	4.136	649.898
2.320	5.093	699.888
2.607	6.164	749.876
2.259	6.819	799.870
2.097	6.781	849.870
2.132	6.729	879.870

PTX06-1064

Contractor: Llano Permian Environmental Services

Contract #: PTX.001.OGA

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

_X_Installation Log

_X_Lithologic Logs
    ___Draft
    _X_Final

_X_Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

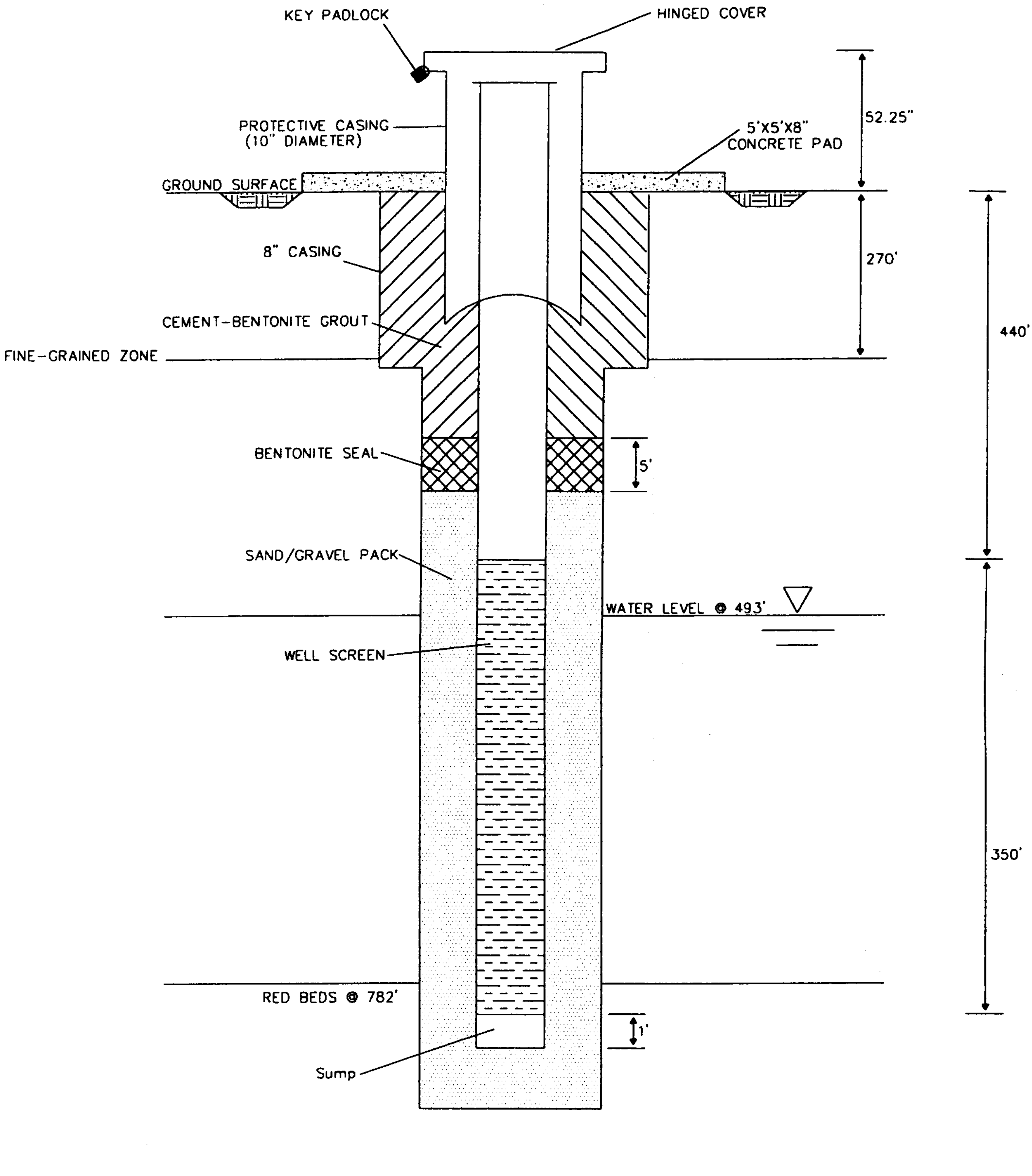
_X_State Well Report

1064
Draft Boring Log

Hard copy is located in volume II of the PTX06 originals book.

The copies are illegible.

12 pages



Total Depth = 792'

LP Environmental Llano-Permian Environmental Services	Date: 8/7/01 Scale: Not To Scale By: AGB	PTX06-1064 Monitor Well Construction Detail (Ogallala)

MONITORING WELL LOG

WELL NO. PTX06-1064

PROJECT: Assessment of the Ogallala Aquifer

PROJECT NO.: PTX.001.OGA

LOCATION: Osborne Property

ELEVATION: 3560.24 Surface

DRILLER: Talon Drilling

DATE DRILLED: May 21, 2001

DATE COMPLETED: May 31, 2001

WATER DEPTH: 493'

LOGGER: Chado/Hagan

COMPLETION DEPTH: 792 feet

DEPTH (ft.)	Well Construction Diagram / Sampler / Soil Graphic	DESCRIPTION
0		Moderate brown 5yr4/4 clay, damp, stiff, some silt and sand
		Dusky yellowish brown 10yr2/2 clay, moist, stiff, some silt
		Light brown 5yr6/4 silty sand, dry, very fine grained, well sorted, subrounded to subangular
15		Moderate brown 5yr4/4 sandy clay, fine grained, subrounded to rounded, dry, stiff
		Light brown 5yr5/6 sandy clay fine grained, subrounded, slightly moist, stiff
30		
		less sand
45		
		more silt
60		some caliche nodules
		Light brown 5yr5/6 clayey sand, very fine grained, subangular to subrounded, soft, slightly moist
75		more clay
		Light brown 5yr5/6 sand, fine grained, subangular, very little clay, dry, moderately well sorted
		Grayish orange 10yr7/4 silty sand, very fine grained, well sorted, subangular particles, slightly moist
90		
105		Dark yellowish orange 10yr6/6 silty sand, fine grained, well

PROTECTIVE COVER TYPE:
10" dia. steel upright locking

SURFACE COMPLETION:
Type: concrete pad

Size: 5'X5'X8"

Total Depth of Concrete: 15'

GROUT:
Type: Portland/Volclay

Total Thickness: 412

CASING:
Diameter: 4"

Length: 365

Stick Up: 2

SEAL
Type: Bentonite

Quantity: 427'-432'

Total Thickness: 5'

SCREEN
Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010 factory

Screened Interval(s): 440'-790'

COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1064

PROJECT: Assessment of the Ogallala Aquifer

PROJECT NO.: PTX.001.OGA

LOCATION: Osborne Property

ELEVATION: 3560.24 Surface

DRILLER: Talon Drilling

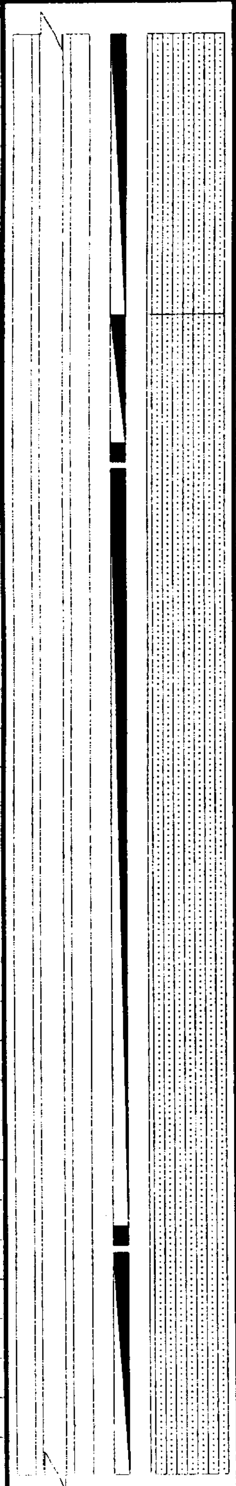
DATE DRILLED: May 21, 2001

DATE COMPLETED: May 31, 2001

WATER DEPTH: 493'

LOGGER: Chado/Hagan

COMPLETION DEPTH: 792 feet

DEPTH (ft.)	Well Construction Diagram / Sampler / Soil Graphic	DESCRIPTION
		sorted, subrounded particles
120		
		Grayish orange 10yr7/4 silty sand, fine grained, well sorted, subrounded particles
135		
150		
165		
180		
195		
210		

PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: concrete pad

Size: 5'X5'X8"

Total Depth of Concrete: 15'

GROUT:

Type: Portland/Volclay

Total Thickness: 412

CASING:

Diameter: 4"

Length: 365

Stick Up: 2

SEAL

Type: Bentonite

Quantity: 427'-432'

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SCREEN

Type: Stainless Steel

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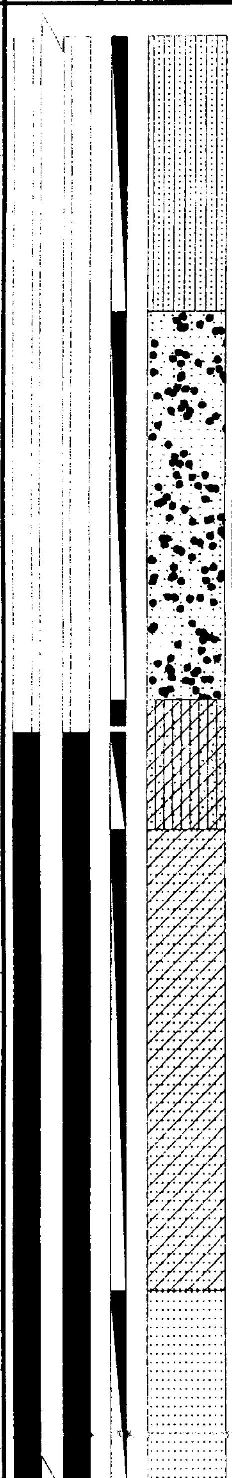
COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1064

PROJECT: Assessment of the Ogallala Aquifer
PROJECT NO.: PTX.001.OGA
LOCATION: Osborne Property
ELEVATION: 3560.24 Surface
DRILLER: Talon Drilling
DATE DRILLED: May 21, 2001
DATE COMPLETED: May 31, 2001
WATER DEPTH: 493'
LOGGER: Chado/Hagan
COMPLETION DEPTH: 792 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
225				
240				Grayish orange 10yr7/4 poorly sorted sand and gravel, sand angular to subangular, gravel rounded.
255				more clay, slightly moist
				some gravel, subrounded, 1/4" size
270				Very pale orange 10yr8/2 sandstone, very fine grained, tightly cemented (calcareous), very hard
				Top of FGZ Dark yellowish orange 10yr6/6 clayey sand, poorly sorted, angular to subangular coarse particles
285				moderately sorted, less clay
300				
315				Grayish orange 10yr7/4 sand, medium to coarse grained, well sorted, subangular particles, some clay



PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: concrete pad
Size: 5'X5'X8"
Total Depth of Concrete: 15'

GROUT:

Type: Portland/Volclay
Total Thickness: 412

CASING:

Diameter: 4"
Length: 365
Stick Up: 2

SEAL

Type: Bentonite
Quantity: 427'-432'
Total Thickness: 5'

SCREEN

Type: Stainless Steel
Diameter: 4"
Slot Size: 0.010 factory
Screened Interval(s): 440'-790'

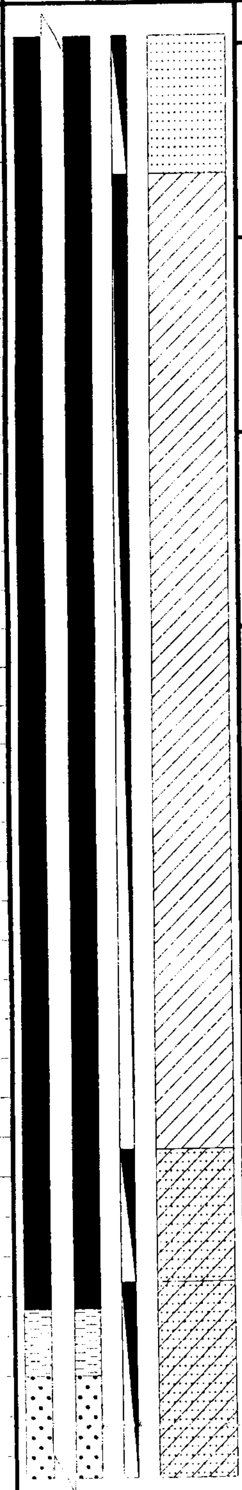
COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1064

PROJECT: Assessment of the Ogallala Aquifer
LOCATION: Osborne Property
DRILLER: Talon Drilling　DATE DRILLED: May 21, 2001
WATER DEPTH: 493'　LOGGER: Chado/Hagan

PROJECT NO.: PTX.001.OGA
ELEVATION: 3560.24 Surface
DATE COMPLETED: May 31, 2001
COMPLETION DEPTH: 792 feet



DEPTH (ft.)	DESCRIPTION
330	more clay content
	Grayish orange 10yr7/4 sandy clay, medium to coarse grained, well sorted, subangular particles
345	
360	more sand content
375	fine rounded to subrounded sand particles
390	
405	
	Grayish orange pink 5yr7/2 clayey sand, very fine grained, rounded to subrounded, well sorted
420	
	Grayish orange 10yr7/4 clayey sand, very fine to fine grained, moderately well sorted, subrounded to rounded particles, some gravel
435	

PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:
Type: concrete pad
Size: 5'X5'X8"
Total Depth of Concrete: 15'

GROUT:
Type: Portland/Volclay
Total Thickness: 412

CASING:
Diameter: 4"
Length: 365
Stick Up: 2

SEAL
Type: Bentonite
Quantity: 427'-432'
Total Thickness: 5'

SCREEN
Type: Stainless Steel
Diameter: 4"
Slot Size: 0.010 factory
Screened Interval(s): 440'-790'

COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1064

PROJECT: Assessment of the Ogallala Aquifer
PROJECT NO.: PTX.001.OGA

LOCATION: Osborne Property
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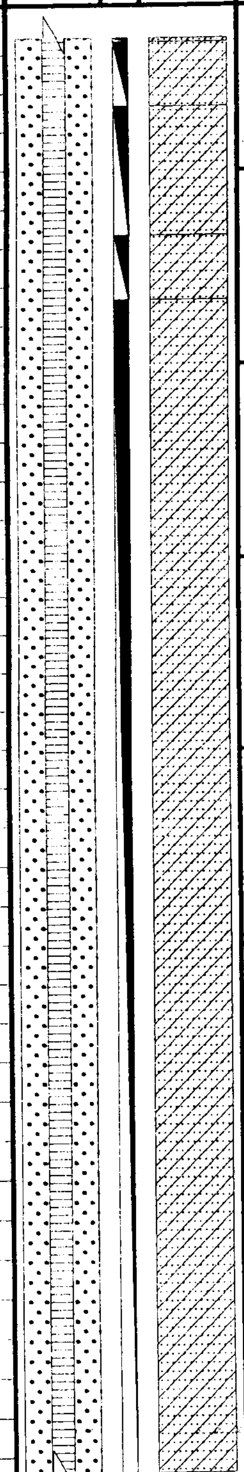
DRILLER: Talon Drilling
DATE DRILLED: May 21, 2001
DATE COMPLETED: May 31, 2001

WATER DEPTH: 493'
LOGGER: Chado/Hagan
COMPLETION DEPTH: 792 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
				Grayish orange 10yr7/4 clayey sand, very fine grained, moderately well sorted
				Grayish orange 10yr7/4 clayey sand, rounded to subrounded
450				
				Pale yellowish brown 10yr6/2 sand and clay
				Grayish orange 10yr7/4 sand and clay, very fine to fine grained, well sorted, rounded to subrounded
465				
				moderately well sorted
480				more sand
495				
				well sorted
510				
525				
540				



PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: concrete pad
Size: 5'X5'X8"
Total Depth of Concrete: 15'

GROUT:

Type: Portland/Volclay
Total Thickness: 412

CASING:

Diameter: 4"
Length: 365
Stick Up: 2

SEAL

Type: Bentonite
Quantity: 427'-432'
Total Thickness: 5'

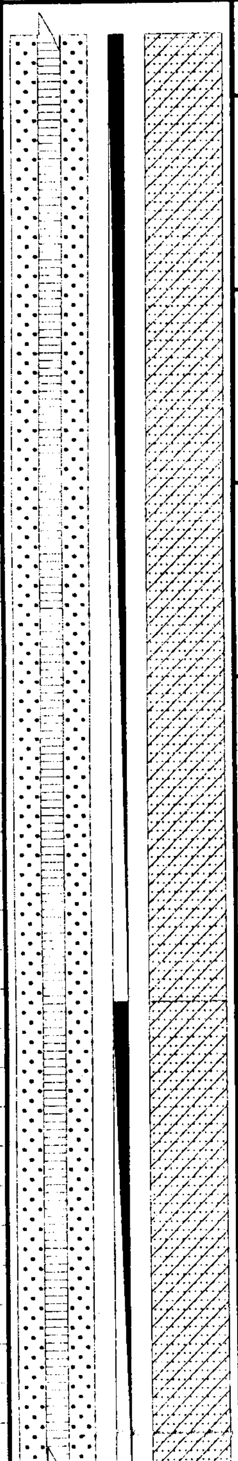
SCREEN

Type: Stainless Steel
Diameter: 4"
Slot Size: 0.010 factory
Screened Interval(s): 440'-790'

COMMENTS

MONITORING WELL LOG
WELL NO. PTX06-1064

PROJECT: Assessment of the Ogallala Aquifer
PROJECT NO.: PTX.001.OGA
LOCATION: Osborne Property
ELEVATION: 3560.24 Surface
DRILLER: Talon Drilling
DATE DRILLED: May 21, 2001
DATE COMPLETED: May 31, 2001
WATER DEPTH: 493'
LOGGER: Chado/Hagan
COMPLETION DEPTH: 792 feet

DEPTH (ft.)	Well Construction Diagram / Sampler / Soil Graphic	DESCRIPTION
555		
570		
585		
600		
615		
630		Dark yellowish orange 10yr6/6 sand and clay, very fine grained, well sorted, rounded to subrounded particles
645		with dark yellowish brown 10yr4/2 clay
660		

PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:
Type: concrete pad
Size: 5'X5'X8"
Total Depth of Concrete: 15'

GROUT:
Type: Portland/Volclay
Total Thickness: 412

CASING:
Diameter: 4"
Length: 365
Stick Up: 2

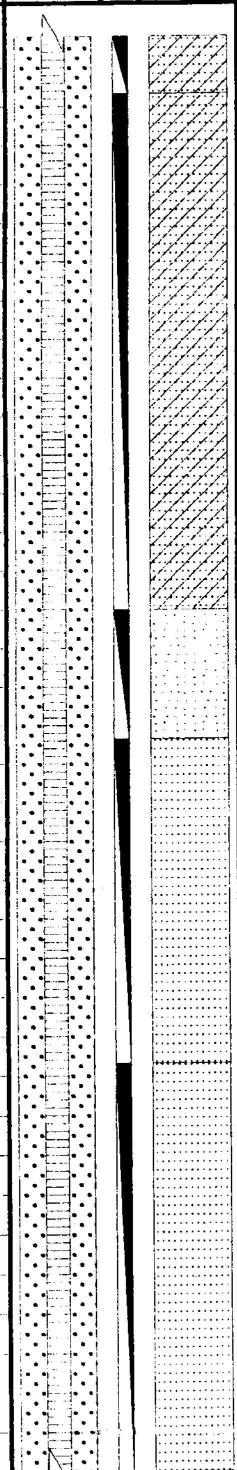
SEAL
Type: Bentonite
Quantity: 427'-432'
Total Thickness: 5'

SCREEN
Type: Stainless Steel
Diameter: 4"
Slot Size: 0.010 factory
Screened Interval(s): 440'-790'

COMMENTS

MONITORING WELL LOG
WELL NO. PTX06-1064

PROJECT: Assessment of the Ogallala Aquifer
PROJECT NO.: PTX.001.OGA
LOCATION: Osborne Property
ELEVATION: 3560.24 Surface
DRILLER: Talon Drilling
DATE DRILLED: May 21, 2001
DATE COMPLETED: May 31, 2001
WATER DEPTH: 493'
LOGGER: Chado/Hagan
COMPLETION DEPTH: 792 feet

DEPTH (ft.)	Well Construction Diagram / Sampler / Soil Graphic	DESCRIPTION
		Dark yellowish orange 10yr6/6 sand and clay, very fine grained, well sorted, rounded particles, intermixed with dark yellowish brown 10yr4/2 clay
675		
		moderately well sorted, fine to very fine grained
690		subangular to rounded particles
		rounded to subrounded particles
705		Dark yellowish orange 10yr6/6 sand, medium to fine grained, moderately sorted, subangular particles
		medium to coarse grained, subangular to angular
		Moderate yellowish brown 10yr5/4 coarse grained, moderately sorted, subangular to angular
720		
735		
		Pale yellowish brown 10yr6/2 sand medium to coarse grained, moderately sorted, angular to subangular
750		
		angular to subrounded
765		

PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:
Type: concrete pad
Size: 5'X5'X8"
Total Depth of Concrete: 15'

GROUT:
Type: Portland/Volclay
Total Thickness: 412

CASING:
Diameter: 4"
Length: 365
Stick Up: 2

SEAL
Type: Bentonite
Quantity: 427'-432'
Total Thickness: 5'

SCREEN
Type: Stainless Steel
Diameter: 4"
Slot Size: 0.010 factory
Screened Interval(s): 440'-790'

COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1064

PROJECT: Assessment of the Ogallala Aquifer

PROJECT NO.: PTX.001.OGA

LOCATION: Osborne Property

ELEVATION: 3560.24 Surface

DRILLER: Talon Drilling

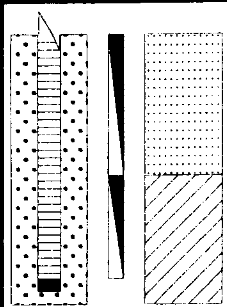
DATE DRILLED: May 21, 2001

DATE COMPLETED: May 31, 2001

WATER DEPTH: 493'

LOGGER: Chado/Hagan

COMPLETION DEPTH: 792 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
780				Moderate reddish brown 10r4/6 clay, very little sample Top of red beds
795				
810				
825				
840				
855				
870				

PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: concrete pad

Size: 5'X5'X8"

Total Depth of Concrete: 15'

GROUT:

Type: Portland/Volclay

Total Thickness: 412

CASING:

Diameter: 4"

Length: 365

Stick Up: 2

SEAL

Type: Bentonite

Quantity: 427'-432'

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010 factory

Screened Interval(s): 440'-790'

COMMENTS

COLOG Division of Layne Christensen Company
17301 West Colfax, Suite 265, Golden Colorado 80[illegible]
PHONE: (303) 279-01[illegible] FAX: (303) 278-0[illegible]

ELECTRIC LOG

COM: Llano Permian
WELL: PTX06-1064
FLD: Pantex Plant
ST: TX COUNTY: Carson

COMPANY: Llano Permian
WELL: PTX06-1064
FIELD: Pantex Plant
STATE: TX COUNTY: Carson

LOCATION:

SEC TWP RGE

OTHER SERVICES:

PERMANENT DATUM: GL ELEVATION: NA
LOG MEAS. FROM: GL 0.0 FT ABOVE PERM. DATUM
DRILL MEAS. FROM: GL

DATE ACQUIRED	May 31, 2001			
RUN NUMBER	1	1		
LOG TYPE	Electric	Natural Gamma		
DEPTH—DRILLER	790'			
DEPTH—LOGGER	790'			
BTM LOGGED INTERVAL	789'	785		
TOP LOGGED INTERVAL	260'	24		
RECORDED BY	T. Stoetz			
WITNESSED BY	J. Chado			
FLUID LEVEL	NA			
FLUID TYPE	Water			
Rm at TEMP	NA			
TIME SINCE CIRC.	NA			
PROBE TYPE, S/N	2PEA 2076			
MODULE TYPE, S/N	MGX II 1144			
LOGGING SPEED	10 ft/min			
A.S.D.E.	NA			
SAMPLE INTERVAL	0.1			
SOURCE SIZE, S/N	none			

BOREHOLE RECORD			CASING RECORD		
BIT SIZE	FROM	TO	SIZE/WGT	FROM	TO
10 3/4"	GL	260'	8 5/8"	GL	260'
7 7/8"	260'	TD			

COMMENTS:

COMMENTS:

NA – NOT AVAILABLE, N/A – NOT APPLICABLE

DIGITAL FILES: 1064.eol, 1064.plp, elec.hdp

Pantex, PTX06-1064, 31 May 2001

COLOG

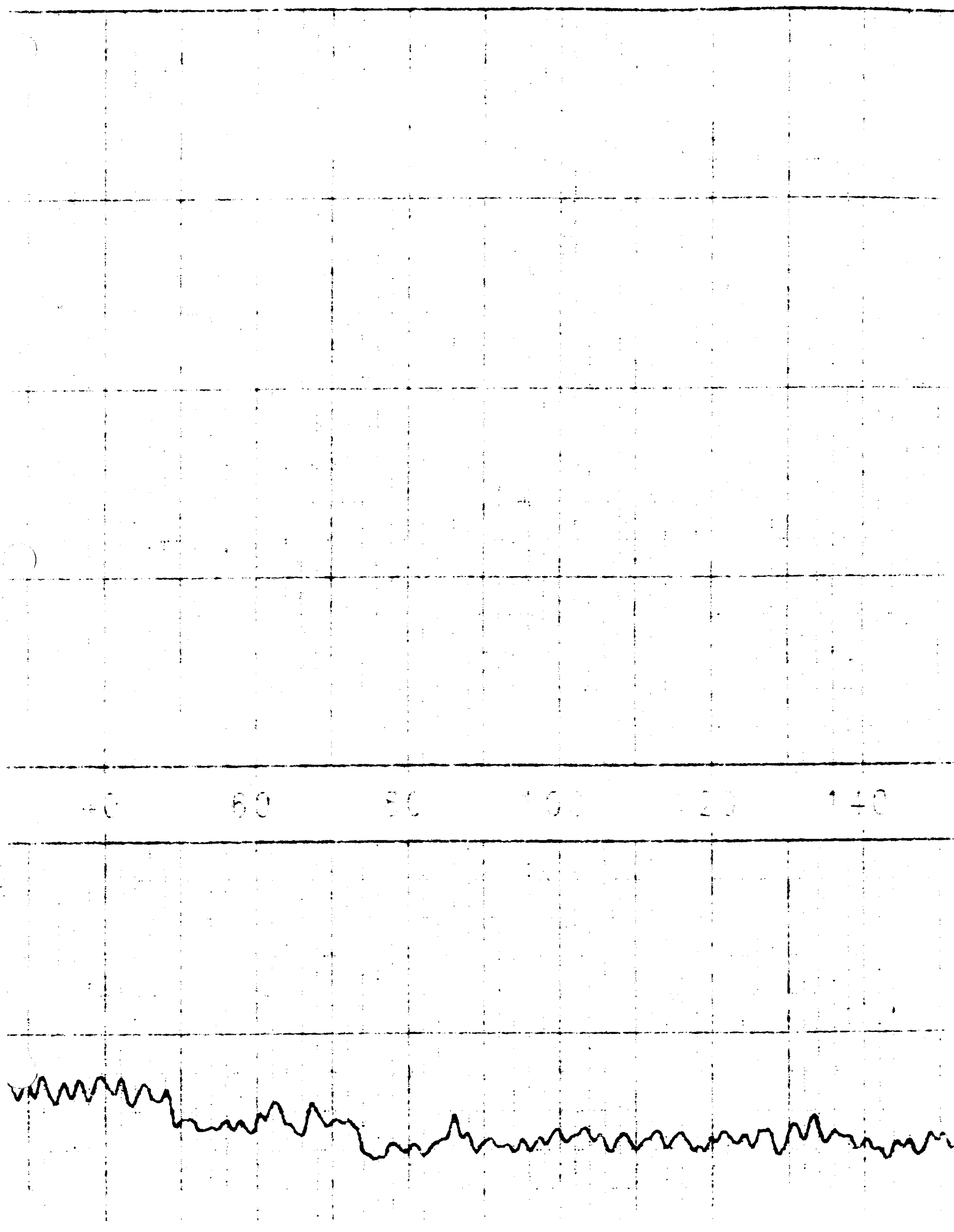
Single Point Resistance
0 Ohms 250

Spontaneous Potential
200 milli Volts 600

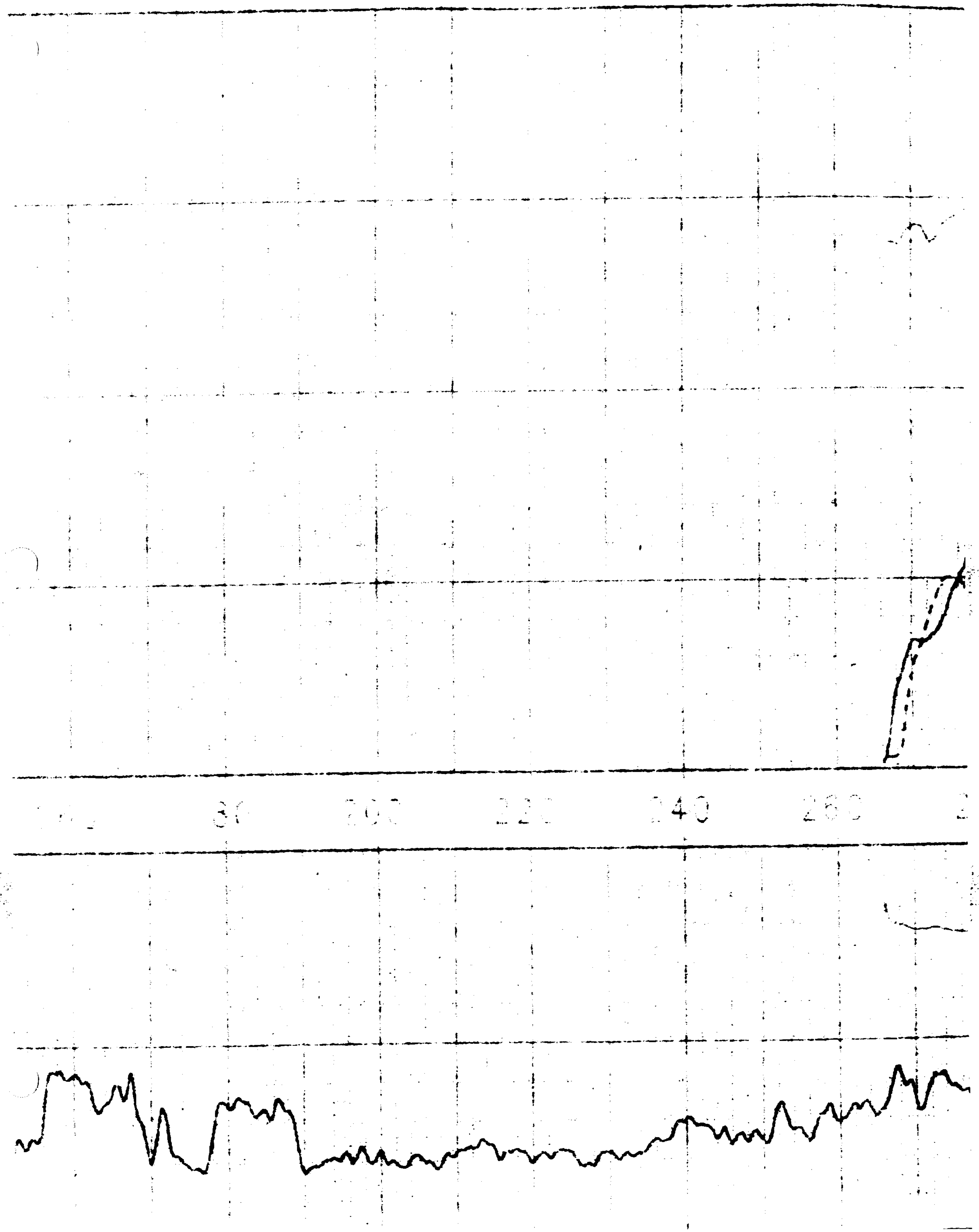
64" Normal Resistivity
0 Ohm-Meters 200

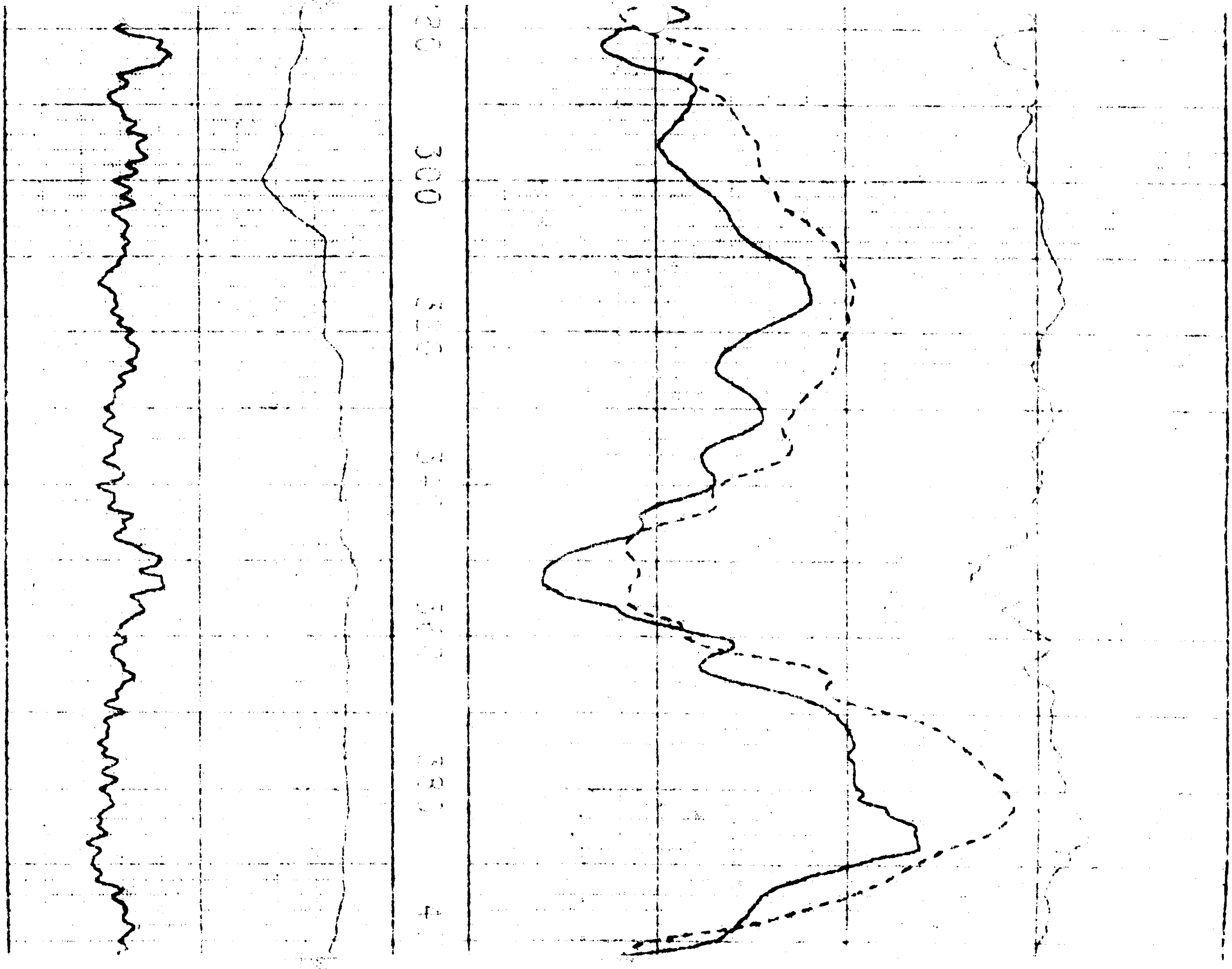
Natural Gamma
0 CPS 150

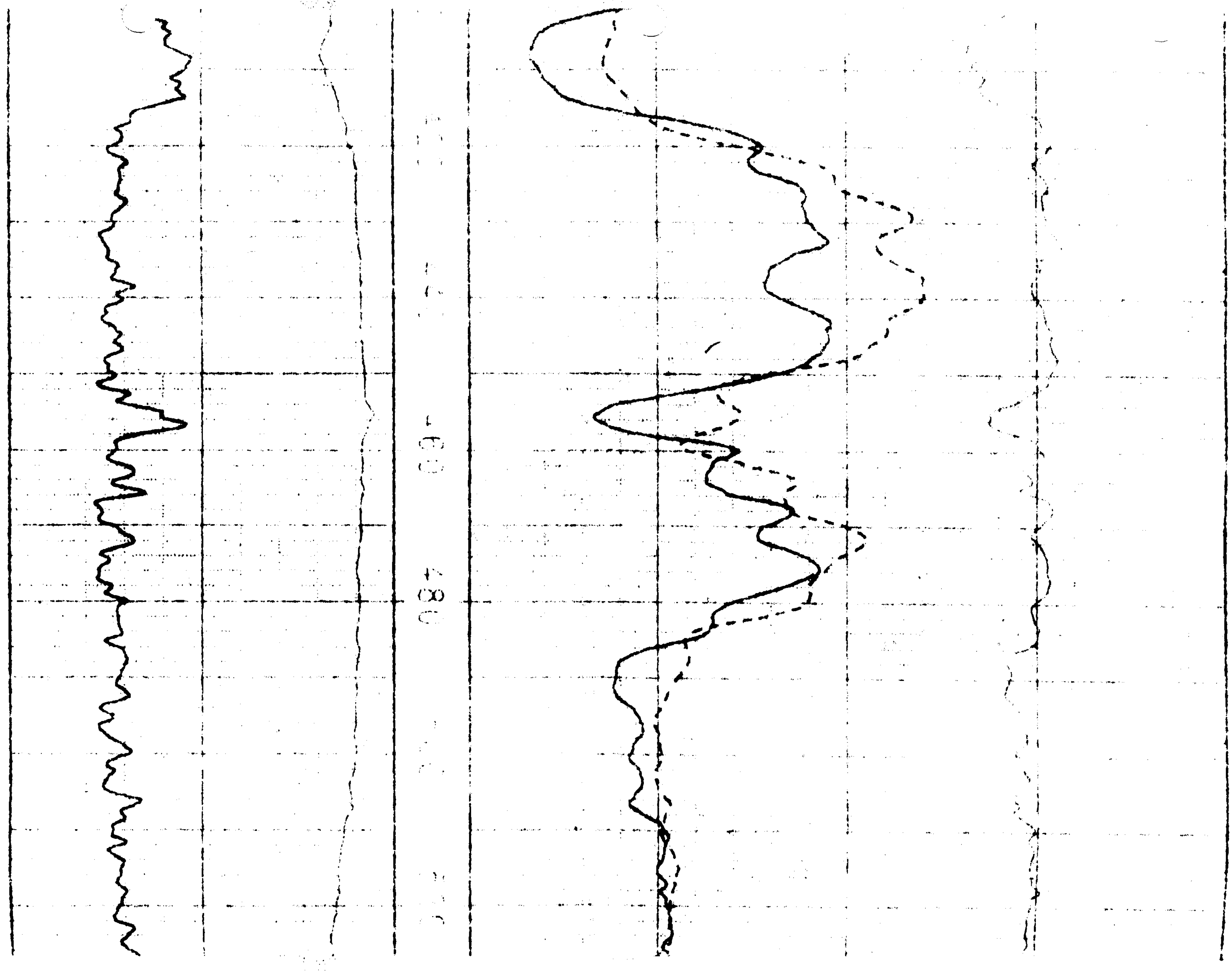
16" Normal Resistivity
0 Ohm-Meters 200

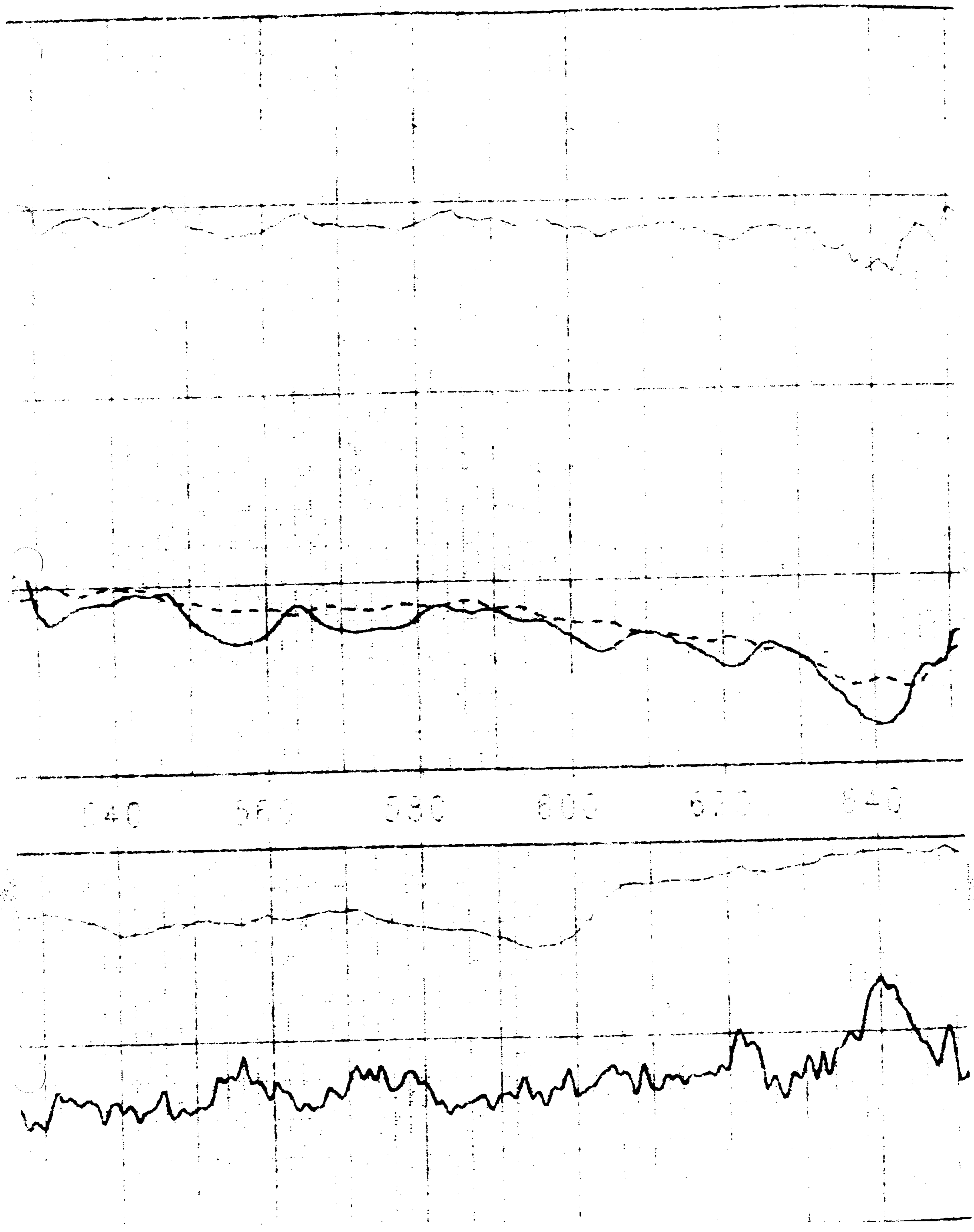


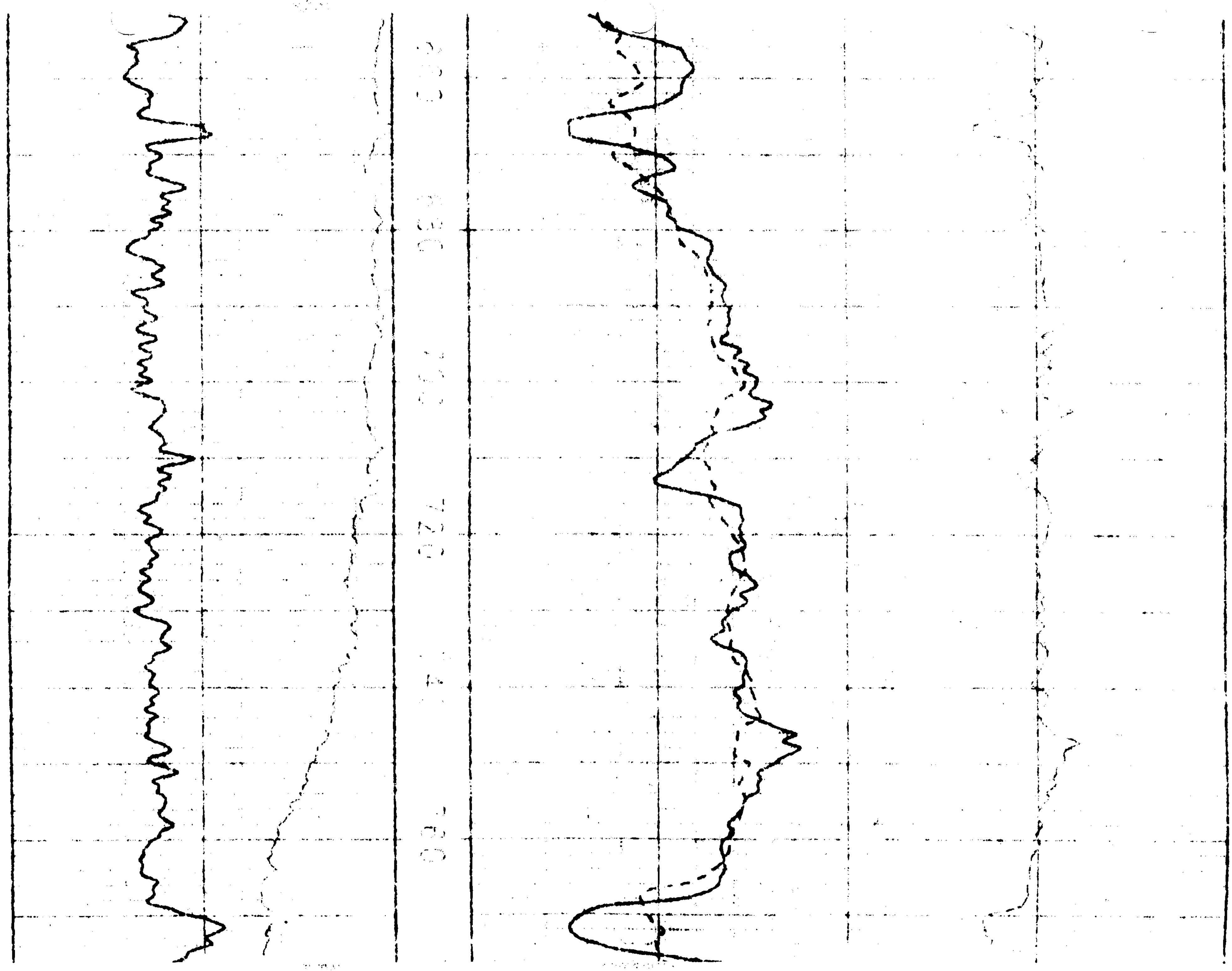
60
140

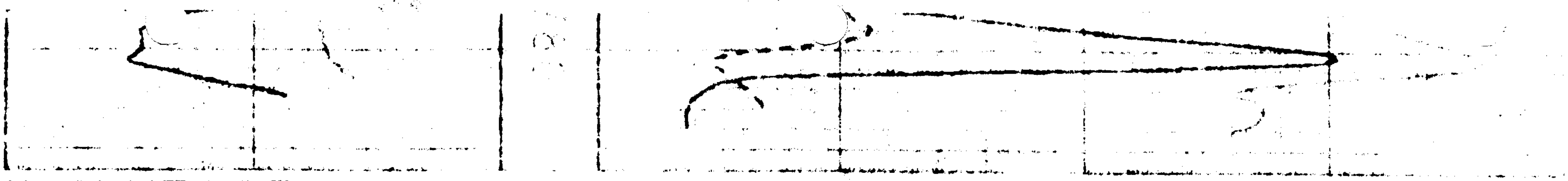

240
260


300




580
600
640





Natural Gamma

0 CPS 150

Spontaneous Potential

200 milli Volts 600

16" Normal Resistivity

0 Ohm-Meters 200

64" Normal Resistivity

0 Ohm-Meters 200

Single Point Resistance

0 Ohms 200

Pantex, PTX06-1064, 31 May 2001

COLOG

Pantex, PTX06-1064, 31 May 2001

COLOG

Single Point Resistance

0 Ohms 200

Spontaneous Potential

200 milli Volts 600

64" Normal Resistivity

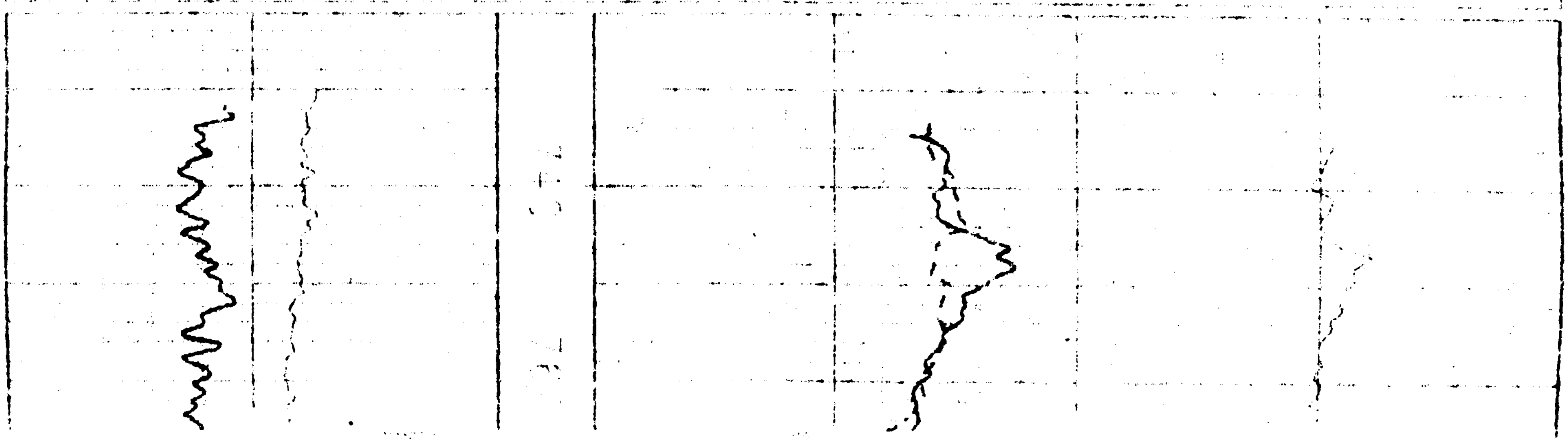
0 Ohm-Meters 200

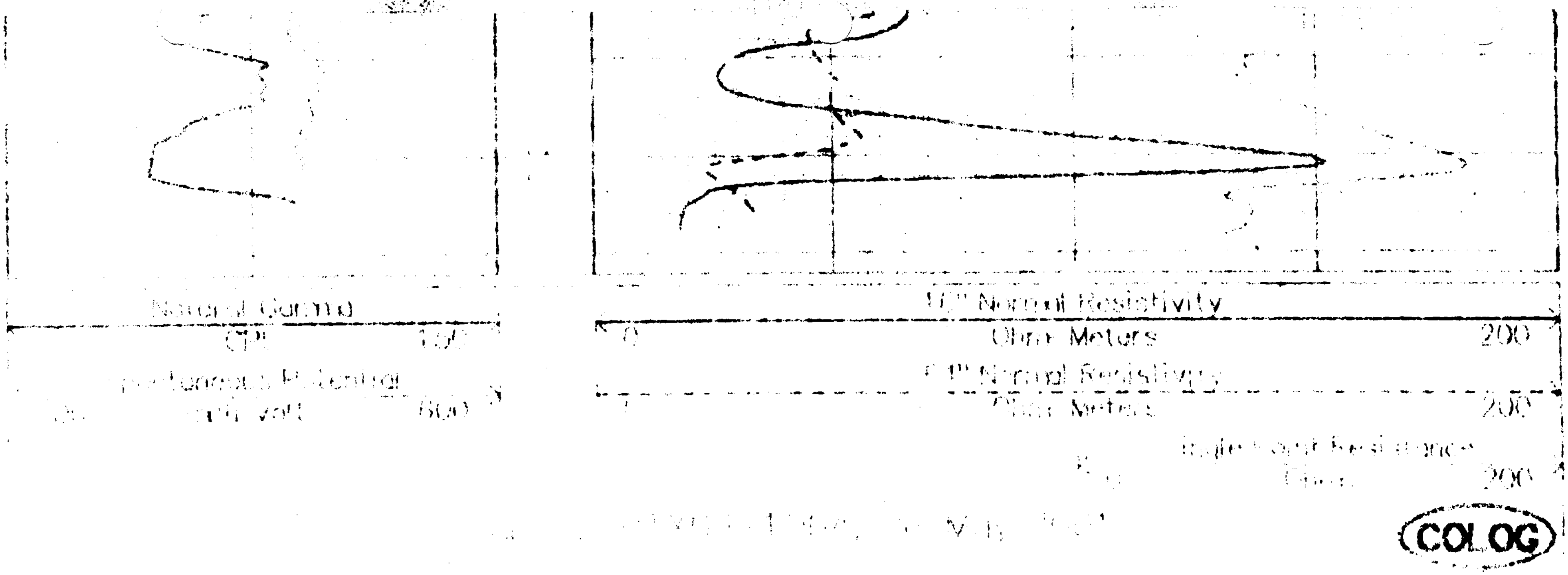
Natural Gamma

0 CPS 150

16" Normal Resistivity

0 Ohm-Meters 200





Natural Gamma
CPS
Normal Resistivity
0
Ohm Meters
200
Normal Resistivity
Ohm Meters
200
600
200
COLOG

COLOG Division of Layne GeoSciences, Inc.

Deviation Survey for: Llano Permian **Field:** Pantex Plant **Date:** 06/23/2001

Well: PTX06-1064 **Depth Ref.:** T.O.C. **Total Depth:** 778.00 **Probe Type, S/N:** SLP, nsn

Depth (feet)	Inclination (degrees)	Bearing (degrees)	ClosureLength (line ft.)	ClosureDist. (horiz. ft.)	ClosureDepth (vertical ft.)	Northing (feet)	Easting (feet)	TrueDepth (feet)	Dist.Sum (feet)	NorthSum (feet)	EastSum (feet)
0	1.0	208	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
25	1.0	50	25	0.42	25.00	0.27	0.32	25.00	0.42	0.27	0.32
50	1.1	318	25	0.48	25.00	0.36	-0.32	49.99	0.63	0.63	0.00
75	1.0	30	25	0.44	25.00	0.38	0.22	74.99	1.03	1.00	0.22
100	1.0	43	25	0.41	25.00	0.30	0.28	99.98	1.40	1.31	0.50
125	0.9	339	25	0.41	25.00	0.38	-0.15	124.98	1.73	1.69	0.35
150	0.9	54	25	0.41	25.00	0.24	0.33	149.98	2.05	1.93	0.68
175	1.0	185	25	0.44	25.00	-0.43	-0.04	174.97	1.63	1.49	0.64
200	0.9	348	25	0.39	25.00	0.38	-0.08	199.97	1.96	1.88	0.56
225	1.0	345	25	0.44	25.00	0.42	-0.11	224.97	2.34	2.30	0.45
250	1.0	356	25	0.44	25.00	0.44	-0.03	249.96	2.77	2.73	0.42
275	0.8	185	25	0.33	25.00	-0.33	-0.03	274.96	2.44	2.41	0.39
300	0.7	185	25	0.28	25.00	-0.28	-0.02	299.96	2.16	2.13	0.37
325	0.9	326	25	0.37	25.00	0.31	-0.21	324.96	2.44	2.43	0.16
350	0.8	330	25	0.35	25.00	0.30	-0.17	349.95	2.74	2.74	-0.02
375	0.8	15	25	0.35	25.00	0.34	0.09	374.95	3.07	3.07	0.07
400	0.9	358	25	0.37	25.00	0.37	-0.01	399.95	3.44	3.44	0.06
425	0.9	335	25	0.39	25.00	0.36	-0.17	424.95	3.80	3.80	-0.10
450	0.9	320	25	0.39	25.00	0.30	-0.25	449.94	4.12	4.10	-0.36
475	0.9	350	25	0.37	25.00	0.37	-0.06	474.94	4.49	4.47	-0.42
500	1.0	330	25	0.42	25.00	0.37	-0.21	499.94	4.87	4.83	-0.63
525	1.0	320	25	0.44	25.00	0.34	-0.28	524.93	5.25	5.17	-0.92
550	0.8	332	25	0.35	25.00	0.31	-0.16	549.93	5.58	5.48	-1.08
575	0.9	305	25	0.39	25.00	0.23	-0.32	574.93	5.87	5.70	-1.40
600	1.2	273	25	0.52	24.99	0.03	-0.52	599.92	6.05	5.73	-1.92
625	1.0	292	25	0.44	25.00	0.16	-0.40	624.92	6.34	5.89	-2.33
650	1.0	264	25	0.44	25.00	-0.05	-0.43	649.91	6.47	5.85	-2.76
675	0.9	308	25	0.38	25.00	0.23	-0.30	674.91	6.81	6.08	-3.06
700	1.0	346	25	0.44	25.00	0.42	-0.11	699.91	7.23	6.50	-3.16
725	0.9	185	25	0.37	25.00	-0.37	-0.03	724.90	6.92	6.13	-3.20
750	1.8	173	25	0.76	24.99	-0.76	0.09	749.89	6.21	5.38	-3.10
775	0.4	33	25	0.15	25.00	0.13	0.08	774.89	6.28	5.50	-3.02

Totals:

True Depth	DistSum	NorthSum	EastSum
774.89	**6.28**	**5.50**	**-3.02**

Orientations are with respect to Magnetic North

Attention Owner:
Confidentiality Privilege Notice on reverse side of owner's copy.

Texas Department of License and Regulation

Water Well Driller/Pump Installer Program
P.O. Box 12157 Austin, Texas 78711 (512) 463-7880 FAX (512) 463-8616
Toll free (800) 803-9202
Email address: water.well@license.state.tx.us

This form must be completed and filed with the department and owner within 60 days upon completion of the well.

WELL REPORT

A. WELL IDENTIFICATION AND LOCATION DATA

1) OWNER

Name	Address	City	State	Zip
United States Department of Energy	P.O. Box 30020	Amarillo	Texas	79120-0020

2) WELL LOCATION

County	Physical Address	City	State	Zip
Carson	F.M. 2373 & U.S. Hwy. 60	Panhandle	Texas	79068

Lat. | Long. | Grid # 06-44-02

3) Type of Work
■ New Well ☐ Deepening
☐ Reconditioning
PTX-06-1064

4) Proposed Use (check) ■ Monitor ☐ Environmental Soil Boring ☐ Domestic ☐ Industrial ☐ Irrigation ☐ Injection ☐ Public Supply ☐ De-watering ☐ Testwell
If Public Supply well, were plans submitted to the TNRCC? ☐ Yes ☐ No

5) N↑
X

6) Drilling Date
Started 05/18/01
Completed 05/31/01

Diameter of Hole

Dia. (in)	From (ft)	To (ft)
12.75	0	270
8.875	270	792

7) Drilling Method (check) ☐ Driven ☐ Air Rotary ■ Mud Rotary ☐ Bored ☐ Air Hammer ☐ Cable Tool ☐ Jetted ■ Other Dual Rotary Method

From (ft)	To (ft)	Description and color of formation material
0	5	Yellowish Brown Clay
5	100	Light Brown Sandy Clay
100	125	Yellowish Orange Silty Sand
125	265	Grayish Orange Fine Silty Sand
265	280	Pale Orange Sand
280	310	Yellowish Orange Clayey Sand
310	425	Grayish Orange Fine Sand
425	440	Brownish Black Fine Gravel
440	450	Grayish Orange Fine sand
450	455	Yellowish Brown Sand
455	625	Grayish Orange Fine Sand
625	710	Yellowish Orange Fine-Medium Sand

(Use reverse side of Well Owner's copy, If necessary)

8) Borehole Completion ☐ Open Hole ☐ Straight Wall ☐ Under-reamed ☐ Gravel Packed ■ Other Sand
If Gravel Packed give the interval from 432 ft. to 791 ft.

Casing, Blank Pipe, and Well Screen Data

Dia. (in.)	New Or Used	Steel, Plastic, etc. Perf., Slotted, etc. Screen Mfg., if commercial	Setting (ft) From	To	Gage Casing Screen
8.875	N	Steel Riser	0	270	0.250
4.25	N	Stainless Steel Riser	0	440	0.125
4.25	N	Stainless Steel Screen	440	790	0.125
4.25	N	Stainless Steel Riser	790	791	0.125

9) Cementing Data
Cementing from 0 ft. to 270 ft. # of sacks used 34
0 ft. to 432 ft. # of sacks used 33
Method Used Grout Pump/Tremmie Line
Cementing By Quanah Gilmore
Distance to septic system field or other concentrated contamination ____ ft.
Method of verification of above distance ____

13) Plugged ☐ Well plugged within 48 hours
Casing left in well: Cement/Bentonite placed in well:

From (ft)	To (ft)	From (ft)	To (ft)	Sacks used

10) Surface Completion
☐ Specified Surface Slab Installed
■ Specified Surface Sleeve Installed
☐ Pitless Adapter Used
☐ Approved Alternative Procedure Used

14) Typepump
☐ Turbine ☐ Jet ☐ Submersible ☐ Cylinder
☐ Other ____
Depth to pump bowls, cylinder, jet, etc., ____ ft.

11) Water Level
Static level 493 ft. below Date 06/01/01
Artesian Flow ____ gpm. Date / /

15) Water Test
Typetest ☐ Pump ☐ Bailer ☐ Jetted ■ Estimated
Yield: 7 gpm with 20 ft. drawdown after 1 hrs.

16) Water Quality
Did you knowingly penetrate any strata which contain undesirable constituents?
☐ Yes ■ NO If yes, did you submit a REPORT OF UNDESIRABLE WATER?
Type of water ____ Depth of Strata ____
Was a chemical analysis made? ☐ Yes ☐ No

12) Packers Type Depth
None

Company or Individual's Name (type or print) Quanah Gilmore Talon Drilling, Inc. Lic. No. 54519WI
Address P.O. Box 20596 City Amarillo State Texas Zip 79114

Signature	07/16/01	Signature	/ /
Licensed Driller/Pump Installer	Date	Apprentice	Date

TDLR FORM 004WWD Copies to TDLR - Owner - Driller/Pump Installer

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

Section 32.005 of the Texas Water Code, concerning confidential information in the Reporting of Well Logs, reads as follows:

> "Every licensed driller drilling, deepening, or otherwise altering a water well within this State shall make and keep a legible and accurate well log in accordance with the department rule on forms prescribed by the department. Not later than the 60th day after the completion or cessation of drilling, deepening, or otherwise altering the well, the licensed driller shall deliver or transmit by certified mail a copy of the well log to the department and to the owner of the well or the person for whom the well was drilled. Each copy of a well log, other than a department copy, must include the name, mailing address, and telephone number of the department. The well log shall be recorded at the time of drilling, and must show the depth, thickness, and character of the strata penetrated, the location of water-bearing strata, the depth, size, and character of casing installed, and any other information required by department rule. The department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner or person for whom the well was drilled.

The last sentence specifies the means whereby you may, if you wish, assure that logs of your wells will be kept confidential.

From (ft.)	To (ft.)	Description and color of formation material
710	782	Yellowish Brown Coarse to
		Medium Sand
782	792	Dense Red Clay

PTX06-1068

aka: <none>

Contractor: Layne Christensen
Contract #:
Contractor's Project #: 3615
Drilled date: 05/01/01 – 05/08/01

OPTIX #:
Last Update: 6/1/2004 (previously had only cover sheet; added missing well record)

Standard Included Documents

(Others may also be included)

Drilling/Boring Log
___Draft
___Final

___Installation Log/Diagram

Lithologic Logs
___Draft Visual Classification of Soils (handwritten)
_X_Final Visual Classification of Soils (computerized)

Geophysical Logs
___Neutron
___Gamma
___e-Log
___Bond Log
___Deviation Log

___State Well Report

PTX06-1068

Burning Grounds Soil Gas | **Pantex Plant (Northeast Corner of Plant)** | **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	T. Hall/P. Fahringer/R. Rupp	Northing: 3773360.30	Easting: 643403.70
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	805' BGS
Dates Drilled:	05/01/01 - 05/08/01	Depth to Water:	501.6' BTOC 08/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3533.88'	TOC Elevation:	3536.85'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML	0-3' SILT, clayey, sandy, brown , moist, Topsoil		
	10		CL	3-15' CLAY, slightly sandy, reddish yellow (7.5YR 6/6), slightly plastic, soft, damp, very fine grain sand		
	20		CL	15-25' CLAY, sandy, 60% clay, 40% sand, reddish yellow (7.5YR 6/6) to pinkish white (7.5YR 8/2), very fine grain sand, loose, dry		
	30		CL	25-35' CLAY, sandy to SAND, clayey, 50/50 clay/sand, light brown (7.5YR 6/3), very fine grain sand, loose, damp		
			SC	35-40' SAND, clayey, 70% sand, 30% clay, reddish yellow (7.5YR 6/6), low plasticity, very fine grained, dense, dry		
	40		SC	40-50' SAND, clayey, 80% sand, 20% clay, trace silt, light brown (7.5YR 6/4), very fine grained, loose, dry		
	50		CL	50-60' CLAY, sandy, 80% clay, 20% sand, strong brown (7.5YR 5/6), very fine grained sand, medium stiff angular clay nodules, slightly damp		
	60		SC	60-65' SAND, clayey, silty, 80% sand, 20% clay, pink (7.5YR 7/3), very fine grained, loose, damp		
			SM	65-70' SAND, silty, clayey, 60% sand, 30% silt, 10% clay, pink (5YR 7/4), trace small angular gravel, loose, damp		
	70		SM	70-78' SAND, silty, clayey, reddish yellow (5YR 6/6), damp		
	80		SLT STN	78-88' CALICHE CAPROCK, pinkish white (7.5YR 8/2); sandy, silty from 78-80'; more developed at 80'; competent caprock at 85'		
	90		SM	88-100' SAND, with caliche, pinkish white (7.5YR 8/2)		

PTX06-1068

Burning Grounds Soil Gas | **Pantex Plant (Northeast Corner of Plant)** | **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	T. Hall/P. Fahringer/R. Rupp	Northing: 3773360.30	Easting: 643403.70
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	805' BGS
Dates Drilled:	05/01/01 - 05/08/01	Depth to Water:	501.6' BTOC 08/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3533.88'	TOC Elevation:	3536.85'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SM	100-110' SAND, silty, pink (7.5YR 8/3), very fine grained, loose, slightly damp, very silty, with caliche nodes to 1/4" diameter		PTX06-1068-2-0100 HE/VOC
	110		SM	110-115' SAND, silty, pink (5YR 7/3), very fine grained, loose, slightly damp		
			SM	115-120' SAND, silty, pink (7.5YR 8/3), very fine grained, rounded, loose, slightly damp to dry, silt dropping out		
	120		SM	120-125' SAND, slightly silty with 20% hard caliche nodules, pink (7.5YR 8/3), loose, slightly damp		
			SM	125-130' SAND, silty, loose, damp to slightly moist, caliche nodes dropping out		
	130		SM	130-145' SAND, silty, pink (7.5YR 7/3), very fine grain, rounded, loose, damp to slightly moist, decreasing silt at 140'		
	140					
			SP	145-150' SAND, slightly silty, pink (7.5YR 7/4), very fine grain, poorly graded, loose, slightly damp		
	150		SP	150-160' SAND, slightly silty, pink (7.5YR 7/3), very fine grain, 10% fine grain, poorly graded, loose, slightly damp		PTX06-1068-2-0150 HE/VOC
	160		SP	160-180' SAND, pink (7.5YR 7/4), very fine to fine grain, 10-15% medium grain, angular to subangular, loose, slightly damp, increase in mafic material		
	170					
	180		SM	180-190' SAND, silty, 30% silt, pink (7.5YR 7/3), very fine to fine grain, subrounded, loose, very slightly damp, angular caliche nodules to 1/2" diameter		
	190		SM	190-200' SAND, silty, reddish yellow (7.5YR 6/6), very fine grain, loose, damp, very silty with caliche nodes decreasing in abundance and size		

S:\WELLOG\Pantex BGSG #3615\PTX06-1068.wld

PTX06-1068

Burning Grounds Soil Gas | **Pantex Plant (Northeast Corner of Plant)** | **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	T. Hall/P. Fahringer/R. Rupp	Northing: 3773360.30	Easting: 643403.70
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	805' BGS
Dates Drilled:	05/01/01 - 05/08/01	Depth to Water:	501.6' BTOC 08/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3533.88'	TOC Elevation:	3536.85'

Depth (Ft.)	USCS	Description	Sample Number
200	SP	200-210' SAND, light brown (7.5YR 6/3), very fine grained with mafic material, loose, dry	PTX06-1068-2-0200 HE/VOC
210	SM	210-220' SAND, silty, pink (7.5YR 7/3), very fine grained, loose, slightly damp to moist	
220	SC	220-223' SAND, clayey, pink (7.5 YR 7/3), fine grain sand with medium plastic clay, medium dense, damp to moist	PTX06-1068-2-0223 HE/VOC/Permeability
	CL	223-230' CLAY, sandy, light reddish brown (7.5YR 6/4), medium plastic (ropes when wet), medium grain sand, stiff, slightly moist to moist	
230	SC	230-240' SAND, brown (7.5YR 5/4), very coarse grain sand with clay balls, loose, moist to saturated	
240	GW	240-244' GRAVEL, sandy, brown (7.5YR 5/4), very large gravel to 1 1/2" diameter (some fresh surfaces), fine to medium grain sand, dense, moist	
	SC	244-247' SAND, clayey, brown (7.5YR 5/4), fine to medium grain, medium dense, moist	
250	CL	247-257' CLAY, silty, pink (7.5YR 7/4), stiff, dry, fine grain zone material	PTX06-1068-2-0255 HE/VOC
		Conductor Casing cemented at 253.25 feet	
260–290	CL	257-309' CLAY, some silt, brown (7.5YR 5/4), plastic, hard	

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PTX06-1068

Burning Grounds Soil Gas | **Pantex Plant (Northeast Corner of Plant)** | **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	T. Hall/P. Fahringer/R. Rupp	Northing: 3773360.30	Easting: 643403.70
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	805' BGS
Dates Drilled:	05/01/01 - 05/08/01	Depth to Water:	501.6' BTOC 08/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3533.88'	TOC Elevation:	3536.85'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			CL			
	310, 320, 330		SC	309-340' SAND, clayey, silty, light brown (7.5YR 6/4), fine to very fine grain, well sorted, decreasing clays wih depth		
	340		ML	340-350' SILT, clayey, sandy, light brown (7.5YR 6/4), some very fine grain sandstone, increasing clay with depth		
	350		CL	350-360' CLAY, caliche, pink (7.5YR 7/4), hard, trace very fine grain subangular quartzose sand, some feldspar		
	360, 370		SC	360-375' SAND, clayey, with caliche, pale brown (10YR 6/3), very fine grain, rounded, quartzose, caliche as medium to coarse grain fragments, clay dropping out with depth		
			SP	375-380' SAND, with caliche, very pale brown (10YR 7/3), fine grain, some medium grains, subangular to angular, quartzose		
	380		SLT STN	380-385' CALICHE ROCK, white to light gray (10YR 8/1 - 10YR 7/1), hard		
	390		SP	385-400' SAND, with caliche, light yellowish brown (10YR 6/4), very fine to fine grain, subrounded to rounded, poorly graded, quartzose, trace brown clay increasing to 10% with depth		

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PTX06-1068

Burning Grounds Soil Gas	Pantex Plant (Northeast Corner of Plant)	Amarillo, Texas	
Project Number:	3615	Client:	BWXT Pantex
Geologist:	T. Hall/P. Fahringer/R. Rupp	Northing: 3773360.30	Easting: 643403.70
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	805' BGS
Dates Drilled:	05/01/01 - 05/08/01	Depth to Water:	501.6' BTOC 08/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3533.88'	TOC Elevation:	3536.85'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
				400-500' SANDSTONE, silty, with caliche, light brownish gray (10YR 6/2), very fine to medium grain, subangular to subrounded, graded, dense		
	410					
	420					
	430					
	440					
	450		SM			
	460			@ 460' SAND, silty as above, light gray (10YR 7/2)		
	470					
				@ 475' SAND, silty, as above, some clay, pale brown to light yellowish brown (10YR 6/3 - 6/4)		
	480					
	490			@ 490' increasing brown clay		

PTX06-1068

Burning Grounds Soil Gas | **Pantex Plant (Northeast Corner of Plant)** | **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	T. Hall/P. Fahringer/R. Rupp	Northing: 3773360.30	Easting: 643403.70
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	805' BGS
Dates Drilled:	05/01/01 - 05/08/01	Depth to Water:	501.6' BTOC 08/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3533.88'	TOC Elevation:	3536.85'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	510		CL	500-522' CLAY, sandy, yellowish brown (10YR 5/4), plastic, fine grain subangular sand Water Level at 501.6 feet BTOC on August 7, 2001		
	520					
			SC	522-528' SAND, clayey, fine to coarse grain, subrounded to angular		
	530		CL	528-535' CLAY, sandy, gravelly, yellowish brown (10YR 5/8), very coarse sand, subangular to subrounded		
	540			535-567' GRAVEL, sandy, very coarse, multi-colored lithic fragments, angular to subrounded, some residual clay from above		
	550		GW			
	560					
	570		GP	567-577' GRAVEL, very little sand, angular to rounded and flattened peagravel		
			GC	577-580' GRAVEL, peagravel as above with interbedded clay		
	580			580-597' GRAVEL, particle size to very coarse sand		
			GW	@ 587' clay drops out		
	590					
			GW	597-617' GRAVEL, sandy, multi-colored, fine to very coarse		

PTX06-1068

Burning Grounds Soil Gas | **Pantex Plant (Northeast Corner of Plant)** | **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	T. Hall/P. Fahringer/R. Rupp	Northing: 3773360.30	Easting: 643403.70
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	805' BGS
Dates Drilled:	05/01/01 - 05/08/01	Depth to Water:	501.6' BTOC 08/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3533.88'	TOC Elevation:	3536.85'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	610		GW	sand and gravel, subrounded to angular		
	620, 630, 640		SW	617-645' SAND, fine to very coarse sand as above with trace clay		
	650		SC	645-657' SAND, clayey, sand as above with significant clay to 40%		
	660, 670		CL	657-677' CLAY, sandy, gravelly		
			SC	677-680' SAND, gravelly, clayey, fine to very fine grained sand; Transition Zone about 680'		
	680, 690		SW	680-697' SAND, coarse to fine grained, poorly sorted, angular to rounded, less gravel with depth		
			SP	697-702' SAND, medium to fine grained, well sorted,		

PTX06-1068

Burning Grounds Soil Gas | **Pantex Plant (Northeast Corner of Plant)** | **Amarillo, Texas**

Project Number:	3615	Client:	BWXT Pantex
Geologist:	T. Hall/P. Fahringer/R. Rupp	Northing: 3773360.30	Easting: 643403.70
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	805' BGS
Dates Drilled:	05/01/01 - 05/08/01	Depth to Water:	501.6' BTOC 08/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3533.88'	TOC Elevation:	3536.85'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP	moderately well rounded		
	710, 720		CL	702-730' CLAY, gravelly, sandy, light brown, plastic, soft, some interbedding after 720'		
	730, 740, 750		GC	730-760' SAND/GRAVEL, clayey, silty, 65% coarse sand and gravels mixed with 25% clay and 10% silt 745-760' interbedding of gravels, sands, and clays		
	760, 770		CL	760-781' CLAY, some fine grain sand mixed in as interbeds, some white clays at 777-781'		
	780		CL	781-785' CLAY, light reddish brown (5YR 6/4), hard, little return on cuttings, some thin sand layers, drilling fluid is light brown and thick		
	790		CL	785-796' CLAY, medium plastic, stiff to very stiff, mixed with light gray caliche and red brown siltstone		
			CL	796-805' CLAY, red (2.5YR 5/4) to light brown (7.5YR 6/4),		

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PTX06-1068

Burning Grounds Soil Gas	**Pantex Plant (Northeast Corner of Plant)**	**Amarillo, Texas**	
Project Number:	3615	Client:	BWXT Pantex
Geologist:	T. Hall/P. Fahringer/R. Rupp	Northing: 3773360.30	Easting: 643403.70
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	805' BGS
Dates Drilled:	05/01/01 - 05/08/01	Depth to Water:	501.6' BTOC 08/07/01
Borehole Type:	11" ARCH 8" Mud Rotary	Well Type:	Monitoring Well, 4" Type 316 SS
Ground Elevation:	3533.88'	TOC Elevation:	3536.85'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			CL	very stiff to very hard, very slow drilling (penetration rate 15 minutes/ft. from 798-802'), little return of cuttings, drilling fluid turning red		
	810			Total Depth of Borehole 805' BGS Fine Grain Zone 247-295' BGS Red Beds 796' BGS		
	820			Well Completion Details: Borehole Diameter: 11" from surface to 253' 8" from 253' to 805'		
	830			8 5/8" steel conductor casing cemented from surface to 253' Total Depth of Well 804' 4-inch, Schedule 10, Type 316, Stainless Steel Casing and 10-Slot Screen		
	840			457' Blank (+3-454') 300' Screen (454-754') 20' Blank (754-774') 25' Screen (774-799') 5' Sump (799-804')		
	850			22' Cement seal (0-22') 403' Volclay bentonite grout (22-425') 11' Bentonite seal (425-436') 325' Filter pack, 10/20 Colorado Silica Sand (436-761') 9' Bentonite seal (761-770') 35' Filter pack, 10/20 Colorado Silica Sand (770-805')		
	860					
	870			Surface Completion: Concrete pad (5'X5'X8") with four bollards and 10-inch steel protective casing with locking cover.		
	880					
	890					

COLOG Division of Layne Christensen Company
17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

GAMMA-ELECTRIC

COM: S.M. Stoller
WELL: PTX06-1068
FLD: Pantex Plant
ST: TX COUNTY: Carson

COMPANY: S.M. Stoller
WELL: PTX06-1068
FIELD: Pantex Plant
STATE: TX COUNTY: Carson

LOCATION:

SEC TWP RGE

OTHER SERVICES:
DEVIATION

PERMANENT DATUM: GL ELEVATION: NA
LOG MEAS. FROM: GL 0.0 FT ABOVE PERM. DATUM
DRILL MEAS. FROM: GL

DATE ACQUIRED	May 15, 2001			
RUN NUMBER	1			
LOG TYPE	GAMMA-ELECTRIC			
DEPTH-DRILLER	805'			
DEPTH-LOGGER	805'			
BTM LOGGED INTERVAL	804'			
TOP LOGGED INTERVAL	GL			
RECORDED BY	T. Staatz			
WITNESSED BY	P. Fahringer			
FLUID LEVEL	NA			
FLUID TYPE	Water			
Rm at TEMP	NA			
TIME SINCE CIRC.	NA			
PROBE TYPE, S/N	2PEA, 2078			
MODULE TYPE, S/N	MGX II 1144			
LOGGING SPEED	15 ft/min			
A.S.D.E.	NA			
SAMPLE INTERVAL	0.5'			
SOURCE SIZE, [illegible]	none			

BOREHOLE RECORD			CASING RECORD		
BIT SIZE	FROM	TO	SIZE/WGT	FROM	TO
12 3/4"	GL	253'	8 5/8"	-1'	253'
7 5/8"	253'	TD			

COMMENTS:

COMMENTS:

\ - NOT AVAILABLE, N/A - NOT APPLICABLE

DIGITAL FILES: 1068.eb3, 1068.eb2, 1068.hdp

PANTEX WELL PTX06-1068 15 MAY 2001

COLOG

Single Point Resistance

PANTEX WELL PTX06-1068 15 MAY 2001 COLOG

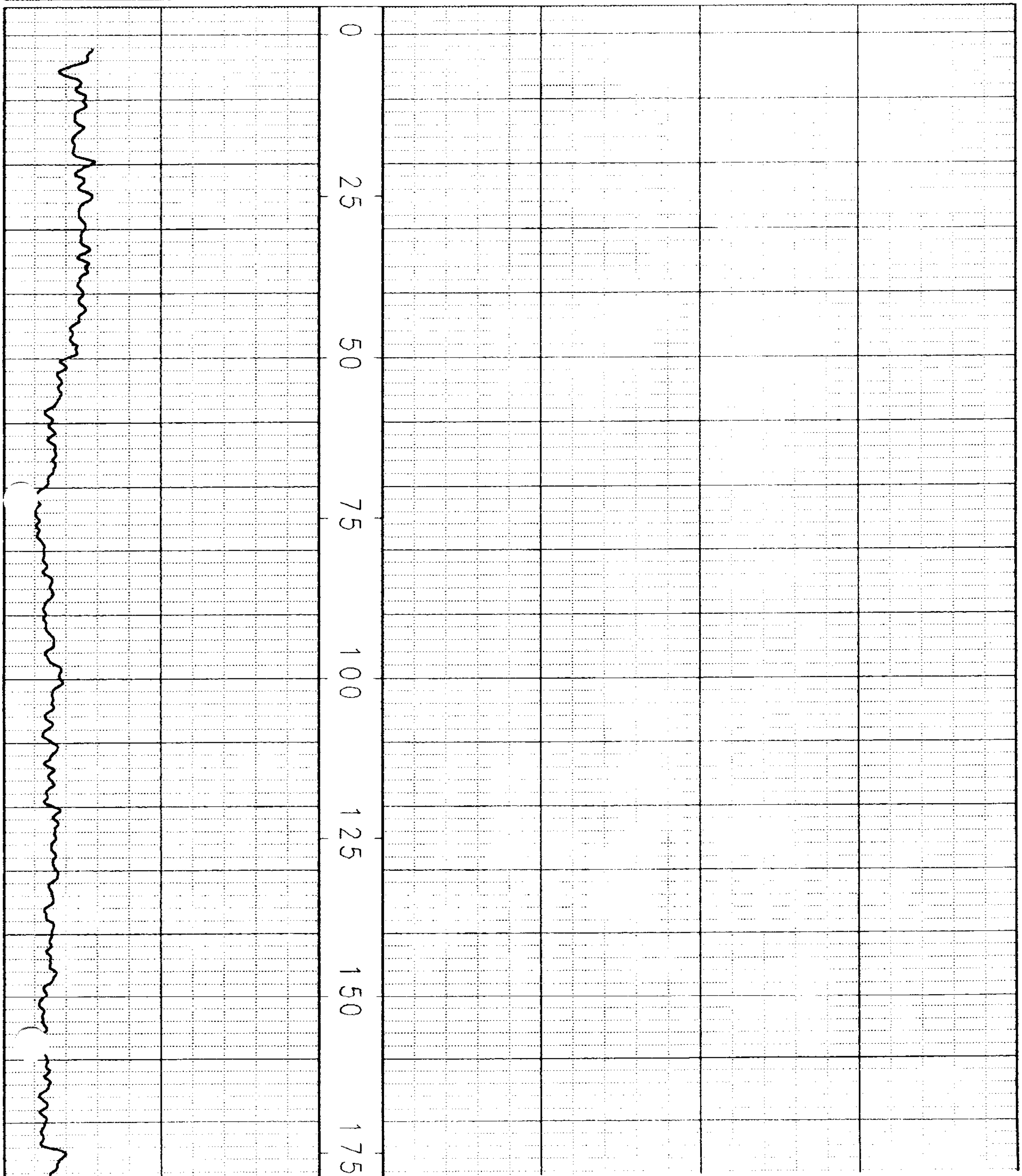
Single Point Resistance
0 Ohms 200

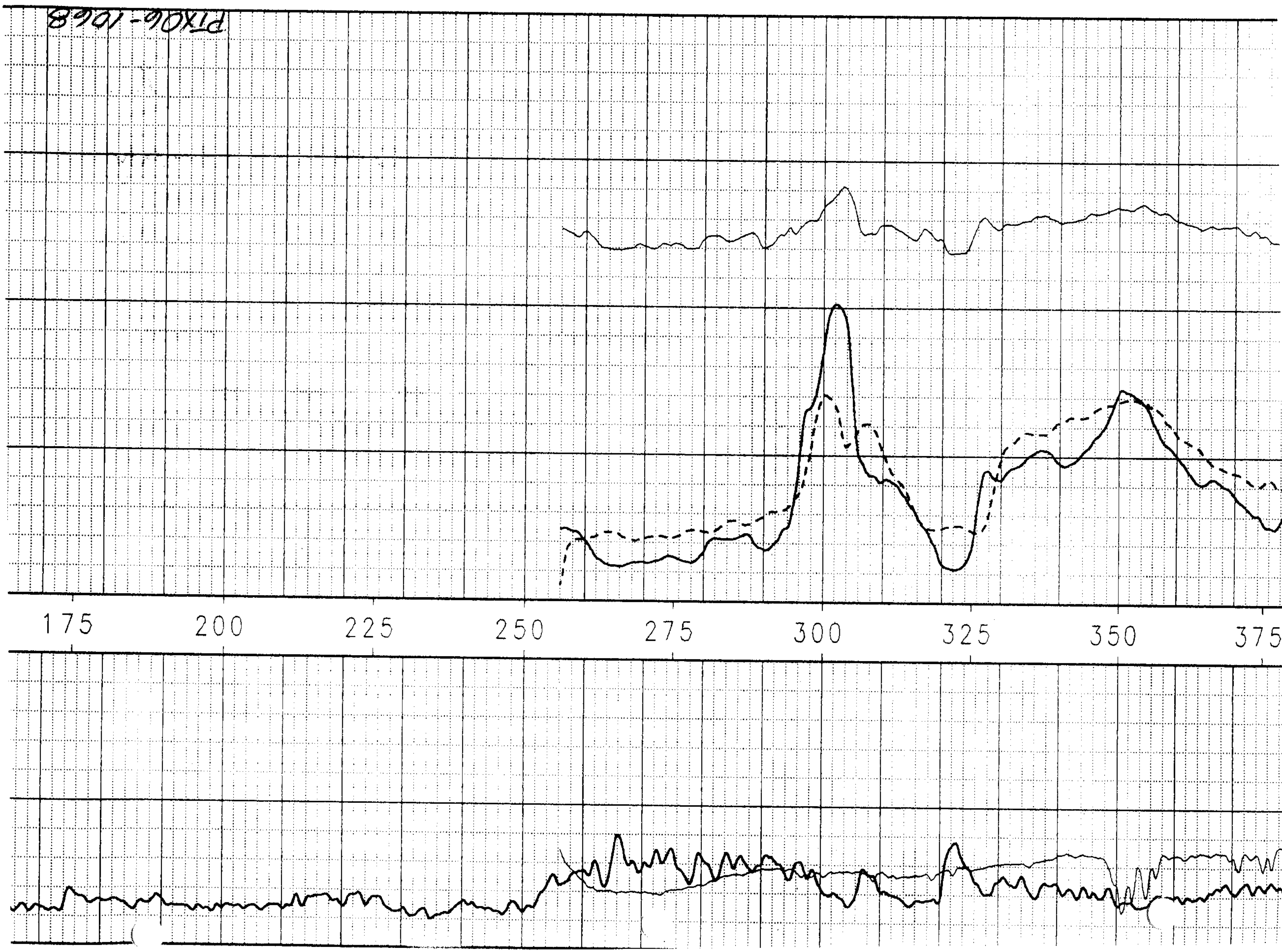
Spontaneous Potential
800 milli Volts 1200

64" Normal Resistivity
0 Ohm-Meters 200

Natural Gamma
0 CPS 200

16" Normal Resistivity
0 Ohm-Meters 200





PTX06-1068
175
200
225
250
275
300
325
350
375


PTX06-1068
375
400
425
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575


575
600
625
650
675
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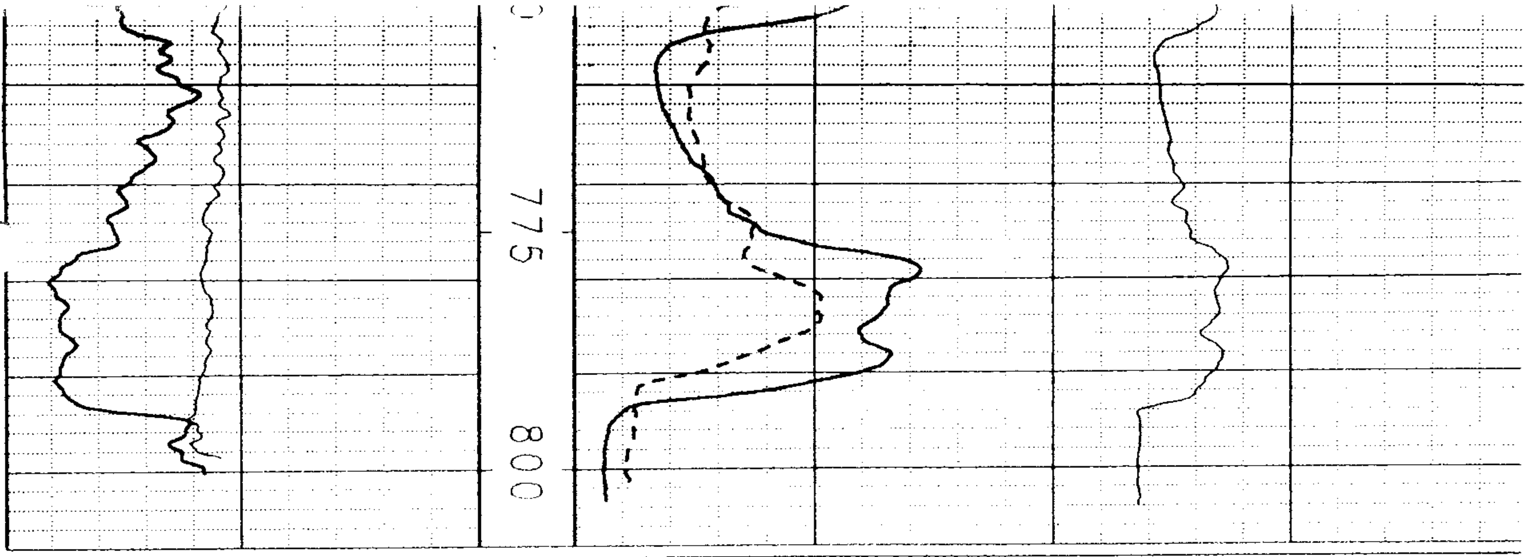
725
750
775
PTX06-1068



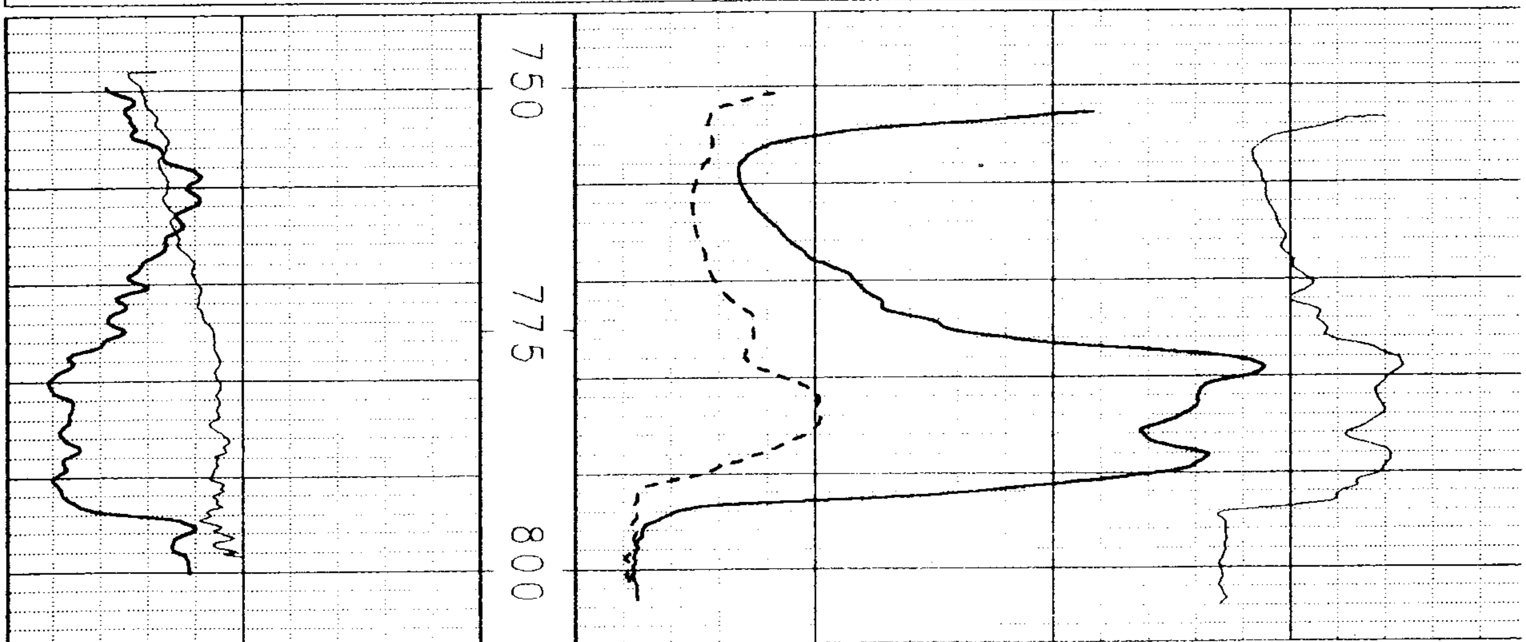
Natural Gamma
0 CPS 200
Spontaneous Potential
800 milli Volts 1200

16" Normal Resistivity
0 Ohm-Meters 200
64" Normal Resistivity
0 Ohm-Meters 200
Single Point Resistance
0 Ohms 200

PANTEX WELL PTX06-1068 15 MAY 2001 COLOG

PANTEX WELL PTX06-1068 COMPARISON COLOG

Single Point Resistance
0 Ohms 100
Spontaneous Potential
800 milli Volts 1200
64" Normal Resistivity
0 Ohm-Meters 200
Natural Gamma
0 CPS 200
16" Normal Resistivity
0 Ohm-Meters 100



Natural Gamma
0 CPS 200
Spontaneous Potential
800 milli Volts 1200

16" Normal Resistivity
0 Ohm-Meters 100
64" Normal Resistivity
0 Ohm-Meters 200
Single Point Resistance
0 Ohms 100

PANTEX WELL PTX06-1068 COMPARISON COLOG

Deviation Survey for: S. M. Stoller **Field:** Pantex Plant **Date:** 5/15/2001

Well: PTX06-1068 **Depth Ref.:** GL **Total Depth:** 779.87 **Probe Type, S/N:** SLP

Depth (feet)	Inclination (degrees)	Bearing (degrees)	ClosureLength (line ft.)	ClosureDist. (horiz. ft.)	ClosureDepth (vertical ft.)	Northing (feet)	Easting (feet)	TrueDepth (feet)	Dist.Sum (feet)	NorthSum (feet)	EastSum (feet)
0.00	0.87	297	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
50.01	0.86	222	50.01	0.75	50.00	-0.56	-0.50	50.00	0.75	-0.56	-0.50
100.05	1.20	80	50.04	1.05	50.03	0.18	1.03	100.03	0.65	-0.38	0.53
150.01	1.51	179	49.96	1.32	49.94	-1.32	0.02	149.98	1.78	-1.69	0.55
200.10	1.46	122	50.09	1.28	50.07	-0.68	1.08	200.05	2.88	-2.37	1.64
250.01	1.25	67	49.91	1.09	49.90	0.43	1.00	249.95	3.28	-1.94	2.64
300.05	2.12	24	50.04	1.85	50.01	1.69	0.75	299.95	3.40	-0.25	3.39
350.01	1.91	20	49.96	1.67	49.93	1.56	0.57	349.89	4.17	1.31	3.96
400.02	1.65	12	50.01	1.44	49.99	1.41	0.30	399.88	5.05	2.72	4.26
459.33	0.30	27	59.31	0.31	59.31	0.28	0.14	459.18	5.32	3.00	4.40
500.07	0.18	125	40.74	0.13	40.74	-0.07	0.10	499.92	5.37	2.92	4.50
550.03	0.27	342	49.96	0.24	49.96	0.22	-0.07	549.88	5.44	3.15	4.43
600.03	0.50	296	50.00	0.44	50.00	0.19	-0.39	599.88	5.24	3.34	4.04
650.02	1.01	295	49.99	0.88	49.98	0.37	-0.80	649.86	4.93	3.71	3.24
700.45	1.38	291	50.43	1.21	50.42	0.44	-1.13	700.28	4.65	4.15	2.11
750.04	0.07	213	49.59	0.06	49.59	-0.05	-0.03	749.87	4.59	4.10	2.07
780.04	0.46	21	30.00	0.24	30.00	0.22	0.09	779.87	4.83	4.32	2.16

Totals:

True Depth	DistSum	NorthSum	EastSum
779.87	**4.83**	**4.32**	**2.16**

Definitions

Bearing = Azimuth Degrees from Magnetic North (Raw Data)

ClosureDistance = Horizontal Feet Between Each Station

ClosureDepth = Vertical Feet Between Each Interval

Northing = North/South Component of Horizontal Distance Between Each Station (Negative = South)
(Closure Dist.) x cos(Bearing)

Easting = East/West Component of Horizontal Distance Between Each Station (Negative = West)
(Closure Dist.) x sin(Bearing)

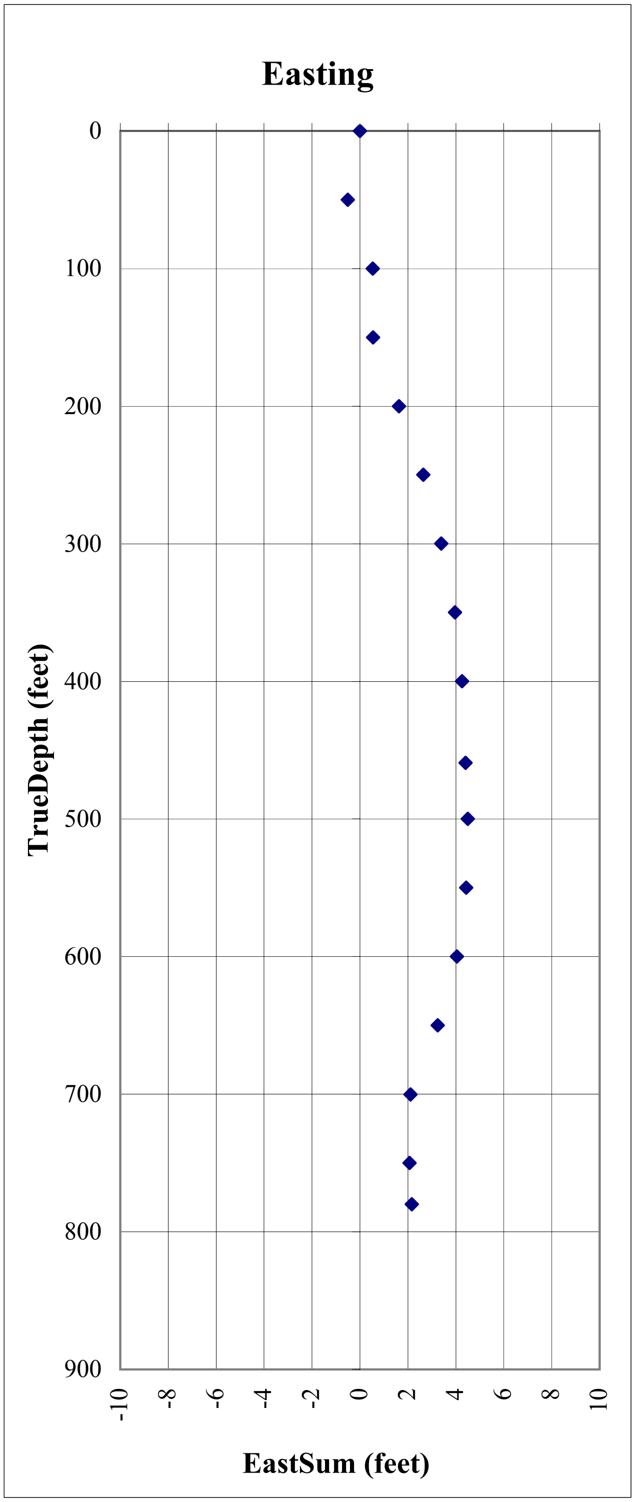
TrueDepth = Vertical Depth from the Surface to This Station

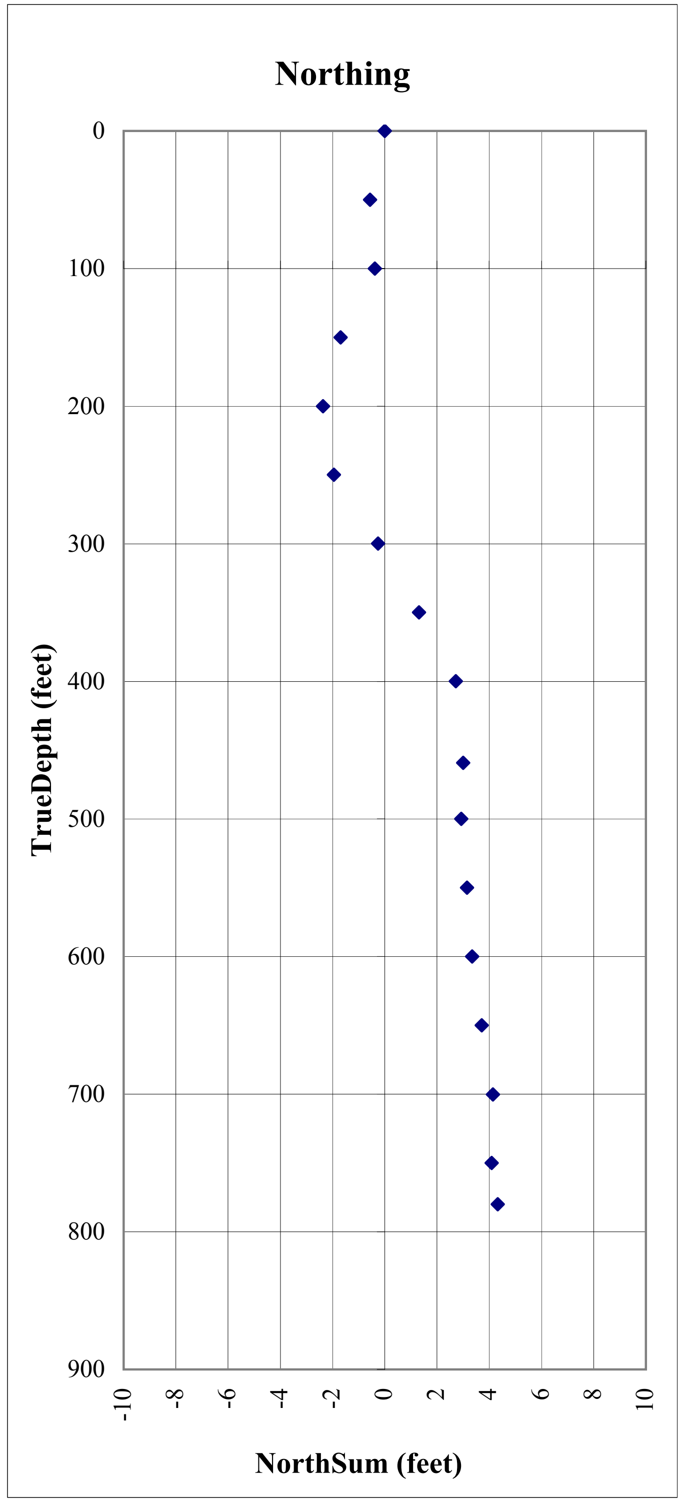
DistanceSum = Horizontal Distance from Wellhead to this Station

NorthSum = North/South Component of Horizontal Distance from the Wellhead to This Station (Negative = South)
Running Sum of Northing

EastSum = East/West Component of Horizontal Distance from the Wellhead to This Station (Negative = West)
Running Sum of Easting

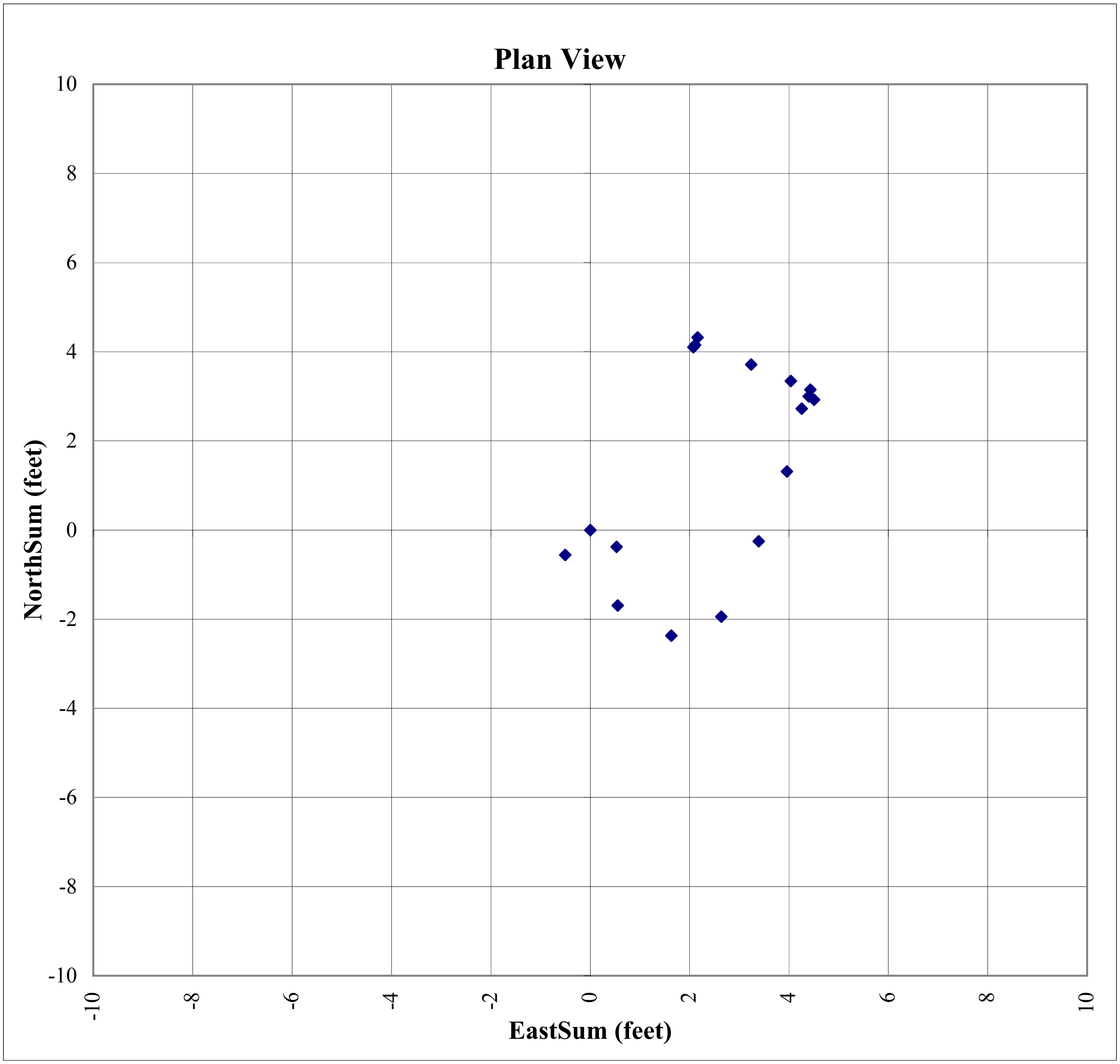
Deviation Survey for: S. M. Stoller **Field:** Pantex Plant **Date:** 5/15/2001
Well: PTX06-1068 **Depth Ref.:** GL **Total Depth:** 779.87 **Probe Type, S/N:** SLP





Orientations are with respect to Magnetic North

Deviation Survey for: S. M. Stoller **Field:** Pantex Plant **Date:** 5/15/2001
Well: PTX06-1068 **Depth Ref.:** GL **Total Depth:** 779.87 **Probe Type, S/N:** SLP



Orientations are with respect to Magnetic North

east	north	depth
0.000	0.000	0.000
-0.502	-0.558	50.004
0.530	-0.376	100.033
0.553	-1.692	149.976
1.635	-2.368	200.050
2.637	-1.943	249.948
3.390	-0.252	299.954
3.960	1.313	349.886
4.259	2.721	399.875
4.400	2.998	459.184
4.505	2.925	499.924
4.432	3.148	549.884
4.040	3.340	599.882
3.241	3.712	649.864
2.108	4.147	700.279
2.075	4.097	749.869
2.161	4.321	779.868

PTX06-1072

aka:

Associated with: SWMU 113 (near bldg 11-36); Pantex Multiple Operable Units

Contractor: S.M. Stoller
Contract #: <number/ID>
Contractor's Project #: 3641
Drilled date: 05/06/01 – 05/18/01
Drilling Contractor: Layne Christensen

OPTIX #: <if known>
Last Update: 9/28/04 (add Lith Log)

Standard Included Documents

(Others may also be included)

Drilling/Boring Log
- ___ Draft
- ___ Final

_X_ Draft Installation Log/Diagram (handwritten/drawn)
___ Final Installation Log/Diagram (computerized)

Lithologic Logs
- ___ Draft Visual Classification of Soils (handwritten)
- _X_ Final Visual Classification of Soils (computerized)

Geophysical Logs
- ___ Neutron
- ___ Gamma
- ___ Compensated Density
- ___ e-Log
- ___ Bond Log
- ___ Deviation Log

___State Well Report
___State Plugging Report

Monitor Well Installation Diagram

Project: Pantex Multiple Operable Units

Location: Pantex Plant (SWMU 113 near Bldg 11-36)

Contractor: Layne Christensen

Driller: D. Walton / B. Latimer

Well Coordinates: N-3758434.63 E-635047.45

TOC Elevation: 3549.69'

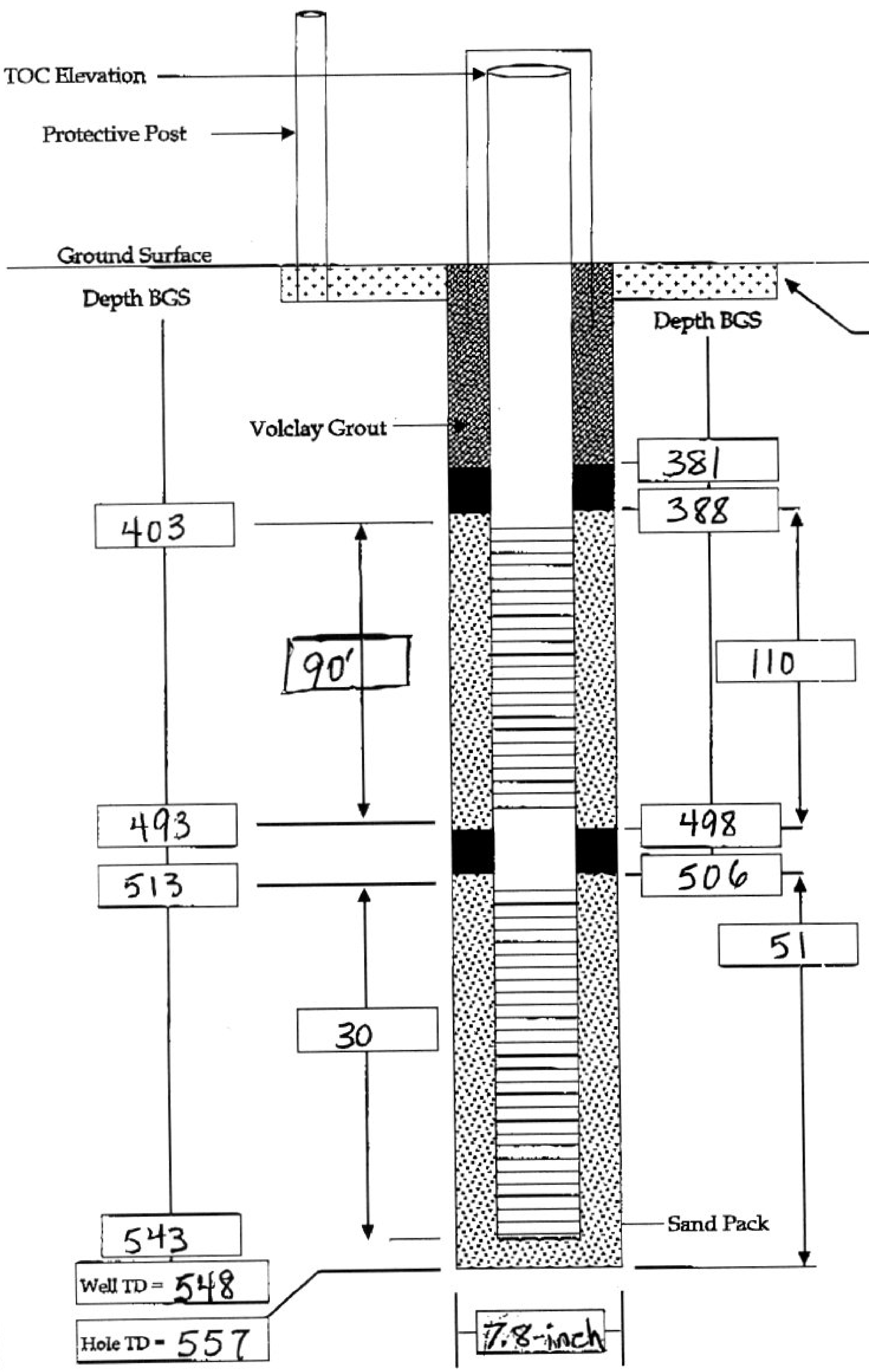
Surface Elevation: 3547.36'

Monitor Well No: PTX06-1072

Date Constructed: 5-19-01

Observed by: J. Ford

Sheet 1 of 1



Protective Casing
- Material: steel
- Diameter: 10-inch with 8-inch to

Surface Pad
- Composition & Size: Concrete 5'x5'x8"

Riser Pipe
- Type: Schedule 10, Type 316 Stainless Steel
- Diameter: 4-inch

Grout
- Composition: Volclay Grout (Bentonite)

Seal
- Type: 3/8-inch Bentonite Pellets

Filter Pack
- Type: Silica Sand
- Source: Colorado Silica Sand
- Gradation: 10/20

Screen
- Type: Schedule 10, Type 316 Stainless Steel
- Diameter: 4-inch
- Slot Size: 0.010-inch

Sump
- Type: Schedule 10, Type 316 Stainless Steel
- Bottom Cap: (Y) / N

PTX06-1072

Pantex Multiple Operable Units | **Pantex Plant (SWMU 113 near Bldg. 11-36)** | **Amarillo, Texas**

Project Number:	3641	Client:	BWXT Pantex
Geologist:	S. Brinkman / T. Hall / J. Ford	Northing: 3758434.63	Easting: 635047.45
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	557' BGS
Dates Drilled:	05/06/01 - 05/18/01	Depth to Water:	404.3' BGS 06/06/01
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3547.36'	TOC Elevation:	3549.69'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			ML	0-5' TOPSOIL, dry.		
	5		CL	5-15' CLAY, light brown (7.5YR 6/4), low plasticity, moderately dense, slightly damp to damp.		
	10					
	15		CL	15-40' CLAY, sandy, reddish yellow (7.5YR 6/6), sand is very fine grain, moderately dense, dry.		
	20					
	25					
	30					
	35					
	40		CL	40-50' CLAY, sandy, slightly silty, light brown (7.5YR 6/4), loose, dry to slightly damp.		
	45					
	50		SM	50-55' SAND, silty, clayey, pink (7.5YR 7/4), moderately dense, dry.		
	55		SM	55-70' SAND, silty, clayey, reddish yellow (7.5YR 6/6), sand is very fine grain, moderately loose, dry.		
	60					
	65					
	70		SC	70-73' SAND, clayey, silty, reddish yellow (7.5YR 7/6), moderately dense, slightly damp.		
	75		CAP RX	73-81' CALICHE, caprock, silty, sandy, pinkish white (5YR 8/2) to white (7.5YR 8/1). Most competent and dense from 80-81'		
	80					
	85		ML	81-90' SILT, slightly sandy, pink (7.5YR 7/3), sand very fine grain, loose, slightly damp.		
	90		ML	90-95' SILT, sandy (<20%), pink (7.5YR 7/4), trace CaCO3, moderately dense, slightly damp to damp.		
	95		ML	95-100' SILT, sandy (40%), light brown (7.5YR 6/4), increase in very fine grain sand, trace CaCO3, moderately loose, damp		

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PTX06-1072

Pantex Multiple Operable Units **Pantex Plant (SWMU 113 near Bldg. 11-36)** **Amarillo, Texas**

Project Number:	3641	Client:	BWXT Pantex
Geologist:	S. Brinkman / T. Hall / J. Ford	Northing: 3758434.63	Easting: 635047.45
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	557' BGS
Dates Drilled:	05/06/01 - 05/18/01	Depth to Water:	404.3' BGS 06/06/01
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3547.36'	TOC Elevation:	3549.69'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	105		SM	100-110' SAND, silty, pinkish white (5YR 8/2), very fine to fine grain, poorly graded, loose, very damp to slightly moist. Increased silt @ 105-110'		
	110, 115		SP	110-120' SAND, pink (7.5YR 7/3), very fine to fine grain, subrounded, poorly graded, loose, damp.		
	120, 125		SP	120-130' SAND, pink (7.5YR 7/3), very fine to fine grain, dense caliche nodules, angular, loose, damp. Increasing silt with depth.		
	130, 135		SM	130-140' SAND, silty, pinkish white (7.5YR 7/2), very fine to fine grain, some caliche nodules, loose, damp.		
	140, 145		SP	140-150' SAND, pink (7.5YR 7/3), fine grain, subrounded to rounded, poorly graded, loose, damp to moist.		
	150, 155		SP	150-160' SAND, as above, subrounded, moist.		
	160, 165		SP	160-170' SAND, very pale brown (10YR 7/4), very fine to fine grain, poorly graded, loose, damp to moist, some caliche nodules		
	170		SM	170-175' SAND, silty, very pale brown (10YR 7/4), poorly graded, loose, damp, some caliche nodules.		
	175, 180		SP	175-185' SAND, reddish yellow (7.5YR 6/6), fine grain, poorly graded, loose, damp, some caliche nodules.		
	185		SP	185-190' SAND, reddish yellow (7.5YR 6/6), fine to medium grain, subrounded, poorly graded, loose, moist.		
	190, 195		SP	190-200' SAND, slightly silty, very pale brown (10YR 7/4), very fine to fine grain, poorly graded, loose, moist.		

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PTX06-1072

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Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	557' BGS
Dates Drilled:	05/06/01 - 05/18/01	Depth to Water:	404.3' BGS 06/06/01
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3547.36'	TOC Elevation:	3549.69'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	205		SW	200-205' SAND, with ~20% gravel, light gray (10YR 7/2), fine to coarse grained, subrounded to subangular, moderately dense, dry.		
	210, 215		SP	205-220' SAND, light gray (10YR 7/2), poorly graded, loose, moist. @ 215' sandstone lense		
	220		SP	220-225' SAND, slightly silty, very pale brown (10YR 7/3), fine grain, poorly graded, loose, moist.		
	225		SW	225-230' SAND, gravelly, light gray (7.5YR 7/1) to light brown (7.5YR 6/3), fine to medium grain sand, well graded, dense, damp.		
	230, 235		SW/GW	230-240' SAND/GRAVEL, (50/50), light gray (10YR 7/2 - 7/1), fine to coarse grain sand, subangular, well graded, dense, moist.		
	240		SW	240-245' SAND, with gravel, light brownish gray (10YR 6/2), medium to coarse grain, pebble-size gravel, dense, moist.		
	245		SP	245-250' SAND, very pale brown (10YR 8/3), fine grain, poorly graded, some pebbles, loose, moist.		
	250		SP	250-255' SAND, light brown (7.5YR 6/3), fine grain, poorly graded, loose, dry.		
	255, 260		SP	255-262' SAND, slightly silty, light gray (10YR 7/2), fine to medium grain, poorly graded, loose, moist.		
	265, 270		SC	262-272' SAND, clayey, light gray (10YR 7/2), dense		
	275		CL	272-280' CLAY, slightly sandy, brown (7.5YR 5/4), plastic, stiff. 8 5/8" steel conductor casing cemented from surface to 273'.	■	PTX06-1072-2-0272 VOC
	280, 285		ML	280-290' SILT, clayey, sandy (5-10%), light reddish brown (5YR 6/4), very fine grain sand, medium plastic, stiff.		
	290, 295		CL/ML	290-308' CLAY, silty/SILT, clayey, trace sand, light reddish brown (5YR 6/4) to light brown (7.5YR 6/3), low plasticity.		

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PTX06-1072

Pantex Multiple Operable Units	Pantex Plant (SWMU 113 near Bldg. 11-36)		Amarillo, Texas
Project Number:	3641	Client:	BWXT Pantex
Geologist:	S. Brinkman / T. Hall / J. Ford	Northing: 3758434.63	Easting: 635047.45
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	557' BGS
Dates Drilled:	05/06/01 - 05/18/01	Depth to Water:	404.3' BGS 06/06/01
Borehole Type:	12" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3547.36'	TOC Elevation:	3549.69'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	305		CL/ML			
	310, 315		SC	308-320' SAND, clayey, silty, light brown (7.5YR 6/4) to reddish brown (5YR 5/3), fine grain.		
	320, 325		SC	320-330' SAND, silty, clayey, light brown (7.5YR 6/4), fine grain, sorted.		
	330, 335		SC	330-340' SAND, clayey, some gravel, light reddish brown (5YR 6/3), fine grain, well graded.		
	340, 345, 350, 355		SC	340-360' SAND, clayey, trace gravel, light reddish brown (5YR 6/3), 60% fine grain, graded.		
	360, 365, 370, 375		SM	360-380' SAND, silty, clayey, trace small gravel, reddish brown (5YR 6/4).		
	380, 385		SC	380-390' SAND, clayey, light reddish brown (5YR 6/4), fine grain.		
	390, 395		SC	390-450' SAND, clayey, light reddish brown (5YR 6/4) to pink (5YR 7/4), fine grain.		

PTX06-1072

Pantex Multiple Operable Units **Pantex Plant (SWMU 113 near Bldg. 11-36)** **Amarillo, Texas**

Project Number:	3641	Client:	BWXT Pantex
Geologist:	S. Brinkman / T. Hall / J. Ford	Northing: 3758434.63	Easting: 635047.45
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	557' BGS
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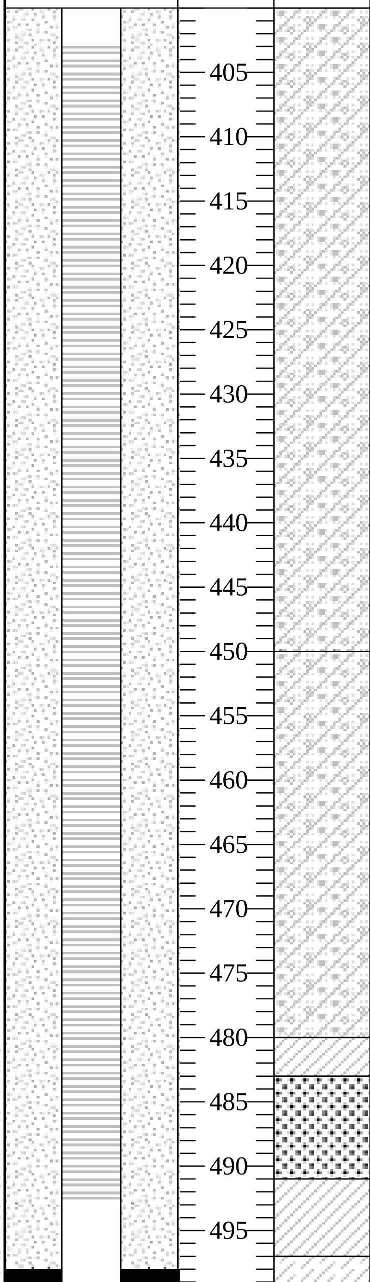

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	403–450		SC			
	450–480		SC	450-480' SAND, clayey, 5% small gravel, light reddish brown (5YR 6/4), a bit harder.		
	480–483		CL	480-483' CLAY, sandy, dark red (2.5YR 3/6) to red (2.5YR 5/6), hard.		
	483–491		SW	483-491' SAND, gravelly, light gray to very pale brown (10YR 7/2 -7/3), medium to coarse grain sand, rounded pebbles to small (1/4") gravel.		
	491–497		CL	491-497' CLAY, yellowish red (5YR 5/6 -5/8), stiff, medium plasticity.		
	497–		CH	497-512' CLAY, as above except red (2.5YR 4/6), more plastic.		

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PTX06-1072

Pantex Multiple Operable Units | **Pantex Plant (SWMU 113 near Bldg. 11-36)** | **Amarillo, Texas**

Project Number:	3641	Client:	BWXT Pantex
Geologist:	S. Brinkman / T. Hall / J. Ford	Northing: 3758434.63	Easting: 635047.45
Drilling Contractor:	Layne Christensen	Total Depth of Borehole:	557' BGS
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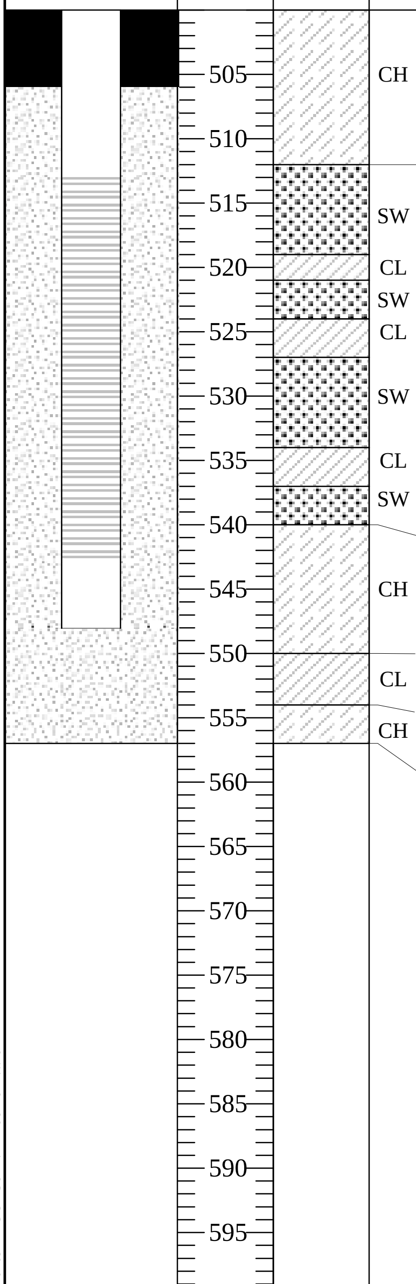
Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number



512-540' SAND, very pale brown to gray (10YR 7/3 - 7/1), fine to coarse grain with interbedded thin clay beds @ 520, 525, and 535, red (2.5YR 5/6), medium to high plasticity, hard to stiff, some silt.

Sand becoming finer with depth, white to light gray (5YR 8/1-7/1).

540-550' CLAY, interbeds of dark red (2.5YR 3/6) to red (2.5YR 4/8 - 5/8) clays with lighter sands (possibly from above), hard layer begining at 545', trace of black siltstone in cuttings.

550-554' CLAY, sandy, red (2/5YR 4/6), medium plasticity, med. to cse. angular to subrounded sand (possibly from above).

554-557' CLAY/SHALE, dark red to dusky red (10R 3/6 - 3/4), very stiff high plasticity, some white mottling noted throughout.

Total Depth of Borehole 557' BGS
Fine Grain Zone 262' based on lithology notes
Geophysical log indicates top of Permian redbeds at 540' BGS

Well Completion Details:
Borehole Diameter: 12" to 273', 8" 273-557'
Conductor casing set with cement to 273'
Total Depth of Well 548'
4-inch, Type 316 stainless steel casing and 10-slot screen
5' sump (543-548'), 30' screen (513-543'), 20' blank (493-513'), 90' screen (403-493'), 406' of blank (+3-403')
9' Backfill (548-557'), 42' 10/20 CSS filter pack (506-548'), 8' bentonite seal (498-506'), 110' 10/20 CSS filter pack (388-498'), 7' bentonite seal (381-388'), 378' Volclay bentonite grout (3-381'), 3' cement seal (0-3')

S.M. STOLLER CORPORATION

COLOG Division of Layne Christensen Company

17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

GAMMA-ELECTRIC

COM: S.M. Stoller
WELL: PTX06-1072
FLD: Pantex Plant
ST: TX COUNTY: Carson

COMPANY: S.M. Stoller
WELL: PTX06-1072
FIELD: Pantex Plant
STATE: TX COUNTY: Carson

LOCATION:

SEC TWP RGE

OTHER SERVICES:
DEVIATION

PERMANENT DATUM: GL ELEVATION: NA
LOG MEAS. FROM: GL 0.0 FT ABOVE PERM. DATUM
DRILL MEAS. FROM: GL

DATE ACQUIRED	May 18, 2001			
RUN NUMBER	1			
LOG TYPE	GAMMA-ELECTRIC			
DEPTH-DRILLER	557'			
DEPTH-LOGGER	552'			
BTM LOGGED INTERVAL	551'			
TOP LOGGED INTERVAL	GL			
RECORDED BY	T. Staatz			
WITNESSED BY	John Ford			
FLUID LEVEL	NA			
FLUID TYPE	Water			
Rm at TEMP	NA			
TIME SINCE CIRC.	NA			
PROBE TYPE, S/N	2PEA, 2078			
MODULE TYPE, S/N	MGX II 1144			
LOGGING SPEED	12 ft/min			
A.S.D.E.	NA			
SAMPLE INTERVAL	0.1'			
SOURCE SIZE, S/N	none			

BOREHOLE RECORD			CASING RECORD		
BIT SIZE	FROM	TO	SIZE/WGT	FROM	TO
10 5/8"	GL	274'	8 5/8"	-2'	274'
7 7/8"	274'	TD			

COMMENTS:

COMMENTS:

NA – NOT AVAILABLE, N/A – NOT APPLICABLE

DIGITAL FILES: 1062A.eb1, 1062.hdp

PANTEX WELL PTX06-1072 18 MAY 2001

COLOG

Single Point Resistance

PANTEX WELL PTX06-1072 18 MAY 2001

COLOG

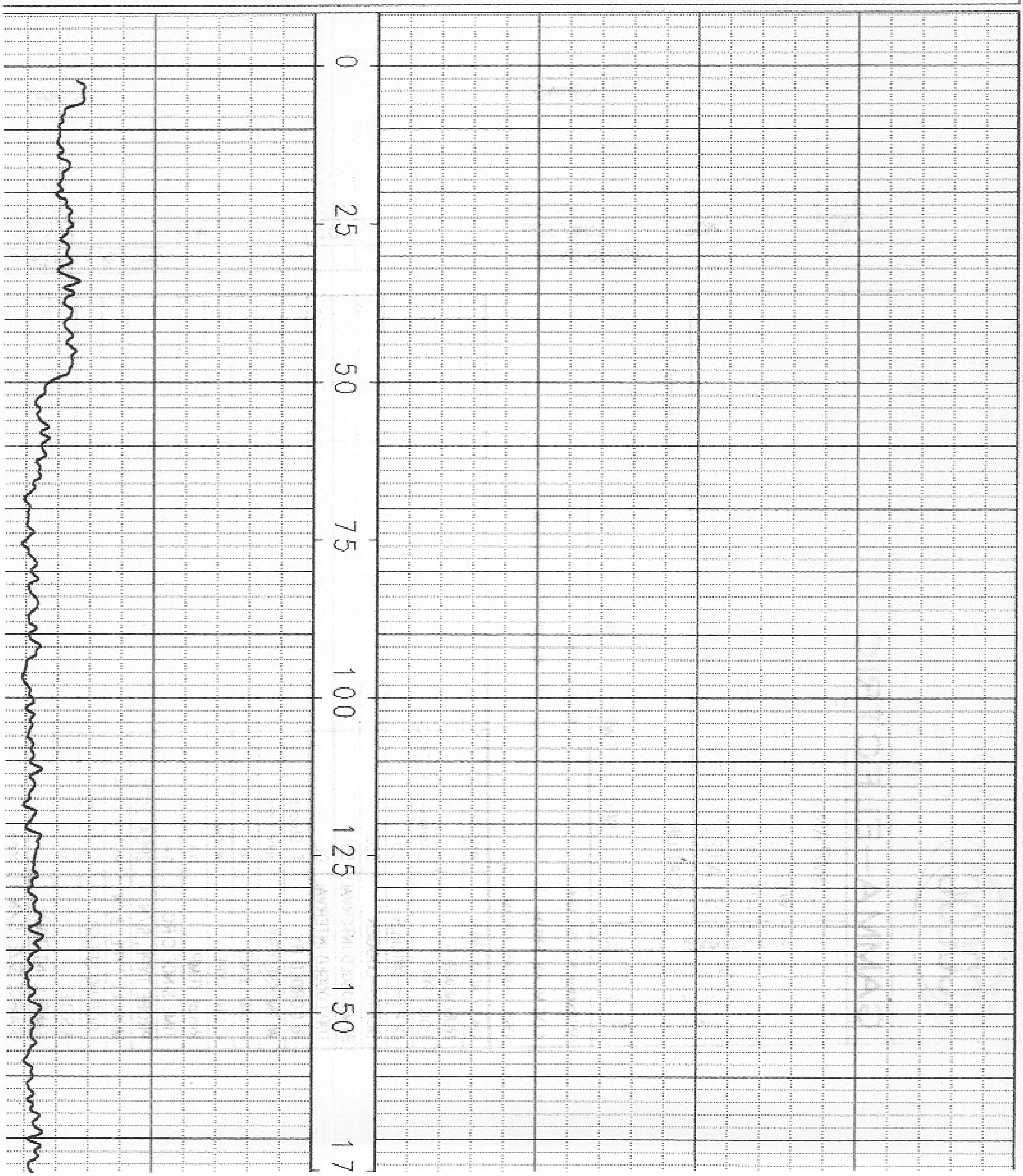
Single Point Resistance
50 Ohms 150

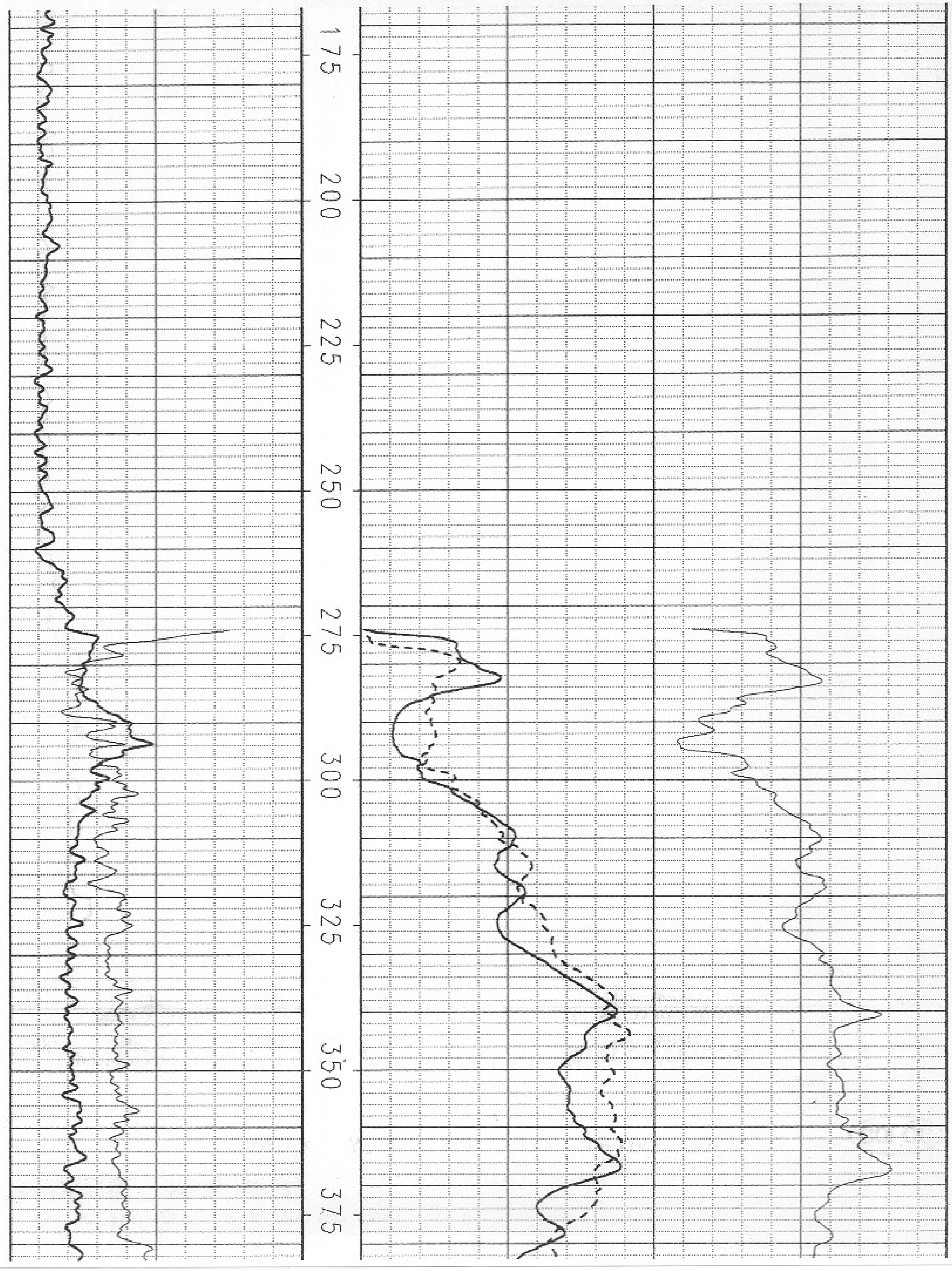
Spontaneous Potential
200 milli Volts 600

64'' Normal Resistivity
0 Ohm-Meters 200

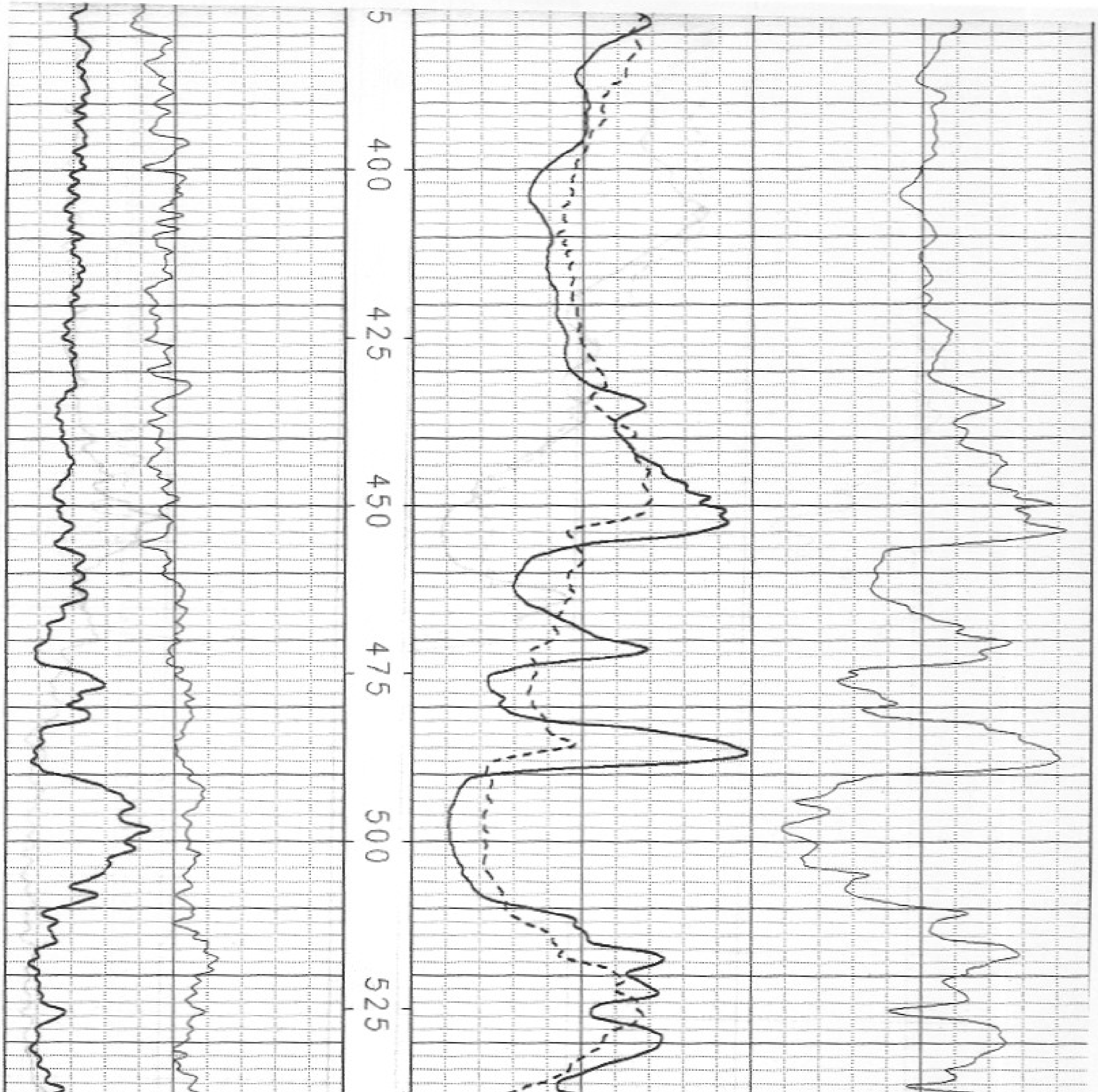
Natural Gamma
0 CPS 200

16'' Normal Resistivity
0 Ohm-Meters 200



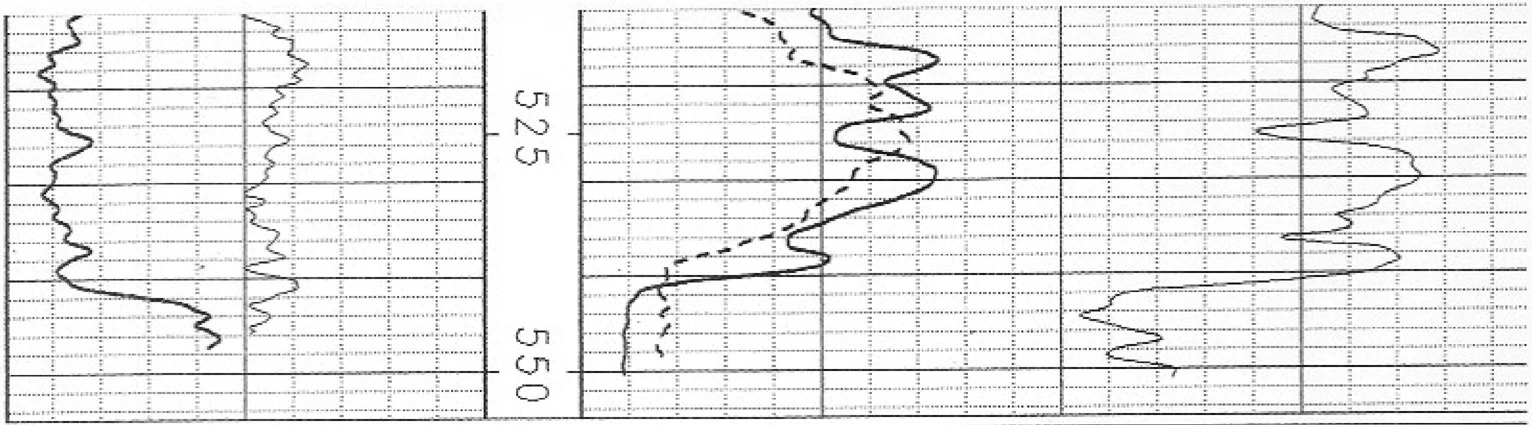


175
200
225
250
275
300
325
350
375



PANTEX WELL PTX06-1072 18 MAY 2001 COLOG

PANTEX WELL PTX06-1072 COMPARISON COLOG



Natural Gamma
0 CPS 200

Spontaneous Potential
200 milli Volts 600

16" Normal Resistivity
0 Ohm–Meters 200

64" Normal Resistivity
0 Ohm–Meters 200

Single Point Resistance
50 Ohms 150

PANTEX WELL PTX06–1072 18 MAY 2001

COLOG

PANTEX WELL PTX06–1072 COMPARISON

COLOG

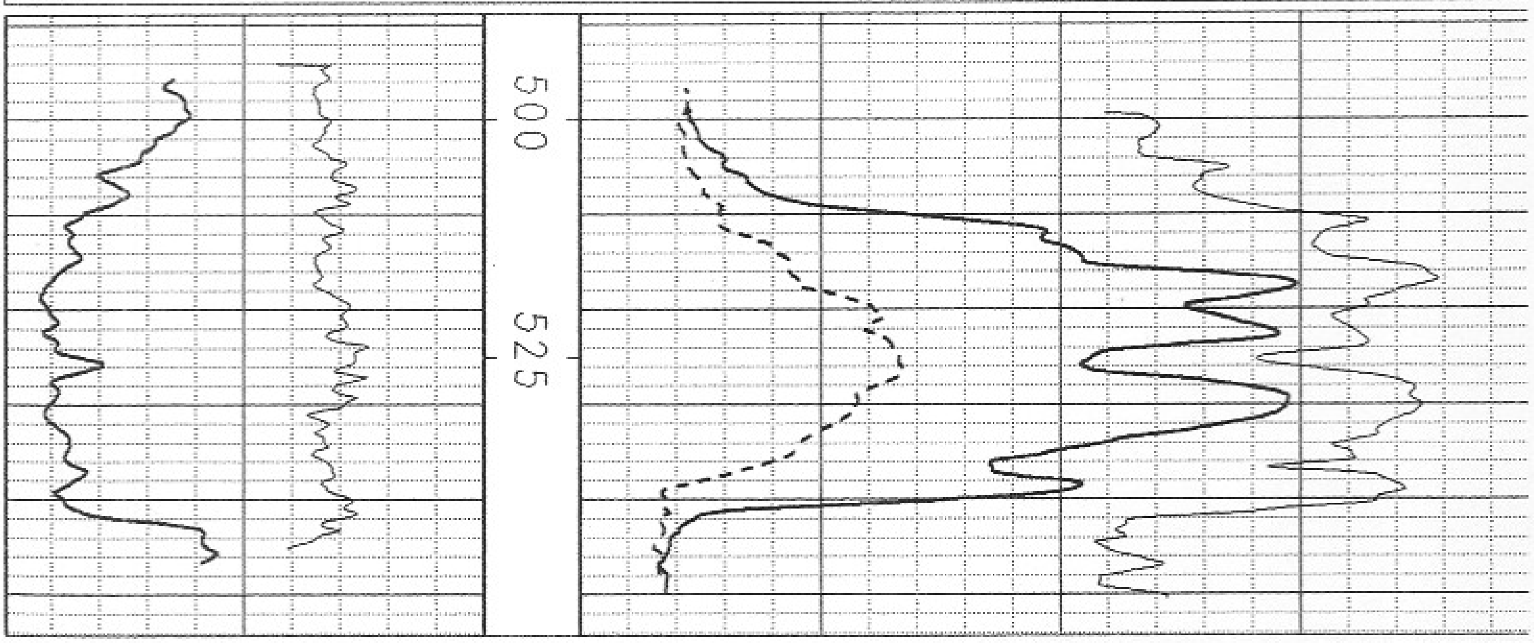
Single Point Resistance
50 Ohms 150

Spontaneous Potential
200 milli Volts 600

64" Normal Resistivity
0 Ohm–Meters 200

Natural Gamma
0 CPS 200

16" Normal Resistivity
0 Ohm–Meters 100



Natural Gamma
0 CPS 200

Spontaneous Potential
200 milli Volts 600

16" Normal Resistivity
0 Ohm–Meters 100

64" Normal Resistivity
0 Ohm–Meters 200

Single Point Resistance
50 Ohms 150

PANTEX WELL PTX06–1072 COMPARISON

COLOG

Deviation Survey for: S. M. Stoller **Field:** Pantex Plant **Date:** 5/18/2001

Well: PTX06-1072 **Depth Ref.:** GL **Total Depth:** 517.68 **Probe Type, S/N:** SLP

Depth (feet)	Inclination (degrees)	Bearing (degrees)	ClosureLength (line ft.)	ClosureDist. (horiz. ft.)	ClosureDepth (vertical ft.)	Northing (feet)	Easting (feet)	TrueDepth (feet)	Dist.Sum (feet)	NorthSum (feet)	EastSum (feet)
0.00	0.84	290	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52.39	1.04	231	52.39	0.95	52.38	-0.60	-0.74	52.38	0.95	-0.60	-0.74
100.02	1.21	131	47.63	1.01	47.62	-0.66	0.76	100.00	1.26	-1.26	0.02
150.08	1.33	42	50.06	1.16	50.05	0.86	0.78	150.05	0.89	-0.39	0.80
200.02	1.26	94	49.94	1.10	49.93	-0.08	1.10	199.98	1.95	-0.47	1.89
250.33	1.04	15	50.31	0.91	50.30	0.88	0.24	250.28	2.17	0.41	2.13
300.05	1.27	73	49.72	1.10	49.71	0.32	1.05	299.98	3.27	0.73	3.18
350.12	1.24	45	50.07	1.08	50.06	0.77	0.77	350.04	4.22	1.50	3.95
400.75	1.54	18	50.63	1.36	50.61	1.29	0.42	400.65	5.19	2.79	4.37
450.05	1.71	9	49.30	1.47	49.28	1.45	0.23	449.93	6.26	4.25	4.60
500.14	2.02	353	50.09	1.77	50.06	1.75	-0.22	499.99	7.43	6.00	4.38
517.83	0.96	27	17.69	0.30	17.69	0.26	0.13	517.68	7.72	6.26	4.52
								True Depth	DistSum	NorthSum	EastSum
								517.68	**7.72**	**6.26**	**4.52**

Definitions

Bearing = Azimuth Degrees from Magnetic North (Raw Data)

ClosureDistance = Horizontal Feet Between Each Station

ClosureDepth = Vertical Feet Between Each Interval

Northing = North/South Component of Horizontal Distance Between Each Station (Negative = South)
(Closure Dist.) x cos(Bearing)

Easting = East/West Component of Horizontal Distance Between Each Station (Negative = West)
(Closure Dist.) x sin(Bearing)

TrueDepth = Vertical Depth from the Surface to This Station

DistanceSum = Horizontal Distance from Wellhead to this Station

NorthSum = North/South Component of Horizontal Distance from the Wellhead to This Station (Negative = South)
Running Sum of Northing

EastSum = East/West Component of Horizontal Distance from the Wellhead to This Station (Negative = West)
Running Sum of Easting

Orientations are with respect to Magnetic North

			Example equations:		
Stoller's raw data			=B5-B4	=C5-C4	=SQRT(B5^2+C5^2)
east	north	depth			
0.000	0.000	0.000	Calculations by PX GIS		
-0.739	-0.598	52.381	-0.74	-0.60	0.951
0.020	-1.258	100.001	0.76	-0.66	1.258
0.798	-0.395	150.047	0.78	0.86	0.890
1.893	-0.471	199.975	1.10	-0.08	1.951
2.129	0.411	250.277	0.24	0.88	2.169
3.183	0.733	299.985	1.05	0.32	3.266
3.949	1.499	350.043	0.77	0.77	4.224
4.370	2.793	400.655	0.42	1.29	5.186
4.600	4.246	449.933	0.23	1.45	6.260
4.385	5.999	499.992	-0.22	1.75	7.430
4.519	6.263	517.679	0.13	0.26	7.723

PTX06-1074

Contractor:

Contract #:

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

✓ Installation Log

✓ Lithologic Logs
    ___Draft
    ___Final

✓ Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

7/11/02

APEX SURVEYING & MAPPING, Inc.

Phone (806) 353-7231
Fax (806) 353-7232

1619 S KENTUCKY B-202
AMARILLO, TX 79102-2202

May 15, 2002

Llano Permian Environmental
Attn: Clay Wright
921 N. Bivins Street
Amarillo, Texas 79107

Re: Coordinates for new monitor wells at the USDOE Pantex Plant, Carson County, Texas

Name	Northing	Easting	Elevation	Description
PTX-06-1074	3,765,626.52	620,994.02	3573.36' 3576.20' 3573.2'	Brass Cap Top Casing Ground
PTX-06-1075	3,753,624.01	630,512.54	3544.25' 3546.52' 3544.0'	Brass Cap Top Casing Ground
PTX-06-1076	3,752,978.41	637,327.32	3525.68' 3528.34' 3525.5'	Brass Cap Top Casing Ground

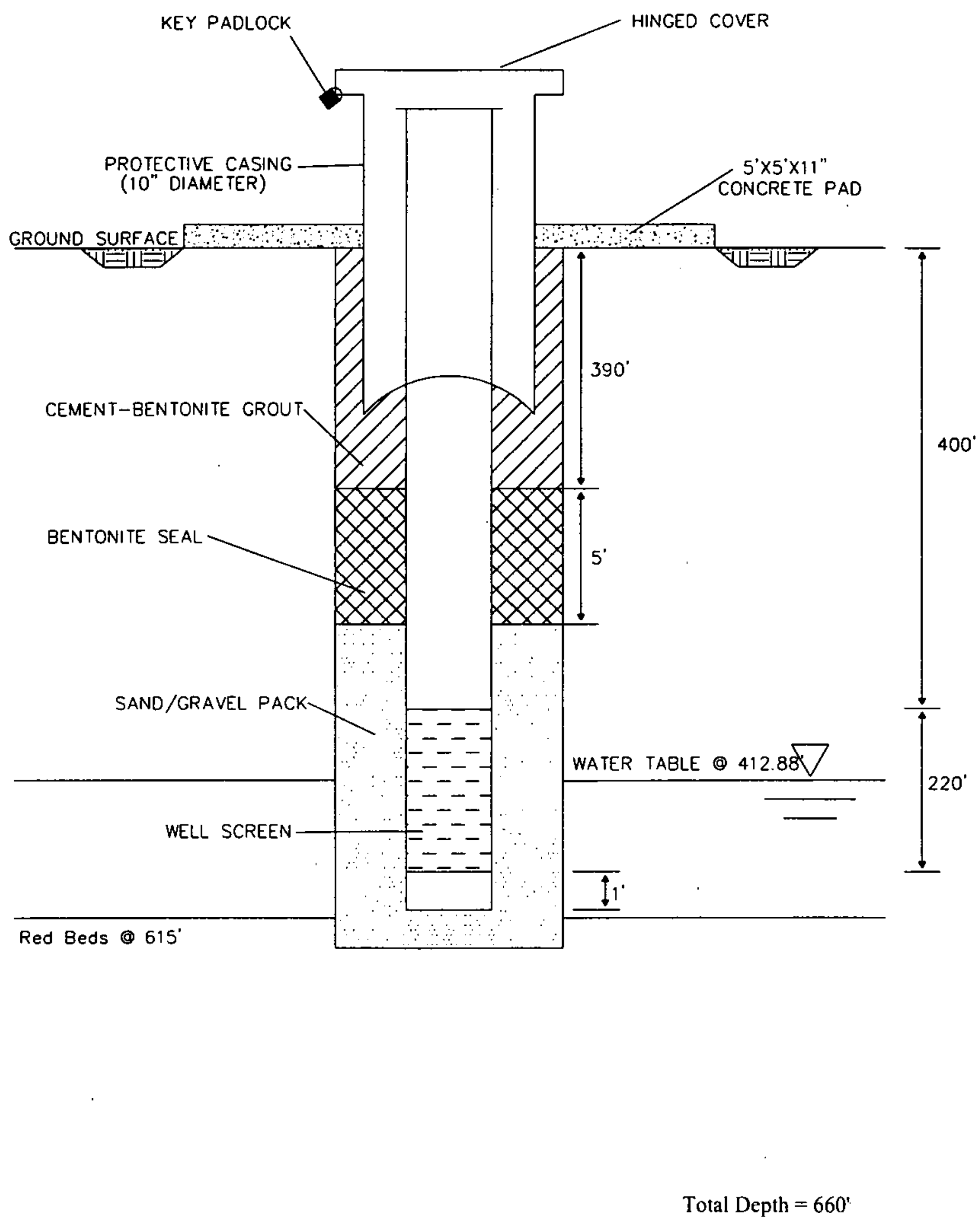
Coordinates and elevations are relative to Pantex NAD83 - NAVD88 Control network as established by "Kelley and Associates".

The undersigned does hereby certify that this survey was made upon the ground the 14th Day of May, 2002, by myself or others under my direct supervision and is true and correct. The undersigned further certifies that this survey meets or exceeds the required 1 foot horizontal and vertical accuracies, as set forth by Llano Permian Environmental specifications.

STATE OF TEXAS
REGISTERED
CURT McPHERSON
5275
PROFESSIONAL
LAND SURVEYOR

CURT McPHERSON
REGISTERED PROFESSIONAL LAND SURVEYOR
REG. NO. 5275
AMARILLO, TEXAS
DATE: 5/15/02

202-179-1.wps



Llano-Permian Environmental Services

Date:	5/28/02
Scale:	Not To Scale
By:	JTC

PTX06-1074
Monitor Well Construction Detail
(Ogallala)

MONITORING WELL LOG

WELL NO. PTX06-1074

PROJECT NO.: PTX003OGA

LOCATION: Approximately 0.25-Mile North of West Gate, Pantex Plant

ELEVATION: 3573.2 Surface

DRILLER: THF Drilling

DATE DRILLED: March 26, 2002

DATE COMPLETED: April 10, 2002

WATER DEPTH: 412.88'

LOGGER: Clay Wright

COMPLETION DEPTH: 660 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
0				Light brown 5yr5/6 silty clay, some sand, very fine grained, poorly sorted, dry
				Moderate yellowish brown 10yr5/4 silty clay, some sand, very fine grained, poorly sorted, dry
15				
30				
45				
				Pale yellowish brown 10yr6/2 sandy, silty clay, very fine grained, poorly sorted, dry
				Light brown 5yr5/6 clayey silt, some sand, very fine grained, well sorted, dry subangular to subrounded grains
60				
				Grayish orange 10yr7/4 clayey silty sand, very fine grained, well sorted, dry, subangular to subrounded
				Grayish orange 10yr7/4 silty sand, very fine grained, well sorted, dry, subangular to subrounded
75				Moderate yellowish brown 10yr5/4 clayey silty sand, very fine grained, well sorted, dry, subangular to subrounded, some caliche nodules
				Moderate yellowish brown 10yr5/4 clayey sand, very fine to fine grained, dry, subangular, some caliche nodules
90				Grayish orange 10yr2/4 sand, fine to medium grained, dry, subangular
				Dark yellowish orange 10yr6/6 silty sand, very fine to fine grained, subangular, well sorted
105				Moderate yellowish brown 10yr5/4 clayey silty sand, very fine

PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: Concrete

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland 8% Bentonite

Total Thickness: 390

CASING:

Diameter: 4" Stainless Steel

Length: 402

Stick Up: 2'

SEAL

Type: Bentonite Chip

Quantity: 14 bags

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 400'-620'

COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1074

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells

PROJECT NO.: PTX003OGA

LOCATION: Approximately 0.25-Mile North of West Gate, Pantex Plant

ELEVATION: 3573.2 Surface

DRILLER: THF Drilling

DATE DRILLED: March 26, 2002

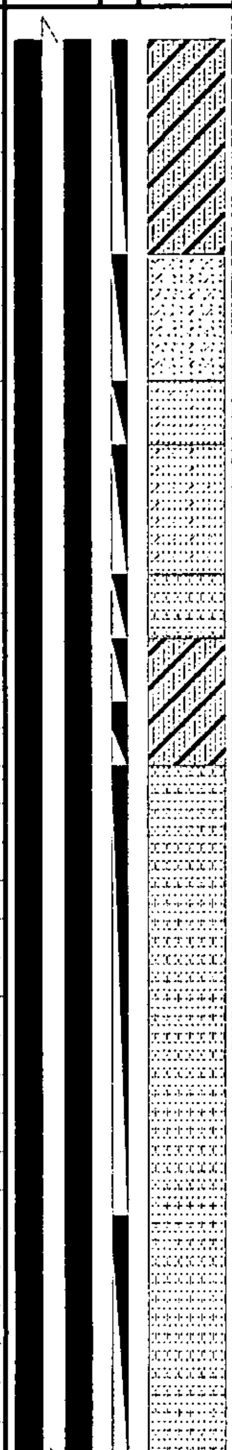
DATE COMPLETED: April 10, 2002

WATER DEPTH: 412.88'

LOGGER: Clay Wright

COMPLETION DEPTH: 660 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
				to medium grained, dry, subangular, poorly sorted
120				
				Moderate yellowish brown 10yr5/4 clayey sand, very fine to medium grained, dry, subangular, poorly sorted
135				Dark yellowish orange 10yr6/6 clayey sand, fine to coarse grained, poorly sorted, subangular, dry
				Moderate yellowish brown 10yr5/4 clayey sand, fine to medium grained, dry, subangular, poorly sorted
150				Moderate brown 5yr4/4 silty sand, very fine to medium grained, moderately sorted, subangular to subrounded, dry
				Dark yellowish brown 10yr6/6 silty clayey sand, very fine to medium grained, poorly sorted, dry, subangular to subrounded
165				Grayish orange 10yr7/4 silty sand, very fine to medium grained, moderately sorted, subangular, slightly damp
180				
195				
210				
				dry



PROTECTIVE

COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: Concrete

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland 8% Bentonite

Total Thickness: 390

CASING:

Diameter: 4" Stainless Steel

Length: 402

Stick Up: 2'

SEAL

Type: Bentonite Chip

Quantity: 14 bags

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 400'-620'

COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1074

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells

PROJECT NO.: PTX003OGA

LOCATION: Approximately 0.25-Mile North of West Gate, Pantex Plant

ELEVATION: 3573.2 Surface

DRILLER: THF Drilling

DATE DRILLED: March 26, 2002

DATE COMPLETED: April 10, 2002

WATER DEPTH: 412.88'

LOGGER: Clay Wright

COMPLETION DEPTH: 660 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
225				very fine to fine grained very fine grained
240				
				Very pale orange 10yr8/2 silty sand, very fine to medium grained poorly sorted subangular, dry
255				Very pale orange 10yr8/2 sandy silt, very fine to medium grained poorly sorted subangular, dry
				Grayish orange 10yr7/4 sand, med to very coarse grained, poorly sorted, subangular to angular
				Dark yellowish orange 10yr6/6 clayey silty sand, very fine to fine grained, subangular to subrounded
270				Very pale orange 10yr8/2 sandy silt, very fine to fine grained, well sorted, subangular to subrounded
285				Grayish orange 10yr7/4 sandy silt, very fine to fine grained, well sorted, subangular to subrounded
				Grayish orange 10yr7/4 clayey sandy silt, very fine grained, well sorted, subrounded
300				
315				

PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: Concrete

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland 8% Bentonite

Total Thickness: 390

CASING:

Diameter: 4" Stainless Steel

Length: 402

Stick Up: 2'

SEAL

Type: Bentonite Chip

Quantity: 14 bags

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 400'-620'

COMMENTS

MONITORING WELL LOG

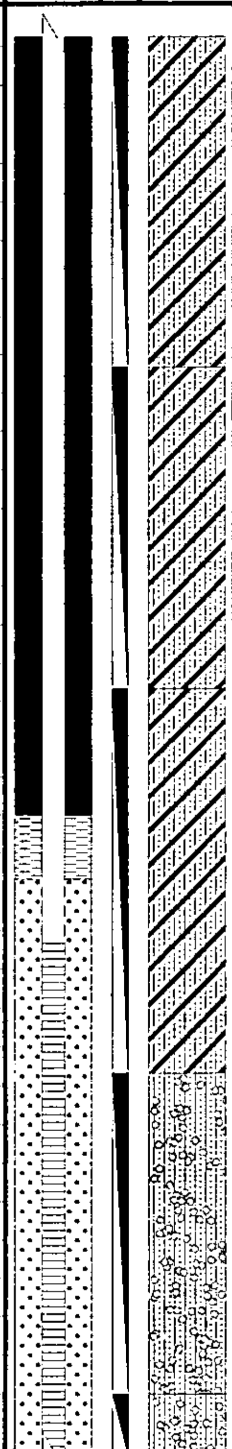
WELL NO. PTX06-1074

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells | PROJECT NO.: PTX003OGA

LOCATION: Approximately 0.25-Mile North of West Gate, Pantex Plant | ELEVATION: 3573.2 Surface

DRILLER: THF Drilling | DATE DRILLED: March 26, 2002 | DATE COMPLETED: April 10, 2002

WATER DEPTH: 412.88' | LOGGER: Clay Wright | COMPLETION DEPTH: 660 feet



DEPTH (ft.)	DESCRIPTION
330	
345	
360	Grayish orange 10yr7/4 clayey sandy silt, very fine to medium grained, subangular
375	intermixed red clay
	Grayish orange 10yr7/4 clayey silty sand, very fine to medium grained, subangular, intermittent caliche nodules
390	
405	clayey sandy silt
	Pale yellowish orange 10yr8/6 sandy silt, very fine to medium grained, subangular
420	
435	Grayish orange 10yr7/4 silty sand, very fine to medium grained, subangular

PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: Concrete

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland 8% Bentonite

Total Thickness: 390

CASING:

Diameter: 4" Stainless Steel

Length: 402

Stick Up: 2'

SEAL

Type: Bentonite Chip

Quantity: 14 bags

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 400'-620'

COMMENTS

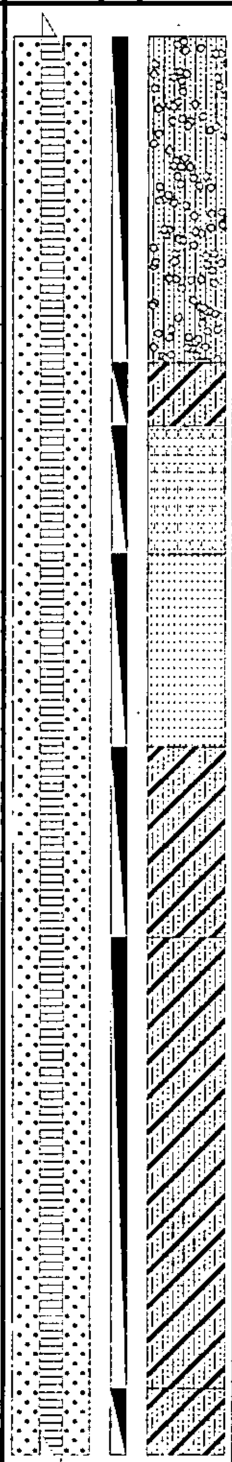
MONITORING WELL LOG
WELL NO. PTX06-1074

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells | PROJECT NO.: PTX003OGA

LOCATION: Approximately 0.25-Mile North of West Gate, Pantex Plant | ELEVATION: 3573.2 Surface

DRILLER: THF Drilling | DATE DRILLED: March 26, 2002 | DATE COMPLETED: April 10, 2002

WATER DEPTH: 412.88' | LOGGER: Clay Wright | COMPLETION DEPTH: 660 feet

DEPTH (ft.)	Well Construction Diagram / Sampler / Soil Graphic	DESCRIPTION
		red clay intermixed
450		no red clay
465		Grayish orange 10yr7/4 sandy clayey silt, very fine to fine grained
		Grayish orange 10yr7/4 silty sand, very fine to fine grained
480		Grayish orange 10yr7/4 sand, very fine to fine grained
495		Grayish orange 10yr7/4 sandy silty clay, very fine to fine grained, red clay intermixed
510		Grayish orange 10yr7/4 sandy clayey silt, very fine to fine grained, red clay intermixed
525		
540		
		Grayish orange 10yr7/4 clayey silty sand, very fine to fine grained, red clay intermixed

PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: Concrete

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland 8% Bentonite

Total Thickness: 390

CASING:

Diameter: 4" Stainless Steel

Length: 402

Stick Up: 2'

SEAL

Type: Bentonite Chip

Quantity: 14 bags

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 400'-620'

COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1074

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells — PROJECT NO.: PTX003OGA

LOCATION: Approximately 0.25-Mile North of West Gate, Pantex Plant — ELEVATION: 3573.2 Surface

DRILLER: THF Drilling — DATE DRILLED: March 26, 2002 — DATE COMPLETED: April 10, 2002

WATER DEPTH: 412.88' — LOGGER: Clay Wright — COMPLETION DEPTH: 660 feet

DEPTH (ft.)	DESCRIPTION
555	
570	Grayish orange 10yr7/4 silty sand, very fine to fine grained, red clay intermixed
	Dark yellowish orange 10yr6/6 sand, very fine to medium grained, red clay intermixed
585	Moderate brown 5yr4/4 clayey sand, very fine to medium grained, red clay intermixed
	Moderate yellowish brown 10yr5/4 clayey sand, very fine to medium grained, red clay intermixed
600	
615	predominantly red clay
630	
645	Moderately reddish brown 10r6/4 clay
660	

PROTECTIVE COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: Concrete
Size: 5'x5'x11"
Total Depth of Concrete: 10'

GROUT:

Type: Portland 8% Bentonite
Total Thickness: 390

CASING:

Diameter: 4" Stainless Steel
Length: 402
Stick Up: 2'

SEAL

Type: Bentonite Chip
Quantity: 14 bags
Total Thickness: 5'

SCREEN

Type: Stainless Steel
Diameter: 4"
Slot Size: 0.010
Screened Interval(s): 400'-620'

COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1074

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells | PROJECT NO.: PTX003OGA

LOCATION: Approximately 0.25-Mile North of West Gate, Pantex Plant | ELEVATION: 3573.2 Surface

DRILLER: THF Drilling | DATE DRILLED: March 26, 2002 | DATE COMPLETED: April 10, 2002

WATER DEPTH: 412.88' | LOGGER: Clay Wright | COMPLETION DEPTH: 660 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
				Bottom of Hole - 660'
675				
690				
705				
720				
735				
750				
765				

PROTECTIVE

COVER TYPE: 10" dia. steel upright locking

SURFACE COMPLETION:

Type: Concrete

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland 8% Bentonite

Total Thickness: 390

CASING:

Diameter: 4" Stainless Steel

Length: 402

Stick Up: 2'

SEAL

Type: Bentonite Chip

Quantity: 14 bags

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 400'-620'

COMMENTS

COLOG

COLOG Division of Layne Christensen Company

17301 West Colfax, Suite 265, Golden Colorado 80401
Office 303.279.0171, Fax 303.278.0135

CO Llano Permian
WELL PTX06-1074
FLD Pantex Plant
CTY Carson
STE TX

COMPANY Llano Permian Environmental
WELL PTX06-1074
FIELD Pantex Plant
COUNTRY USA **STATE** Texas

LOCATION
Amarillo, Texas

SEC NA TWP NA RGE NA

OTHER SERVICES

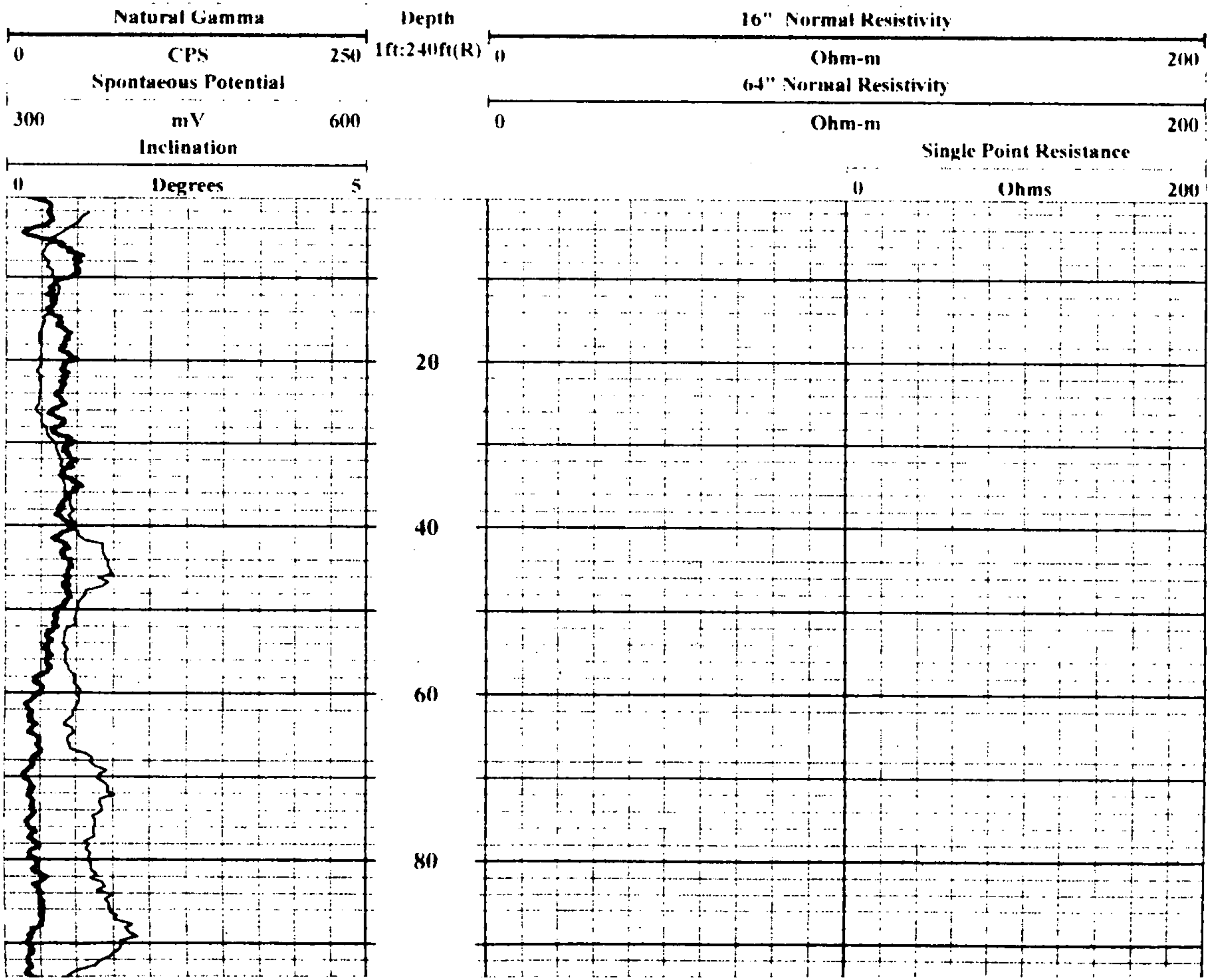
PERMANENT DATUM GROUND LEVEL **ELEVATION** NA

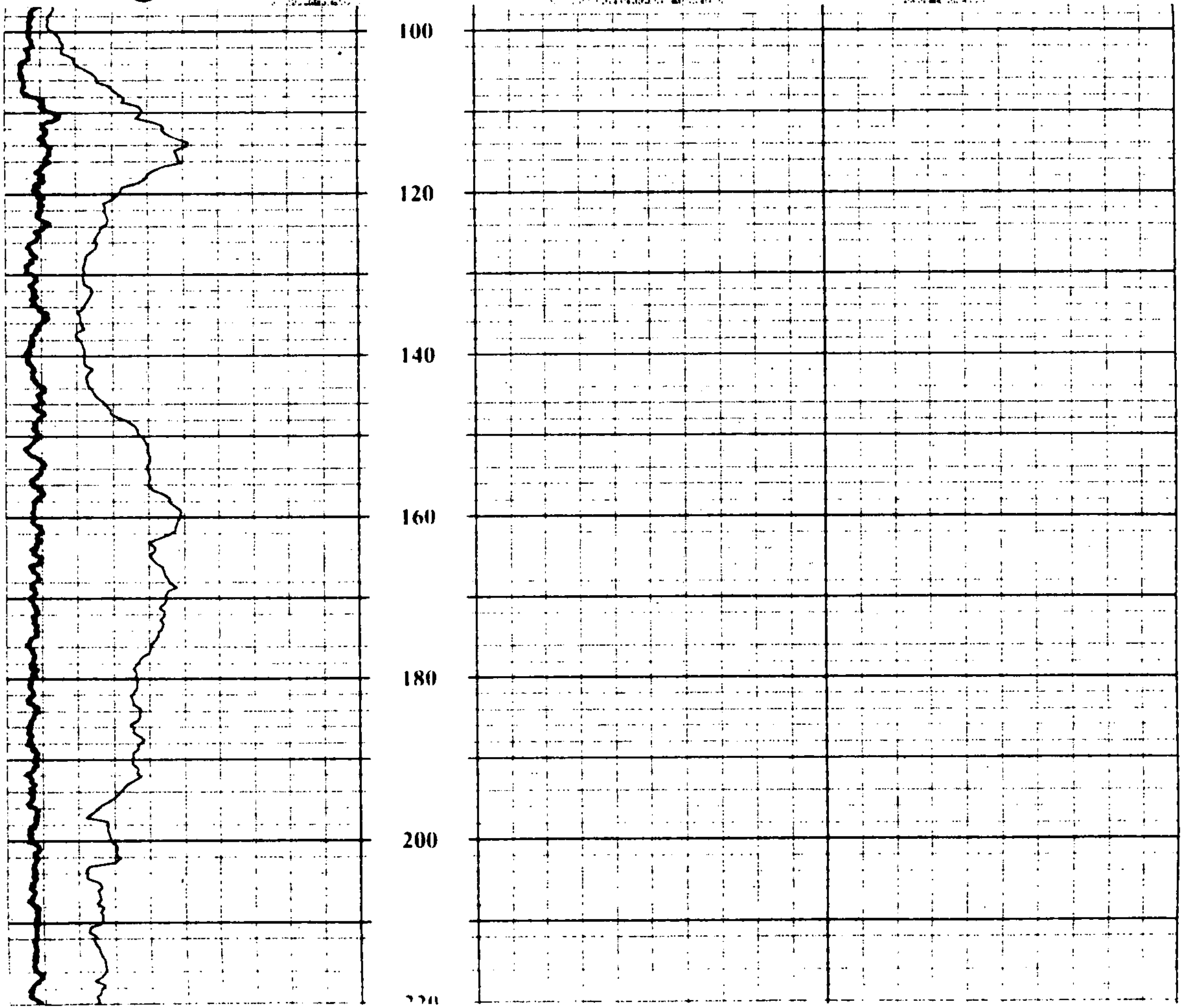
LOG MEAS. FROM GL 0.0 ABOVE PERMINANT DATUM

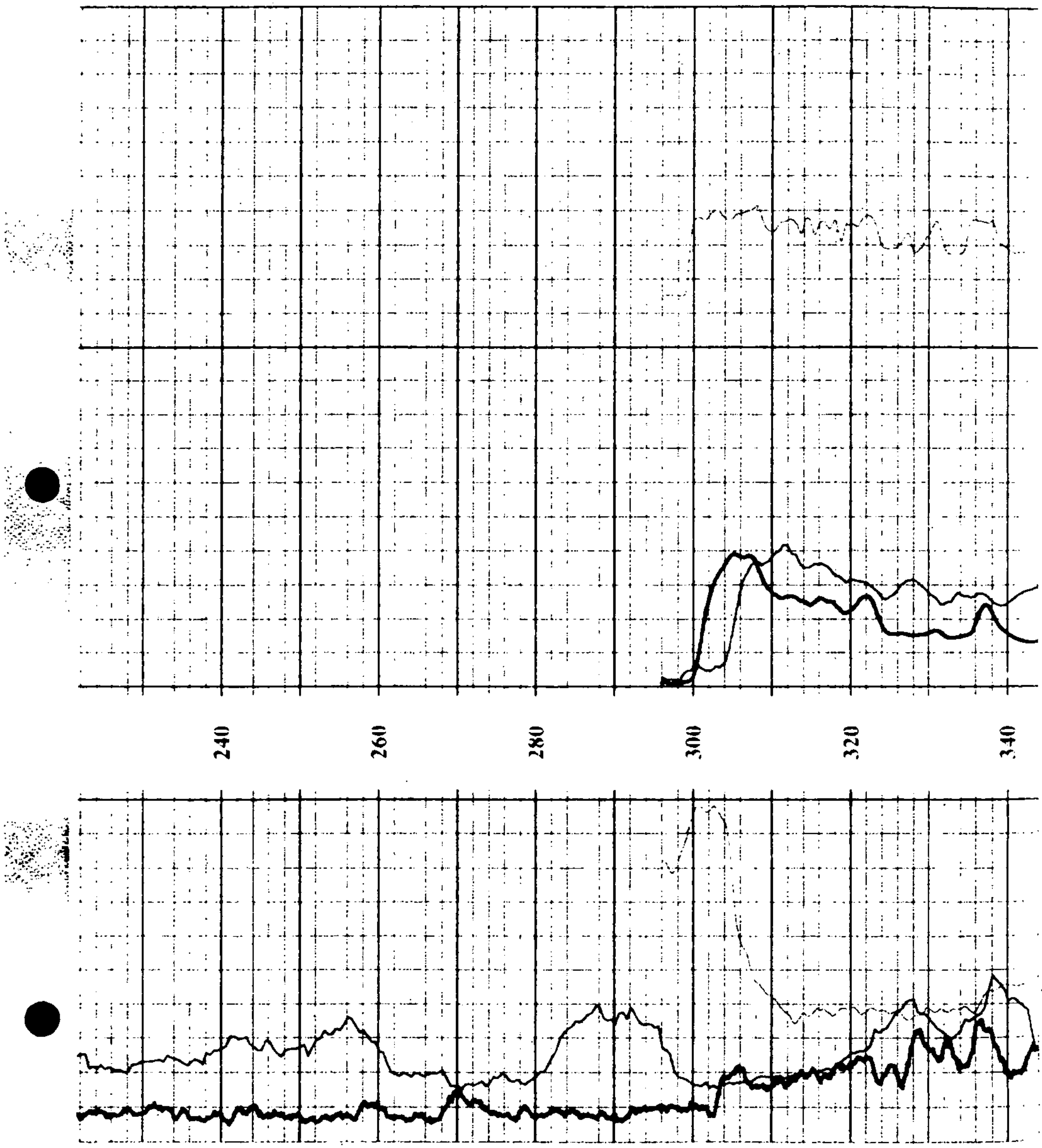
DRILLING MEAS. FROM GROUND LEVEL

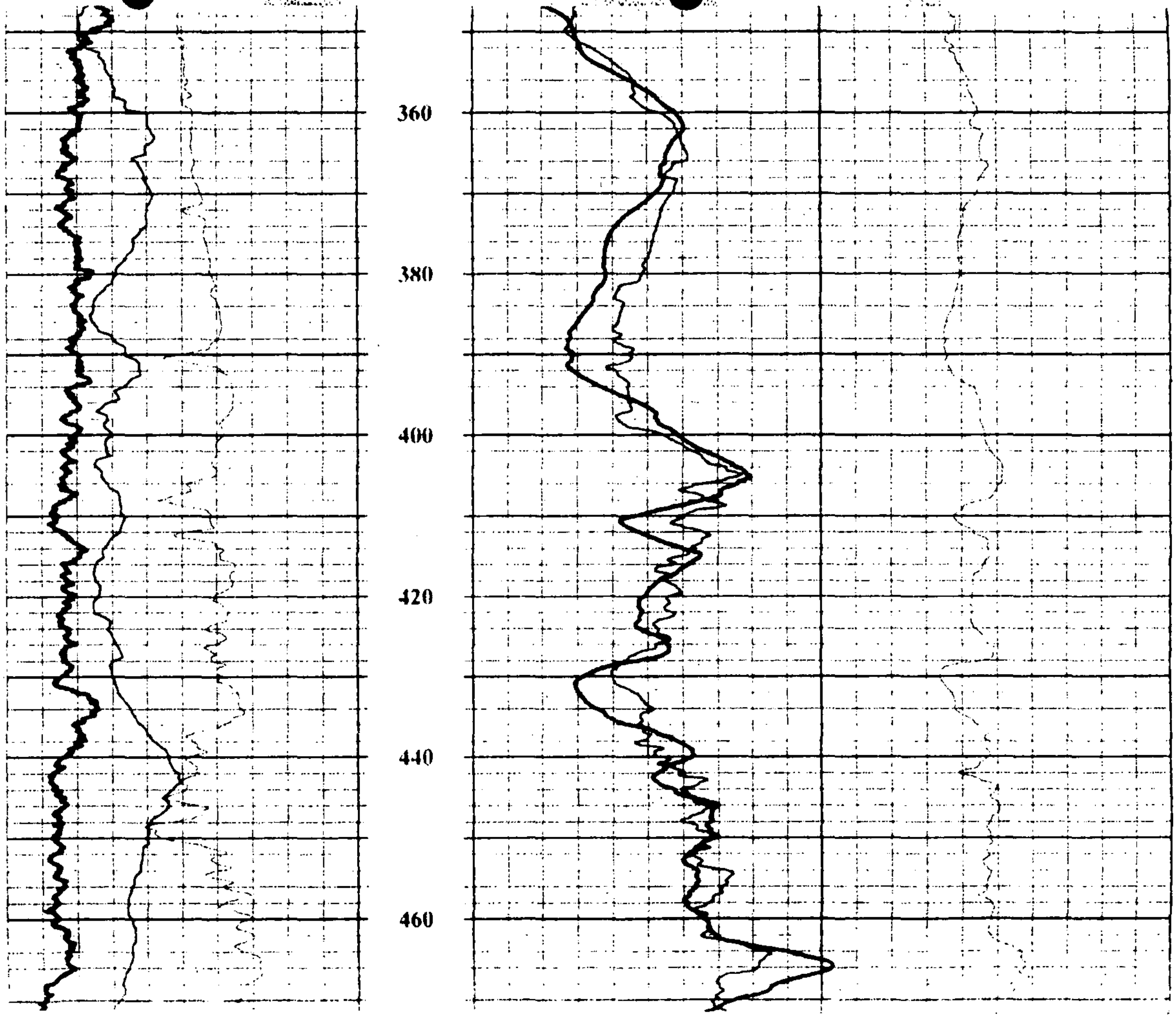
DATE ACQUIRED	10 April 2002	10 April 2002	3 May 2002	
RUN NUMBER	1	1	2	
LOG TYPE	Natural Gamma	Electric Log	Deviation Log	
DEPTH-DRILLER	650 ft			
DEPTH-LOGGER	651 ft			
BTM LOGGED INTERVAL	648 ft	651 ft	623 ft	
TOP LOGGED INTERVAL	0.0 ft	296 ft	2 ft	
RECORDED BY	M. Whitney		N. Davis	
WITNESSED BY	Clay Wright		Clay Wright	
PROBE TYPE, S/N	2PGA, 2278	2PEA, 2529	2PDA	
LOGGING SPEED	17 ft/min	17 ft/min	20 ft/min	
A.S.D.E.	0.1 ft		0.5 ft	
SAMPLE INTERVAL	0.1 ft.	0.1 ft	0.5 ft	

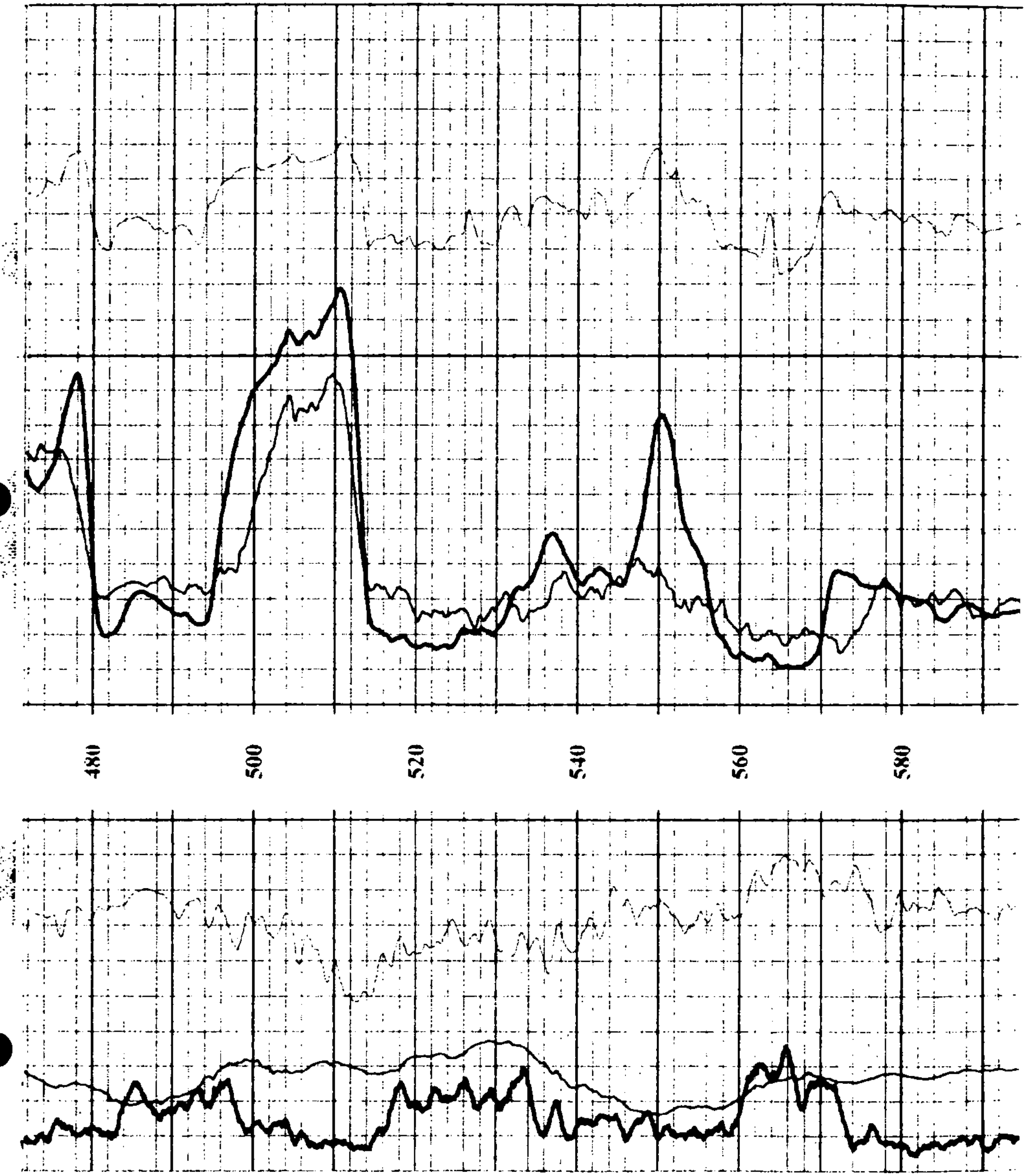
BOREHOLE RECORD				CASING RECORD			
RUN NO	BIT	FROM	TO	SIZE	WGT.	FROM	TO
	10.875"	G.L.	300 Ft.	10" Steel		0	300 Ft.
	7.875	300 Ft.	TD				


Natural Gamma
0 CPS 250
Spontaeous Potential
300 mV 600
Inclination
0 Degrees 5
Depth
1ft:240ft(R)
16" Normal Resistivity
0 Ohm-m 200
64" Normal Resistivity
0 Ohm-m 200
Single Point Resistance
0 Ohms 200
20
40
60
80

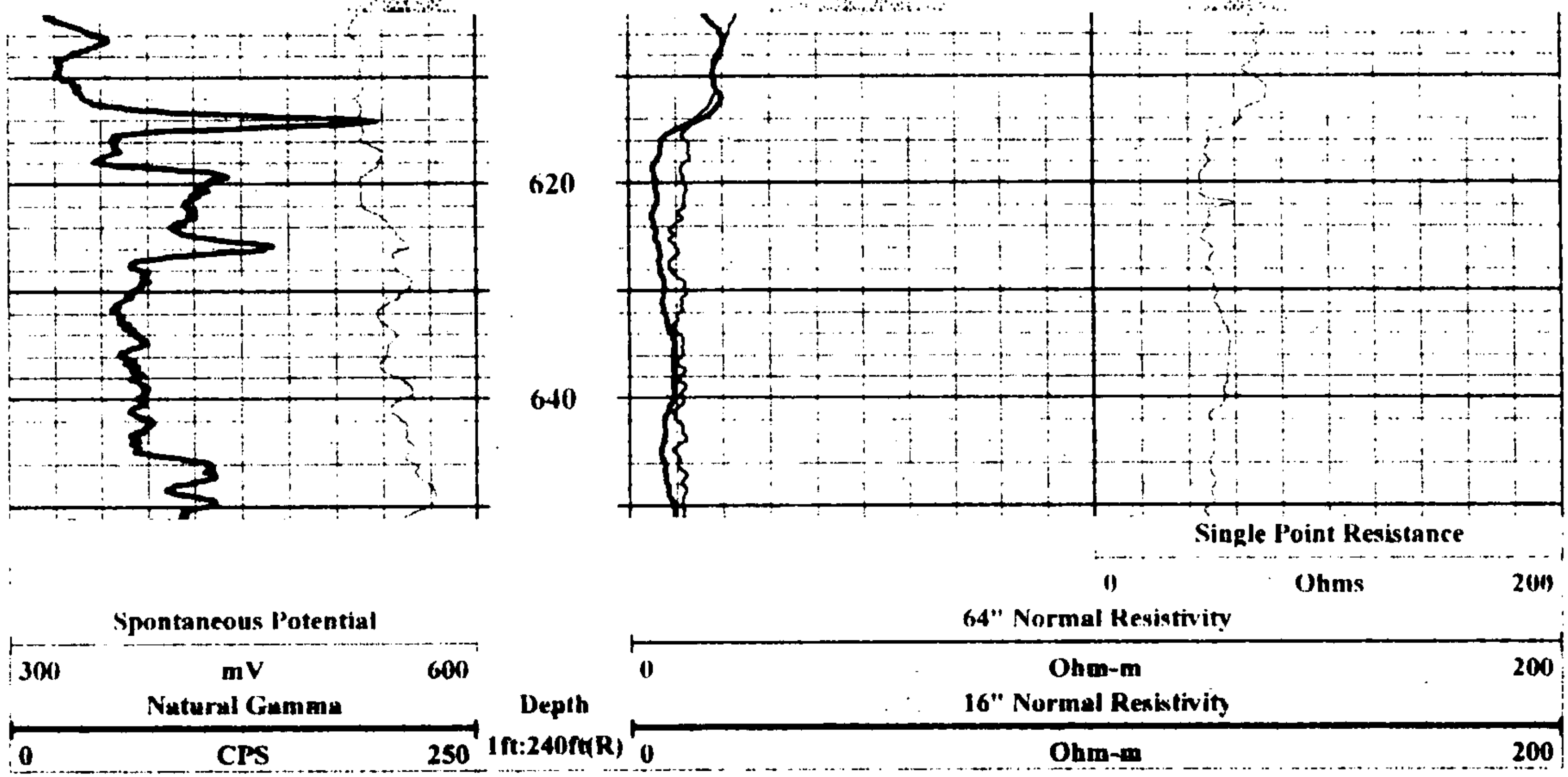

100
120
140
160
180
200


240
260
280
300
320
340


360
380
400
420
440
460



480
500
520
540
560
580


620
640
Single Point Resistance
0
Ohms
200
Spontaneous Potential
300
mV
600
Natural Gamma
0
CPS
250
Depth
1ft:240ft(R)
64" Normal Resistivity
0
Ohm-m
200
16" Normal Resistivity
0
Ohm-m
200

PTX06-1075

Contractor:

Contract #:

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

___Installation Log

___Lithologic Logs
    ___Draft
    ___Final

___Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

MONITORING WELL LOG

WELL NO. PTX06-1075

PROJECT NO.: PTX0030GA

LOCATION: Pantex Plant, Zone 10 South

ELEVATION: 3544.25 Brass

DRILLER: THF Drilling

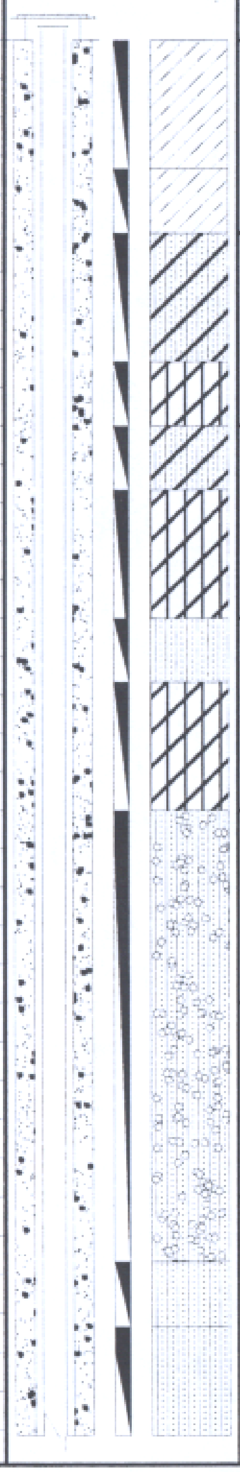
DATE DRILLED: 4/19/02

DATE COMPLETED: 5/5/02

WATER DEPTH: 355.28

LOGGER: Clay Wright

COMPLETION DEPTH: 415 feet

DEPTH (ft.)	Well Construction Diagram / Sampler / Soil Graphic	DESCRIPTION
0		Light brown 5yr5/6 sandy clay, very fine grained, well sorted, dry
		Moderate brown 5yr4/4 sandy clay, very fine grained, well sorted, dry
15		Moderate brown 5yr4/4 sandy silty clay, very fine grained, well sorted, dry, caliche nodules
		Light brown 5yr5/6 silty clay, dry, some caliche
30		Moderate brown 5yr4/4 sandy silty clay, well sorted, very fine grained, dry
		Light brown 5yr6/4 silty clay, well sorted, dry some caliche intermixed
45		Light brown 5yr6/4 silty sand, very fine grained, well sorted, dry
		Light brown 5yr5/6 silty clay, very fine grained, dry, well sorted
60		Light brown 5yr5/4 sandy silt, very fine grained, dry, well sorted, caliche nodules
75		
90		some clay
		Light brown 5yr5/6 silty sand, very fine grained, dry, well sorted, some caliche nodules
		Light brown 5yr6/4 silty sand, very fine grained, dry, well sorted
105		

PROTECTIVE COVER TYPE:

Steel

Upright Locking

SURFACE COMPLETION:

Type: Concrete Pad

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland, bentonite added

Total Thickness: 347'

CASING:

Diameter: 4" Stainless Steel

Length: 355'

Stick Up: 2

SEAL

Type: Bentonite Chip

Quantity: 8 sacks

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 353'-413'

COMMENTS

LLANO-PERMIAN ENVIRONMENTAL SERVICES

MONITORING WELL LOG
WELL NO. PTX06-1075

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells
PROJECT NO.: PTX003OGA
LOCATION: Pantex Plant, Zone 10 South
ELEVATION: 3544.25 Brass
DRILLER: THF Drilling
DATE DRILLED: 4/19/02
DATE COMPLETED: 5/5/02
WATER DEPTH: 355.28
LOGGER: Clay Wright
COMPLETION DEPTH: 415 feet

DEPTH (ft.)	DESCRIPTION
120	Grayish orange 10yr7/4 silty sand, very fine grained, dry, well sorted
	Light brown 5yr5/6 silty sand, very fine grained, dry, well sorted
135	
	Dark yellowish orange 10yr6/6 sand, very fine to fine grained, well sorted, dry, subangular
	Dark yellowish orange 10yr6/6 silty sand, very fine to fine grained, poorly sorted, dry, subangular, some caliche intermixed
150	Grayish orange 10yr7/4 very fine grained sandy silt, well sorted, dry
165	
180	
195	
	Grayish orange 10yr7/4 very fine grained silty sand, well sorted, dry
210	Grayish orange 10yr7/4 very fine to medium grained silty sand, well sorted, dry
	Grayish orange 10yr7/4 very fine grained silty sand, well

PROTECTIVE COVER TYPE: Steel

Upright Locking

SURFACE COMPLETION:

Type: Concrete Pad

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland, bentonite added

Total Thickness: 347'

CASING:

Diameter: 4" Stainless Steel

Length: 355'

Stick Up: 2

SEAL

Type: Bentonite Chip

Quantity: 8 sacks

Total Thickness: 5'

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Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 353'-413'

COMMENTS

MONITORING WELL LOG

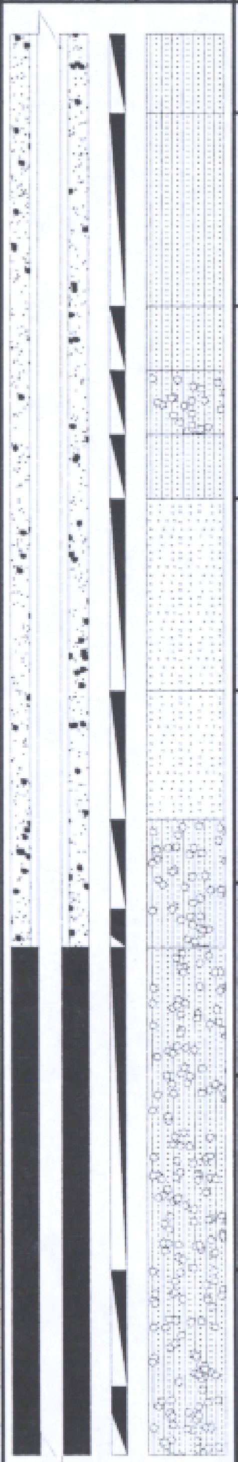
WELL NO. PTX06-1075

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells | PROJECT NO.: PTX003OGA

LOCATION: Pantex Plant, Zone 10 South | ELEVATION: 3544.25 Brass

DRILLER: THF Drilling | DATE DRILLED: 4/19/02 | DATE COMPLETED: 5/5/02

WATER DEPTH: 355.28 | LOGGER: Clay Wright | COMPLETION DEPTH: 415 feet



DEPTH (ft.)	Well Construction Diagram / Sampler / Soil Graphic	DESCRIPTION
		sorted, dry
225		Grayish orange 10yr7/4 very fine to medium grained silty sand, poorly sorted, dry, subangular to angular
240		Moderate yellowish brown 10yr5/4 fine to coarse grained silty sand, poorly sorted, some caliche nodules
		Grayish orange 10yr7/4 very fine to very coarse grained silty sand, well sorted, dry
		Moderate yellowish brown 10yr5/4 very fine to coarse grained silty sand, poorly sorted, some gravel intermixed
255		Very pale orange 10yr8/2 fine to coarse grained sand, poorly sorted, subangular to angular, dry
270		Very pale orange 10yr8/2 fine to medium grained sand, poorly sorted, subangular to subrounded, dry
		Grayish orange 10yr7/4 sandy silt, very fine grained, poorly sorted, moist, cemented calcareous nodules
285		
		Grayish orange 10yr7/4 sandy silt, very fine to coarse grained, poorly sorted, moist, angular to subangular
300		
315		Grayish orange 10yr7/4 sand, very fine to coarse grained, poorly sorted, moist, angular to subangular

PROTECTIVE COVER TYPE: Steel Upright Locking

SURFACE COMPLETION:

Type: Concrete Pad

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland, bentonite added

Total Thickness: 347'

CASING:

Diameter: 4" Stainless Steel

Length: 355'

Stick Up: 2

SEAL

Type: Bentonite Chip

Quantity: 8 sacks

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 353'-413'

COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1075

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells

PROJECT NO.: PTX003OGA

LOCATION: Pantex Plant, Zone 10 South

ELEVATION: 3544.25 Brass

DRILLER: THF Drilling

DATE DRILLED: 4/19/02

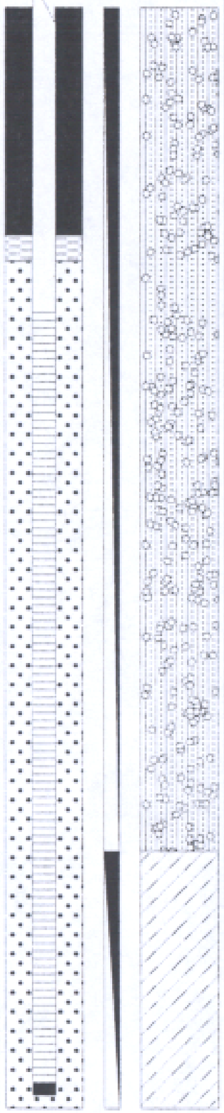
DATE COMPLETED: 5/5/02

WATER DEPTH: 355.28

LOGGER: Clay Wright

COMPLETION DEPTH: 415 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
330				
345				
360				
375				
				moderate reddish brown 10r4/6, some clay intermixed
390				
				Moderate reddish brown 10r4/6 clay
405				
				Bottom of Hole - 415'
420				
435				



PROTECTIVE COVER TYPE: Steel

Upright Locking

SURFACE COMPLETION:

Type: Concrete Pad

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland, bentonite added

Total Thickness: 347'

CASING:

Diameter: 4" Stainless Steel

Length: 355'

Stick Up: 2

SEAL

Type: Bentonite Chip

Quantity: 8 sacks

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 353'-413'

COMMENTS

LLANO-PERMIAN ENVIRONMENTAL SERVICES

COLOG Division of Layne Christensen Company

17301 West Colfax, Suite 265, Golden Colorado 80401
Office 303.279.0171, Fax 303.278.0135

CO Llano Permian
WELL PTX06-1075
FLD Pantex Plant
CTY Carson
STE TX

COMPANY Llano Permian Environmental
WELL PTX06-1075
FIELD Pantex Plant
COUNTRY USA **STATE** Texas

LOCATION
Amarillo, Texas

SEC NA **TWP** NA **RGE** NA

OTHER SERVICES

PERMANENT DATUM GROUND LEVEL **ELEVATION** NA

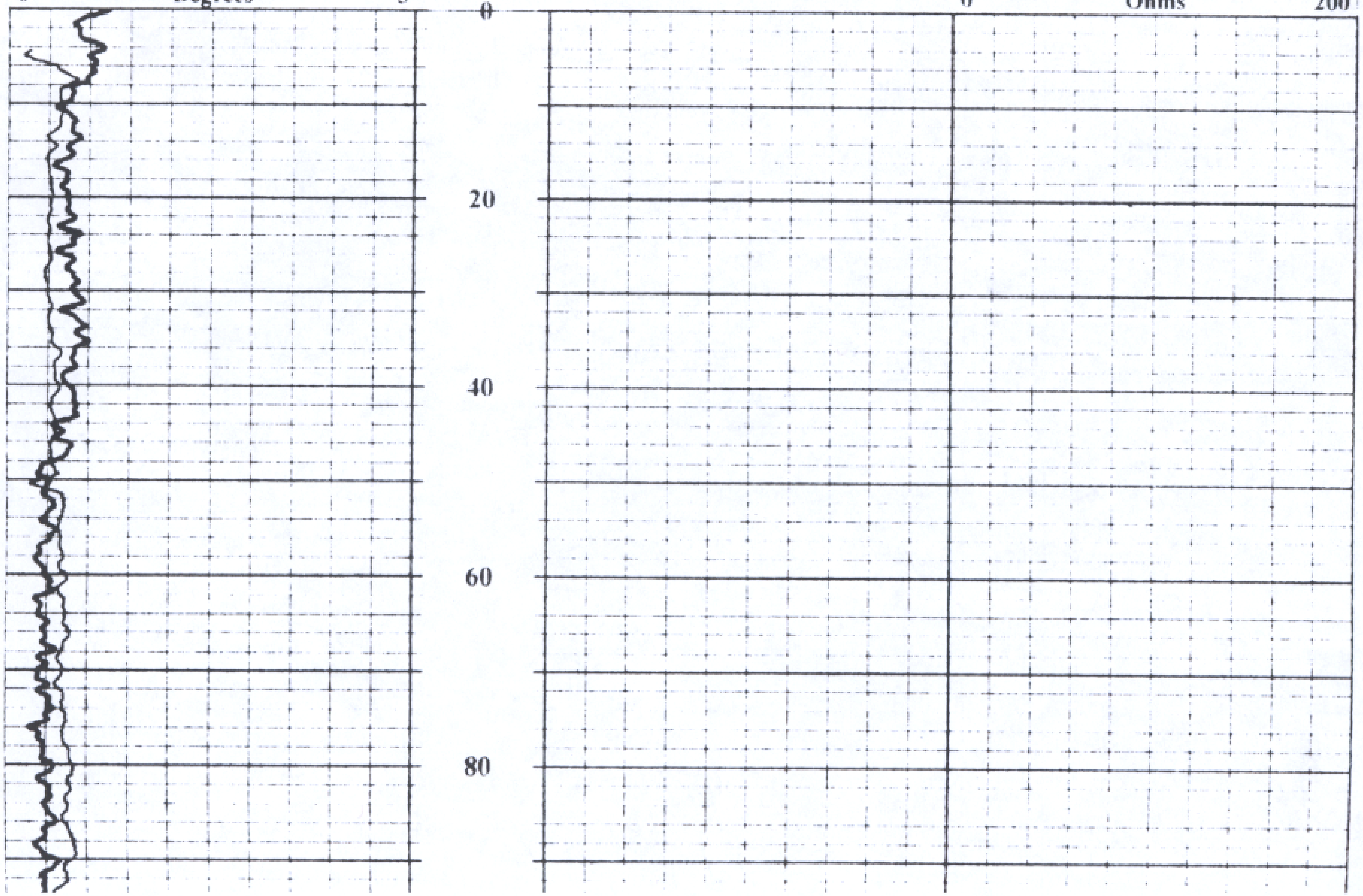
LOG MEAS. FROM G.L. 0.0 ABOVE PERMINANT DATUM

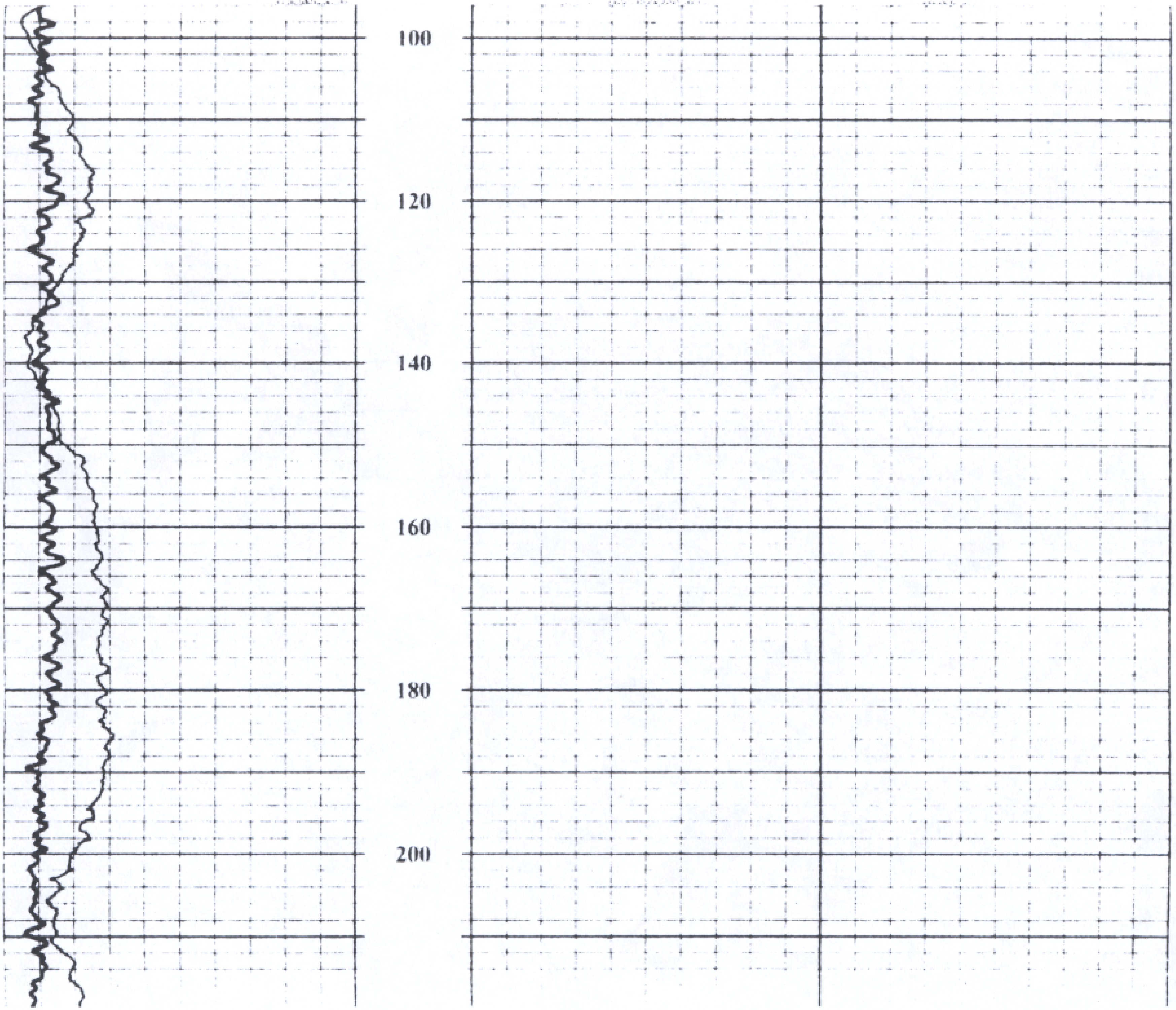
DRILLING MEAS. FROM GROUND LEVEL

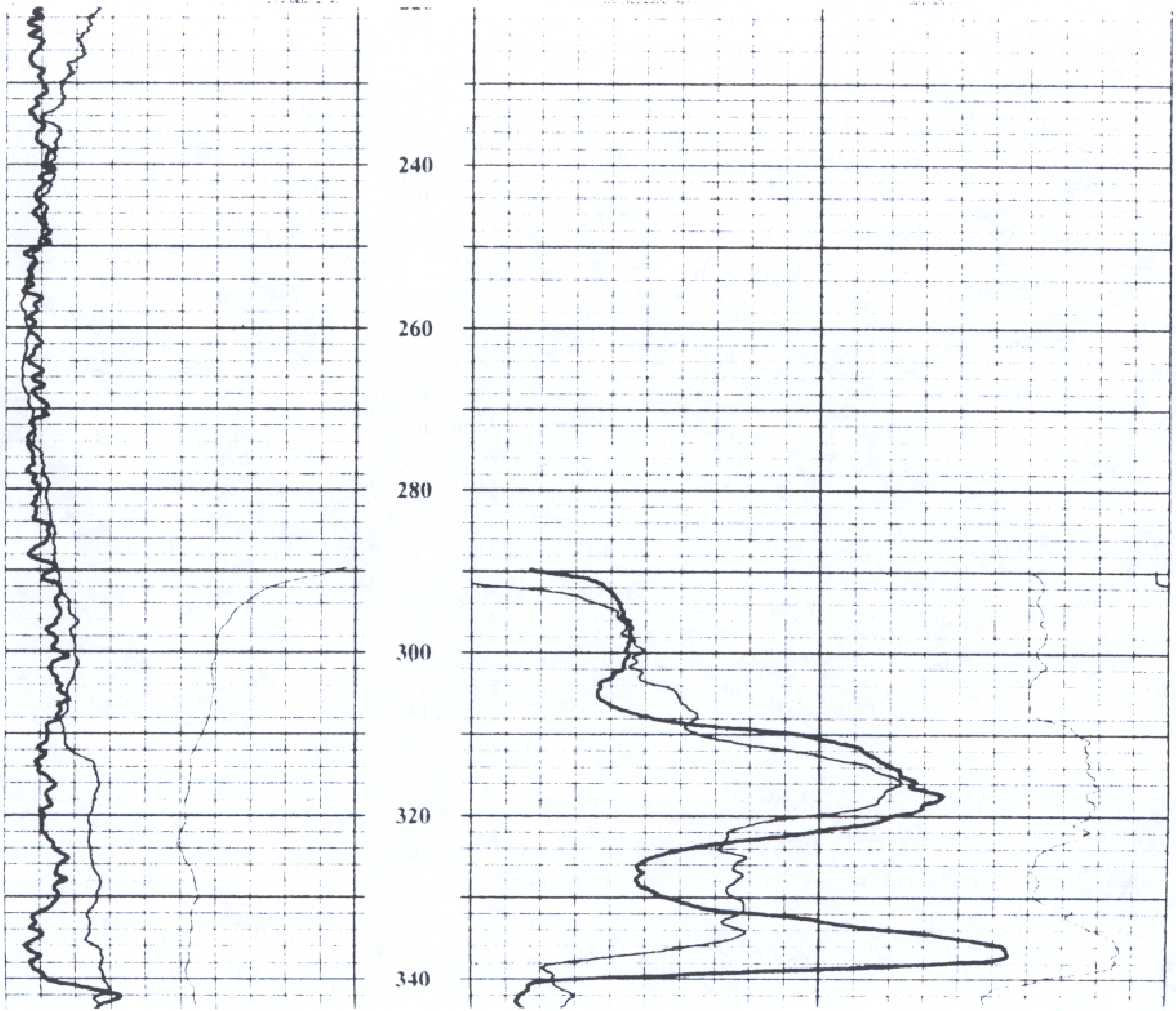
DATE ACQUIRED	2 May 2002	2 May 2002	2 May 2002	
RUN NUMBER	1	1	2	
LOG TYPE	Natural Gamma	Electric Log	Deviation Log	
DEPTH-DRILLER	415 ft			
DEPTH-LOGGER	416 ft			
BTM LOGGED INTERVAL	413 ft	416 ft	414 ft	
TOP LOGGED INTERVAL	0.0 ft	292 ft	5 ft	
RECORDED BY	N. Davis			
WITNESSED BY	Clay Wright			
PROBE TYPE, S/N	RABPF	EPF	2PDA	
LOGGING SPEED	20 ft/min	20 ft/min	20 ft/min	
A.S.D.E.	0.1 ft		0.5 ft	
SAMPLE INTERVAL	-0.2 ft	-0.2 ft	1.0 ft	

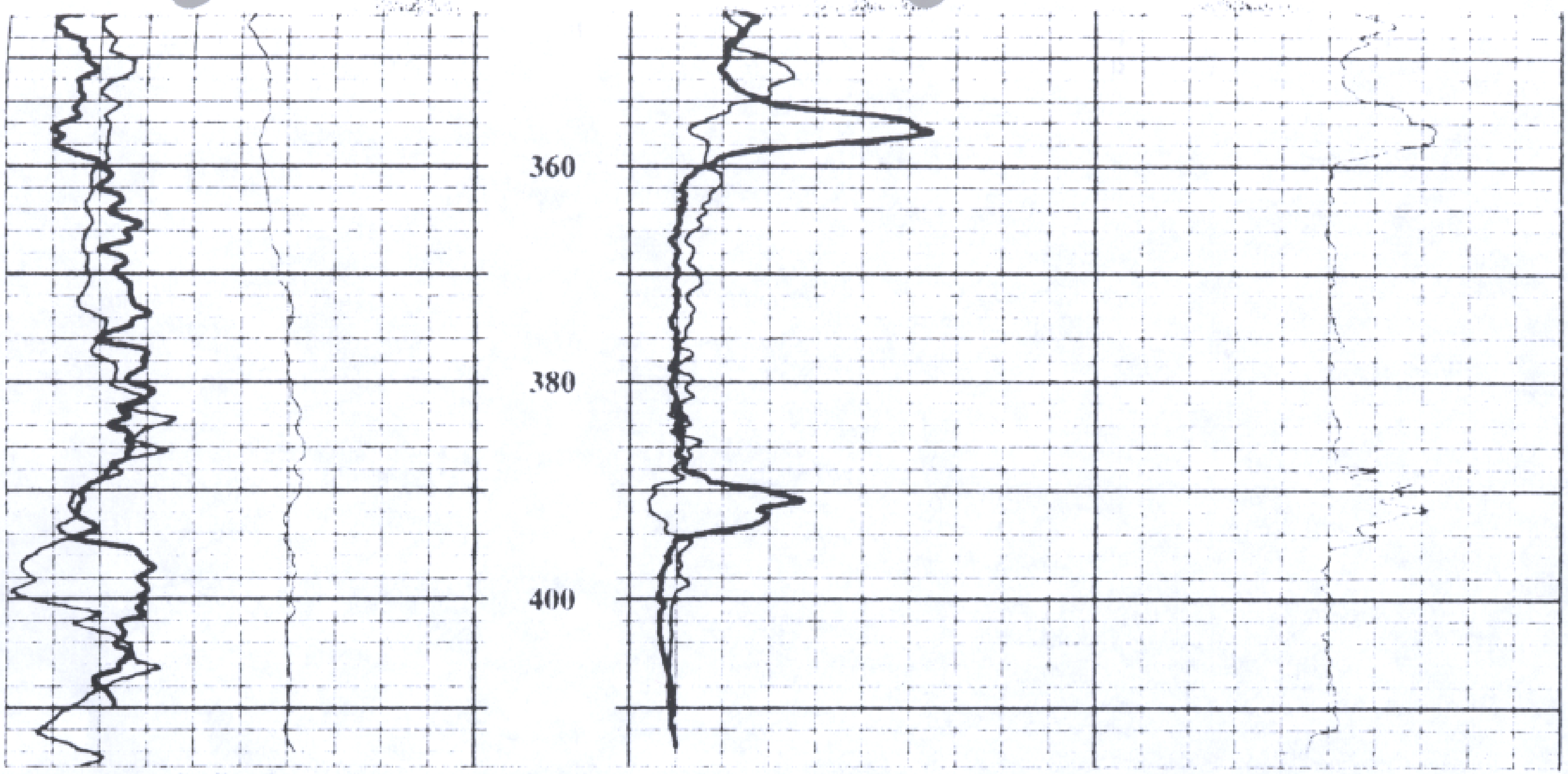
BOREHOLE RECORD				CASING RECORD			
RUN NO	BIT	FROM	TO	SIZE	WGT.	FROM	TO
	12"	G.L.	292'	8" Steel		G.L.	292'
	7.875	292'	TD				

Natural Gamma	Depth	16" Normal Resistivity
0 CPS 250	1ft:240ft(R)	0 Ohm-m 200
Spontaneous Potential		64" Normal Resistivity
-200 mV 100		0 Ohm-m 200
Inclination		Single Point Resistance
0 Degrees 5		0 Ohms 200




100
120
140
160
180
200


240
260
280
300
320
340



Inclination		Single Point Resistance

Track 1			Depth	Track 2		
	Inclination				**Single Point Resistance**	
0	Degrees	5		0	Ohms	200
	Spontaneous Potential				**64" Normal Resistivity**	
-200	mV	100		0	Ohm-m	200
	Natural Gamma		**Depth**		**16" Normal Resistivity**	
0	CPS	250	1ft:240ft(R)	0	Ohm-m	200

	Natural Gamma		**Depth**		**16" Normal Resistivity**	
0	CPS	250	1ft:240ft(R)	0	Ohm-m	200
	Spontaneous Potential				**64" Normal Resistivity**	

7/11/02

APEX SURVEYING & MAPPING, Inc.

Phone (806) 353-7231
Fax (806) 353-7232

1619 S KENTUCKY B-202
AMARILLO, TX 79102-2202

May 15, 2002

Llano Permian Environmental
Attn: Clay Wright
921 N. Bivins Street
Amarillo, Texas 79107

Re: Coordinates for new monitor wells at the USDOE Pantex Plant, Carson County, Texas

Name	Northing	Easting	Elevation	Description
PTX-06-1074	3,765,626.52	620,994.02	3573.36' 3576.20' 3573.2'	Brass Cap Top Casing Ground
PTX-06-1075	3,753,624.01	630,512.54	3544.25' 3546.52' 3544.0'	Brass Cap Top Casing Ground
PTX-06-1076	3,752,978.41	637,327.32	3525.68' 3528.34' 3525.5'	Brass Cap Top Casing Ground

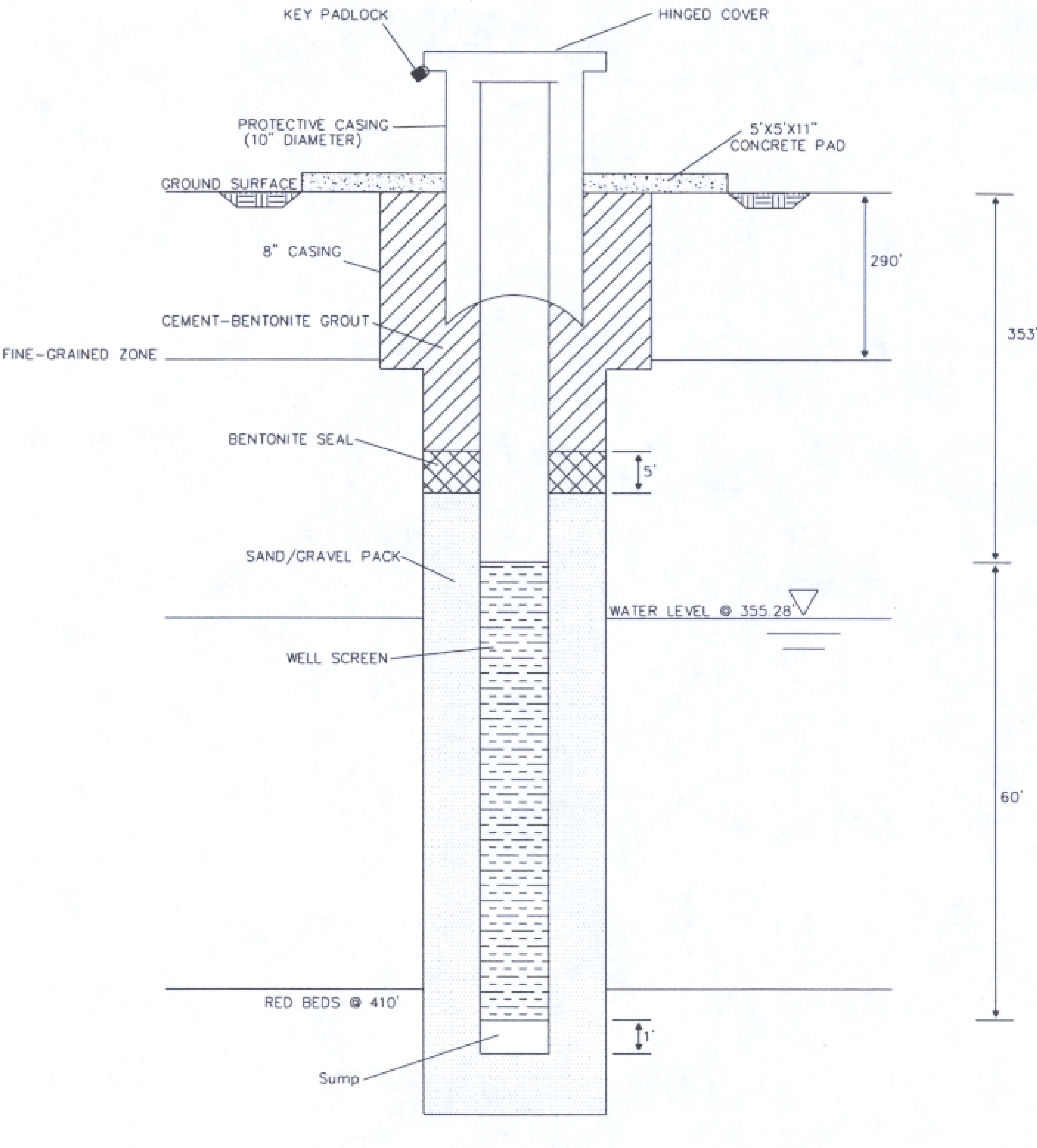
Coordinates and elevations are relative to Pantex NAD83 - NAVD88 Control network as established by "Kelley and Associates".

The undersigned does hereby certify that this survey was made upon the ground the 14th Day of May, 2002, by myself or others under my direct supervision and is true and correct. The undersigned further certifies that this survey meets or exceeds the required 1 foot horizontal and vertical accuracies, as set forth by Llano Permian Environmental specifications.

STATE OF TEXAS
REGISTERED
CURT McPHERSON
5275
PROFESSIONAL
LAND SURVEYOR

CURT McPHERSON
REGISTERED PROFESSIONAL LAND SURVEYOR
REG. NO. 5275
AMARILLO, TEXAS
DATE: 5/15/02

202-179-1.wps



Total Depth = 415'

LP Environmental
Llano-Permian Environmental Services

Date:	5/28/02
Scale:	Not To Scale
By:	JTC

PTX06-1075
Monitor Well Construction Detail
(Ogallala)

PTX06-1076

Contractor:

Contract #:

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

___Installation Log

_X_Lithologic Logs
    ___Draft
    _X_Final

___Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

7/11/02

APEX SURVEYING & MAPPING, Inc.

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1619 S KENTUCKY B-202
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May 15, 2002

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Coordinates and elevations are relative to Pantex NAD83 - NAVD88 Control network as established by "Kelley and Associates".

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STATE OF TEXAS
REGISTERED
CURT McPHERSON
5275
PROFESSIONAL
LAND SURVEYOR

CURT McPHERSON
REGISTERED PROFESSIONAL LAND SURVEYOR
REG. NO. 5275
AMARILLO, TEXAS
DATE: 5/15/02

202-179-1.wps

MONITORING WELL LOG

WELL NO. PTX06-1076

PROJECT NO.: PTX003OGA

LOCATION: South of Pantex Plant, Texas Tech Property

ELEVATION: 3525.5 Surface

DRILLER: THF Drilling

DATE DRILLED: 3/6/02

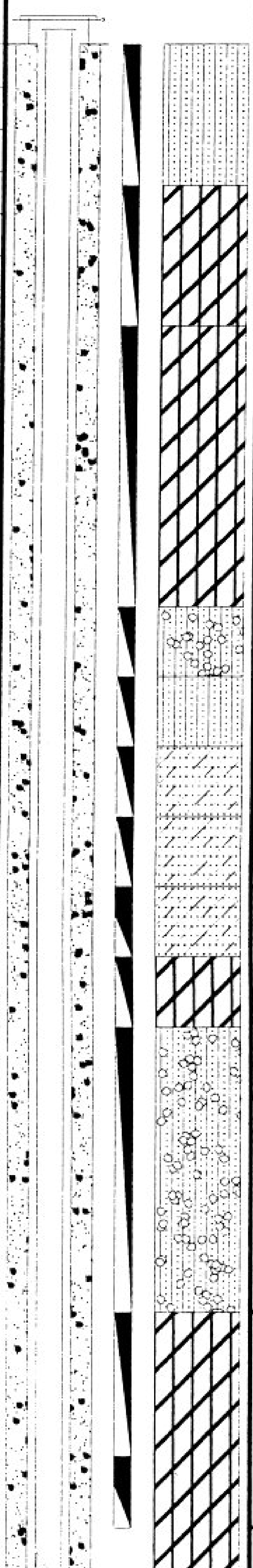
DATE COMPLETED: 3/25/02

WATER DEPTH: 345.46'

LOGGER: Clay Wright

COMPLETION DEPTH: 371 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
0				Grayish orange 10yr7/4 silty sand, very fine grained, well sorted, clay nodules intermixed
				Light brown 5yr6/4 silty clay, some sand, very fine grained, poorly sorted, dry
15				
				Grayish orange 10yr7/4 silty clay, very fine grained sand intermixed, well sorted, dry
30				
				Very pale orange 10yr8/2 sandy silt, very fine to fine grained
45				
				Moderate orange pink 5yr8/4 silty sand, very fine to fine grained, well sorted, dry, some intermittent caliche
				Light brown 5yr6/4 clayey sand, very fine to fine grained, subrounded, poorly sorted, dry, some intermittent caliche
				Light brown 5yr5/6 clayey sand, very fine to fine grained, subrounded, poorly sorted, dry
60				
				Moderate brown 5yr4/4 clayey sand, very fine to fine grained, subrounded, poorly sorted, dry
				Moderate brown 5yr4/4 silty clay, very fine to fine grained, subrounded, poorly sorted, dry
				Grayish orange 10yr7/4 sandy silt, very fine grained, well sorted, dry
75				
90				
				Very pale orange 10yr8/2 clayey silt, very fine grained, calcareous nodules intermixed, dry
105				no calcareous nodules



PROTECTIVE COVER TYPE: Steel

Upright locking

SURFACE COMPLETION:

Type: Concrete Pad

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

Type: Portland, benonite added

Total Thickness: 158 sacks

CASING:

Diameter: 4" Stainless Steel

Length: 342'

Stick Up: 2'

SEAL

Type: Bentonite Chip

Quantity: 11 sacks

Total Thickness: 5'

SCREEN

Type: Stainless Steel

Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 340'-360'

COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1076

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells

PROJECT NO.: PTX003OGA

LOCATION: South of Pantex Plant, Texas Tech Property

ELEVATION: 3525.5 Surface

DRILLER: THF Drilling

DATE DRILLED: 3/6/02

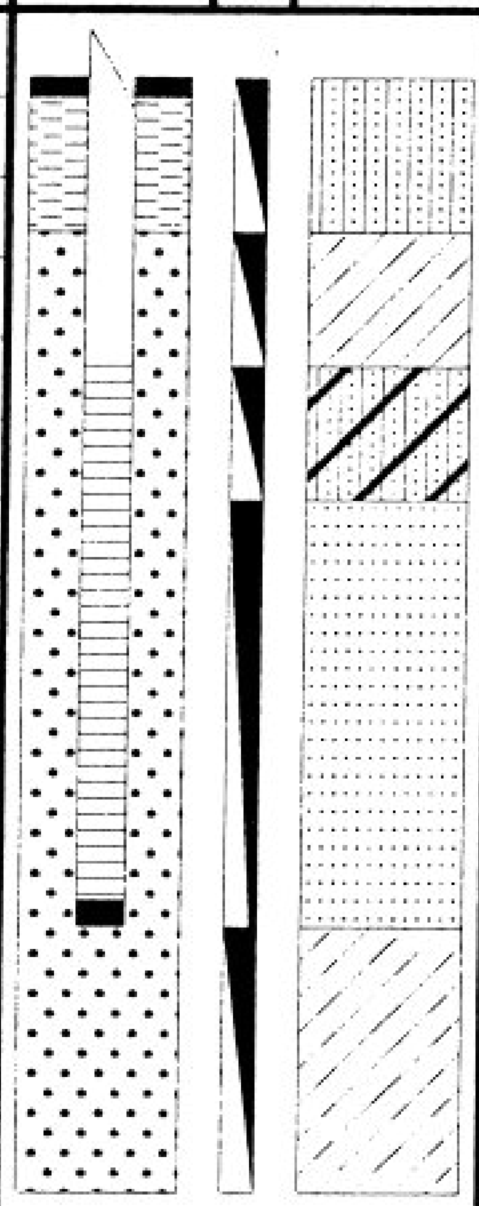
DATE COMPLETED: 3/25/02

WATER DEPTH: 345.46'

LOGGER: Clay Wright

COMPLETION DEPTH: 371 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
330				
				Moderate reddish brown sandy clay 10r4/6, very fine grained
				Dark yellowish orange 10yr6/6 sandy silty clay, very fine to very coarse grained, poorly sorted, subangular to angular
345				Dark yellowish orange 10yr6/6 sand, very fine to very coarse grained, poorly sorted, subangular to angular
360				
				Red Bed
				Bottom of Hole - 371'
375				
390				
405				
420				
435				



PROTECTIVE COVER TYPE: Steel

Upright locking

SURFACE COMPLETION:

Type: Concrete Pad

Size: 5'x5'x11"

Total Depth of Concrete: 10'

GROUT:

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Total Thickness: 158 sacks

CASING:

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Length: 342'

Stick Up: 2'

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Diameter: 4"

Slot Size: 0.010

Screened Interval(s): 340'-360'

COMMENTS

MONITORING WELL LOG

WELL NO. PTX06-1076

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells
PROJECT NO.: PTX003OGA
LOCATION: South of Pantex Plant, Texas Tech Property
ELEVATION: 3525.5 Surface
DRILLER: THF Drilling
DATE DRILLED: 3/6/02
DATE COMPLETED: 3/25/02
WATER DEPTH: 345.46'
LOGGER: Clay Wright
COMPLETION DEPTH: 371 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
				Dark yellowish orange 10yr6/6 silty sand, very fine grained, subangular, well sorted, dry
120				
135				Grayish orange 10yr7\4 sandy silt, very fine grained, well sorted, slightly moist
				Grayish orange 10yr7\4 silty sand, very fine grained, well sorted, subangular, dry
150				
165				
180				Grayish orange 10yr7\4 sandy silt, very fine grained, well sorted, dry
195				
				Very pale orange 10yr8/2 sandy silt, very fine grained, well sorted, dry
210				Grayish orange 10yr7/4 silty sand very fine grained, well sorted, subangular, dry

PROTECTIVE

COVER TYPE: Steel
Upright locking

SURFACE COMPLETION:

Type: Concrete Pad
Size: 5'x5'x11"
Total Depth of Concrete: 10'

GROUT:

Type: Portland, benonite added
Total Thickness: 158 sacks

CASING:

Diameter: 4" Stainless Steel
Length: 342'
Stick Up: 2'

SEAL

Type: Bentonite Chip
Quantity: 11 sacks
Total Thickness: 5'

SCREEN

Type: Stainless Steel
Diameter: 4"
Slot Size: 0.010
Screened Interval(s): 340'-360'

COMMENTS

MONITORING WELL LOG
WELL NO. PTX06-1076

PROJECT: Assessment of the Ogallala Aquifer Sentinel Wells PROJECT NO.: PTX003OGA
LOCATION: South of Pantex Plant, Texas Tech Property ELEVATION: 3525.5 Surface
DRILLER: THF Drilling DATE DRILLED: 3/6/02 DATE COMPLETED: 3/25/02
WATER DEPTH: 345.46' LOGGER: Clay Wright COMPLETION DEPTH: 371 feet

DEPTH (ft.)	Well Construction Diagram	Sampler	Soil Graphic	DESCRIPTION
				Grayish orange 10yr7/4 sand, fine to medium grained, well sorted, subangular, dry
225				
				Grayish orange 10yr7/4 silty sand very fine grained, well sorted, subangular, dry
				Very pale orange 10yr8/2 sandy silt, very fine grained, well sorted, dry
240				Grayish orange 10yr7/4 sand fine grained, well sorted, subangular, dry
				Grayish orange 10yr7/4 sand, intermixed gravel, fine grained, well sorted, subangular, dry
				Grayish orange 10yr7/4 sand fine grained, well sortedsubangular, dry
255				
				Very pale orange 10yr8/2 sandy silt, cemented, very fine to fine grained, poorly sorted, dry, some gravel intermixed
270				
				Grayish orange 10yr7/4 clayey sand, very fine to fine grained, well sorted, dry
285				Grayish orange 10yr7/4 sand fine to medium grained, poorly sorted, subrounded to subangular, dry
				moist
300				
				Pale yellowish brown 10yr6/2 sand, fine to coarse grained, subangular to angular, poorly sorted
315				fine to medium grained
				Grayish orange 10yr7/4 silty sand, very fine to medium grained, subangular, poorly sorted very coarse sand intermixed

PROTECTIVE

COVER TYPE: Steel

Upright locking

SURFACE COMPLETION:

Type: Concrete Pad
Size: 5'x5'x11"
Total Depth of Concrete: 10'

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Type: Stainless Steel
Diameter: 4"
Slot Size: 0.010
Screened Interval(s): 340'-360'

COMMENTS

COLOG Division of Layne Christensen Company

17301 West Colfax, Suite 265, Golden Colorado 80401
Office 303.279.0171, Fax 303.278.0135

CO Llano Permian
WELL PTX06-1076
FLD Pantex Plant
CTY USA
STE TX

COMPANY Llano Perminan Environmental
WELL PTX06-1076
FIELD Pantex Plant
COUNTRY USA **STATE** Texas

LOCATION
Amarillo, TX

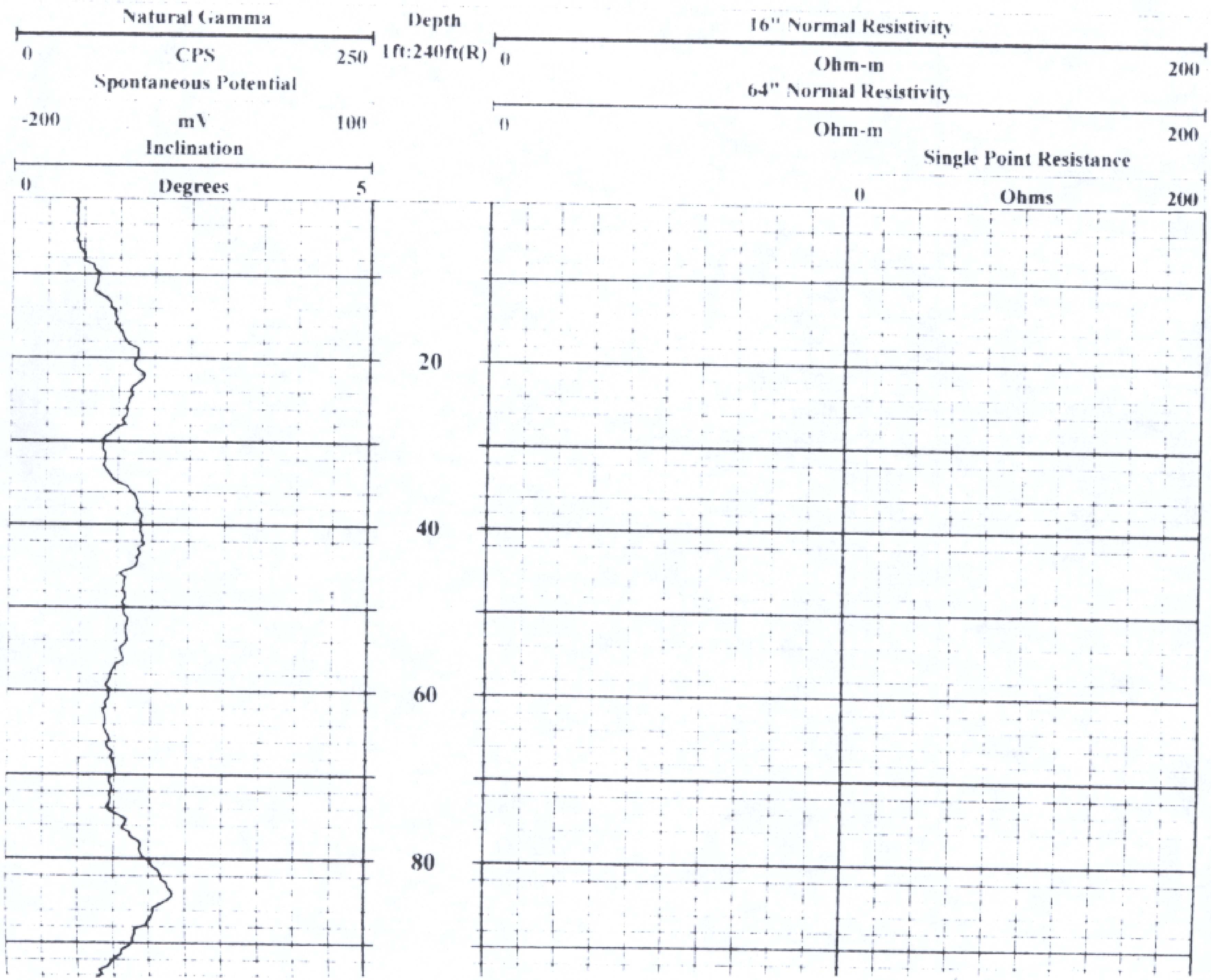
SEC **TWP** **RGE**

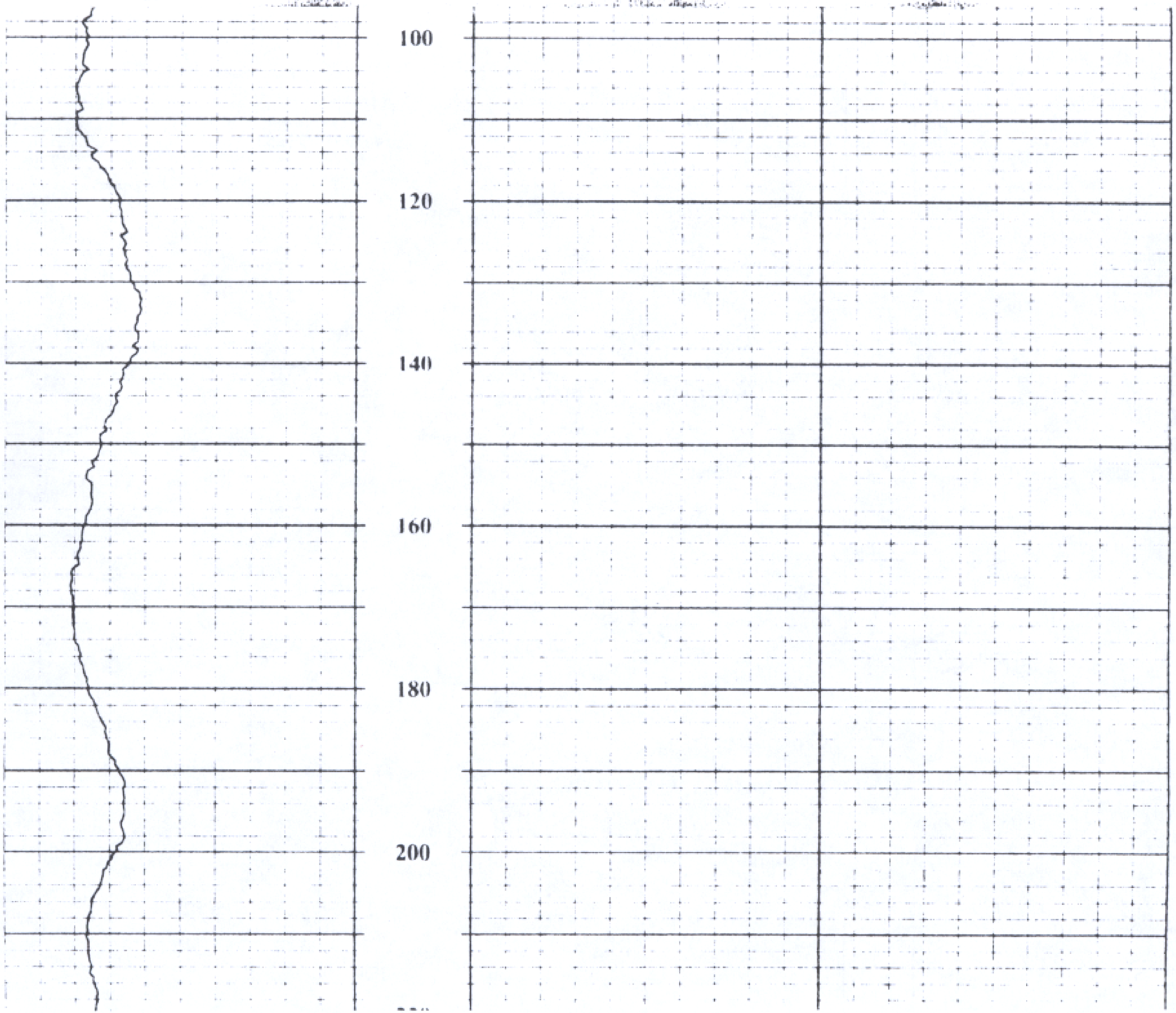
OTHER SERVICES

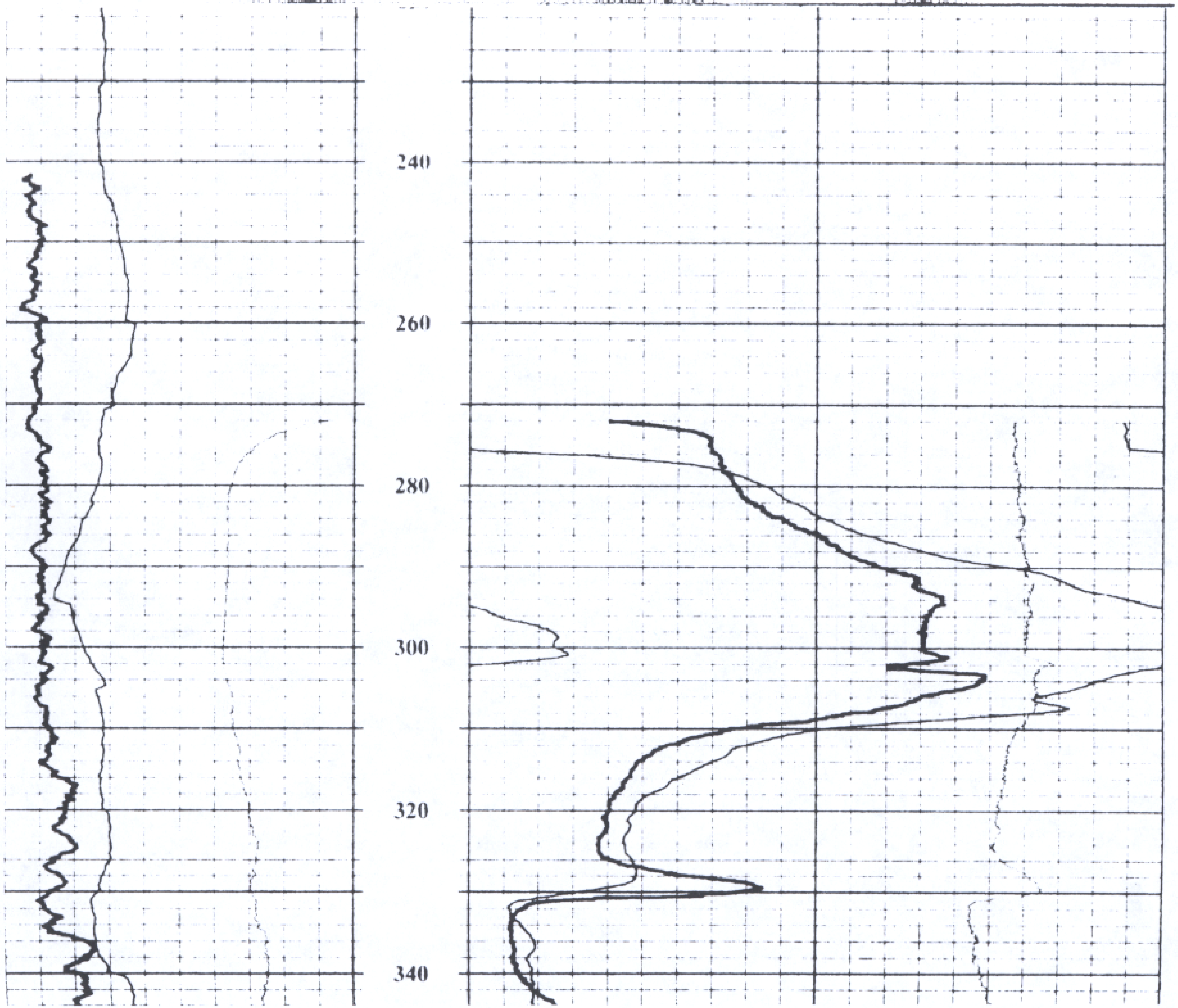
PERMANENT DATUM GROUND LEVEL **ELEVATION** NA
LOG MEAS. FROM GROUND LEVEL 0.0 ABOVE PERMINANT DATUM
DRILLING MEAS. FROM GROUND LEVEL

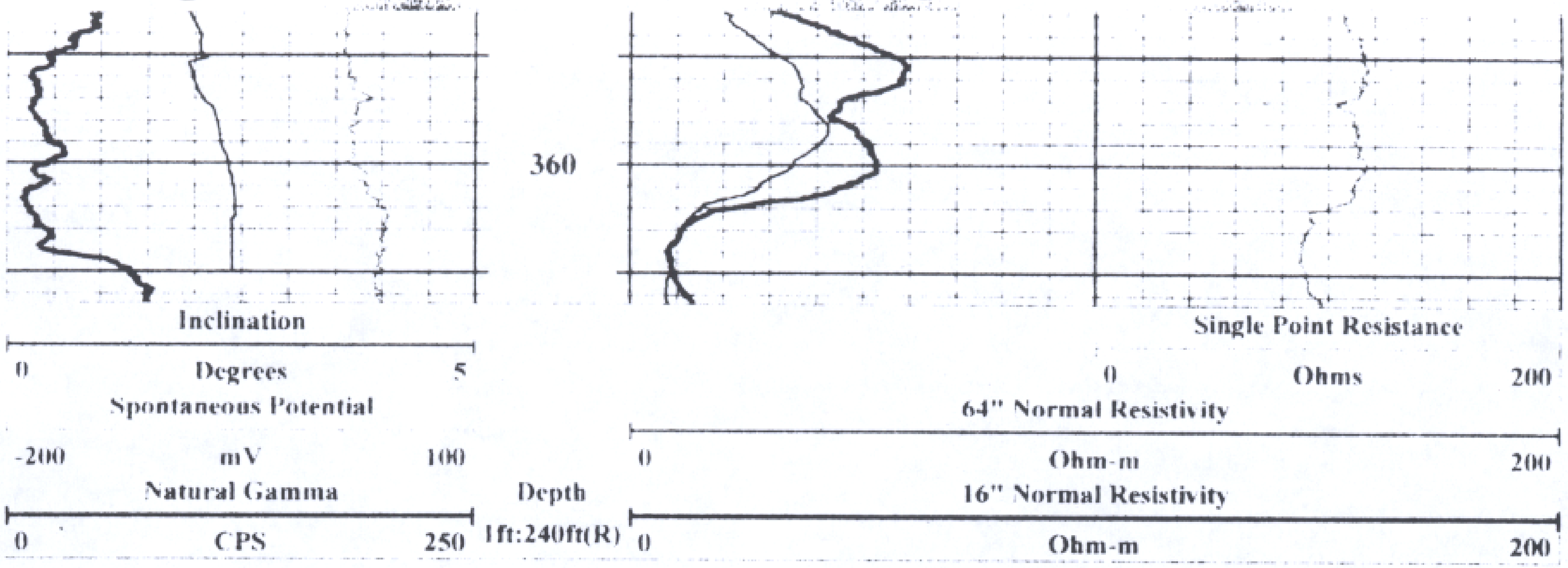
DATE ACQUIRED	23 March 2002	23 March 2002	3 May 2002	
RUN NUMBER	1	1	2	
LOG TYPE	Natural Gamma	Electric Log	Deviation Log	
DEPTH-DRILLER	371 ft.			
DEPTH-LOGGER	372 ft.			
BTM LOGGED INTERVAL	372 ft.	372 ft.		
TOP LOGGED INTERVAL	240 ft.	272 ft		
RECORDED BY	B. Goff		N. Davis	
WITNESSED BY	Clay Wright		Clay Wright	
PROBE TYPE, S/N	RABPF	EPF	2PDA-1000	
LOGGING SPEED	25 ft/min	25 ft/min	20 ft/min	
A.S.D.F.	0.9 ft	0.9 ft	0.5 ft	
SAMPLE INTERVAL	0.1 ft	0.1 ft	0.5 ft	

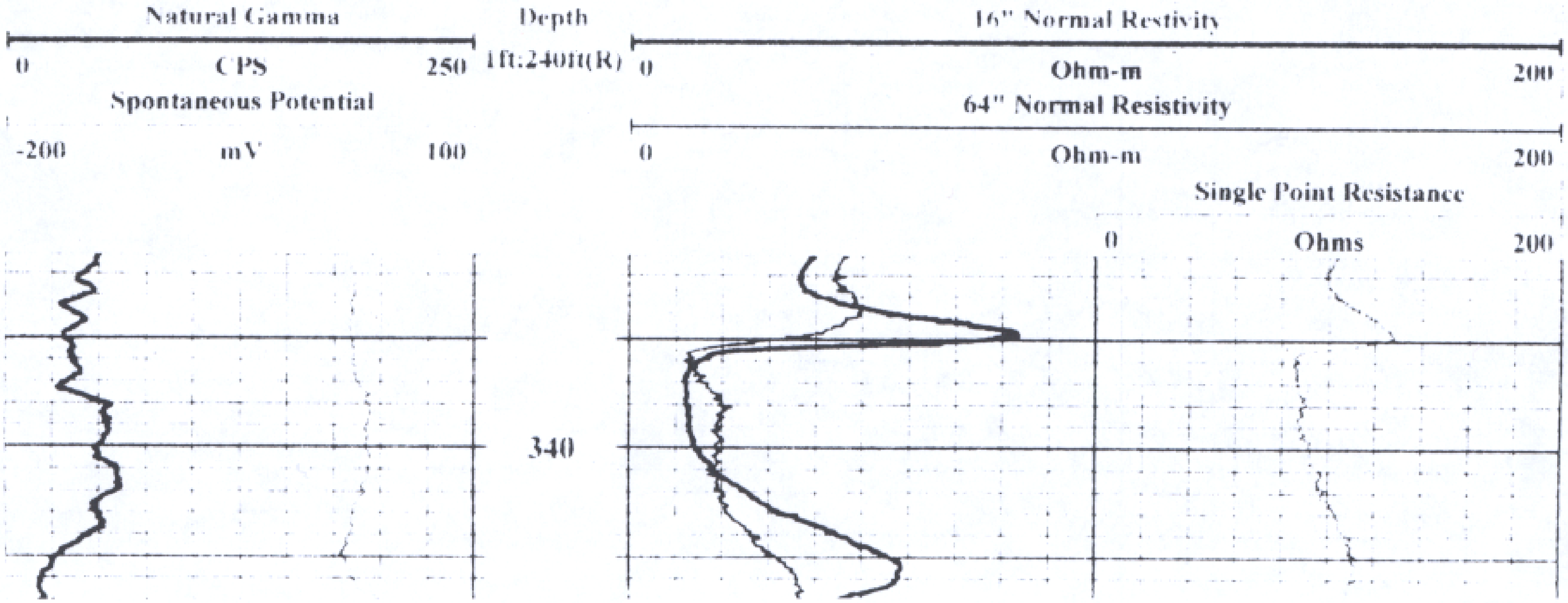
BOREHOLE RECORD				CASING RECORD			
RUN NO	BIT	FROM	TO	SIZE	WGT.	FROM	TO
	12"	G.L.	270'	8" Steel		G.L	270'
	7.875"	270'	TD				

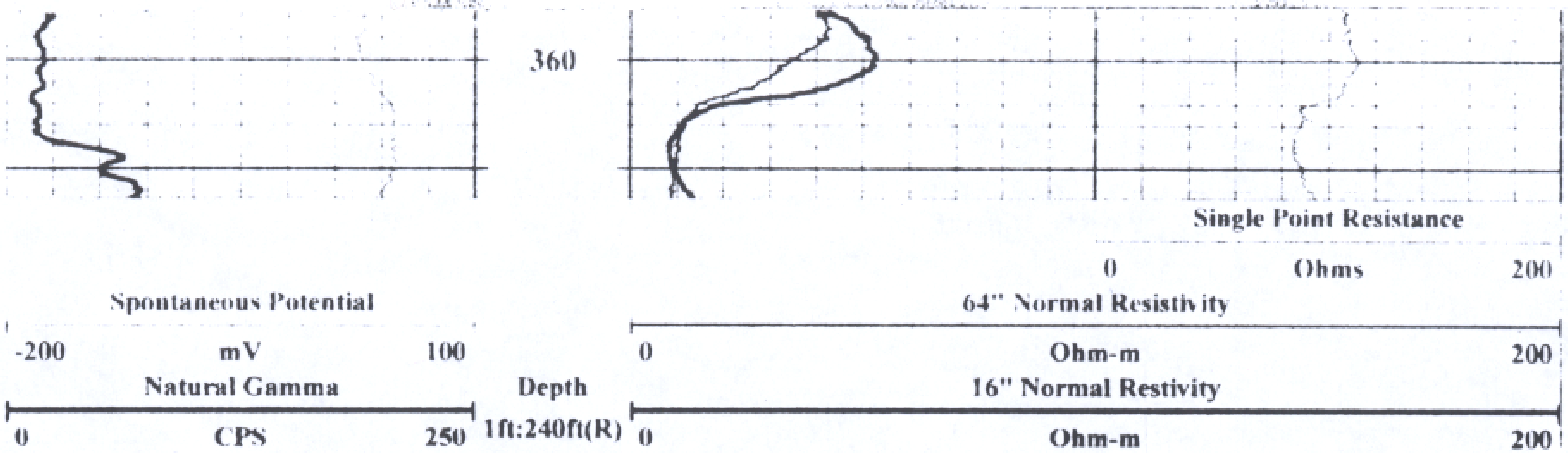

Natural Gamma
0 CPS 250
Spontaneous Potential
-200 mV 100
Inclination
0 Degrees 5
Depth
1ft:240ft(R)
20
40
60
80
16" Normal Resistivity
0 Ohm-m 200
64" Normal Resistivity
0 Ohm-m 200
Single Point Resistance
0 Ohms 200

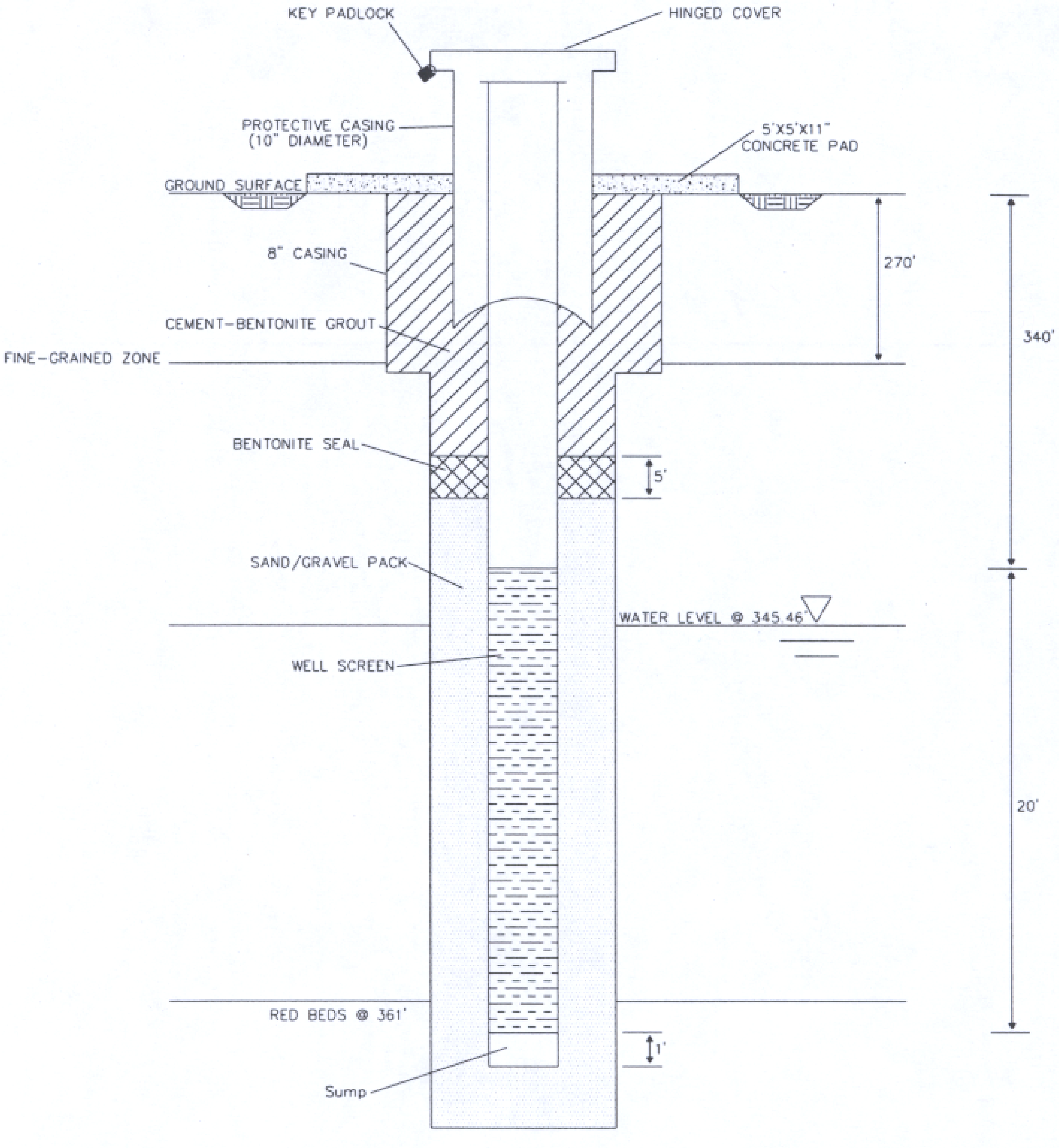

100
120
140
160
180
200


240
260
280
300
320
340


360
Inclination
0 Degrees 5
Spontaneous Potential
-200 mV 100
Natural Gamma
0 CPS 250
Depth
1ft:240ft(R)
Single Point Resistance
0 Ohms 200
64" Normal Resistivity
0 Ohm-m 200
16" Normal Resistivity
0 Ohm-m 200


Natural Gamma
0 CPS 250
Depth
1ft:240ft(R)
Spontaneous Potential
-200 mV 100
16" Normal Restivity
0 Ohm-m 200
64" Normal Resistivity
0 Ohm-m 200
Single Point Resistance
0 Ohms 200
340


360
Single Point Resistance
0 Ohms 200
Spontaneous Potential
64" Normal Resistivity
-200 mV 100
0 Ohm-m 200
Natural Gamma
Depth
16" Normal Restivity
0 CPS 250
1ft:240ft(R)
0 Ohm-m 200



Total Depth = 371'

Environmental Llano-Permian Environmental Services	Date: 5/28/02 Scale: Not To Scale By: JTC	PTX06-1076 Monitor Well Construction Detail (Ogallala)

PTX07-1R01

Contractor: S.M. Stoller

Contract #: 3589-102

OPTIX #:

Included Documents

___Drilling Log
    ___Draft
    ___Final

_X_Installation Log

_X_Lithologic Logs
    ___Draft
    _X_Final

_X_Geophysical Logs
    ___Neutron
    ___Gamma
    ___e-log
    ___Bond Log
    ___Deviation log

___State Well Report

APEX SURVEYING & MAPPING

1619 S KENTUCKY E-540
AMARILLO, TX 79102-2202

Phone (806) 353-7231
Fax (806) 353-7232

October 01, 1999

ETAS
ATTN: Donny Ives
P.O. BOX 202
GORE, OK 74435
(918)489-5511 ex 13 email: ellisj@ipa.net
fax: 477-3320 email: donives@arn.net

COORDINATE LIST
(for 99171P4)
TOPOGRAPHIC SURVEY OF MONITOR WELLS
EAST OF PLANT, NORTH PLYA, & LAND FILL
USDOE PANTEX PLANT, CARSON COUNTY, TEXAS

NAME	NORTHING	EASTING	ELEVATION	DESCRIPTION
PTX06-1043			3519.01	NATURAL GROUND
PTX06-1044			3539.33	NATURAL GROUND
PTX06-9919	3759671.683	644633.944	3534.9	NATURAL GROUND
PTX07-1R01	3764159.912	627914.279		CASSING
PTX07-1R02	3764319.890	627899.756		CASSING
PTX07-1R03	3764501.985	627666.079	3569.45	BRASS CAP
	3764501.800	627664.391	3571.96	TOP OF CASSING
			3568.82	NATURAL GROUND
PTX07-1R04	3764680.499	627976.896	3569.65	BRASS CAP
	3764680.613	627975.246	3571.91	TOP OF CASSING
			3568.92	NATURAL GROUND
PTX07-1R05	3764138.695	627712.633	3568.55	BRASS CAP
	3764138.779	627711.011	3570.32	TOP OF CASSING
			3567.97	NATURAL GROUND

Sincerely,

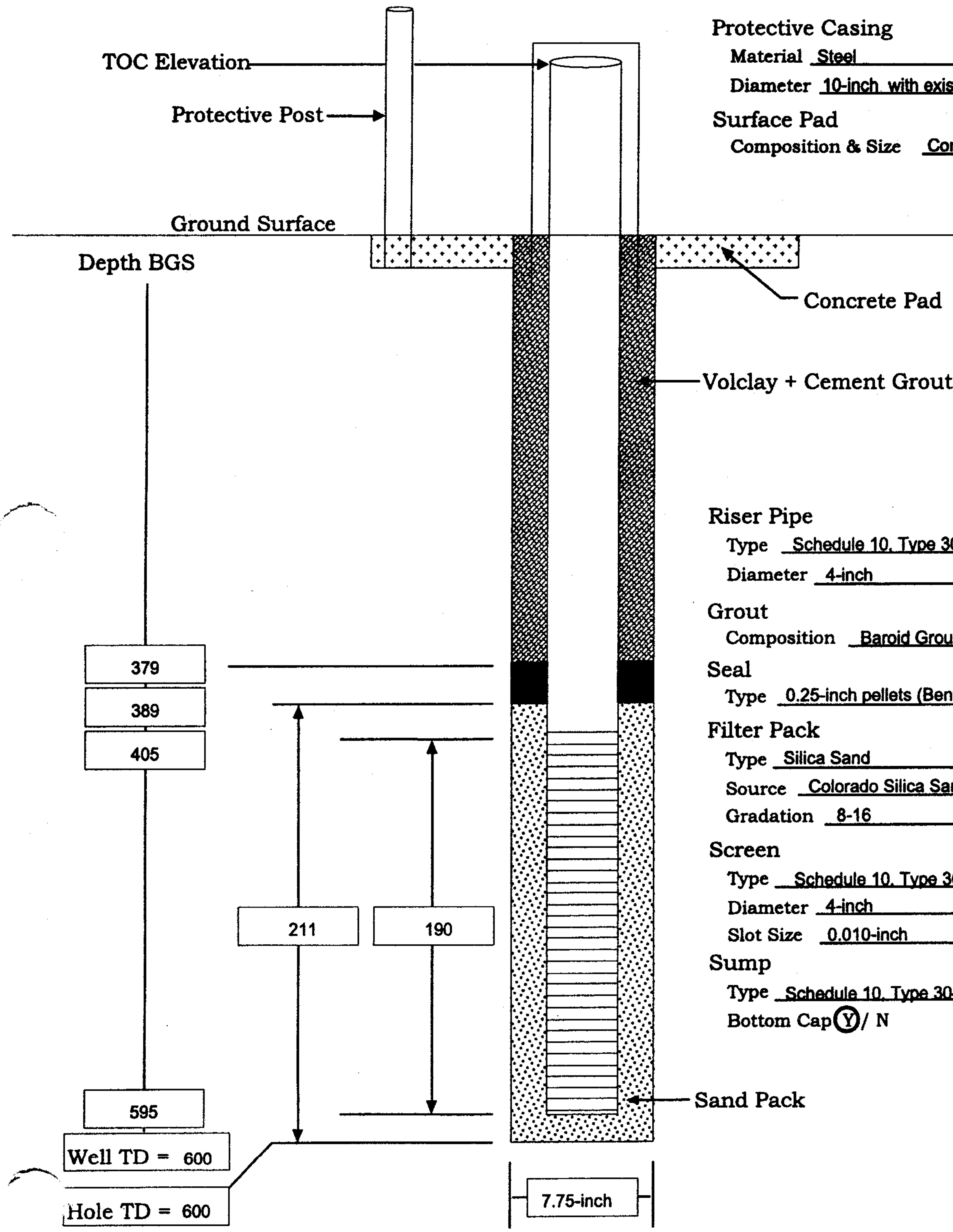
James W. Adams
APEX Surveying & Mapping

ja

Monitor Well Installation Diagram

Project: Pantex GW RFI
Location: South of Landfill 13
Contractor: Stewart Brothers Drilling Co.
Driller: M.King
Well Coordinates: N-3764160.14 / E-627915.06
TOC Elevation: 3571.63
Surface Elevation: 3569.33

Monitor Well No: PTX07-1R01
Date Constructed: 4-15-00
Observed by: R.Rupp
Sheet 1 of 1



Protective Casing
Material Steel
Diameter 10-inch with existing 8-inch steel to 238.6'

Surface Pad
Composition & Size Concrete 5'x5'x8"

Riser Pipe
Type Schedule 10, Type 304 Stainless Steel
Diameter 4-inch

Grout
Composition Baroid Grout (Bentonite)

Seal
Type 0.25-inch pellets (Bentonite)

Filter Pack
Type Silica Sand
Source Colorado Silica Sand
Gradation 8-16

Screen
Type Schedule 10, Type 304 Stainless Steel
Diameter 4-inch
Slot Size 0.010-inch

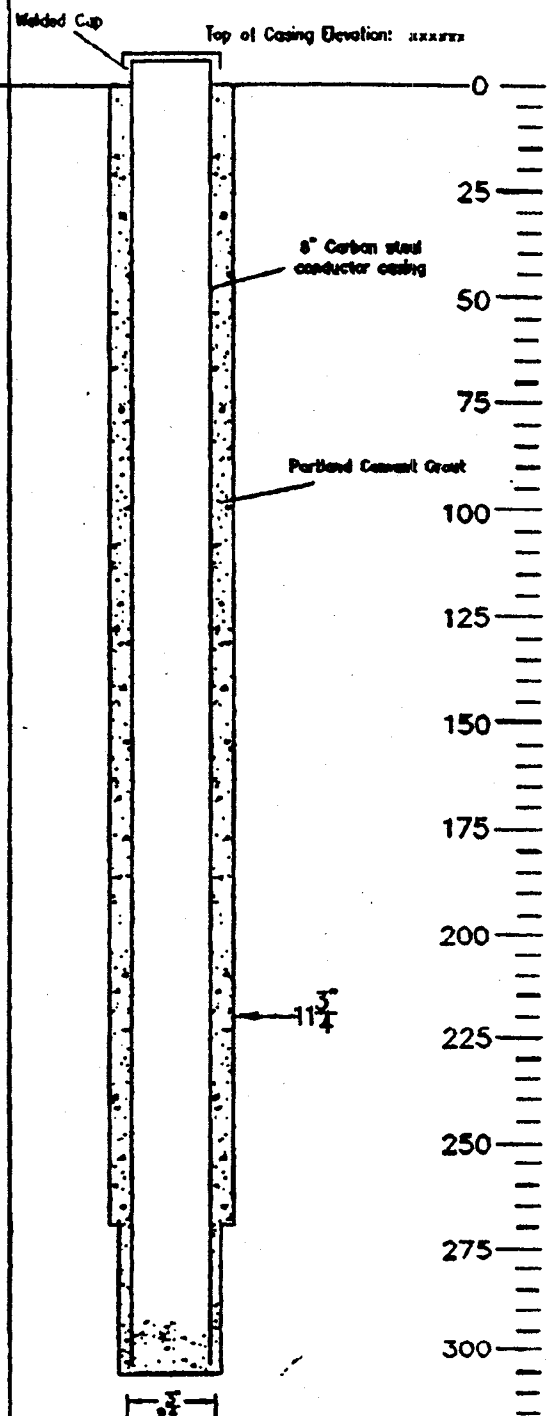
Sump
Type Schedule 10, Type 304 Stainless Steel
Bottom Cap Y / N

PTX07-1R01 WELL LOG

DEPTH (FT)	GRAPHIC LOG	LITHOLOGIC DESCRIPTION	SPLIT SPOON SAMPLE INTERVAL
		Northing (X) : 3764159.912 Easting (Y) : 627914.279 GROUND SURFACE ELEVATION: xxxxx	
0–6'	CH	Topsoil.	
6'–70'	CL	Clay 5yr 6/3 lightreddish brown, with caliche inclusions by 50' and abundant caliche nodules by 60'. Dry, hard and dense. Becoming silty and very sandy by 70'	
70'–245'	SM	Sand 7.5yr 6/4 light brown. Silty and clayey , very fine grain with clay seam @ 140'. Transition from sand to clay between 230'-242'. Slightly moist.	
245'–306.5'	FGZ	Clay 2.5yr 6/4 light reddish brown. Dry. TD@306.5'	305-306.5'
		NOTE: Conductor casing capped @ surface. No well installed.	

Depth scale: 0, 25, 50, 75, 100, 125, 140, 150, 175, 200, 225, 250, 275, 300, 325

WELL COMPLETION DETAIL



TASK ORDER NO. 1552-003 PROJECT 184

ETAS CORPORATION

LOCATION:	Landfill 13
DATE STARTED:	7/29/99
DATE COMPLETED:	8/16/99 DATE PLUGGED: N/A
DRILLING METHOD	CASING HAMMER/AIR ROTARY
DRILLED BY	WATER DEVELOPMENT CORP. ANDERSON
LOGGED BY	HENDRICKS/HALL
CHECKED BY	SCHLAG
DRAWN BY:	ETAS PAGE 1 OF 1

PTX07-1R01

Pantex GW RFI | **Pantex Plant (Landfill 13)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp /J. Moran /T. Hall	Northing: 3764160.14	Easting: 627915.06
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	600' BGS
Dates Drilled:	03/11/00 - 04/16/00	Depth to Water:	438.15' BTOC 04/25/00
Borehole Type:	11 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3569.33'	TOC Elevation:	3571.63'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	10 20 30 40 50 60			0-260' The conductor casing for Ogallala Well PTX07-1R01 was installed by Water Development Corp., drilling subcontractor to ETAS Corp. in August, 1999. Refer to ETAS Corporation Well Logs PTX07-1R01 and PTX07-1R02 for lithology details from surface to 260' BGS.		

S:\WELLOG\Pantex GWRFI #3589\PTX07-1R01.wld

PTX07-1R01

Pantex GW RFI | **Pantex Plant (Landfill 13)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp /J. Moran /T. Hall	Northing: 3764160.14	Easting: 627915.06
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	600' BGS
Dates Drilled:	03/11/00 - 04/16/00	Depth to Water:	438.15' BTOC 04/25/00
Borehole Type:	11 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3569.33'	TOC Elevation:	3571.63'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	80					
	90					
	100					
	110					
	120					
	130					

PTX07-1R01

Pantex GW RFI		**Pantex Plant (Landfill 13)**	**Amarillo, Texas**
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp /J. Moran /T. Hall	Northing: 3764160.14	Easting: 627915.06
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	600' BGS
Dates Drilled:	03/11/00 - 04/16/00	Depth to Water:	438.15' BTOC 04/25/00
Borehole Type:	11 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3569.33'	TOC Elevation:	3571.63'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	150					
	160					
	170					
	180					
	190					
	200					

From 263-330' the borehole was continuously cored using a 3-inch, 20 feet long split barrel sampler.

CORE INTERVAL	RECOVERY
263' - 269'	2.0' - 33%
269' - 274'	0.0' - 0%
274' - 279'	5.0' - 100%
279' - 284'	5.0' - 100%
284' - 293'	8.5' - 93%
293' - 304'	11.0' - 100%
304' - 315'	11.0' - 100%
315' - 330'	15.0' - 100%

@ 263-269' lost core occurs in initial 4-5' and is suspected to be sand
@ 269-274' no recovery of suspected sand & gravel
@ 284-293' lost core occurs from 292.5-293' in silty sand

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PTX07-1R01

Pantex GW RFI | **Pantex Plant (Landfill 13)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp /J. Moran /T. Hall	Northing: 3764160.14	Easting: 627915.06
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	600' BGS
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Ground Elevation:	3569.33'	TOC Elevation:	3571.63'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	220					
	230			236-246' Cement inside of conductor casing		
	240			246-255' Bentonite grout or pellets in conductor casing		
	250					
	260		SP	255-263' SAND, bentonite content decreasing, light brown (7.5YR 6/4), fine grain, subangular, poorly graded, very pale brown (10YR 7/4) when completely dry		
			GP	263-267' GRAVEL, sandy, 1" dia. grading to 1/2" dia., subrnded, qtzose, residual bentonite in top 0.3' of recovered material		
			ML	267-268.7' SILT, sandy, to SILTSTONE, v. fine sand, silt matrix, fractured calcic siltstone at 268-268.7'		
	270		SM	268.7-269' SAND, silty, trace clay, lt. brn (7.5YR 6/4), v. fine grain, med dense, moist; 269-274' NO RECOVERY		
			CL	274-275.5' CLAY, med. plas., v. stiff, mst, 1/4" gravel top 2"		PTX07-1R01-2-0275 Permeability Analysis
			SP	275.5-278.5' SAND, lt brn to brn (7.5YR 6/4-5/4), fine to v. fine, subrnded, med. dense, mst to dmp, silty @ 278'		PTX07-1R01-2-0278 Capillary Moisture

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PTX07-1R01

Pantex GW RFI | **Pantex Plant (Landfill 13)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp /J. Moran /T. Hall	Northing: 3764160.14	Easting: 627915.06
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	600' BGS
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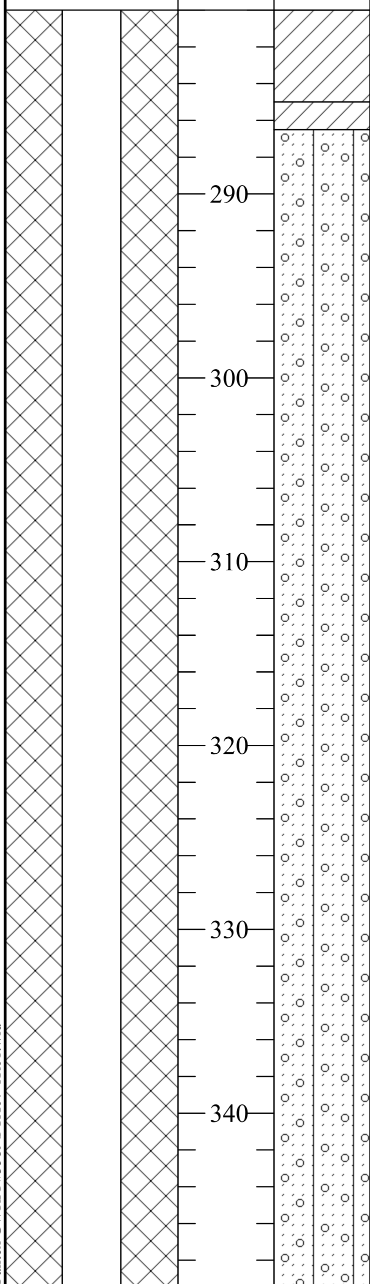
Borehole Type:	11 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3569.33'	TOC Elevation:	3571.63'

Completion | Depth (Ft.) | Lithology | USCS | Description | Sample | Sample Number



USCS	Description	Sample Number
CL	278.5-285' CLAY, strong brn (7.5YR 5/6), med-high plas, stiff-hard, mst-dmp, disseminated FeO2 staining, scattered calcic mottling, 2" cemented sandy zones @ 280.5, 282, 284	PTX07-1R01-2-0285 Permeability Analysis
CL	285-286.5' CLAY, sandy, 30% sand, strong brown (7.5YR 5/6), low plasticity, medium stiff to stiff, moist to damp, disseminated FeO2 staining, some calcic mottling, prevalent MnO2, sand % increasing with depth	
SM	286.5-350' SAND, silty, 70% sand, light reddish brown (5YR 6/4), nonplastic, 80% very fine sand, 15-20% fine sand, trace medium, subangular to subrounded, poorly graded, loose to medium dense, friable, damp to moist, generally drier with depth, calcic mottling throughout as nodes, no large intervals of cementation	PTX07-1R01-2-296.5 Permeability Analysis PTX07-1R01-2-0305 Permeability Analysis PTX07-1R01-2-305.5 Permeability Analysis PTX07-1R01-2-0314 Permeability Analysis PTX07-1R01-2-0315 Capillary Moisture PTX07-1R01-2-0322 Permeability Analysis

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PTX07-1R01

Pantex GW RFI | **Pantex Plant (Landfill 13)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp /J. Moran /T. Hall	Northing: 3764160.14	Easting: 627915.06
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	600' BGS
Dates Drilled:	03/11/00 - 04/16/00	Depth to Water:	438.15' BTOC 04/25/00
Borehole Type:	11 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3569.33'	TOC Elevation:	3571.63'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	360, 370, 380, 390		SM, SM	350-400' SAND, silty (20% silt), pink (7.5YR 7/3) to light reddish brown (5YR 6/4), very fine to medium grain, subangular to subrounded		
	400, 410		SP	400-430' SAND, trace silt, light brown (7.5YR 6/4), very fine to medium grain, subangular, graded		

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PTX07-1R01

Pantex GW RFI | **Pantex Plant (Landfill 13)** | **Amarillo, Texas**

Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp /J. Moran /T. Hall	Northing: 3764160.14	Easting: 627915.06
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	600' BGS
Dates Drilled:	03/11/00 - 04/16/00	Depth to Water:	438.15' BTOC 04/25/00
Borehole Type:	11 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3569.33'	TOC Elevation:	3571.63'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SP			
	430		SW	430-460' SAND, light reddish brown (5YR 6/4) fine to coarse grain, subangular to subrounded, well graded		
	440					
	450					
	460		SW	460-500' SAND, trace silt, pink (7.5YR 7/4), very fine to coarse grain, subangular, well graded		
	470					
	480					

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PTX07-1R01

Pantex GW RFI	Pantex Plant (Landfill 13)		Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp /J. Moran /T. Hall	Northing: 3764160.14	Easting: 627915.06
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	600' BGS
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Borehole Type:	11 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3569.33'	TOC Elevation:	3571.63'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
			SW			
	500		SW	500-520' SAND, slightly silty, pink (7.5YR 7/4), fine to very coarse grain, subangular, well graded, with 10% small gravel		
	510					
	520		GW	520-540' GRAVEL, sandy, 80% gravel 20% sand, light yellowish brown (10YR 6/4), well graded angular to subangular gravel, medium to coarse grain subrounded sand		
	530					
	540		SW-GW	540-560' SAND, gravelly, yellow (10YR 7/6), angular, well graded sands and gravels		
	550					

PTX07-1R01

Pantex GW RFI	Pantex Plant (Landfill 13)		Amarillo, Texas
Project Number:	3589-102	Client:	Mason & Hanger Corporation
Geologist:	R. Rupp /J. Moran /T. Hall	Northing: 3764160.14	Easting: 627915.06
Drilling Contractor:	Stewart Brothers Drilling	Total Depth of Borehole:	600' BGS
Dates Drilled:	03/11/00 - 04/16/00	Depth to Water:	438.15' BTOC 04/25/00
Borehole Type:	11 3/4" ARCH 7 7/8" Mud Rotary	Well Type:	Monitoring Well, 4" Stainless Steel
Ground Elevation:	3569.33'	TOC Elevation:	3571.63'

Completion	Depth (Ft.)	Lithology	USCS	Description	Sample	Sample Number
	570		SW-SP	560-580' SAND, light brown (7.5YR 6/4), fine to very coarse, subangular, well graded, with clay 570' light brown, fine grain sand with clay		
	580 590		SC	580-595' SAND, silty, clayey, 20% clay, pinkish white (7.5YR 8/2), very fine to fine grain		
			CL	595-600' CLAY, reddish brown to dark reddish brown (2.5YR 4/4 - 3/4), high plasticity, very stiff to hard, damp to moist		
	600 610 620			Total Depth of Borehole 600' BGS Fine Grain Zone 250' BGS (ETAS) Red Beds 595' BGS Conductor Casing installed by ETAS Corp. in August, 1999. Refer to ETAS Well Logs PTX07-1R01 and PTX07-1R02 for completion details surface to 260'. Borehole diameter is 11 3/4" from surface to 260' BGS. An 8" conductor casing was cemented from surface to 260' BGS, using ARCH methods. Mud Rotary drilling was used to complete a 7 7/8" borehole from 260' to 600'. Continuous Core was collected from the borehole from 263' to 330'. 415' of 4-inch Schedule 10, Type 304, stainless steel casing and 190' of 4-inch Type 304 Stainless steel screen were used in well construction. 5' Sump (595 - 600'); 190' screen, 0.010" Factory Slot (405 - 595'); 407' Casing (+2 - 405'); Filter Pack, 8/16 Colorado Silica Sand, thickness above screen 16' (389 - 600'); Bentonite Seal, pellet thickness above sand 10' (379 - 389'); Bentonite Grout (Surface - 379'); Concrete Pad (5'X5'X8") with 4 bollards; Steel Protective		

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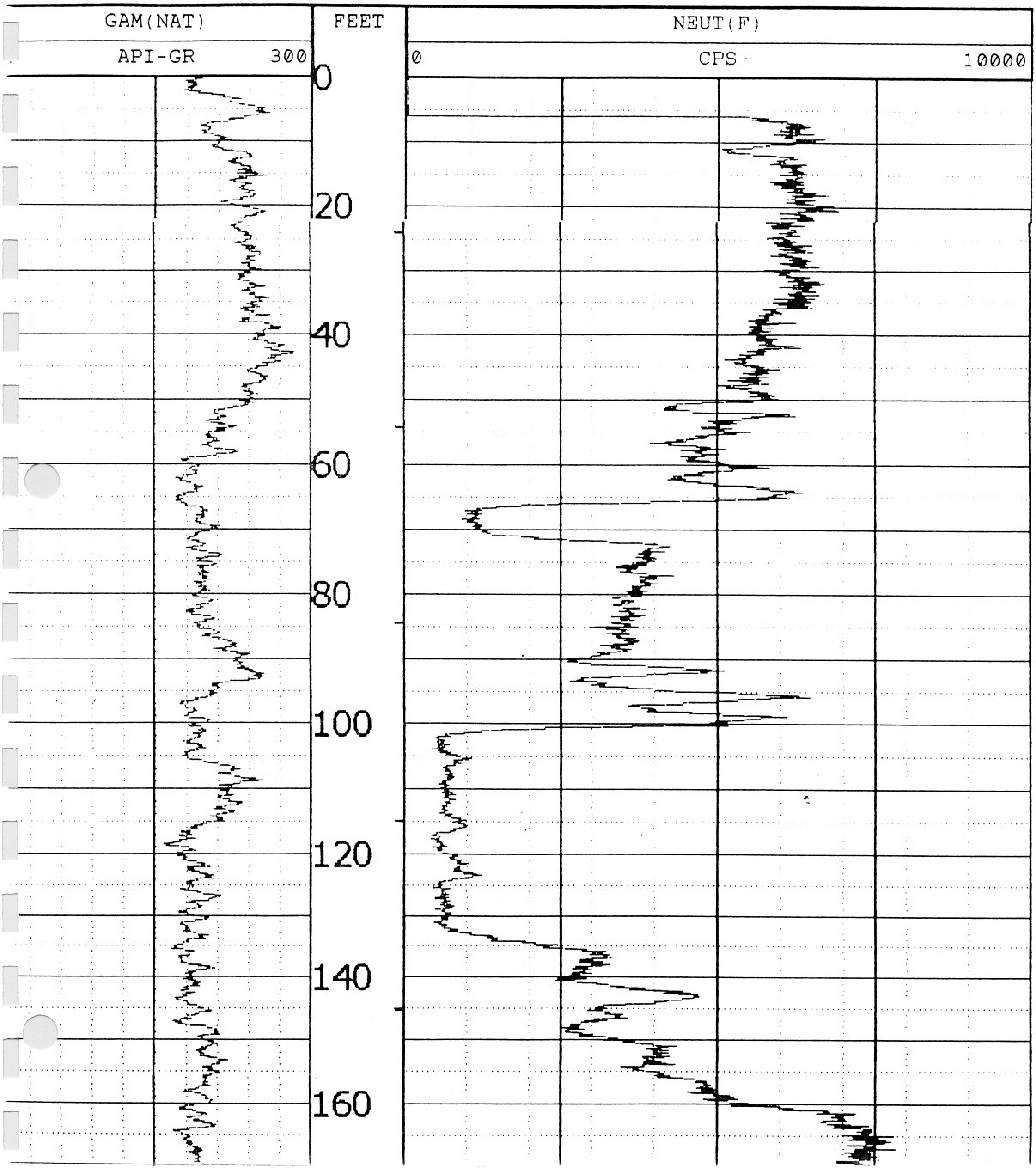
Century
GEOPHYSICAL CORP.

PTX-07-1R03

COMPANY	: ETAS			OTHER SERVICES:	
WELL	: PTX-07-1R03				
LOCATION/FIELD	: Pantex				
COUNTY	: Carson				
STATE	: TX				
SECTION	:	TOWNSHIP	:	RANGE	:
DATE	: 08/31/99	PERMANENT DATUM	:		
DEPTH DRILLER	: 258			KB	:
LOG BOTTOM	: 263.00	LOG MEASURED FROM	: T.O.C.	DF	:
LOG TOP	: -1.30	DRL MEASURED FROM	: G.L.	GL	:
CASING DIAMETER	: 6	LOGGING UNIT	: 9607		
CASING TYPE	: P.V.C.	FIELD OFFICE	: TULSA		
CASING THICKNESS	: .2	RECORDED BY	: Federwisch		
BIT SIZE	: 9.825	BOREHOLE FLUID	: WATER	FILE	: ORIGINAL
MAGNETIC DECL.	: 8	RM	: 0	TYPE	: 9072A
MATRIX DENSITY	: 2.71	RM TEMPERATURE	: 0		
NEUTRON MATRIX	: sandstone	MATRIX DELTA T	: 54		
				THRESH:	20000

ALL SERVICES PROVIDED SUBJECT TO STANDARD TERMS AND CONDITIONS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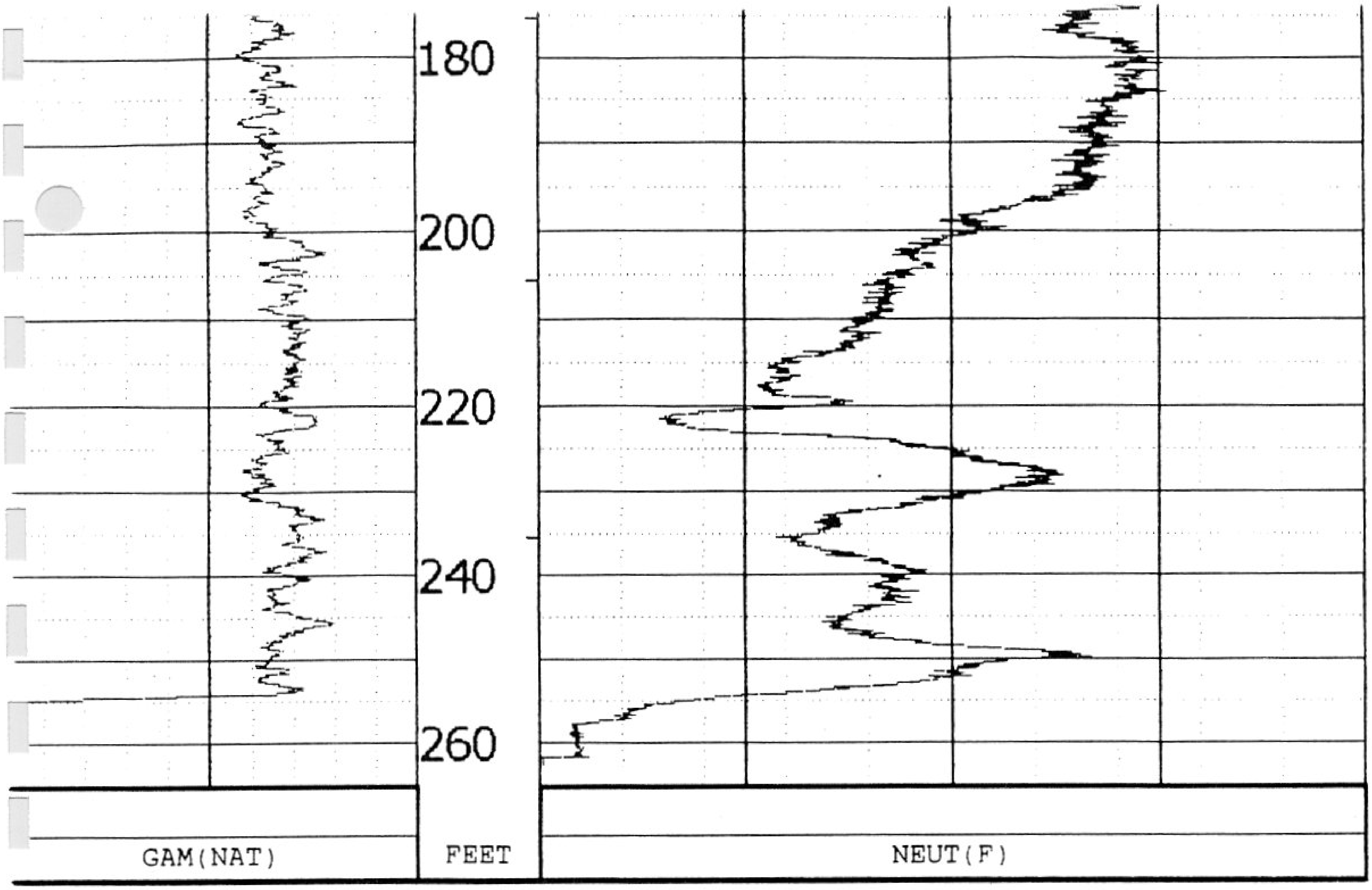

TOOL CALIBRATION PTX-07-1R03 08/31/99 11:55
TOOL 9072A
SERIAL NUMBER 306

	DATE	TIME	SENSOR	STANDARD	RESPONSE
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	Jun07,99	16:21:56	GAM(NAT)	Default [API-GR]	Default [CPS]
2	Jun07,99	16:21:56	VOLTAGE	Default [Mv]	Default [CPS]
	Jun07,99	16:21:56	VOLTAGE	Default [MV]	Default [CPS]
3	Jun07,99	16:21:56	CURRENT	Default [UA]	Default [CPS]
	Jun07,99	16:21:56	CURRENT	Default [UA]	Default [CPS]
4	Jun07,99	16:21:56	NEUT(N)	10520.000 [CPS]	
5	Jun07,99	16:21:56	NEUT(F)	397.000 [CPS]	

COLOG Division of Layne Christensen Company
17301 West Colfax, Suite 265, Golden Colorado 80401
PHONE: (303) 279-0171 FAX: (303) 278-0135

COM: SM STOLLER
WELL: PTX07-1R01
FLD: PANTEX
ST: TX COUNTY: CARSON

ELECTRIC LOG

COMPANY: SM STOLLER
WELL: PTX07-1R01
FIELD: PANTEX
STATE: TX COUNTY: CARSON
LOCATION: NA
SEC TWP RGE
OTHER SERVICES:

PERMANENT DATUM: Ground Surface ELEVATION: NA
LOG MEAS. FROM: Ground Surface 0.0 FT ABOVE PERM. DATUM
DRILL MEAS. FROM: Ground Surface

DATE ACQUIRED	4/15/00	4/15/00		
RUN NUMBER	1	1		
LOG TYPE	Gamma	Electric		
DEPTH-DRILLER	600'			
DEPTH-LOGGER	599'			
BTM LOGGED INTERVAL	597	568'		
TOP LOGGED INTERVAL	Surface	252'		
RECORDED BY	Davis			
WITNESSED BY	Ford			
FLUID LEVEL	70'			
FLUID TYPE	Surface			
Rm at TEMP	N/A			
TIME SINCE CIRC.	N/A			
PROBE TYPE, S/N	RABPF 2171	EPF1567		
MODULE TYPE, S/N	UM 1524	UM 1524		
LOGGING SPEED	15 ft/min	15 ft/min		
A.S.D.E.	0.7'	0.7'		
SAMPLE INTERVAL	0.1'	0.1'		
SOURCE SIZE, S/N	None	None		

BOREHOLE RECORD			CASING RECORD		
BIT SIZE	FROM	TO	SIZE/WGT	FROM	TO
11 3/4"	Surface	254'	Sump	595'	600'
7 7/8"	405	595'	Screen	470'	845'
			Riser	Surface	405'

COMMENTS:

Drill Type: ARCH 0-260'
Mud Rotary 260-600'

8" Conductor Casing Set Surface to 254'

COMMENTS:

4" Type 304 Stainless Steel Casing & Screen
Screen Slot 0.010

Borehole Logged Open Hole from 252-599'

NA - NOT AVAILABLE, N/A - NOT APPLICABLE

DIGITAL FILES: 1R01.dat, 1R01.HDP, 1R01.PLP

SM STOLLER, PTX07-1R01, 4/15/00

COLOG

SPONTANEOUS POTENTIAL
100 MILLIVOLTS 200

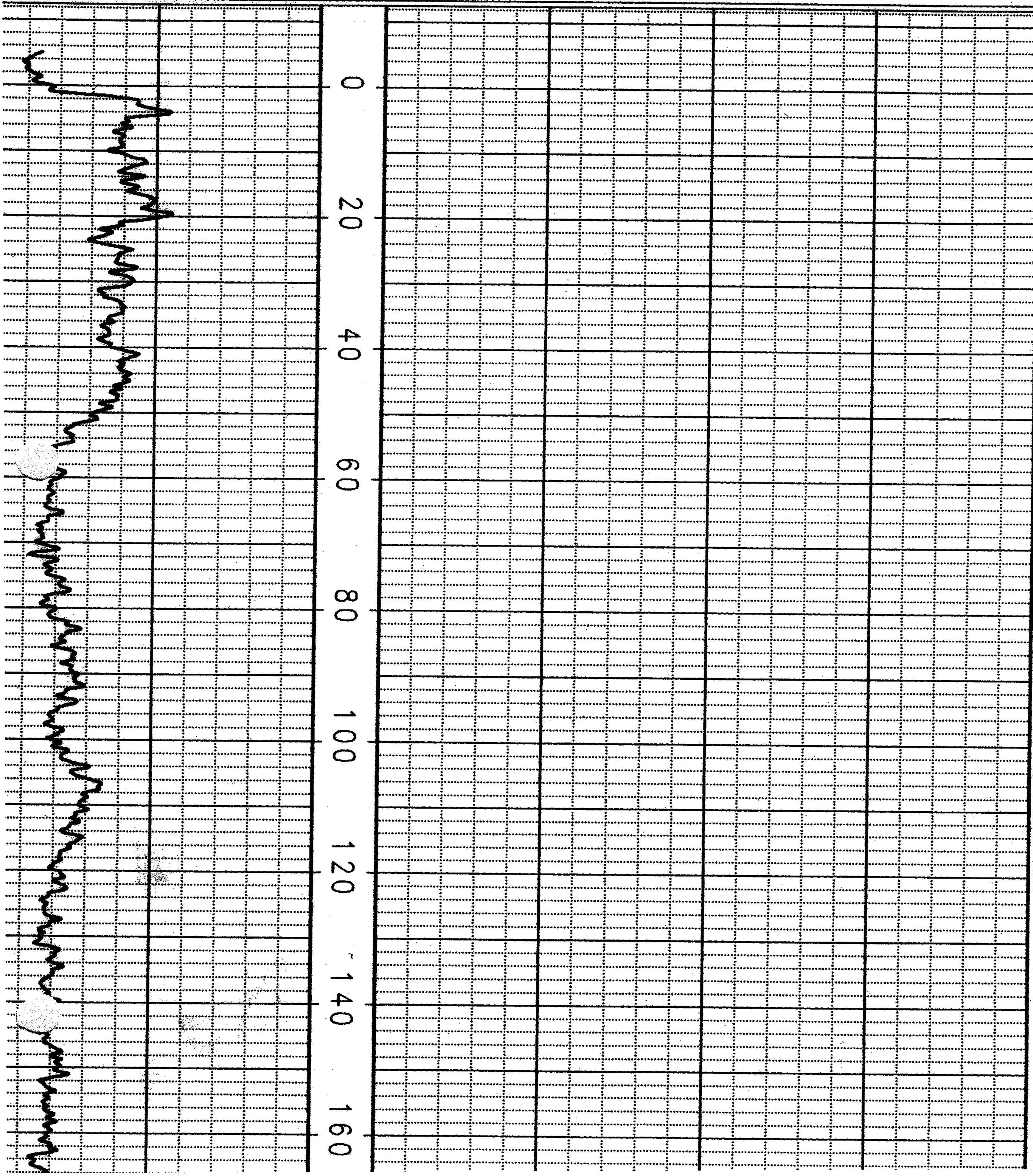
NATURAL GAMMA
0 CPS 200

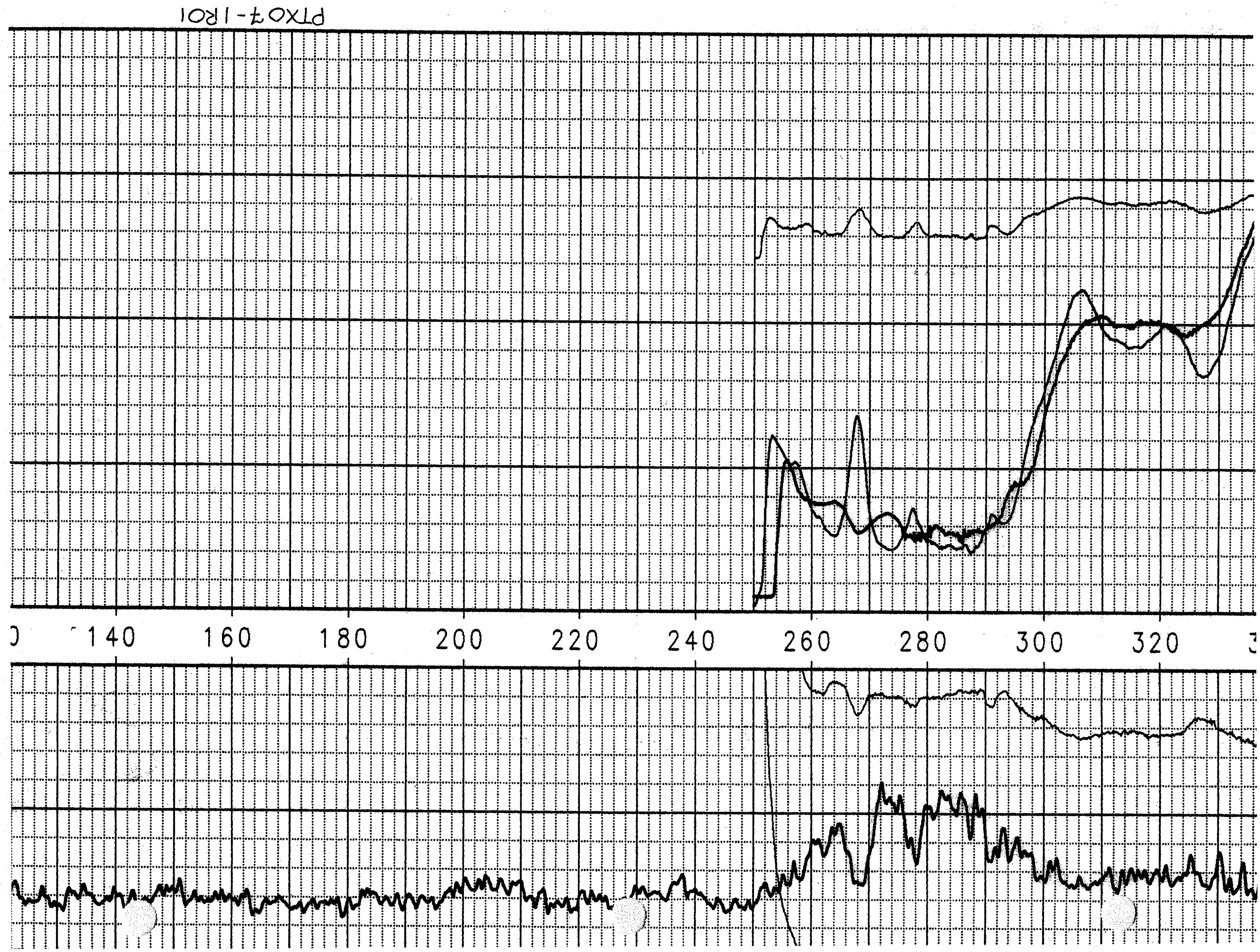
NATURAL GAMMA
0 CPS 200

SINGLE POINT RESISTANCE
0 OHM 100

64" NORMAL
0 OHM-M 100

16" NORMAL
0 OHM-M 100




PTX07-1R01
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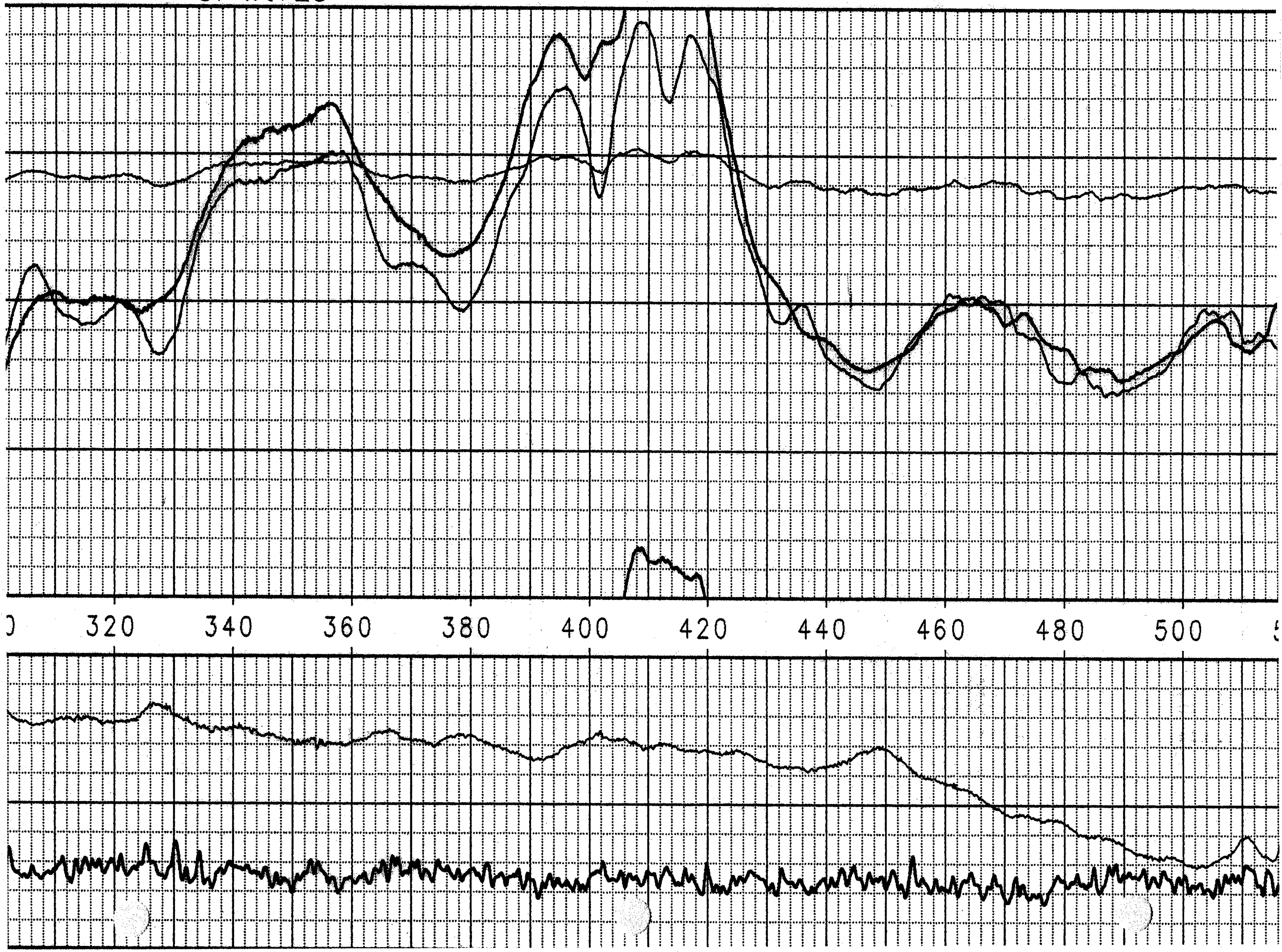
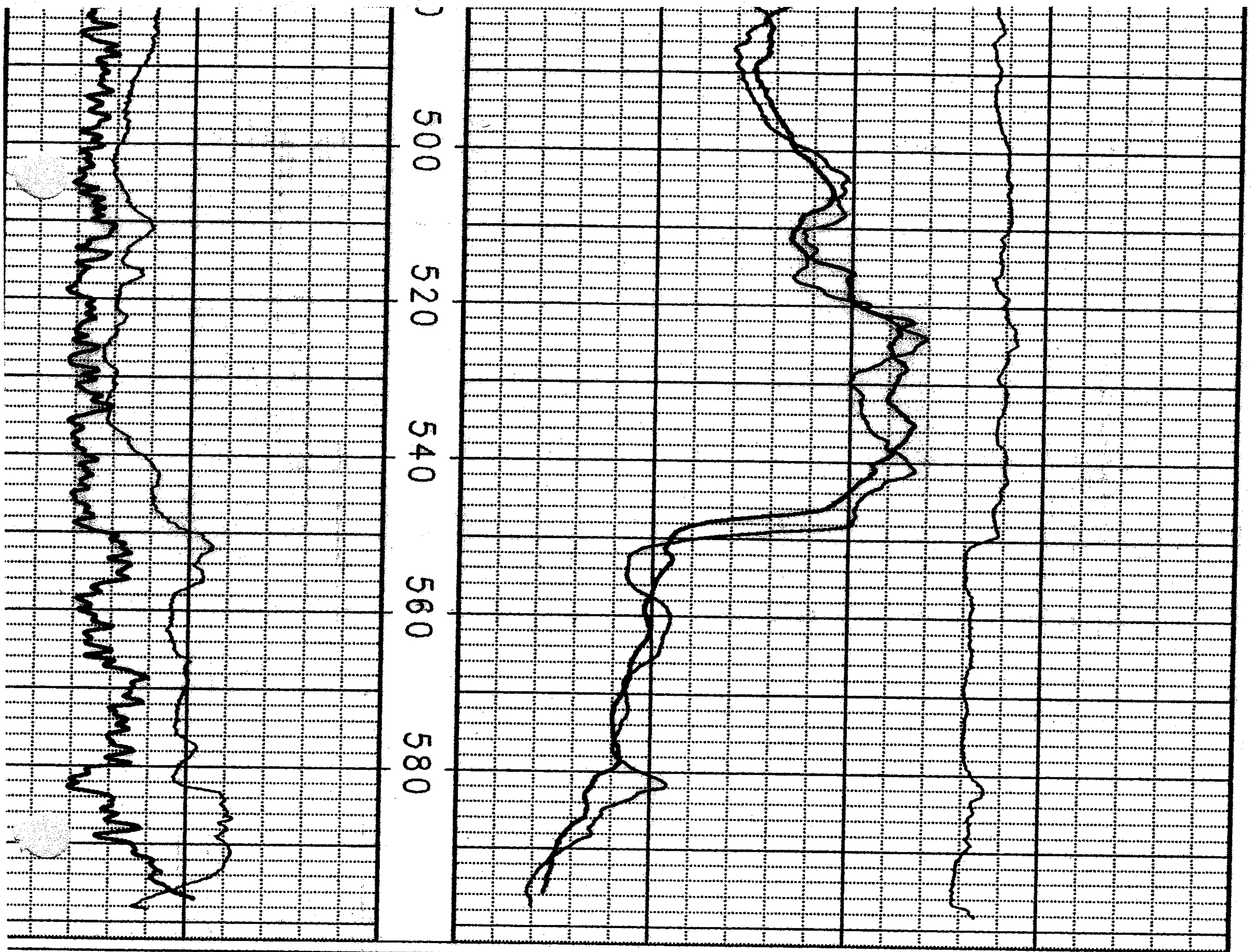
PTX07-IR01





NATURAL GAMMA
0 CPS 200

NATURAL GAMMA
0 CPS 200

SPONTANEOUS POTENTIAL
100 MILLIVOLTS 200

16" NORMAL
0 OHM-M 100

64" NORMAL
0 OHM-M 100

SINGLE POINT RESISTANCE
0 OHM 100

SM STOLLER, PTX07-1R01, 4/15/00

COLOG