# VOLUME II - APPENDICES

# HYDROGEOLOGICAL AND GEOCHEMICAL SITE CHARACTERIZATION REPORT

Prepared For:

Sequoyah Fuels Corporation
I-40 & Highway 10
Gore, Oklahoma 74435

Prepared By:

MFG
consulting scientists and engineers

3801 Automation Way, Suite 100
Fort Collins, Colorado 80525

October 2002

Appendices update sheet

| Appendix | Appendix Name | Corresponding Appendix from Previous Report |
|---|---|---|
| A | Hydrogeological Characterization Work Plan, SOPs and Health and Safety Plan | Appendix A |
| B | Supplemental Data Collection Trip Report | N/A – new appendix |
| C | Boring Logs and Well Installation Diagrams | Appendix B |
| D | Electrical Resistivity Survey | Appendix D |
| E | Laboratory Chemical Analysis Report Sheets | Appendix E |
| F | Transport Calibration Chemgraphs | N/A – new appendix |
| G | Borehole Data for EVS Model | Appendix F |
| H | EVSTRIM.EXE | Appendix G |
| I | Vegetation Water Balance Estimates for Sequoyah Site | Appendix H |
| J | Hydrologic Test Data | Appendix C |
| K | Sufficient Yield Memo | Appendix I |

# APPENDIX A

# HYDROGEOLOGICAL CHARACTERIZATION WORK PLAN

# SOPS

# HEALTH AND SAFETY PLAN

# APPENDIX B

# SUPPLEMENTAL DATA COLLECTION TRIP REPORT

# SUPPLEMENTAL DATA COLLECTION TRIP REPORT

*Prepared For:*
**Sequoyah Fuels Corporation**
I-40 & Highway 10
Gore, Oklahoma 74435

*Prepared By:*
**Shepherd Miller**
3801 Automation Way, Suite 100
Fort Collins, Colorado 80525

**April 2002**

SHEPHERD MILLER

# TABLE OF CONTENTS



## LIST OF TABLES

## LIST OF FIGURES



## LIST OF PHOTOGRAPHS



## LIST OF ATTACHMENTS

## 1.0 INTRODUCTION

Sequoyah Fuels Corporation (SFC) recently submitted new groundwater characterization and modeling data (Shepherd Miller, 2001) to support decommissioning and reclamation of its Gore, Oklahoma facility. As a result of discussions with the Nuclear Regulatory Commission (NRC) regarding these submittals, several issues regarding site conditions characterization and the groundwater modeling have been identified that need further study. These issues include:

- Increasing arsenic concentrations in well MW095A not predicted by, and inconsistent with, the groundwater modeling;
- Anomalous uranium and arsenic water quality values in 005 Drainage not predicted by, and inconsistent with, the groundwater modeling; and
- Concerns with delineation and characterization of the hydrogeologic and geochemical conditions associated with the subsurface Swale near well MW010.

As a result of these issues, SFC initiated a supplemental data collection effort. This effort was performed February 7 through February 13, 2002. The scope and findings of this effort are presented herein, although results of analytical testing (partitioning coefficient testing on terrace, fill and colluvium) and model revisions are pending. This report discusses the field efforts for each of the three areas described above and concludes with recommendations for additional studies for characterization and evaluation of potential groundwater mitigation efforts. Relevant tables, figures and photographs are included.

## 2.0 WELL MW095A ARSENIC ANOMALY

The objective of the field effort associated with well MW095A (Figure 1) was to better understand the basis for the arsenic anomaly at this location. Partitioning coefficient ($K_d$) testing for arsenic and transport modeling did not predict the measured concentrations and increasing arsenic concentration trend at this location (Figure 2). Potential controls of arsenic mobility are thought to include local hydrologic conditions that are not representative of the rest of the site and possible chemical complexation of the arsenic with organic compounds found in Pond 2, the probable past local source for arsenic flowing toward well MW095A.

The investigation approach included hydraulic conductivity tests on wells MW095A, MW097A, MW097, MW093A, MW059A (Figure 1), as well as analysis of water samples from selected wells for evidence of arsenic complexation with organic compounds. Based on these data, additional transport modeling will be performed to identify what $K_d$ or hydraulic conductivity conditions might be required to account for the observed anomaly at well MW095A. The following sections discuss the specific field efforts and available preliminary findings.

### 2.1 Hydraulic Conductivity Testing

Slug tests were performed to see if anomalously high hydraulic conductivity conditions, which could cause locally faster constituent transport rates, were present in this area. The wells tested for hydraulic conductivity include MW095A, MW097A, MW097, MW093A, MW059A (Figure 1), which are proximal to or downgradient from Pond 2, and are near the predicted flow path from Pond 2 to well MW095A. Three of these wells, MW093A, MW95A, and MW97A, are completed in Shale Unit 4. MW059A is completed in both Shale Unit 3 and Shale Unit 4. MW097 is completed in the unconsolidated colluvial material.

The slug tests were performed and analyzed in exactly the same manner as described in SMI, 2001. Table 1 summarizes the calculated hydraulic conductivity for these wells.

Slug test data analyses for this investigation are presented in Attachment A. Prior to this investigation, the hydraulic conductivity of the colluvium was assumed to be 5 feet per day (ft/day), although no test on this material had been performed. MW097 slug test results indicate that the colluvial deposits have a hydraulic conductivity of 39 ft/day, which exceeds the 5 ft/day value used in the model by a factor of eight. The slug test results for the Shale Unit 4 wells indicate a hydraulic conductivity of between 0.93 ft/day and 4.73 ft/day. These values vary from good agreement with the previously modeled value of 0.5 ft/day to an order of magnitude greater than the previously modeled value. The measured hydraulic conductivity for MW059A, 21.38 ft/day, was higher than previously measured formations for either Shale Unit 3 or Shale Unit 4 by one to two orders of magnitude.

The aquifer testing program indicates that some of the hydraulic conductivity values used in the 2001 groundwater model may have been underestimated. The consequence of underestimating the hydraulic conductivity is reduced contaminant transport velocity, all other parameters held equal. However, the underestimation of hydraulic conductivity is likely not sufficient, on its own, to account for the apparent early arrival of arsenic at well MW095A (Figure 2). Changes to the revised groundwater model, which is currently under development, will be implemented to reflect recently acquired data.

## 2.2 Arsenic Speciation Testing

Materials deposited in the Pond 2 (Unit 18) area included raffinate and sludge by-products, contaminated rock, yellowcake drums, soda ash, anode blades, drum liners, electrolyte sludge and laboratory wastes (SFC, 1998). In addition, SFC personnel have indicated that significant amounts of the organic compounds tributylphosphate ($C_{12}H_{27}PO_4$) and hexane ($C_6H_{14}$), which were associated with the solvent extraction process, were also deposited in Pond 2. This has led to speculation that the arsenic in Pond 2 may have formed organic-arsenic complexes or possibly ammonium-arsenic complexes that could migrate at a less retarded rate than the un-complexed arsenic. Therefore, analytical testing of water samples for arsenic speciation (As III, As V, mononmethylarsonic acid [MMAs], dimethylarsinic acid [DMAs], thioarsenates, and other organoarsenicals) was undertaken.

Raw water samples were collected from wells in areas thought to be impacted by Pond 2 seepage and associated organic compounds (MW095A, MW057A, MW059A [Figure 1]) and from wells not likely impacted by Pond 2 seepage and associated organic compounds (MW064A, MW035A, MW042A, MW071A [Figure 1]) in an attempt to identify differences in arsenic speciation and transport mobility. The water samples were sent to Frontier Laboratories in Seattle, Washington for analysis.

## 2.3 Analytical Results

Samples sent to Frontier Geosciences (FG) for arsenic speciation were initially analyzed by ion-chromatography inductively coupled plasma mass-spectrometry (IC-ICP-MS). Using this analytical method, the As species As(III), As(V), MMAs, and DMAs, as well as other unknown As-species are separated by anion-chromatography using a hydroxide eluent. After separation/speciation, the eluent stream is injected into the plasma flame of the ICP-MS and As in the various fractions is quantified by detection of mass/charge75. Total As is then determined by direct introduction of the filtered sample to ICP-MS after acidification with 1 percent $HNO_3$.

The results of these analyses are presented in Table 2. Interference was observed during As speciation with IC-ICP-MS, peaks were broadened and retention times were shifted with respect to standards (Figure 3). Peaks were observed at retention times unspecific for known As-species. As(V) matrix spikes were not recovered intact, the signal was shifted more than 2 minutes and the approximate recovery is about 180 percent. Due to the peak shifting, it is not possible to determine which species are present with any certainty, and therefore the approximate concentrations are listed by their retention times (Table 2). Dilution did not overcome the interference, and the reason for the strong interference remains unknown. Common interferents (anions and Fe) are not present at concentrations that would explain these results. Therefore, the analyses for As speciation using the IC-ICP-MS analyses are inconclusive and analysis of these waters for individual As species using this analytical method does not appear to achieve reliable results.

Total arsenic (TAs), as determined by IC-ICP-MS (i.e. by addition of all As-species), suggests that As levels ranges from 0.4 µg/L to 5,180 µg/L. Total arsenic levels determined by direct ICP-MS range from 0.58 to 3,940 µg/L, but there is very poor sample-to-sample agreement for As concentrations determined by the two methods. A comparison of the results from these analyses is presented in Table 2. It should be noted that at the conclusion of the IC-ICP-MS analysis the anion exchange column on the IC needed to be recharged. This suggests that an unidentified As species was present and was irreversibly or very tightly bound to the resin, thereby necessitating column regeneration. It is of interest to note that, if present, the interferent was present in all samples and not just those samples thought to be impacted by organic solvents. Given the discrepancies in results and the atypical chromatograms, a second analytical method was used to investigate As speciation.

The second investigative analytical methodology used consisted of hydride generation cryotrapping gas chromatography atomic absorption spectrometry (HG-CT-GC-AAS). The "cryo" method is similar to EPA method 1632. The overall quality of the HG-CT-GC-AAS and ICP-MS data look good; no analytical issues were encountered and all QA measurements were within established control limits (Tables 3 through 6). Sample MW059A exhibited some peak broadening during the As(III) and total inorganic arsenic (TIA) analysis by HG-CT-GC-AAS which might have lead to an overestimation of the As levels in this sample (Figure 4). However, comparing total As determined by ICP-MS to the TIAs detected by HG-CT-GC-AAS (Table 2), it is obvious that the majority of the As is not accounted for in the sum of the inorganic species. TIAs levels determined by HG-CT-GC-AAS ranged from 0.034 to 0.668 μg/L compared to total As levels that ranged from 0.58 to 3940 μg/L via ICP-MS, a difference of almost four orders of magnitude. Thus, either much of the As in the samples were present as non-hydride forming As species and therefore not detected by the cryo-method or total ICP-MS results are biased high due to the presence of an unknown interference. The presence of a non-hydride forming organic As-species cannot be ruled out.

In summary, results from the As speciation analysis are inconclusive. The possibility exists that the total As data obtained by ICP-MS is biased high due to an unknown interference. It is also possible that there are unknown As species present at comparable concentrations that are not amenable to hydride generation and therefore were not detected by the Cryo method, and were not eluted efficiently from the IC column during analysis with IC-ICP-MS, yielding uncertain results. However, total As numbers determined by ICP-MS are in reasonably good agreement with historical sampling values determined by ICP (Figure 3). Because both of these methods are considered very reliable for determination of total As and employ different detection methods it is unlikely that both would error high with a comparable magnitude. Therefore, it seems prudent to assume that the total As numbers that have been determined by ICP-MS and ICP are accurate and represent actual arsenic levels at the site. Because it was not possible to isolate and identify the unknown As species, the geochemical reactivity of these complexes cannot be determined. It is therefore also not reasonable to assume that partition coefficients ($K_d$s) determined experimentally using and inorganic arsenic species (As(V)) are representative the $K_d$s of these potentially present unknown species.

As a result of the analytical complexities encountered while investigating As speciation, two actions will be taken to more accurately model As transport. First, the revised ground water flow model will incorporate the recent hydraulic conductivity tests data to more accurately represent measured flow conditions. Second, the transport model will include calibration of As $K_d$ to accurately reproduce the trends of As arrival at well MW095A, as well as As trends in other site wells.

## 3.0 005 DRAINAGE ANOMALY

Recent sampling of the 005 Drainage surface waters (Figures 5 and 6) indicate elevated levels of uranium and nitrate that were not predicted by, and are inconsistent with, the most recent groundwater modeling. As a result of these new data, monthly sampling of site drainages has been implemented. Due to limited flows during the low rainfall periods, only a few sample locations are amenable to regular and consistent sampling. Figures 5 and 6 illustrate and Table 7 summarizes the recent surface water samples collected for the 005 Drainage, Figure 7 illustrates the 005 Drainage trenching and soil sampling locations of this investigation. It is suspected that when the 005 Sump pump failed, the groundwater flowing above the bedrock through the backfill materials at the head of the drainage migrated past the French drain collection system and into the 005 Drainage surface waters. These waters are typically collected through a French drain system located in the backfill and pumped from the 005 Sump to the Emergency Basin (Figure 5). It is also possible that the French drain collection and pump back system is not intercepting all of the groundwater flow from the backfill materials. Regardless of their source, the current site model did not predict the occurrence of the constituents in the drainage or in the 005 Sump.

The objectives of the field efforts for the 005 Drainage area were to:

- Better characterize the hydrogeologic conditions in the backfill at the head of the 005 Drainage,
- Determine if the measured concentrations in the drainage are caused by impacted groundwater flowing from the backfill area, and
- Determine geochemical properties (e.g., $K_d$) of native soils and fill materials.

The technical approach for the 005 Drainage study included two components. The first component consisted of excavating a trench in the fill materials at the head of the 005 Drainage between the emergency basin and the existing 005 Sump, south of Fluoride Holding Basin No. 2 (Figure 7); this trench is referred to as 005 Drainage Trench 1. The second component consisted of sampling soils and water from small excavations in the banks of the 005 Drainage at various points along its alignment (Figure 7).

Soil samples were collected from each trench or pit excavated during the investigation. Soil samples were collected with a stainless steel spoon the day after excavation activities concluded. To obtain a fresh sample, six inches of soil were removed prior to sampling. In some instances, hard soils and shale bedrock samples were first broken into smaller sizes using a rock hammer. Composite samples were collected from materials of similar character at three to four separate locations within each pit or trench. Soils were placed into clean 250-mL glass jars for shipment to the laboratory for geochemical analysis and testing. Soil samples were split and subsampled at the lab. One subsample was dried at 38 $^{O}$C for percent moisture determinations and digested according to EPA Method 3050 and analyzed for total As, F and U. The other splits were used for adsorption or desorption batch tests designed to provide additional information on contaminant partitioning within these solid materials.

Water samples were collected within 48 hours, once sufficient waters had collected in the respective trenches. No precipitation fell within this period and the samples are considered to be representative of groundwater water quality conditions. Water samples were collected using a Geotech peristaltic pump with an inline 0.45-micron filter. Tubing was replaced or cleaned with deionized water between sampling events. Decontamination of sampling tubing was performed by pumping trench water through the tubing for five minutes prior to sampling. Three samples were collected at each location. One of these samples was left unpreserved, while the other samples were preserved with either trace metal grade nitric acid or phosphoric acid. The samples were analyzed for fluoride, uranium and arsenic, and dissolved organic carbon (DOC) respectively.

### 3.1 005 Drainage Trench 1: Top of Drainage

The trench located in the fill material near the head of the drainage (005 Drainage Trench 1) was advanced to characterize the hydrogeologic conditions associated with the buried drainage channel and to collect soil and water samples for analysis.

A track hoe was used to excavate down to competent bedrock (Photo 1). The excavation stratigraphy was documented and visually logged by a professional geologist from the top of the trench wall, and digital photographs were taken of the excavation. The end points of the trench were recorded with a hand-held GPS unit. Table 8 summarizes the GPS coordinates of the trench and Table 7 summarizes the samples collected from the trench. Depths of geologic contacts were visually estimated due to the hazards associated with instability of the trench sidewalls. The cross section illustrated in Figure 8 was developed from these field observations.

The buried channel bottom was encountered at approximately six to eight feet deep. Stratigraphy observed in the trench consisted of a hard sandstone unit overlain by one to two feet of clay (Figure 8). Based on its elevation and lateral occurrence, the sandstone is believed to be Sandstone Unit 3 and the overlying clay is interpreted to be weathered remnants of Shale Unit 3. Overlying the clay/weathered shale unit is a one-foot thick layer of gravel with clay. This unit is interpreted to be the basal gravel on which fill or gravelly fill material was placed in the old 005 Drainage bottom. The unit was observed to be producing water in the trench sidewall, although it was not possible to estimate the rate of water production. Visual estimates of the clayey gravel hydraulic conductivity are approximately 30 feet per day based on particle size distribution and professional judgement. Water and soil samples collected from the pit are summarized in Table 7.

The sandstone bedrock unit was observed to gradually rise in the southern portion of the trench, with the clayey gravel unit thinning to the south. The bedrock abruptly rose in the northern portion of the trench due to what is interpreted to be the buried outcrop on the north side of the buried drainage (Figure 8).

The clayey gravel unit was covered with roughly five to six feet of fill material consisting of clay with gravel and sand (Photo 2). The fill material is believed to be re-worked terrace deposits cut from higher portions of the site during facility construction. A layer of 10-mil black plastic was observed below the upper one to two feet of fill. This liner was apparently placed to reduce infiltration into the fill. The one to two feet of fill above the plastic liner was observed to be reddish brown clay that contained a trace of gravel.

SFC personnel indicate that a French drain system was installed within the fill to collect seepage in the buried drainage. Although there are no known drawings of this drain system, it is believed to consist of perforated plastic pipe with a surrounding gravel pack that collects the seepage from the upper portions of the filled drainage and drains it to the 005 Sump, where it is pumped back to the Emergency Basin.

Two portions of the French drain system were exposed during excavation of the trench; one portion near the center of the trench above the deepest section of the buried channel, and one portion near the southern end of the trench (Figure 8 and Photograph 2). The pipes and associated gravel pack were located approximately one to two feet above the clayey gravel unit. The pipe in the southern portion of the trench was observed to produce roughly 0.25 gpm of relatively clear water. Little water was observed from the pipe and gravel pack in the northern portion of the trench.

Waters pooling in the trench were differentiated by color. The northern portion of the trench contained cloudy water, while the southern portion of the trench contained clearer water that may have originated primarily from the pipe and associated gravel pack. The center of the trench appeared to contain a mixture of these two waters. Soil and water samples were collected from the northern and southern portions of the trench (Figure 8). Soil Sample 005-S-01-01 was a composite sample collected from the clay with gravel fill at the northern portion of the trench (Figure 8). Soil Sample 005-S-01-02 was collected from the gravel with clay material on top of the weathered shale near the base of the trench. This sample was collected below the previously discussed sample. Water Sample 005-2 was taken in the bottom of the trench at his location.

Soil Sample 005-S-02-01 was collected from the southern portion of the trench (Figure 8) from the gravely clay fill material. The sample was composited from the excavated spoils pile. Soil Sample 005-S-02-02 was collected from near the bottom of the trench in the gravel material. Water Sample 005-2 was collected slightly north of where the soil samples were collected.

### 3.2 005 Drainage Test Pits: Drainage Alignment

Small pits were excavated down to sandstone bedrock along the margins of the 005 Drainage using a backhoe (Figure 8). The pits were advanced to evaluate whether or not the uranium and nitrate detected in surface water samples could potentially be coming from the native aquifer materials adjacent to the stream. Soil and groundwater samples were collected, with the groundwater samples collected from the pit excavations after sitting over night to allow sufficient water to accumulate. Pit nomenclature and sampling was based upon three trench lines; each of the three trench lines (3, 4 and 5) consists of a pit N, north of the drainage, a M pit near the middle of the drainage, and a pit S, located south of the drainage. Samples were collected from the colluvial materials and the underlying shale bedrock, where present. If the colluvium was underlain by sandstone, no bedrock sample was collected. Sample designation 1 refers to the colluvial soil sample and a designation of 2 indicates a shale bedrock sample. For example, sample 005-4M-2 was collected in the medial pit of trench line 4 in the bedrock shale. Water samples were collected from all pits except the most downstream northern pit (Pit 005-5N) because no water was present after 48 hours. Table 7 summarizes the samples collected and sample matrix from each trench and pit location. Table 9 summarizes the lithologic characteristics of the material encountered at each trench.

### 3.3 Sample Analysis

A complete list of solid samples (soil fill or bedrock shale) collected from the 005 Drainage are listed in Table 10 along with the analyses and tests conducted on each sample. Whole rock analysis was done on all samples to provide information on the total concentrations of As, U, and F in the solid matrix. Selected samples were used in absorption and/or batch desorption tests. These tests were undertaken to enhance our understanding of contaminant transport within the fill, colluvium and adjacent bedrock shale. Previous investigations had used batch desorption tests to establish partition coefficients ($K_d$) as described in SMI 2001. There are numerous methods commonly used for establishing a $K_d$, each of which is associated with certain advantages and disadvantages. The current transport model under-predicts uranium contamination in the drainage. Low $K_d$ values in the transport model were suspected because the previously established $K_d$ values may not have accurately predicted apparent uranium mobility. Therefore, absorption tests were performed to arrive at $K_d$ values using alternate methods. In addition, batch desorption tests were initiated on colluvium and bedrock samples to provide $K_d$ values that could be compared to those obtained in the previous site investigation. Preliminary results from this analysis are presented in the following section. Adsorption isotherm and batch desorption tests are still in progress.

### 3.4 Analytical Results and Conclusions

Conceptually, if groundwater contaminant concentrations are determined to be equal or higher in the banks than the stream, the source of the contamination would be inferred to be derived from the bedrock aquifers. Conversely, if concentrations were higher in the stream, the 005 Sump overflow would be considered as the source of contaminants in the drainage. The same concept would be valid for bedrock and unconsolidated sediment uranium concentrations. Analytical results of the groundwater samples are summarized in Figures 9 through 13 and Tables 11 and 12. Groundwater analyses indicate that all constituents are higher in the waters collected in the center pits with one notable exception, fluoride in trench 005-4S is slightly higher (0.8 mg/L) than in trench 005-4M (0.4 mg/L) (see Figure 11). Uranium and arsenic concentrations in all trench lines are greatest in the M or middle pit, indicating the source of the contamination to the drainage is not from the bedrock. Additionally, concentrations of all constituents diminish in a downstream direction indicating a source near the head of the stream.

Analytical results for the bedrock and soil samples are presented in Table 13 and Figures 14 through 18. In general, constituent concentrations for 005 Drainage test pit samples were higher in bedrock than the overlying colluvial soils. The one exception is fluoride in pit 005-4M. Fluoride concentrations were 3.3 mg/kg in bedrock and 3.8 mg/kg in the soils. Laboratory analyses of the unconsolidated material indicate that uranium concentrations increase in a downstream direction. Uranium concentrations increase from 14.5 mg/kg in 005 Drainage Trench 1 to 564 mg/kg in trench 005-5M. Uranium concentrations in shale bedrock generally decrease downstream. Analytical data for Trench 005-3N indicate uranium concentration of 4.69 mg/kg in bedrock whereas 005-5S contained 2.1 mg/kg.

Interpretation of the laboratory results indicate that the groundwater uranium concentrations are greatest in the 005 Drainage Trench 1, especially in the gravel deposit beneath the French drain lines. It is likely that some of the impacted groundwater in the gravel is not being intercepted by the French drain system and ultimately flows down gradient, either within the unconsolidated sediments or as surface water. The unconsolidated sediments appear to contain more uranium than would be suggested by the groundwater uranium concentrations and are likely due to past spills or contaminated solids washed from the site being transported downstream prior to construction of the storm water intercept trench in 1990. Fluoride was below drinking water standards in all water analysis.

## 4.0 MW010 SWALE AREA

An additional objective of the field investigation was to evaluate the swale suspected near monitoring well MW010A (Figure 19). This swale is essentially a small surface drainage channel that was covered with local fill materials at the time of facility construction and is suspected of being a subsurface feature that significantly influences local groundwater flow. The technical approach to this field effort consisted of excavating a trench and several test pits. Each pit or trench was excavated until sandstone bedrock was encountered with the exception of trench 5, where sandstone was deeper than the maximum possible excavation depth. Geologic mapping of the material encountered in each pit was conducted. In particular, a lens of well-rounded, well-sorted river gravel was encountered just above sandstone bedrock. Soil samples were collected from the gravel and the overlying fill.

A trench (MW010 Trench 1) approximately 130 feet long was excavated perpendicular to the expected slope of the swale in an attempt to establish the extent of the fill material. The excavation stratigraphy was documented and visually logged by a professional geologist from the top of the trench wall, and digital photographs of the excavation were taken. The pit sidewalls were prone to collapse. Therefore only visual estimates of depths were recorded. The end points of the trench were recorded with a hand-held GPS unit. Table 8 summarizes the GPS coordinates of the trench and summarizes the samples collected from the trench. Depths of geologic contacts were visually estimated. The cross section illustrated in Figure 20 was developed from these field observations.

Depth to bedrock (weathered shale or sandstone) was approximately 15 feet. The excavated area was found to be predominantly compacted fill material to bedrock. The fill consisted of basal gravel varying from one to three feet thick. The gravel consisted of well sorted (washed) well rounded, coarse gravels. The presence of this basal gravel caused the excavated trench to be unstable, and sloughing was common. An additional gravel layer was intermittently present at a depth of approximately seven feet. The balance of the fill material consists of clay with varying amounts of gravel.

The trench was excavated eastward until the basal gravel pinched out. Both gravel layers produced water in varying amounts. Figure 20 is a cross-sectional schematic that illustrates lithology and sample locations. Soil and water samples were collected for analysis. Soil and water samples were collected and preserved in the same manner as samples collected for the 005 Drainage sampling.

Four additional smaller pits (MW010 Trench 2, MW010 Trench 3, MW010 Trench 4 and MW010 Trench 5) were excavated to further investigate the gravel fill and to evaluate its extent, if possible (Figure 19). Each pit was excavated to sandstone bedrock and each encountered the gravel fill to some extent. Overall, the depth to bedrock diminished down slope and the gravel layer thinned and contained more fine-grained material. Table 9 summarizes the geologic conditions identified in these smaller trenches.

Groundwater was observed entering MW010 Trench 2, MW010 Trench 3 and MW010 Trench 4 from the south, the direction of the Decorative Pond. A lesser amount of groundwater was observed entering from up slope. After two days, the water levels in the pits and the trench were surveyed to establish the approximate groundwater elevation. Groundwater entering the western-most trench (MW010 Trench 4) was discolored and appeared yellowish, with light foam of a darker yellow color. The color of the trench water changed from yellow to reddish yellow and finally to a reddish brown during the three days the excavation was open. Subsequent laboratory analyses indicate that the water sampled from the trench contained low uranium concentrations (see Table 12).

The MW010A swale appears to be a much broader feature than was originally estimated. The presence of laterally extensive gravels at the base of the fill materials appears to provide a preferential path for groundwater flow. Groundwater elevations collected in surrounding wells and within the trenches indicate that there is a groundwater mound associated with the Decorative Pond, deflecting groundwater flow to the southwest from the southward dip of the swale. Furthermore, the gravel appears to thin in every direction except northward. The northern direction was not investigated because of the proximity to buildings and the weigh station. Future evaluation of pre-operational topographic information will aid in further delineation of the swale and potential distribution of the gravel fill. Results of these evaluations will be documented and incorporated in the revised modeling that is currently being performed.

Gravels encountered during excavation appeared to be washed river gravel that was probably imported to the site during the initial phase of site construction. Hydraulic conductivity was visually estimated to be on the order of 50 feet per day, based on the observed inflow of water into the trenches. The gravel contained few fines and chemical retardation is anticipated to be low. Because of the nature of the fill placement, the gravel is interpreted to thin toward the edges. Clays in the fill appear to cause confining conditions, as observed in the gravel in pits excavated between the trench and the Decorative Pond. Confined conditions are suspected because the surveyed trench water levels and groundwater elevations in surrounding wells indicate a water level above the top of the basal gravel though no water was observed to flow from the overlying clayey fill. Furthermore, the bedrock well MW030A, located nearest to the Decorative Pond and completed in the shallow bedrock system, exhibits confined conditions evidenced by water levels above the ground surface, preventing downward contaminant migration. Water levels in unconsolidated fill materials encountered in the pits, trench and Decorative Pond indicate groundwater flowing in these deposits flow from up slope and from the Decorative Pond. The lowest groundwater elevations were encountered in the pits. Diminished flow velocities are expected as groundwater encounters colluvial deposits and the gravel fill pinches out. Hydrologic data from this evaluation will be incorporated into the revised groundwater model and documented in the associated report.

Soil samples were collected from the excavated spoils pile for analysis. Sample locations and sample matrix are described in Table 8. Samples analyses, as described in Section 3.3 and Tables 12 and 13, will aid in determination of in-situ $K_d$ value to be used in the updated groundwater transport model. Additional adsorption tests will be conducted on selected samples. The sample selection will be based on analytical results.

## 4.1 Hydraulic Conductivity Testing

Slug tests were performed to see if anomalously high hydraulic conductivity conditions, which could cause locally faster constituent transport rates, were present in this area. The tests were performed and analyzed in exactly the same manner as described in Shepherd Miller (2001). The raw data and analysis of these tests is provided in the Attachment A to this report. Table 1 summarizes the calculated hydraulic conductivity for these wells.

Previous to this investigation, the hydraulic conductivity of the terrace soils in this area was assumed to be 5 ft/day, which is similar to Shale Unit 1. A slug test performed on well MW010 yielded a calculated hydraulic conductivity of 72.6 ft/day, assuming a saturated thickness of approximately 3 feet, based on visual inspections of the MW010 Trench 1 located 15 feet away from MW010. In the trench it was observed that only the basal three feet of gravel fill material was saturated, the balance of the overlying material in the screened interval was a relatively low permeability gravelly clay that did not appear to be producing water indicating semi-confined conditions. Therefore, it was considered appropriate and conservative to calculate the hydraulic conductivity of well MW010 using the 3-foot producing zone as the saturated thickness. With this assumption, the calculated hydraulic conductivity at this well represents an order of magnitude increase in hydraulic conductivity over the current model configuration for this area.

MW010A is completed in Shale Unit 2 and Shale Unit 3. The average hydraulic conductivity used for Shale Unit 2 and Shale Unit 3 in the groundwater model was 1.2 ft/day and 0.1, respectively. The hydraulic conductivity that was established by the MW010A slug test was 1.5 ft/day, which is consistent with the previously modeled value.

The aquifer testing program indicates that the hydraulic conductivity values used in the groundwater model for layers 1 and 2 (Terrace and Shale Unit 1) in the areas investigated may have been underestimated. The consequence of underestimating the hydraulic conductivity is reduced contaminant transport velocity, all other parameters held equal. Changes to the groundwater model to reflect the recently acquired data will be implemented in the future.

### 4.2 Analytical Results and Conclusions

Groundwater was sampled in MW010 Trench 1, MW010 Trench 2, MW010 Trench 4 and MW010 Trench 5. The analytical results were used in conjunction with nearby monitoring wells in the unconsolidated deposits. Analytical results are presented in Table 12 and the resulting uranium contour map is presented in Figure 21. The results indicate that the contaminant migration is limited to the gravel deposits of the backfilled swale. The localized hydraulic gradient reversal due to the water level in the decorative pond prevents southward migration of the uranium plume.

Uranium analyses for the current MW010 swale investigations combined with the most recent monitoring well analytical results are depicted in Figure 21. Uranium migration in the unconsolidated sediments appears to be limited in extent to the gravel deposits. Uranium groundwater concentrations appear to diminish where more fines are present in the distal edges of the fill material. Further analysis will be performed in the swale area. The interpreted nature and extent of the gravel fill will be incorporated in the groundwater flow and transport model and will presented in the final modeling report.

## 5.0 TERRACE BACKGROUND SAMPLING

Two pits were excavated into un-impacted terrace materials east of Highway 10 (Background Trench E-1 and Background Trench E-2; Figure 1). Soil and water samples from these locations will be used to develop $K_d$ values for the terrace materials using batch tests. The trenches were excavated to bedrock and the soil and groundwater samples were collected, stored and shipped in the same manner as the samples collected for the 005 and MW010 swale investigations. Twelve liters of water were collected from the southern pit (Background Trench E-2) to use in batch testing. This trench was selected because there was more water available for sampling than in pit E-1. Both soil and groundwater samples were analyzed for U, F, and As. These results are summarized in Tables 12 and 13.

## 6.0 RECOMMENDATIONS FOR ADDITIONAL STUDY AND FIELD EFFORTS

The recent supplemental field data collection activities are anticipated to resolve many of the outstanding site characterization issues, although some additional studies may be of value to enhance the site characterization and help support potential future groundwater mitigation efforts. A comprehensive list of potential study topics cannot be assembled at this time because all the recent field data results are not yet available. The following presents a brief discussion of potential areas of additional study or effort.

### 6.1 All Site Drainages

The potential exists for transport of impacted site groundwater along portions of the drainages covered with fill. Monthly surface water sampling of the site drainages has been initiated. Based on the results of this sampling, additional trenching could be considered for those drainages where anomalous water quality is identified.

### 6.2 005 Drainage Alternatives

Recent surface water sampling data and excavation of fill at the head of the 005 Drainage indicate that the French drain/005 Sump system may not be intercepting all the subsurface waters from the upper portions of the buried 005 Drainage. The following sections present designs for field scale pilot tests of mitigation alternatives. Two alternatives were evaluated. The first approach consists of a hydraulic containment and pump back system. The second approach employs a passive permeable reactive barrier using zero valant iron or similar reductant. SFC has selected the containment/pumpback approach for the 005 Drainage. Installation will be completed in calendar year 2002

### 6.3 Well MW010/Swale Area

Some questions remain regarding the distribution of basal gravel and fill materials in the Swale and regarding the hydrologic/hydraulic relationship of the Decorative Pond to local groundwater flow. Stratigraphic and hydrologic mapping of the Swale currently being performed will shed light on these issues. However, additional trenching around the Decorative Pond, especially to the southwest and southeast, may be of value to better delineate the extent of gravel, the groundwater quality and flow path, and the influence of the Decorative Pond head. This trenching is planned for later in 2002.

Based on the existing site information, it appears that installing a hydraulic containment and pumpback system (similar to the system described for the 005 Drainage above), could provide an effective way to intercept and treat a significant amount of terrace groundwater potentially flowing from this area. However, revision of the site flow model is best completed before conceptual or detailed design is undertaken.

### 6.3.1 Hydraulic Collection and Pumpback System

Design of a hydraulic collection and pumpback system is described below. Details and specifications are presented on Figure 22. The existing trench excavated to the top of the uppermost sandstone unit (Sandstone Unit 3, approximately 8 feet deep) would be expanded to have 2H:1V side slopes and a minimum three-foot bottom width over a 100-foot long alignment spanning the deepest portions of the buried drainage. The side slope lay-back is intended to provide sufficient worker safety and trench wall stability during construction. The trench bottom would be cleaned of residual sediment and materials.

A 60-mil HDPE membrane or similar material liner placed between geofabric protection layers would be installed on the down gradient side of the trench and sealed to the sandstone using site clay. A perforated 4-inch to 6-inch drainage collection pipe would be installed on the sandstone outcrop upgradient of the membrane liner and covered with well graded gravel to slightly above the zone producing water or a minimum thickness of at least two feet. The excavation side walls would be brought in to approximate a vertical wall as the gravel and liner are installed.

A 12-inch to 16-inch, standpipe would be placed vertically in the deepest portion of the excavation as a sump into which the perforated drainage collection pipe will drain. The natural slope of the sandstone to the lowest portion of the trench will allow the drainage pipe to convey water to the sump. A submersible pump with automatic controls would be installed in the sump. The pump would be piped to the site water treatment facility. The liner material would be placed over the top surface of the gravel and cover with random fill placed to the elevation of the ground surface. Alternatively, a filter sand layer with a minimum thickness of one foot could be placed on top of the gravel layer and then covered by native fill materials to the ground surface.

The French drain pipes that currently daylight into the existing trench would remain in place. The upgradient pipe ends would be trimmed and remain open to transmit flow. The gravel backfill would be placed to a minimum elevation of one-foot above the invert of the French drain pipes. Pipe ends on the downgradient side would be trimmed, capped and covered by the plastic membrane liner installed on the downgradient side of the trench.

Two 2-inch PVC monitoring wells points would be installed approximately 10 feet and 20 feet downgradient of the collection trench in the deepest portion of the buried drainage to provide performance monitoring. In addition, surface water sampling throughout the 005 Drainage should be performed monthly until it is verified that the uranium-bearing water has been successfully intercepted.

### 6.3.2 Permeable Reaction Barrier (PRB)

A conceptual design of a PRB using zero valent iron (ZVI or FeO) is described below. Figure 23 illustrates the conceptual design of this alternative. This second alternative could be installed as a field scale pilot test of this approach, following bench scale tests, for long-term passive mitigation of groundwater impacts.

A new trench could be excavated upgradient of the collection trench described above. Similar to the collection trench, the ZVI trench would be excavated to the top of the uppermost sandstone unit approximately 8 feet deep) with 2H:1V side slopes and a minimum five-foot bottom width over a 100-foot long alignment spanning the deepest portions of the buried drainage. The side slope lay back is intended to provide sufficient worker safety and trench wall stability during construction. The trench bottom would be cleaned of residual sediment and materials.

A funnel and gate type system would be installed in the trench, utilizing a low permeability material at the ends of the trench and ZVI in the center of the trench, as shown on Figure 23.

The low permeability material could be a slurry wall, compacted clay or HDPE membrane as described in the collection trench alternative. Conceptually, a 300-foot trench would be excavated, with a 100-foot wide ZVI section flanked by two 45-foot wide low permeability sections. The actual width of each portion of the trench would be dictated by subsurface flow analysis and bench scale permeability testing of the ZVI to ensure adequate flow through the reactive portion of the trench.

The ZVI portion of the trench would be filled in uniform with ZVI using a backhoe bucket and hand shovels to a maximum height of 5 feet. The excavation side walls would be brought in to approximate a vertical wall as the ZVI is installed. If the French drain pipes are intercepted during excavation, the ZVI would be installed up to one foot above the pipe ends in the upgradient side of the trench wall to provide treatment of any flows from these pipes. Pipe ends on the downgradient side would be trimmed, plugged and covered by the low permeability liner installed on the down gradient side of the trench. A one-foot thick layer of filter sand would also be installed on the upgradient side of the ZVI, as well as above the ZVI with clean native fill materials filling the remained of the excavation. Figure 23 presents conceptual details of the ZVI trench.

Two 2-inch PVC monitoring wells points would be installed approximately 10 feet and 20 feet downgradient of the PRB in the deepest portion of the buried drainage to provide performance monitoring. In addition, surface water monitoring throughout the 005 Drainage would be performed monthly.

#### 6.3.2.1 Summary

The hydraulic collection and pumpback system is the most proven and immediate alternative to mitigate impacted groundwater discharge to the 005 drainage. However, testing of a PRB is suggested to provide efficient passive mitigation in the long-term.

## 7.0 REFERENCES

Shepherd Miller, Inc. (SMI), 2001. Hydrogeological and Geochemical Site Characterization Report. October.

Sequoyah Fuels Corporation (SFC), 1998. "Site Characterization Report."

## TABLES

**Table 1 Calculated Hydraulic Conductivity Tests**

| Well Location | Hydrologic Unit | Hydrologic Condition | Borehole Diameter (ft) | Screen Length (ft) | Saturated Thickness (ft) | Hydraulic Conductivity (ft/day) | Storage Coefficient | Analysis Method |
|---|---|---|---|---|---|---|---|---|
| MW010 | Gravel Backfill | Confined | 0.615 | ~3 | ~3 | 72.63 | na | Bouwer and Rice (1976) |
| MW010A | 2SH/3SH | Confined | 0.500 | 13.50 | 14.00 | 1.52 | 6.25E-03 | Cooper, et. al. (1967) |
| MW059A | 3SH/4SH | Unconfined | 0.500 | 4.71 | 5.43 | 21.38 | na | Bouwer and Rice (1976) |
| MW093A | 4SH | Unconfined | 0.615 | 16.57 | 17.09 | 2.51 | na | Bouwer and Rice (1976) |
| MW095A | 4SH | Confined | 0.615 | 5.50 | 5.50 | 4.73 | na | Bouwer and Rice (1976) |
| MW097 | Colluvium | Unconfined | 0.615 | 0.90 | 1.55 | 39.00 | na | Bouwer and Rice (1976) |
| MW097A | 4SH | Confined | 0.615 | 17.00 | 17.00 | 0.93 | na | Bouwer and Rice (1976) |

na – data not derived from this test

| Hydrologic Unit | Previous Slug Tests (ft/day) | | | | Modeled Value (ft/day) |
|---|---|---|---|---|---|
| | no. tests | log mean | max | min | |
| Alluvium | 2 | 0.334 | 5.01 | 0.0223 | 50.0 |
| shale 1 | 13 | 0.0246 | 0.261 | 0.00416 | 0.800 |
| shale 2 | 4 | 0.138 | 1.35 | 0.0118 | 1.200 |
| shale 3 | 3 | 0.0478 | 0.488 | 0.0103 | 0.100 |
| shale 4 | 5 | 0.0314 | 1.3 | 0 00466 | 0.500 |

**Table 2 Results from Arsenic Speciation Analysis**

| HG-CT-GC-AAS Results | | | | | | COMPARISON | | |
|---|---|---|---|---|---|---|---|---|
| Sample ID | As (III) | TIA | *As(V) | TA by ICP-MS | | TIA by HG-CT-GC-AAS | TA by ICP-MS | Sum of As Species by IC-ICP-MS |
| MW071A | 0.015 | 0.275 | 0.260 | 0.58 | | 0.275 | 0.58 | 558 |
| MW042A | 0.250 | 0.191 | ND | 670 | | 0.191 | 670 | 20 |
| MW064A | 2.814 | 0.668 | ND | 3940 | | 0.668 | 3940 | 1200 |
| MW035A (1:1 diluted) | 0.014 | 0.034 | 0 020 | 3 | | 0.034 | 3 | 0.7 |
| MW059A | 0.988 | 0.603 | ND | 1420 | | 0.603 | 1420 | 5180 |
| MW095A | 0 018 | 0.089 | 0.071 | 52.7 | | 0.089 | 52.7 | 0.4 |
| MW057A | 0.134 | 0.258 | 0.124 | 3310 | | 0.258 | 3310 | 5.0 |
| | | | | | | | | |
| IC-ICP-MS Results | | | | | | | | |
| | As(III) | As(V) | US-1 | US-2 | US-3 | US-4 | US-5 | Sum of |
| Sample ID | (3.7 min) | (14.20 min) | (15.80 min) | (16.80 min) | (17.50 min) | (18.40 min) | (19.50 min) | As Species |
| MW071A | <1 | <1 | 0 0 | <1 | 557.7 | <1 | <1 | 558 |
| MW042A | <1 | <1 | 0 0 | <1 | <1 | 19.7 | <1 | 20 |
| MW064A | <10 | <10 | 0.0 | <10 | 1202 | <10 | <10 | 1200 |
| MW035A (1:1 diluted) | <0 1 | <0.1 | 0.1 | <0.1 | 0.3 | <0.1 | <0.1 | 0.7 |
| MW059A | 16 | <10 | 0 0 | <10 | 5183 | <10 | <10 | 5180 |
| MW095A | <0.1 | <0.1 | 0.0 | <0.1 | 0.3 | <0.1 | <0.1 | 0.4 |
| MW057A | <10 | <10 | 0.0 | <10 | 0.0 | <10 | <10 | 5.0 |
| **MW042A MD | <1 | <1 | 0.0 | <1 | 452.6 | <1 | <1 | 453 |
| **MW042A MS+500 ppb | 354 | <1 | 872.6 | <1 | <1 | <1 | <1 | 873 |
| **MW042A MSD+500 ppb | 364 | <1 | 946.7 | <1 | <1 | <1 | <1 | 947 |

All results in µg/L
TIA = Total Inorganic Arsenic, essentially all As(III) and As(V)
TA = Total Arsenic, regardless of species
ND = not detected
US – Unidentified Species
* Arsenate is calculated by difference: As(V)=TIAs-As(III)
** Matrix Duplicate (MD), Matrix spike (MS) and matrix spike duplicate (MSD) using 500 ppb As(III)
IC-ICP-MS = ion-chromatography inductively coupled plasma mass-spectrometry
ICP-MS = Inductively coupled plasma mass Spectrometry
HG-CT-GC-AAS = hydride generation cryotrapping gas chromatography atomic absorption spectrometry

**Table 3 Quality Control Data - Duplicate Report**

| Analyte (µg/L) | Sample QC'd | Rep. 1 | Rep. 2 | Mean | RPD |
|---|---|---|---|---|---|
| As(III) | SC3-UUI-201 | 0.207 | 0.196 | 0.201 | 5.3 |
| TIAs | SB-A2 | 0.850 | 0.812 | 0.831 | 4.6 |
| Tas | MW071A | 0.58 | 0.59 | 0.58 | 1.4 |

**Table 4 Quality Control Data - Matrix Spike / Matrix Spike Duplicate Report**

| Analyte (µg/L) | Sample QC'd | Sample conc. | Spike Level | MS | % Rec. | MSD | % Rec. | RPD |
|---|---|---|---|---|---|---|---|---|
| As(III) | SC3-UUI-201 | 0.207 | 0.400 | 0.586 | 94.7 | 0.621 | 103.5 | 5.8 |
| TIAs | SB-A2 | 0.850 | 1.000 | 1.829 | 97.9 | 1.872 | 102.2 | 2.3 |
| TAs | MW071A | 0.58 | 20.00 | 21.43 | 104.3 | 19.94 | 96.8 | 7.2 |

MS = matrix spike
MSD = matrix spike duplicate
RPD = relative percent difference

**Table 5 Quality Control Data - Preparation Blank Report**

| Analyte (µg/L) | IBW1 | IBW2 | IBW3 | IBW4 | Mean | Std Dev | Est. MDL |
|---|---|---|---|---|---|---|---|
| As(III) HG-CT-GC-AAS | 0.000 | 0.002 | 0.000 | 0.001 | 0.001 | 0.0007 | 0.003 |
| TIAs HG-CT-GC-AAS | 0.006 | 0.002 | 0.003 | 0.003 | 0.003 | 0.0015 | 0.005 |
| Tas | -0.03 | -0.04 | -0.03 | 0.00 | -0.02 | 0.017 | 0.060 |

Std Dev = Standard deviation
Est MDL = Estimated method detection limit

**Table 6 Quality Control Data - Standard Reference Material Report**

| Analyte (µg/L) | SRM Identity | Cert. Value | Obs. Value | % Rec. |
|---|---|---|---|---|
| As(III) HG-CT-GC-AAS | not available | | | |
| TIAs HG-CT-GC-AAS | NIST1640 | 26.67 | 23.83 | 89.4 |
| Tas | NIST1640 | 26.67 | 26.28 | 98.5 |

SRM Identity = Standard reference material identity
Obs Value = Experimental result
Cert. Value = Certified value
% Rec. = Percent recovery

**Table 7 Recent Sampling for the 005 Drainage**

| Trench Line | Sample ID | Matrix | Location |
|---|---|---|---|
| 005 Drainage Trench 1 | 005-1 | Water | North end of trench |
| | 005-2 | Water | South end of trench |
| | 005-S-01-01 | Soil | clay and gravel fill at north end of trench @2.5' |
| | 005-S-01-02 | Soil | gravel with clay fill at north end of trench @ 6' |
| | 005-S-02-01 | Soil | clay and gravel fill at south end of trench @ 4' |
| | 005-S-02-02 | Soil | gravel with clay fill a south end of trench @5.5 |
| 005 Drainage Trench 3 | 005-03N | Water | |
| | 005-03M | Water | |
| | 005-03S | Water | |
| | 005-03N-1 | Soil | composite sample |
| | 005-03N-2 | Shale | composite sample |
| | 005-03M-1 | Soil | composite sample |
| | 005-03S-1 | Soil | composite sample |
| | 005-03S-2 | Shale | composite sample |
| 005 Drainage Trench 4 | 005-04N | Water | |
| | 005-04M | Water | |
| | 005-04S | Water | |
| | 005-04N-1 | Soil | composite sample |
| | 005-04N-2 | Shale | composite sample |
| | 005-04M-1 | Soil | composite sample |
| | 005-04M-2 | Shale | composite sample |
| | 005-04S-1 | Soil | composite sample |
| | 005-04S-2 | Shale | composite sample |
| 005 Drainage Trench 5 | 005-05M | Water | |
| | 005-05S | Water | |
| | 005-05N-1 | Soil | composite sample |
| | 005-05M-1 | Soil | composite sample |
| | 005-05S-1 | Soil | composite sample |
| MW010 Trench 1 | MW010-1 | Gravel | Basal gravel @ 12' |
| | MW010-2 | Shale | Weathered shale @ 14' |
| | MW010-3 | Soil | Composite above 12' |
| | MW010-1W | Water | Collected near exposed pipe |
| MW010 Trench 2 | MW010-2-1 | Soil | Composite clay/gravelly clay |
| | MW010-2-2 | Gravel | Basal gravel @ 8' |
| | MW010-2 | Water | |
| MW010 Trench 4 | MW010-4-1 | Soil | Composite clay/gravelly clay |
| | MW010-4-2 | Gravel | Basal Gravel @ 6' |
| | MW010-4 | Water | |
| MW010 Trench 5 | MW010-5-1 | Soil | Composite clay/gravelly clay |
| | MW010-5 | Water | |
| Background Trench E1 | E1-1 | Soil | Terrace Material |
| | E1 | Water | |
| Background Trench E2 | E2-1 | Soil | Terrace/Colluvial Material |
| | E2 | Water | |
| | E2 - background | Water | 12 liters for batch tests |

Table 8 Summary of GPS Coordinates for the Trenches and Trench Sampling

| Waypoint | Northing | Easting | Location |
|---|---|---|---|
| Wpt 001* | 196439 | 2836121 | 005 10' N of North End of Trench 1 |
| Wpt 002* | 196374 | 2836107 | 005 West Bank at Bend in Trench 1 |
| Wpt 003* | 196337 | 2836119 | 005 South End of Trench 1 |
| Wpt 004* | 196399 | 2836055 | MW037 Location Check |
| Wpt 005* | 196409 | 2836117 | 005 Trench 1 Drainage Bottom - Approx. |
| Wpt 006* | 196412 | 2836028 | 005 Trench 3 South Excavation |
| Wpt 007* | 196439 | 2836022 | 005 Trench 3 Middle Excavation |
| Wpt 008* | 196449 | 2836024 | 005 Trench 3 North Excavation |
| Wpt 009* | 196396 | 2835849 | 005 Trench 4 South Excavation |
| Wpt 010* | 196412 | 2835864 | 005 Trench 4 Middle Excavation |
| Wpt 011* | 196444 | 2835858 | 005 Trench 4 North Excavation |
| Wpt 012* | 196594 | 2835580 | 005 Trench 5 South Excavation |
| Wpt 013* | 196631 | 2835568 | 005 Trench 5 Middle Excavation |
| Wpt 014* | 196649 | 2835548 | 005 Trench 5 North Excavation |
| Wpt 015* | 196667 | 2835534 | MW100B Location Check |
| Wpt 016* | 195492 | 2837148 | MW010 Trench 1 East End |
| Wpt 017* | 195488 | 2837014 | MW010 Trench 1 West End |
| Wpt 018* | 195432 | 2837034 | MW010 Trench 2 Center on South Bank |
| Wpt 019* | 195433 | 2837056 | MW010 Trench 3 Center on South Bank |
| Wpt 020* | 195396 | 2836979 | MW010 Trench 4 Center on South Bank |
| Wpt 021* | 195473 | 2836974 | MW010 Trench 5 Center on South Bank |
| Wpt 022* | 195488 | 2837035 | MW010 Trench 1 Water Sample Location |
| Wpt 023* | 195047 | 2838179 | East of Hwy 10 South Trench (Trench E2) |
| Wpt 024* | 195937 | 2838356 | East of Hwy 10 North Trench (Trench E1) |
| Wpt 025* | 198380 | 2836248 | Drainage North of Plant N of Salt Branch |
| Wpt 026* | 195883 | 2841887 | Outcrop at NE Corner of Old Pond Dam |

## Table 9 Trench Lithologic Description

| Trench | Depth (ft) | Lithology |
|---|---|---|
| MW010 Trench 1 (West Side) | 0-1 | Fill, Topsoil, dark grayish brown, loose moist |
| | 1-2.5 | Fill, Gravel, clayey, reddish brown, moist, gravel ~20%, firm |
| | 2.5-3 | Fill, Clay, gravelly, tans to light brown, firm, moist, gravel ~20% |
| | 3-6 | Fill, Clay, gravelly, dark reddish brown to black, moist, wet in places, gravel ~20% |
| | 6-9 | Fill, clay, sandy, trace gravel, some gravel lenes, Reddish brown to black, moist, wt in places, especially in gravel lenses |
| | 9-12 | Fill, Gravel, some clay~30%, reddish brown, wet, loose, rounded, gravel moderately well sorted, 1-3 inches, makes good water |
| | 12-15 | Clay, weathered shale, light brown to buff, wet, soft, plastic |
| MW010 Trench 2 | 0-8 | Fill, Interbeds of gravelly clay and clayey gravel, moist moderate brown to yellowish brown, gravel <10% |
| | 8-8.5 | Fill, Gravel, wet, rounded river rock, water entering pit predominantly from pond side |
| | 8.5-9.5 | Clay, weather shale, light brown, stiff, saturated, plastic |
| | 9.5 | Sandstone |
| MW010 Trench 3 | 0-6 | Fill, Interbeds of clayey gravel and gravelly clay, moist, becomes very gravelly near base |
| | 6-8.5 | Clay, weathered shale light brown, stiff, saturated, plastic |
| | 8.5 | Sandstone |
| MW010 Trench 4 | 0-5 | Fill, Interbeds of clayey gravel and gravelly clay, moist, becomes very gravelly near base |
| | 5-6 | Gravel, sparse clay, loose, saturated, rounded river rock |
| | 6-8 | Clay, weathered shale light brown, stiff, saturated, plastic |
| | 8 | Sandstone |
| MW010 Trench 5 | 0-1 | Topsoil |
| | 1-2 | Gravelly clay, light brown to buff, moist |
| | 2-16 | gravel with clay and sand. Poorly sorted, Seeps at 6', 8', 12', and 15' |
| 005 Drainage Trench 1 | See Figure 8 for approximate depths | Fill, Clay, silty, reddish brown, moist to wet, underlain by 6 mil black plastic |
| | | Clay, with gravel and sand, dark reddish brown to black, poorly sorted, clay~50% gravel 30%, sand 20%, moist to very moist. Contains two French drain pipes that were broken during excavation. Southern pipe flows <5 gpm |
| | | Gravel with clay, reddish brown, very moist to wet. gravel 55%, clay 45%, soft |
| | | Weathered shale, clay, dark brown, wet plastic, firm |
| | | Sandstone, hard well cemented, laminated, dark gray |
| 005 Drainage Trench 3N | 0-8 | Clay, some sand and gravel, reddish brown |
| | 8-12 | sandstone, hard, well cemented, very shaley |
| 005 Drainage Trench 3M | 0-3 | Sandy, silty, gravelly clay, moist to saturated, moderate brown |
| | 3 | Sandstone |
| 005 Drainage Trench 3S | 0-3 | Overburden, gravelly, sandy clay, reddish brown, moist becomes saturated near bottom |
| | 3-6 | sandstone, shaley, wet near top |
| 005 Drainage Trench 3S | 0-3 | Overburden, gravelly, sandy clay, reddish brown, moist becomes saturated near bottom |
| | 3-6 | sandstone, shaley, wet near top |

**Table 9 Trench Lithologic Description (continued)**

| Trench | Depth (ft) | Lithology |
|---|---|---|
| 005 Drainage Trench 3S | 0-3 | Overburden, gravelly, sandy clay, reddish brown, moist becomes saturated near bottom |
| | 3-6 | sandstone, shaley, wet near top |
| 005 Drainage Trench 4N | 0-3 | Clay, reddish brown |
| | 3-5 | shale, saprolitic, black to dark gray with abundant iron stains |
| | 5-8 | Same as above but less weathered |
| 005 Drainage Trench 4M | 0-1 | Sandy clay, moderate brown, moist to wet |
| | 1-6 | shale, gray with iron stains |
| 005 Drainage Trench 4S | 0-3 | clay, reddish brown, soft, moist |
| | 3-8 | Clay, weathered shale, dark gray to black, soft moist |
| | 8-12 | sandstone, hard, well cemented, 1.5-3" interbeds |
| 005 Drainage Trench 5N | 0-2 | clay, reddish brown to brown wet, plastic, soft |
| | 2 | Sandstone |
| 005 Drainage Trench 5M | 0-0.75 | Clay, sandy, silty |
| | 0.75 | Sandstone |
| 005 Drainage Trench 5S | 0-4.5 | clay, yellowish brown, saturated at 4' |
| | 4.5 | Sandstone |
| E-2 | 0-0.75 | silty loam, dark brown, moist, soft |
| | 0.75-2 | clay, moderate brown to buff |
| | 2 | Sandstone |
| E-1 | 0-0.5 | silty loam, moderate brown, moist |
| | 0.5-4.5 | clay, some gravel, moist, saturated at 2.0' |
| | 4.5 | Sandstone |

**Table 10 List of Samples Collected at Sequoyah Fuels Site during February 2002 and a List of Analytical Procedures Performed on Each Sample**

| Sample ID | Whole Rock 3050 | Adsorption Test | Element(s) | Desorption Test | Element(s) |
|---|---|---|---|---|---|
| 005-03M-1 | X | | | | |
| 005-03N-1 | X | X | U | | |
| 005-03N-2 | X | X | U | | |
| 005-03S-1 | X | | | | |
| 005-03S-2 | X | | | | |
| 005-04M-1 | X | X | U | | |
| 005-04M-2 | X | | | | |
| 005-04N-1 | X | | | | |
| 005-04N-2 | X | X | U, As | X | U, As |
| 005-04S-1 | X | X | U, As | X | U, As |
| 005-04S-2 | X | X | U, As | X | U, As |
| 005-05M-1 | X | | | X | U, As |
| 005-05N-1 | X | | | | |
| 005-05S-1 | X | | | | |
| 005-S-01-01 | X | | | X | U, As |
| 005-S-01-02 | X | | | X | U, As |
| 005-S-02-01 | X | X | As | | |
| 005-S-02-02 | X | X | As | | |
| E1-1 | X | X | U | | |
| E2-1 | X | X | U | | |
| MW-10-1 | X | | | | |
| MW-10-2 | X | | | | |
| MW-10-3 | X | | | | |
| MW010-2-1 | X | | | | |
| MW010-2-2 | X | | | | |
| MW010-4-1 | X | X | U | | |
| MW010-4-2 | X | X | U | | |
| MW010-5-1 | X | | | | |

## Table 11 Drainage Surface Water Sampling Results

| Location | Date | Uranium µg/l | Nitrate mg/l | Arsenic mg/l |
|---|---|---|---|---|
| 2241 | 1/4/02 | 60.2 | 12.4 | < 0.009 |
| | 2/22/02 | 40.0 | 5.0 | < 0.009 |
| | 3/6/02 | 35.3 | 11.9 | < 0.009 |
| 2242 | 1/4/02 | 46.8 | 15.8 | < 0.009 |
| | 2/22/02 | 40.1 | 8.0 | < 0.009 |
| | 3/6/02 | 30.4 | 262 | < 0.009 |
| 2243 | 1/4/02 | 2.92 | 1.2 | < 0.009 |
| | 2/22/02 | 1.07 | < 1 | < 0.009 |
| | 3/6/02 | 5.16 | < 1 | < 0.009 |
| 2244 | 1/4/02 | < 1 | 70.0 | 0.021 |
| | 2/22/02 | < 1 | 39.8 | < 0.009 |
| | 3/6/02 | 1.03 | 38.4 | < 0.009 |
| 2245 | 1/4/02 | < 1 | 388 | 0.027 |
| | 2/22/02 | < 1 | 13.9 | 0.015 |
| | 3/6/02 | < 1 | 97.3 | < 0.009 |
| 2246 | 1/4/02 | 34.6 | 13.0 | < 0.009 |
| | 2/22/02 | 4.52 | 8.7 | < 0.009 |
| | 3/6/02 | 4.00 | 4.9 | < 0.009 |
| Drainage 005 Trench 2 | 12/3/01 | 49.8 | 31.8 | |
| Drainage 005 Trench 3 | 12/3/01 | 69 | 34.8 | |
| Drainage 005 Trench 4 | 12/3/01 | 66.5 | 37.4 | |
| Drainage 005 Trench 5 | 12/3/01 | 30 | 46 2 | |
| Drainage 005 Trench 6 | 12/3/01 | 58 | 82.6 | |
| Drainage 005 Trench 7 | 12/3/01 | 210 | 82.6 | |
| Drainage 005 Trench 8 | 12/3/01 | 275 | 310 | |
| 005 Sump (2224) | 12/3/01 | 274 | 309 | |

| Location | Northing | Easting | Description |
|---|---|---|---|
| 2241 | 196799 | 2835306 | 005 Drainage ~25' East of COE Boundary Fence |
| 2242 | 196641 | 2835501 | 005 Drainage - Pool near MW100B |
| 2243 | 197492 | 2835812 | 007 Drainage North of North Fluoride Holding Basin Area |
| 2244 | 195726 | 2834825 | 004 Drainage - Pool ~20' East of COE Boundary Fence |
| 2245 | 195151 | 2834303 | Seep North of Port Road Bridge |
| 2246 | 195204 | 2834191 | 001 Drainage North of Port Road Bridge |

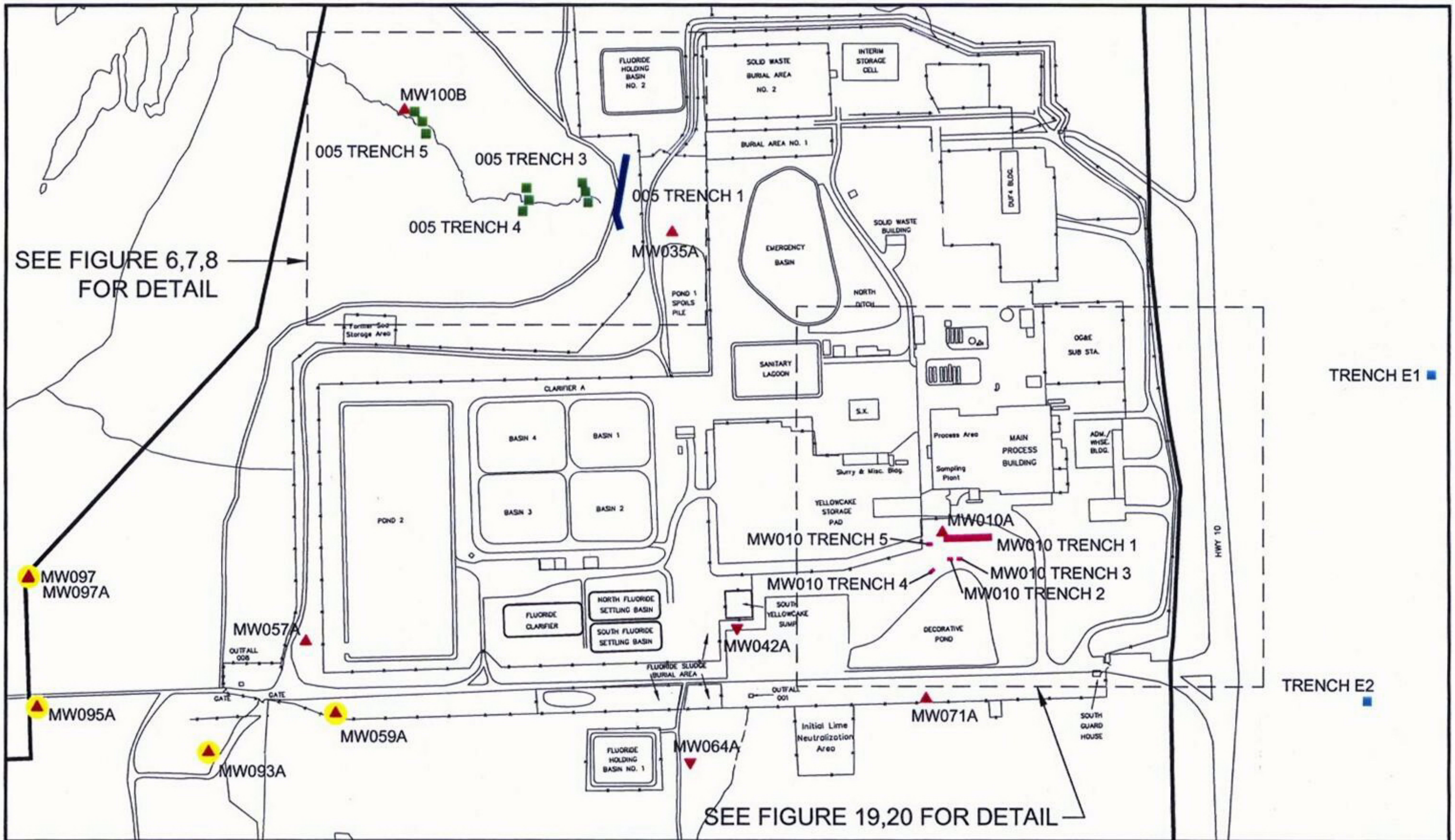
Table 12 2002 Trench Aqueous Sampling Data

| Station | Date Sampled | Matrix | Organic Carbon, Dissolved (DOC) (mg/L) | Arsenic (mg/L) | Fluoride (mg/L) | Uranium (mg/L) |
|---|---|---|---|---|---|---|
| 005-03M (3) | 2/9/02 | Aqueous | 5.31 | 0.0044 | 0.5 | 0.13 |
| 005-03N (3) | 2/9/02 | Aqueous | 4.14 | 0.002 | 0.1 | 0.0007 |
| 005-03S (3) | 2/9/02 | Aqueous | 6.07 | 0.0011 | 0.2 | 0.002 |
| 005-04M | 2/9/02 | Aqueous | 4.29 | 0.0029 | 0.4 | 0.143 |
| 005-04N | 2/9/02 | Aqueous | 5.16 | 0.001 | 0.1 | 0.0077 |
| 005-04S | 2/9/02 | Aqueous | 2.41 | 0.0011 | 0.8 | 0.0035 |
| 005-05M | 2/9/02 | Aqueous | 4.44 | 0.001 | 0.2 | 0.0317 |
| 005-05S | 2/9/02 | Aqueous | 3.96 | 0.001 | 0.2 | 0.0004 |
| 005-1 | 2/9/02 | Aqueous | 7.84 | 0.0223 | 0.6 | 0.626 |
| 005-2 | 2/9/02 | Aqueous | 8.32 | 0.0346 | 0.3 | 0.121 |
| E1 | 2/12/02 | Aqueous | 19.47 | 0.0375 | 0.2 | 0.0016 |
| E2 | 2/12/02 | Aqueous | 7.55 | 0.0032 | 0.1 | 0.0003 |
| MW010-1W (3) | 2/9/02 | Aqueous | 7.81 | 0.0143 | 0 3 | 0.0863 |
| MW010-2 (3) | 2/9/02 | Aqueous | 10.74 | 0.0121 | 0.2 | 0.0085 |
| MW010-4 (3) | 2/9/02 | Aqueous | 22.64 | 0.0618 | 0.4 | 0.0307 |
| MW010-5 (3) | 2/9/02 | Aqueous | 5.34 | 0.006 | 0.5 | 0.108 |

**Table 13 2002 Soil Sampling Data**

| Station | Date Sampled | Matrix | Moisture % | Arsenic (mg/kg) | Fluoride (mg/kg) | Uranium (mg/kg) |
|---|---|---|---|---|---|---|
| 005-03M-1 | 2/9/02 | Soil | 14.1 | 26.3 | 6.6 | 66.7 |
| 005-03N-1 | 2/9/02 | Soil | 14.1 | 9.74 | 1.4 | 9.55 |
| 005-03N-2 | 2/9/02 | Soil | 4.43 | 8.52 | 1.4 | 4.69 |
| 005-03S-1 | 2/9/02 | Soil | 15.7 | 12.6 | 0.83 | 7.56 |
| 005-03S-2 | 2/9/02 | Soil | 4.07 | 11.4 | 1.4 | 1.08 |
| 005-04M-1 | 2/9/02 | Soil | 20.2 | 8.25 | 3.8 | 396 |
| 005-04M-2 | 2/9/02 | Soil | 12 | 4.7 | 3.3 | 2.56 |
| 005-04N-1 | 2/9/02 | Soil | 19.1 | 37.5 | 1.4 | 1.09 |
| 005-04N-2 | 2/9/02 | Soil | 14.9 | 6 | 2.8 | 1.2 |
| 005-04S-1 | 2/9/02 | Soil | 19.7 | 64.5 | 0.84 | 1.76 |
| 005-04S-2 | 2/9/02 | Soil | 11.3 | 7.12 | 1.9 | 1.22 |
| 005-05M-1 | 2/9/02 | Soil | 36.3 | 12.7 | 3.3 | 564 |
| 005-05N-1 | 2/9/02 | Soil | 21.6 | 11 | 1.9 | 1.19 |
| 005-05S-1 | 2/9/02 | Soil | 14.1 | 10.1 | 0.73 | 2.1 |
| 005-S-01-01 | 2/9/02 | Soil | 18.5 | 12.5 | 9.1 | 18.9 |
| 005-S-01-02 | 2/9/02 | Soil | 12.6 | 19.7 | 7.2 | 14.5 |
| 005-S-02-01 | 2/9/02 | Soil | 18.3 | 8.77 | 7.9 | 11 |
| 005-S-02-02 | 2/9/02 | Soil | 11.1 | 14 | 4.6 | 144 |
| E1-1 | 2/10/02 | Soil | 14.3 | 26 | 1.7 | 1.93 |
| E2-2 | 2/10/02 | Soil | 18 | 4.33 | 1.3 | 1.39 |
| MW-10-1 | 2/8/02 | Soil | 14.6 | 8.91 | 3.8 | 92.4 |
| MW-10-2 | 2/8/02 | Soil | 20.3 | 8.7 | 3.5 | 6.15 |
| MW-10-3 | 2/8/02 | Soil | 16.2 | 7.61 | 2.8 | 2.14 |
| MW010-2-1 | 2/9/02 | Soil | 26.5 | 14.3 | 1.7 | 3.91 |
| MW010-2-2 | 2/9/02 | Soil | 12.1 | 7.02 | 2.5 | 1.82 |
| MW010-4-1 | 2/9/02 | Soil | 17.4 | 16.6 | 12 | 0.892 |
| MW010-4-2 | 2/9/02 | Soil | 15.9 | 6.11 | 2.7 | 3.84 |
| MW010-5-1 | 2/9/02 | Soil | 14.5 | 8.64 | 3.8 | 13.6 |

FIGURES




LEGEND

- SLUG TEST LOCATIONS
- ▲ MONITORING WELL LOCATIONS SAMPLED FOR ARSENIC SPECIATION TESTING
- ■ 005 DRAINAGE BANK SOIL AND WATER SAMPLE LOCATIONS

NORTH

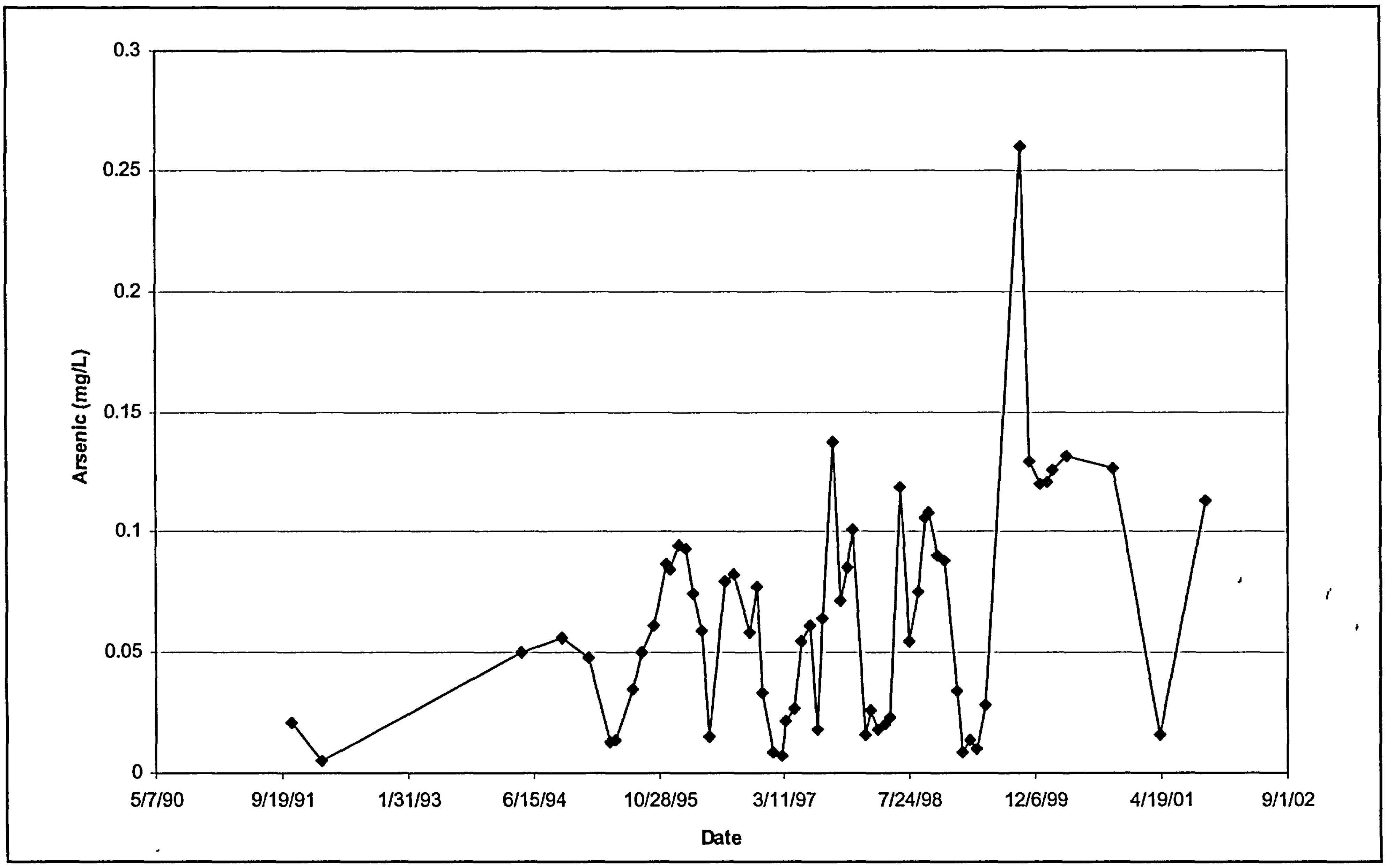
SCALE IN FEET
0 500

C01

SHEPHERD MILLER

FIGURE 1
SUPPLEMENTAL DATA COLLECTION LOCATIONS

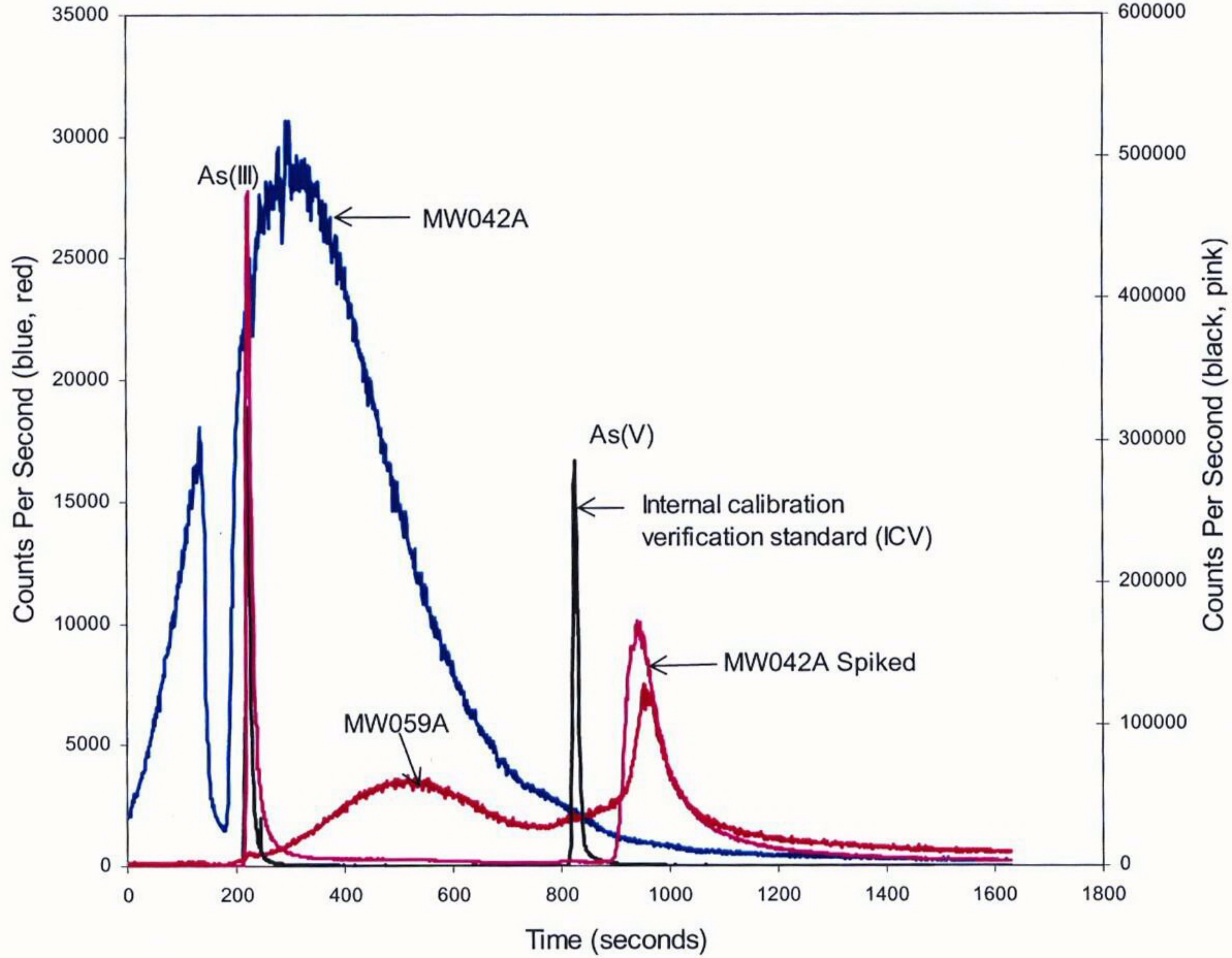
| | |
|---|---|
| Date: | APRIL 2002 |
| Project: | 100734 |
| File: | TRENCH-01.DWG |




SHEPHERD MILLER

FIGURE 2
WELL MW095A ARSENIC CONCENTRATIONS

| | |
|---|---|
| Date: | MARCH 2002 |
| Project | P.100734\PRJMGT\ |
| File: | TRIPFIGS ppt |

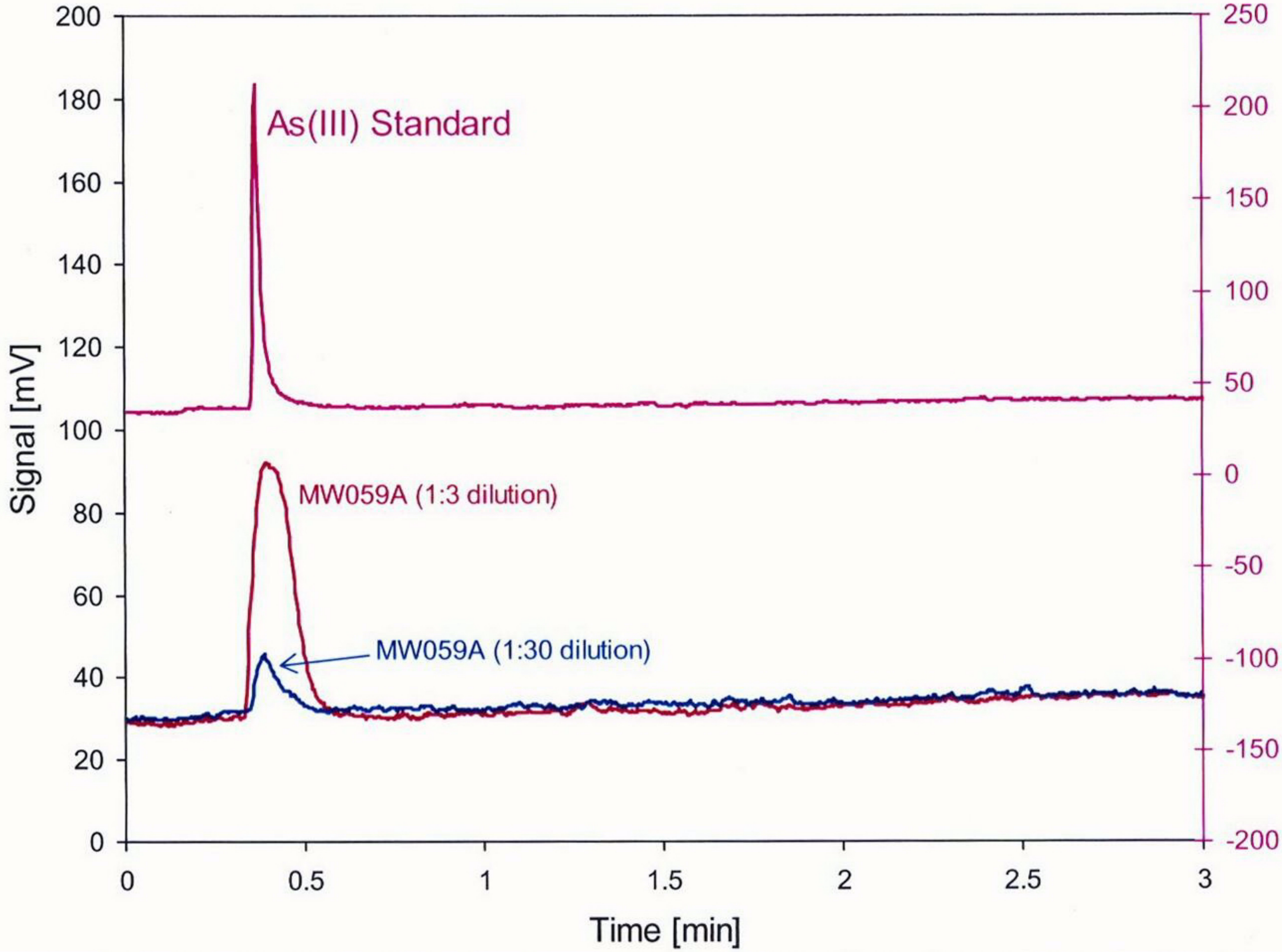



C02

SHEPHERD MILLER

FIGURE 3
ANALYTICAL RESULTS OF ARSENIC SPECIATION: IC-ICP-MS CHROMATOGRAM

| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |

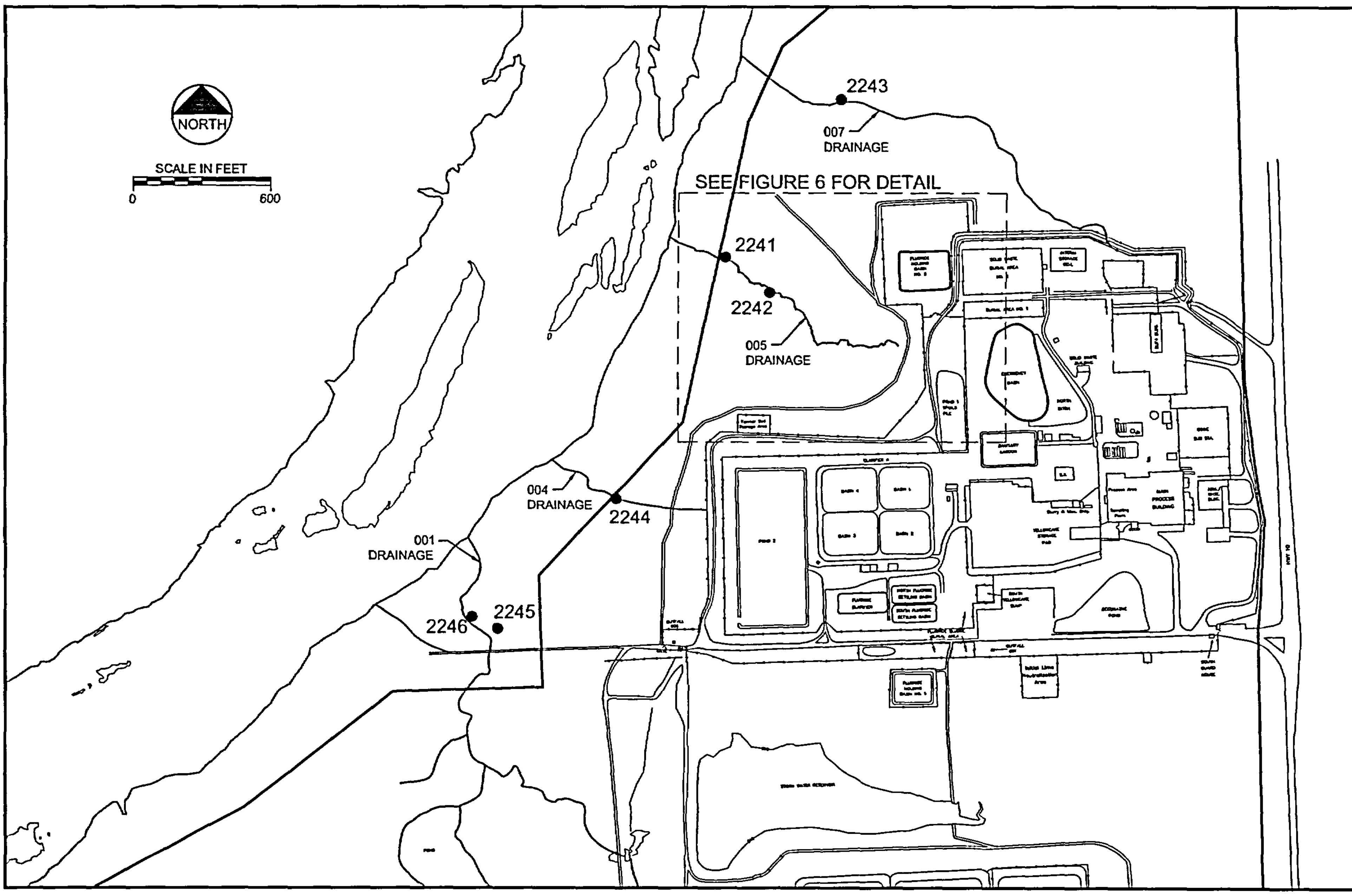



C03

SHEPHERD MILLER

FIGURE 4
CHROMATOGRAM OBTAINED OF SAMPLE MW059A DURING HG-CT-GC-AAS SPECIATION OF ARSENIC

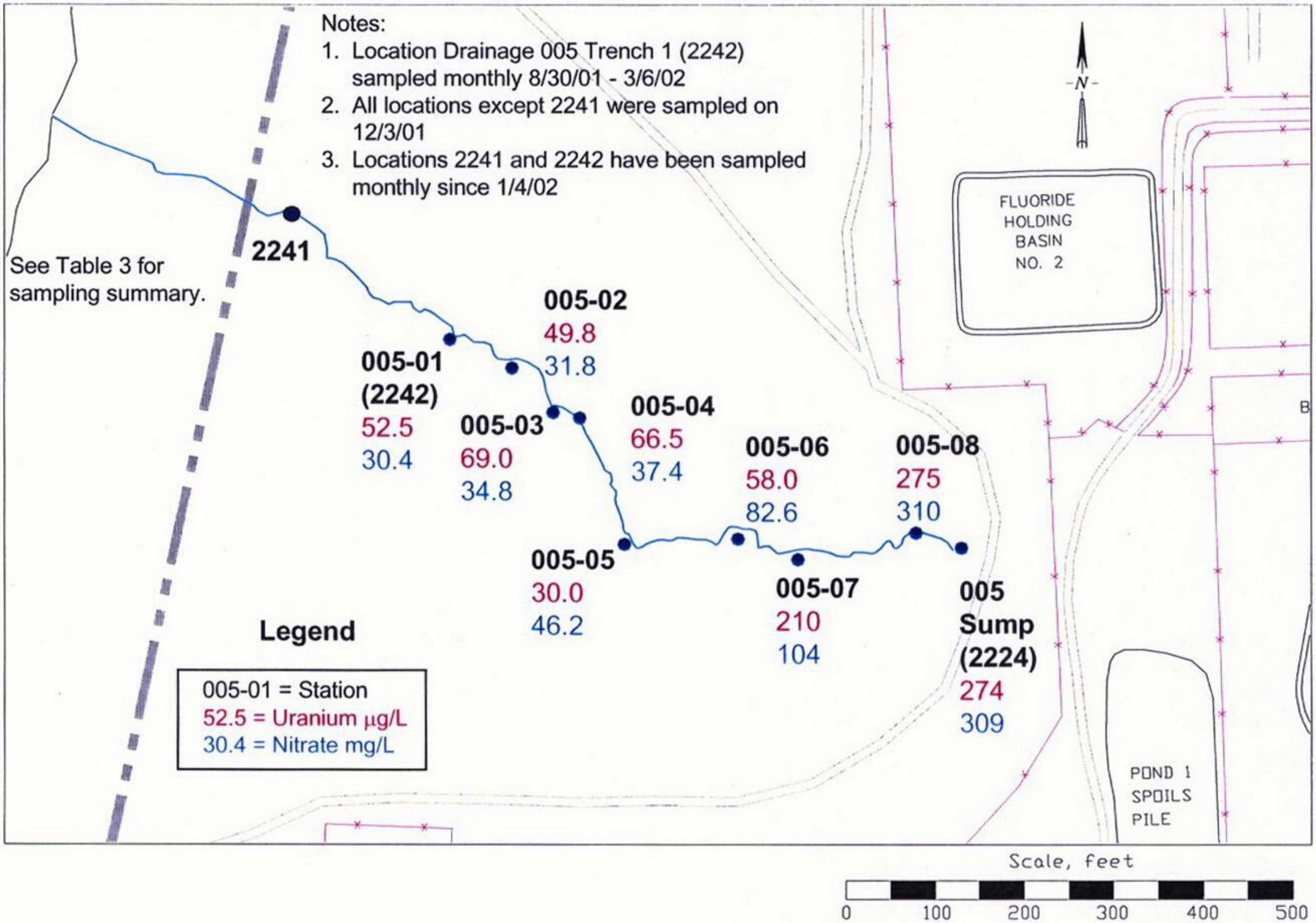
| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |




SHEPHERD MILLER

FIGURE 5
SITE DRAINAGES AND SURFACE WATER SAMPLING LOCATIONS

| | |
|---|---|
| Date: | APRIL 2002 |
| Project: | 100734 |
| File: | DRAINAGESAM....-01 |

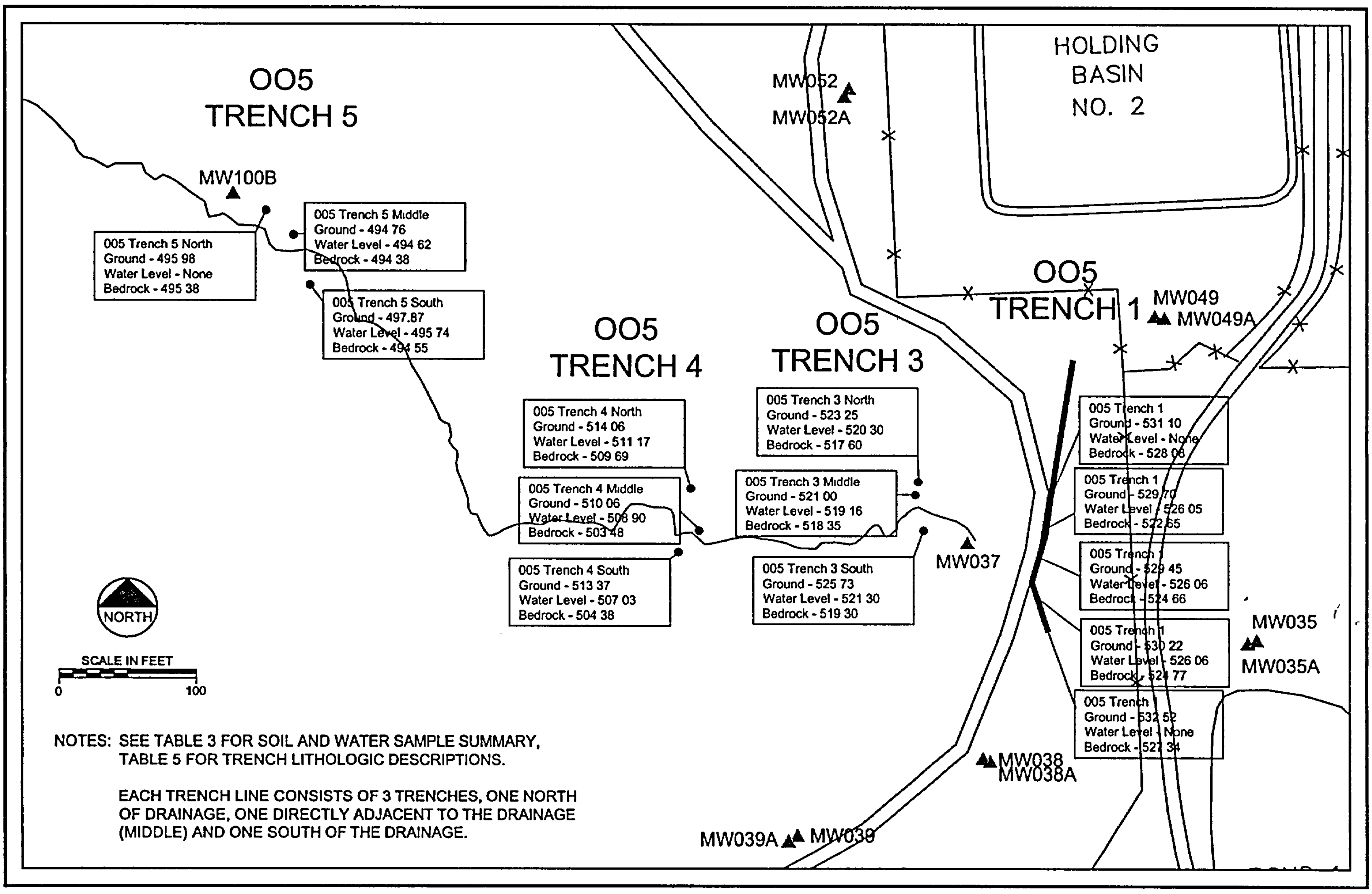



C04

SHEPHERD MILLER

FIGURE 6
005 DRAINAGE SURFACE
WATER SAMPLING LOCATIONS

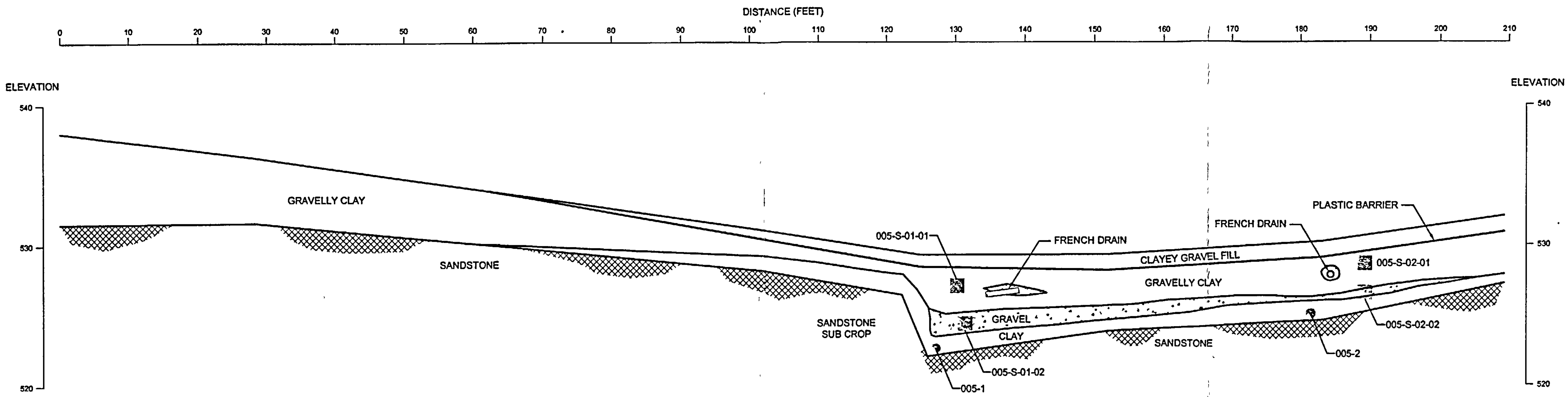
| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |




SHEPHERD MILLER

FIGURE 7
005 DRAINAGE TRENCHING AND SOIL/WATER SAMPLING LOCATIONS

| | |
|---|---|
| Date: | APRIL 2002 |
| Project: | 100734 |
| File: | TRENCH-FIGS |




LEGEND

- SOIL SAMPLE LOCATIONS AND ASSOCIATED SAMPLE NUMBER
- WATER SAMPLE LOCATIONS AND ASSOCIATED SAMPLE NUMBER

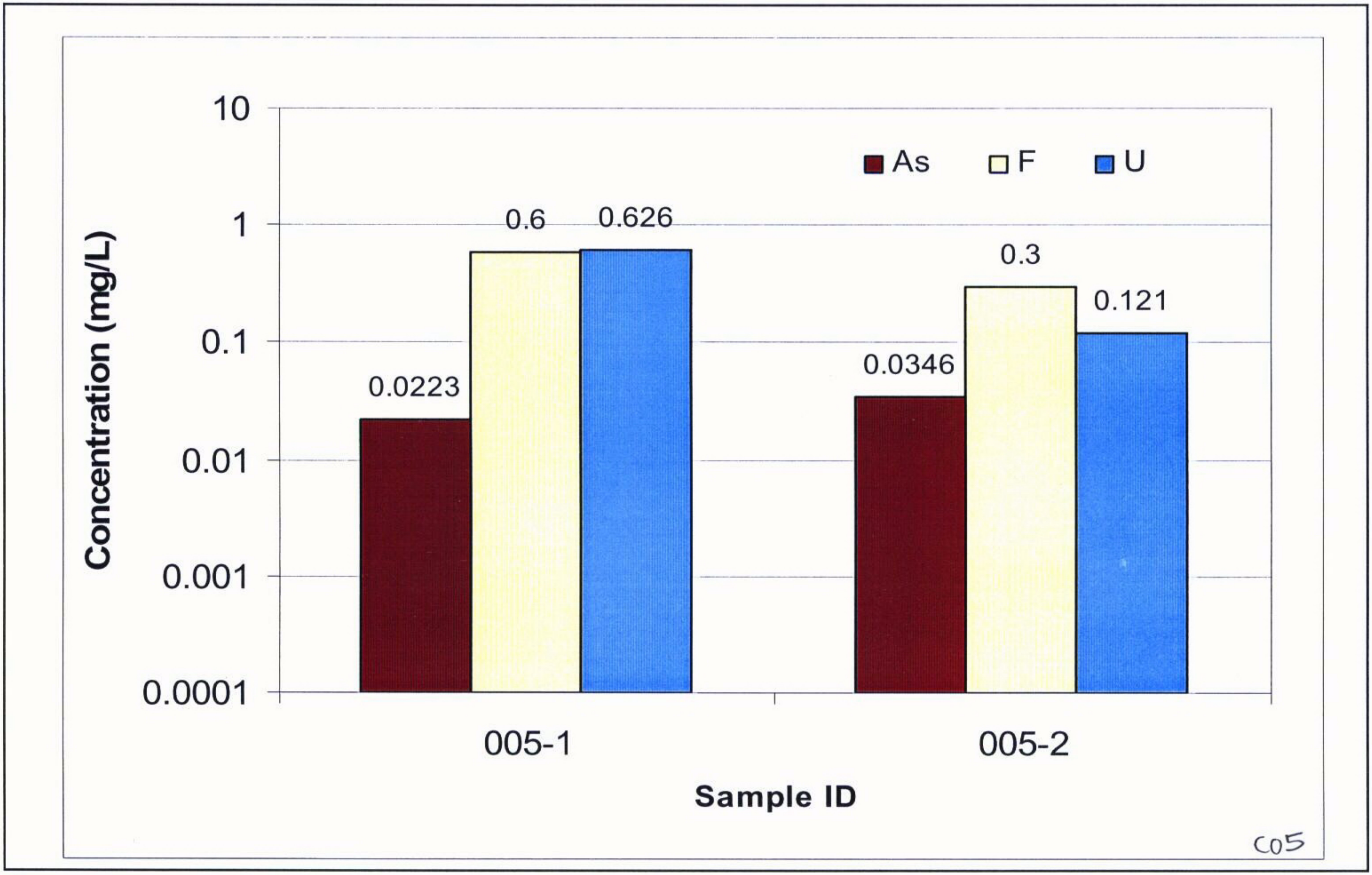
SEE TABLE 3 FOR SOIL AND WATER SAMPLE SUMMARY

FIGURE 8
CROSS SECTION VIEW OF 005
DRAINAGE TRENCH 1

SHEPHERD MILLER

| | |
|---|---|
| Date: | APRIL 2002 |
| Project: | 100734 |
| File: | PROFILES-01.DWG |

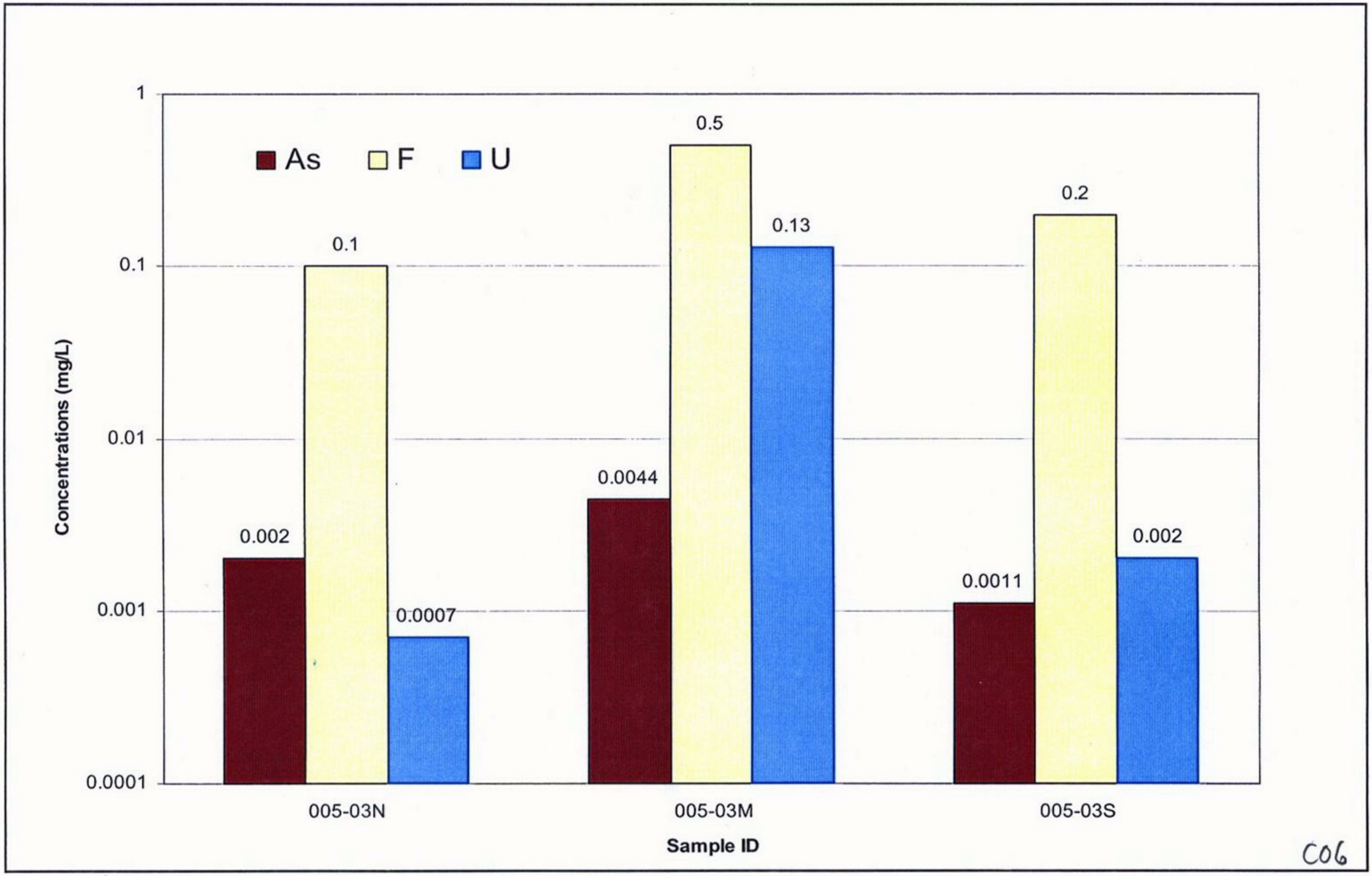
Filename: E:\100734\profiles-01.dwg
Date: 04/17/2002
Time: 13:11:41.38




SHEPHERD MILLER

FIGURE 9
AQUEOUS ANALYTICAL RESULTS FOR 005 DRAINAGE TRENCH 1

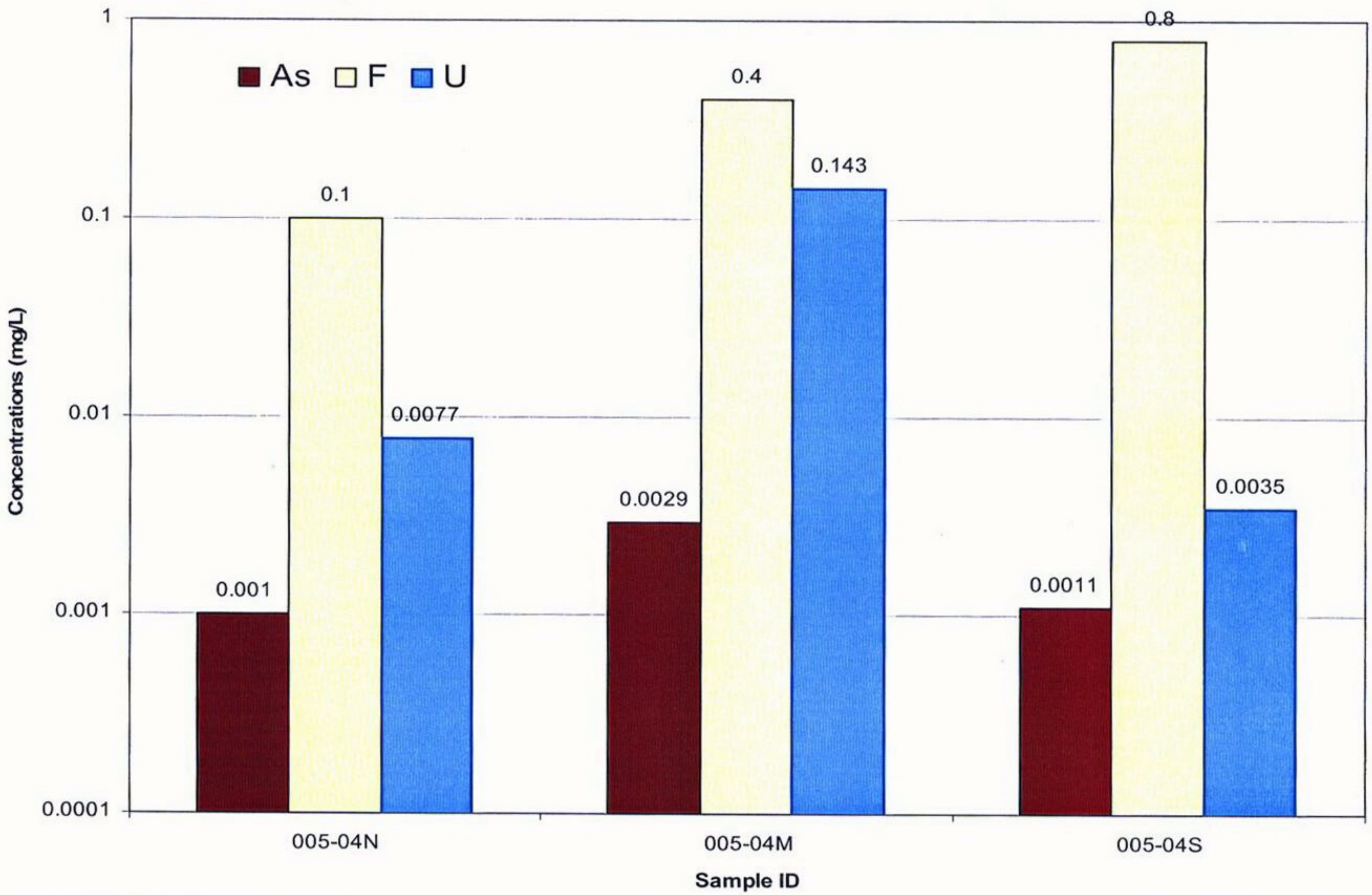
| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |




SHEPHERD MILLER

FIGURE 10
AQUEOUS ANALYTICAL RESULTS FOR 005 DRAINAGE TRENCH 3

| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |

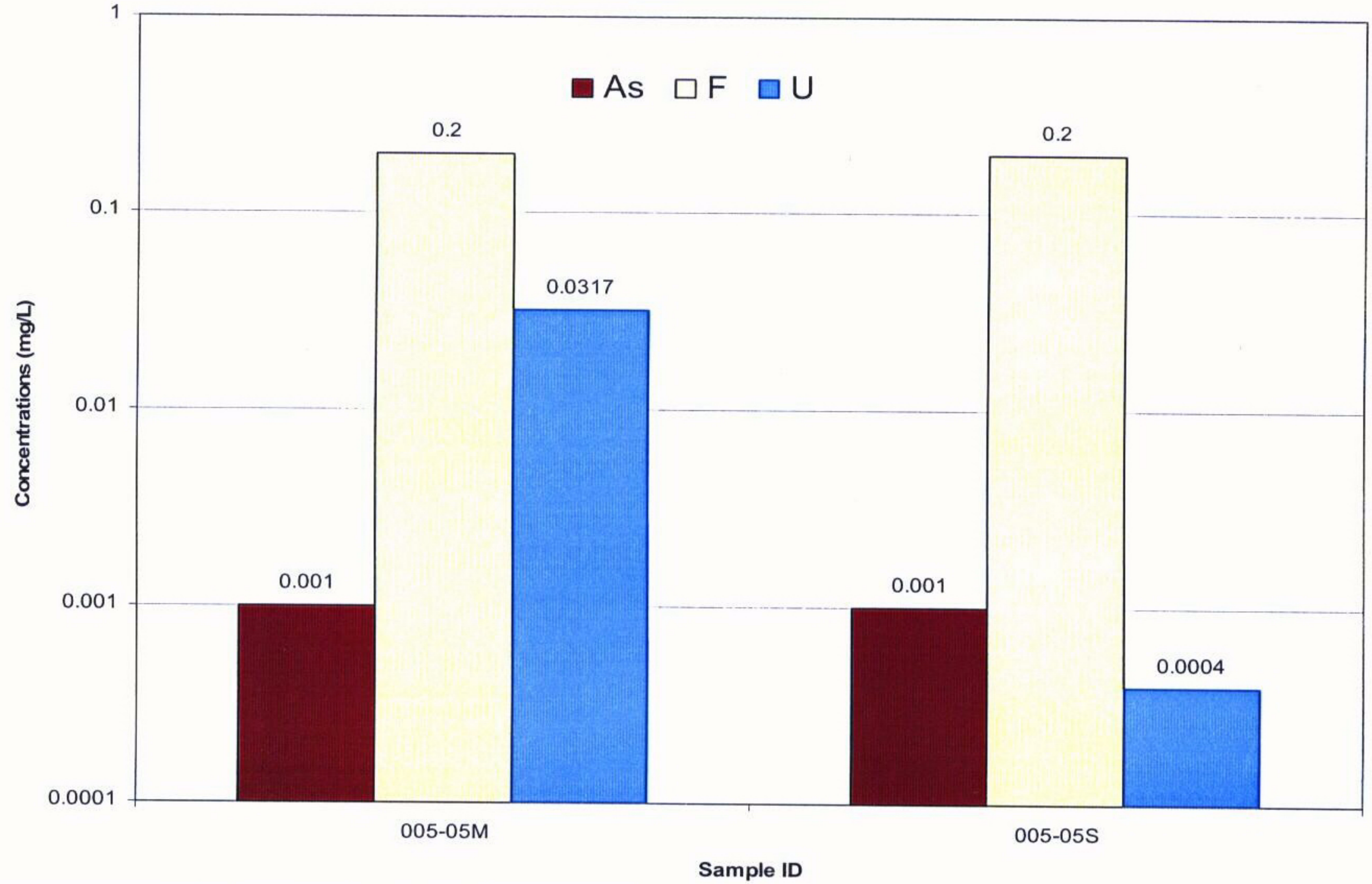



C07

SHEPHERD MILLER

FIGURE 11
AQUEOUS ANALYTICAL RESULTS FOR 005 DRAINAGE TRENCH 4

| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |

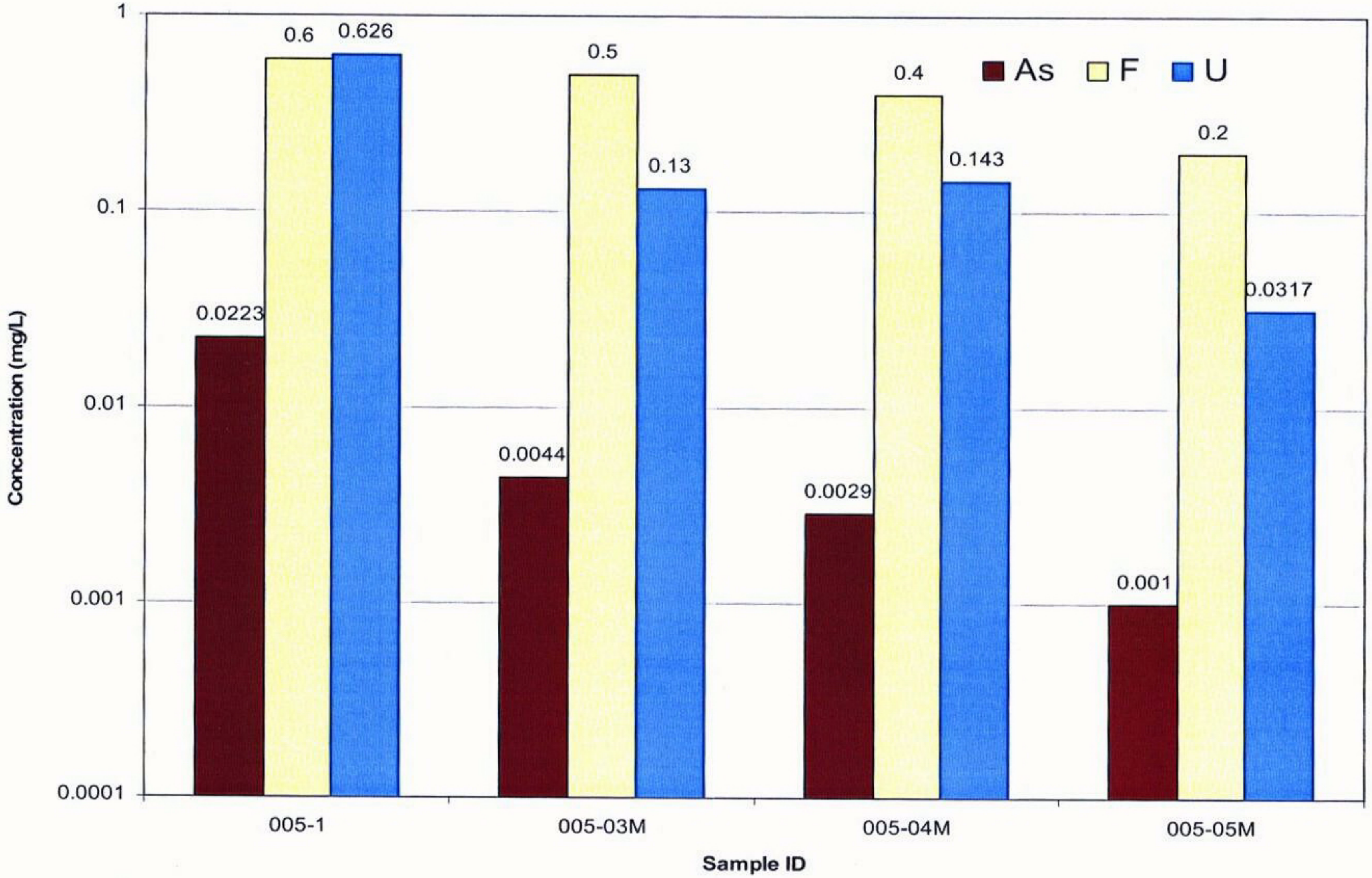



C08

SHEPHERD MILLER

FIGURE 12
AQUEOUS ANALYTICAL RESULTS FOR 005 DRAINAGE TRENCH 5

| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |

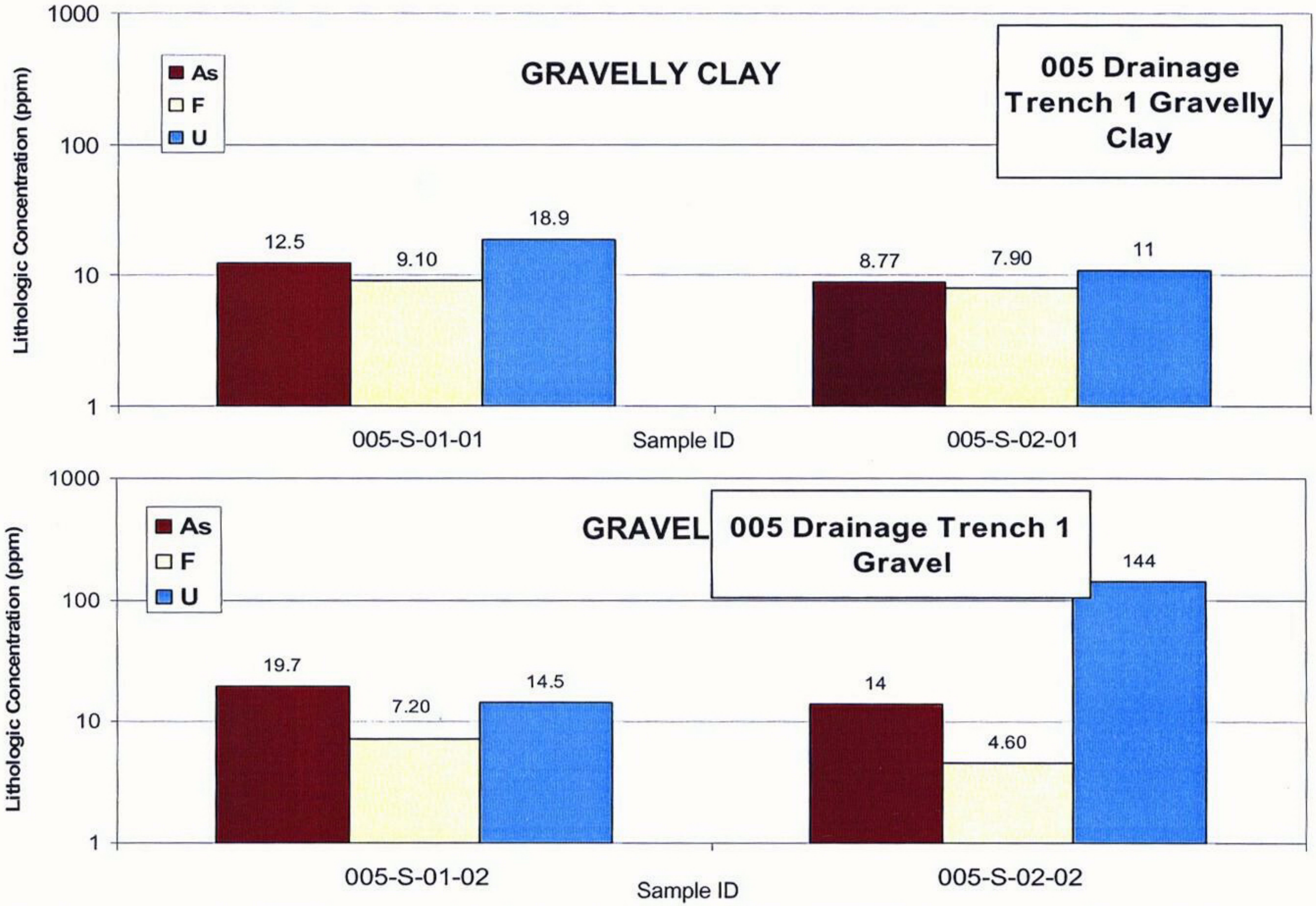



C09

SHEPHERD MILLER

FIGURE 13
AQUEOUS ANALYTICAL RESULTS FOR 005 DRAINAGE FOR DOWNSTREAM THROUGH MIDDLE TRENCH

| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |

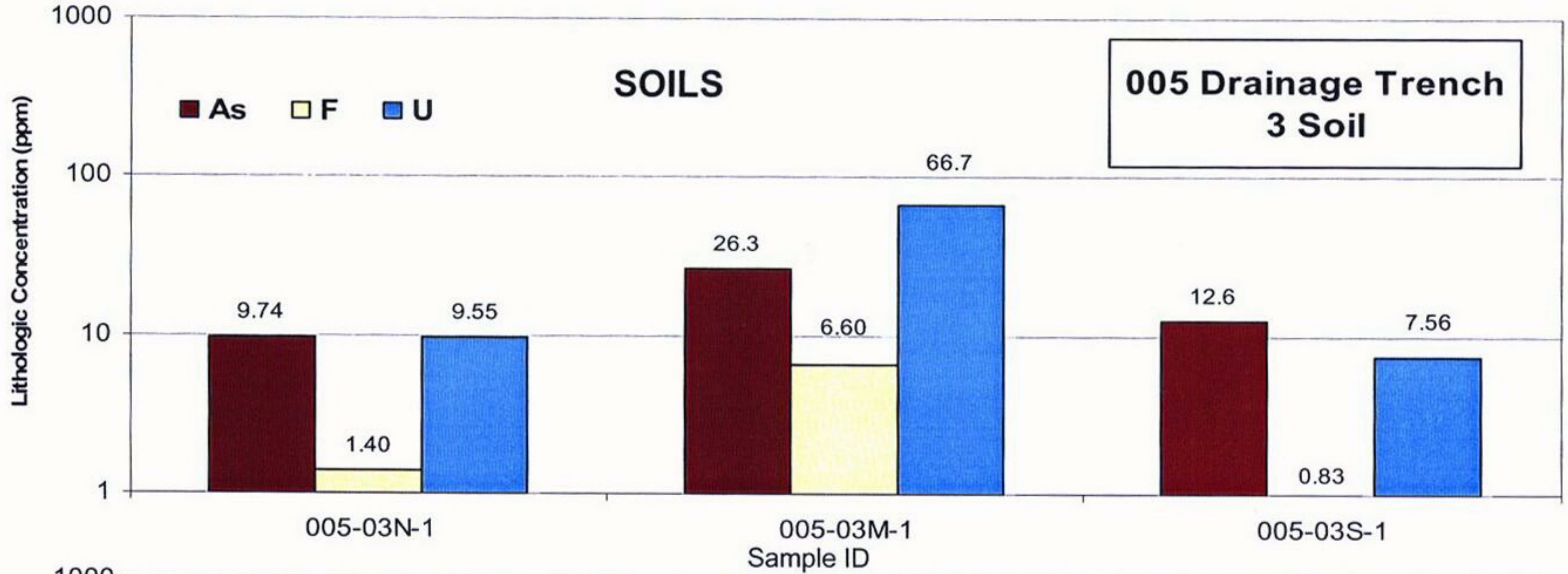


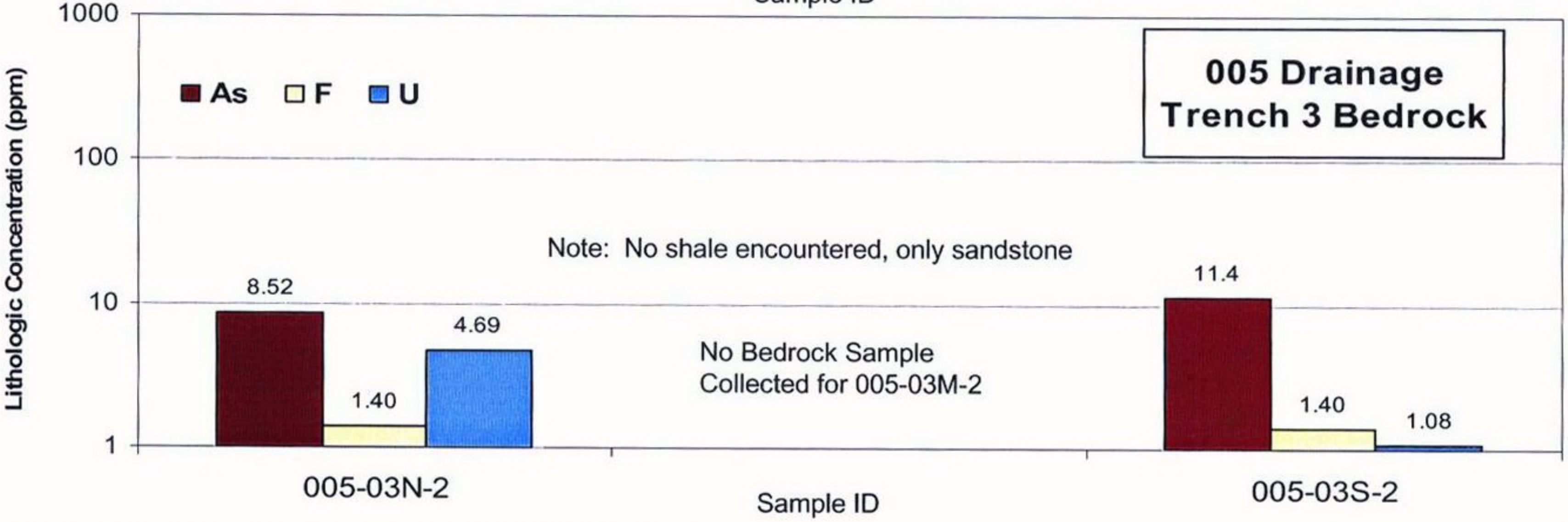

C10

SHEPHERD MILLER

FIGURE 14
SOLIDS ANALYTICAL RESULTS
DRAINAGE 005 TRENCH 1

| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |



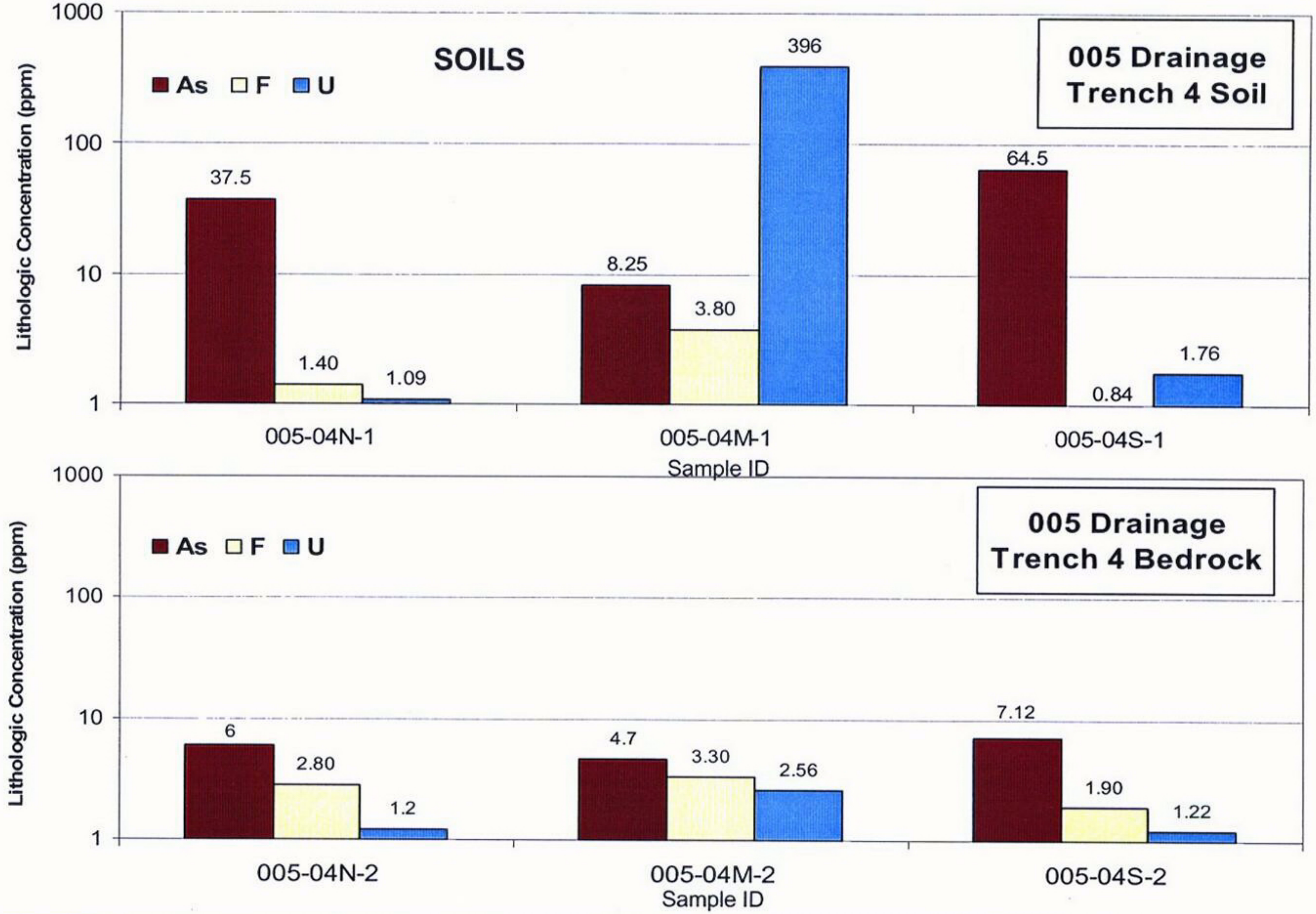




C11

SHEPHERD MILLER

FIGURE 15
SOLIDS ANALYTICAL RESULTS
DRAINAGE 005 TRENCH 3

| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |

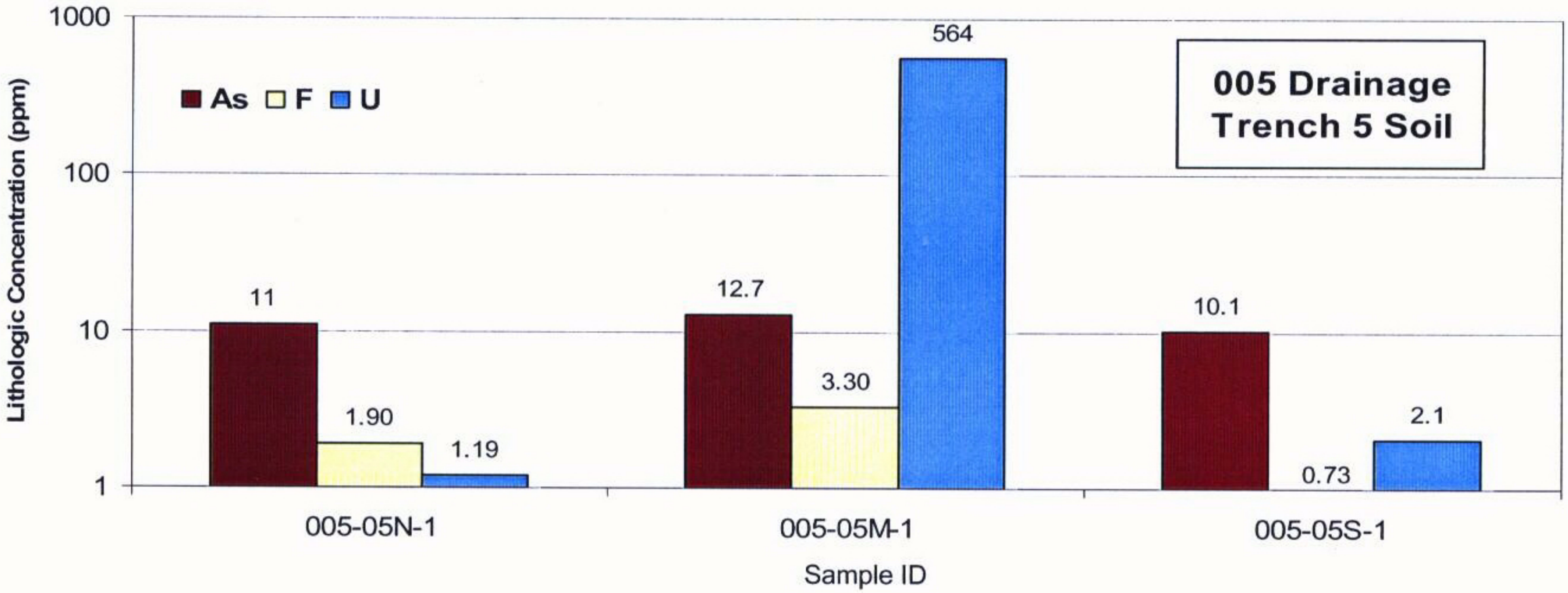



C12

SHEPHERD MILLER

FIGURE 16
SOLIDS ANALYTICAL RESULTS
005 DRAINAGE TRENCH 4

| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |




**NO BEDROCK SAMPLE**

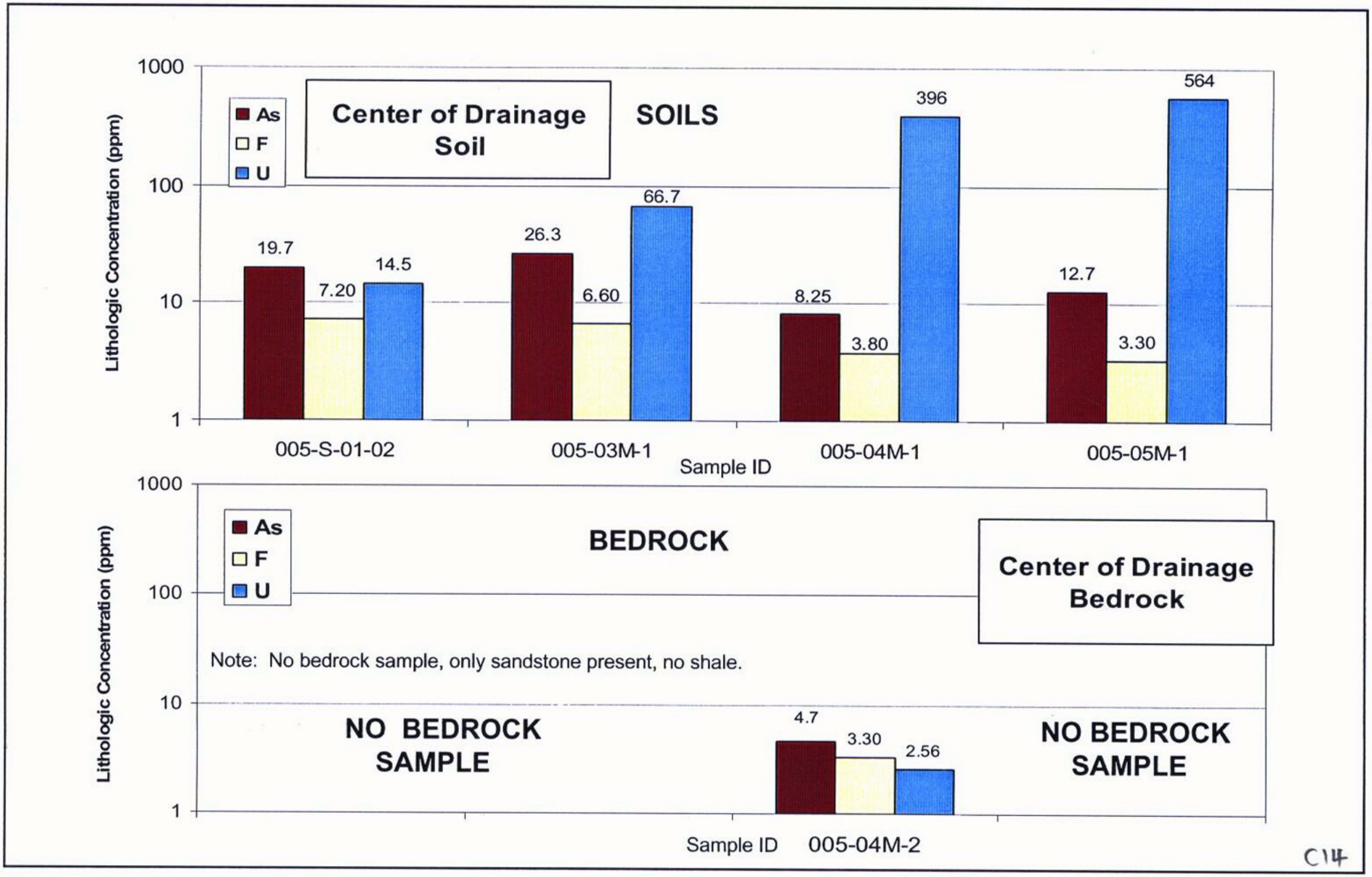
**NO BEDROCK SAMPLE**

**NO BEDROCK SAMPLE**

Note: No bedrock sample, only sandstone present, no shale.

C13

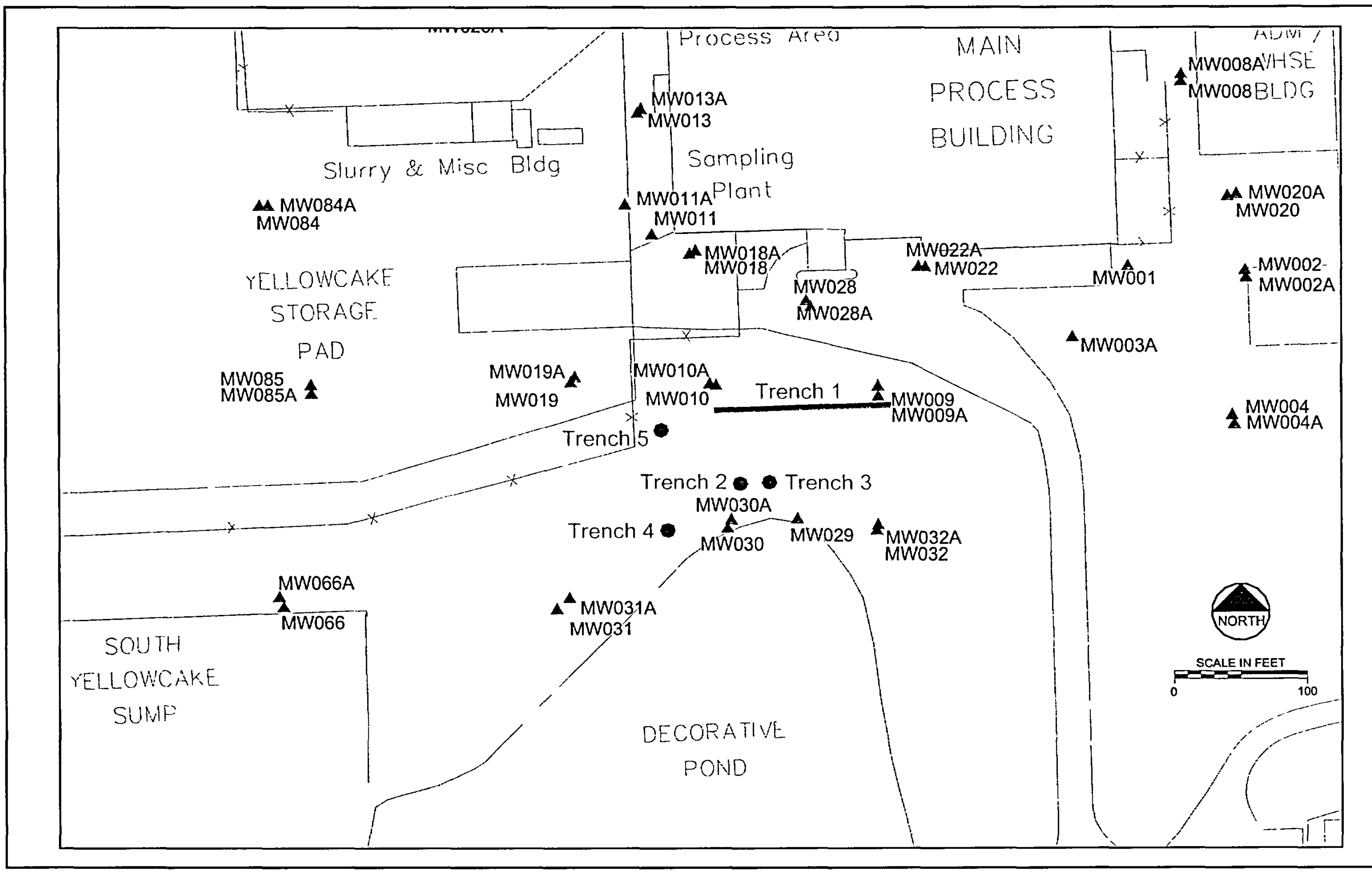
| SHEPHERD MILLER | FIGURE 17<br>SOLIDS ANALYTICAL RESULTS<br>005 DRAINAGE TRENCH 5 | Date: MARCH 2002<br>Project: P:100734\PRJMGT\<br>File: TRIPFIGS.ppt |
|---|---|---|




SHEPHERD MILLER

FIGURE 18
SOLIDS ANALYTICAL RESULTS
DOWNSTREAM THROUGH MIDDLE TRENCH

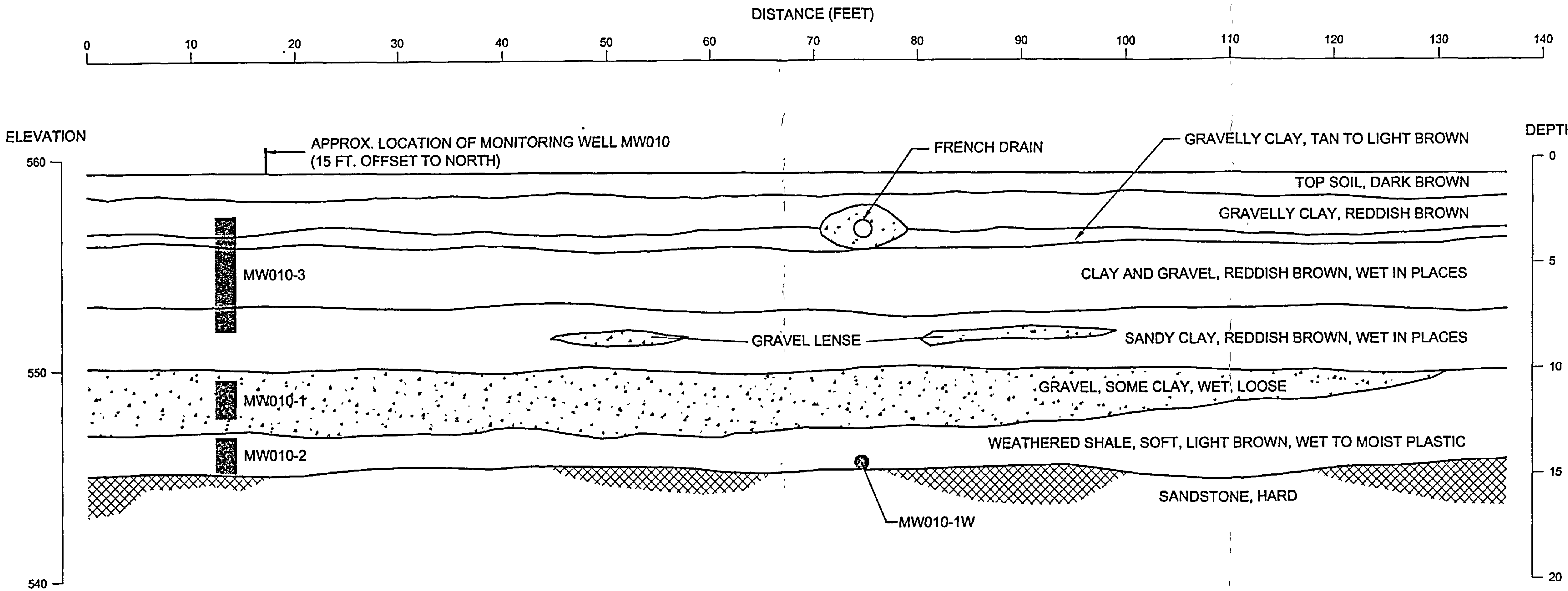
| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |




SHEPHERD MILLER

FIGURE 19
MW010 SWALE AREA TRENCH LOCATIONS

| | |
|---|---|
| Date | MARCH 2002 |
| Project | P.100734\PRJMGT\ |
| File | TRIPFIGS ppt |




LEGEND

SOIL SAMPLE LOCATIONS AND ASSOCIATED SAMPLE NUMBER

WATER SAMPLE LOCATIONS AND ASSOCIATED SAMPLE NUMBER

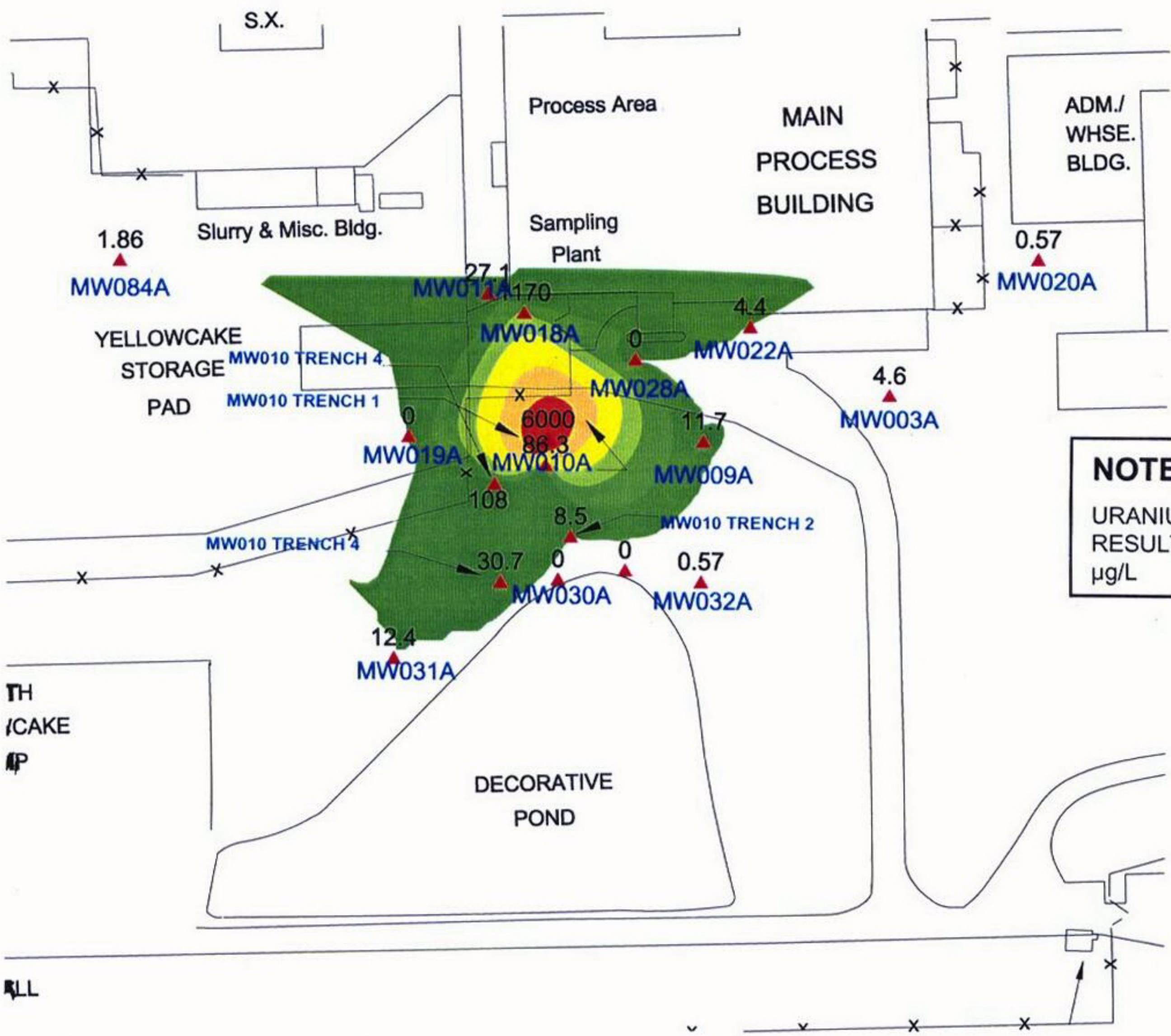
SEE TABLE 3 FOR SOIL AND WATER SAMPLE SUMMARY

FIGURE 20
CROSS SECTION VIEW OF MW010
AREA TRENCH 1

SHEPHERD MILLER

| | |
|---|---|
| Date: | APRIL 2002 |
| Project: | 100734 |
| File: | PROFILES-01.DWG |

Filename: E:\100734\profiles-01.dwg
Date: 04/25/2002
Time: 10:32:32.11




**NOTE**

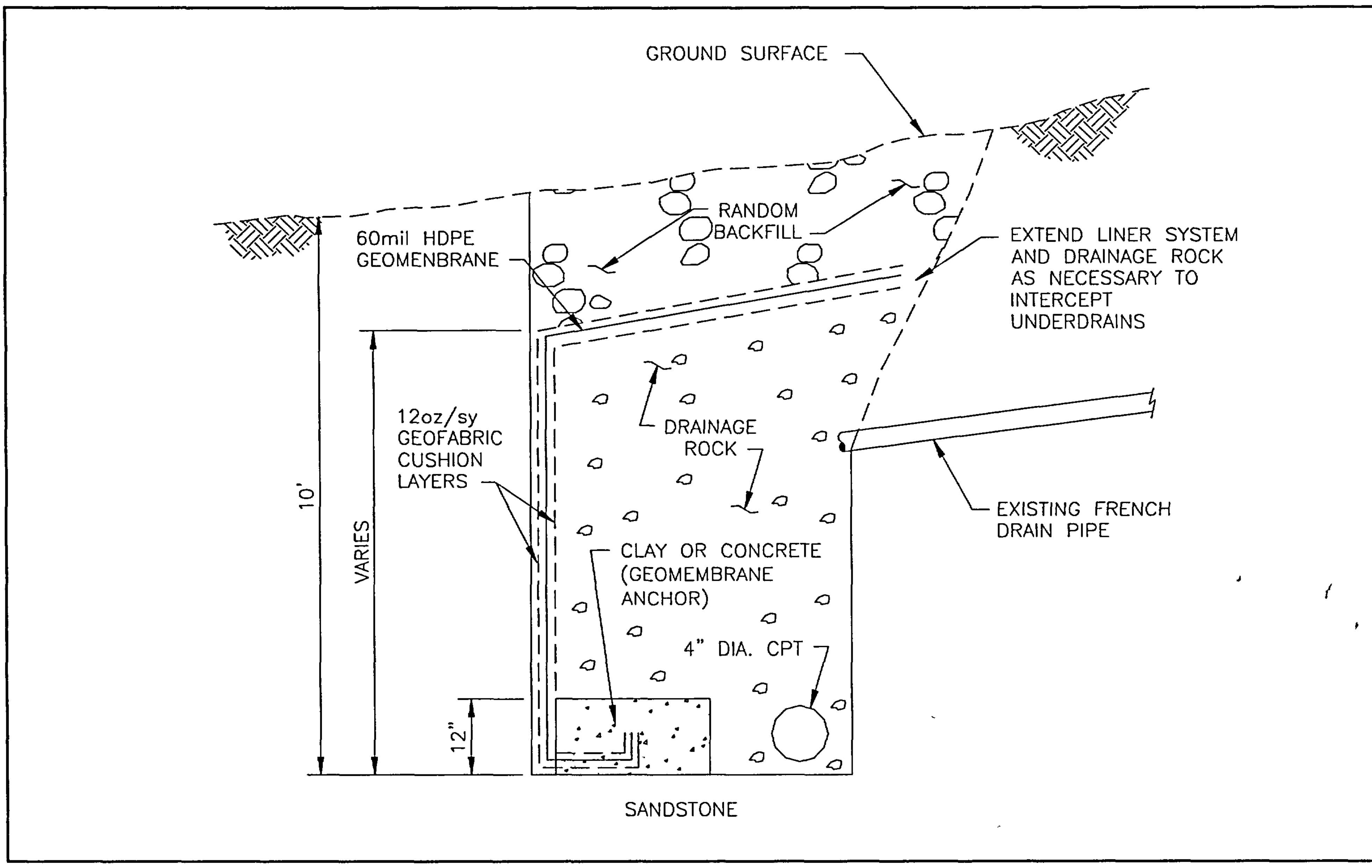
URANIUM SAMPLING RESULTS FROM 2/09/02 IN µg/L

C15

SHEPHERD MILLER

FIGURE 21
MW010 SWALE URANIUM CONCENTRATIONS
IN GROUNDWATER OF UNCONSOLIDATED MATERIAL

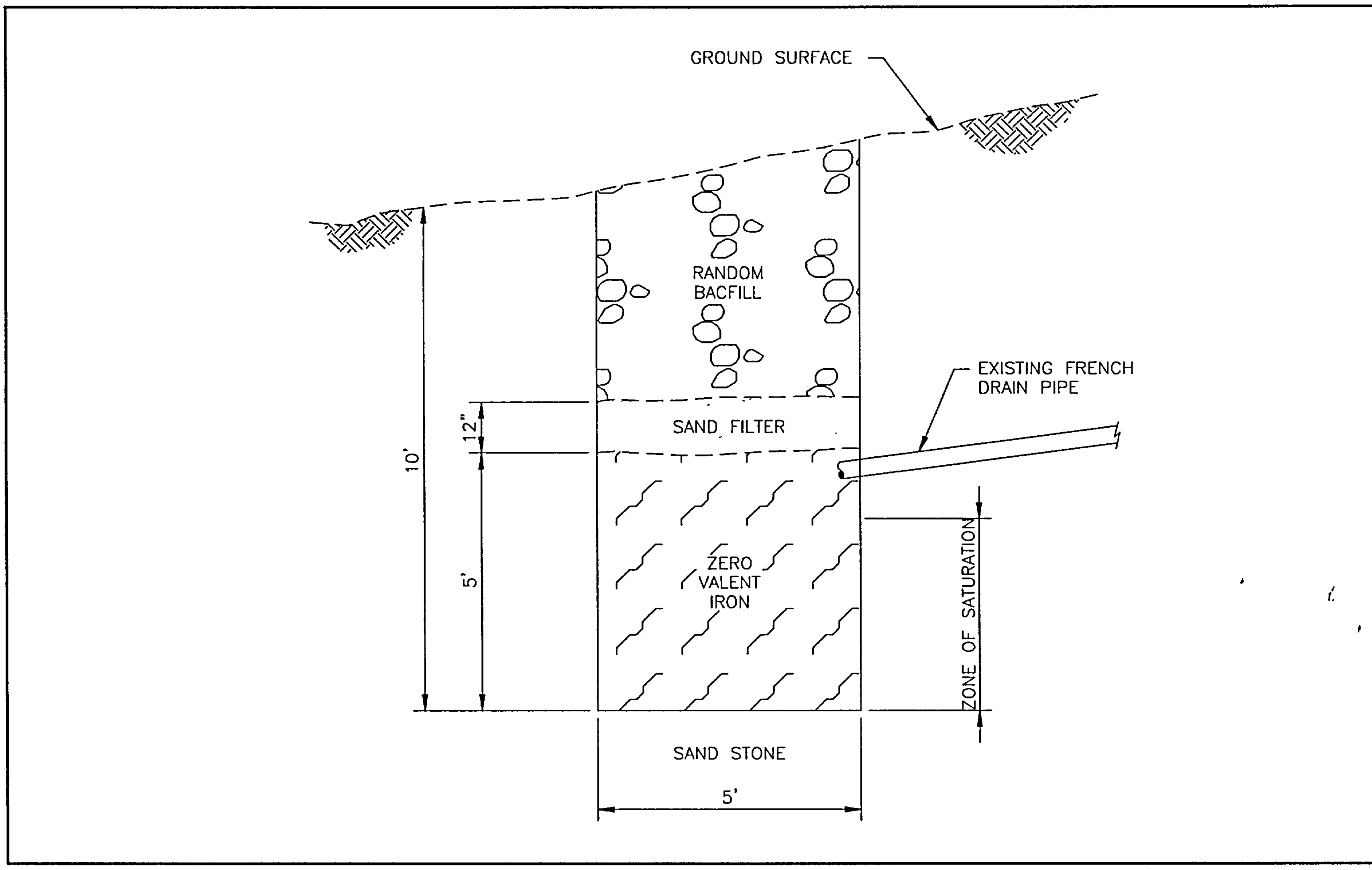
| | |
|---|---|
| Date: | MARCH 2002 |
| Project: | P:100734\PRJMGT\ |
| File: | TRIPFIGS.ppt |




SHEPHERD MILLER

FIGURE 22
HYDRAULIC CONTAINMENT / PUMP BACK SYSTEM DESIGN

| | |
|---|---|
| Date | MARCH 2002 |
| Project: | P.100734\PRJMGT\ |
| File. | TRIPFIGS ppt |




SHEPHERD MILLER

FIGURE 23
PERMEABLE REACTIVE BARRIER
WITH ZERO VALENT IRON DESIGN

| | |
|---|---|
| Date. | MARCH 2002 |
| Project: | P.100734\PRJMGT\ |
| File. | TRIPFIGS ppt |

**PHOTOS**

**Photo 1** **Excavation of 005 Drainage Trench 1 at Head of Drainage**

**Photo 2** **Photograph of 005 Drainage Trench 1 Features, South End**

**Photo 3 Photograph of MW010 Trench 1 Features, West End**

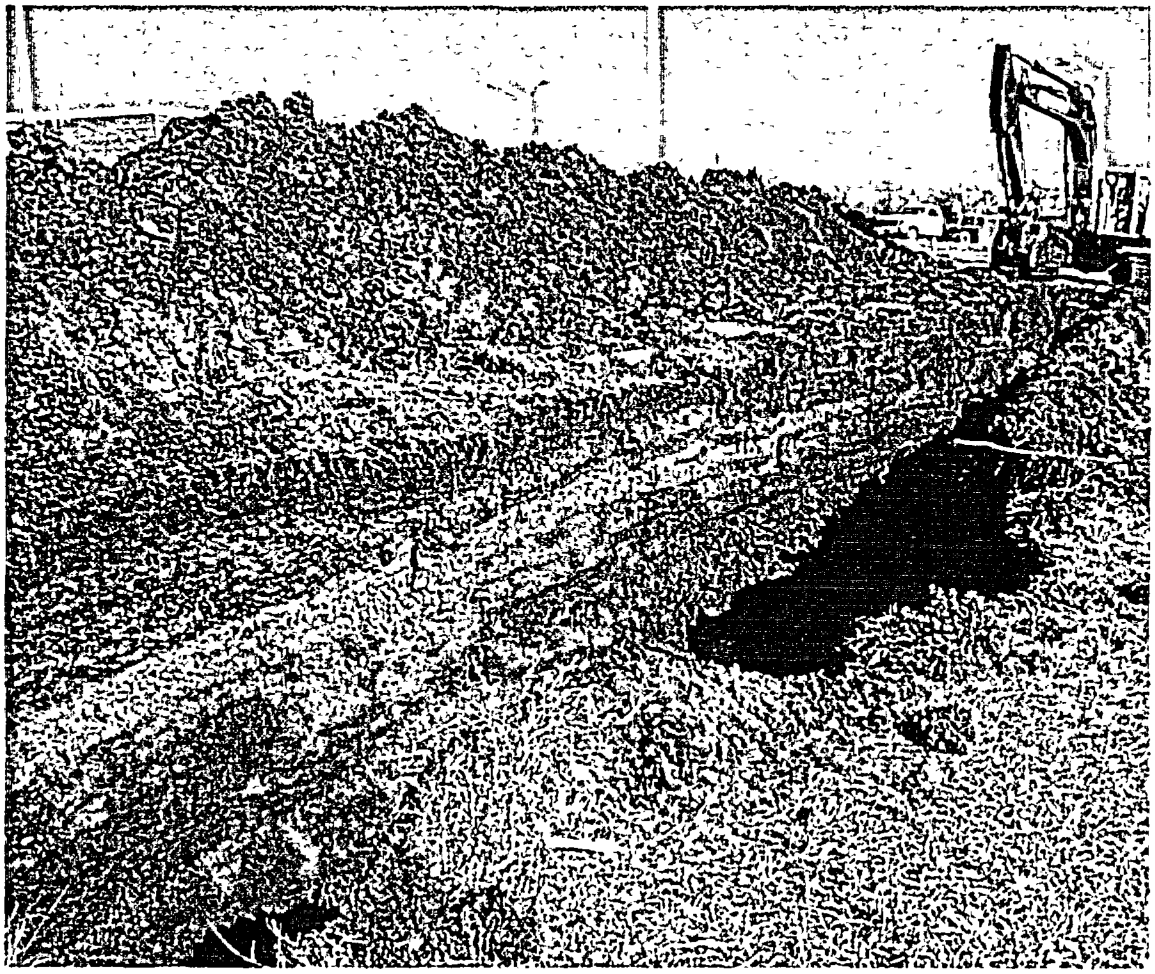


**Photo 4** **Photograph of MW010 Trench 1 Features, South End Bottom**

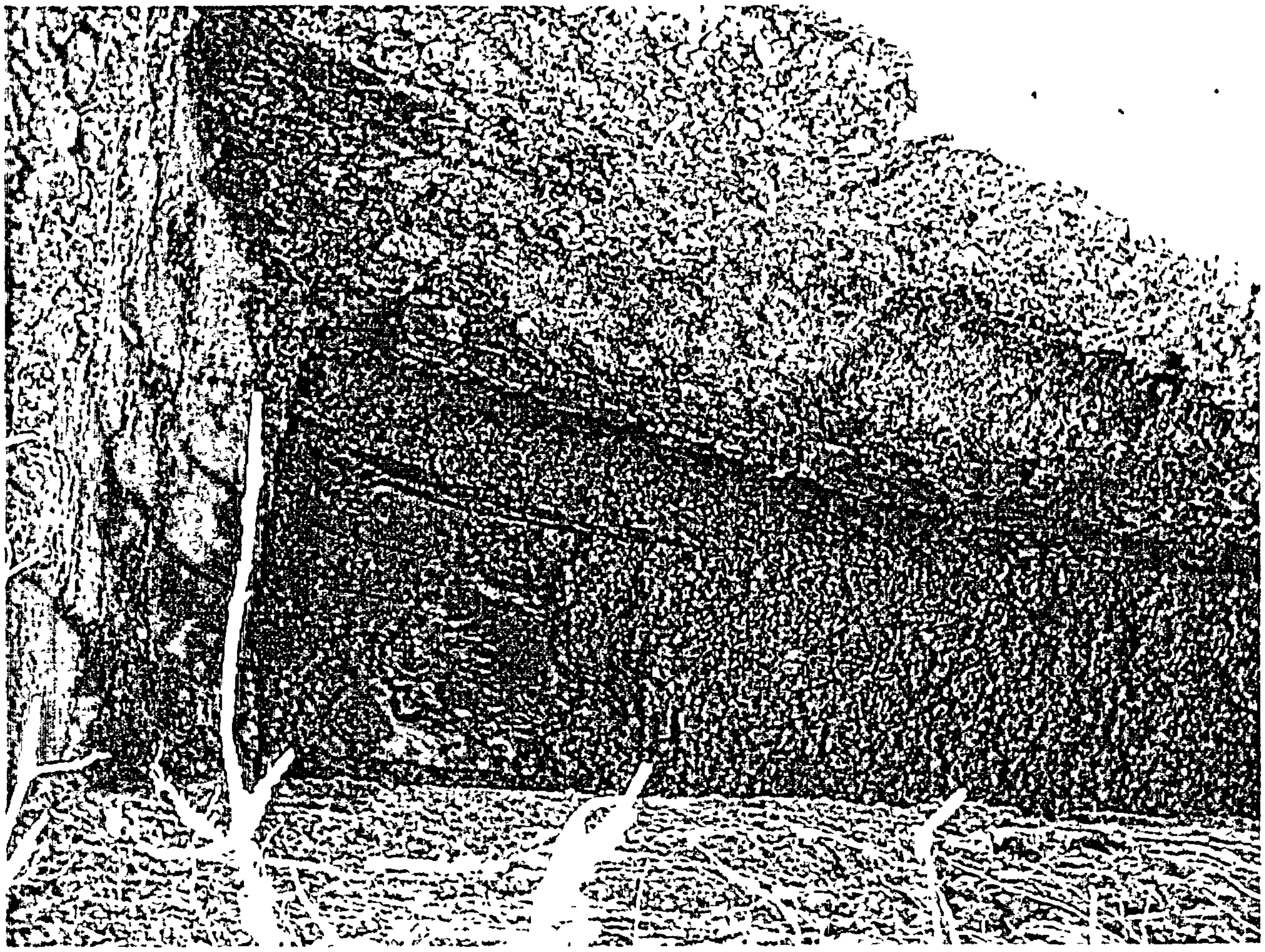
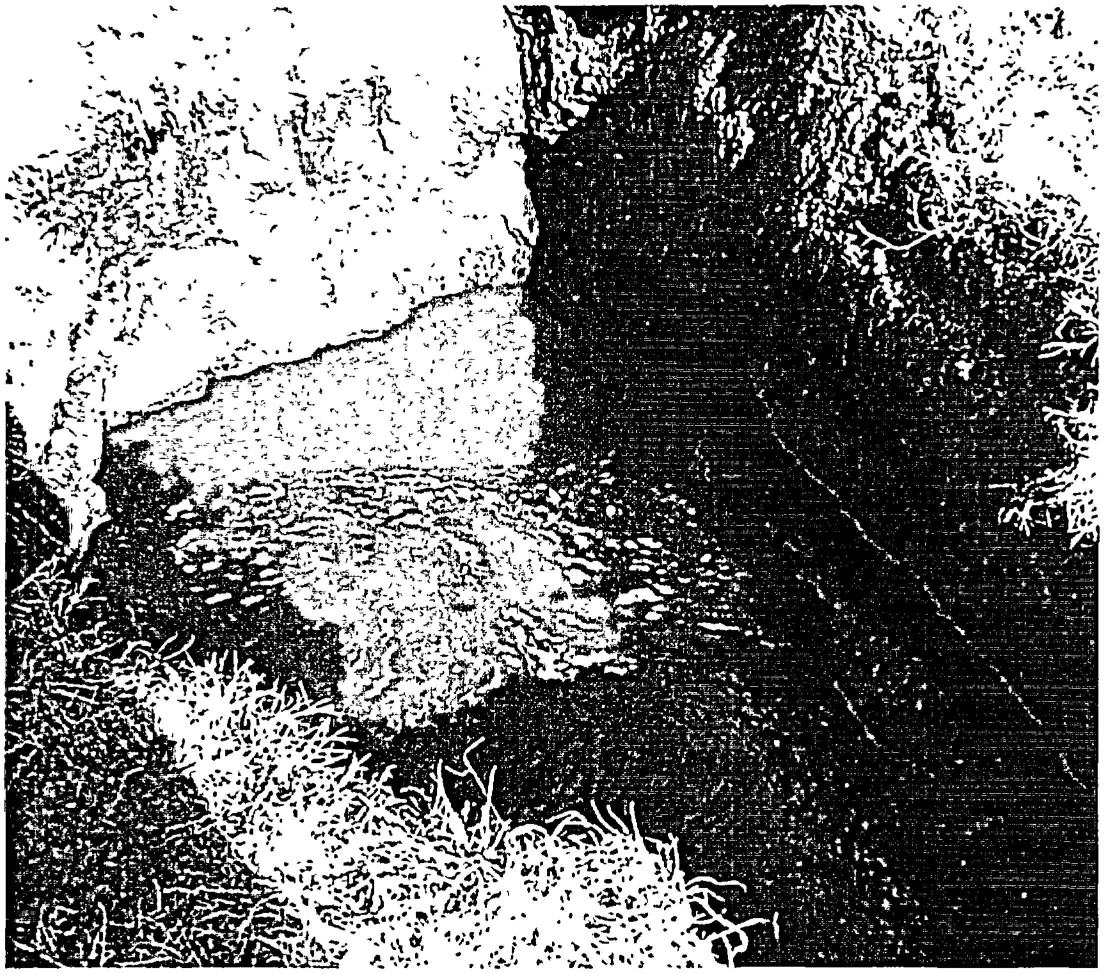


Photo 5 Photograph of MW010 Trench 4 Features



# ATTACHMENT A

# SLUG TESTS LOCATIONS AND DATA ANALYSIS

SHEPHERD MILLER
*Environmental and Engineering Consultants*

# TECHNICAL MEMORANDUM

**DATE:** February 27, 2002 **SMI #** 180734

**TO:** Toby Wright

**FROM:** Paul Sorek

**SUBJECT:** Sequoyah Slug Testing

**COPY:** Micheal Gard

---

The purpose of this memo is to document the field procedures and analytical methodology relating to the supplemental slug testing at the Sequoyah Fuels Facility (Facility). Slug tests were performed at 7 wells on February 12, 2002. These wells include MW010, MW010A, MW059A, MW093A, MW095A, MW097, and MW097A. MW093A, MW095A, and MW097A are screened in Unit 4 Shale. MW010A and MW059A are both dually completed in Unit 2 Shale/3 Shale and Unit 3 Shale/4 Shale, respectively. MW097 is screened in alluvium, and MW010 is screened in gravel backfill material. The well locations are presented in Figure 1.

For each test, a 10 psi pressure transducer connected to an Insitu Hermit 3K datalogger was placed at the appropriate depth in the well, and a reference head was determined with and electronic water level indicator. The wells were then allowed to re-equilibrate to static conditions for approximately 1 hour before the slug test was conducted, at which point a 1-inch diameter PVC slug was submerged in the well. The length of the slug varied between wells depending on the column of water in the well. The datalogger collected falling pressure head data at logrhythmic intervals until the water level returned to 95% of the static level, or a maximum of 1 hour. The slug was then removed from the well, and the datalogger collected rising head data. Static water level data are presented in Table 1. The time-drawdown data from the slug tests are attached to this memorandum.

Two methods were utilized to analyze the data. Data from wells under unconfined conditions were analyzed with the Bouwer and Rice (1976) method, which models unsteady, unconfined flow from a partially penetrating well in a homogeneous and isotropic aquifer. These wells include MW059A, MW093A, and MW097. MW010A was tested under confined conditions, and the data were analyzed with Cooper, et. al. (1967) method for unsteady radial flow under confined conditions in a homogeneous and isotropic aquifer. Static water level data at MW010, MW095A, and MW097A suggest that these tests were conducted under confined conditions. However, the time-drawdown data can not be accurately fitted with the Cooper method type


3801 Automation Way, Suite 100, Fort Collins, Colorado 80525 • Telephone (970) 223-9600 / FAX (970) 23-7171

curves, indicating that this is not the correct model for these data. It is possible that the hydrogeology at these locations is more accurately described as semi-confined or partially confined. Field observations from a trench located near MW010 support this assumption. Therefore, the Bouwer and Rice method is considered to be the most appropriate solution, and was used to analyze the data from these tests.

For all wells except MW010 and MW097, the rising head data were used in the analyses. Falling head data were analyzed for MW010 and MW097 because sufficient rising head data were not collected. Well construction and borehole lithology data required for the solutions were obtained from well completion reports presented in SFC, 1997. Solution plots for tests are presented in Figures 2 through 8. Table 2 summarizes the input parameters and results for each analysis.

Table 3 presents other estimates of hydraulic conductivity for each unit, including statistics from previous slug tests and values from the SMI flow model (SMI, 2001). It should be noted that the previous test results only include data from wells that are screened in a single hydrologic unit. Overall, hydraulic conductivity values calculated from these tests are greater than average values from previous tests. The results from MW093A, MW095A, and MW097A, all screened in Unit 4 Shale, are significantly greater than the log mean of the previous tests, and are the same order of magnitude as the previously observed maximum. MW010A is dually completed in Unit 2 Shale and 3 Shale. This location also has a hydraulic conductivity greater than the log mean of either shale unit from previous tests, and is consistent with the maximum observed conductivity value for Shale Unit 2 from previous tests (Table 3). The result of the MW097 test, 39.00 ft/day, is significantly greater than previously observed values in the alluvium, but is consistent with the modeled value of 50 ft/day. MW059A is dually completed in Unit 3 Shale and 4 Shale, and has an estimated hydraulic conductivity of 21.38 ft/day. This value is greater than any observed conductivity for the shale units, and is 1-2 orders of magnitude greater than the modeled shale values. MW010 is completed in backfill and the results of this test are therefore not appropriate for comparison with the naturally occurring units.

## REFERENCES

Bouwer, H. and R.C. Rice, 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, v. 12, p. 423-428.

Cooper, H.H., J.D. Bredehoeft, and I.S. Papadopulos, 1967, Response of a finite-diameter well to an instantaneous charge of water, Water Resources Research, v.3, no. 1, p. 263-2

Sequoyah Fuels Corporation (SFC), 1997. "Final RCRA Facility Investigation of the Sequoyah Fuels Uranium Conversion Industrial Facility."

SMI, 2001, Final Hydrogeological and geochemical site characterization report, consultants report, Shepherd Miller, Inc. Fort Collins, Colorado.

**Table 1 Static Water Level Data**

| Well Location | Easting (ft) | Northing (ft) | Measuring Point Elevation (ft msl) | Depth to Groundwater 2/12/02 (ft bmp) | Groundwater Elevation 2/12/02 (ft msl) |
|---|---|---|---|---|---|
| MW010 | 2837016 | 195508 | 565.17 | 11.09 | 554.08 |
| MW010A | 2837011 | 195509 | 563.72 | 10.79 | 552.93 |
| MW059A | 2835336 | 195016 | 529.31 | 19.36 | 509.95 |
| MW093A | 2834987 | 194911 | 521.18 | 25.95 | 495.23 |
| MW095A | 2834517 | 195032 | 488.71 | 11.76 | 476.95 |
| MW097 | 2834491 | 195382 | 488.88 | 11.61 | 477.27 |
| MW097A | 2834493 | 195387 | 488.93 | 15.50 | 473.43 |

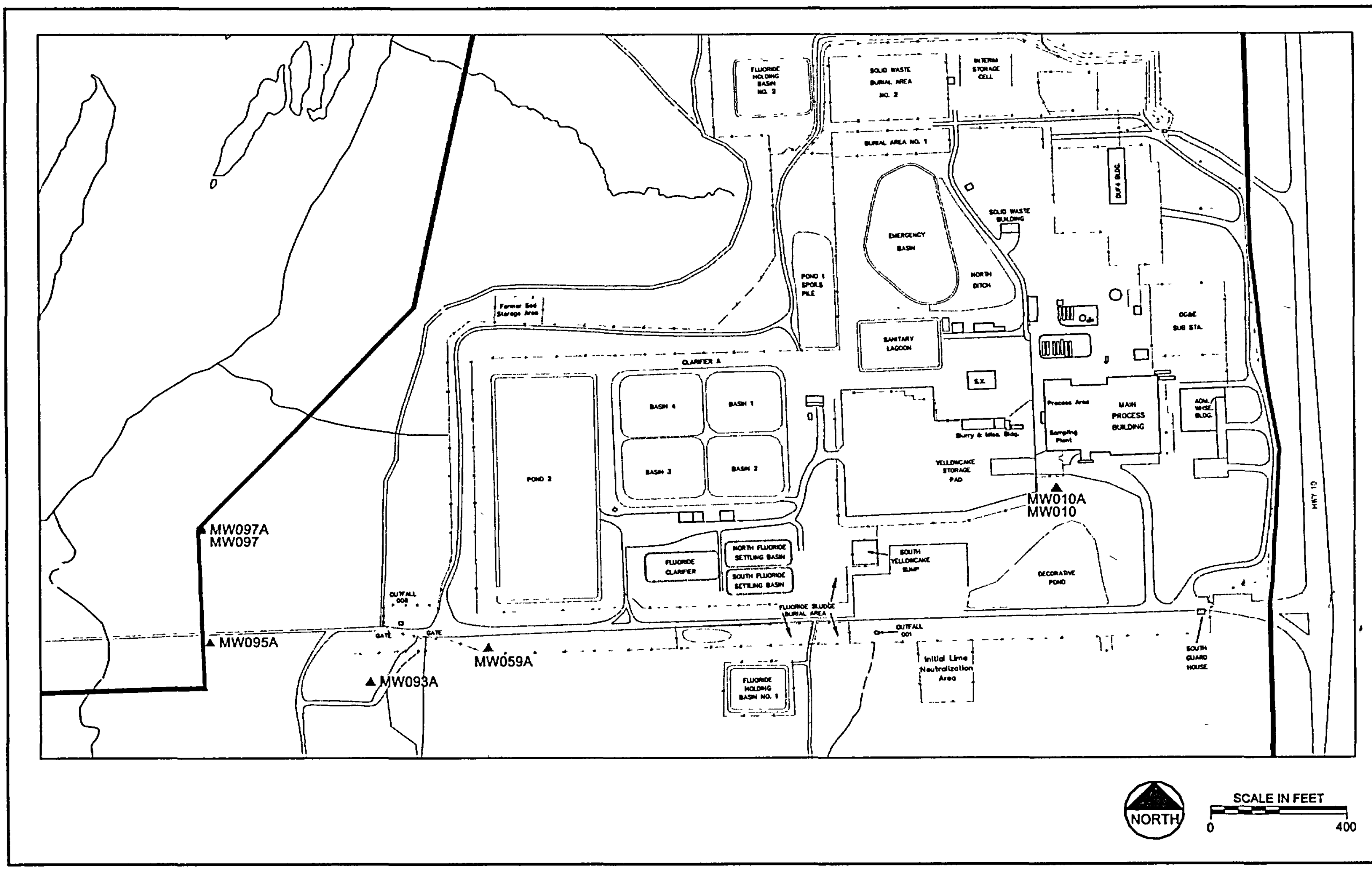
**Table 2 Well Data and Results**

| Well Location | Hydrologic Unit | Hydrologic Condition | Borehole Diameter (ft) | Screen Length (ft) | Saturated Thickness (ft) | Hydraulic Conductivity (ft/day) | Storage Coefficient | Analysis Method |
|---|---|---|---|---|---|---|---|---|
| MW010 | Gravel Backfill | Confined | 0.615 | ~3 | ~3 | 72.63 | na | Bouwer and Rice (1976) |
| MW010A | 2SH/3SH | Confined | 0 500 | 13.50 | 14.00 | 1.52 | 6.25E-03 | Cooper, et. al. (1967) |
| MW059A | 3SH/4SH | Unconfined | 0.500 | 4.71 | 5.43 | 21.38 | na | Bouwer and Rice (1976) |
| MW093A | 4SH | Unconfined | 0.615 | 16.57 | 17.09 | 2.51 | na | Bouwer and Rice (1976) |
| MW095A | 4SH | Confined | 0.615 | 5.50 | 5.50 | 4.73 | na | Bouwer and Rice (1976) |
| MW097 | Colluvium | Unconfined | 0.615 | 0.90 | 1.55 | 39.00 | na | Bouwer and Rice (1976) |
| MW097A | 4SH | Confined | 0.615 | 17.00 | 17.00 | 0.93 | na | Bouwer and Rice (1976) |

na – data not derived from this test

**Table 3 Other Estimates of Hydraulic Conductivity**

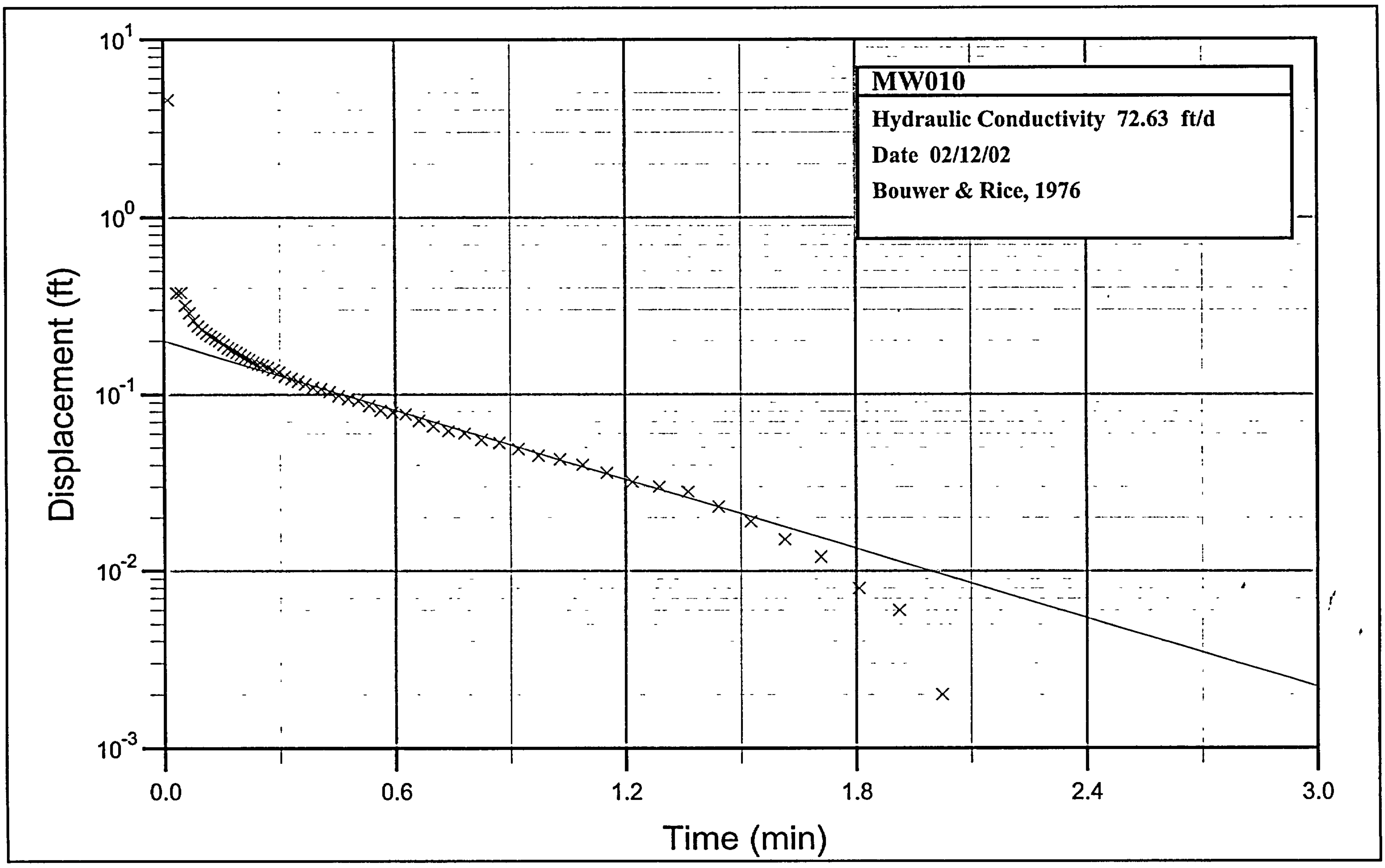
| Hydrologic Unit | Previous Slug Tests (ft/day) | | | | Modeled Value (ft/day) |
|---|---|---|---|---|---|
| | no. tests | log mean | max | min | |
| Alluvium | 2 | 0.334 | 5.01 | 0.0223 | 50.0 |
| shale 1 | 13 | 0.0246 | 0.261 | 0.00416 | 0.800 |
| shale 2 | 4 | 0.138 | 1.35 | 0.0118 | 1.200 |
| shale 3 | 3 | 0.0478 | 0.488 | 0.0103 | 0.100 |
| shale 4 | 5 | 0.0314 | 1.3 | 0.00466 | 0.500 |




| | |
|---|---|
| SHEPHERD MILLER INCORPORATED | |

## FIGURE 1
## SLUG TEST LOCATIONS

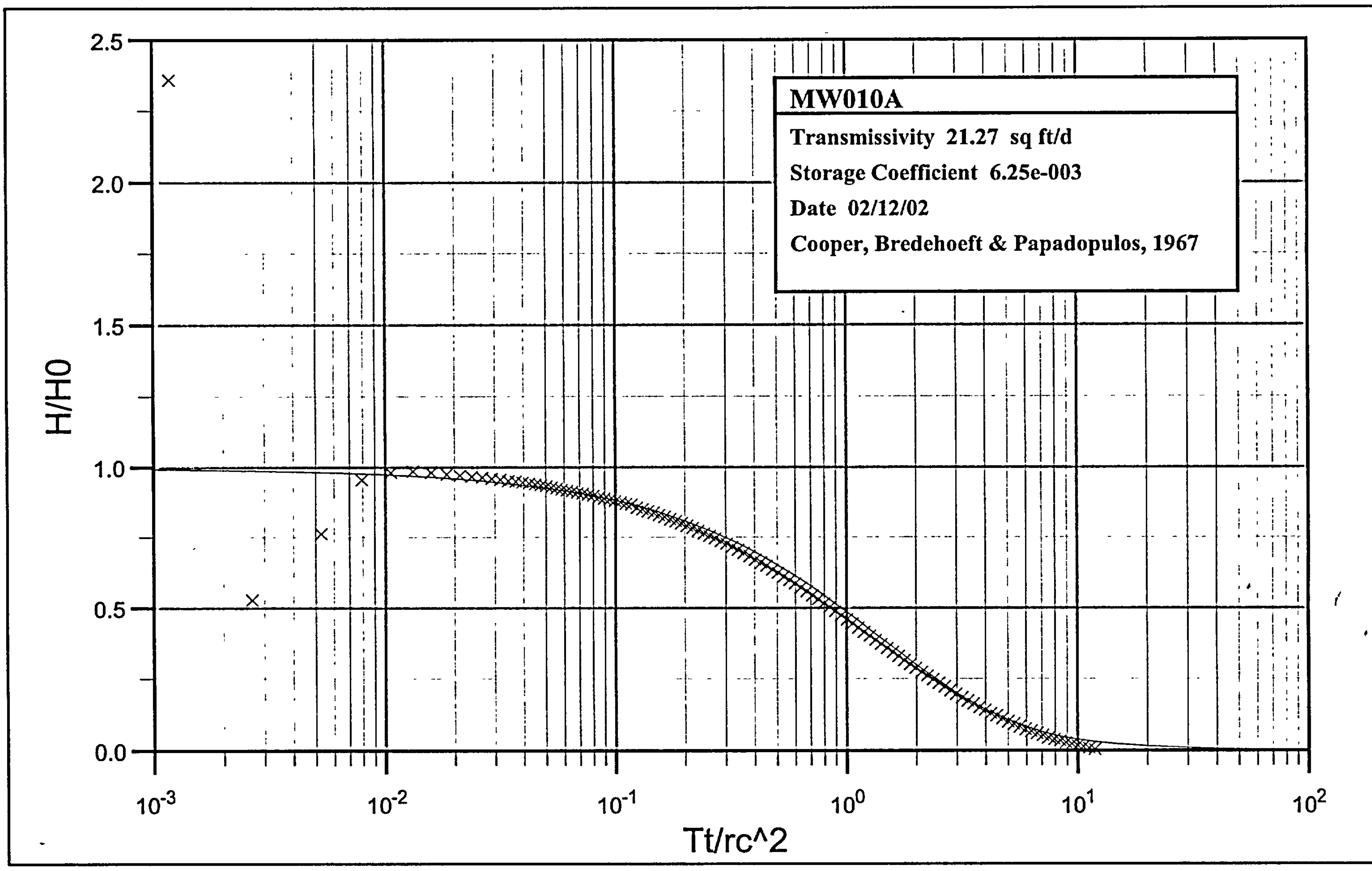
| | |
|---|---|
| Date: | February 2002 |
| Project: | P:\100734/HYDROGE |
| File: | SLUG TESTS.ppt |




SHEPHERD MILLER INCORPORATED

FIGURE 2
MW010 SLUG TEST RESULTS

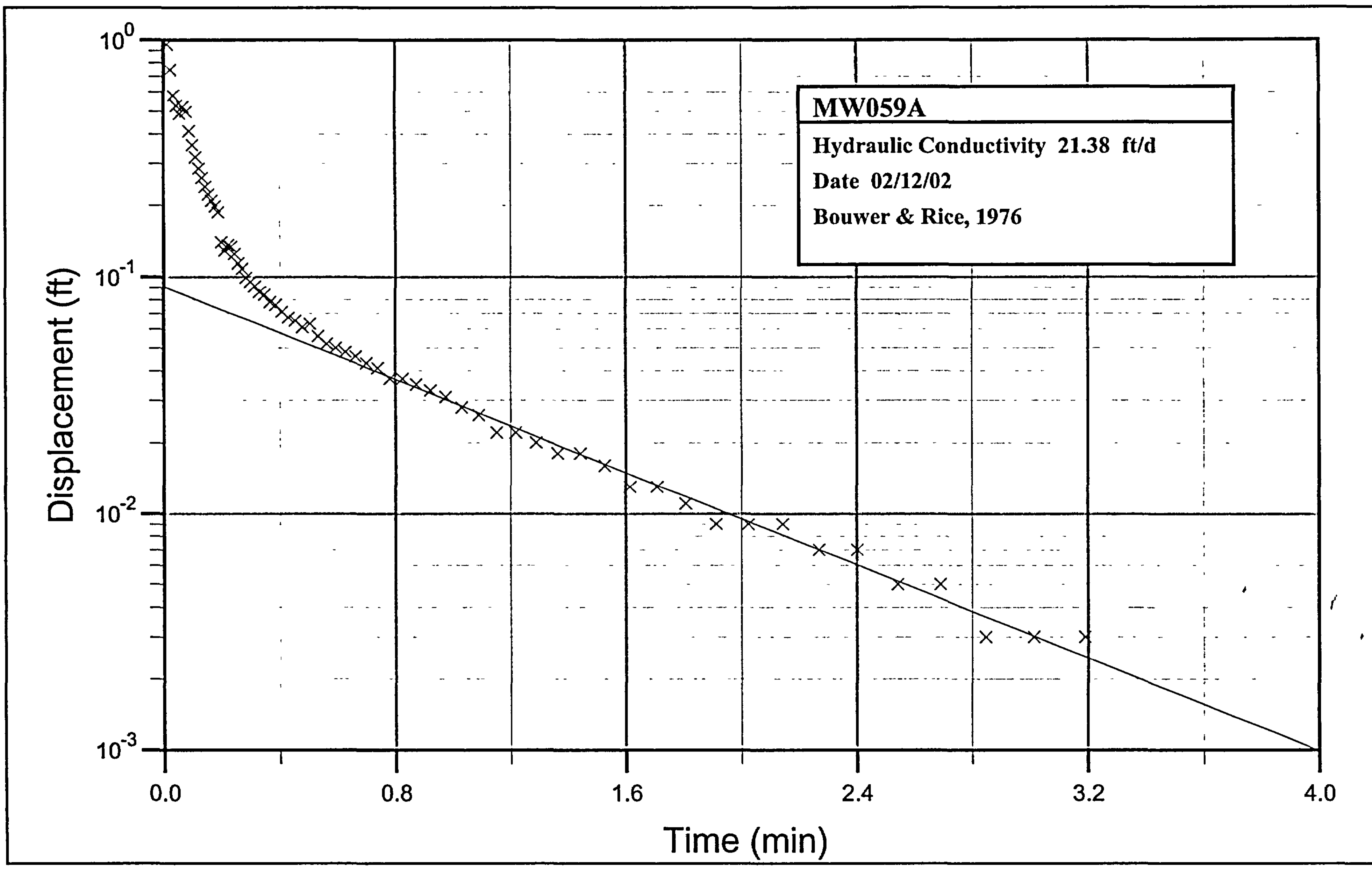
| | |
|---|---|
| Date: | February 2002 |
| Project: | P:\100734/HYDROGE |
| File: | SLUG TESTS.ppt |




SHEPHERD MILLER
INCORPORATED

FIGURE 3
MW010A SLUG TEST RESULTS

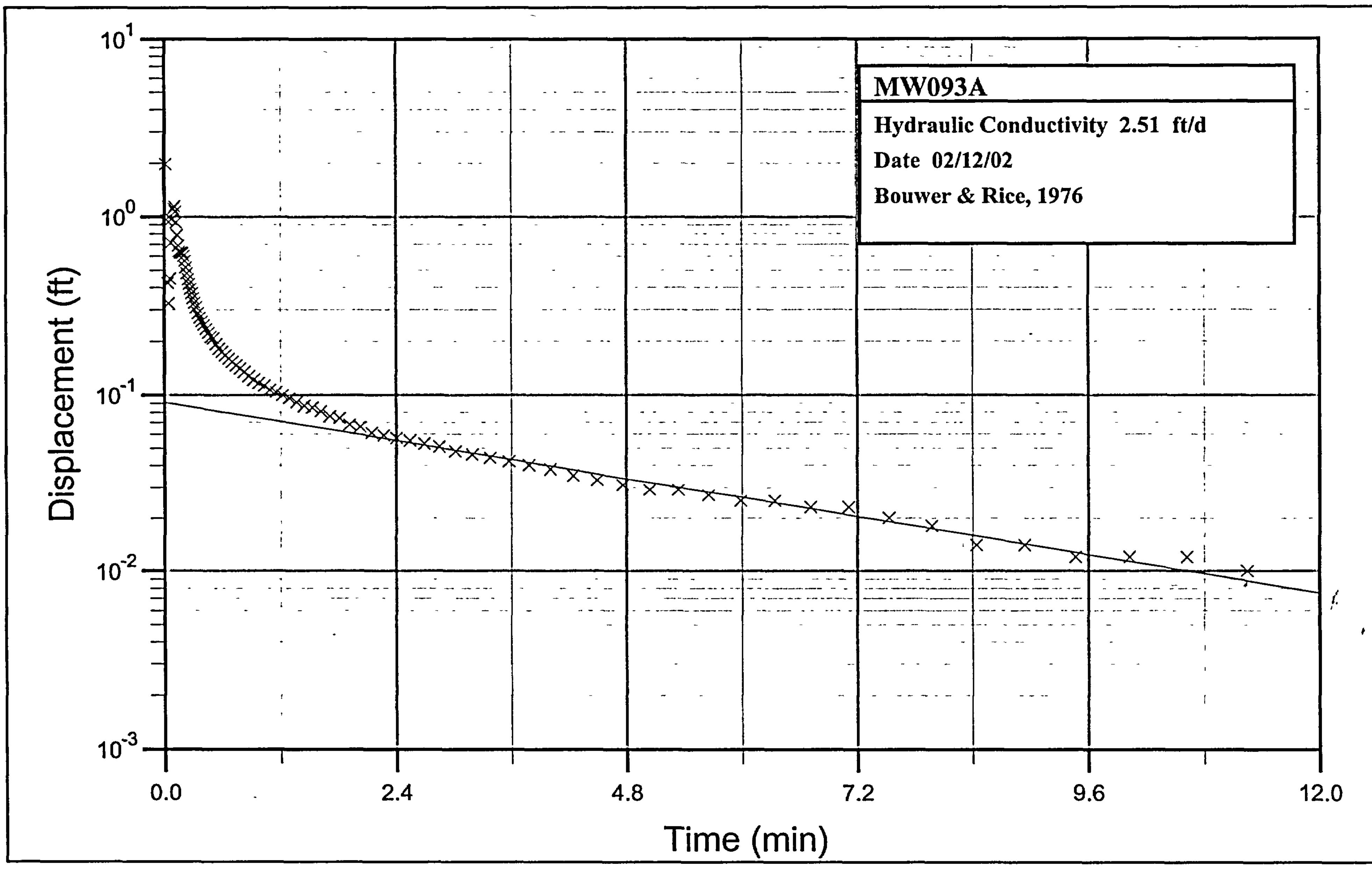
| | |
|---|---|
| Date: | February 2002 |
| Project: | P:\100734/HYDROGE |
| File: | SLUG TESTS.ppt |




SHEPHERD MILLER INCORPORATED

FIGURE 4
MW059A SLUG TEST RESULTS

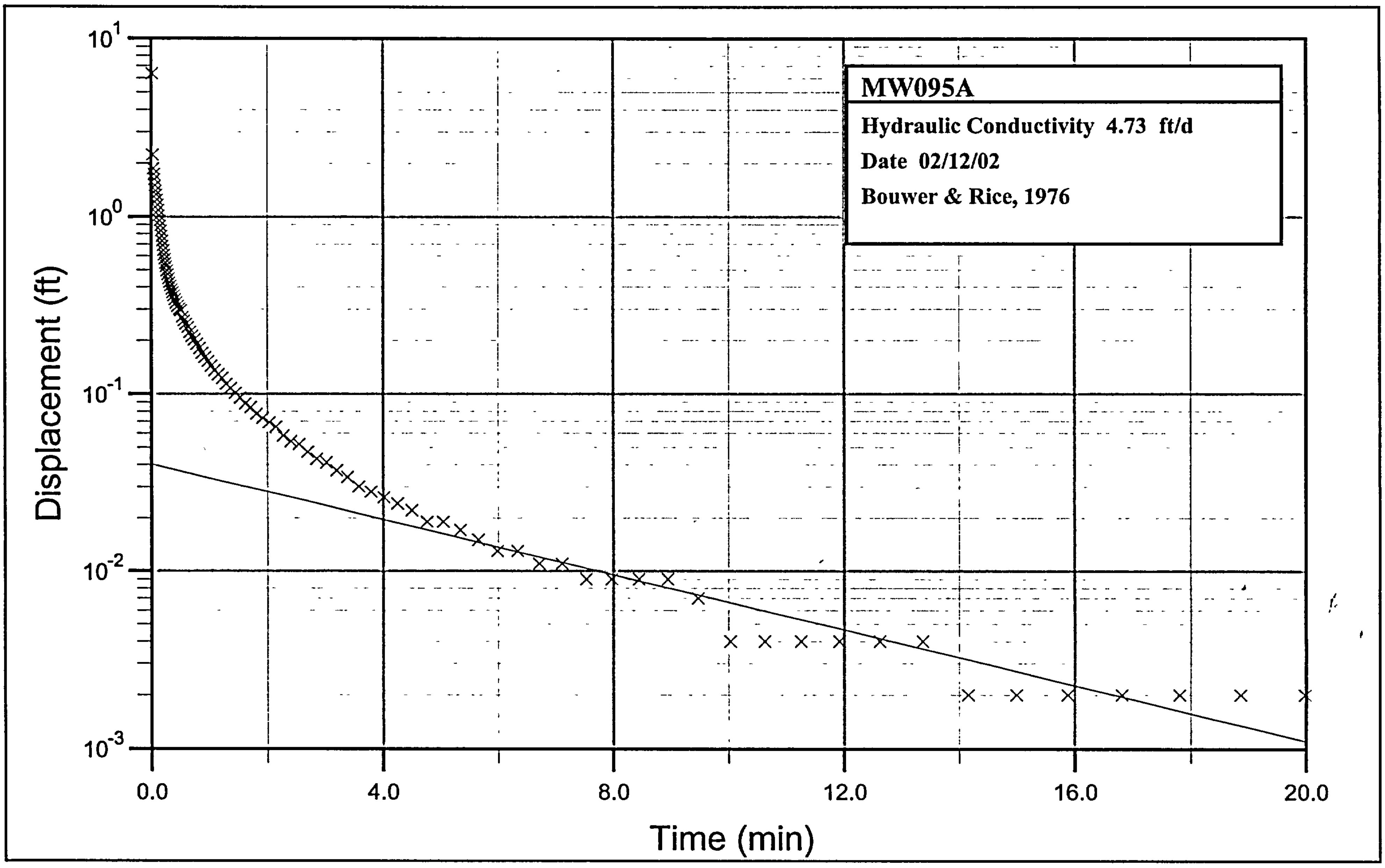
| Date: | February 2002 |
|---|---|
| Project: | P:\100734/HYDROGE |
| File: | SLUG TESTS.ppt |



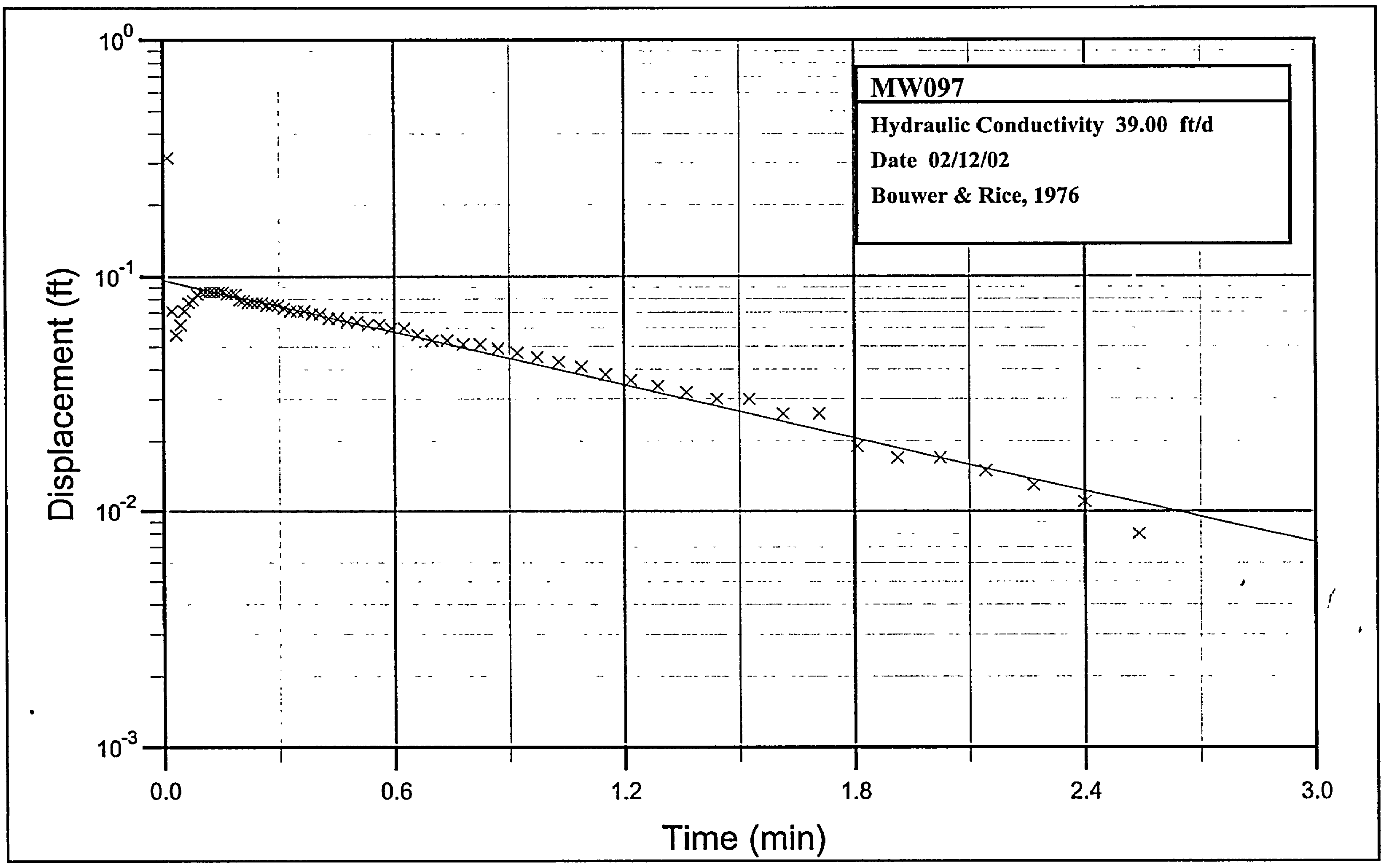

SHEPHERD MILLER INCORPORATED

FIGURE 5
MW093A SLUG TEST RESULTS

| | |
|---|---|
| Date: | February 2002 |
| Project: | P:\100734/HYDROGE |
| File: | SLUG TESTS.ppt |



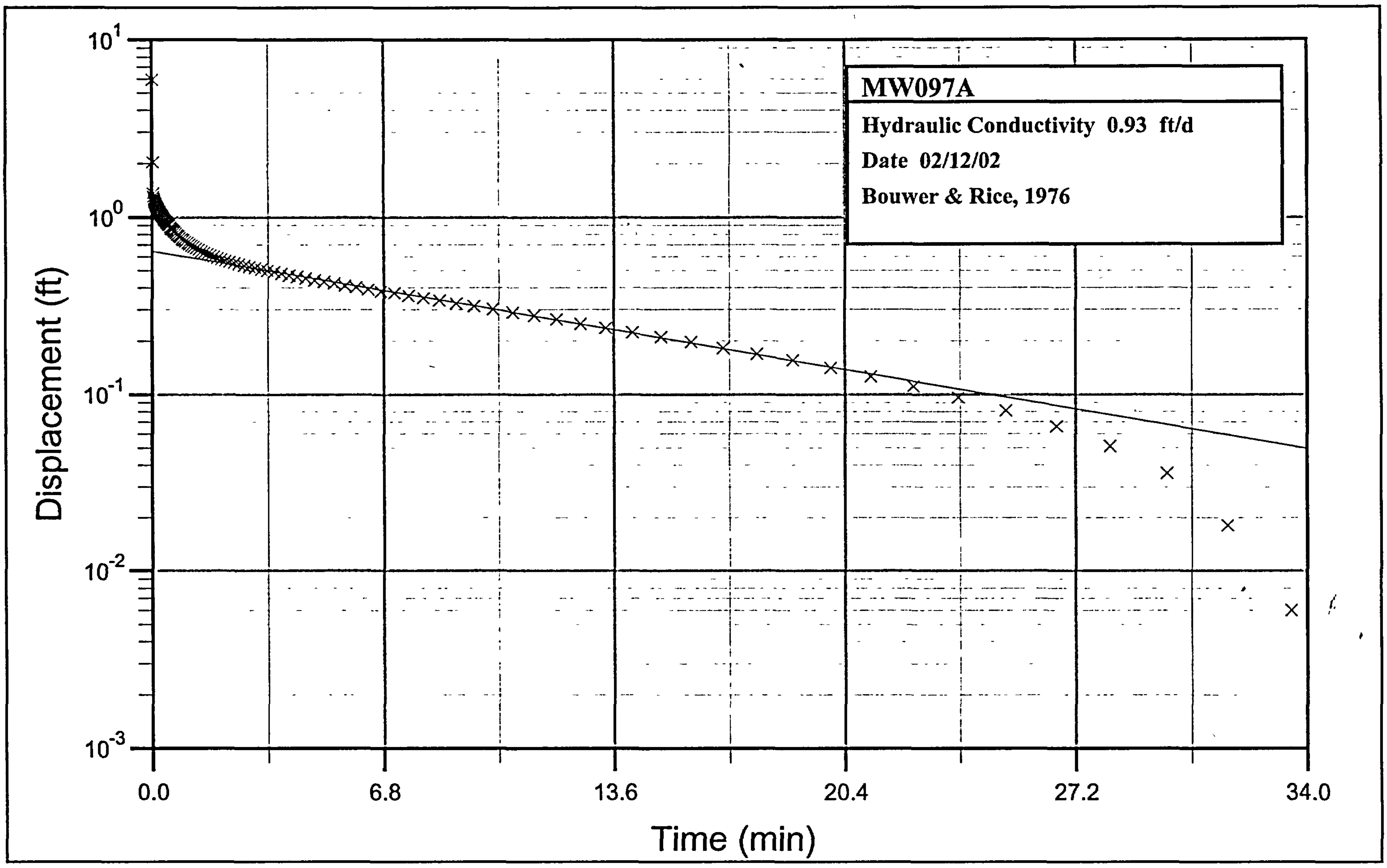

| SHEPHERD MILLER INCORPORATED | FIGURE 6<br>MW095A SLUG TEST RESULTS | Date: February 2002<br>Project: P:\100734/HYDROGE<br>File: SLUG TESTS.ppt |
|---|---|---|




SHEPHERD MILLER
INCORPORATED

FIGURE 7
MW097 SLUG TEST RESULTS

| | |
|---|---|
| Date: | February 2002 |
| Project: | P:\100734/HYDROGE |
| File: | SLUG TESTS.ppt |




SHEPHERD MILLER INCORPORATED

FIGURE 8
MW097A SLUG TEST RESULTS

| | |
|---|---|
| Date: | February 2002 |
| Project: | P:\100734/HYDROGE |
| File: | SLUG TESTS.ppt |

# SMI Supplemental Slug Test Data 2/12/02

| MW010 (falling head) | | MW010A (rising head) | | MW059A (rising head) | | MW093A (rising head) | | MW095A (rising head) | | MW097 (falling head) | | MW097A (rising head) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) |
| 0 011 | 4 538 | 0 005 | 4 481 | 0 011 | 0 957 | 0.011 | 1 970 | 0 011 | 6 348 | 0.011 | 0 316 | 0.011 | 5.931 |
| 0 022 | -0 059 | 0 011 | 1 005 | 0.022 | 0 746 | 0 022 | 0 960 | 0 022 | 2.232 | 0 022 | 0 071 | 0 022 | 2.032 |
| 0 033 | 0 374 | 0 022 | 1 449 | 0.033 | 0 579 | 0 033 | 0 425 | 0 033 | 1.869 | 0 033 | 0 056 | 0.033 | 1.360 |
| 0 044 | 0 376 | 0 034 | 1 815 | 0.044 | 0 527 | 0 044 | 0.326 | 0 044 | 1.738 | 0 044 | 0 062 | 0.044 | 1.304 |
| 0 055 | 0 318 | 0 045 | 1.864 | 0 055 | 0 486 | 0.055 | 0 449 | 0 055 | 1.626 | 0 055 | 0 071 | 0 055 | 1.269 |
| 0 066 | 0 288 | 0.056 | 1.873 | 0 066 | 0.521 | 0 066 | 0.714 | 0 066 | 1.503 | 0 066 | 0 077 | 0 066 | 1.241 |
| 0 077 | 0 262 | 0.067 | 1.864 | 0 077 | 0 497 | 0.077 | 0 968 | 0 077 | 1.396 | 0 077 | 0 079 | 0 077 | 1 213 |
| 0 088 | 0 243 | 0 078 | 1.853 | 0 088 | 0 411 | 0 088 | 1.112 | 0 088 | 1.327 | 0 088 | 0 084 | 0 088 | 1 198 |
| 0 099 | 0 232 | 0 089 | 1.845 | 0 099 | 0.359 | 0 099 | 1.143 | 0 099 | 1.243 | 0 099 | 0 086 | 0 099 | 1 192 |
| 0 110 | 0 221 | 0 101 | 1 838 | 0 110 | 0 319 | 0.110 | 1 067 | 0 110 | 1.163 | 0 110 | 0 086 | 0 110 | 1 175 |
| 0 121 | 0 213 | 0 112 | 1 832 | 0 121 | 0 286 | 0.121 | 0 927 | 0 121 | 1.088 | 0.121 | 0 086 | 0 121 | 1.157 |
| 0 132 | 0 206 | 0 123 | 1 823 | 0 132 | 0 261 | 0.132 | 0 789 | 0 132 | 1 015 | 0.132 | 0 086 | 0 132 | 1.147 |
| 0.143 | 0 200 | 0 134 | 1 817 | 0 143 | 0 239 | 0.143 | 0 688 | 0 143 | 0 948 | 0.143 | 0 086 | 0.143 | 1 136 |
| 0 154 | 0 191 | 0 145 | 1 808 | 0.154 | 0 222 | 0.154 | 0 639 | 0 154 | 0 886 | 0.154 | 0 086 | 0.154 | 1.125 |
| 0 165 | 0 182 | 0.156 | 1.804 | 0.165 | 0 209 | 0.165 | 0 626 | 0.165 | 0 830 | 0 165 | 0 084 | 0.165 | 1.117 |
| 0 176 | 0 178 | 0.168 | 1.797 | 0 176 | 0.198 | 0.176 | 0.628 | 0.176 | 0.776 | 0.176 | 0 084 | 0.176 | 1.104 |
| 0 187 | 0.172 | 0 179 | 1.791 | 0 187 | 0.187 | 0 187 | 0 624 | 0.187 | 0.729 | 0 187 | 0 084 | 0.187 | 1 095 |
| 0.198 | 0 167 | 0 190 | 1.784 | 0 198 | 0 140 | 0 198 | 0 602 | 0 198 | 0.686 | 0 198 | 0 079 | 0.198 | 1 084 |
| 0 209 | 0 161 | 0 201 | 1.778 | 0 209 | 0.129 | 0 209 | 0 563 | 0 209 | 0 645 | 0 209 | 0 079 | 0 209 | 1 076 |
| 0.220 | 0 157 | 0 212 | 1 772 | 0 220 | 0 136 | 0 220 | 0 518 | 0 220 | 0 609 | 0 220 | 0 077 | 0 220 | 1 067 |
| 0 231 | 0 152 | 0 223 | 1.763 | 0 231 | 0 134 | 0 231 | 0 481 | 0 231 | 0.576 | 0 231 | 0 077 | 0 231 | 1.058 |
| 0 243 | 0 148 | 0 235 | 1.756 | 0 243 | 0 125 | 0.243 | 0 445 | 0 243 | 0 546 | 0.243 | 0 077 | 0 243 | 1 048 |
| 0 255 | 0 146 | 0 248 | 1.748 | 0 255 | 0 114 | 0.255 | 0 419 | 0 255 | 0 523 | 0.255 | 0 077 | 0 255 | 1 039 |
| 0 268 | 0 142 | 0.261 | 1.741 | 0.268 | 0 108 | 0 268 | 0 393 | 0 268 | 0 495 | 0.268 | 0.075 | 0 268 | 1 030 |
| 0 282 | 0 137 | 0.275 | 1.735 | 0.282 | 0 099 | 0 282 | 0 371 | 0 282 | 0 471 | 0 282 | 0.075 | 0 282 | 1.022 |
| 0 297 | 0.133 | 0 290 | 1.726 | 0 297 | 0.095 | 0 297 | 0.348 | 0 297 | 0 447 | 0 297 | 0 075 | 0 297 | 1.013 |
| 0 313 | 0 126 | 0 305 | 1.720 | 0 313 | 0.091 | 0 313 | 0.328 | 0 313 | 0 426 | 0 313 | 0 073 | 0 313 | 1.002 |
| 0 330 | 0 122 | 0 322 | 1.711 | 0 330 | 0 086 | 0 330 | 0 309 | 0.330 | 0 407 | 0 330 | 0 071 | 0.330 | 0 990 |
| 0.347 | 0 118 | 0 340 | 1 705 | 0 347 | 0 084 | 0 347 | 0 287 | 0.347 | 0.387 | 0 347 | 0 071 | 0.347 | 0.979 |
| 0 366 | 0 114 | 0 358 | 1 692 | 0 366 | 0 078 | 0 366 | 0 272 | 0 366 | 0.372 | 0 366 | 0 071 | 0.366 | 0 968 |
| 0 386 | 0 109 | 0 378 | 1 685 | 0 386 | 0 076 | 0 386 | 0 259 | 0 386 | 0 357 | 0 386 | 0 069 | 0 386 | 0 957 |
| 0 407 | 0 107 | 0 399 | 1 677 | 0 407 | 0 071 | 0 407 | 0 247 | 0 407 | 0 340 | 0 407 | 0 069 | 0 407 | 0 946 |
| 0 429 | 0.103 | 0.421 | 1 668 | 0 429 | 0 067 | 0.429 | 0 234 | 0 429 | 0 327 | 0 429 | 0 066 | 0 429 | 0 931 |
| 0 452 | 0 098 | 0.445 | 1.660 | 0.452 | 0 065 | 0.452 | 0 223 | 0 452 | 0 312 | 0 452 | 0 066 | 0 452 | 0 921 |
| 0 477 | 0 094 | 0 470 | 1.649 | 0.477 | 0 061 | 0 477 | 0 212 | 0 477 | 0 301 | 0 477 | 0 064 | 0 477 | 0 908 |
| 0.504 | 0 092 | 0 496 | 1.645 | 0 504 | 0.063 | 0 504 | 0 208 | 0 504 | 0 295 | 0.504 | 0 064 | 0 504 | 0 903 |
| 0 532 | 0 086 | 0 524 | 1 623 | 0 532 | 0.056 | 0 532 | 0.193 | 0 532 | 0 271 | 0.532 | 0.062 | 0 532 | 0 882 |
| 0 561 | 0 081 | 0 554 | 1.612 | 0 561 | 0.052 | 0 561 | 0.182 | 0 561 | 0 258 | 0 561 | 0.062 | 0 561 | 0 865 |
| 0 593 | 0 079 | 0 585 | 1.599 | 0 593 | 0 050 | 0 593 | 0.175 | 0.593 | 0 247 | 0 593 | 0 060 | 0 593 | 0 854 |
| 0 626 | 0 077 | 0 618 | 1 589 | 0 626 | 0 048 | 0 626 | 0 167 | 0.626 | 0.237 | 0 626 | 0 060 | 0 626 | 0.841 |
| 0 661 | 0 071 | 0 653 | 1 573 | 0 661 | 0 046 | 0 661 | 0 160 | 0 661 | 0.222 | 0 661 | 0 056 | 0 661 | 0.828 |
| 0 698 | 0.066 | 0 691 | 1.561 | 0.698 | 0 043 | 0.698 | 0 154 | 0 698 | 0 211 | 0 698 | 0 053 | 0.698 | 0 813 |
| 0.738 | 0 062 | 0 730 | 1 546 | 0 738 | 0 041 | 0.738 | 0 147 | 0.738 | 0 202 | 0.738 | 0 053 | 0 738 | 0 798 |

## SMI Supplemental Slug Test Data 2/12/02

| MW010 (falling head) | | MW010A (rising head) | | MW059A (rising head) | | MW093A (rising head) | | MW095A (rising head) | | MW097 (falling head) | | MW097A (rising head) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) |
| 0.780 | 0.060 | 0.772 | 1.533 | 0.780 | 0.037 | 0.780 | 0.141 | 0.780 | 0.191 | 0.780 | 0.051 | 0.780 | 0.785 |
| 0.824 | 0.055 | 0.816 | 1.518 | 0.824 | 0.037 | 0.824 | 0.135 | 0.824 | 0.181 | 0.824 | 0.051 | 0.824 | 0.772 |
| 0.871 | 0.053 | 0.863 | 1.502 | 0.871 | 0.035 | 0.871 | 0.128 | 0.871 | 0.170 | 0.871 | 0.049 | 0.871 | 0.757 |
| 0.921 | 0.049 | 0.913 | 1.487 | 0.921 | 0.033 | 0.921 | 0.122 | 0.921 | 0.161 | 0.921 | 0.047 | 0.921 | 0.744 |
| 0.973 | 0.045 | 0.966 | 1.470 | 0.973 | 0.031 | 0.973 | 0.117 | 0.973 | 0.153 | 0.973 | 0.045 | 0.973 | 0.731 |
| 1.029 | 0.043 | 1.022 | 1.451 | 1.029 | 0.028 | 1.029 | 0.113 | 1.029 | 0.144 | 1.029 | 0.043 | 1.029 | 0.718 |
| 1.088 | 0.040 | 1.081 | 1.434 | 1.088 | 0.026 | 1.088 | 0.107 | 1.088 | 0.136 | 1.088 | 0.041 | 1.088 | 0.705 |
| 1.151 | 0.036 | 1.143 | 1.418 | 1.151 | 0.022 | 1.151 | 0.104 | 1.151 | 0.129 | 1.151 | 0.038 | 1.151 | 0.692 |
| 1.217 | 0.032 | 1.210 | 1.397 | 1.217 | 0.022 | 1.217 | 0.100 | 1.217 | 0.123 | 1.217 | 0.036 | 1.217 | 0.682 |
| 1.288 | 0.030 | 1.280 | 1.380 | 1.288 | 0.020 | 1.288 | 0.096 | 1.288 | 0.114 | 1.288 | 0.034 | 1.288 | 0.669 |
| 1.362 | 0.028 | 1.355 | 1.360 | 1.362 | 0.018 | 1.362 | 0.091 | 1.362 | 0.108 | 1.362 | 0.032 | 1.362 | 0.658 |
| 1.441 | 0.023 | 1.434 | 1.339 | 1.441 | 0.018 | 1.441 | 0.087 | 1.441 | 0.101 | 1.441 | 0.030 | 1.441 | 0.643 |
| 1.525 | 0.019 | 1.517 | 1.319 | 1.525 | 0.016 | 1.525 | 0.085 | 1.525 | 0.095 | 1.525 | 0.030 | 1.525 | 0.632 |
| 1.613 | 0.015 | 1.606 | 1.298 | 1.613 | 0.013 | 1.613 | 0.081 | 1.613 | 0.088 | 1.613 | 0.026 | 1.613 | 0.621 |
| 1.707 | 0.012 | 1.700 | 1.274 | 1.707 | 0.013 | 1.707 | 0.076 | 1.707 | 0.084 | 1.707 | 0.026 | 1.707 | 0.611 |
| 1.807 | 0.008 | 1.799 | 1.255 | 1.807 | 0.011 | 1.807 | 0.074 | 1.807 | 0.077 | 1.807 | 0.019 | 1.807 | 0.602 |
| 1.912 | 0.006 | 1.904 | 1.233 | 1.912 | 0.009 | 1.912 | 0.068 | 1.912 | 0.073 | 1.912 | 0.017 | 1.912 | 0.589 |
| 2.023 | 0.002 | 2.016 | 1.207 | 2.023 | 0.009 | 2.023 | 0.066 | 2.023 | 0.069 | 2.023 | 0.017 | 2.023 | 0.580 |
| | | 2.134 | 1.186 | 2.142 | 0.009 | 2.142 | 0.061 | 2.142 | 0.065 | 2.142 | 0.015 | 2.142 | 0.570 |
| | | 2.259 | 1.160 | 2.267 | 0.007 | 2.267 | 0.059 | 2.267 | 0.058 | 2.267 | 0.013 | 2.267 | 0.561 |
| | | 2.392 | 1.136 | 2.399 | 0.007 | 2.399 | 0.057 | 2.399 | 0.054 | 2.399 | 0.011 | 2.399 | 0.552 |
| | | 2.532 | 1.113 | 2.540 | 0.005 | 2.540 | 0.055 | 2.540 | 0.052 | 2.540 | 0.008 | 2.540 | 0.544 |
| | | 2.681 | 1.085 | 2.689 | 0.005 | 2.689 | 0.053 | 2.689 | 0.047 | | | 2.689 | 0.533 |
| | | 2.838 | 1.061 | 2.846 | 0.003 | 2.846 | 0.051 | 2.846 | 0.043 | | | 2.846 | 0.524 |
| | | 3.005 | 1.035 | 3.013 | 0.003 | 3.013 | 0.048 | 3.013 | 0.041 | | | 3.013 | 0.516 |
| | | 3.182 | 1.009 | 3.190 | 0.003 | 3.190 | 0.046 | 3.190 | 0.037 | | | 3.190 | 0.507 |
| | | 3.369 | 0.981 | 3.377 | 0.000 | 3.377 | 0.044 | 3.377 | 0.034 | | | 3.377 | 0.499 |
| | | 3.568 | 0.956 | 3.575 | 0.000 | 3.575 | 0.042 | 3.575 | 0.030 | | | 3.575 | 0.490 |
| | | 3.778 | 0.928 | 3.786 | 0.000 | 3.786 | 0.040 | 3.786 | 0.028 | | | 3.786 | 0.479 |
| | | 4.001 | 0.900 | | | 4.008 | 0.038 | 4.008 | 0.026 | | | 4.008 | 0.468 |
| | | 4.236 | 0.872 | | | 4.244 | 0.035 | 4.244 | 0.024 | | | 4.244 | 0.460 |
| | | 4.486 | 0.846 | | | 4.494 | 0.033 | 4.494 | 0.022 | | | 4.494 | 0.451 |
| | | 4.751 | 0.818 | | | 4.759 | 0.031 | 4.759 | 0.019 | | | 4.759 | 0.440 |
| | | 5.031 | 0.790 | | | 5.039 | 0.029 | 5.039 | 0.019 | | | 5.039 | 0.432 |
| | | 5.328 | 0.764 | | | 5.336 | 0.029 | 5.336 | 0.017 | | | 5.336 | 0.423 |
| | | 5.643 | 0.736 | | | 5.650 | 0.027 | 5.650 | 0.015 | | | 5.650 | 0.410 |
| | | 5.976 | 0.708 | | | 5.983 | 0.025 | 5.983 | 0.013 | | | 5.983 | 0.402 |
| | | 6.329 | 0.680 | | | 6.336 | 0.025 | 6.336 | 0.013 | | | 6.336 | 0.391 |
| | | 6.702 | 0.654 | | | 6.710 | 0.023 | 6.710 | 0.011 | | | 6.710 | 0.380 |
| | | 7.098 | 0.626 | | | 7.106 | 0.023 | 7.106 | 0.011 | | | 7.106 | 0.372 |
| | | 7.518 | 0.598 | | | 7.525 | 0.020 | 7.525 | 0.009 | | | 7.525 | 0.359 |
| | | 7.962 | 0.572 | | | 7.970 | 0.018 | 7.970 | 0.009 | | | 7.970 | 0.348 |
| | | 8.433 | 0.546 | | | 8.440 | 0.014 | 8.440 | 0.009 | | | 8.440 | 0.337 |

## SMI Supplemental Slug Test Data 2/12/02

| MW010 (falling head) | | MW010A (rising head) | | MW059A (rising head) | | MW093A (rising head) | | MW095A (rising head) | | MW097 (falling head) | | MW097A (rising head) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) | Time (min) | Drawdown (feet) |
| | | 8 931 | 0 518 | | | 8.939 | 0 014 | 8 939 | 0 009 | | | 8.939 | 0 324 |
| | | 9 459 | 0 495 | | | 9.467 | 0 012 | 9 467 | 0 007 | | | 9.467 | 0 313 |
| | | 10 019 | 0 469 | | | 10.026 | 0 012 | 10.026 | 0 004 | | | 10.026 | 0 301 |
| | | 10 611 | 0 445 | | | 10.619 | 0 012 | 10 619 | 0 004 | | | 10.619 | 0 288 |
| | | 11 239 | 0 422 | | | 11.246 | 0 010 | 11.246 | 0 004 | | | 11.246 | 0 277 |
| | | 11.903 | 0 398 | | | | | 11.911 | 0 004 | | | 11.911 | 0 264 |
| | | 12 608 | 0 374 | | | | | 12.615 | 0 004 | | | 12 615 | 0 249 |
| | | 13.353 | 0 351 | | | | | 13.361 | 0 004 | | | 13.361 | 0 236 |
| | | 14 143 | 0.329 | | | | | 14.151 | 0 002 | | | 14.151 | 0 223 |
| | | 14 980 | 0 310 | | | | | 14.988 | 0 002 | | | 14.988 | 0 210 |
| | | 15 867 | 0 286 | | | | | 15 874 | 0 002 | | | 15.874 | 0 197 |
| | | 16 806 | 0 267 | | | | | 16 813 | 0 002 | | | 16 813 | 0 182 |
| | | 17 800 | 0 245 | | | | | 17.808 | 0 002 | | | 17.808 | 0 169 |
| | | 18.854 | 0 230 | | | | | 18 862 | 0 002 | | | 18 862 | 0 156 |
| | | 19.970 | 0 211 | | | | | 19 978 | 0 002 | | | 19 978 | 0 141 |
| | | 21.152 | 0.191 | | | | | | | | | 21.160 | 0 126 |
| | | 22.404 | 0 176 | | | | | | | | | 22 412 | 0 111 |
| | | 23.731 | 0.159 | | | | | | | | | 23.739 | 0 096 |
| | | 25.136 | 0 142 | | | | | | | | | 25 144 | 0.081 |
| | | 26 624 | 0.129 | | | | | | | | | 26 632 | 0.066 |
| | | 28.201 | 0 116 | | | | | | | | | 28 208 | 0.051 |
| | | 29 871 | 0 103 | | | | | | | | | 29 878 | 0 036 |
| | | 31.639 | 0 088 | | | | | | | | | 31 647 | 0.018 |
| | | 33.513 | 0 077 | | | | | | | | | 33 521 | 0.006 |
| | | 35.498 | 0 066 | | | | | | | | | | |
| | | 37.600 | 0 053 | | | | | | | | | | |
| | | 39 827 | 0.043 | | | | | | | | | | |
| | | 42 186 | 0 034 | | | | | | | | | | |
| | | 44 684 | 0.025 | | | | | | | | | | |
| | | 47.331 | 0 015 | | | | | | | | | | |
| | | 50 135 | 0 008 | | | | | | | | | | |

## APPENDIX C

## BORING LOGS AND WELL INSTALLATION DIAGRAMS

# APPENDIX D

# ELECTRICAL RESISTIVITY SURVEY

# APPENDIX E

# LABORATORY CHEMICAL ANALYSIS REPORT SHEETS