DESIGN BASIS REPORT
PERMEABLE REACTIVE BARRIER
GROUNDWATER
INTERIM MEASURE

prepared for

ArvinMeritor, Inc.
Troy, Michigan

May 2001
Revised April 2003

27-19071.001

DESIGN BASIS REPORT
PERMEABLE REACTIVE BARRIER
GROUNDWATER INTERIM MEASURE

GRENADA MANUFACTURING SITE
GRENADA, MISSISSIPPI

Prepared for:

ArvinMeritor, Inc.
Troy, Michigan

Prepared by:

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May 2001
Revised April 2003

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April 18, 2003 27-19071.001

BROWN AND CALDWELL

Mr. Donald Webster
USEPA Region IV
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303-8960

RE: Grenada Manufacturing Facility
Grenada, Mississippi
USEPA ID No.: MSD 007 037 278

Dear Mr. Webster:

Enclosed for your review are two copies of the revised *Design Basis Report for the Permeable Reactive Barrier Groundwater Interim Measure* for the referenced site. Two copies have also been transmitted to the Mississippi Department of Environmental Quality (MDEQ).

This report describes the scope of the design effort, a summary of the relevant site conditions, the performance requirements of the permeable reactive barrier, and the design criteria for the wall. The various critical issues associated with this interim measure are discussed in the report. This report is a revised version of the May 2001 submittal. At the time of the initial submittal, some information was still being collected and not all supporting documents referenced in this report had been completed. This revision includes completed versions of all report components. In addition, the report has been updated, where appropriate, to reflect supplemental information obtained since the first submittal.

The interested parties (i.e., Grenada Manufacturing, ArvinMeritor, and Collins & Aikman) would like to proceed with this project as soon as practicable. Four tasks need to be completed to accomplish this:

- Response from the US Army Corps of Engineers on the wetland delineation for the site and compliance with applicable permitting requirements (e.g., mitigation, archaeological survey, and floodplain).
- Completion of an access agreement for a portion of the project site.
- Completion of negotiations for purchase, handling, and storage of the iron filings.
- Receipt of approval from the USEPA on this Design Basis Report.

The wetland delineation, as well as a Pre-Construction Notification and a Wetlands Mitigation Plan, has been submitted to the Corps and we are awaiting the results. In addition, ArvinMeritor is in the process of negotiating an access agreement with the current owner of the property immediately south of the Grenada Manufacturing property along Riverdale Creek. Lastly, ArvinMeritor is also negotiating the purchase, handling (i.e., transportation and unloading), and storage of the necessary iron filings with the appropriate parties.

We look forward to hearing from you regarding this project. If you have any questions or comments, please feel free to call us at (615) 255-2288.

Sincerely,

BROWN AND CALDWELL

Dale R. Showers, P.E.
Project Manager
Design & Solid Waste

Robert E. Ash, IV, P.E.
Department Manager
Design & Solid Waste

cc: Louis Crawford, MDEQ
John Bozick, ArvinMeritor
Don Williams, Grenada Mfg.
John Devic, Collins & Aikman
Anthony Lobred, US Army Corps of Engineers
Mike Duchene, EnviroMetal Technologies

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PROFESSIONAL ENGINEER'S CERTIFICATION

This is to certify that the Design for the Permeable Reactive Barrier Groundwater Interim Measure at the Grenada Manufacturing, LLC Site was prepared under my direction and supervision.

Robert E. Ash, IV, P.E.
Registration No. 13005
State of Mississippi

4/18/03
Date

1.0 INTRODUCTION

This document contains the design basis for groundwater interim measure for the Grenada Manufacturing, LLC facility (Site) located at 635 Highway 332, in Grenada, Mississippi (Figure 1-1). In accordance with the facility's Hazardous and Solid Waste Amendment (HSWA) Permit issued July 31, 1998, the facility is undergoing Resource Conservation and Recovery Act (RCRA) Corrective Action for prior and suspected ongoing releases of hazardous waste, including hazardous constituents from various solid waste management units (SWMUs). To that end, interim measures for the Site were required by the United States Environmental Protection Agency (USEPA) Region IV in its letter to Grenada Mfg. dated April 11, 2000. According to the letter, the USEPA requests that the facility address site-wide groundwater contamination, as well as source removal and soil contamination, for the following SWMUs and Areas of Concern (AOC):

- SWMU 12 – Wet Well Sump
- SWMU 14 – Chromium Destruct Pit
- SWMU 15 – Process Sewers
- AOC A – Former Trichloroethylene Storage Area
- AOC B – Former Toluene Underground Storage Area

Figure 1-2 identifies these SWMUs and AOCs in relationship to existing Site features.

A project meeting was held on site in April 2000. During the project meeting, it was agreed that interim measures at SWMU 12 would not be necessary. As discussed with USEPA and the Mississippi Department of Environmental Quality (MDEQ), the Interim Measures Work Plan (June 2000) addresses priority SWMUs 14 and 15, AOCs A and B, and site-wide groundwater. SWMU 12 will be addressed indirectly through site-wide groundwater interim measures. This agreement is addressed in a USEPA letter to Grenada Mfg. dated May 18, 2000. The May 18 letter also mentions SWMU 13, the Wastewater Treatment Plant. However, this SWMU was noted in previous documents, including the April 11 USEPA letter, as not requiring interim measures.

The purpose of this Design Basis Report is to present the objectives of the selected interim measure and to document the decisions made during the detailed design. The primary objective of the

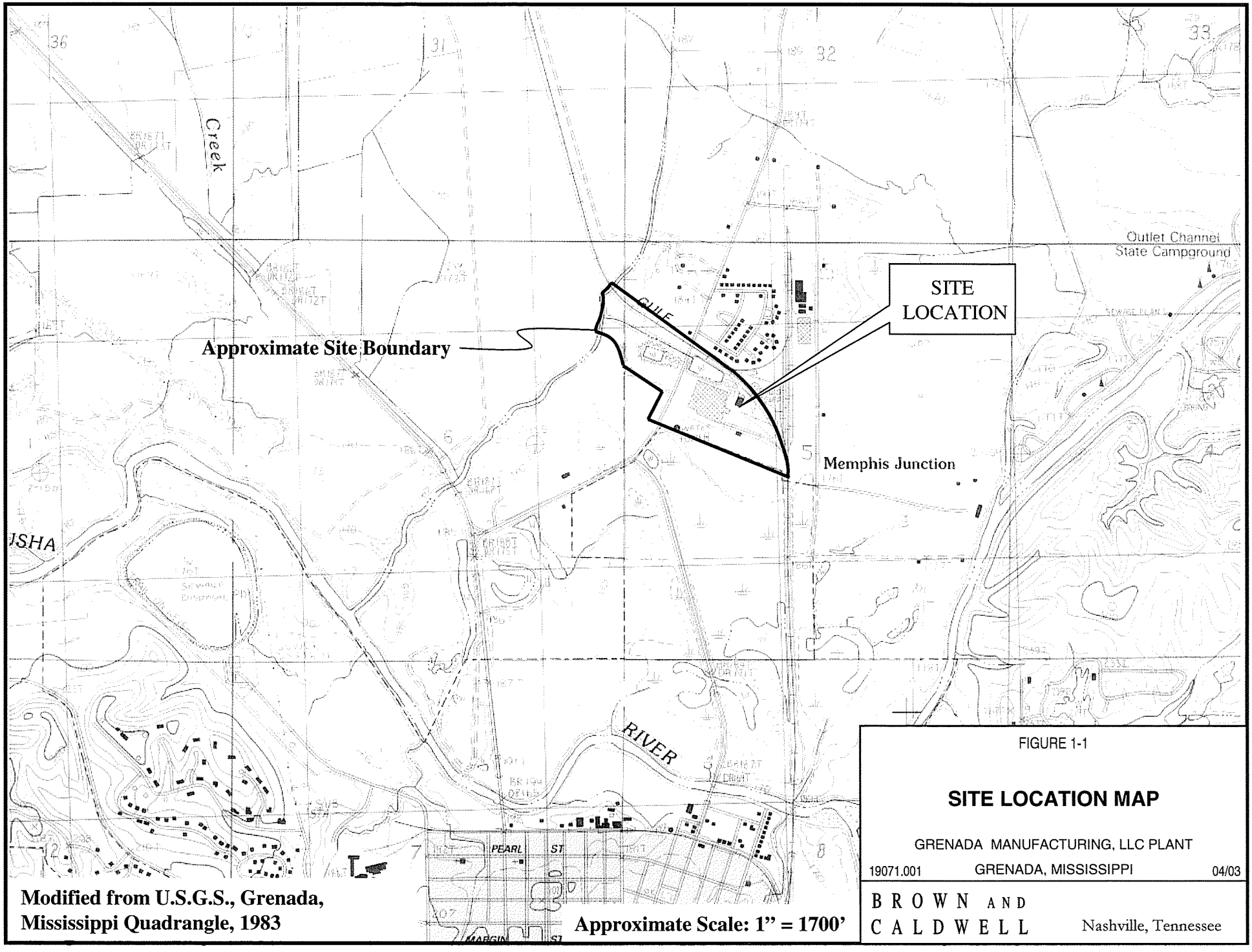


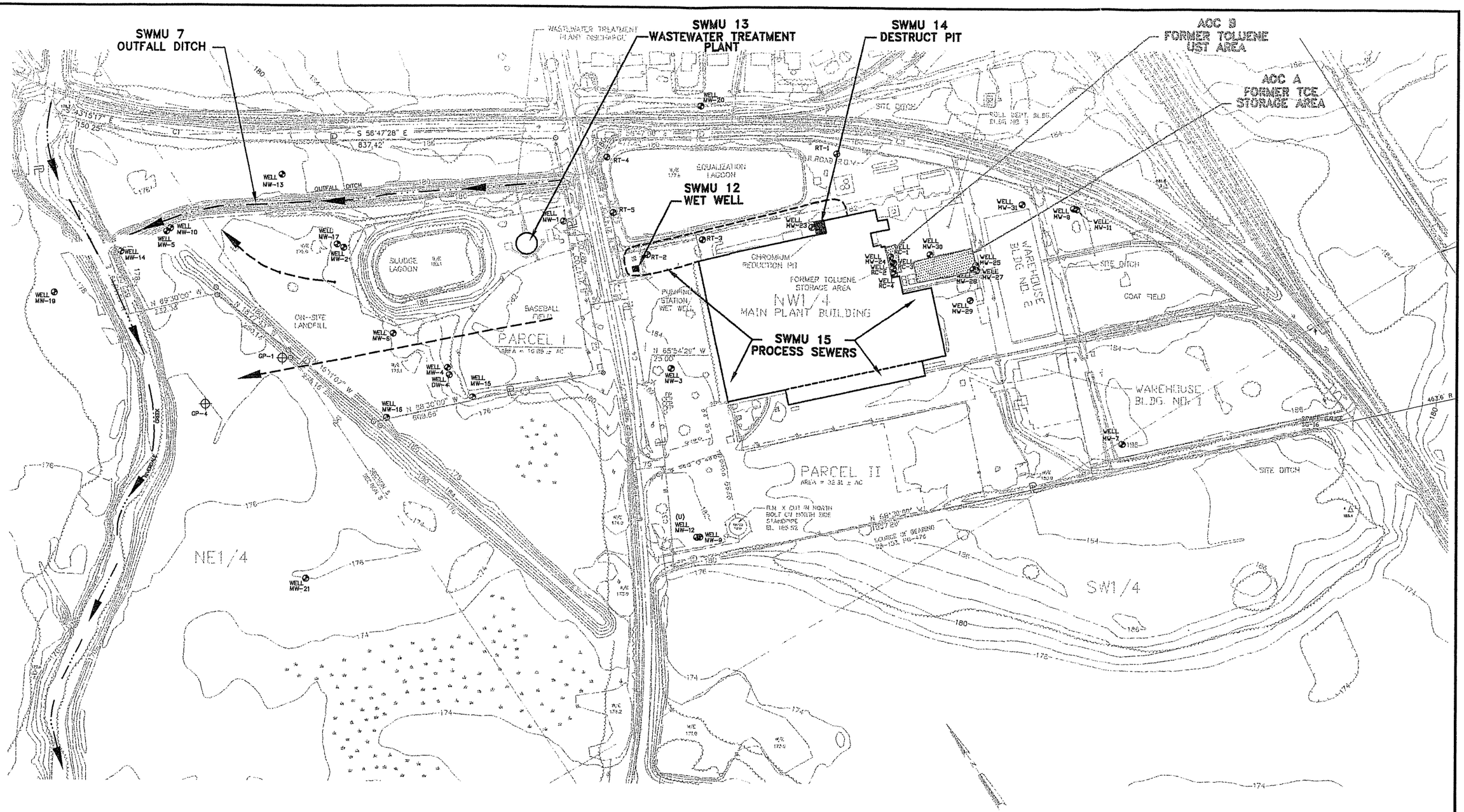
FIGURE 1-1

SITE LOCATION MAP

GRENADA MANUFACTURING, LLC PLANT

19071.001 GRENADA, MISSISSIPPI 04/03

BROWN AND CALDWELL Nashville, Tennessee



LEGEND

- Monitoring Well
- Geoprobe Piezometer
- Groundwater Flow Direction
- Surface Water Flow Direction

PRIORITY SWMUs

12–WET WELL
13–WASTEWATER TREATMENT PLANT
14–CHROME DESTRUCT PIT
15–PROCESS SEWERS

PRIORITY AOCs

A–FORMER TRICHLOROETHYLENE STORAGE AREA
B–FORMER TOLUENE UNDERGROUND STORAGE AREA

250 0 250 500
SCALE FEET

SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

FIGURE 1–2
SITE MAP SHOWING LOCATIONS OF PRIORITY SOLID WASTE MANAGEMENT UNITS AND AREAS OF CONCERN

GRENADA MANUFACTURING, LLC PLANT
GRENADA, MISSISSIPPI

19071.001 05/01

BROWN AND CALDWELL Nashville, Tennessee

DRAWING NO.: 19071-011 DATE: 05/11/01 PLOT SCALE 1=250

selected groundwater interim measure is to minimize or prevent the further migration of contaminants, and to limit actual or potential human and environmental exposure to contaminants while long-term corrective action remedies are evaluated. Section 2.0 of this report summarizes the results of pre-design efforts performed to address data gaps previously identified. Section 3.0 summarizes the design criteria for each component of the interim measure, while Section 4.0 describes the plan for satisfying permit requirements. Section 5.0 presents a preliminary construction schedule, and Sections 6.0 and 7.0 address construction quality assurance and performance monitoring, respectively.

1.1 BACKGROUND

Rockwell Automotive North America, now ArvinMeritor, Inc., operated a wheel cover manufacturing facility in Grenada, Mississippi from 1966 to 1985 before selling the operations and property to Textron Automotive Company, formerly Randall Textron, who then sold the operations and property to Grenada Manufacturing, LLC in 1999. Grenada Mfg. (Permittee) continues to operate the wheel cover plant. ArvinMeritor and Textron have conducted a number of environmental investigations at the referenced facility. The most extensive investigative work is reported in the 1994 Remedial Investigation (RI) Report conducted by ECKENFELDER INC., now Brown and Caldwell (BC). The work was performed in response to an MDEQ Administrative Order on Consent designed to investigate the on-site landfill, and was subsequently expanded to include other areas of the Site.

The 1994 RI Report detailed the sampling and analysis of soil, surface water, sediment, and groundwater at the facility. The report contained a description of the Site, including its geology and hydrogeology, as well as the sampling and analysis work that was conducted. The results of the investigation were discussed on a site-wide basis, because SWMUs and AOCs had not yet been determined. In addition to soil and groundwater impact, two areas containing free-phase organics, light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL), were identified.

The RI identified the presence of trichloroethylene (TCE) and its degradation products, as well as toluene and chromium, in the soil and groundwater at the Site. A Baseline Risk Assessment was

performed for soil and groundwater as part of a Supplemental RI (March 1994). The primary concern with respect to impacted groundwater is the migration of chlorinated volatile organic compounds (VOCs) to Riverdale Creek on the west side of the Site. The baseline risk assessment identified 8 VOCs (1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene (total), tetrachloroethene, toluene, 1,1,2-trichloroethane, trichloroethylene, and vinyl chloride), 1 semi-volatile organic compound (bis 2-ethylhexyl phthalate), and 2 metals (chromium VI and arsenic) as constituents of concern.

Subsequent to the submittal of the RI Report, the facility became subject to regulation under RCRA. A RCRA Facility Assessment (RFA) was performed by the USEPA and its contractor (A.T. Kearney, Inc.) as part of the HSWA permit process for the facility in 1996 and 1997. As a result of the Preliminary Review (PR) and Visual Site Inspection (VSI), 26 SWMUs and 3 AOCs were identified.

In 1998, ArvinMeritor collected another set of groundwater samples to determine VOC concentrations and to evaluate the potential for natural attenuation to contribute to a remedy for groundwater. Analyses included VOCs and bioremediation parameters recommended in the USEPA document "Technical Protocol for Evaluating Monitored Natural Attenuation of Chlorinated Solvents in Ground Water". The data are presented in a January 1999 report by BC entitled "Supplemental Groundwater Sampling and Analysis: Natural Attenuation Evaluation".

In March 1999, USEPA issued a combined RCRA Facility Investigation (RFI)/Confirmatory Sampling (CS) Work Plan call letter. ArvinMeritor and Textron requested a meeting at the USEPA office to review the results of the RI and to identify potential data gaps. During a meeting held in May 1999, it was agreed that nearly all of the information that might be generated in an RFI/CS effort already existed. USEPA requested that summaries of data obtained subsequent to issuance of the RI Report be prepared and that the available data be organized by SWMU or AOC. Specifically, summaries documenting media-specific concentrations were requested for priority SWMUs 7, 12, 13, 14, and 15, and AOCs A, B, and C. A Summary of Investigative Work (SOIW) document was prepared by BC in response to that request and was transmitted to USEPA and MDEQ in July 1999. Comments on the SOIW were received from the USEPA in its April 11, 2000 letter. As

stated in the April 2000 letter, Grenada Mfg. was required to respond to USEPA comments on the SOIW and to revise and resubmit the SOIW as the Draft RCRA Facility Investigation (RFI) Report.

Additional data have been obtained during various post-closure activities and in conjunction with interim measures. These data are documented in several reports, which have been previously submitted to the USEPA and/or MDEQ. During the meeting held at Grenada Mfg. in April 2000, the results of these previous investigations and interim measures were discussed and it was concluded that Site information was insufficient to complete the evaluation of interim measures. Therefore, additional soil and groundwater data collection was proposed. The USEPA, MDEQ, Grenada Mfg., ArvinMeritor, and BC agreed that additional groundwater sampling would be performed to update the groundwater database and incorporate the updated information into the RFI Report (revised SOIW).

An Interim Measures Work Plan was submitted in June 2000 and approved in July 2000 by the USEPA. The Interim Measures Work Plan addressed additional data collection and the evaluation of interim measures for both source control and site-wide groundwater. The additional data collected would be reported in the RFI Report and used in the evaluation of interim measures. Accordingly, a site-wide groundwater-sampling event was conducted in October 2000 to update the groundwater database. Twenty-five (25) monitoring wells were sampled and analyzed for VOCs, semi-volatile organic compounds, target analyte list metals, and hexavalent chromium to assess groundwater quality at the Site. The RFI Report, including responses to USEPA comments on the Draft SOIW and the results of the additional sampling, was transmitted to the USEPA and MDEQ on January 31, 2001.

Concurrent with the October 2000 groundwater sampling event, additional groundwater sampling using direct-push technology was conducted to provide additional data. The objective of the direct-push groundwater sampling was to determine the lateral and vertical extent of the groundwater plume along Riverdale Creek and to determine the elevation of the top of the aquitard. Seven direct-push sampling locations were used to meet data needs. The sample locations were positioned strategically between the extent of the plumes (as identified prior to sampling) and Riverdale Creek to assess the presence of constituents of concern. Additionally, two piezometers were installed near Riverdale Creek to supplement groundwater elevations and flow estimates.

Groundwater analyses were performed in accordance with the updated Quality Assurance Project Plan (QAPP; Brown and Caldwell, November 2000) for the Site, which was approved by the USEPA in December 2000. A review of the TCE data indicates that, in general, the groundwater quality has changed little over the period 1993 to 2000 with the exception of select monitoring wells, particularly some located adjacent to Riverdale Creek, which showed an increase in TCE concentration. Concentrations of chromium have remained relatively unchanged. Chromium VI concentrations, however, have declined and have fallen below the Site risk-based action level of 0.14 mg/L. In general, the new groundwater data suggest the need for additional groundwater interim measures at the Site.

1.2 INTERIM MEASURES EVALUATION

TCE and its degradation products currently impact a large portion of the Site groundwater. Additionally, there is a significant portion of the Site where chromium impacts groundwater. Groundwater at the Site appears to discharge primarily directly to Riverdale Creek. Potential impact to the creek appears to be limited to TCE and its degradation products. Groundwater may also enter the Outfall Ditch, which discharges to Riverdale Creek. Impact to Riverdale Creek due to discharge of groundwater containing TCE and its degradation products has been identified as an environmental condition that could significantly benefit from implementation of interim measures.

A number of source control interim measures have been previously implemented at the Site. These measures include installation of a DNAPL recovery system for TCE at AOC A, installation of an LNAPL recovery system for toluene at AOC B, and ex-situ soil vapor extraction at the On-Site Landfill Area (SWMU 4). NAPL recovery efforts were initiated in 1993. These activities included the installation and operation of automated DNAPL and LNAPL recovery units in wells located at AOC A and B, respectively. The amount of NAPL recovered from these areas decreased over the years to levels where automated systems are no longer efficient. Currently, NAPL is more efficiently removed manually (i.e., using bailers) from the wells on a monthly basis. Grenada Mfg. expects to continue NAPL recovery as an interim measure. In addition, the Former Equalization Lagoon was closed under the oversight of MDEQ. Previously performed source control measures have been successful in terms of meeting their intended objectives.

The facility also is in the process of implementing another source control measure; specifically, shutdown and closure of the existing chromium plating operation. Active chrome plating operations were discontinued on January 18, 2001. Use of the Chrome Destruct Pit (SWMU 14) for treating chromium-laden wastewater from the discontinued operations was completed by March 9, 2001. Grenada Mfg. submitted a Closure Plan for the associated sumps, pits, and the Chrome Destruct Pit, which was subsequently approved in October 2001. That Closure Plan identifies and discusses further closure steps. In March 2002, Grenada Mfg. transmitted a letter to the USEPA that presents the results of soil and groundwater sampling in the vicinity of the Chrome Destruct Pit and the Chrome Plating Lines area. The USEPA issued an approval letter of clean closure for the Chrome Destruct Pit, which was subsequently filled and capped with concrete. As a result of the soil and groundwater testing, the Chrome Plating Area was identified as a new SWMU (#27). At the request of the USEPA, Grenada Mfg. prepared an Assessment Report and Closure Plan for the Chrome Plating Line Area in July 2002, which was revised in September 2002 and again in January 2003. The Assessment Report and Closure Plan was approved in a letter from the USEPA dated January 30, 2003. Grenada Mfg. is in the process of implementing the actions identified in that Closure Plan.

More detailed discussions regarding the previous, ongoing, and proposed source control measures are provided in the Interim Measures Work Plan (Brown and Caldwell, June 2000).

There is one primary and a number of secondary potential remaining source areas for TCE, some of which may not be easily accessed. Addressing hot spots, particularly where DNAPL may exist, will have minimal impact on groundwater quality unless TCE removal/destruction exceeds 95 percent or possibly 99 percent. Unless all significant source areas are adequately treated, impact to groundwater is likely to continue. Currently, available technologies have not, in general, been able to meet this requirement. Thus, it is not likely that additional source area treatment on an interim basis would have near-term impact on the quality of groundwater reaching Riverdale Creek. If a measure capable of preventing impact to Riverdale Creek is implemented, then the potential environmental impact from source areas, as well as the site-wide groundwater plume, will be controlled. Thus, the focus of the identification and evaluation of interim measures has been on controlling the migration of groundwater impacted by TCE and its degradation products to the creek (i.e., migration control).

While the source control interim measures have provided obvious benefit to the Site, the October 2000 groundwater data suggest additional interim measures are appropriate near Riverdale Creek. Based on the results of the site-wide groundwater sampling event completed in October 2000, it appears that the constituent plume has migrated to Riverdale Creek. As such, it would appear that interim measures should consist of migration control measures and that the appropriate location for such additional interim measures would be near the creek. If necessary, migration control interim measures could later be combined with more aggressive source control measures as part of final corrective measures.

Because the most appropriate location of the additional interim measures appears to be near Riverdale Creek, the use of groundwater extraction and treatment options was not favorably considered due to the high volume of groundwater (in the absence of a barrier wall) that would be anticipated to be collected in such close proximity to the creek. Rather, proven in-situ treatment technologies were evaluated, including:

- Permeable reactive barrier (i.e., zero valence iron)
- Air sparging curtain
- Enhanced bioremediation

These technologies have been evaluated for use at the Site both on an individual basis and in combination. Screening of applicable technologies was limited to known Site and waste characteristics and technology limitations. A permeable reactive barrier using zero valence iron filings was generally thought to be the most appropriate option for use at this Site and, therefore, it was used as a point of comparison for other options. The wall would likely be installed as a trench to the top of the underlying aquitard and would intercept the entire cross-section of the groundwater plume depicted by the October 2000 sampling data. The actual wall location, length, and thickness have been determined during this design phase and are outlined in Section 3.0. Based on available information, the permeable reactive barrier may also address metal concentrations (e.g., hexavalent chromium) in the groundwater, although metals are not significant contributors to the groundwater plume in this area of the Site.

The results of this limited evaluation of these potential interim measures were documented for USEPA in a letter dated March 9, 2001. In general, it was determined that the permeable reactive

barrier is attractive for this Site due to its anticipated effectiveness and its low operation and maintenance (O&M) requirements. Because these technologies were evaluated for potential use as an interim measure and because additional discussions regarding the applicability of various technologies has occurred in the past, this evaluation was limited to groundwater technologies that are known to have a good chance to work at the Site. This limited evaluation of potential interim measures does not constitute a full remedial technology evaluation (i.e., Corrective Measures Study (CMS)). A CMS is being performed for the Site and the results of the various interim measures will be considered as part of that study. However, this evaluation did include consideration of incorporating interim measures into final corrective measures. Other considerations for selection of interim measures included effectiveness, implementability, O&M requirements, and cost.

Subsequent to receiving concurrence from the agencies on the design of the selected groundwater interim measure, the various components will be installed. The system will then be monitored and its performance included in the overall CMS process for the Site.

2.0 SUMMARY OF PRE-DESIGN TASKS

To complete the detailed design components for the selected interim measure, two pre-design tasks were completed to provide the necessary information. These tasks include a focused geotechnical study and bench-scale treatability studies. Brief descriptions of these tasks and their outputs are provided below.

2.1 GEOTECHNICAL INVESTIGATION

The preferred method for installation of the permeable reactive barrier at this Site is the slurry trench method. The depth of the barrier wall is expected to be 45 to 60 feet below ground surface. These depths are greater than the capabilities associated with typical open trench methods or trenching equipment (i.e., one-pass trenchers). A focused geotechnical investigation was performed to obtain the soil data necessary for the design of the slurry trench. The investigation included soil borings down to the aquitard below the aquifer and the collection of soil samples at five boring locations along the proposed wall alignment. The soil samples were then submitted to a geotechnical laboratory to obtain the necessary design parameters. A geotechnical firm (QORE Property Science) was retained to collect and test the samples of the various soil layers or types. This work was performed between April 16 and May 4, 2001. The following tests were performed on the number of samples indicated:

- Unit Weight/Moisture Content — 8 samples
- Particle Size Distribution (Coarse Fraction Only) — 6 samples
- Direct Shear Strength (Non-cohesive Soil) — 3 samples
- Atterberg Limits (Cohesive Soil) — 1 samples
- Triaxial Shear Strength (Cohesive Soil) — 5 samples

A copy of the summary report from the geotechnical laboratory is included in Appendix A. A geologic profile of the subsurface along the alignment of the trench is included with the engineering drawings (Appendix B).

In general, the geology encountered during completion of the soil borings was similar to that described in previous reports for the Site. The soil profile encountered can generally be described as the following: the uppermost soil layer is generally a clayey silt or silty clay with a typical thickness of approximately 10 to 15 feet, the next soil layer encountered was typically a saturated fine to medium grained sand with varying amounts of silt with a thickness ranging from approximately 30 to 50 feet. In addition, throughout the drilling efforts the fine to medium grained sand exhibited the properties of a "running sand" and flowed into the hollow-stem augers despite the additional effort of keeping the augers filled with bentonite drilling mud. Silty layers ranging in thickness from a few inches to approximately 5 feet were encountered in the sand unit at varying frequencies and depths. Blow count values and visual descriptions obtained during split-spoon sampling indicate these silty layers are relatively weak and consist primarily of saturated very fine sand and silt. Thinly bedded, slightly sandy, clayey silt was encountered below the sand layer at depths ranging from 47 to 60 feet below the ground surface. This layer has previously been identified as marl and it exhibited much higher blow count values than the soil encountered above it.

The results of the geotechnical laboratory testing generally supports the observations made during completion of the soil borings. Triaxial shear and direct shear testing were performed on relatively undisturbed samples (Shelby tubes) collected during performance of the soil borings. The results of this testing generally indicate that only the uppermost soil unit exhibited significant cohesion values, that the effective angle of internal friction for the relatively silty layers ranged from 0.6 to 40 degrees, and that the effective angle of internal friction of the sand unit ranged from 31.3 to 43.2 degrees. Grain size distribution test results indicate that the sand unit is comprised primarily of fine grained sand with lesser amounts of medium grained sand and with a fines content ranging from 4 to 24 percent. Porosity values of the sand unit were determined to range from approximately 38.5 to 45.7 percent. Soil properties are shown on the permeable reactive barrier profile sheet in the Engineering Design Drawings (Appendix B).

The results of the initial geotechnical investigation suggested the presence of a very weak soil layer along a portion of the wall alignment. Based on these initial results, additional field testing was performed in June 2002. This additional testing consisted of the collection of vane shear data in the field at the approximate locations of the five initial soil borings. The results of this supplemental data collection indicated that the soil layer was not as weak as initial information suggested. A copy

of the vane shear report prepared by QORE Property Sciences is included in Appendix A. The results of the soil laboratory and field testing were used to evaluate the trench stability for the slurry trench and to evaluate construction methods. Summaries of the initial and revised trench stability calculations are provided in Appendix A.

2.2 BENCH-SCALE TREATABILITY STUDIES

Two bench-scale treatability studies were conducted by EnviroMetal Technologies, Inc. The first study began in April 2001 and was completed in July 2001. The second study was completed from February to May 2002. The studies were commissioned to evaluate the effectiveness of commercially available granular iron material for treating groundwater collected from the Site. The first treatability study was performed using Site groundwater collected from an area of the Site that represented some of the highest concentrations of constituents of concern in the vicinity of the permeable reactive barrier. This groundwater was used to assess the overall effectiveness of the permeable reactive barrier technology to treat Site groundwater. Based on the results of the first study, a second study was conducted to evaluate the technology using more moderate or average groundwater concentrations to assess the impact of the lower concentrations on the effectiveness of the technology (i.e., the amount of iron filings required to meet preliminary cleanup goals).

The EnviroMetal Process is a metal enhanced reductive dehalogenation process that will degrade the VOCs present in the Site groundwater. EnviroMetal Technologies was founded specifically for the purpose of marketing and implementing this patented technology and has been granted exclusive commercialization rights by the patent holder (the University of Waterloo). EnviroMetal Technologies has access to the expertise and resources of the University of Waterloo and sponsors ongoing research of the technology. They typically act as a subconsultant and/or subcontractor and have staff that assist in design, installation, and evaluation of information. Senior staff at EnviroMetal Technologies have been involved with the technology from its initial development and are among the most experienced professionals in the application of permeable reactive barriers. In addition to performing the two treatability studies, EnviroMetal Technologies has assisted in the preparation of key design components.

The bench-scale treatability studies involved laboratory column tests to establish site-specific constituent degradation rates, which enables the prediction of system performance and provides data for field design. The degradation rates determined from the column tests were used to determine the required residence time in the granular iron. Using the residence time and the expected groundwater flow rate, the flow-through thickness of the permeable reactive barrier was determined. The column test also included inorganic sampling of column influent and effluent which provided information concerning potential mineral precipitation in the reactive material caused by changing redox potential (Eh) and pH conditions. In addition to degradation of VOCs, granular iron will remove hexavalent chromium [Cr (VI)] through reduction of the oxidized metal species followed by precipitation of the reduced species in the iron permeable reactive barrier. The potential for mineral precipitation was also considered in the design of the permeable reactive barrier.

EnviroMetal Technologies has identified and utilized two sources of granular iron material – Connelly-GPM, Inc. in Chicago and Peerless Metal Powders & Abrasives, Inc. in Detroit. EnviroMetal Technologies has completed side-by-side column tests to evaluate the degradation rates of VOCs in the presence of iron from both sources. The tests showed that the degradation rate for TCE with iron from both sources was similar. The degradation rates with the Connelly-GPM iron for cis-1,2 dichloroethylene and vinyl chloride were approximately 2 and 4 times faster, respectively (i.e., the Peerless iron is less reactive). Since cis-1,2 dichloroethylene is present at high concentrations in the Site groundwater and will also be partially produced from the degradation of TCE, the degradation rate of the cis-1,2-dichloroethylene will be an important design parameter. Less Connelly-GPM iron will, therefore, be required to degrade the VOCs to the preliminary treatment criteria (i.e., MCLs). Iron from Connelly-GPM was used in the first bench-scale test, while both sources were used for the second study. The second study results confirmed other data accumulated by EnviroMetal Technologies that show the Connelly-GPM iron is more reactive and, therefore, more effective at treating Site groundwater.

Almost 50 liters of Site groundwater was collected from monitoring wells located near the intersection of Riverdale Creek and the Outfall Ditch. Monitoring well MW-5 was selected for the first study because of its proximity to the proposed alignment for the permeable reactive barrier and the fact that constituent concentrations historically detected in that well represent high levels for the

Site. Monitoring well MW-14 was used for the second study because the October 2000 data suggested that it represented "average" constituent concentrations for the Site. The water from the wells was transported to the laboratory at the University of Waterloo in Canada for conduct of each study under the supervision of EnviroMetal Technologies. Data on the groundwater from the Site shows the following constituent concentrations were tested:

	First Study	Second Study
• Tetrachloroethene	25 μg/L	--
• Trichloroethylene	36,000 μg/L	7,000 μg/L (spiked)
• 1,1 Dichloroethylene	15 μg/L	Not Detected
• Cis 1,2 Dichloroethylene	29,000 μg/L	6,000 μg/L (spiked)
• Trans 1,2 Dichloroethylene	140 μg/L	58 μg/L
• Vinyl Chloride	30 μg/L	Not Detected
• 1,1,2 Trichloroethane	80 μg/L	--

The Site groundwater was passed through a column containing iron filings at a flow rate selected to approximate groundwater flow velocity at the Site. For these treatability studies, a flow rate of 2.2 feet per day was used. This rate is roughly twice that estimated in the field; however, a quicker rate was necessary to complete the treatability studies in a timely manner relative to design. Constituent concentrations were measured along the column until a steady-state profile was achieved. Eh and pH profiles were also measured periodically during the test. Lastly, inorganic parameters were monitored to help predict possible mineral precipitation.

The results of the two bench-scale treatability studies indicate that this technology is capable of degrading Site constituents of concern to concentrations below the preliminary treatment goals (i.e., MCLs). The use of preliminary treatment goals set as low as MCLs for the purpose of the treatability studies allows for the evaluation of other applicable goals that may be higher than the MCLs. The study results have been used to calculate constituent degradation rates and estimated residence time requirements for the field application. This information, in turn, has been used to establish the dimensions (i.e., the thickness) of the permeable reactive barrier (see Section 3.1).

The two treatability tests completed by EnviroMetal Technologies showed that the degradation rates of TCE and cis-DCE for the moderate concentration groundwater (second study) are quicker than the degradation rates for the high concentration groundwater (first study). This is likely due to the decreased competition for reactive sites on the iron at lower groundwater concentrations. The influent concentrations of TCE and cis-DCE were used to determine which degradation rates to use in calculating the residence time required for treatment. The results from the treatability study with the high concentration groundwater (first study) were used for the sections of the wall where the influent concentration of TCE was equal to or greater than 22,000 μg/L and the influent concentration of cis-DCE was equal to or greater than 11,000 μg/L. The results of the second study with moderate concentration groundwater were used for the remaining sections. Certain inorganic compounds can have an adverse impact on the degradation of VOCs by granular iron. However, based on the results of the treatability studies and the range of concentrations of inorganic compounds in the vicinity of the wall, it is expected the inorganics will have minimal effect on the degradation rates.

For design, the wall was divided into upper and lower zones vertically and 50 foot sections along the length. The expected influent concentrations for TCE, cis-DCE and vinyl chloride along the proposed alignment for each section of the wall were obtained from the concentration maps developed with data collected in October 2000. The concentrations of TCE and cis-DCE in the upper zone were projected based on partial backfilling of the Outfall Ditch (see Section 3.1). EnviroMetal Technologies completed simulations of the EnviroMetal Process using the results of the treatability studies to estimate the residence time required to degrade the VOCs to the treatment goals (i.e., MCLs). The residence times required for treatment for 12 possible influent concentration scenarios are summarized in Table 2-1.

The flow-through thickness of granular iron required is equal to the residence time required multiplied by the groundwater flow velocity. The estimated groundwater flow velocity in the vicinity of the wall is 0.72 ft/day. This translates into required iron flow-through thickness of between 0.8 ft and 3.9 ft.

The actual trench width will be approximately 2.0 to 4.0 feet (i.e., wider than the minimum thickness of 100 percent iron). The space difference between the necessary iron thickness and the actual wall

Table 2-1

Estimated Residence Time Requirement
Grenada Manufacturing Site
Grenada, Mississippi

VOC	Influent Concentration (µg/L)	Target Effluent[a] Concentration (µg/L)	Total Residence Time Required[b] (hours)
Trichloroethene	69,000	5	**216**
cis 1,2-dichloroethene	45,000	70	
Vinyl chloride	50	2	
Trichloroethene	69,000	5	**216**
cis 1,2-dichloroethene	45,000	70	
Vinyl chloride	10	2	
Trichloroethene	69,000	5	**216**
cis 1,2-dichloroethene	45,000	70	
Vinyl chloride	2	2	
Tetrachloroethene	30	5	**186**
Trichloroethene	22,000	5	
cis 1,2-dichloroethene	11,000	70	
Vinyl chloride	1,000	2	
Tetrachloroethene	30	5	**181**
Trichloroethene	22,000	5	
cis 1,2-dichloroethene	11,000	70	
Vinyl chloride	500	2	
Trichloroethene	7,000	5	**155**
cis 1,2-dichloroethene	7,000	70	
Vinyl chloride	100	2	
Trichloroethene	7,000	5	**152**
cis 1,2-dichloroethene	7,000	70	
Vinyl chloride	10	2	
Trichloroethene	7,000	5	**152**
cis 1,2-dichloroethene	7,000	70	
Vinyl chloride	2	2	
Trichloroethene	5,000	5	**142**
cis 1,2-dichloroethene	5,000	70	
Vinyl chloride	2	2	
Trichloroethene	1,000	5	**117**
cis 1,2-dichloroethene	1,000	70	
Vinyl chloride	100	2	
Trichloroethene	1,000	5	**97**
cis 1,2-dichloroethene	1,000	70	
Vinyl chloride	0	2	

Table 2-1 (Continued)

Estimated Residence Time Requirement
Grenada Manufacturing Site
Grenada, Mississippi

VOC	Influent Concentration (µg/L)	Target Effluent[a] Concentration (µg/L)	Total Residence Time Required[b] (hours)
Trichloroethene	100	5	
cis 1,2-dichloroethene	100	70	
Vinyl chloride	2	2	**25**
1,1-dichloroethene	8.8	7	
Chromium (total)	100	100	

a – Maximum Contaminant Levels (MCLs) established by the USEPA and published at 40 CFR 141.6 and .62.

b – Based on results of Bench-Scale Test completed with high concentration groundwater (July 2001) and with moderate concentration groundwater (May 2002), and as summarized in Table 1 of the EnviroMetal Technologies memorandum to Brown and Caldwell dated April 3, 2003.

thickness will be occupied by sand. Therefore, while the wall thickness will remain constant along sections of the wall, the proportion of iron to sand will vary to meet the minimum needs for granular iron. These values include a factor of safety for variations in groundwater velocity and temperature, as well as constituent concentration.

3.0 DESIGN CRITERIA

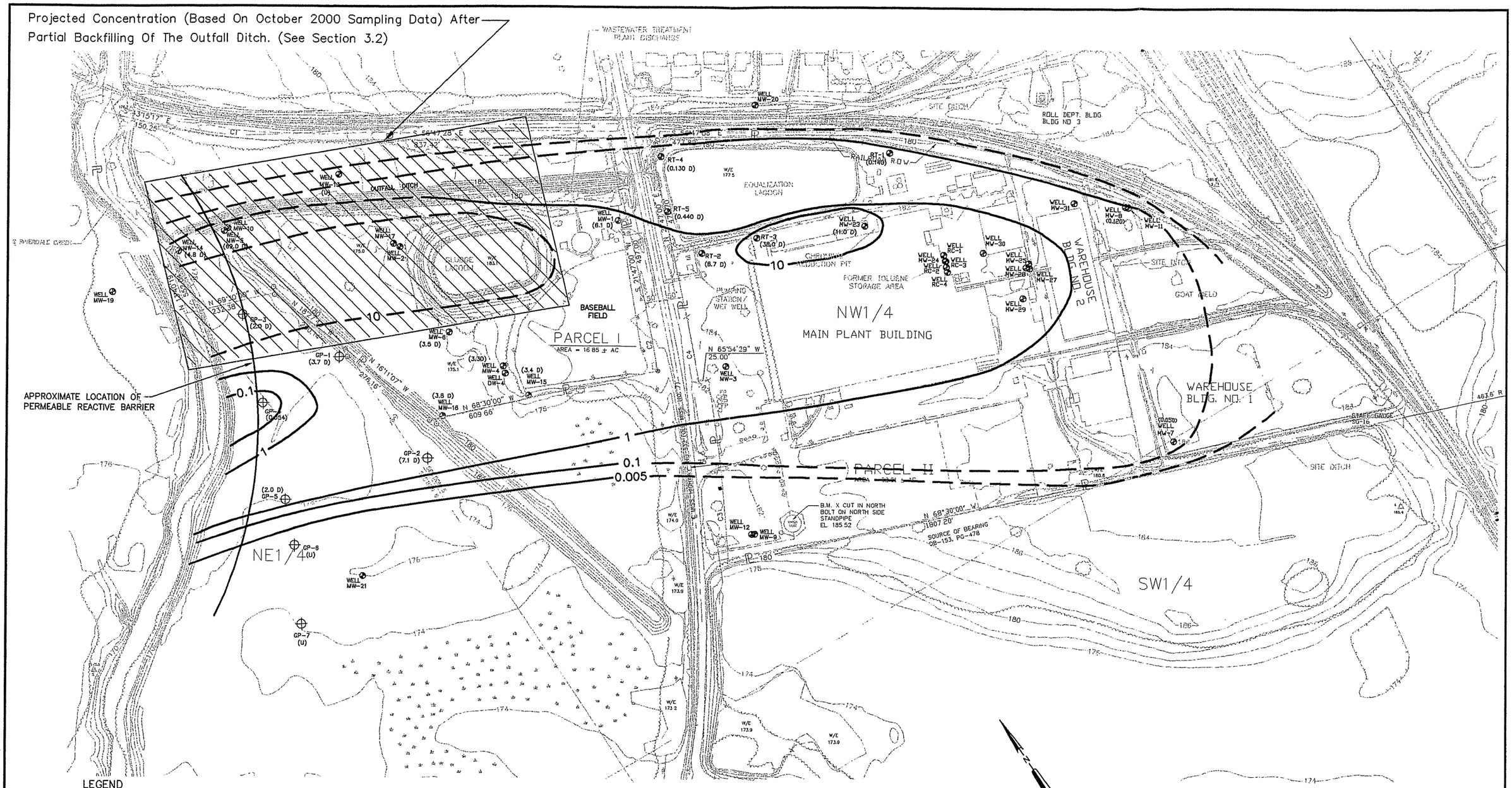
A permeable reactive barrier using granular iron is a simple, passive process that degrades a wide range of VOCs, including those found at this Site, has nontoxic end products, and requires no equipment or energy/power source. This technology offers long-term treatment of constituents at moderate capital costs and low O&M costs while allowing continued use of the property. Some of the factors affecting the overall cost include groundwater velocity, plume dimensions, site geology, required residence time, granular iron source, and the installation method. The requirements for the permeable reactive barrier are as follows:

- Intercept the impacted Site groundwater prior to discharging to Riverdale Creek.
- Key into the competent clay layer underlying the uppermost aquifer at the Site.
- Reduce concentrations of constituents of concern to below established treatment levels.
- Achieve a higher hydraulic conductivity than the surrounding soil layers.

The results of a geotechnical investigation program and the preliminary results of two bench-scale treatability studies were discussed in Section 2.0. The various required design criteria resulting from the completion of these efforts are described below.

3.1 WALL DIMENSIONS

The primary purpose of the permeable reactive barrier is to intercept impacted groundwater and reduce constituent concentrations prior to groundwater discharging into Riverdale Creek. To that end, the wall will be placed approximately parallel to the creek and will intercept Site groundwater with constituent concentrations above the respective MCLs (as depicted by the October 2000 site-wide groundwater sampling event) for the various constituents of concern. A review of the isoconcentration maps presented in the RFI Report (October 2001) indicates that the two maps depicting TCE concentrations represent the northernmost and southernmost boundaries of the various constituent plumes (see Figures 3-1 and 3-2). To intercept these plumes, the wall will be approximately 1,200 feet long. In addition, the wall will be continuous along the length and will not be constructed as a funnel and gate system. Because constituents are present in the groundwater over the entire vertical thickness of the saturated zone, the wall will extend from slightly above the



LEGEND

- Monitoring Well
- Geoprobe Location
- (0.05) Trichloroethene Concentration in mg/L
- (U) Non-Detection
- (J) Estimated Concentration
- (D) Diluted Sample
- Concentration Contour, mg/L (Dashed where inferred)
  Minimum contour is equivalent to the USEPA MCL.

NOTE: DNAPL was observed in monitoring well MW-2.

SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

250 0 250 500
SCALE FEET

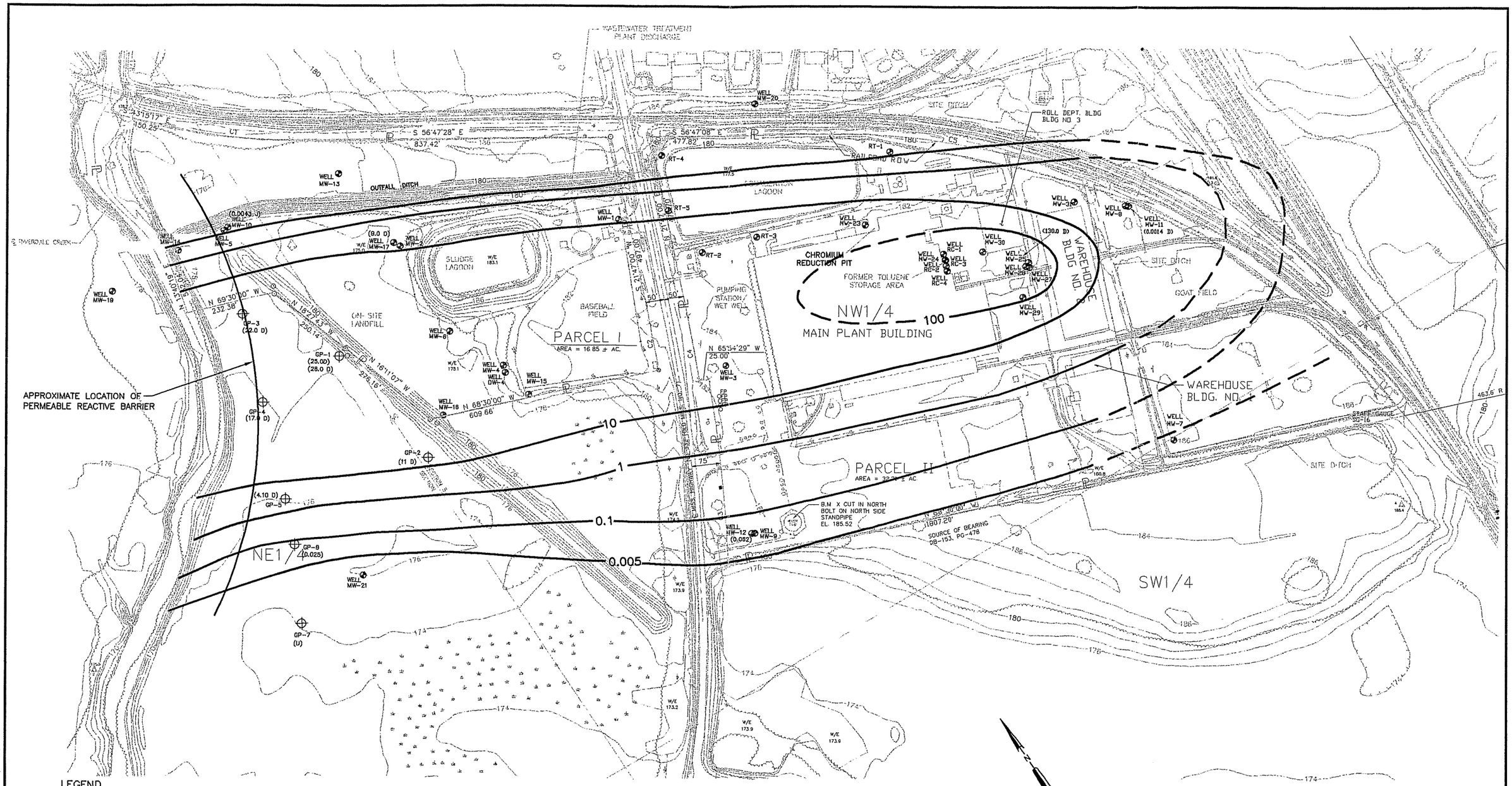
FIGURE 3-1
PROJECTED TRICHLOROETHENE CONCENTRATION MAP OF THE UPPER PORTION OF THE UPPER MOST AQUIFER

GRENADA MANUFACTURING, LLC PLANT
GRENADA, MISSISSIPPI

19071.001 05/01

BROWN AND CALDWELL Nashville, Tennessee

DRAWING NO.: 19071-23B DATE: 05/18/01 PLOT SCALE 1=250



LEGEND

- Monitoring Well
- Geoprobe Location
- (0.0043) Trichloroethene Concentration in mg/L
- (U) Non-Detection
- (J) Estimated Concentration
- (D) Diluted Sample
- Concentration Contour, mg/L (Dashed where inferred)
  Minimum contour is equivalent to the USEPA MCL.

NOTE: DNAPL was observed in monitoring well MW-28.

SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

250 0 250 500
SCALE FEET

FIGURE 3-2
OCTOBER 2000 TRICHLOROETHENE CONCENTRATION MAP OF THE LOWER PORTION OF THE UPPER MOST AQUIFER

GRENADA MANUFACTURING, LLC PLANT
GRENADA, MISSISSIPPI

19071.001 05/01

BROWN AND CALDWELL Nashville, Tennessee

DRAWING NO.: 19071-23A DATE: 05/11/01 PLOT SCALE 1=250

historical high groundwater elevation down into the top of the underlying aquitard. Historically, the measured high groundwater elevation has been observed at approximately 10 feet below the ground surface. Based upon geologic data obtained during the geotechnical investigation, the top of the aquitard lies roughly 47 to 60 feet below the ground surface along the alignment of the wall. This represents a typical wall height of approximately 37 to 50 feet. To help ensure that the vertical extent of the groundwater is intercepted by the wall, it will be tied into the aquitard a minimum of 1 foot and will extend to at least 1 foot above the measured high groundwater elevation.

The thickness of the permeable reactive barrier is based on the results of the bench-scale treatability studies, the groundwater velocity in this vicinity of the Site, and the characteristics of the groundwater plumes. As such, the thickness of the granular iron will vary over the length of the wall to accommodate heterogeneity in the flow characteristics and the existing constituent concentrations. Based on a review of Site data and study results, EnviroMetal Technologies estimates that the necessary granular iron thickness will vary between 0.8 feet and 3.9 feet (assuming 100 percent iron). This varying thickness allows sufficient residence time to reduce groundwater constituent concentrations to below the target goals for the Site (i.e., potentially as low as MCLs). The wall will consist of a sand and granular iron mixture with an average hydraulic conductivity greater than that of the surrounding soil. Typical excavation equipment will require a trench width greater than the minimum thickness required for the granular iron. Therefore, the sand will be mixed with the granular iron as a bulking agent. To accommodate the variation in the needed thickness of granular iron, the proportions of iron to sand will vary. For example, where 1.5 feet of granular iron is needed in a 2.5 foot wide trench, the mixture will consist of about 60 percent iron and 40 percent sand, by volume. The mixture will change to 80 percent iron and 20 percent (by volume) sand in the section of the wall where 2 feet of granular iron is needed.

Because the October 2000 groundwater data suggests that VOCs are flowing to Riverdale Creek, it is desirable to place the permeable reactive barrier as close as possible to the creek and intercept as much impacted groundwater as is practicable. However, there are technical factors that require the location of the wall to be a reasonable distance from the creek. As indicated in Section 2.2, mineral precipitation is a potential issue for this technology. The precipitation typically occurs on the upgradient side of the permeable reactive barrier. However, existing data shows that this does not significantly impact the effectiveness of the granular iron. Groundwater leaving the wall will exhibit

increased pH, decreased REDOX potential, and low inorganic carbon (alkalinity), calcium, magnesium, and sulfate concentrations. Monitoring results from existing iron permeable reactive barriers indicate that Eh and pH are buffered by the aquifer within a short distance (5 to 10 feet) downgradient at most sites. Therefore, the wall will be placed a reasonable distance from the creek to allow the treated groundwater to equilibrate with the environment prior to discharging into the creek. Additional factors for locating the wall some distance away from the creek include creek bank stability and available work area for the contractor. The selected wall location is roughly parallel to Riverdale Creek, ranging in distance from about 66 feet to 118 feet to the east.

3.2 WALL CONSTRUCTION

Due to the depth required for placement of the permeable reactive barrier and the relatively shallow groundwater surface elevation, the anticipated wall construction method will be the use of a slurry trench method. Of course, the wall must allow groundwater to flow through it after completion. Therefore, biodegradable slurry will be used to install the trench. This slurry (typically composed of guar gum) will degrade within a couple of days thereby allowing normal groundwater flow. This brief temporary period of blocked flow has been estimated to be insufficient to significantly impact the normal groundwater flow patterns. Additionally, studies have shown that while the biopolymer slows VOC degradation rates over the short-term, this impact is not significant in the long-term.

Due to the minimal topographic relief across the Site, the general project area is typically wet and cannot support heavy construction equipment. In addition, a minimum working hydraulic head will need to be placed on the trench to keep the walls from collapsing into the trench (see Section 3.3). Because of this, a work platform will be required as part of construction. In general, this work platform will consist of the placement of a geotextile over the existing ground surface followed by the placement of structural fill material of sufficient thickness and gradation to support the construction equipment and method. Because the construction method is specific to a contractor, the exact dimensions and composition of the work platform will be the responsibility of the selected contractor, while meeting minimum design criteria.

Construction of the wall has been designed to minimize disturbance of the surrounding area. Once the sand and granular iron mix has been placed, the trench will be backfilled to match the existing

surrounding contours and the vegetative cover will be restored as necessary. The access road and work platform will remain in place. In addition, the soil excavated from the trench may remain along the wall alignment (see Section 4.4). As such, net fill will be limited to the work platform/access road and the excavated soil. With the exception of piezometers and monitoring wells in the vicinity, no aboveground structures or items will remain at the completion of the project.

Currently, a small component of the upper portion of the aquifer discharges into the Outfall Ditch near the north end of the project area. To address this groundwater component, the bottom of the ditch will be raised such that groundwater flow will shift to the west and more closely reflect the patterns in the lower portion of the aquifer. To capture this projected redirection of constituent flow, the permeable reactive barrier will be installed across the ditch to a distance of roughly 100 feet north of the north ditch bank. Separation of the surface water flowing in the ditch and the groundwater flowing through the permeable reactive barrier must be made to avoid mixing the two flows and potentially allowing the groundwater to circumvent the wall or to allow unnecessary surface water flow through the wall. To accomplish this, a geocomposite clay layer (GCL) will be placed along a portion of the ditch extending across the wall. The GCL will extend up the sides of the ditch a sufficient distance to separate flows. A thin layer of soil overlain by geotextile and crushed stone (rip rap) will then be placed over the GCL to protect it from scour.

The sand and granular iron mixture will be placed through the slurry into the trench using a tremie method whereby the mixture is placed at the bottom of the trench and displaces the slurry. The sand and granular iron will be mixed aboveground to the appropriate proportions and then placed into the trench. Experience has shown that, if proper care is taken by the contractor, separation of the sand and iron will not occur to a significant degree. To ensure that the vertical extent of groundwater is intercepted by the wall, the permeable reactive barrier will be placed at least 1 foot into the aquitard that exists at the base of the aquifer. Quality assurance requirements are included with the technical specifications for wall construction to verify that this tie-in has been achieved and that separation of the iron and sand has not occurred.

3.3 TRENCH STABILITY

A stability analysis was conducted for slurry trench construction. Input data for the analysis included physical and engineering properties for the soil formations into which the trench will be cut (see Section 2.1). Additional input data include the assumption that the slurry density used in the construction of the trench would be 64 pounds/cubic foot. The analysis was performed for a trench of infinite length (as opposed to alternating panels of limited length), which is a conservative assumption. The available data in the area near the proposed trench location indicate groundwater has been encountered between 10 and 15 feet below the ground surface. Based on the ground surface elevations and the elevations of the surface of the marl stratum interpreted from the field data, trench depths are anticipated to range from approximately 47 to 60 feet.

For the trench stability analysis, the soil at the sides and bottom of the trench are considered to be in a Rankine state of elastic equilibrium. Upon excavation of the trench and placement of the slurry, the surrounding soil is considered to be in an active Rankine state. Based on the Rankine method of analysis and the trench configurations described above, factors of safety were calculated for trenching conditions in which the depth to groundwater varied from 5 to 10 feet. The stability analysis indicates that for the conditions anticipated during wall construction, the initial factors of safety against trench instability are approximately 1.2 for a trench depth of 60 feet below the existing ground surface and with a work platform height of 3 feet. The calculated factor of safety falls to slightly above 1.0 for a trench depth greater than 60 feet and depth to groundwater of less than or equal to 10 feet and no work platform.

The calculated factors of safety would only be applicable during the trench excavation prior to backfilling the trench. The factor of safety for the backfilled trench would rise to approximate the existing conditions at the Site. The expected consequences of a trench sidewall failure during excavation would be limited to loss of slurry into the weaker soil zones, sloughing of the trench walls resulting in a widening of the trench, and potential localized settlement or subsidence of the ground surface in the area of the trench. A panel method of construction (i.e., sequential installation of wall sections with limited length) may be appropriate based on these conditions (rather than a method of continuous trenching). This method would improve stability and limit the extent of

rework required if a section of trench required reworking. A copy of the trench stability calculations showing input parameters and analysis results are included in Appendix A.

The calculated factors of safety were initially calculated to be lower based solely on data from the initial investigation due, in part, to the presence of low-strength soil layers interspersed within the sand. The lowest strength values (as determined in the laboratory and the field) for these low-strength layers were initially used in the trench stability calculations. Use of these lowest strength values was a very conservative assumption. The lowest strength values determined were from a sample collected 30.0 to 32.0 feet below the ground surface that had a saturated unit weight of approximately 128 pounds per cubic foot, an effective angle of internal friction (phi) of 0.6 degrees, and an effective cohesion of 0.09 kips per square foot (KSF). These laboratory-determined strength values are lower than would reasonably be expected from a soil located 30 feet below the ground surface, and likely do not accurately reflect the in-situ properties of the soil. As a result, a second geotechnical investigation was performed to collect in-place data using vane shear testing (see Section 2.1). The results of this second investigation indicated that the soil layer was not as weak as initial data suggested. BC revised its trench stability calculations using this new data (see Appendix A) and the discussion above regarding factors of safety reflect the new data. Because the trench stability evaluation yielded marginal factors of safety, prior to construction the contractor will be required to conduct additional sample collection and analysis to further define the in-situ properties of the soil. These additional data will be used to re-evaluate trench stability and will be used by the contractor to determine the methods and configuration of construction of the trench. The information collected during the geotechnical investigation and the trench stability analysis will be provided to the prospective contractors during the bidding process. The trench contractor will be required to employ methods that account for the soil characteristics and for successful construction of the trench.

During construction of the trench, the contractor will be required to maintain the level of the slurry to within 1 foot of the ground (or work platform) surface and at least 9 feet above the top of groundwater in sections of the trench with final depths of 60 feet or less. The biopolymer slurry proposed for the trench construction loses viscosity in a relatively short time period (e.g., 1 to 2 days) if additives are not employed to prevent this breakdown. In addition, increases in temperature (e.g., summer construction) also increase the rate at which the biopolymer loses

viscosity. To address these factors, the contractor will be required to maintain sufficient slurry viscosity and to have sufficient reserve quantities of slurry to maintain a stable trench during construction. If the groundwater levels encountered during construction do not meet the anticipated conditions, then the stability of the trench will be re-evaluated. A determination of the necessary mitigation measures (i.e., dewatering, raised work platform, slurry formula alteration, etc.) will then be performed.

3.4 SURFACE WATER DRAINAGE

As stated previously, a small component of groundwater flow currently discharges to the Outfall Ditch on the north side of the project area. To address this flow component, the bottom of a portion of the ditch will be filled to above the historical high groundwater elevation such that groundwater flow does not intercept the bottom of the ditch. This activity will cause the groundwater flow in the immediate area to turn west toward Riverdale Creek similar to the flow patterns in the lower portion of the aquifer. Because a portion of the ditch will be filled, the surface water flow characteristics of the ditch were evaluated such that any impacts from the filling tasks could be addressed. The result of this evaluation is the placement of rip rap along the bottom of that portion of the ditch that will be disturbed and regraded as part of this interim measure.

Flow in the ditch comes from three sources: flow through the existing culvert under the highway that serves an area east of the highway, the NPDES outfall discharge, and incident and local runoff. The largest component of flow is that from the culvert during a significant storm event. This flow is limited by the size of the culvert, which will not be impacted by this interim measure. Therefore, none of the flow components will change as a result of this interim measure. Based on this fact, protection of the regraded ditch was evaluated based on the estimated flows. Flow calculations are included in Appendix A. The results of this evaluation indicate that rip rap will be placed along the entire section of the ditch to be disturbed as part of construction activities. The portion of the ditch from the top of the permeable reactive barrier upstream to the limits of disturbance will be backfilled such that the new slope will be approximately 0.0033 feet/foot (or 0.33 percent). However, the section from the top of the wall to the discharge point into Riverdale Creek will be somewhat steeper at 0.015 feet/foot (or 1.5 percent). Based on these slopes, BC determined that rip

rap will be necessary to address erosion forces. Rip rap placed in the ditch will be underlain by a geotextile to separate the coarse fraction (rip rap) from the underlying soil.

The area of the ditch to be improved is divided into two sections, upstream and downstream of the permeable reactive barrier. Stormwater flow calculations were performed using the Rational Method to estimate both the amount of stormwater runoff expected during a design storm and the material necessary to protect the surfaces of the drainage ditch from erosion in each of these sections. For purposes of design, a storm with a recurrence of 25 years (i.e., a 25-year, 30-minute storm event) was used to define the drainage ditch improvements. Based on the amount of anticipated runoff and the channel geometry, a peak flow of 61 cubic feet per second (cfs) was calculated. Again using channel geometry, maximum depths of flow for each section were estimated at 3 feet upstream of the wall and 2.5 feet downstream of the wall. The amount of ditch lining and protection was also determined. National Stone Association (NSA) R-3 designated rip rap (an average size of 3 inches) is required in both sections of the ditch at a minimum thickness of 8 inches (12 inches will be utilized). The rip rap lining has been extended one foot above the calculated depth of flow to provide freeboard.

During construction activities in the ditch, the contractor will be required to divert the flow in the ditch around the disturbed area into Riverdale Creek. The contractor will likely construct some type of temporary dam or other diversion structure near the upstream limits of work in the ditch. This will allow approximately 400 feet of the eastern portion of the ditch to act as a temporary storage unit while water is pumped around the construction area and into the creek. In addition, the contractor will likely construct a "bridge" across the ditch along the wall alignment to allow trench equipment to cross the ditch. This will create a temporary ponded area between the dam and the "bridge" that the contractor will be required to maintain in a proper working condition (i.e., relatively dry). Finally, the section of ditch between the "bridge" and the discharge point into Riverdale Creek will be filled, graded, and covered with rip rap. During construction activities, a rock filter dam will be constructed across the base of the ditch to filter sediment from stormwater runoff that passes through this disturbed section of the ditch prior to discharging into the creek.

The intent for this project is that construction activities occur during the drier months of the year so that stormwater runoff is unlikely to cause potential problems. However, due to the uncertainty

surrounding precipitation events, the contractor will be required to minimize the time during which the Outfall Ditch is blocked. In addition, the contractor will be required to maintain the water level in the ditch at a maximum depth equal to the invert elevation on the culvert under the highway. The contractor may also be required to allow the NPDES discharge from the facility treatment plant to fill a portion of the blocked ditch and then pump from the collected water at a rate equal to the NPDES discharge flow rate. This is intended to reduce the impact to the flow in Riverdale Creek. Pumping of water collected in the Outfall Ditch is addressed in the technical specifications.

3.5 ENGINEERING DESIGN

Utilizing the various design criteria described in this section, along with the results of the pre-design efforts described in Section 2.0, BC prepared detailed engineering plans and specifications. These plans and specifications are suitable for prospective contractors to bid on the project and for the selected contractor to construct the permeable reactive barrier and related components. A copy of the engineering plans are included as Appendix B. The technical specifications to be included in the bid package are included as Appendix C.

4.0 PLAN FOR SATISFYING PERMIT REQUIREMENTS

Interim measure activities will be performed in accordance with the requirements of applicable federal, state, and local laws and regulations. Implementation of the interim measure is not expected to require the crossing of any streams, railroads, or public roads. Local construction permits and/or approvals associated with the daily construction activities will be the responsibility of the selected contractor and will be discussed and coordinated with local authorities. A discussion of the regulatory issues identified to date is provided below.

4.1 CONSTRUCTION IN WETLANDS AND/OR FLOODPLAIN

Construction of the interim measure will occur in an area adjacent to Riverdale Creek. To accommodate construction of the permeable reactive barrier, an access road and work platform will be necessary. The construction is expected to be relatively brief (i.e., three to four months duration) and portions will be temporary (i.e., only the work platform, access road, and excavated soil along the wall will remain after construction). In addition, the main components of the interim measure will be below grade and there will be minimal net fill associated with this project, which will include the access road/work platform and excavated soil (if they are allowed to remain in place; see Section 4.4) and the Outfall Ditch where roughly half of the ditch will be regraded to include approximately 2 feet of clean backfill above the wall. None of the anticipated activities are expected to drain the area, as standing water appears to result from ponded surface water and does not intersect the aquifer or any surface water body or result from groundwater discharge to the surface.

Initially, it was not clear whether any of these activities would be performed in a wetlands area. A formal determination has not been made whether this area would be classified as jurisdictional wetlands regulated by the United States Army Corps of Engineers (USACE). An interpretation of the National Wetlands Inventory map of the area suggests that a portion of the project area may lie within a wetlands area. However, these maps are prepared primarily by stereoscopic analysis of high altitude aerial photographs and do not necessarily reflect jurisdictional wetland boundaries. Mississippi wetlands regulations appear to be inapplicable to potential wetlands at the Site, as they mostly pertain to coastal wetlands. An application for a Jurisdictional Determination was prepared and submitted to the USACE office in Vicksburg, Mississippi in May 2001 with additional information submitted in July 2001. The request sought the opinion of the USACE as to the

presence of wetlands within the project area and, if wetlands are present, identification of applicable permit requirements (if any).

Subsequent to submittal of the request for a Jurisdictional Determination, conversations with the USACE indicated that they no longer performed wetland delineations; rather, that requirement fell upon the owner. As a result, BC performed a wetland delineation of the project area on behalf of ArvinMeritor in January 2002. This delineation effort also considered the results of a wetland survey performed as part of the RI, which was discussed in Section 4.11 of the RI Report (Eckenfelder Inc., 1994). The results of the January 2002 delineation efforts were reported in a technical memorandum to the USACE (with copies to the USEPA and MDEQ) in August 2002. In general, the delineation indicated that a portion of the project area is located within a wetland area. In the August 2002 technical memorandum, BC requested concurrence from the USACE that the identified wetlands are jurisdictional and indicated that the work may be eligible for permitting under Nationwide Permit #38 (NWP 38, Cleanup of Hazardous and Toxic Waste). A Pre-Construction Notification (PCN) was subsequently transmitted to the USACE in September 2002 notifying it of the request for consideration under NWP 38. A copy of that PCN was also transmitted to the USEPA and MDEQ.

As a result of this written request, the USACE replied that an archaeological survey of the project area must be completed prior to construction. ArvinMeritor and BC are in the process of performing the required survey. This survey will be completed as soon as practicable such that potential impacts to construction of the permeable reactive barrier are avoided or minimized should the site be found to include areas of archaeological significance. Upon completion of the survey, ArvinMeritor and BC anticipate that a written approval from the USACE for construction of the permeable reactive barrier will be granted.

An additional requirement from the USACE for construction in the wetlands area is the provision of a Wetlands Mitigation Plan. The Wetlands Mitigation Plan was transmitted to the USACE on March 4, 2003 with copies to the USEPA and MDEQ. To meet the USACE mitigation requirements, ArvinMeritor and BC evaluated the available options and elected to mitigate the disturbed wetlands by purchasing credits at a wetlands mitigation bank. As part of the Wetlands Mitigation Plan, the USACE also requested that the design include storm culverts under the access road so that run-off in the vicinity of the permeable reactive barrier is not significantly modified.

Based on an evaluation of the project area topography, storm culverts (18-inch diameter) will be installed under the access road at four locations. The approximate locations of these culverts are shown on the design drawings (see Appendix B).

The existing FEMA map for the stretch of Riverdale Creek adjacent to the Site indicates that the project area is within the 100-year floodplain. The Jurisdictional Determination request submitted to the USACE also requests that the USACE provide information regarding applicable permit requirements associated with the interim measure. To date, the USACE has not indicated that such permits are required for this site. As with the wetlands determination, if permits are required for construction within a floodplain, the applicable permit applications will be submitted and approvals received prior to beginning construction activities.

4.2 THREATENED AND ENDANGERED SPECIES SURVEY

As a result of comments from the USEPA on the May 2001 version of this Design Basis Report, BC performed a desktop evaluation of the potential presence of threatened or endangered species in the vicinity of the project area. This evaluation was performed to update a similar evaluation originally performed in 1992 and presented in the 1994 RI Report. The results of the new evaluation were transmitted to ArvinMeritor (with copies to the USEPA and MDEQ) in a letter dated May 9, 2002. In general, the evaluation confirmed that the activities associated with construction of the permeable reactive barrier are not expected to negatively impact any state or federally protected species or habitats. However, in an email dated June 5, 2002, the USEPA requested that a one-day field survey be conducted by a qualified person to verify the results of the desktop evaluations. As stated in Section 3.1 of the CMS Work Plan (October 2002), this field survey will be completed for the project site prior to beginning construction activities and the results of the field survey will be transmitted to the USEPA and MDEQ. This one-day field survey is expected to be completed in May 2003.

4.3 EROSION CONTROLS

Construction of this interim measure will largely follow a linear pattern with activities focused around the alignment of the permeable reactive barrier and the access road. Because the location of the access road will be the responsibility of the contractor, the total area disturbed by construction

activities is unknown. BC contacted a local county official regarding erosion control requirements and we were informed that preparation and transmittal of an erosion and sedimentation control plan is not necessary. The contact stated that there are no city or county requirements for submittal of an erosion control plan. However, the selected contractor will be required to implement and maintain erosion controls as a part of construction. The vicinity in and around the limits of construction has minimal topographic relief (with the exception of the Outfall Ditch). Therefore, temporary erosion controls will take the form of silt fence and/or hay bales surrounding the disturbed area. Within the ditch, erosion controls will include diversion of stormwater, the use of silt fence and/or hay bales, and the use of a rock filter berm. At the completion of the construction activities, the contractor will be required to vegetate disturbed areas using vegetation similar to that existing in the project area.

Part of the construction activities will include the filling and grading of the western portion of the Outfall Ditch. To permanently protect the backfilled area, rip rap will be placed in the ditch along the disturbed portion. The graded length of ditch from the permeable reactive barrier upstream to the limits of grading will have minimal topographic relief and, therefore, requires relatively small crushed stone lining for protection. The segment from the wall to the discharge point into the creek will be somewhat steeper, but calculations indicate the same stone size is appropriate for this length of ditch. Details regarding the placement of the rip rap in the ditch are shown on the engineering drawings included in Appendix B.

4.4 TREATMENT AND/OR DISPOSAL OF EXCAVATED SOIL AND SLURRY

Installation of the permeable reactive barrier will require the excavation of roughly 7,500 cubic yards (in place) of soil. A portion of this soil may be impacted by the groundwater that is to be treated by this wall. Based on existing data, it is likely that the impacted soil will be nonhazardous. However, it is also possible that if treatment or off-site disposal is required constituent concentrations may be high enough that disposal at a local municipal landfill may not be feasible without some pretreatment. Due to the mixing inherent in the slurry trench construction method, the soil above the groundwater surface may be mixed with the impacted soil from below the groundwater surface. As such, the excavated soil may require treatment and/or disposal as part of these construction activities. In addition, once the slurry wall is complete, excess slurry will exist that will also need to

be addressed. This excess slurry will likely be mixed with and handled in the same manner as the excavated soil.

Although it is not anticipated to be required, BC has evaluated disposal and on-site treatment options for handling of the impacted material, if this is required. This evaluation included a review of applicable RCRA regulations, the cost of various options, and the timing involved with the various options. Various treatment options exist that are likely applicable to the conditions at the Site, including low temperature thermal desorption, chemical oxidation (e.g., using sodium or potassium permanganate, ozone, or Fenton's reagent), and biodegradation. Issues relating to treatment that were considered include residual chemicals and byproducts in the treated soil, the need to drain the soil regardless of whether treatment or disposal is selected, and the final disposition of the soil.

Low temperature thermal desorption is likely not the best treatment technology for the types of soil to be encountered during this project. The soil is comprised of a large portion of small size particles (i.e., fine sand and silt) with relatively low constituent concentrations, which may limit the effectiveness of the process. Biodegradation would also not be the best selection for this project due to the longer time required to reach treatment goals and the reduced control over the treatment process. The use of ozone or Fenton's reagent may be more cumbersome, but the process leaves fewer residuals than use of permanganate and, therefore, may be more attractive. The excavated soil will likely have a high water content and, therefore, will need to be drained. This has been addressed by requiring the selected contractor to contain the soil in a bermed area adjacent to and upgradient of the wall and allow the water to drain into the underlying soil.

On-site soil treatment interim measures have been implemented at this Site in the past. The On-Site Landfill Area (SWMU 3) was previously treated using ex-situ soil vapor extraction. The purpose of that interim measure was to remove constituent mass of TCE. Although other VOCs were present, TCE was the only constituent where measured concentrations exceeded the calculated interim target cleanup level. The interim target goal for TCE was calculated to be 7.8 mg/kg. Preliminary indications are that the soil to be excavated during installation of the permeable reactive barrier will exhibit concentrations below this target cleanup level. The selected contractor will be required to characterize the excavated soil as part of this interim measure. Excavated soil will be placed adjacent

to the work platform on the upgradient (east) side of the permeable reactive barrier. Any water in the excavated soil will be allowed to freely drain vertically downward to the groundwater table where it will flow through the wall. The excavated soil will be placed in a thickness no greater than that of the work platform. Once the soil has drained adequately, samples will be collected and analyzed for characterization of the soil. If the soil concentrations exceed the action levels, that portion of the soil will be treated and/or disposed off-site at an appropriate facility. However, if concentrations are below the interim target cleanup level, excavated soil will remain in place along the work platform/access road and will be covered with topsoil and vegetated as part of site restoration activities. Additionally, if excess water accumulates and ponds in this bermed stockpile area, the contractor may be required to remove the water for off-site treatment or disposal.

The decision regarding on-site treatment or off-site disposal will be made by ArvinMeritor based on the soil characterization results. If the volume of soil with TCE concentrations above the interim target goal is relatively small, it is likely that it will be more economically feasible to dispose of the material off-site. However, if the volume is significant, on-site treatment to concentrations below the interim target goal for TCE may be more attractive. At that point, the soil will be treated on-site (or in-situ) and will be placed with the other excavated material adjacent to the work platform.

5.0 INTERIM MEASURE SCHEDULE

A preliminary schedule for implementation of the groundwater interim measure at the Site is shown here as Figure 5-1. The actual schedule is dependent on the following efforts:

- USEPA Review – The time required for the USEPA to complete its review of this document and any others identified by the agencies as requiring approval prior to implementation will directly impact the implementation schedule.

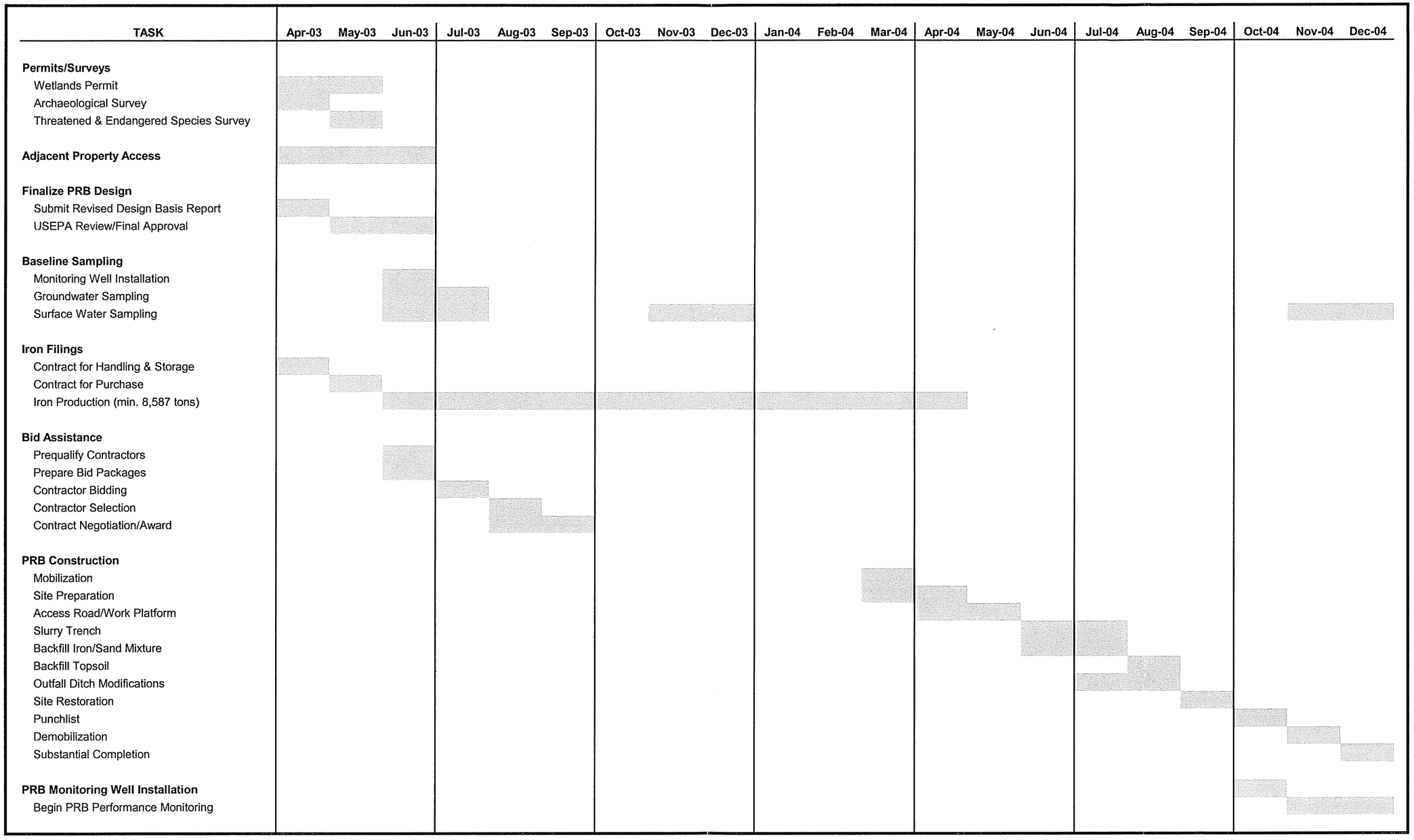
- Permitting Process – A wetlands delineation has been performed at the project site and the results transmitted to the USACE in August 2002 (see Section 4.1). An application for coverage under NWP38 was also transmitted in August 2002 and a Pre-Construction Notification submitted to the USACE in September 2002. As a result of these submittals, the USACE requested that a Wetlands Mitigation Plan be transmitted for review and that an archaeological survey be performed at the project site. The Wetlands Mitigation Plan was transmitted in March 2003. The archaeological survey is tentatively scheduled for April 2003. At the completion of these activities, ArvinMeritor anticipates that final approval for PRB construction will be obtained from the USACE. Construction of the interim measure will not begin until the required permit approvals have been received.

- Access Agreements – ArvinMeritor is currently in negotiations with the owner of the property along Riverdale Creek not owned by Grenada Mfg. Construction of the interim measure will likely not be allowed to begin until the appropriate agreements are in place.

- Identify and Select Contractor – Once the efforts described above are complete (or at least substantially complete), ArvinMeritor will identify and screen prospective contractors, request and review bids, and select a contractor. This effort is not anticipated to require a significant amount of time and may be performed while awaiting completion of the other tasks described above.

- Production of Iron Filings – Information obtained from the likely source of iron filings to be used for this project (Connelly-GPM of Chicago) indicates that iron filings can be produced

FIGURE 5-1
PRELIMINARY PRB CONSTRUCTION SCHEDULE
Grenada Manufacturing Site
Grenada, Mississippi



at a rate of about 1,000 tons per month. Preliminary design scenarios prepared by EnviroMetal Technologies based on Site information and the results of the treatability studies indicate that a minimum of 8,587 tons of iron may be necessary. At this volume, Connelly-GPM has also indicated that an approximate 2-month lead time will be necessary prior to starting production. As a result, it will require approximately 11 months to complete production of all the iron filings necessary for this project. During construction, all of the iron filings will be required in a very short period (i.e., 1 to 2 months). Therefore, construction of the permeable reactive barrier will not start until all or nearly all of the required iron filings have been produced and delivered to the Site.

Due to conditions associated with the area of the Site where the permeable reactive barrier will be constructed, Grenada Mfg. prefers to perform construction during dry weather months (i.e., June through October). At this time, BC anticipates that the entire construction phase will require only approximately three to four months to complete. However, a more detailed construction schedule will be established by the selected contractor as part of its bid.

6.0 CONSTRUCTION QUALITY ASSURANCE

Installation of the permeable reactive barrier will be conducted in accordance with the Construction Quality Assurance Plan (CQAP) included in Appendix D. The technical specifications (Appendix C) for the project define the quality control requirements for the selected contractor. The CQAP addresses the quality assurance requirements for monitoring and documenting conformance with the design plans and specifications. At this time, ArvinMeritor anticipates that a contractor will be identified, selected, and retained directly by ArvinMeritor and an independent engineering firm will be retained to provide construction quality assurance services. It is likely that a single contractor will be selected as the prime contractor and subcontractors (e.g., surveyor and landscaper) will be used.

Prospective contractors will be pre-qualified before the bid solicitation process begins. As such, only qualified contractors will be asked to submit bids for the construction. As part of the bid solicitation process, a Pre-Bid Meeting will be held on Site to enable qualified contractors to view the Site and be briefed on issues related to the Site and the project. At this time, ArvinMeritor expects that the project will be bid as one lump sum contract. Review of bids and selection of a contractor will require approximately two weeks followed by contract negotiations (about two weeks more). Prior to initial mobilization by the selected contractor, a Pre-Construction Meeting will be conducted on Site.

Construction activities are expected to be continuous from the initial mobilization by the contractor through completion and demobilization from the Site. The contractor will be responsible for procurement of all equipment, materials, and labor. An exception to this is the iron filings. ArvinMeritor will initially procure the iron. However, once a contractor is selected ArvinMeritor anticipates that the related necessary contracts for iron purchase, handling, and storage will be transferred to the selected contractor. Submittals are required by the technical specifications to be approved prior to use or implementation of the associated equipment or materials. The prime contractor will be responsible for health and safety of all on-site personnel. Prior to demobilization, a Final Construction Inspection will be conducted and preparation of a Final Construction Report will begin. Operation and maintenance in accordance with the Performance Monitoring Plan (see Section 7.0) will also begin after demobilization.

7.0 PERFORMANCE MONITORING

The interim measure discussed in this Design Basis Report was selected, in part, due to its low operation and maintenance requirements. The installation anticipated for this Site is expected to require only groundwater monitoring for long-term operation and maintenance tasks (although some iron "regeneration" may be necessary periodically, i.e., approximately every ten years, if needed). This monitoring program has been established based on the results of bench-scale treatability studies using groundwater collected from the Site and granular iron to be used in the permeable reactive barrier (see Section 2.0). A Performance Monitoring Plan is included as Appendix E and it outlines the sampling parameters and frequency, as well as the reporting requirements for the interim measure. In addition, the Performance Monitoring Plan outlines a site-wide groundwater monitoring program to be used to monitor all past, on-going, and future interim and final corrective measures.

In general, the primary approach for monitoring the effectiveness of the permeable reactive barrier will be through the use of groundwater monitoring wells installed following construction of the wall. These wells will be located upgradient and downgradient of the permeable reactive barrier, as well as within the wall. Due to the hydrogeology in this area of the Site, monitoring wells will be installed such that the upper and lower portions of the aquifer can be monitored separately using nested pairs of monitoring wells. The number and location of the wells to be used to monitor the wall depend, in part, on the variability of the wall thickness and the observed concentrations for the key constituents of concern. Preliminary well locations are shown on the engineering drawings (Appendix B; sheets 03 and 04). Where possible, existing monitoring wells have been utilized to monitor the wall (particularly the upgradient side). However, as noted in the Performance Monitoring Plan, additional wells have been proposed to supplement the existing network.

To monitor the effectiveness of the wall, groundwater samples will be analyzed primarily for select VOCs and metals. Because SVOCs are less of a concern in this area of the Site, these parameters will not be included in the more frequent monitoring program. Instead, SVOCs will be included in a less frequent site-wide monitoring program.

In addition to groundwater monitoring, surface water sampling and analysis will be performed, at the request of the USEPA, to monitor Site constituents in Riverdale Creek. In general, the surface water monitoring will be very similar to the groundwater monitoring for the permeable reactive barrier (i.e., the same frequency and parameters). However, surface water sampling will begin prior to installation of the permeable reactive barrier to obtain more recent data to supplement that collected during the RI and to establish a "baseline" for the creek. In fact, the surface water sample locations proposed in the Performance Monitoring Plan approximate those of the RI.

APPENDIX A

DESIGN CALCULATIONS

- Geotechnical Testing Results
- Initial Trench Stability Calculations
- Van Shear Report and Revised Trench Stability Calculations
- Outfall Ditch Flow Calculations

GEOTECHNICAL TESTING RESULTS

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May 2, 2001

Brown & Caldwell Consultants
501 Great Circle Road, Suite 150
Nashville, Tennessee 37228

Attention: Mr. Mike Freehling

Subject: Soil Testing
QORE Job No. 22258, Report No. 191146

Gentlemen:

QORE, Inc. has completed the laboratory testing on the soil samples sent by your office. The following tests were performed:

- Natural Moisture Content (ASTM D-2216)
- Atterberg Limits (ASTM D-4318)
- Unit Weight
- UU with Pore Pressure (ASTM D-2850)
- Direct Shear (ASTM D-3080)

QORE, Inc. performs soil tests in general accordance with the applicable American Society for Testing and Materials (ASTM) or AASHTO procedures. These procedures are generally recognized as the basis for uniformity and consistency of test results in the geotechnical engineering profession. All the work is supervised by a qualified engineer. Attached are test results for your review.

QORE, Inc. appreciates the opportunity to provide these laboratory services. Please contact us if you have any questions concerning this report or if we may be of further service.

Respectfully submitted,
QORE, INC.

Ashok K. Mangla

Ashok K. Mangla, B.E. (Civil)
Geotechnical Laboratory Manager
Member ASTM D-18, D-35

C. Scott Fletcher

C. Scott Fletcher, P.E.
Chief Geotechnical Engineer
Reg. Ga. 16170

AKM/CSF/jk
Attachment

11420 Johns Creek Parkway Duluth, Georgia 30097 (770) 476-3555 fax (770) 476-0213

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TRIAXIAL SHEAR TEST REPORT
(ASTM D 2850)

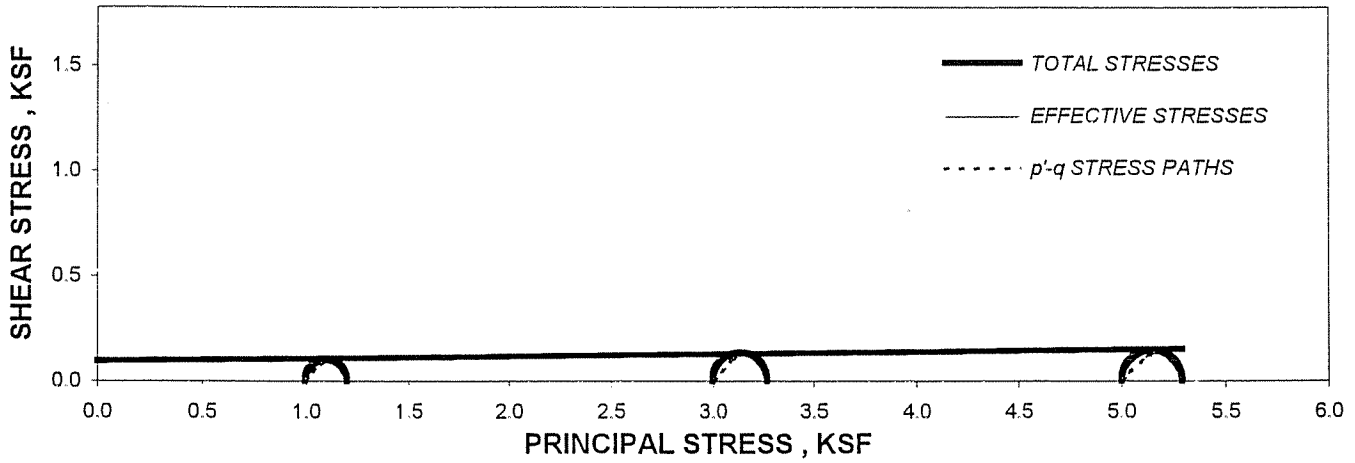
JOB NAME:	Arvin - Meritor Site				
JOB NO.:	22258	REPORT NO. :	191146	REVIEWED BY :	DATE 4/24/01
BORING / PIT NO. :	B-1	DEPTH / ELEV. :	30'-32'	SAMPLE NO . : -	TYPE: UD
SAMPLE LOCATION :	-				
SOIL DESCRIPTION :	Gray silty fine to medium sand .				
LIQUID LIMIT, % :	N.P.	PLASTICITY INDEX , % :	N.P.	FINES, % : 23	G_s : 2.67

SPECIMEN PROPERTIES									TEST TYPE : UU / PORE PRESSURE				
	INITIAL				AFTER CONSOLIDATION				TEST PARAMETERS				
SPECIMEN NO.		1	2	3		1	2	3	SPECIMEN NO.		1	2	3
DIAMETER , INCHES	D_o	2.88	-	-	D_c	2.87	-	-	BACK PRESSURE, KSF	U_o	1.0	3.0	5.0
HEIGHT , INCHES	H_o	5.90	-	-	H_c	5.89	-	-	CONFINING PRESSURE , KSF	σ_3	1.0	3.0	5.0
WATER CONTENT, %	W_o	21.3	-	-	W_c	21.4	-	-	MAX. DEVIATOR STRESS ,KSF	σ_1-σ_3	-	-	0.3
DRY DENSITY, PCF	γ_{dryo}	105.0	-	-	γ_{dryc}	105.9	-	-	ULT. DEVIATOR STRESS , KSF	σ_1-σ_3	-	-	0.2
SATURATION ,%	S_o	97.5	-	-	S_c	100	-	-	CONTROLLED				
VOID RATIO	e_o	0.583	-	-	e_c	0.571	-	-	Strain @ 0.5 % per minute				

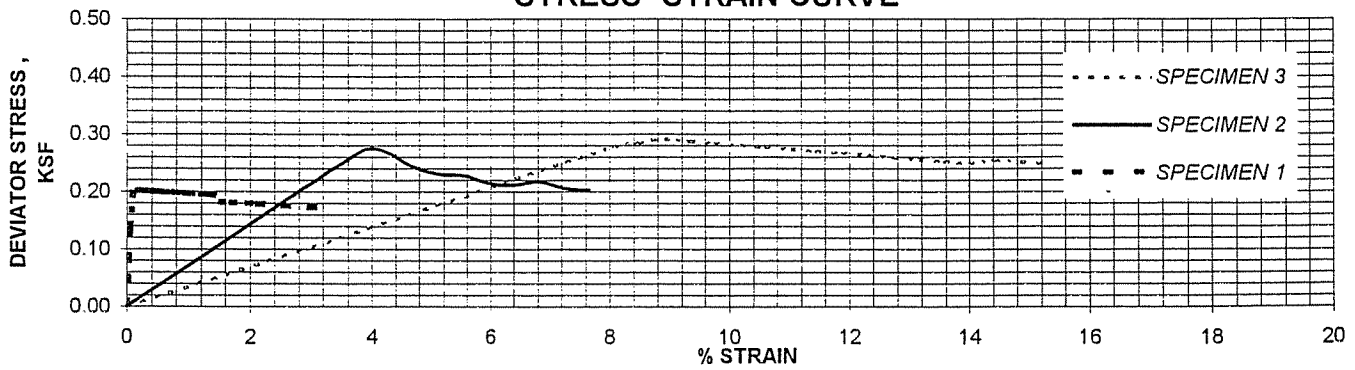
NOTE : *THIS IS A MULTISTAGE TRIAXIAL*

SHEAR STRENGTH PARAMETERS	TOTAL	EFFECTIVE
	COHESION , C (KSF) : 0.09	COHESION , C' (KSF) : 0.09
	ANGLE OF INTER. FRICTION, Φ(DEGREES) : 0.6	ANGLE OF INTER. FRICTION, Φ' (DEGREES) : 0.6

MOHR / p'-q DIAGRAM



STRESS- STRAIN CURVE



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TRIAXIAL SHEAR TEST REPORT
(ASTM D 2850)

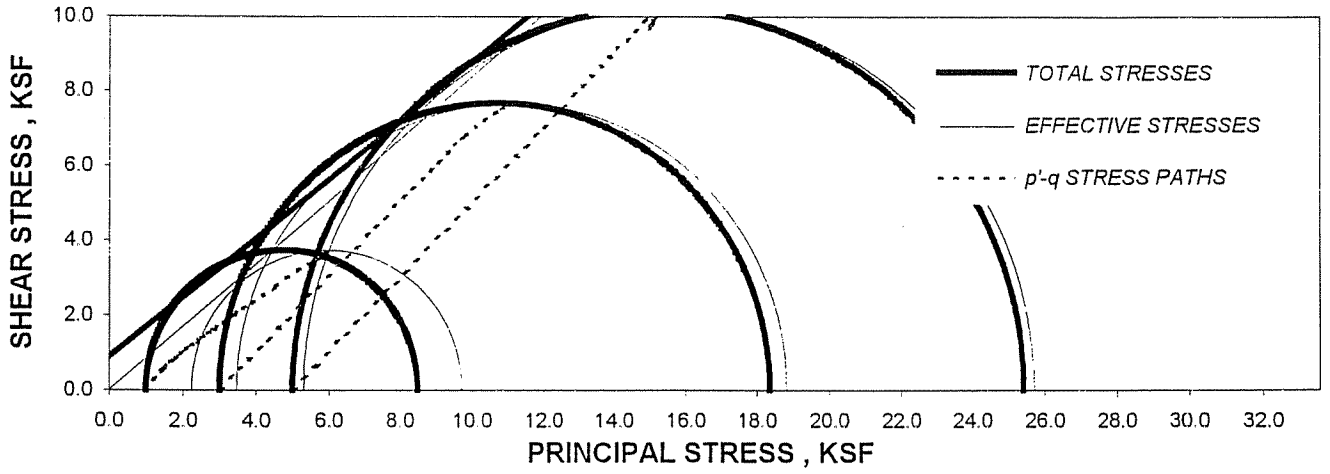
JOB NAME:	Arvin - Meritor Site						
JOB NO.:	22258	REPORT NO. :	191146	REVIEWED BY :		DATE	4/24/01
BORING / PIT NO. :	B-2	DEPTH / ELEV. :	33.5'-35.5'	SAMPLE NO . :	-	TYPE:	UD
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Gray fine to medium sand .						
LIQUID LIMIT, % :	N.P.	PLASTICITY INDEX , % :	N.P.	FINES, % :	5	G_s :	2.63

SPECIMEN PROPERTIES									TEST TYPE : UU / PORE PRESSURE				
		INITIAL			AFTER CONSOLIDATION				TEST PARAMETERS				
SPECIMEN NO.		1	2	3		1	2	3	SPECIMEN NO.		1	2	3
DIAMETER , INCHES	D_o	2.88	-	-	D_c	2.88	-	-	BACK PRESSURE, KSF	U_o	0.5	-0.4	-0.9
HEIGHT , INCHES	H_o	5.60	-	-	H_c	5.59	-	-	CONFINING PRESSURE , KSF	σ_3'	1.0	3.0	5.0
WATER CONTENT, %	W_o	24.3	-	-	W_c	27.0	-	-	MAX. DEVIATOR STRESS ,KSF	$\sigma_1-\sigma_3$	-	-	20.4
DRY DENSITY, PCF	γ_{dryo}	95.7	-	-	γ_{dryc}	96.1	-	-	ULT. DEVIATOR STRESS , KSF	$\sigma_1-\sigma_3$	-	-	19.4
SATURATION ,%	S_o	89.5	-	-	S_c	100	-	-	CONTROLLED				
VOID RATIO	e_o	0.716	-	-	e_c	0.710	-	-	Strain @ 0.5 % per minute				

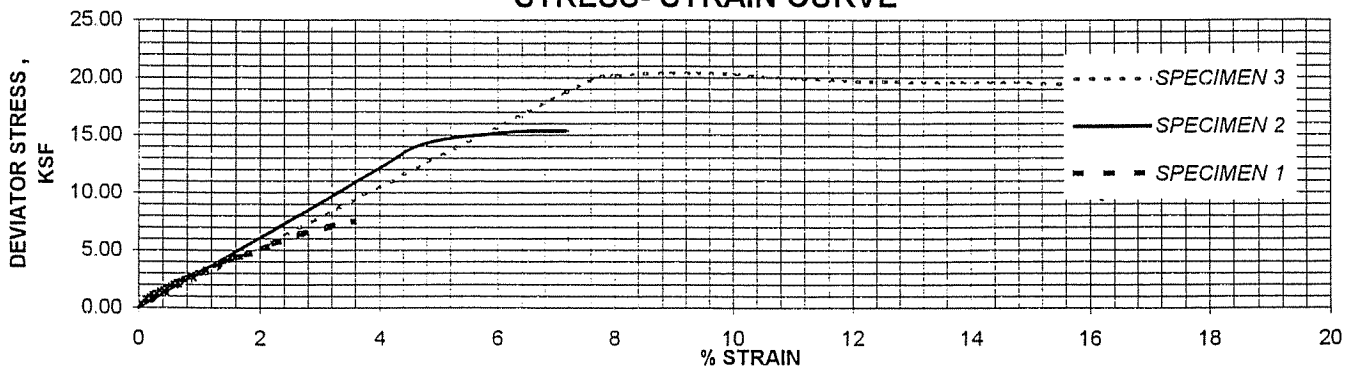
NOTE : *THIS IS A MULTISTAGE TRIAXIAL*

SHEAR STRENGTH PARAMETERS	TOTAL	EFFECTIVE
	COHESION , C (KSF) : **0.88**	COHESION , C' (KSF) : **0.00**
	ANGLE OF INTER. FRICTION, Φ(DEGREES) : **38.3**	ANGLE OF INTER. FRICTION, Φ' (DEGREES) : **40.0**

MOHR / p'-q DIAGRAM



STRESS- STRAIN CURVE



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TRIAXIAL SHEAR TEST REPORT
(ASTM D 2850)

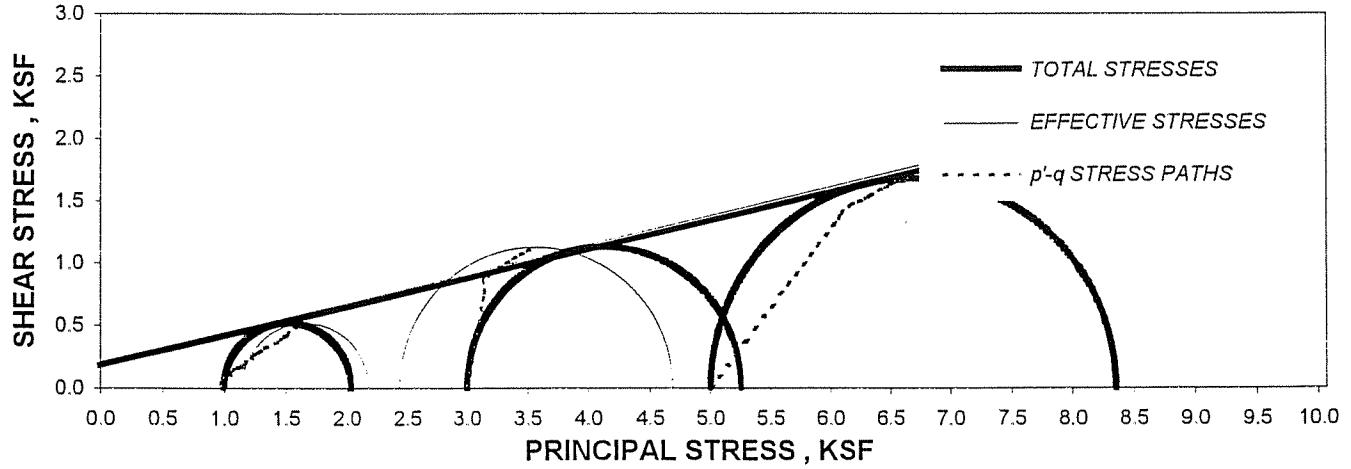
JOB NAME:	Arvin - Meritor Site						
JOB NO.:	22258	REPORT NO. :	191146	REVIEWED BY :		DATE	4/24/01
BORING / PIT NO. :	B-3	DEPTH / ELEV. :	26'-28'	SAMPLE NO . :	-	TYPE:	UD
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Gray fine to medium sand .						
LIQUID LIMIT, % :	N.P.	PLASTICITY INDEX , % :	N.P.	FINES, % :	4	G_s :	2.65

SPECIMEN PROPERTIES									TEST TYPE : UU / PORE PRESSURE				
	INITIAL				AFTER CONSOLIDATION				TEST PARAMETERS				
SPECIMEN NO.		1	2	3		1	2	3	SPECIMEN NO.		1	2	3
DIAMETER , INCHES	D_o	2.87	-	-	D_c	2.86	-	-	BACK PRESSURE, KSF	U_o	0.9	1.8	3.8
HEIGHT , INCHES	H_o	5.89	-	-	H_c	5.87	-	-	CONFINING PRESSURE , KSF	σ_3	1.0	3.0	5.0
WATER CONTENT, %	W_o	31.5	-	-	W_c	26.8	-	-	MAX. DEVIATOR STRESS ,KSF	σ_1-σ_3	-	-	3.4
DRY DENSITY, PCF	γ_{dryo}	95.7	-	-	γ_{dryc}	96.7	-	-	ULT. DEVIATOR STRESS , KSF	σ_1-σ_3	-	-	3.4
SATURATION ,%	S_o	114.6	-	-	S_c	100	-	-	CONTROLLED				
VOID RATIO	e_o	0.728	-	-	e_c	0.710	-	-	Strain @ 0.5 % per minute				

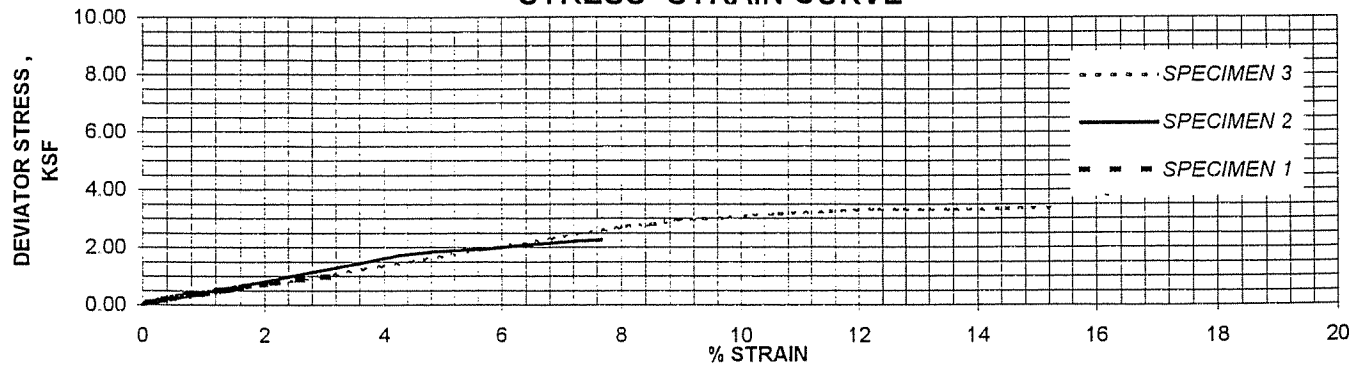
NOTE : *THIS IS A MULTISTAGE TRIAXIAL*

SHEAR STRENGTH PARAMETERS	TOTAL	EFFECTIVE
	COHESION , C (KSF) : **0.19**	COHESION , C' (KSF) : **0.21**
	ANGLE OF INTER. FRICTION, Φ(DEGREES) : **13.0**	ANGLE OF INTER. FRICTION, Φ' (DEGREES) : **13.1**

MOHR / p'-q DIAGRAM



STRESS- STRAIN CURVE



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TRIAXIAL SHEAR TEST REPORT
(ASTM D 2850)

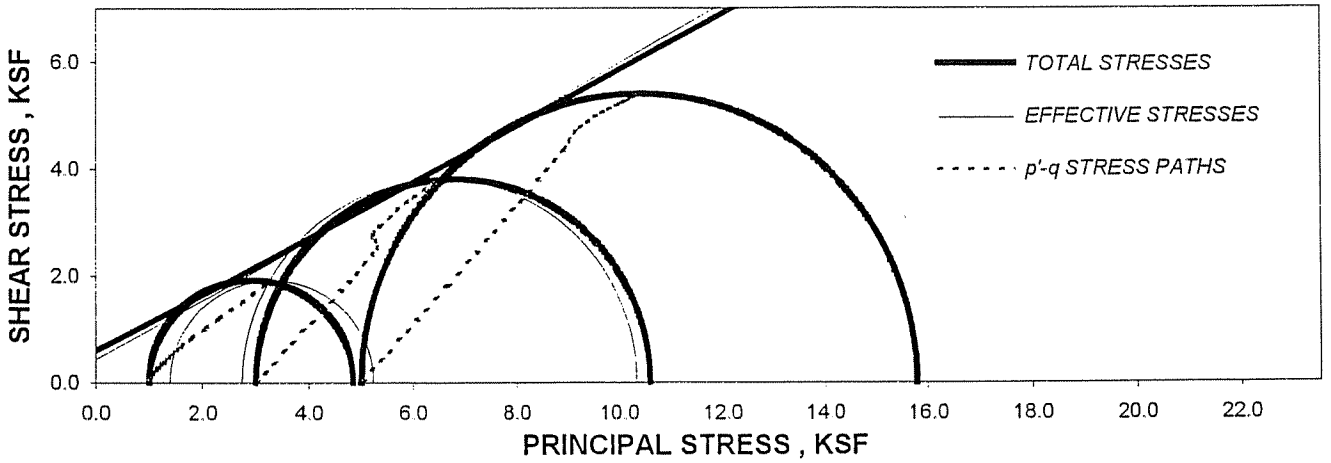
JOB NAME:	Arvin - Meritor Site				
JOB NO.:	22258	REPORT NO. :	191146	REVIEWED BY :	DATE 4/24/01
BORING / PIT NO. :	B-4	DEPTH / ELEV. :	26'-28'	SAMPLE NO . : -	TYPE: UD
SAMPLE LOCATION : -					
SOIL DESCRIPTION :	Gray fine to medium sand .				
LIQUID LIMIT, % :	N.P.	PLASTICITY INDEX , % :	N.P.	FINES, % : 3	G_s : 2.62

SPECIMEN PROPERTIES									TEST TYPE : UU / PORE PRESSURE				
	INITIAL				AFTER CONSOLIDATION				TEST PARAMETERS				
SPECIMEN NO.		1	2	3		1	2	3	SPECIMEN NO.		1	2	3
DIAMETER , INCHES	D_o	2.86	-	-	D_c	2.86	-	-	BACK PRESSURE, KSF	U_o	0.7	0.8	1.4
HEIGHT , INCHES	H_o	5.94	-	-	H_c	5.93	-	-	CONFINING PRESSURE , KSF	σ_3'	1.0	3.0	5.0
WATER CONTENT, %	W_o	18.7	-	-	W_c	17.9	-	-	MAX. DEVIATOR STRESS ,KSF	$\sigma_1-\sigma_3$	-	-	10.8
DRY DENSITY, PCF	γ_{dryo}	110.8	-	-	γ_{dryc}	111.4	-	-	ULT. DEVIATOR STRESS , KSF	$\sigma_1-\sigma_3$	-	-	10.8
SATURATION ,%	S_o	103.1	-	-	S_c	100	-	-	CONTROLLED				
VOID RATIO	e_o	0.477	-	-	e_c	0.469	-	-	Strain @ 0.5 % per minute				

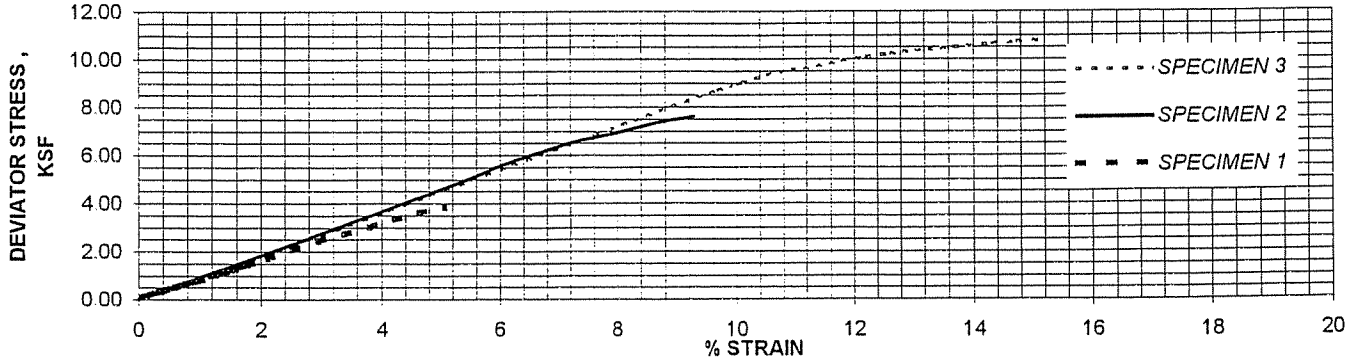
NOTE : *THIS IS A MULTISTAGE TRIAXIAL*

SHEAR STRENGTH PARAMETERS	TOTAL	EFFECTIVE
	COHESION , C (KSF) : **0.59**	COHESION , C' (KSF) : **0.43**
	ANGLE OF INTER. FRICTION, Φ(DEGREES) : **27.7**	ANGLE OF INTER. FRICTION, Φ' (DEGREES) : **29.0**

MOHR / p'-q DIAGRAM



STRESS- STRAIN CURVE



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TRIAXIAL SHEAR TEST REPORT
(ASTM D 2850)

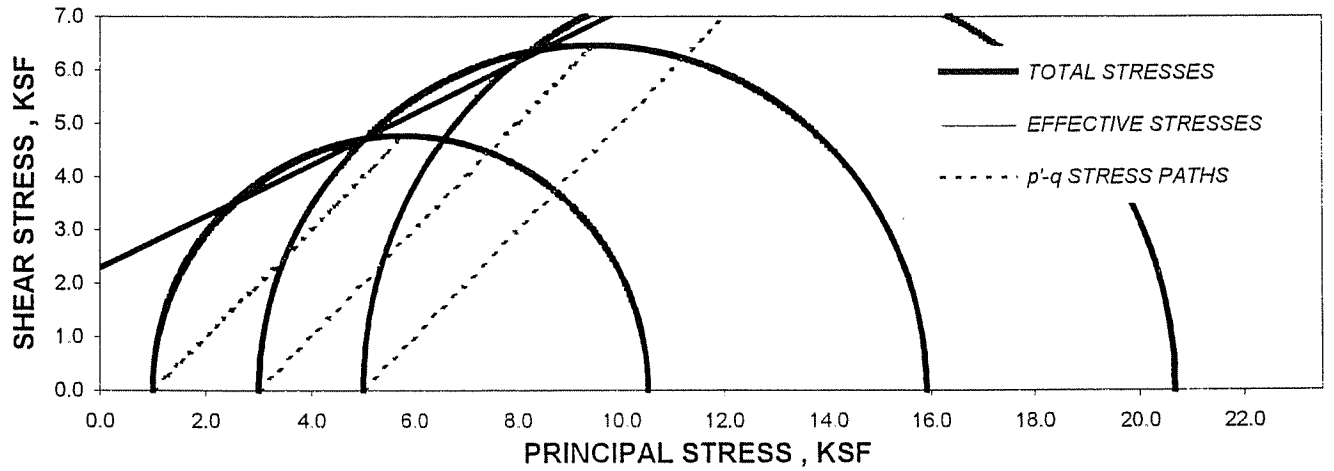
JOB NAME:	Arvin - Meritor Site						
JOB NO.:	22258	REPORT NO. :	191146	REVIEWED BY:		DATE	4/24/01
BORING / PIT NO. :	B-5	DEPTH / ELEV. :	6'-8'	SAMPLE NO . :	-	TYPE:	UD
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Gray silty fine to medium sand .						
LIQUID LIMIT, % :	23	PLASTICITY INDEX , % :	4	FINES, % :	58	G_s :	2.61

SPECIMEN PROPERTIES									TEST TYPE : UU				
	INITIAL				AFTER CONSOLIDATION				TEST PARAMETERS				
SPECIMEN NO.		1	2	3		1	2	3	SPECIMEN NO.		1	2	3
DIAMETER , INCHES	D_o	2.86	-	-	D_c	2.85	-	-	BACK PRESSURE, KSF	U_o	0.0	0.0	0.0
HEIGHT , INCHES	H_o	5.86	-	-	H_c	5.85	-	-	CONFINING PRESSURE , KSF	σ_3'	1.0	3.0	5.0
WATER CONTENT, %	W_o	10.8	-	-	W_c	20.6	-	-	MAX. DEVIATOR STRESS ,KSF	$\sigma_1-\sigma_3$	-	-	15.7
DRY DENSITY, PCF	γ_{dryo}	105.1	-	-	γ_{dryc}	105.9	-	-	ULT. DEVIATOR STRESS , KSF	$\sigma_1-\sigma_3$	-	-	15.0
SATURATION ,%	S_o	51.2	-	-	S_c	100	-	-	CONTROLLED				
VOID RATIO	e_o	0.549	-	-	e_c	0.537	-	-	Strain @ 0.5 % per minute				

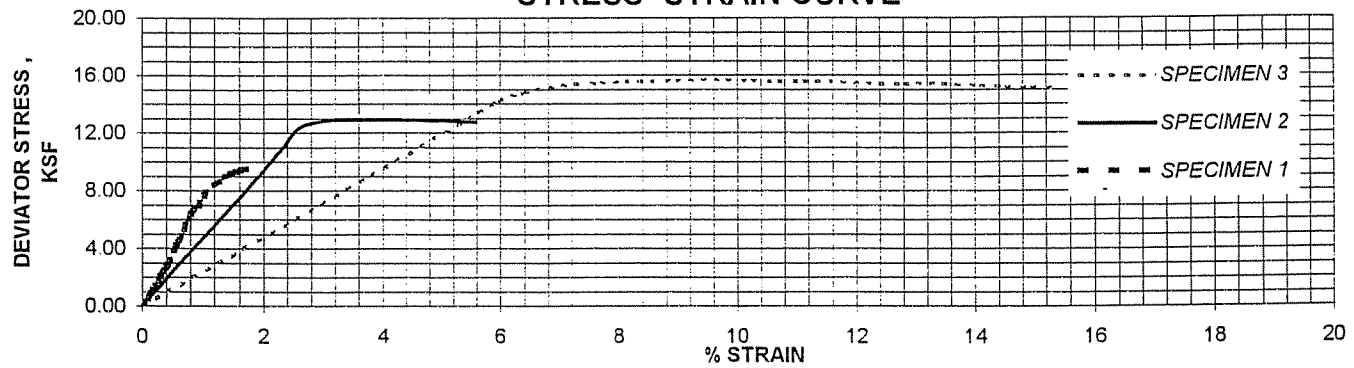
NOTE : *THIS IS A MULTISTAGE TRIAXIAL*

SHEAR STRENGTH PARAMETERS	TOTAL	EFFECTIVE
	COHESION , C (KSF) : **2.29**	COHESION , C' (KSF) : -
	ANGLE OF INTER. FRICTION, Φ(DEGREES) : **25.7**	ANGLE OF INTER. FRICTION, Φ' (DEGREES) : -

MOHR / p'-q DIAGRAM

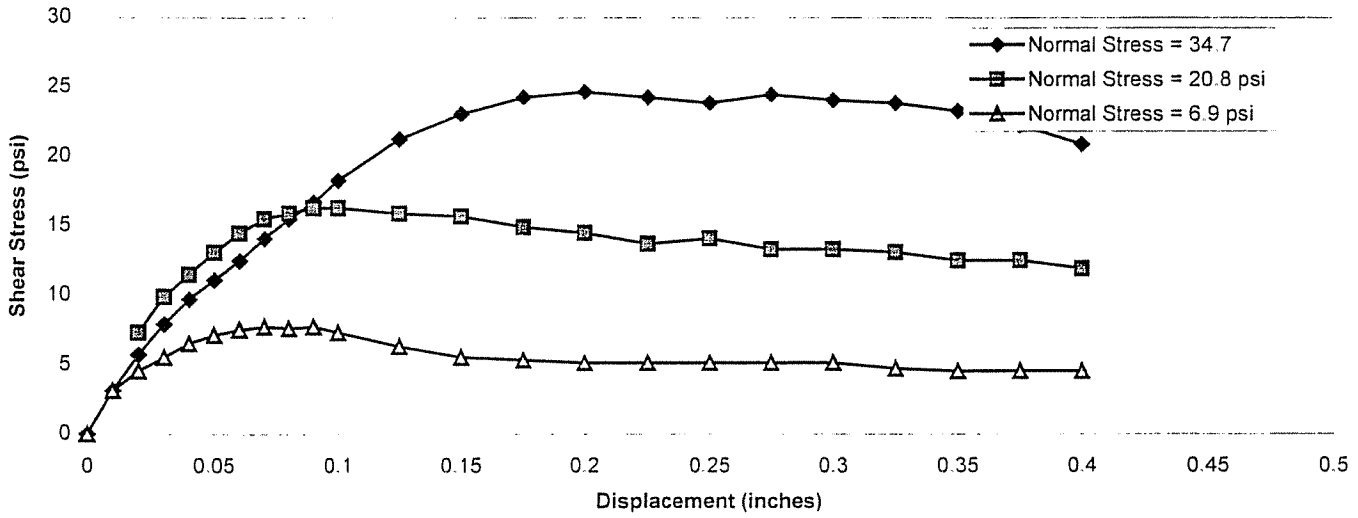


STRESS- STRAIN CURVE



DIRECT SHEAR TEST REPORT
(ASTM D 3080)

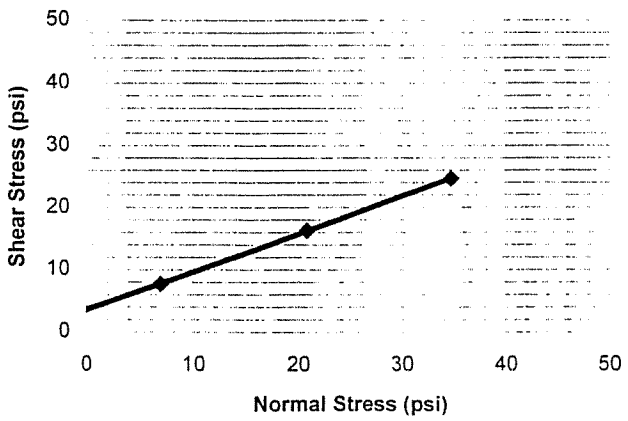
Job Name:	**Arvin Meritor Site**	**Job Number:**	22258
Location:	**B - 2 @ 43.5'-45.5'**	**Report Number:**	191146
Interface Tested:	Internal Shear Strength		
Soil Description:	Greyish silty fine to medium sand .		
Test Conditions:	Inundated		
Shear Rate:	0.010 Inches per minute		
Reviewed By:			



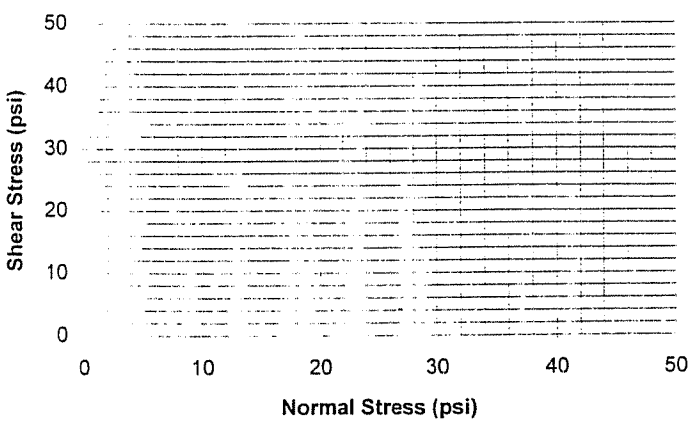
SPECIMEN NO.	MOISTURE CONTNET %	DRY UNIT WEIGHT PCF	POROSITY	% FINES
1	28.6	93.7	0.434	
2	33.1	91.8	0.445	
3	33.5	89.8	0.457	24

Normal Stress (psi)	Shear Stress		SOIL	Peak		Residual	
	Peak (psi)	Residual (psi)	Final Moisture Content (%)	ϕ (degrees)	c_c (psi)	ϕ (degrees)	c_c (psi)
6.9	7.70	-	-	**31.3**	**3.5**	-	-
20.8	16.26	-	-				
34.7	24.62	-	-				

Peak Shear Stress

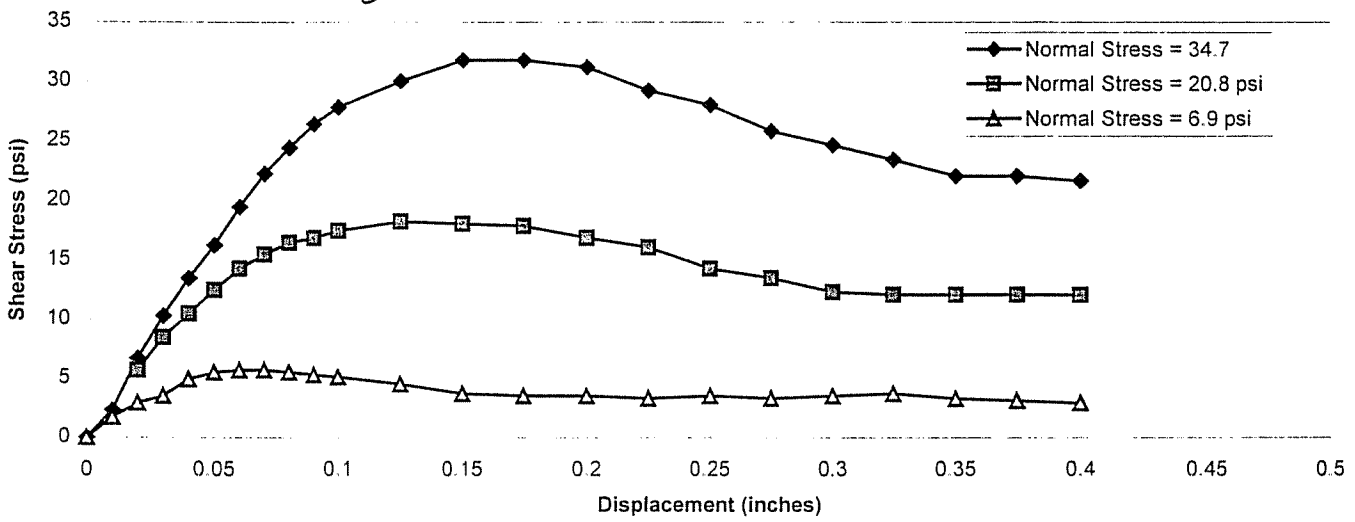


Residual Shear Stress



DIRECT SHEAR TEST REPORT
(ASTM D 3080)

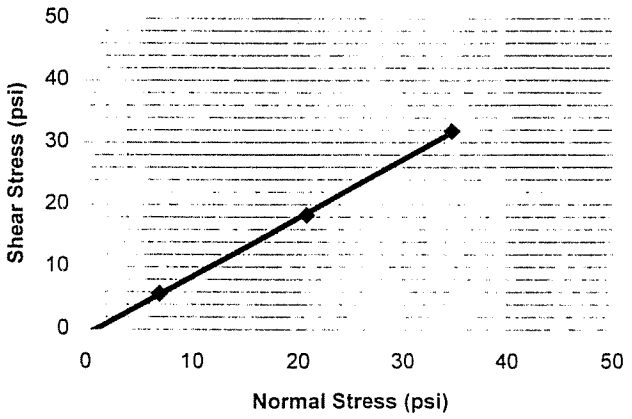
Job Name:	**Arvin Meritor Site**	**Job Number:**	22258
Location:	**B - 3 @ 46.6'-47.6'**	**Report Number:**	191146
Interface Tested:	Internal Shear Strength		
Soil Description:	Tan fine to medium sand .		
Test Conditions:	Inundated		
Shear Rate:	0.010 Inches per minute		
Reviewed By:			



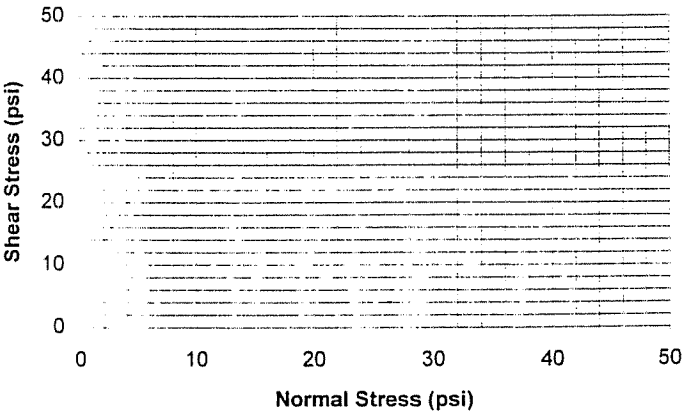
SPECIMEN NO.	MOISTURE CONTNET %	DRY UNIT WEIGHT PCF	POROSITY	% FINES
1	29.9	95.2	0.426	
2	25.9	102.1	0.385	
3	27.6	99.1	0.403	2

Normal Stress (psi)	Shear Stress		SOIL	Peak		Residual	
	Peak (psi)	Residual (psi)	Final Moisture Content (%)	ϕ (degrees)	c_c (psi)	ϕ (degrees)	c_c (psi)
6.9	5.71	-	-	**43.2**	**-0.9**	-	-
20.8	18.25	-	-				
34.7	31.78	-	-				

Peak Shear Stress

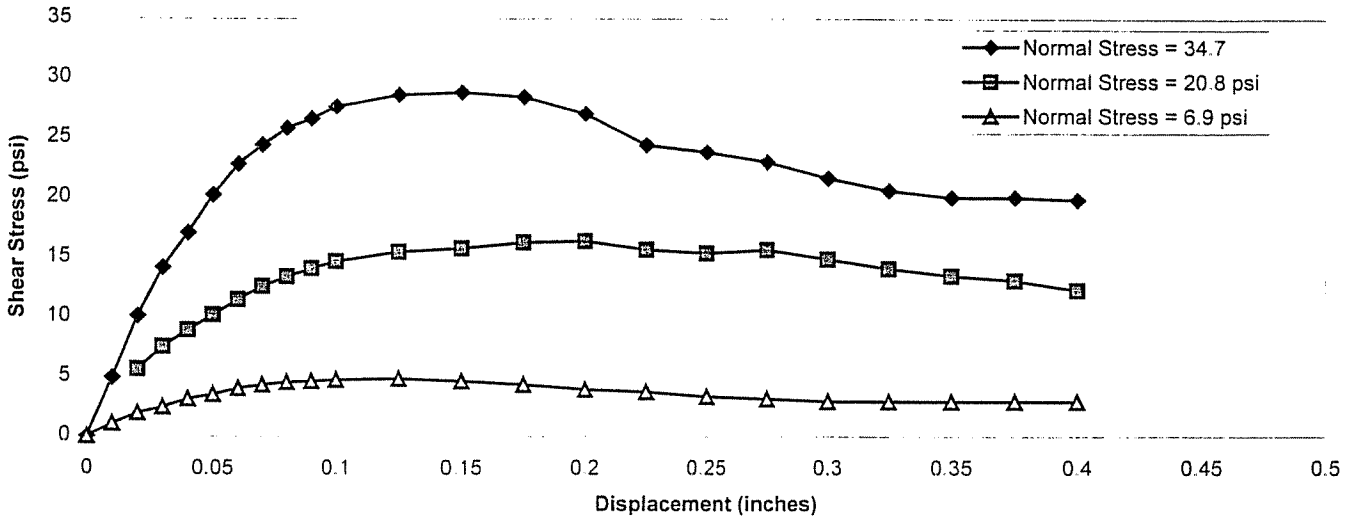


Residual Shear Stress



DIRECT SHEAR TEST REPORT
(ASTM D 3080)

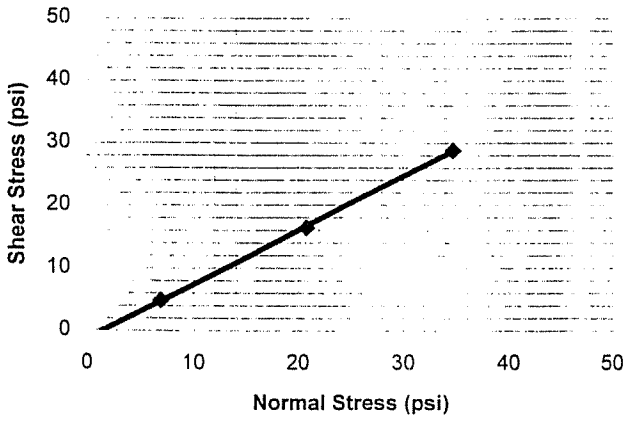
Job Name:	**Arvin Meritor Site**	**Job Number:**	22258
Location:	**B - 5 @ 47'-49.2'**	**Report Number:**	191146
Interface Tested:	Internal Shear Strength		
Soil Description:	Tan fine to medium sand .		
Test Conditions:	Inundated		
Shear Rate:	0.010 Inches per minute		
Reviewed By:			



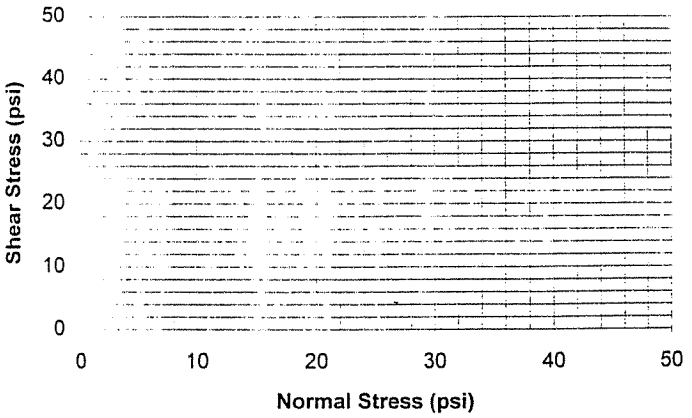
SPECIMEN NO.	MOISTURE CONTNET %	DRY UNIT WEIGHT PCF	POROSITY	% FINES
1	26.2	93.8	0.434	
2	30.1	92.2	0.443	
3	28.3	93.6	0.435	2

Normal Stress (psi)	Shear Stress Peak (psi)	Shear Stress Residual (psi)	SOIL Final Moisture Content (%)	Peak ϕ (degrees)	Peak c_c (psi)	Residual ϕ (degrees)	Residual c_c (psi)
6.9	4.82	-	-	**40.8**	**-1.3**	-	-
20.8	16.36	-	-				
34.7	28.79	-	-				

Peak Shear Stress



Residual Shear Stress



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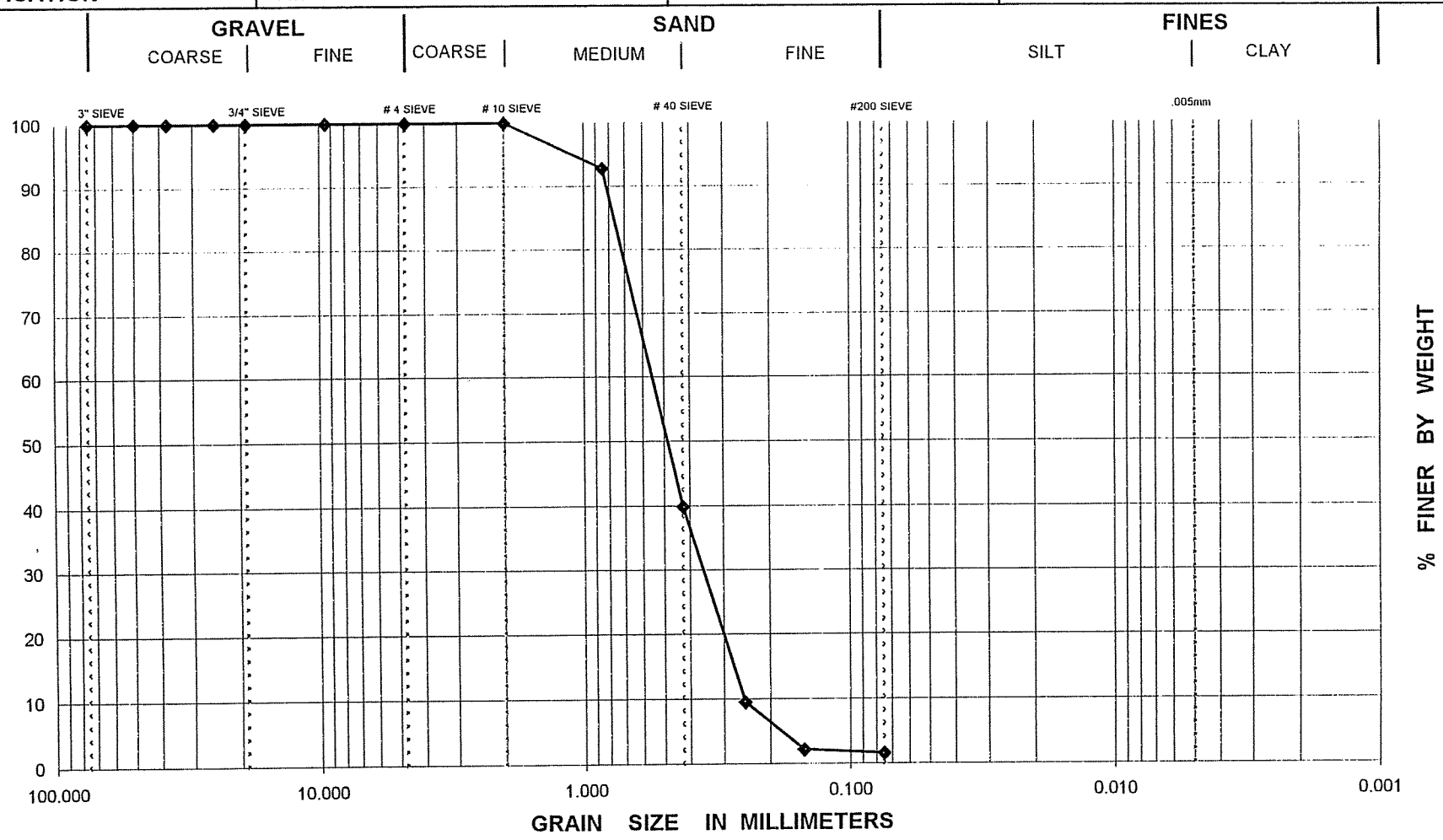
PROPERTY SCIENCES

GRAIN SIZE DISTRIBUTION TEST REPORT

(ASTM D422)

AAP AASHTO R18

JOB NAME :	Arvin - Meritor Site						
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01	REVIEWED BY :	
BORING / PIT NO. :	B-3	DEPTH / ELEV. :	46'-47'	SAMPLE NO. :	-	SAMPLE TYPE :	UD
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Tan fine to medium sand .					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	-	FINES , % :	2
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-



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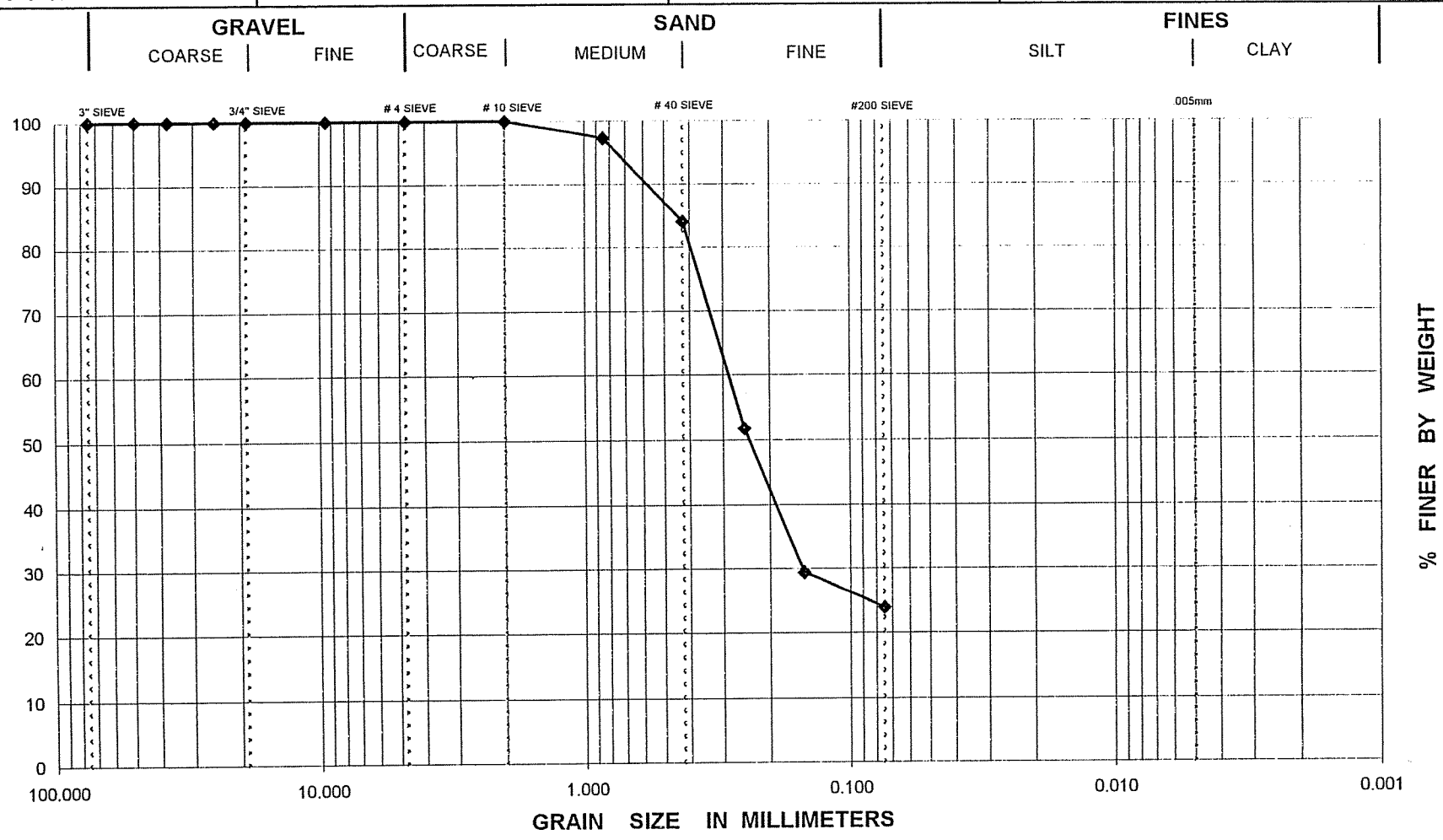
GRAIN SIZE DISTRIBUTION TEST REPORT
(ASTM D422)

AAP℠ AASHTO R18

JOB NAME :	*Arvin - Meritor Site*						
JOB NO. :	*22258*	REPORT NO. :	*191146*	DATE :	4/25/01	REVIEWED BY :	
BORING / PIT NO. :	*B-2*	DEPTH / ELEV. :	*43.5'-45'*	SAMPLE NO. :	-	SAMPLE TYPE :	*UD*
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	*Greyish silty fine to medium sand .*					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	-	FINES , % :	*24*
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-



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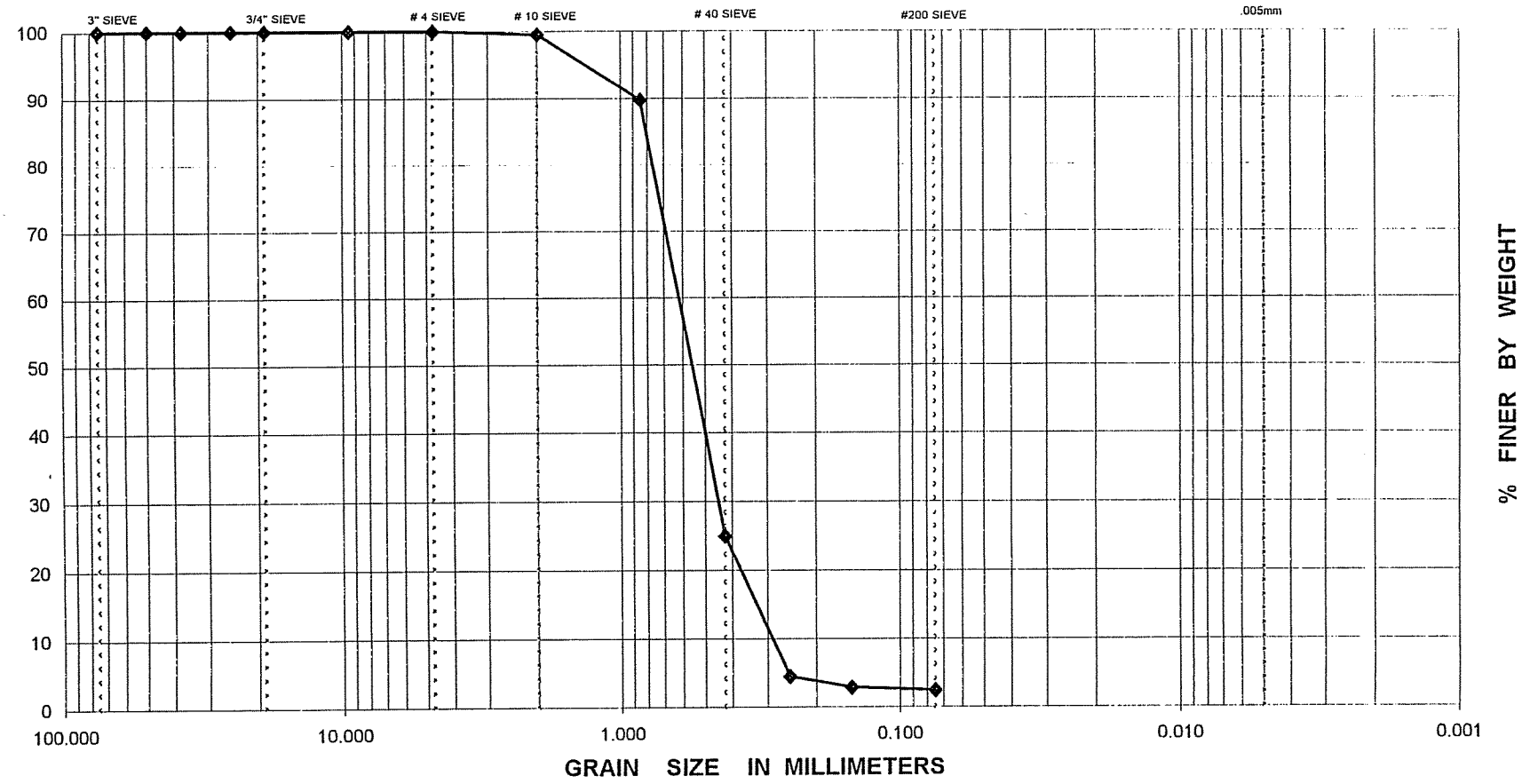
GRAIN SIZE DISTRIBUTION TEST REPORT

(ASTM D422)

AAP AASHTO R18

JOB NAME :	*Arvin - Meritor Site*						
JOB NO. :	*22258*	REPORT NO. :	*191146*	DATE :	4/25/01	REVIEWED BY	
BORING / PIT NO. :	*B-5*	DEPTH / ELEV. :	*47'-49'*	SAMPLE NO. :	-	SAMPLE TYPE :	*UD*
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	*Tan gray fine to medium sand .*					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	-	FINES , % :	*2*
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-



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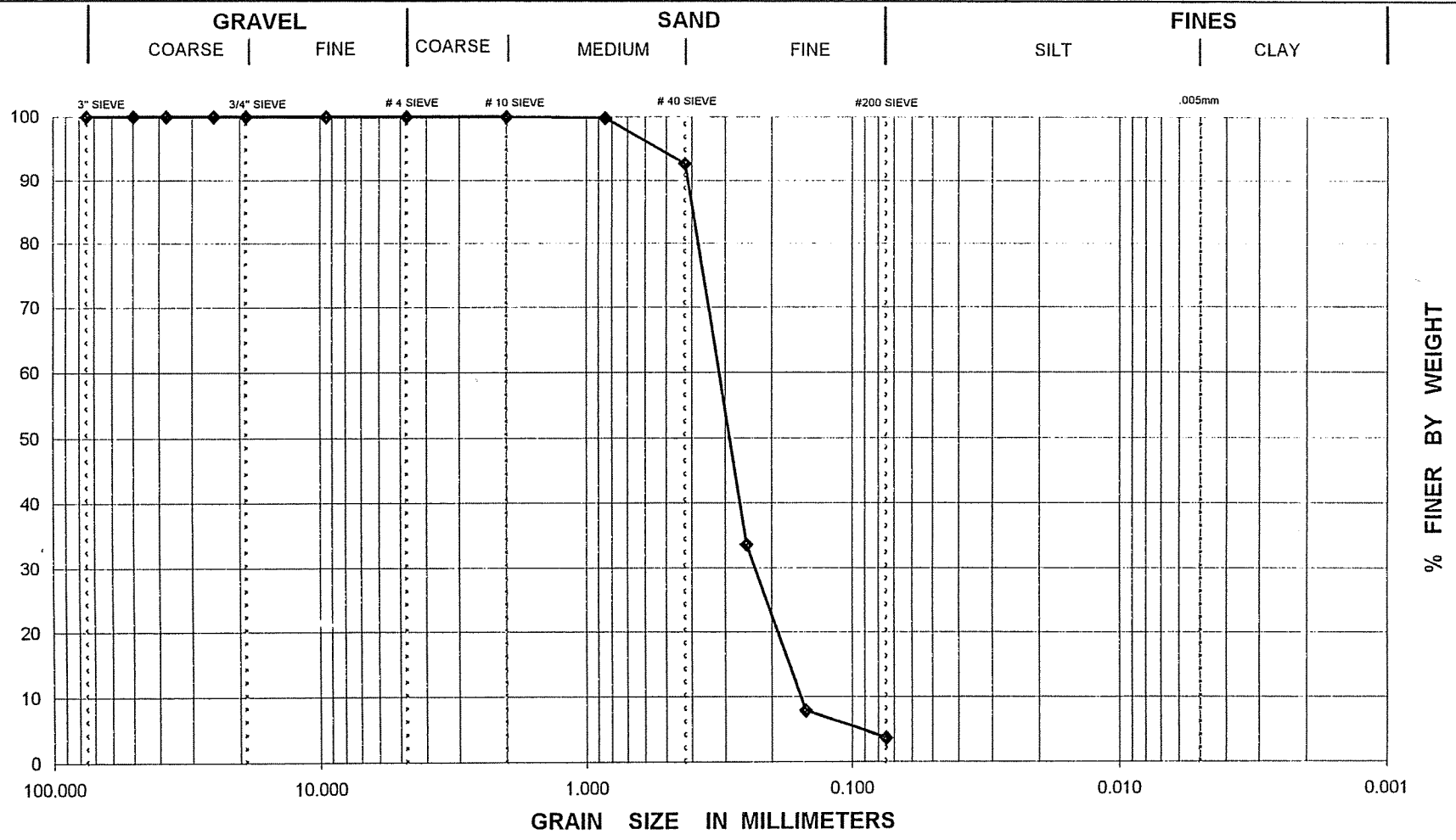
(ASTM D422)

AAP℠ AASHTO R18

JOB NAME :	*Arvin - Meritor Site*						
JOB NO. :	*22258*	REPORT NO. :	*191146*	DATE :	4/25/01	REVIEWED BY :	
BORING / PIT NO. :	*B-1*	DEPTH / ELEV. :	*13.5'-15'*	SAMPLE NO. :	-	SAMPLE TYPE :	*SS*
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	*Tan gray fine to medium sand .*					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	26.9	FINES , % :	*4*
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-



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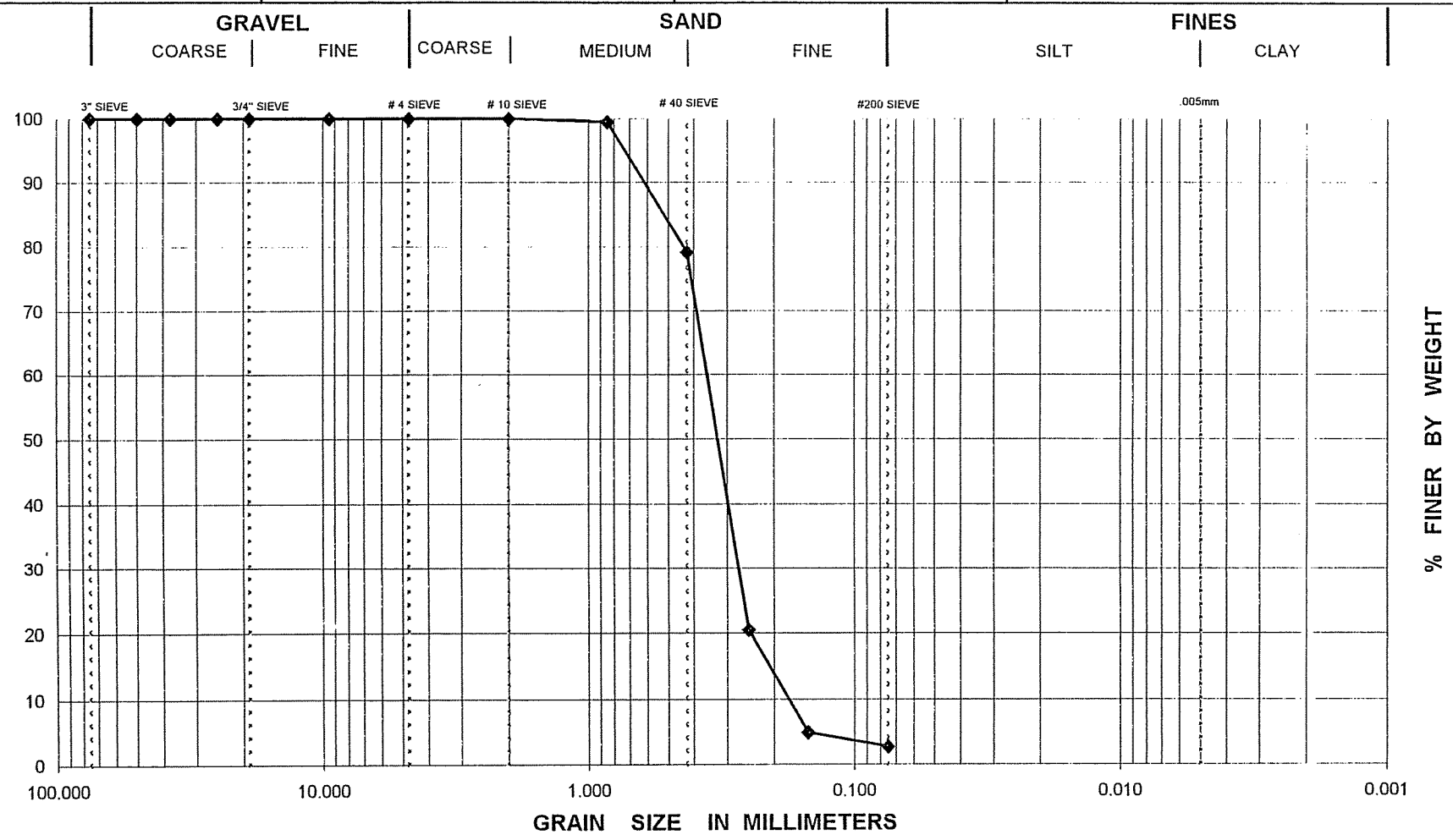
GRAIN SIZE DISTRIBUTION TEST REPORT
(ASTM D422)

AAP AASHTO R18

JOB NAME :	*Arvin - Meritor Site*						
JOB NO. :	*22258*	REPORT NO. :	*191146*	DATE :	4/25/01	REVIEWED BY :	
BORING / PIT NO. :	*B-1*	DEPTH / ELEV. :	*43.5'-45'*	SAMPLE NO. :	-	SAMPLE TYPE :	*SS*
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	*Tan gray fine to medium sand .*					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	27.7	FINES , % :	*3*
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-



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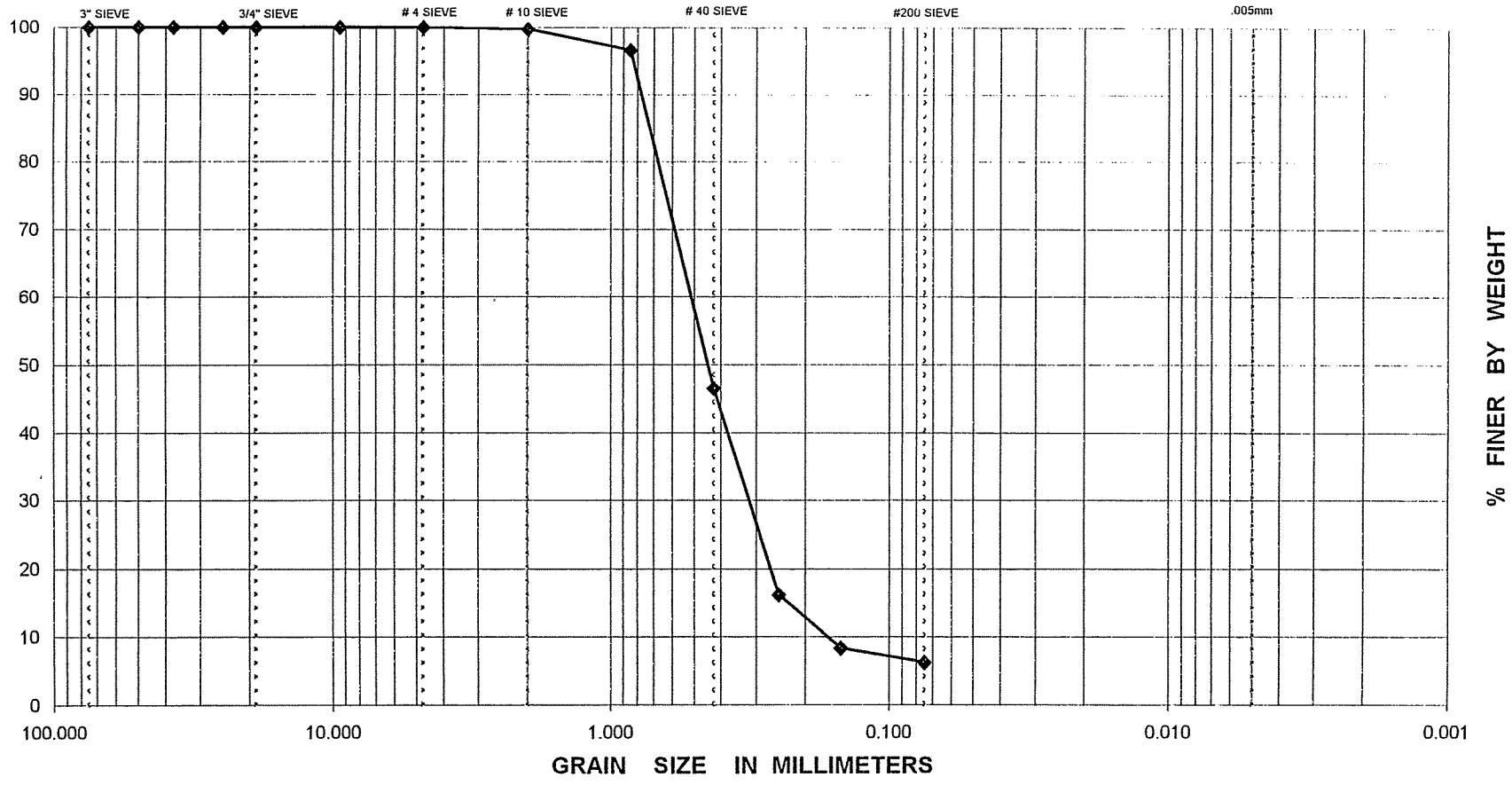
GRAIN SIZE DISTRIBUTION TEST REPORT
(ASTM D422)

AAP AASHTO R18

JOB NAME :	Arvin - Meritor Site						
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01	REVIEWED BY	
BORING / PIT NO. :	B-2	DEPTH / ELEV. :	18.5'-20'	SAMPLE NO. :	-	SAMPLE TYPE :	SS
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Tan gray fine to medium sand .					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	25.3	FINES , % :	6
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-



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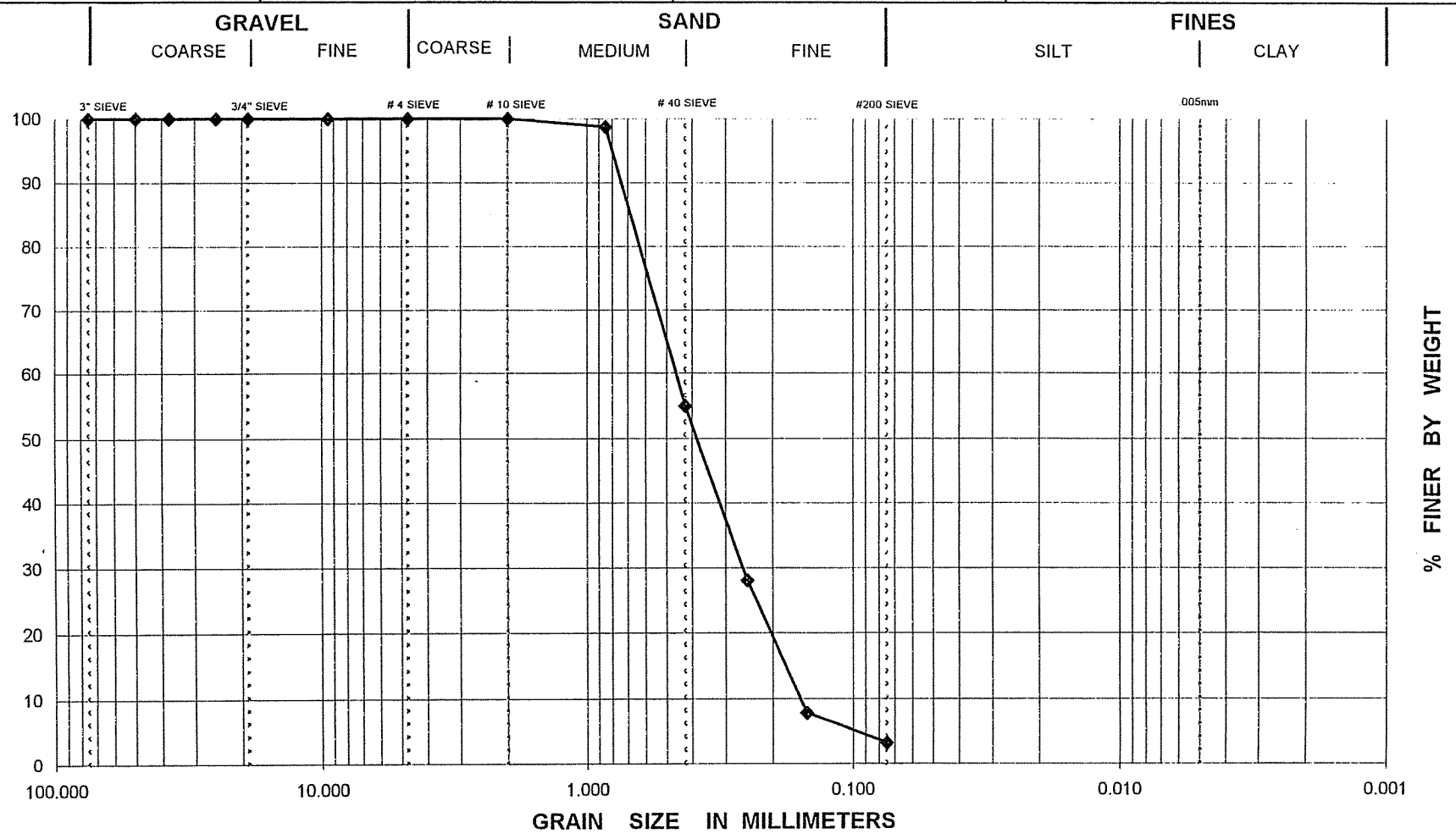
GRAIN SIZE DISTRIBUTION TEST REPORT

(ASTM D422)

AAP AASHTO R18

JOB NAME :	*Arvin - Meritor Site*						
JOB NO. :	*22258*	REPORT NO. :	*191146*	DATE :	4/25/01	REVIEWED BY :	
BORING / PIT NO. :	*B-4*	DEPTH / ELEV. :	*18.5'-20'*	SAMPLE NO. :	-	SAMPLE TYPE :	*SS*
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	*Tan gray fine to medium sand .*					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	21.7	FINES , % :	*3*
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-



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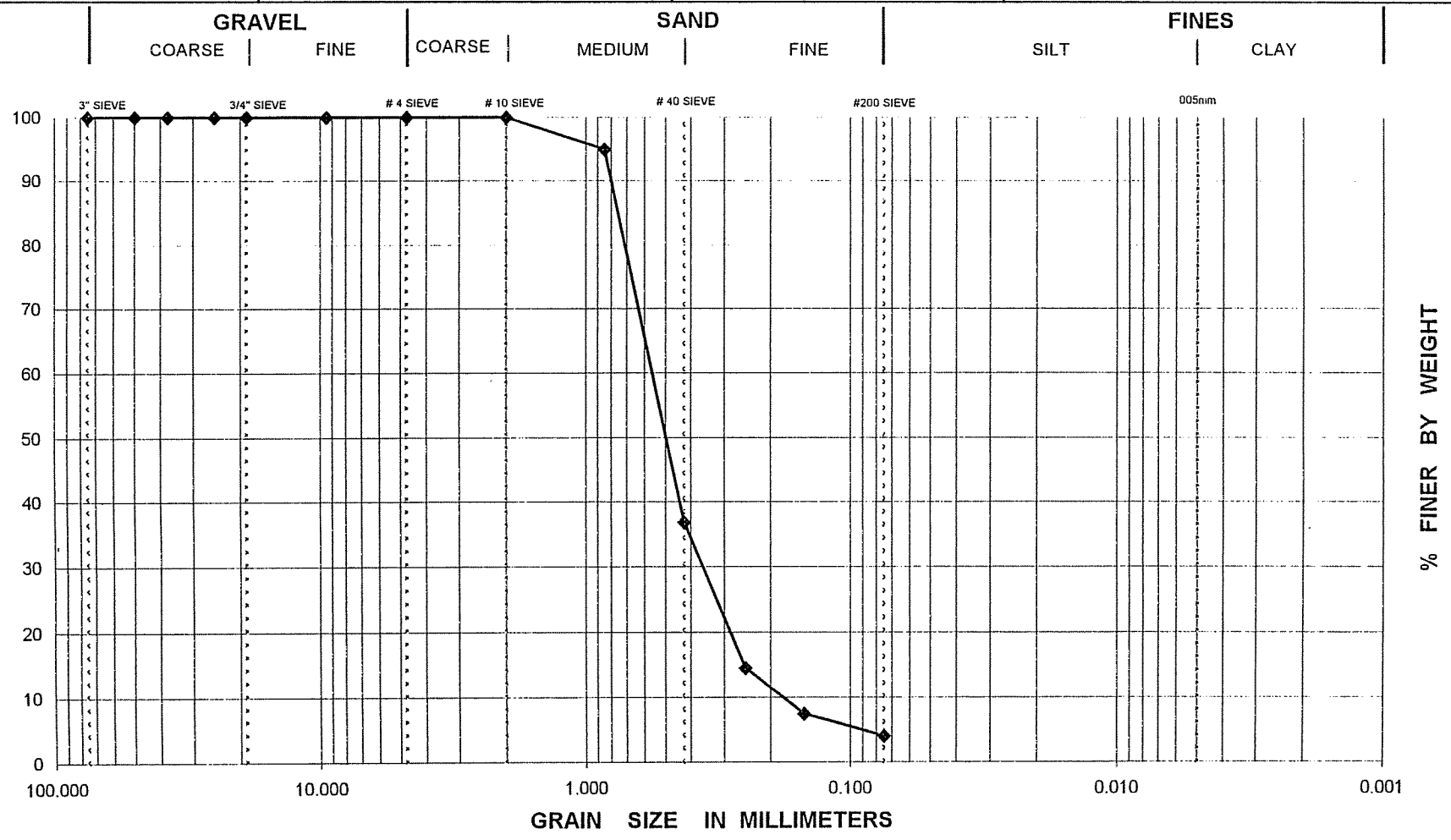
GRAIN SIZE DISTRIBUTION TEST REPORT

(ASTM D422)

AAP AASHTO R18

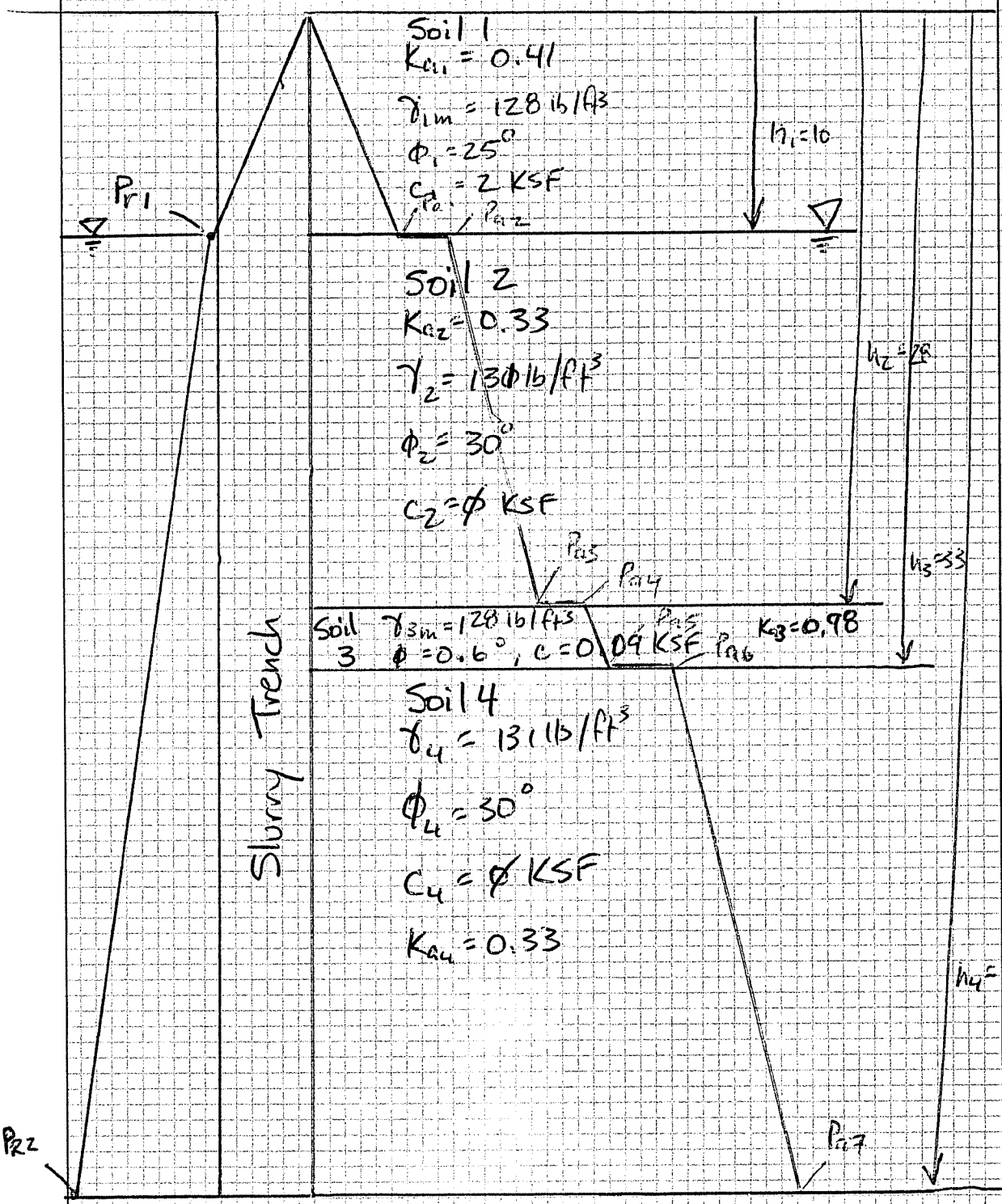
JOB NAME :	Arvin - Meritor Site						
JOB NO. :	22258	REPORT NO. :	191146	DATE :	4/25/01	REVIEWED BY :	
BORING / PIT NO. :	B-4	DEPTH / ELEV. :	38.5'-40'	SAMPLE NO. :	-	SAMPLE TYPE :	SS
SAMPLE LOCATION :	-						
SOIL DESCRIPTION :	Tan gray fine to medium sand .					SP. GRAVITY, Gs :	-
LIQUID LIMIT, % :	-	PLASTICITY INDEX , % :	-	MOISTURE , % :	20.3	FINES , % :	4
D10 , MM :	-	D30 , MM :	-	D60 , MM :	-	COEFF. OF CURVATURE , C_C :	-
CLASSIFICATION		UNIFIED :	-	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	-



INITIAL TRENCH STABILITY CALCULATIONS

BROWN AND CALDWELL

REFERENCES/NOTES



Assume slurry density of 64 gal/ft3

6/4/01	D. Keamey	19071.001	MJF	5/8/01	Case 1	SHEET NO. 1/4
DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	

Arvin-Meritor, Grenada MS	Slurry Trench Stability Calculations
PROJECT	SUBJECT

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 1, 60ft deep trench, no work platform.

$P_{a1} = \gamma_{im} \times h_1 \times K_{a1}$

$= 128\ lb/ft^3 \times 10ft \times 0.41$

$= 524.8\ lbs/ft^2$

$P_{a2} = \gamma_{im} \times h_1 \times K_{a2}$

$= (128\ lb/ft^3 \times 10ft \times 0.33)$

$= 423\ lbs/ft^2$

$P_{a3} = P_{a2} + (\gamma_2 - 62.4)(h_2 - h_1)(K_{a2})$

$= 423 + (131 - 62.4)(28 - 10)(0.33)$

$= 830\ lbs/ft^2$

$P_{a4} = [(\gamma_{im} \times h_1) + (\gamma_2 - 62.4)(h_2 - h_1)] K_{a3}$

$= [(128)(10) + (131 - 62.4)(18)](0.98)$

$= 2,464\ lbs/ft^2$

$P_{a5} = P_{a4} + [(\gamma_3 - 62.4)(h_3 - h_2)] K_{a3}$

$= 2,464 + [(131 - 62.4)(33 - 28)]\ 0.98$

$= 2,801\ lbs/ft^2$

$P_{a6} = [(\gamma_{im} \times h_1) + (\gamma_2 - 62.4)(h_2 - h_1) + (\gamma_3 - 62.4)(h_3 - h_2)] K_{a4}$

$= [(128 \times 10) + (131 - 62.4)(18) + (128 - 62.4)(5)]\ 0.33$

$= 938\ lbs/ft^2$

$P_{a7} = P_{a6} + [(\gamma_4 - 62.4)(h_4 - h_3)] K_{a4}$

$= 938\ lbs/ft^2 + [(131 - 62.4)(60 - 33)]\ 0.33$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
6/4/01	D. Kearney	19071.001	MJF	5/8/01	Case 1	2/4

PROJECT	SUBJECT
Arvin Meritor, Grenada, MS	Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

$P_{a7} = 1{,}550 \text{ lbs/ft}^2$

$$P_a = (h_1/2 \times P_{a1}) + (h_2 - h_1)\left(\frac{P_{a3} + P_{a2}}{2}\right) + (h_3 - h_2)\left(\frac{P_{a5} + P_{a4}}{2}\right) + (h_4 - h_3)\left(\frac{P_{a6} + P_{a7}}{2}\right)$$

$$= (525/2 \times 10) + (28-10)\left(\frac{423 + 1830}{2}\right) + (33-28)\left(\frac{2{,}464 + 2{,}801}{2}\right) + (60-33)\left(\frac{938 + 1550}{2}\right)$$

$$= 2{,}625 + 11{,}277 + 13{,}162 + 133{,}588$$

$$= 60{,}652 \text{ lbs/ft}$$

Assume slurry height 1 ft below ground surface

$P_{r1} = \gamma_{slurry} \times h_1 = 64 \text{ lbs/ft}^3 \times (10\text{ft} - 1\text{ft}) = 576 \text{ lbs/ft}^2$

$$P_{r2} = (\gamma_{slurry} - 62.4)(h_4 - h_1) + P_{r1}$$

$$= (64 - 62.4)(60 - 10) + 576$$

$$= 80 \text{ lbs/ft}^2 + 576$$

$$= 656 \text{ lbs/ft}^2$$

$$P_r = h_1/2 \times P_{r1} + (h_4 - h_1)\left(\frac{P_{r1} + P_{r2}}{2}\right)$$

$$= (10-1)/2 \times (576) + (60-10)\left(\frac{576 + 656}{2}\right)$$

$$= 2{,}592 + 30{,}800$$

$$= 33{,}392 \text{ lbs/ft}$$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
6/4/01	D. Reaney	19071.001	MJF	5/8/01	Case 1	3/4

PROJECT	SUBJECT
Arvin Meritor, Grenada, MS	Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

It is assumed that the only soil with cohesion is soil #1.

Shear

$$\text{Shear} = \text{cohesion} \times (h_1) \times 1/\sin(45 + \phi/2)$$

$$= 2{,}000 \text{ lbs/ft}^2 \times 10\text{ft} \times 1.186$$

$$= 23{,}714 \text{ lbs/ft}$$

Factor of Safety

$$F.S. = \frac{(\text{Shear} + P_R)}{P_A} = \frac{(23{,}714 + 33{,}392)}{60{,}652} = \underline{\underline{0.94}}$$

6/4/01	D. Kenney	19071.001	MJF	5/8/01	Case 1	SHEET NO. 4/4
DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	

Arvin Meritor, Grenada, MS	Slurry Trench Stability Calculations
PROJECT	SUBJECT

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 2, 50 ft deep trench, no work platform

$P_{a1} = \gamma_{1m} \times h_1 \times K_{a1}$

$= 128\ lb/ft^3 \times 10\ ft \times 0.41$

$= 525\ lb/ft^2$

$P_{a2} = \gamma_{1m} \times h_1 \times K_{a2}$

$= 128\ lb/ft^3 \times 10\ ft \times 0.33$

$= 423\ lbs/ft^2$

$P_{a3} = P_{a2} + (\gamma_2 - 62.4)(h_2 - h_1)(K_{a2})$

$= 423 + (131 - 62.4)(28 - 10)(0.33)$

$= 830\ lbs/ft^2$

$P_{a4} = \left[(\gamma_{1m} \times h_1) + (\gamma_2 - 62.4)(h_2 - h_1)\right] K_{a3}$

$= \left[(128)(10) + (131 - 62.4)(28 - 10)\right](0.98)$

$= 2{,}464\ lbs/ft^2$

$P_{a5} = P_{a4} + \left[(\gamma_3 - 62.4)(h_3 - h_2)\right] K_{a3}$

$= 2{,}464 + \left[(131 - 62.4)(33 - 28)\right] 0.98$

$= 2{,}801\ lbs/ft^2$

$P_{a6} = \left[(\gamma_1 \times h_1) + (\gamma_2 - 62.4)(h_2 - h_1) + (\gamma_3 - 62.4)(h_3 - h_2)\right] K_{a4}$

$= \left[(128 \times 10) + (131 - 62.4)(18) + (128 - 62.4)(5)\right] 0.33$

$= 938\ lbs/ft^2$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
6/4/01	D. Kearney	19071.001	MJF	5/8/01	Case 2	1/3

PROJECT: Arvin Meritor, Grenada, MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 2 continued

$$P_{a7} = P_{a6} + [(\gamma_4 - 62.4)(h_4 - h_3)]K_{a4}$$

$$= 938 \text{ lbs/ft}^2 + [(131 - 62.4)(50 - 33)]0.33$$

$$= 1{,}323 \text{ lbs/ft}^2$$

$$P_a = (h_1/2 \times P_{a1}) + (h_2 - h_1)\left(\frac{P_{a3} + P_{a2}}{2}\right) + (h_3 - h_2)\left(\frac{P_{a5} + P_{a4}}{2}\right) + (h_4 - h_3)\left(\frac{P_{a6} + P_{a7}}{2}\right)$$

$$= (525/2 \times 10) + (28 - 10)\left(\frac{423 + 830}{2}\right) + (33 - 28)\left(\frac{2{,}464 + 2{,}801}{2}\right) + (50 - 33)\left(\frac{938 + 1{,}323}{2}\right)$$

$$= 2{,}625 + 11{,}277 + 13{,}163 + 19{,}219$$

$$= \underline{46{,}284 \text{ lbs/ft}}$$

Assume slurry height 1 ft below ground surface

$$P_{r1} = \gamma_{slurry} \times h_1 = 64 \text{ lbs/ft}^3 \times (10 \text{ ft} - 1 \text{ ft}) = 576 \text{ lbs/ft}^2$$

$$P_{r2} = P_{r1} + (\gamma_{slurry} - 62.4)(h_4 - h_1)$$

$$= 576 + (64 - 62.4)(50 - 10)$$

$$= 576 + 64$$

$$= 640 \text{ lbs/ft}^2$$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
6/4/01	D. Kenney	19071.001	MJF	5/8/01	Case 2	2/3

PROJECT: Arvin Meritor, Grenada, MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 2 Continued

$$P_r = (h_1/2 \times P_{r1}) + (h_4 - h_1)\left(\frac{P_{r1} + P_{r2}}{2}\right)$$

$$= (9/2 \times 576) + (50-10)\left(\frac{576 + 640}{2}\right)$$

$$= 2{,}592 + 24{,}320$$

$$= 26{,}912 \text{ lbs/ft}$$

Shear

$$\text{Shear} = \text{cohesion} \times h_1 \times 1/\sin(45 + \phi/2)$$

$$= 2{,}000 \text{ lbs/ft}^2 \times 10\text{ft} \times 1/\sin(45 + 25/2)$$

$$= 2{,}000 \times 10 \times 1.186$$

$$= 23{,}720 \text{ lbs/ft}$$

Factor of Safety

$$F.S. = \frac{(\text{Shear} + P_r)}{P_A} = \frac{(23{,}720 + 26{,}912)}{46{,}284}$$

$$= 1.09$$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
6/4/01	D. Kenney	19071.001	MJF	5/8/01	Case 2	3/3

PROJECT	SUBJECT
Arvin Meritor, Grenada, MS	Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 3, 60 ft Deep, 3 ft work platform

Assume work platform constructed of upper soil layer material

$P_{a1} = \gamma_1 \times (h_1 + \text{workplatform}) \times K_{a1}$

$= 128 \times (10 + 3) \times 0.41$

$= 683 \text{ lb/ft}^2$

$P_{a2} = \gamma_1 \times (h_1 + wp) \times K_{a2}$

$= 128 \times (10 + 3) \times 0.33$

$= 550 \text{ lb/ft}^2$

$P_{a3} = P_{a2} + (\gamma_2 - 62.4)(h_2 - h_1)(K_{a2})$

$= 550 + (131 - 62.4)(28 - 10)(0.33)$

$= 958 \text{ lb/ft}^2$

$P_{a4} = [(\gamma_1 \times (h_1 + wp)) + (\gamma_2 - 62.4)(h_2 - h_1)] K_{a3}$

$= [1664 + 1235](0.98)$

$= 2{,}841 \text{ lb/ft}^2$

$P_{a5} = P_{a4} + [(\gamma_3 - 62.4)(h_3 - h_2)] K_{a3}$

$= 2{,}841 + [(128 - 62.4)(33 - 28)](0.98)$

$= 3{,}162 \text{ lb/ft}^2$

$P_{a6} = [(\gamma_1 \times h_1 + wp) + (\gamma_2 - 62.4)(h_2 - h_1) + (\gamma_3 - 62.4)(h_3 - h_2)] K_{a4}$

$= [(128)(10+3) + (131 - 62.4)(28 - 10) + (128 - 62.4)(5)] 0.33$

$= (3227)(0.33)$

$= 1{,}065 \text{ lb/ft}^2$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
6/4/01	[signature]	19071.001	MJF	5/9/01	Case 3	1/3

PROJECT: Arvin Meritor, Grenada, MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 3 continued

$$P_{a7} = P_{a6} + [(64 - 62.4)(h_4 - h_3)] K_{a4}$$

$$= 1{,}065 + [(131 - 62.4)(60 - 33)] 0.33$$

$$= 1{,}677 \text{ lbs/ft}^2$$

$$P_a = \left(\frac{h_1 + w_p}{2} \times P_{a1}\right) + (h_2 - h_1)\left(\frac{P_{a3} + P_{a2}}{2}\right) + (h_3 - h_2)\left(\frac{P_{a4} + P_{a5}}{2}\right) + (h_4 - h_3)\left(\frac{P_{a6} + P_{a7}}{2}\right)$$

$$= \left(\frac{(10+3)}{2} \times 683\right) + (28 - 10)\left(\frac{958 + 550}{2}\right) + (33 - 28)\left(\frac{2{,}841 + 3{,}162}{2}\right) + (60 - 33)\left(\frac{1{,}065 + 1{,}323}{2}\right)$$

$$= 4{,}440 + 13{,}572 + 15{,}007 + 32{,}238$$

$$= 65{,}257 \text{ lbs/ft}$$

Assume slurry height 1 ft below top of work platform

$$P_r = \gamma_{slurry} \times (h_1 + w_p - 1\text{ ft}) = 64 \text{ lbs/ft}^3 \times (10 + 3 - 1) = 768 \text{ lbs/ft}^2$$

$$P_{r2} = P_{r1} + (\gamma_{slurry} - 62.4)(h_4 - h_1)$$

$$= 768 \text{ lbs/ft}^2 + (64 - 62.4)(60 - 10)$$

$$= 848 \text{ lbs/ft}^2$$

DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	SHEET NO.
6/4/01	D. Kearney	19071.001	MJF	5/9/01	Case 3	2/3

PROJECT	SUBJECT
Arvin Meritor, Grenada, MS	Slurry Trench Stability Calculations

GEN-020-10/96

BROWN AND CALDWELL

REFERENCES/NOTES

Case 3 continued

$$P_r = \frac{(h_1 + wp - 1)}{2}(P_{r1}) + (h_4 - h_1)\left(\frac{P_{r1} + P_{r2}}{2}\right)$$

$$= (6 \times 768) + (60-10)\left(\frac{768 + 848}{2}\right)$$

$$= 4{,}608 + 40{,}400$$

$$= 45{,}008 \text{ lb/ft}$$

Shear

$$\text{Shear} = \text{cohesion} \times h_1 \times 1/\sin(45 + \phi/2)$$

$$= 2{,}000 \text{ lbs/ft}^2 \times 10 \text{ ft} \times 1/\sin(45 + 25/2)$$

$$= 2{,}000 \times 10 \times 1.186$$

$$= 23{,}720 \text{ lbs/ft}$$

Factor of Safety

$$F.S. = \frac{(\text{Shear} + P_r)}{P_A} = \frac{23{,}720 + 45{,}008}{65{,}257}$$

$$= \underline{\underline{1.05}}$$

6/4/01	D. Kearney	19071.001	MJF	5/9/01	Case 3	SHEET NO. 3/3
DATE CHECKED	CHECKED BY	JOB NUMBER	BY	DATE	CALC. NO.	

PROJECT: Arvin Meritor, Grenada, MS

SUBJECT: Slurry Trench Stability Calculations

GEN-020-10/96

VANE SHEAR REPORT AND REVISED TRENCH STABILITY CALCULATIONS

QORE

PROPERTY SCIENCES

July 5, 2002

Brown & Caldwell Consultants
501 Great Circle Road
Suite 150
Nashville, Tennessee 37228

Attention: Mr. Michael J. Freehling

Subject: Field Vane Shear Testing
Grenada Assembly Plant
Grenada, Mississippi
Job No. 23001, Report No. 219204

Gentlemen:

As requested, QORE, Inc. has performed field vane shear testing at the Grenada assembly plant site located in Grenada, Mississippi. The field vane shear tests were conducted in general accordance with the ASTM D-2573 and manufacturer's operating instructions. The apparatus used was the Acker Vane Shear Test Kit No. 700 with a 720:1 gear ratio. The testing was performed by Mr. Abhay J. Joshi of our firm on January 22 and 23, and also June 11 and 12, 2002. Specific test data are presented on the attached Field Vane Shear Test Report Sheets.

QORE, Inc. appreciates the opportunity to provide these services to your firm. Please contact us if you have any questions or comments regarding the attached data.

Respectfully submitted,

QORE, INC.

Abhay J. Joshi
Staff Geotechnical Engineer

Timothy J. Mirocha, P.E.
Senior Geotechnical Engineer
Reg. Ga. 21386

AJJ/TJM/jk

Attachment

11420 Johns Creek Parkway Duluth, Georgia 30097 (770) 476-3555 fax (770) 476-0213

JUL-16-2002 10:38 QORE Property Sciences 770 476 0213 P.02/08

Date 1-22-02

FIELD VANE SHEAR TEST REPORT**

Test No.	1	Job Name	Grenada Assembly
Elev. Top of Boring	Not Avail.	Job No.	23001
Depth of Test Point	10'	Boring	B-7
Elev. of Test Point	N/A		

VANE DATA

Check One

Torque Arm Length	Vane Diameter		Vane Constant
6"	2"	=	5.17
12"	2½"	=	2.59
18"	3⅜"	=	.905

Maximum Dial Reading 34.5 lbs.

Applied Torque Arm Torque Length (Ins.)* — Net Max. Dial Reading (lbs)

Ultimate Shear Strength (S) = Vane Constant x Applied Torque (T)
(Lbs/Sq. Ft.) (In. – Lbs)

NOTE: Rate of Rotation is to be one turn of crank every five seconds or as otherwise directed by engineer. (10 turns of crank = 5° of rotation).

Undisturbed Condition		Remolded Condition (5 minutes)	
Degree of Rotation	Dial Read	Degree of Rotation	Dial Read

Readings and Calculations		Undisturbed Condition	Remolded Condition
Maximum Force Gage Reading for Vane (lbs)		34.5	0
Maximum Force Gage Reading for Shaft (lbs)		—	—
Net Force (lbs)		34.5	0
Applied Torque (T)=Force x Torque Arm (In.-lbs.)		414	0
Ultimate Shear Strength (S)=lbs./Sq.Ft.		1072	0
Sensitivity =	Shear Strength (Undist.)		
	Shear Strength (Remolded)		

Technician AJ Joshi
Checked TJM

** (For use with Acker Vane Shear Test Kit No. 700-720:1 Gear Ratio)

Date 1-23-02

FIELD VANE SHEAR TEST REPORT**

Test No.	2	Job Name	Avenada Ass. Plant
Elev. Top of Boring	N/Avail	Job No.	23001
Depth of Test Point	32.5	Boring	B-2
Elev. of Test Point	—		

VANA DATA

Check One

Torque Arm Length	Vane Diameter		Vane Constant
6"	2"	=	5.17
12"	2½"	=	2.59
18"	3⅝"	=	.905

Maximum Dial Reading 24.5 lbs.

Applied Torque Arm Torque Length (Ins.)* — Net Max. Dial Reading (lbs)

Ultimate Shear Strength (S) = Vane Constant x Applied Torque (T)
(Lbs/Sq. Ft.) (In. – Lbs)

NOTE: Rate of Rotation is to be one turn of crank every five seconds or as otherwise directed by engineer. (10 turns of crank = 5° of rotation).

Undisturbed Condition		Remolded Condition (5 minutes)	
Degree of Rotation	Dial Read	Degree of Rotation	Dial Read

Readings and Calculations		Undisturbed Condition	Remolded Condition
Maximum Force Gage Reading for Vane (lbs)		24.5	0
Maximum Force Gage Reading for Shaft (lbs)			
Net Force (lbs)			
Applied Torque (T)=Force x Torque Arm (In.-lbs.)		294	
Ultimate Shear Strength (S)=lbs./Sq.Ft.		761	0
Sensitivity =	Shear Strength (Undist.)	—	—
	Shear Strength (Remolded)		

Technician A.J. Josgi
Checked TJM

** (For use with Acker Vane Shear Test Kit No. 700-720:1 Gear Ratio)

Date June 11, 2002

FIELD VANE SHEAR TEST REPORT**

Test No.	1	Job Name	Grenada Assembly Plant
Elev. Top of Boring	176' (Approximate)	Job No.	23001
Depth of Test Point	14½'	Boring	VS-2 (Located 10' North of B-3)
Elev. of Test Point	161½'		

VANE DATA

Check One

Torque Arm Length	Vane Diameter		Vane Constant
6"	2"	=	5.17
12"	2½"	=	2.59
18"	3⅝"	=	.905

Maximum Dial Reading 158 lbs.

Applied Torque Arm Torque Length (Ins.)* — Net Max. Dial Reading (lbs)

Ultimate Shear Strength (S) = Vane Constant x Applied Torque (T)
(Lbs/Sq. Ft.) (In. – Lbs)

NOTE: Rate of Rotation is to be one turn of crank every five seconds or as otherwise directed by engineer. (10 turns of crank = 5° of rotation).

Undisturbed Condition				Remolded Condition (10 minutes)	
DOR	DIAL READING	DOR	Dial Read	Degree of Rotation (DOR)	Dial Read
5°	3	65°	152	5°	40
10°	4	70°	156	10°	62
15°	7	75°	158	15°	63
20°	19	80°	158	20°	62
25°	42	85°	156	25°	61
30°	69	90°	154	30°	56
35°	76	95°	152	35°	52
40°	98	100°	145	40°	47
45°	113	105°	140		
50°	130				
55°	139				
60°	147				

Readings and Calculations		Undisturbed Condition	Remolded Condition
Maximum Force Gage Reading for Vane (lbs)		158	63
Maximum Force Gage Reading for Shaft (lbs)		0	0
Net Force (lbs)		158	63
Applied Torque (T)=Force x Torque Arm (In.-lbs.)		1896	756
Ultimate Shear Strength (S)=lbs./Sq.Ft.		4910	1958
Sensitivity =	Shear Strength (Undist.) / Shear Strength (Remolded)	2.5	

Technician William Earl Spivey

Checked Abhay J. Joshi

** (For use with Acker Vane Shear Test Kit No. 700-720:1 Gear Ratio)

Date JUNE 11, 2002

FIELD VANE SHEAR TEST REPORT**

Test No.	2	Job Name	Grenada Assembly Plant
Elev. Top of Boring	176'	Job No.	23001
Depth of Test Point	27'	Boring	VS-2 (Located 10' North of B-3)
Elev. of Test Point	149'		

VANE DATA

Check One

Torque Arm Length	Vane Diameter		Vane Constant
6"	2"	=	5.17
12"	2½"	=	2.59
18"	3⅝"	=	.905

Maximum Dial Reading
34 lbs.

Applied Torque Arm Torque Length (Ins.)* — Net Max. Dial Reading (lbs)

Ultimate Shear Strength (S) = Vane Constant x Applied Torque (T)
(Lbs/Sq. Ft.) (In. – Lbs)

NOTE: Rate of Rotation is to be one turn of crank every five seconds or as otherwise directed by engineer. (10 turns of crank = 5° of rotation).

Undisturbed Condition		Remolded Condition (5 minutes)	
Degree of Rotation	Dial Read	Degree of Rotation	Dial Read
5°	10	5°	21
10°	19	10°	21
15°	27	15°	21
20°	33	20°	21
25°	34	25°	21
30°	34	30°	21
35°	30		
40°	29		
45°	27		
50°	25		

Readings and Calculations		Undisturbed Condition	Remolded Condition
Maximum Force Gage Reading for Vane (lbs)		34	21
Maximum Force Gage Reading for Shaft (lbs)		0	0
Net Force (lbs)		34	21
Applied Torque (T)=Force x Torque Arm (In.-lbs.)		408	252
Ultimate Shear Strength (S)=lbs./Sq.Ft.		2109.	1303
Sensitivity =	Shear Strength (Undist.) / Shear Strength (Remolded)	1.6	

Technician William Earl Spivey
Checked Abhay J. Joshi

** (For use with Acker Vane Shear Test Kit No. 700-720:1 Gear Ratio)

Date JUNE 12, 2002

FIELD VANE SHEAR TEST REPORT**

Test No.	3	Job Name	Grenada Assembly Plant
Elev. Top of Boring	175½'	Job No.	23001
Depth of Test Point	14½'	Boring	VS-3 (Located 9' East of B-5)
Elev. of Test Point	161'		

VANE DATA

Check One

Torque Arm Length	Vane Diameter		Vane Constant
6"	2"	=	5.17
12"	2½"	=	2.59
18"	3⅝"	=	.905

Maximum Dial Reading 19 lbs.

Applied Torque Arm Torque Length (Ins.)* — Net Max. Dial Reading (lbs)

Ultimate Shear Strength (S) = Vane Constant x Applied Torque (T)
(Lbs/Sq. Ft.) (In. – Lbs)

NOTE: Rate of Rotation is to be one turn of crank every five seconds or as otherwise directed by engineer. (10 turns of crank = 5° of rotation).

Undisturbed Condition		Remolded Condition (5 minutes)	
Degree of Rotation	Dial Read	Degree of Rotation	Dial Read
5°	14	5°	13
10°	19	10°	13
15°	19	15°	13
20°	18	20°	13
25°	18	25°	13
30°	18		

Readings and Calculations		Undisturbed Condition	Remolded Condition
Maximum Force Gage Reading for Vane (lbs)		19	13
Maximum Force Gage Reading for Shaft (lbs)		0	0
Net Force (lbs)		19	13
Applied Torque (T)=Force x Torque Arm (In.-lbs.)		228	156
Ultimate Shear Strength (S)=lbs./Sq.Ft.		1179	807
Sensitivity =	Shear Strength (Undist.) / Shear Strength (Remolded)	1.46	

Technician William Earl Spivey

Checked Abhay J. Joshi

** (For use with Acker Vane Shear Test Kit No. 700-720:1 Gear Ratio)

Date JUNE 12, 2002

FIELD VANE SHEAR TEST REPORT**

Test No.	4	Job Name	Grenada Assembly Plant
Elev. Top of Boring	177'	Job No.	23001
Depth of Test Point	30'	Boring	VS-4 (Located 12' West of B-1)
Elev. of Test Point	147'		

VANE DATA

Check One

Torque Arm Length	Vane Diameter		Vane Constant
6"	2"	=	5.17
12"	2½"	=	2.59
18"	3⅝"	=	.905

Maximum Dial Reading 31 lbs.

Applied Torque Arm Torque Length (Ins.)* — Net Max. Dial Reading (lbs)

Ultimate Shear Strength (S) = Vane Constant x Applied Torque (T)
(Lbs/Sq. Ft.) (In. – Lbs)

NOTE: Rate of Rotation is to be one turn of crank every five seconds or as otherwise directed by engineer. (10 turns of crank = 5° of rotation).

Undisturbed Condition		Remolded Condition (5 minutes)	
Degree of Rotation	Dial Read	Degree of Rotation	Dial Read
5°	7	5°	20
10°	14	10°	20
15°	21	15°	18
20°	27	20°	18
25°	29		
30°	31		
35°	31		
40°	30		
45°	28		
50°	26		

Readings and Calculations		Undisturbed Condition	Remolded Condition
Maximum Force Gage Reading for Vane (lbs)		31	20
Maximum Force Gage Reading for Shaft (lbs)		0	0
Net Force (lbs)		31	20
Applied Torque (T)=Force x Torque Arm (In.-lbs.)		372	240
Ultimate Shear Strength (S)=lbs./Sq.Ft.		1923	1241
Sensitivity =	Shear Strength (Undist.) / Shear Strength (Remolded)	1.57	

Technician William Earl Spivey
Checked Akshay J. Joshi
** (For use with Acker Vane Shear Test Kit No. 700-720:1 Gear Ratio)

Revised Trench Stability Calculated Safety Factors
Permeable Reactive Barrier IM Design
Grenada, MS

Case Number	Field Vane Shear* (lbs/ft2)	Soil 3** Resistive Shear Force (lbs/ft)	Soil 3** Revised Estimated Phi (degrees)	Soil 3** Recalculated Active Earth Coefficient (K_{a3})	Soil 3** Recalculated Active Earth Pressure (P_{a4})	Soil 3** Recalculated Active Earth Pressure (P_{a5})	Revised Overall Calculated Safety Factor	Previous Calculated*** Overall Safety Factor
1		0	23	0.44	1101	1252	1.07	0.94
(60 ft depth,		0	25	0.41	1020	1160	1.08	
no platform)		0	27	0.38	944	1073	1.09	
	1100	7778		1.00	2514	2858	1.07	
	2000	14142		1.00	2514	2858	1.17	
2		0	23	0.44	1101	1252	1.30	1.09
(50 ft depth,		0	25	0.41	1020	1160	1.31	
no platform)		0	27	0.38	944	1073	1.33	
	1100	7778		1.00	2514	2858	1.25	
	2000	14142		1.00	2514	2858	1.39	
3		0	23	0.44	1270	1413	1.21	1.05
(60 ft depth,		0	25	0.41	1176	1309	1.22	
3 ft platform)		0	27	0.38	1089	1212	1.23	
	1100	7778		1.00	2899	3226	1.17	
	2000	14142		1.00	2899	3226	1.26	

* Values used correspond to the low and average of the field vane shear data collected in June 2002.
** Soil 3 refers to the soil unit as identified in the IM Design stability calculations dated 5/8/01.
*** "Previously Calculated" refers to the results of the stability calculations for the IM Design dated 5/8/01.

OUTFALL DITCH FLOW CALCULATIONS

Check: JPM 5/15/01

Project: **Meritor Drainage Ditch** **Date:** 5/15/01 25-yr, 30-min. Storm from Total Basin

Calculation of required depth of triangular surface ditch
References: Manual For Erosion and Sediment Control in Georgia, Fifth Edition, 2000.
Erosion and Sediment Pollution Control Program Manual, PA DER #466, 1991.

Manning's Equation:

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

$$A = bd + zd^2$$

$$R = \frac{bd + zd^2}{b + 2d(z^2 + 1)^{1/2}}$$

Ditch: Channel after Permeable Reactive Barrier.
Station: See Construction Plan Sheet (19071-03)

Predetermined Inputs: (see attached Tables)			
Enter Roughness Coefficient (Manning's n)	**0.040**		
Enter Base Dimension of Trapezoid in Feet (b)	**0.0**	ft	
Enter Inside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**		
Enter Outside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**		
Is Ditch "bare earth" OR "lined"?	**lined**		**Bare initially, then rip-rap lined.(Use R-3, max velocity = 6.5 fps)**
Channel Construction	**Silty loam**		
Maximum permissible velocity for R-3 rip rap lined ditch	**6.50**	fps	
Known Inputs:			
Enter Slope of Ditch (So)	**0.016**	ft/ft	
Enter Drainage Area (in acres)	**27.14**	acres	
Enter Runoff Coefficient	**0.95**		See Attached Table
Enter Intensity	**2.35**	in	See Attached Figures
Enter Time of Concentration	**25**	min	See Attached Nomograph
Peak Discharge	**60.59**	cfs	Use 25 yr 30 min. event
Enter Trial Solution For Depth	**2.500**	ft	
Trial Calculations:			Comment
Calculated Flow Volume =	**63.45**	cfs	Acceptable
Calculated Flow Velocity =	**5.08**	fps	Acceptable
Flow Area =	**12.50**	sq. ft.	
Flow Depth =	**2.50**	ft	
Top Flow Width =	**10.00**	ft	
Wetted Perimeter =	**11.18**	ft	
Critical Slope (Sc)=	**0.025**	ft/ft	
Stable flow test (Unstable if 0.7Sc<So<1.3Sc)			Stable Flow
Lower Bound (0.7 x Sc)	**0.018**		
Slope of Ditch (So) =	**0.016**		
Upper Bound (1.3 x Sc)	**0.033**		
Free Board for Trial Calculation:			
If Unstable Flow, Freeboard = 0.075VD	**NA**	ft	
If Stable Flow, Freeboard = 0.5 for bare earth channels	**0.50**	ft	
Freeboard = larger of 0.5 or 0.25D for lined channels	**0.63**	ft	
Design Parameters based on Trial Calculation:			Use
Minimum Design Free Board =	**0.63**	ft	
Minimum Design Channel Depth =	**3.13**	ft	**3.5**
Minimum Design Channel Top Width =	**12.50**	ft	**14.00**
Maximum Flow at Design Depth (includes freeboard depth) =	**115.03**	cfs	**155.62**

Check: JPM 5/15/01

Project: **Meritor Drainage Ditch** **Date:** 5/15/01 25-yr, 30-min. Storm from Total Basin

Calculation of required depth of trapezoidal surface ditch
References: Manual For Erosion and Sediment Control in Georgia, Fifth Edition, 2000.
Erosion and Sediment Pollution Control Program Manual, PA DER #466, 1991.

Manning's Equation:

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

$$A = bd + zd^2$$

$$R = \frac{bd + zd^2}{b + 2d(z^2 + 1)^{1/2}}$$

Ditch: Channel after Permeable Reactive Barrier.
Station: See Construction Plan Sheet (19071-03)

Predetermined Inputs: (see attached Tables)			
Enter Roughness Coefficient (Manning's n)	**0.040**		
Enter Base Dimension of Trapezoid in Feet (b)	**4.2**	ft	
Enter Inside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**		
Enter Outside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**		
Is Ditch "bare earth" OR "lined"?	**lined**		**Bare initially, then rip-rap lined.(Use R-3, max velocity = 6.5 fps)**
Channel Construction	**Silty loam**		
Maximum permissible velocity for R-3 rip rap lined ditch	**6.50**	fps	
Known Inputs:			
Enter Slope of Ditch (So)	**0.016**	ft/ft	
Enter Drainage Area (in acres)	**27.14**	acres	
Enter Runoff Coefficient	**0.95**		See Attached Table
Enter Intensity	**2.35**	in	See Attached Figures
Enter Time of Concentration	**25**	min	See Attached Nomograph
Peak Discharge cfs per tributary acre	**60.59**	cfs	Use 25 yr 30 min. event
Enter Trial Solution For Depth	**1.700**	ft	
Trial Calculations:			Comment
Calculated Flow Volume =	**64.66**	cfs	Acceptable
Calculated Flow Velocity =	**5.00**	fps	Acceptable
Flow Area =	**12.92**	sq. ft.	
Flow Depth =	**1.70**	ft	
Top Flow Width =	**11.00**	ft	
Wetted Perimeter =	**11.80**	ft	
Critical Slope (Sc)=	**0.024**	ft/ft	
Stable flow test (Unstable if 0.7Sc<So<1.3Sc)			Stable Flow
Lower Bound (0.7 x Sc)	**0.017**		
Slope of Ditch (So) =	**0.016**		
Upper Bound (1.3 x Sc)	**0.032**		
Free Board for Trial Calculation:			
If Unstable Flow, Freeboard = 0.075VD	**NA**	ft	
If Stable Flow, Freeboard = 0.5 for bare earth channels	**0.50**	ft	
Freeboard = larger of 0.5 or 0.25D for lined channels	**0.50**	ft	
Design Parameters based on Trial Calculation:			Use
Minimum Design Free Board =	**0.50**	ft	
Minimum Design Channel Depth =	**2.20**	ft	**2.5**
Minimum Design Channel Top Width =	**13.00**	ft	**14.20**
Maximum Flow at Design Depth (includes freeboard depth) =	**108.77**	cfs	**141.72**

Check: gpm 5/18/01

Project: **Meritor Drainage Ditch** **Date:** 5/18/01 25-yr, 30-min. Storm from Eastern Basin

Calculation of required depth of triangular surface ditch
References: Manual For Erosion and Sediment Control in Georgia, Fifth Edition, 2000.
Erosion and Sediment Pollution Control Program Manual, PA DER #466, 1991.

Manning's Equation: $Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$

$A = bd + zd^2$

$R = \frac{bd + zd^2}{b + 2d(z^2 + 1)^{1/2}}$

Ditch: Channel after highway culvert.
Station: See Construction Plan Sheet (19071-03)

Predetermined Inputs: (see attached Tables)

Enter Roughness Coefficient (Manning's n)	**0.030**		
Enter Base Dimension of Trapezoid in Feet (b)	**0.0**	ft	
Enter Inside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**		
Enter Outside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**		
Is Ditch "bare earth" OR "lined"?	**lined**		**Bare initially, then rip-rap lined.(Use R-3, max velocity = 6.5 fps)**
Channel Construction	**Silty loam**		
Maximum permissible velocity for R-3 rip rap lined ditch	**6.50**	fps	

Known Inputs:

Enter Slope of Ditch (So)	**0.003**	ft/ft	
Enter Drainage Area (in acres)	**27.14**	acres	
Enter Runoff Coefficient	**0.95**		See Attached Table
Enter Intensity	**2.35**	in	See Attached Figures
Enter Time of Concentration	**25**	min	See Attached Nomograph
Peak Discharge	**60.59**	cfs	Use 25 yr 30 min. event

Enter Trial Solution For Depth **2.970** ft

Trial Calculations:

			Comment
Calculated Flow Volume =	**60.82**	cfs	Acceptable
Calculated Flow Velocity =	**3.45**	fps	Acceptable
Flow Area =	**17.64**	sq. ft.	
Flow Depth =	**2.97**	ft	
Top Flow Width =	**11.88**	ft	
Wetted Perimeter =	**13.28**	ft	
Critical Slope (Sc)=	**0.013**	ft/ft	
Stable flow test (Unstable if 0.7Sc<So<1.3Sc)			Stable Flow
Lower Bound (0.7 x Sc)	**0.009**		
Slope of Ditch (So) =	**0.003**		
Upper Bound (1.3 x Sc)	**0.017**		

Free Board for Trial Calculation:

If Unstable Flow, Freeboard = 0.075VD	**NA**	ft
If Stable Flow, Freeboard = 0.5 for bare earth channels	**0.50**	ft
Freeboard = larger of 0.5 or 0.25D for lined channels	**0.74**	ft

Design Parameters based on Trial Calculation:

			Use
Minimum Design Free Board =	**0.74**	ft	
Minimum Design Channel Depth =	**3.71**	ft	**4**
Minimum Design Channel Top Width =	**14.85**	ft	**16.00**
Maximum Flow at Design Depth (includes freeboard depth) =	**110.27**	cfs	**134.54**

Check: JPM 5/18/01

Project: **Meritor Drainage Ditch** **Date:** 5/18/01 25-yr, 30-min. Storm from Eastern Basin

Calculation of required depth of trapezoidal surface ditch
References: Manual For Erosion and Sediment Control in Georgia, Fifth Edition, 2000.
Erosion and Sediment Pollution Control Program Manual, PA DER #466, 1991.

Manning's Equation:

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

$$A = bd + zd^2$$

$$R = \frac{bd + zd^2}{b + 2d(z^2 + 1)^{1/2}}$$

Ditch: Channel after highway culvert.
Station: See Construction Plan Sheet (19071-03)

Predetermined Inputs: (see attached Tables)			
Enter Roughness Coefficient (Manning's n)	**0.030**		
Enter Base Dimension of Trapezoid in Feet (b)	**6.2**	ft	
Enter Inside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**		
Enter Outside Ditch Sidewall Slope ,i.e. 2:1 is 2 (z)	**2**		
Is Ditch "bare earth" OR "lined"?	**lined**		**Bare initially, then rip-rap lined.(Use R-3, max velocity = 6.5 fps)**
Channel Construction	**Silty loam**		
Maximum permissible velocity for R-3 rip rap lined ditch	**6.50**	fps	
Known Inputs:			
Enter Slope of Ditch (So)	**0.003**	ft/ft	
Enter Drainage Area (in acres)	**27.14**	acres	
Enter Runoff Coefficient	**0.95**		See Attached Table
Enter Intensity	**2.35**	in	See Attached Figures
Enter Time of Concentration	**25**	min	See Attached Nomograph
Peak Discharge	**60.59**	cfs	Use 25 yr 30 min. event
Enter Trial Solution For Depth	**1.900**	ft	
Trial Calculations:			Comment
Calculated Flow Volume =	**64.33**	cfs	Acceptable
Calculated Flow Velocity =	**3.39**	fps	Acceptable
Flow Area =	**19.00**	sq. ft.	
Flow Depth =	**1.90**	ft	
Top Flow Width =	**13.80**	ft	
Wetted Perimeter =	**14.70**	ft	
Critical Slope (Sc)=	**0.013**	ft/ft	
Stable flow test (Unstable if 0.7Sc<So<1.3Sc)			Stable Flow
Lower Bound (0.7 x Sc)	**0.009**		
Slope of Ditch (So) =	**0.003**		
Upper Bound (1.3 x Sc)	**0.017**		
Free Board for Trial Calculation:			
If Unstable Flow, Freeboard = 0.075VD	**NA**	ft	
If Stable Flow, Freeboard = 0.5 for bare earth channels	**0.50**	ft	
Freeboard = larger of 0.5 or 0.25D for lined channels	**0.50**	ft	
Design Parameters based on Trial Calculation:			Use
Minimum Design Free Board =	**0.50**	ft	
Minimum Design Channel Depth =	**2.40**	ft	**2.5**
Minimum Design Channel Top Width =	**15.80**	ft	**16.20**
Maximum Flow at Design Depth (includes freeboard depth) =	**101.28**	cfs	**109.79**

From: Manual for Erosion and Sediment Control in Georgia, 2000.

APPENDIX A-3

PROCEDURAL GUIDE FOR COMPUTING RUN-OFF BY RATIONAL METHOD

The Rational Method is a method for determining run-off in terms of cubic feet per second at the drainage structure. It is based on the direct relationship between rainfall and run-off and may be expressed by the formula:

$$Q = CIA$$

Q = the run-off in cu. ft. per sec. from a given area.

C = a coefficient representing the ratio of run-off to rainfall (related to impervious area) i.e., 1.0 - 100% run-off.

I = the intensity of rainfall in inches per hour for a duration equal to the time of concentration and for a stated frequency.

A = the drainage area in acres.

		SOIL CLASSIFICATION					
SLOPE	LAND USE	SAND OR SANDY LOAM SOILS (Pervious)			HIGH CLAY SOILS (Impervious)		
		Min.		Max.	Min.		Max.
Flat (0% - 3%)	Woodlands	0.15		0.20	0.20		0.25
	Pasture	0.20		0.25	0.25		0.30
	Paved		0.95			0.95 E, SW	
	Residential	0.35		0.60	0.50		0.60 NW
	Commercial	0.60		0.95	0.60		0.95
Rolling (3% - 7%)	Woodlands	0.15		0.20	0.18		0.25
	Pasture	0.30		0.40	0.35		0.45
	Paved		0.95			0.95	
	Residential	0.50		0.60	0.50		0.60
	Commercial	0.60		0.95	0.60		0.95
Hilly (7% - 11%)	Woodlands	0.20		0.25	0.25		0.30
	Pasture	0.35		0.45	0.45		0.55
	Paved		0.95			0.95	
	Residential	0.50		0.60	0.50		0.60
	Commercial	0.60		0.95	0.60		0.95
Mountainous (11% +)	Woodlands				0.70		0.80
	Bare			0.80	0.80		0.95
Steep Grassed Slopes	Pasture		0.70			0.70	

Table A-3.1

1. Determine "C" by observation in the field of culture and soils and by use of Table A-3.1, p. A-3-1.

2. Determine "I" (intensity rate) from the time of Concentration Figure A-3.1, p. A-3-3 and Rainfall Figures A-3.3 through A-3.7, p. A-3-5 through A-3-9.

NOTE:

a. Height (ft.) is determined in the field or from contour maps. Height is the difference in elevation of the most remote point in the drainage area and the inlet flow line of the structure.

b. Maximum length of travel is determined in the field or from the contour maps. It is the greatest distance the water will travel from the most remote point of the drainage area to the inlet of the drainage structure.

c. Use height and length to determine the time of concentration by use of Figure A-3.1. Use a minimum of 10 minutes for rural and urban areas.

d. Now refer to rainfall figures - Atlanta, Macon, Augusta, Thomasville and Savannah (use figure nearest to project or combination of two figures) and by scaling the time of concentration, which is equal to the rainfall duration, along the bottom of the table and moving up to the selected return period, (10-25-50 yr.), move horizontally to the left and read the intensity "I".

3. Determine the time of concentration using the "Kinematic Wave Nomograph," Figure A-3.2, p. A-3-4. The kinematic wave table incorporates variables, the rainfall intensity and mannings "n." In using the nomograph, the designer has two unknowns starting the computations, the time of concentration and the rainfall density. The problem is attempting to determine a rainfall intensity which, in turn, actually determines the time of concentration. Thus, the problem is one of iteration. A value of "i" must be assumed, compute a time of concentration and then check back to see if the rainfall intensity that was assumed is consistent with the frequency curve of Figures A-3.3 through A-3.7. If one is the given length, slope, roughness coefficient, and intensity-duration-frequency curve the steps are as follows:

a. Assume rainfall intensity.
b. Use kinematic wave nomograph or equation to obtain first estimate of time concentration.
c. Using the time of concentration obtained from Step "b", enter Figures A-3.3 through A-3.7 for appropriate area and find rainfall intensity corresponding to the computed time of concentration. If this rainfall intensity corresponds with the assumed intensity, the problem is solved. If not, proceed to Step "d".
d. Assume a new rainfall intensity that is betwen that assumed in Step "a" and that determined in Step "c."
e. Repeat Steps "a" through "c" until there is good agreement between the assumed rainfall intensity and that obtained from Figures A-3.3 through A-3.7. Experience has shown that a solution can be found on the third iteration with little difficulty.

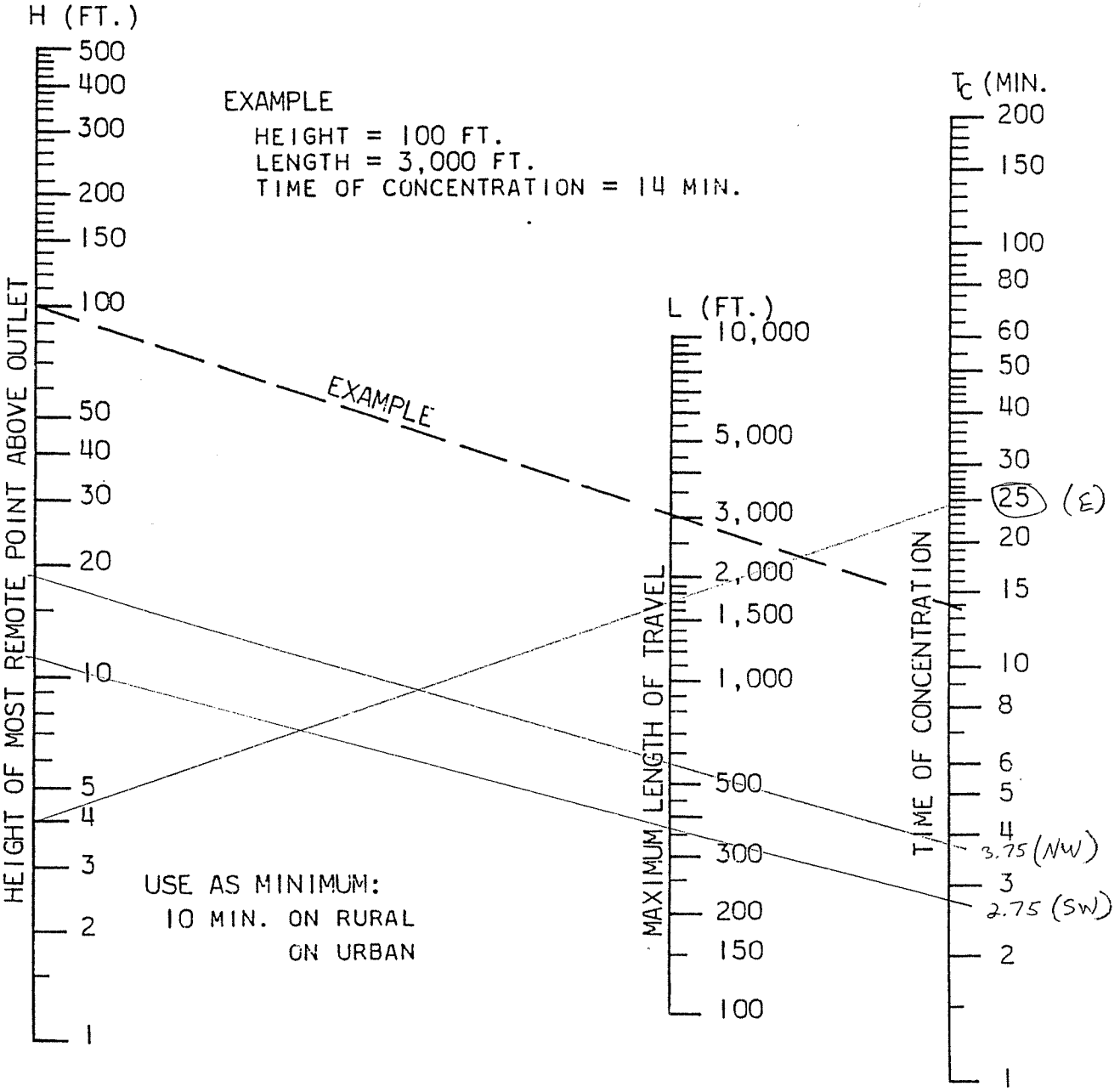
Generally, the time of concentration for overland flow is only a part of the overall design problem. Often one encounters swale flow, confined channel flow, and closed conduit flow-times that must be added as part of the overall time of concentration. When this situation is encountered, it is best to compute the confined flow-times as the first step in the overall determination of the time of concentration. This will give the designer a rough estimate of the time involved for the overland flow which will give a better first start on the rainfall intensity assumption. For example, if the flow time in a channel is 15 minutes and the overland flow time from this ridge line to the channels is 10 minutes, then the total time of concentration is 25 minutes. The channel flow can be determined by length divided by velocity.

4. Determine drainage Area "A" in the field or from contour maps.

5. Multiply the values of C x I x A to determine Q (cu. ft. per sec.).

6. Using "Q" as determined above, solve for size of structure required by use of Culvert Capacity Charts or nomographs.

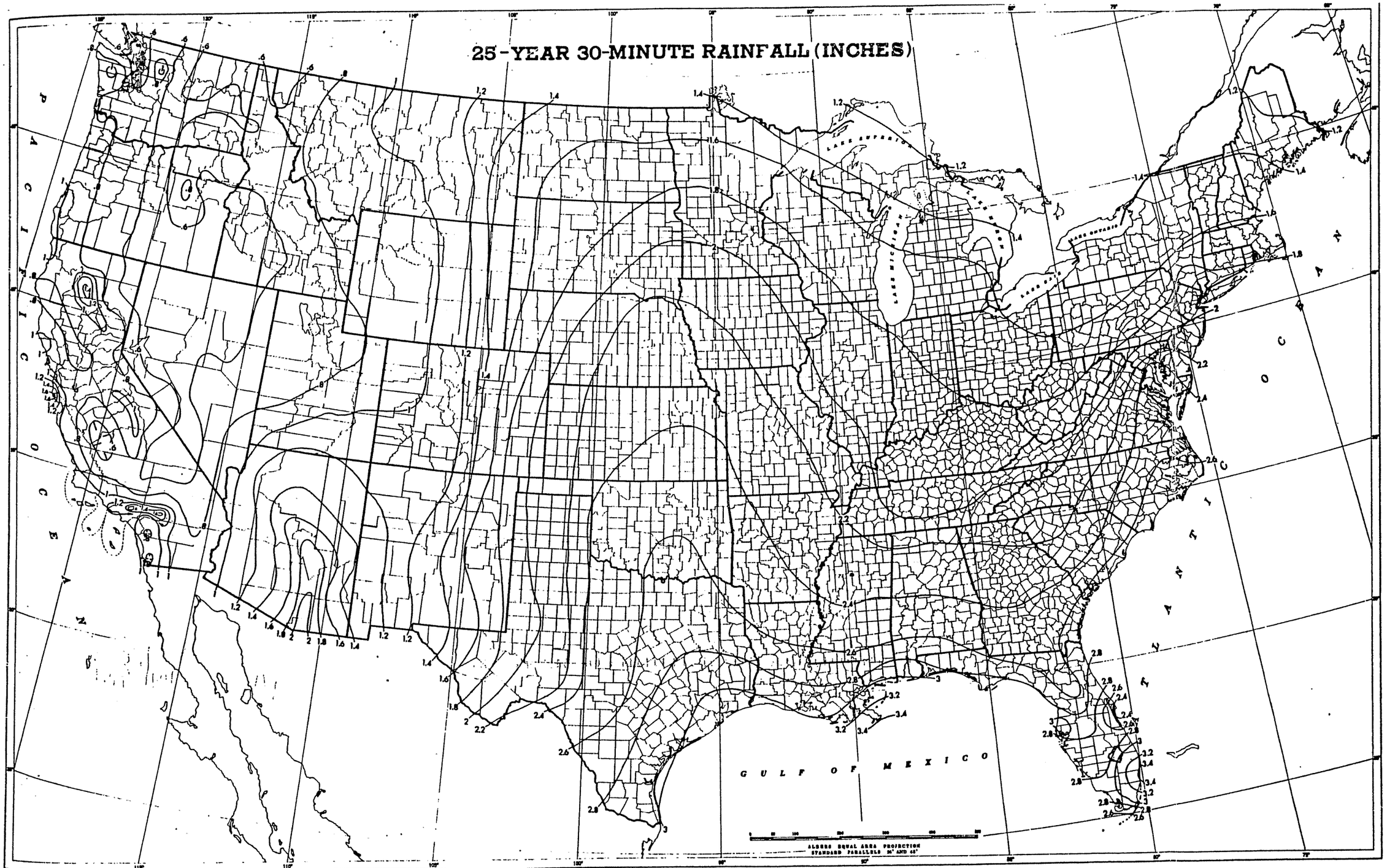
Table A-3.2, p. A-3-10 may be used for organizing computation.

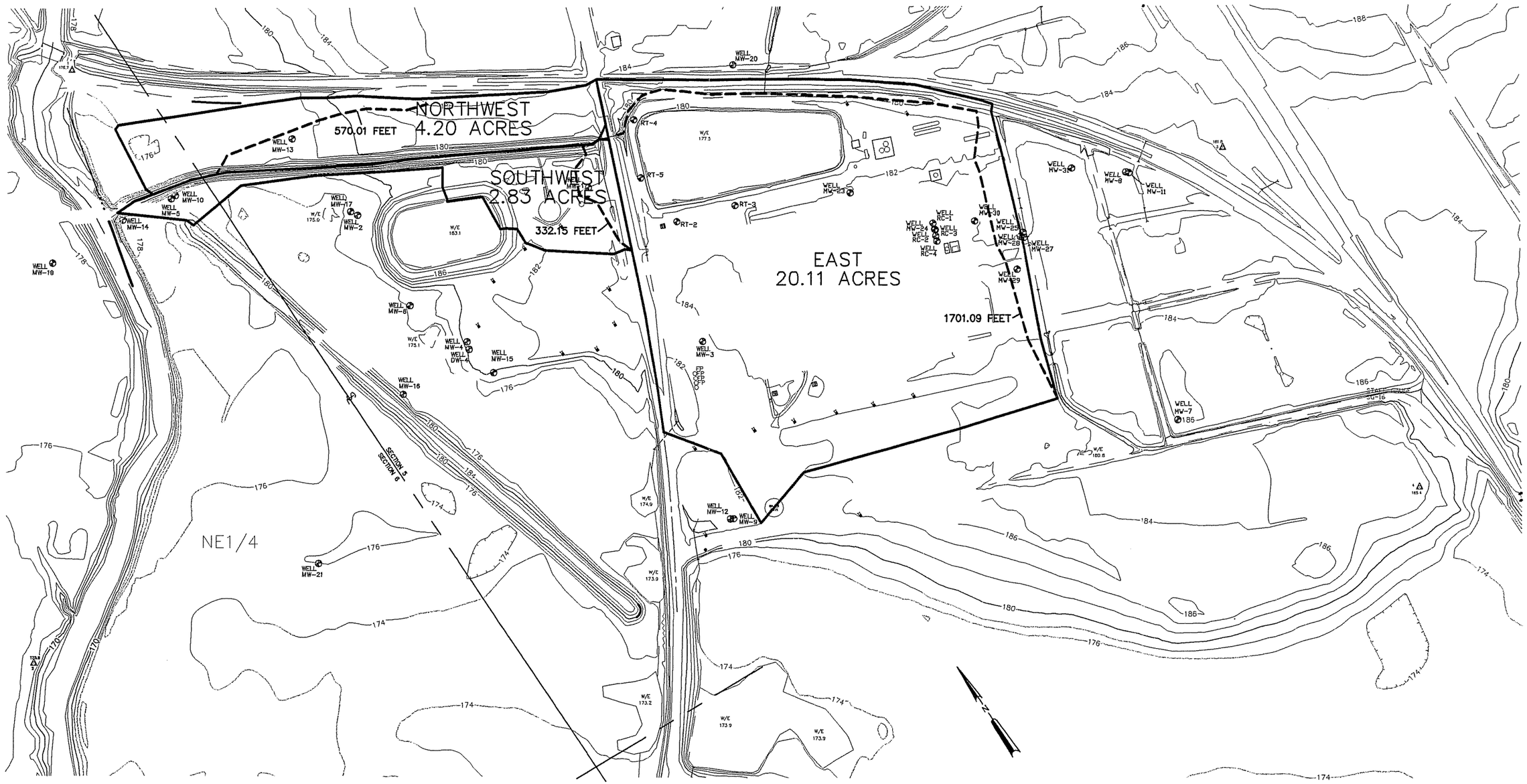


TIME OF CONCENTRATION OF SMALL DRAINAGE BASINS

Based on study by P. Z. Kirpich,
Civil Engineering, Vol.10, No.6, June 1940, p.362

Figure A-3.1


25-YEAR 30-MINUTE RAINFALL (INCHES)
GULF OF MEXICO
ALBERS EQUAL AREA PROJECTION
STANDARD PARALLELS 29° AND 45°



LEGEND

- Monitoring Well
- Drainage Area
- Hydraulic Length

250 0 250 500
SCALE FEET

SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

DRAWING NO.: AREAS.DWG DATE: 5/15/01 PLOT SCALE 1=250

DRAINAGE BASINS AND HYDRAULIC LENGTHS

GRENADA MANUFACTURING, LLC PLANT
GRENADA, MISSISSIPPI

19071.001 5/01

BROWN AND CALDWELL Nashville, Tennessee

FIGURE 4.5 n Values for Riprap Lined Channels

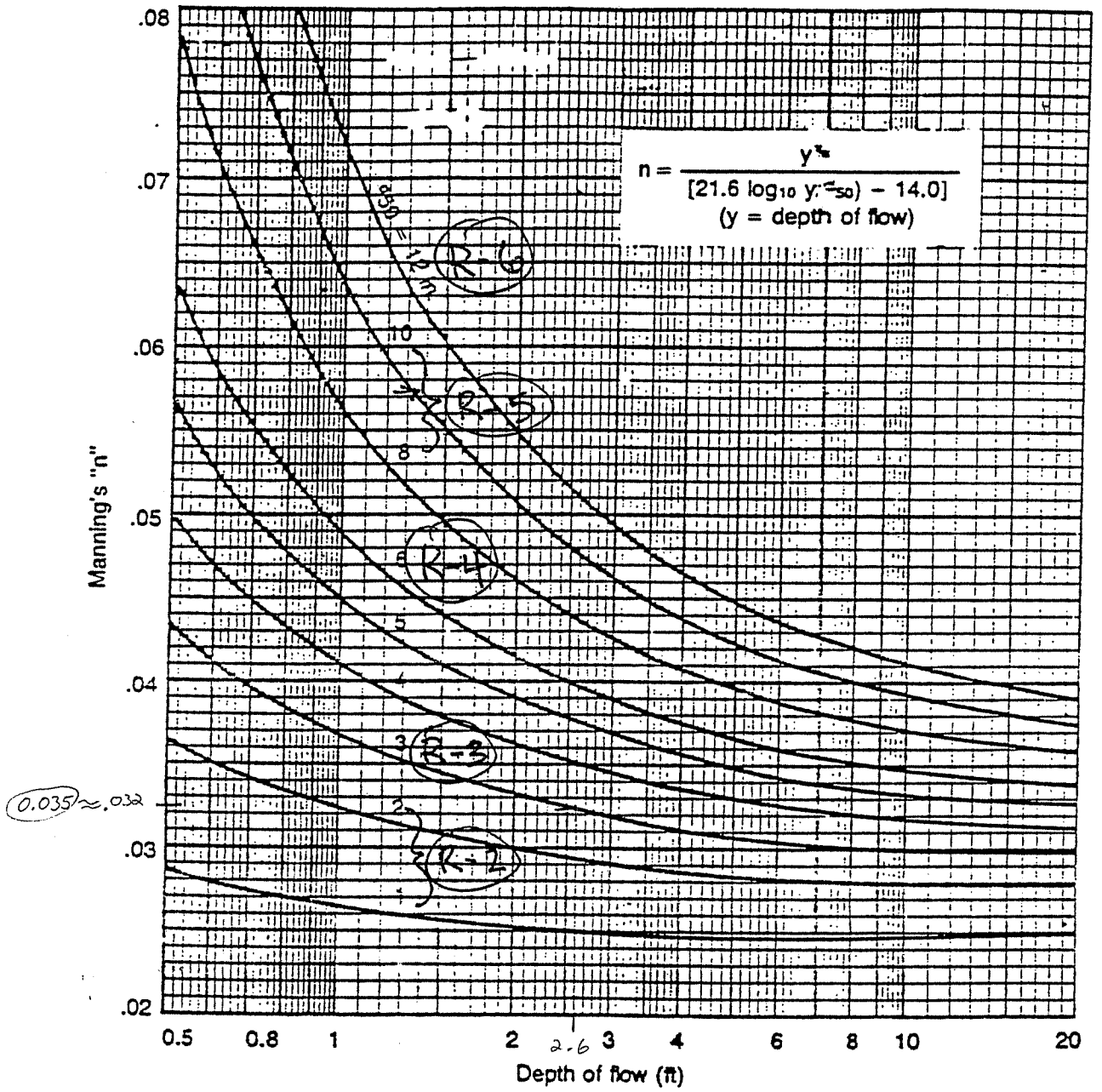


TABLE 4.7c Maximum Permissible Velocities for Rock Lined Channels and Riprap

NSA NO.	Graded Rock Size (In.) Max.	D_{50}	Min.	Permissible velocity fps*
R-1	1.5	.75	NO. 8	2.5
R-2	3	1.50	1	4.5
R-3	6	3	2	6.5
R-4	12	6	3	9.0
R-5	18	9	5	11.5
R-6	24	12	7	13.0
R-7	30	15	12	14.5

* Permissible velocities based on rock at 165 lbs. per cubic foot. Adjust velocities for other rock weights used. See Figure 4.6

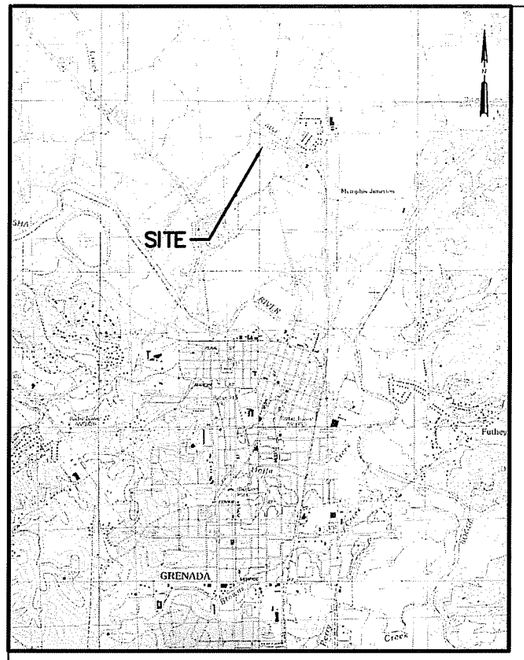
TABLE 4.7d Maximum Permissible Velocities for Reno Mattress and Gabions

Type	n	Thickness inches	Rock fill Gradation-in.	Permissible* Velocity-fps
Reno Mattress	.025	6	3 - 6	13.5
	.025	9	3 - 6	16.0
	.025	12	4 - 6	18.0
Gabion	.027	18 +	5 - 9	22.0

* Permissible velocities may be increased by the introduction of sand mastic grout. Refer to manufacturers recommendations/specifications for permissible velocities.

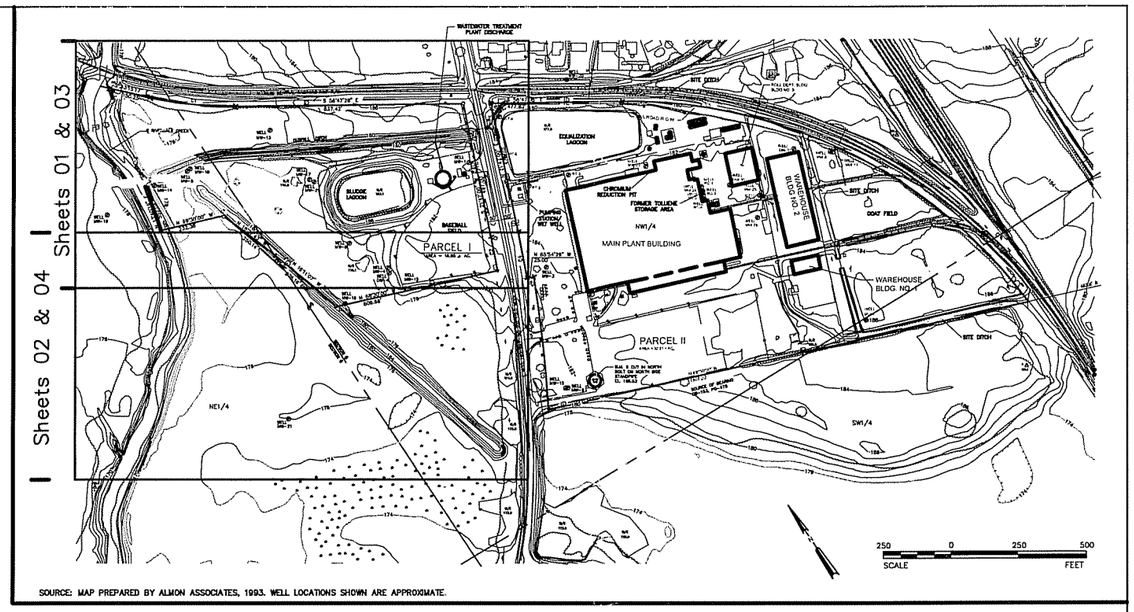
APPENDIX B

ENGINEERING DESIGN DRAWINGS



LOCATION MAP

SCALE: NONE



SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

VICINITY MAP

SCALE : 1"=250'

DESIGN DRAWINGS FOR PERMEABLE REACTIVE BARRIER GROUNDWATER INTERIM MEASURE

PREPARED FOR

ARVIN MERITOR, INC.
GRENADA, MISSISSIPPI

PREPARED BY

BROWN AND CALDWELL

501 Great Circle Road
Nashville, Tennessee 37228
(615) 255-2288

MAY 2001
REVISED APRIL 2003

LIST OF DRAWINGS

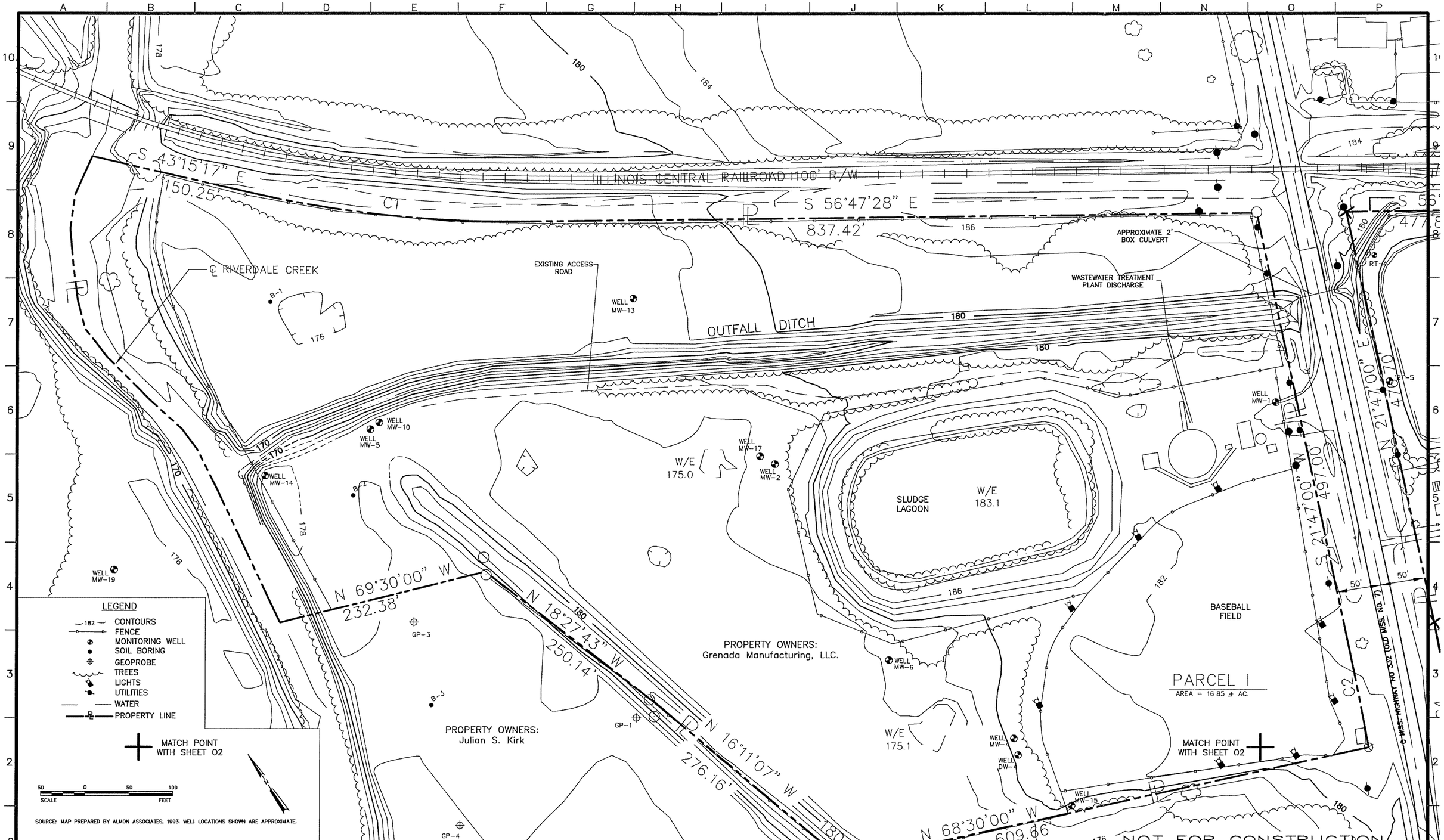
DRAWING NO.	DESCRIPTION
19071-01	EXISTING SITE CONDITIONS – SHEET 1
19071-02	EXISTING SITE CONDITIONS – SHEET 2
19071-03	CONSTRUCTION PLAN – SHEET 1
19071-04	CONSTRUCTION PLAN – SHEET 2
19071-05	PERMEABLE REACTIVE BARRIER PROFILE
19071-06	OUTFALL DITCH PROFILE
19071-07	PERMEABLE REACTIVE BARRIER AND DITCH CROSS-SECTIONS
19071-08	DETAILS
19071-09	PERMEABLE REACTIVE BARRIER PROFILE – MINIMUM IRON THICKNESS AT 100% IRON

ROBERT E. ASH IV, P.E. 4/18/03 DATE
MISSISSIPPI LICENSE NO. 13005

NOT FOR CONSTRUCTION

PROJECT NO. 27-19071.001

DRAWING NO.: 19071cov DATE: 05/18/01 PLOT SCALE 1=1



BROWN AND CALDWELL

SUBMITTED: _____ DATE: _____ (PROJECT MANAGER)
APPROVED: _____ DATE: _____ (BROWN AND CALDWELL)
APPROVED: _____ DATE: _____

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"–SCALE ACCORDINGLY)

FILE 19071–01
DRAWN W. RAINES
DESIGNED D. SHOWERS
CHECKED
CHECKED R. E. ASH

ROBERT E. ASH IV, P.E. DATE 4/18/03
MISSISSIPPI LICENSE NO. 13005

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

ARVIN MERITOR, INC.

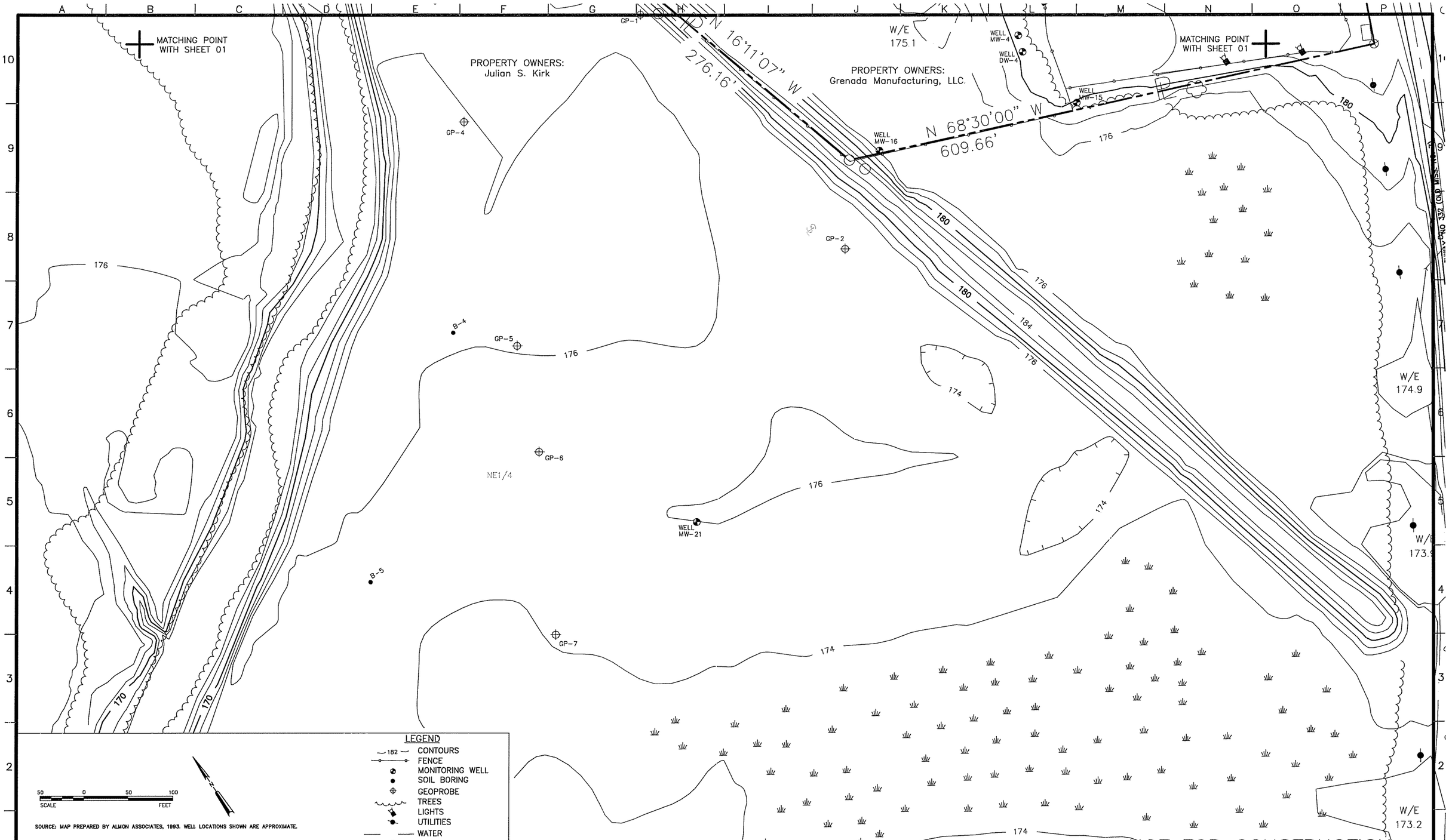
PERMEABLE REACTIVE BARRIER GROUNDWATER INTERIM MEASURE

EXISTING SITE CONDITIONS

SHEET 1

PROJECT NUMBER **19071.001**
DRAWING NUMBER **19071**
SHEET NUMBER **01**

19071–01 05/18/01 1=50



SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

BROWN AND CALDWELL

SUBMITTED: _____ PROJECT MANAGER DATE: _____
APPROVED: _____ BROWN AND CALDWELL DATE: _____
APPROVED: _____ DATE: _____

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

FILE 19071-02
DRAWN W. RAINES
DESIGNED D. SHOWERS
CHECKED _____
CHECKED R. E. ASH

ROBERT E. ASH IV, P.E. 4/18/03 DATE
MISSISSIPPI LICENSE NO. 13005

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

ARVIN MERITOR, INC.

PERMEABLE REACTIVE BARRIER GROUNDWATER INTERIM MEASURE

EXISTING SITE CONDITIONS

SHEET 2

PROJECT NUMBER 19071.001
DRAWING NUMBER 19071
SHEET NUMBER 02

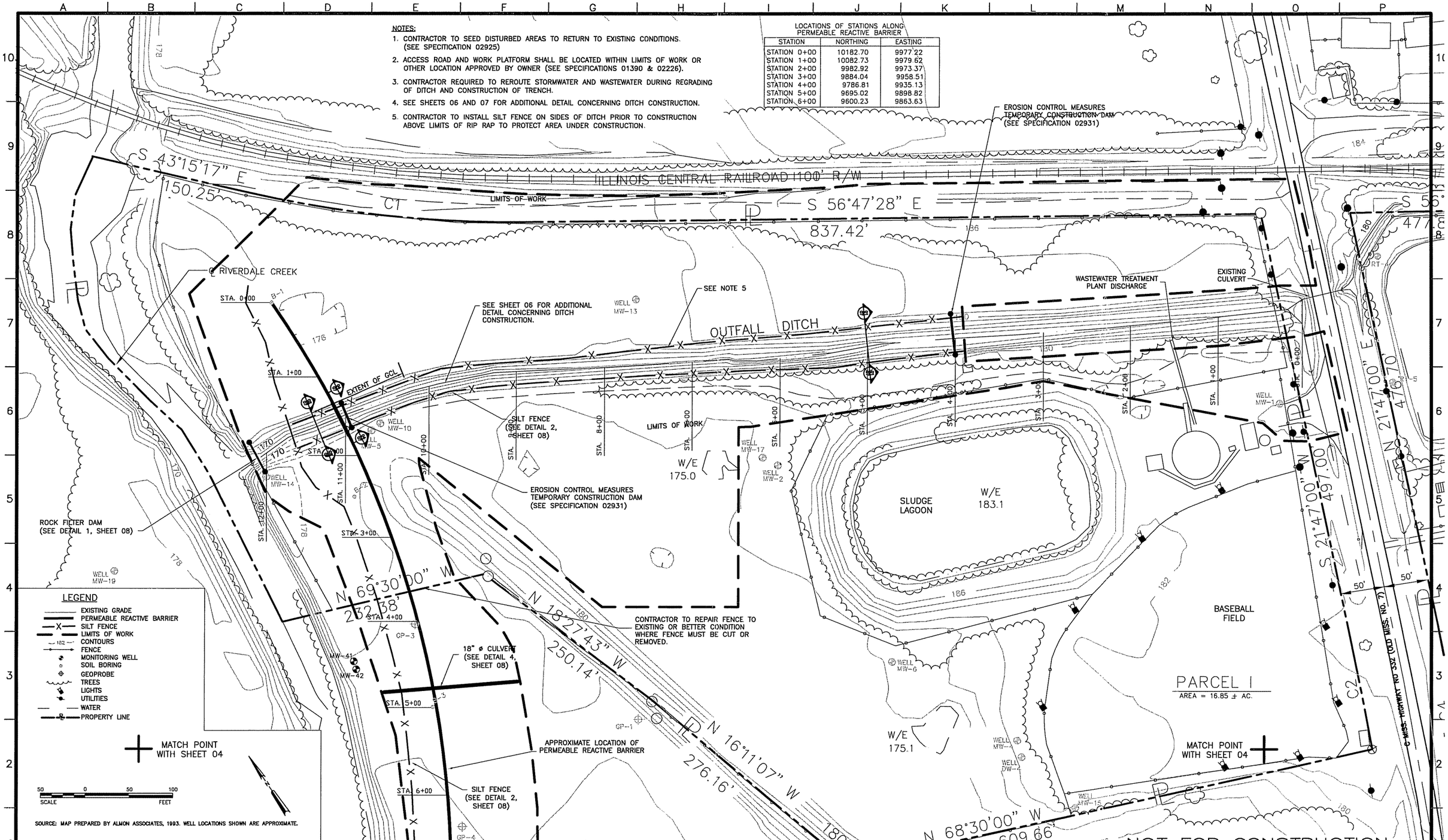
19071-02 05/18/01 1=50

NOTES:

1. CONTRACTOR TO SEED DISTURBED AREAS TO RETURN TO EXISTING CONDITIONS. (SEE SPECIFICATION 02925)
2. ACCESS ROAD AND WORK PLATFORM SHALL BE LOCATED WITHIN LIMITS OF WORK OR OTHER LOCATION APPROVED BY OWNER (SEE SPECIFICATIONS 01390 & 02226).
3. CONTRACTOR REQUIRED TO REROUTE STORMWATER AND WASTEWATER DURING REGRADING OF DITCH AND CONSTRUCTION OF TRENCH.
4. SEE SHEETS 06 AND 07 FOR ADDITIONAL DETAIL CONCERNING DITCH CONSTRUCTION.
5. CONTRACTOR TO INSTALL SILT FENCE ON SIDES OF DITCH PRIOR TO CONSTRUCTION ABOVE LIMITS OF RIP RAP TO PROTECT AREA UNDER CONSTRUCTION.

LOCATIONS OF STATIONS ALONG PERMEABLE REACTIVE BARRIER

STATION	NORTHING	EASTING
STATION 0+00	10182.70	9977.22
STATION 1+00	10082.73	9979.62
STATION 2+00	9982.92	9973.37
STATION 3+00	9884.04	9958.51
STATION 4+00	9786.81	9935.13
STATION 5+00	9695.02	9898.82
STATION 6+00	9600.23	9863.63



BROWN AND CALDWELL

SUBMITTED: _____ DATE: _____ (PROJECT MANAGER)
APPROVED: _____ DATE: _____ (BROWN AND CALDWELL)
APPROVED: _____ DATE: _____

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

FILE 19071-03
DRAWN W. RAINES
DESIGNED D. SHOWERS
CHECKED
CHECKED R. E. ASH

Robert E. Ash IV 4/18/03
ROBERT E. ASH IV, P.E. — DATE
MISSISSIPPI LICENSE NO. 13005

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1	REVISED LIMITS OF WORK AND LOCATIONS OF NEW GROUNDWATER MONITORING WELLS.		4-03	
	2	ADD STORM CULVERT		4-03	

ARVIN MERITOR, INC.

PERMEABLE REACTIVE BARRIER GROUNDWATER INTERIM MEASURE

CONSTRUCTION PLAN

SHEET 1

PROJECT NUMBER 19071.001
DRAWING NUMBER 19071
SHEET NUMBER 03

19071-03 04/18/03 1=50

MATCHING POINT WITH SHEET 03

RIVERDALE CREEK

STA. 6+00

STA. 7+00

STA. 8+00

STA. 9+00

STA. 10+00

STA. 11+00

STA. 12+00

STA. 12+10

LIMITS OF WORK

SILT FENCE (SEE DETAIL 2, SHEET 08)

APPROXIMATE LOCATION OF PERMEABLE REACTIVE BARRIER

18" ø CULVERT (SEE DETAIL 4, SHEET 08)

N 16°11'07" W
276.16'

N 68°30'00" W
609.66'

MATCHING POINT WITH SHEET 03

W/E 175.1

W/E 174.9

W/E 173.9

W/E 173.2

MW-45 MW-46 MW-47 MW-48 MW-53 MW-54

WELL MW-2 WELL DW-2 WELL MW-15 WELL MW-16 WELL MW-21

GP-2 GP-4 GP-5 GP-6 GP-7

E1/4

LOCATIONS OF STATIONS ALONG PERMEABLE REACTIVE BARRIER

STATION	NORTHING	EASTING
STATION 5+00	9695.02	9898.82
STATION 6+00	9600.23	9863.63
STATION 7+00	9512.28	9816.04
STATION 8+00	9428.77	9761.02
STATION 9+00	9350.35	9698.97
STATION 10+00	9277.59	9630.37
STATION 11+00	9211.03	9555.74
STATION 12+00	9151.19	9475.62
STATION 12+10	9145.33	9467.18

LEGEND

- EXISTING GRADE
- PERMEABLE REACTIVE BARRIER
- SILT FENCE
- LIMITS OF WORK
- CONTOURS
- FENCE
- MONITORING WELL
- SOIL BORING
- GEOPROBE
- TREES
- LIGHTS
- UTILITIES
- WATER
- PROPERTY LINE
- MARSH

SCALE 50 0 50 100 FEET

SOURCE: MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

NOT FOR CONSTRUCTION

BROWN AND CALDWELL

SUBMITTED: _____ DATE: _____
PROJECT MANAGER

APPROVED: _____ DATE: _____
BROWN AND CALDWELL

APPROVED: _____ DATE: _____

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

FILE 19071-04
DRAWN W. RAINES
DESIGNED D. SHOWERS
CHECKED _____
CHECKED R. E. ASH

ROBERT E. ASH IV, P.E. DATE 4/18/03
MISSISSIPPI LICENSE NO. 13005

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1	REVISED LIMITS OF WORK AND LOCATIONS OF NEW GROUNDWATER MONITORING WELLS.		4-03	
	2	ADD STORM CULVERTS		4-03	

ARVIN MERITOR, INC.

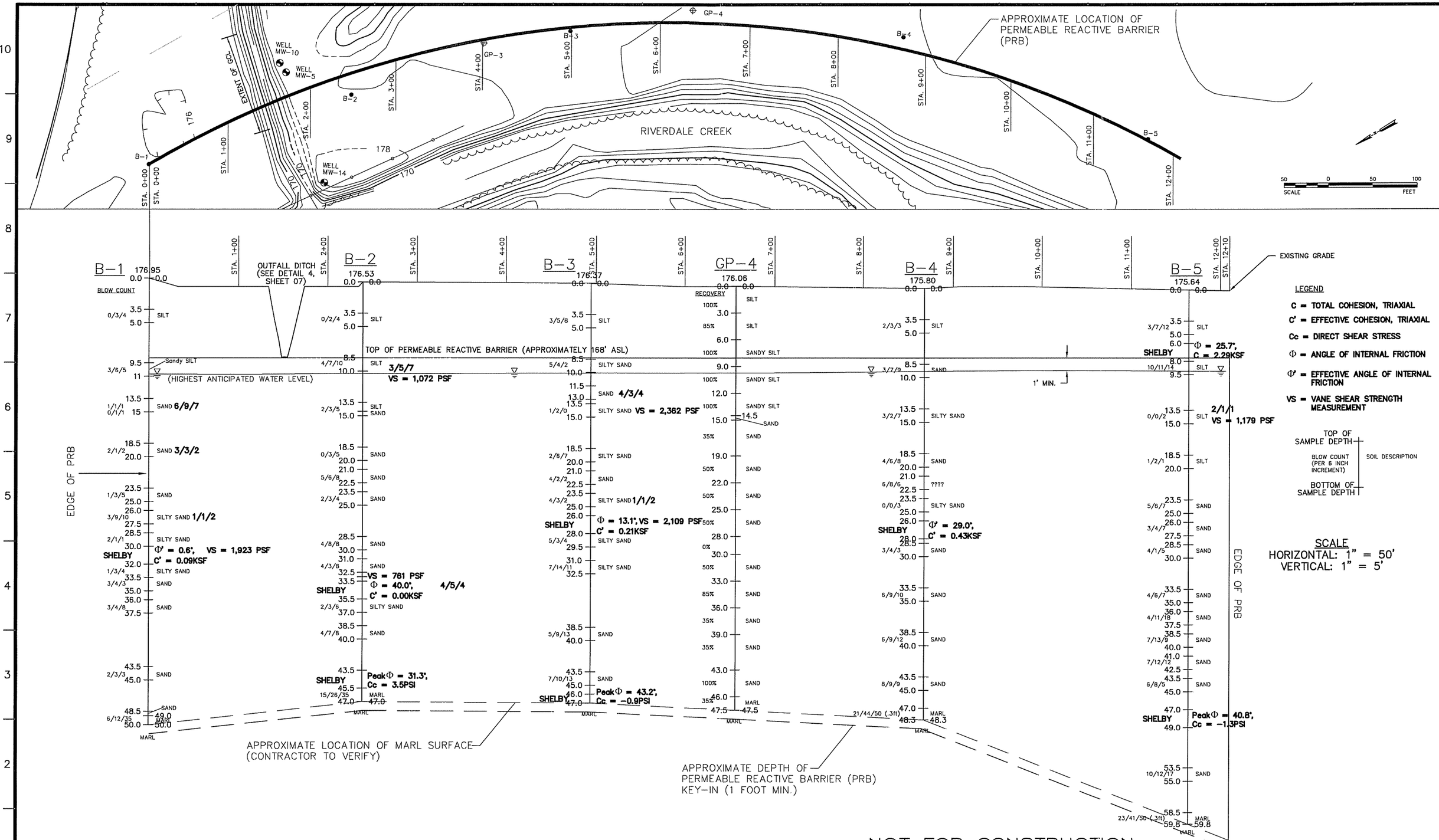
PERMEABLE REACTIVE BARRIER GROUNDWATER INTERIM MEASURE

CONSTRUCTION PLAN

SHEET 2

PROJECT NUMBER 19071.001
DRAWING NUMBER 19071
SHEET NUMBER 04

19071-04 04/18/03 1=50



BROWN AND CALDWELL

SUBMITTED: _____ PROJECT MANAGER DATE: _____
APPROVED: _____ BROWN AND CALDWELL DATE: _____
APPROVED: _____ DATE: _____

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"–SCALE ACCORDINGLY)

FILE 19071–05
DRAWN W. RAINES
DESIGNED D. SHOWERS
CHECKED _____
CHECKED R. E. ASH

ROBERT E. ASH IV, P.E. 4/8/03 DATE
MISSISSIPPI LICENSE NO. 13005

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1	ADD VANE SHEAR TEST DATA		4–03	

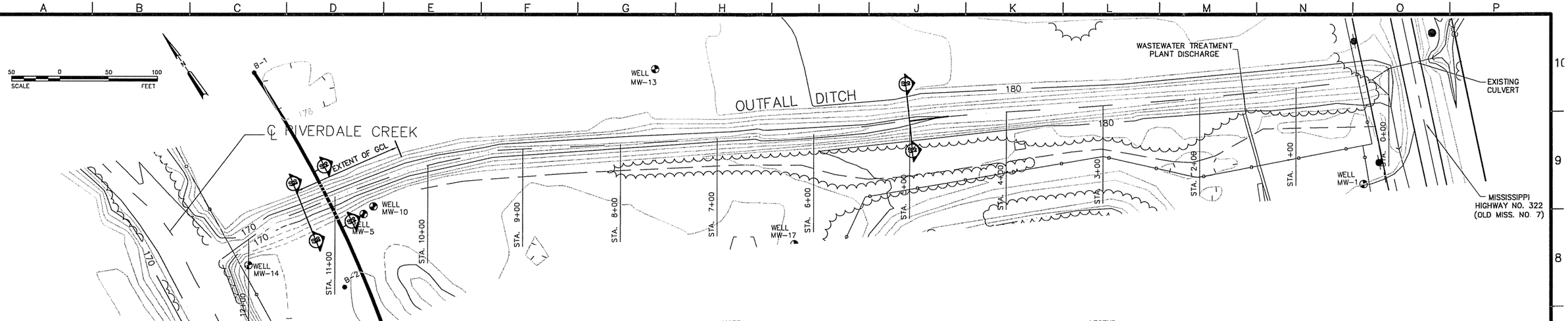
ARVIN MERITOR, INC.

PERMEABLE REACTIVE BARRIER GROUNDWATER INTERIM MEASURE

PERMEABLE REACTIVE BARRIER PROFILE

PROJECT NUMBER 19071.001
DRAWING NUMBER 19071
SHEET NUMBER 05

19071–05 04/11/03 1=50



SCALE
HORIZONTAL: 1" = 50'
VERTICAL: 1" = 2'

NOTES:

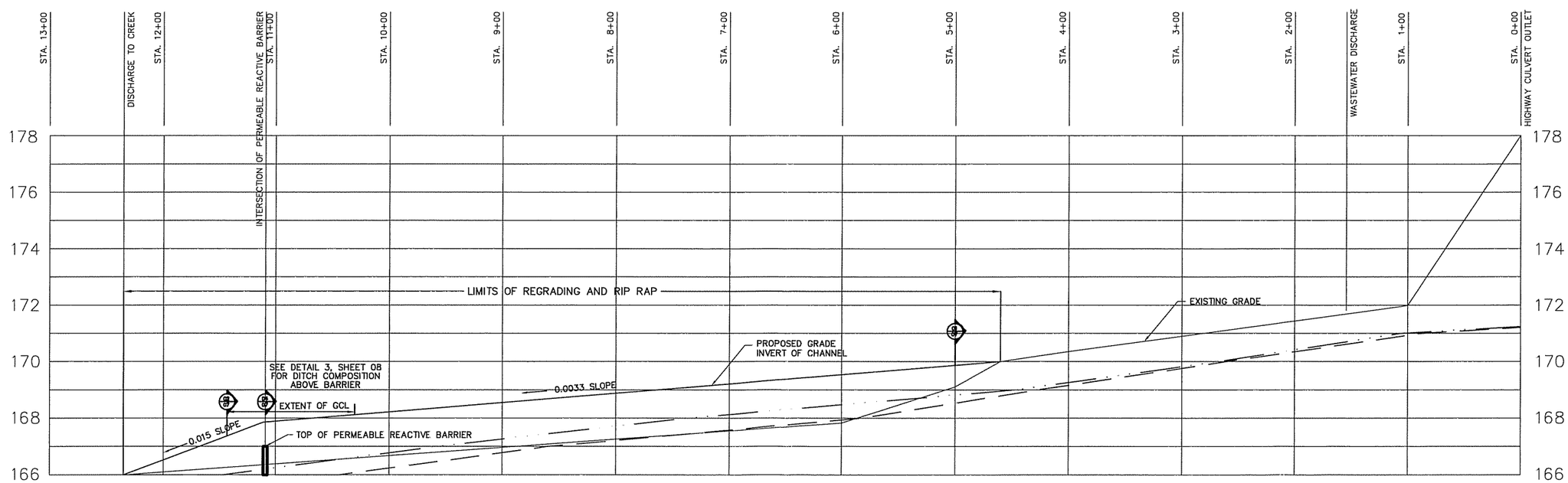
1. CONTRACTOR SHALL PLACE GENERAL FILL (SPECIFICATION 02200) IN BOTTOM OF EXISTING TRENCH UNTIL REQUIRED ELEVATIONS ARE REACHED (SEE PROFILE BELOW).
2. UPSTREAM OF THE PERMEABLE REACTIVE BARRIER, SIZE R-3 RIP RAP SHALL BE PLACED IN A LAYER 12 INCHES (MIN.) THICK ALONG THE WALLS AND BOTTOM TO A HEIGHT OF 4.5 FEET.

   DOWNSTREAM, SIZE R-3 RIP RAP SHALL BE PLACED IN A LAYER 12 INCHES (MIN.) THICK ALONG THE WALLS AND BOTTOM TO A HEIGHT OF 4 FEET.

   SEE SPECIFICATION 02200 AND SHEET 07 FOR MORE DETAIL.

LEGEND

- FINAL GRADE
- EXISTING GRADE
- POTENTIOMETRIC SURFACE SHOWING INFLUENCE OF DRAINAGE DITCH (BASED ON MEASUREMENTS FROM UPPER PORTION OF AQUIFER, FEBRUARY 1993)
- PROJECTED POTENTIOMETRIC SURFACE WITHOUT INFLUENCE OF DRAINAGE DITCH (BASED ON MEASUREMENTS FROM LOWER PORTION OF AQUIFER, FEBRUARY 1993)



NOT FOR CONSTRUCTION

BROWN AND CALDWELL

SUBMITTED: _____ PROJECT MANAGER DATE: _____
APPROVED: _____ BROWN AND CALDWELL DATE: _____
APPROVED: _____ DATE: _____

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

FILE 19071-06
DRAWN W. RAINES
DESIGNED D. SHOWERS
CHECKED _____
CHECKED R. E. ASH

ROBERT E. ASH IV, P.E. 4/18/03 DATE
MISSISSIPPI LICENSE NO. 13005

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.

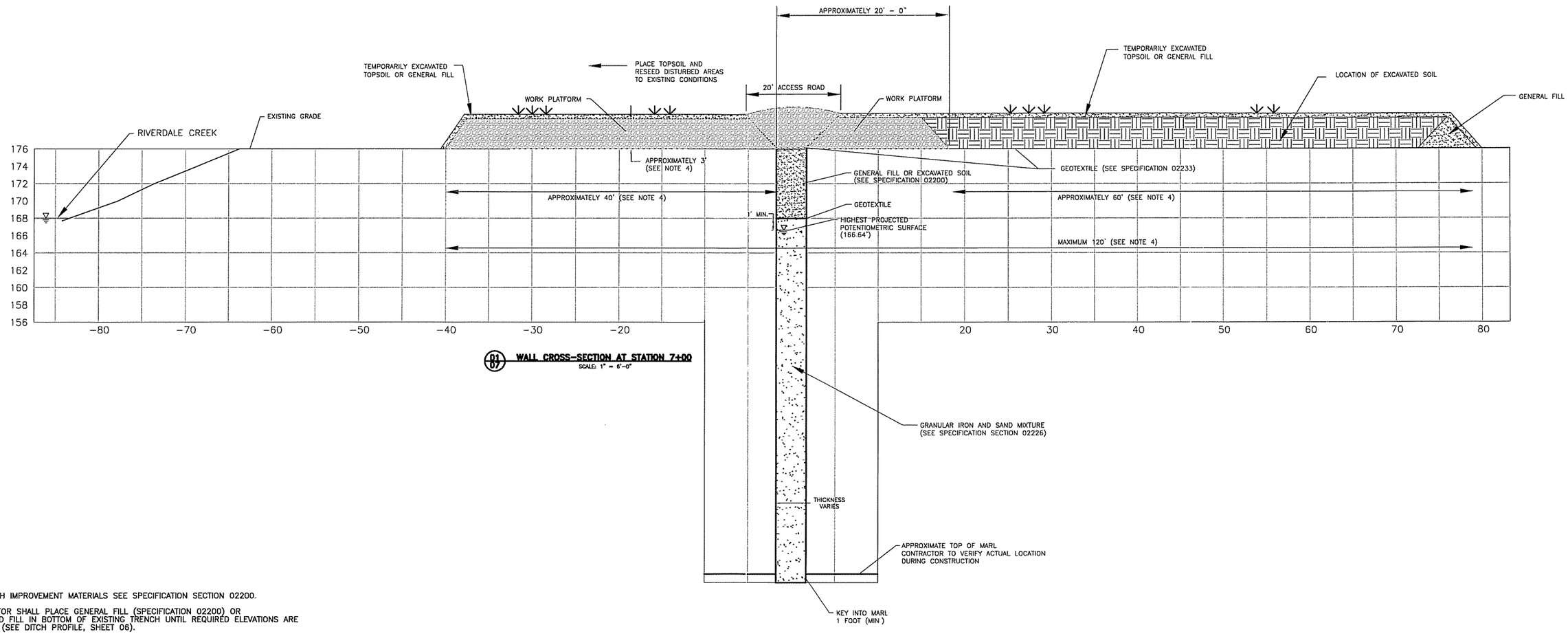
ARVIN MERITOR, INC.

PERMEABLE REACTIVE BARRIER GROUNDWATER INTERIM MEASURE

OUTFALL DITCH PROFILE

PROJECT NUMBER **19071.001**
DRAWING NUMBER **19071**
SHEET NUMBER **06**

19071-06 04/11/03 1=50



D1/07 WALL CROSS-SECTION AT STATION 7+00
SCALE: 1" = 6'-0"

NOTES:

1. FOR DITCH IMPROVEMENT MATERIALS SEE SPECIFICATION SECTION 02200.
2. CONTRACTOR SHALL PLACE GENERAL FILL (SPECIFICATION 02200) OR EXCAVATED FILL IN BOTTOM OF EXISTING TRENCH UNTIL REQUIRED ELEVATIONS ARE REACHED (SEE DITCH PROFILE, SHEET 06).
3. UPSTREAM OF THE PERMEABLE REACTIVE BARRIER, SIZE R-3 RIP RAP SHALL BE PLACED IN A LAYER 12 INCHES (MIN.) THICK ALONG THE WALLS AND BOTTOM TO A HEIGHT OF 4.5 FEET.

   DOWNSTREAM, SIZE R-3 RIP RAP SHALL BE PLACED IN A LAYER 12 INCHES (MIN.) THICK ALONG THE WALLS AND BOTTOM TO A HEIGHT OF 4 FEET.

   SEE SHEET 08 FOR MORE DETAIL.
4. CONTRACTOR SHALL PROVIDE WORK PLATFORM. PLATFORM MATERIALS SHALL BE CONSTRUCTED ON A GEOTEXTILE AND SHALL ADEQUATELY SUPPORT NECESSARY EQUIPMENT.

LEGEND

- EXISTING GRADE
- FINAL GRADE
- RIP RAP
- GENERAL FILL
- WORK PLATFORM
- GRANULAR IRON/SAND MIXTURE

6 0 6 12
SCALE FEET

NOT FOR CONSTRUCTION

BROWN AND CALDWELL

SUBMITTED: _____ DATE: _____
PROJECT MANAGER
APPROVED: _____ DATE: _____
BROWN AND CALDWELL
APPROVED: _____ DATE: _____

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

FILE 19071-07
DRAWN W. RAINES
DESIGNED D. SHOWERS
CHECKED _____
CHECKED R. E. ASH

ROBERT E. ASH IV, P.E. 4/18/03 DATE
MISSISSIPPI LICENSE NO. 13005

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

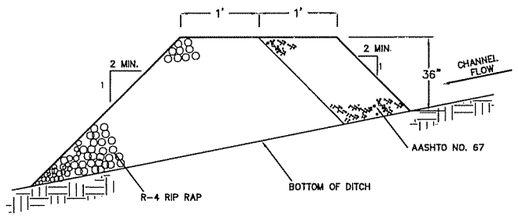
ARVIN MERITOR, INC.

PERMEABLE REACTIVE BARRIER GROUNDWATER INTERIM MEASURE

PERMEABLE REACTIVE BARRIER WORK PLATFORM CROSS-SECTION

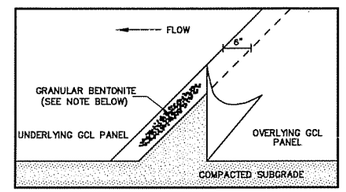
PROJECT NUMBER **19071.001**
DRAWING NUMBER **19071**
SHEET NUMBER **07**

19071-07 04/11/03 1=5



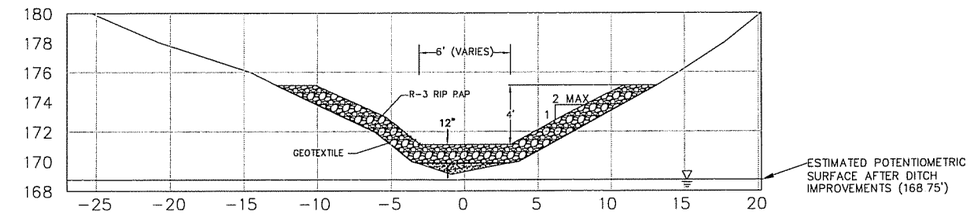
1/08 ROCK FILTER BERM
SCALE: NONE

MAINTENANCE:
ROCK FILTERS WILL BE REMOVED WHEN CLOGGED WITH SEDIMENTS. MATERIALS MUST BE WASHED COMPLETELY FREE OF ALL FOREIGN MATERIALS OR NEW ROCK USED TO REBUILD THE FILTER.

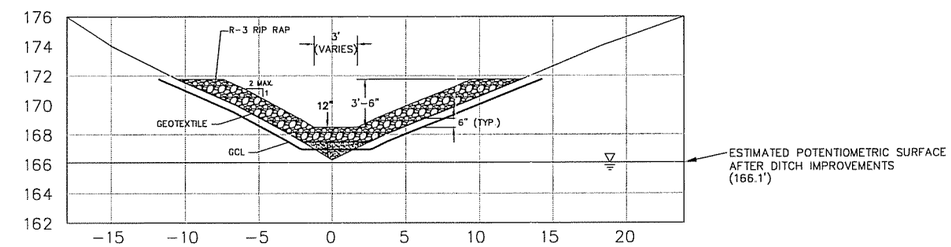


3/08 ISOMETRIC VIEW OF A GCL BENTONITE-ENHANCED OVERLAPPED SEAM
SCALE: NONE

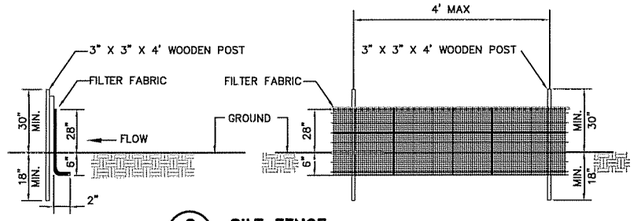
NOTES:
1. GRANULAR BENTONITE OR A BENTONITE MASTIC SHALL BE APPLIED LIBERALLY (APPROX. 1/4 LBS./LN FT) ALONG ROLL WIDTH.
2. OVERLAP AREA TO BE CLEAN AND FREE OF SOIL AND DEBRIS. OVERLAP SHALL BE PERPENDICULAR TO FLOW DIRECTION.



05/08 DITCH CROSS-SECTION AT STATION 5+00
SCALE: 1" = 5'-0"

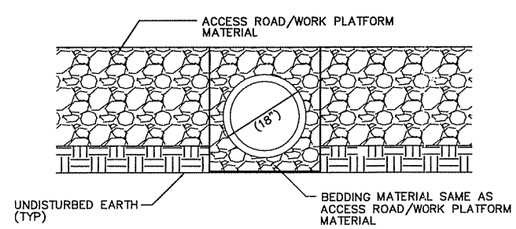


06/08 DITCH CROSS-SECTION AT STATION 11+35
SCALE: 1" = 5'-0"

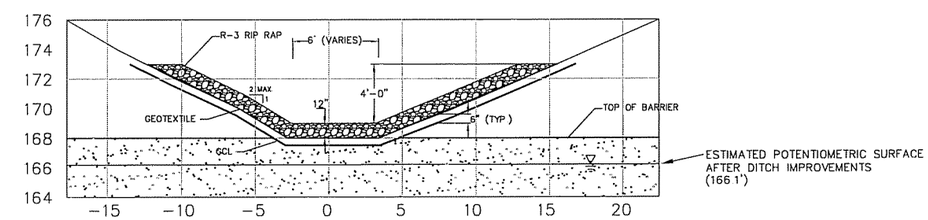


2/08 SILT FENCE
SCALE: NONE

NOTE: A SILT FENCE SHALL BE PLACED AT THE LOCATIONS SHOWN ON THE DRAWINGS. SEE ALSO SPECIFICATION 02931 AND MS DOT SPECIFICATION 234.01.



4/08 STORM CULVERT
SCALE: NONE



07/08 DRAINAGE DITCH/PERMEABLE REACTIVE BARRIER INTERSECTION
SCALE: 1" = 5'-0"

LEGEND
- RIP RAP
- GRANULAR IRON/SAND MIXTURE
- GENERAL FILL

NOTES:
1. FOR DITCH IMPROVEMENT MATERIALS SEE SPECIFICATION SECTION 02200.
2. CONTRACTOR SHALL PLACE GENERAL FILL (SPECIFICATION 02200) IN BOTTOM OF EXISTING TRENCH UNTIL REQUIRED ELEVATIONS ARE REACHED (SEE DITCH PROFILE, SHEET 06).
3. UPSTREAM OF THE PERMEABLE REACTIVE BARRIER, SIZE R-3 RIP RAP SHALL BE PLACED IN A LAYER 12 INCHES (MIN.) THICK ALONG THE WALLS AND BOTTOM TO A HEIGHT OF 4.5 FEET.
   DOWNSTREAM, SIZE R-3 RIP RAP SHALL BE PLACED IN A LAYER 12 INCHES (MIN.) THICK ALONG THE WALLS AND BOTTOM TO A HEIGHT OF 4 FEET.
   SEE SPECIFICATION 02200 FOR MORE DETAIL.
4. CONTRACTOR SHALL PROVIDE WORK PLATFORM. PLATFORM MATERIALS SHALL BE CONSTRUCTED ON A GEOTEXTILE AND SHALL ADEQUATELY SUPPORT NECESSARY EQUIPMENT.

NOT FOR CONSTRUCTION

BROWN AND CALDWELL

SUBMITTED: _____ DATE: _____ (PROJECT MANAGER)
APPROVED: _____ DATE: _____ (BROWN AND CALDWELL)
APPROVED: _____ DATE: _____

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

FILE 19071-08
DRAWN W. RAINES
DESIGNED D. SHOWERS
CHECKED
CHECKED R. E. ASH

ROBERT E. ASH IV, P.E. DATE 4/18/03
MISSISSIPPI LICENSE NO. 13005

REVISIONS

ZONE	REV.	DESCRIPTION	BY	DATE	APP.
	1	ADD STORM CULVERT DETAIL		4/03	

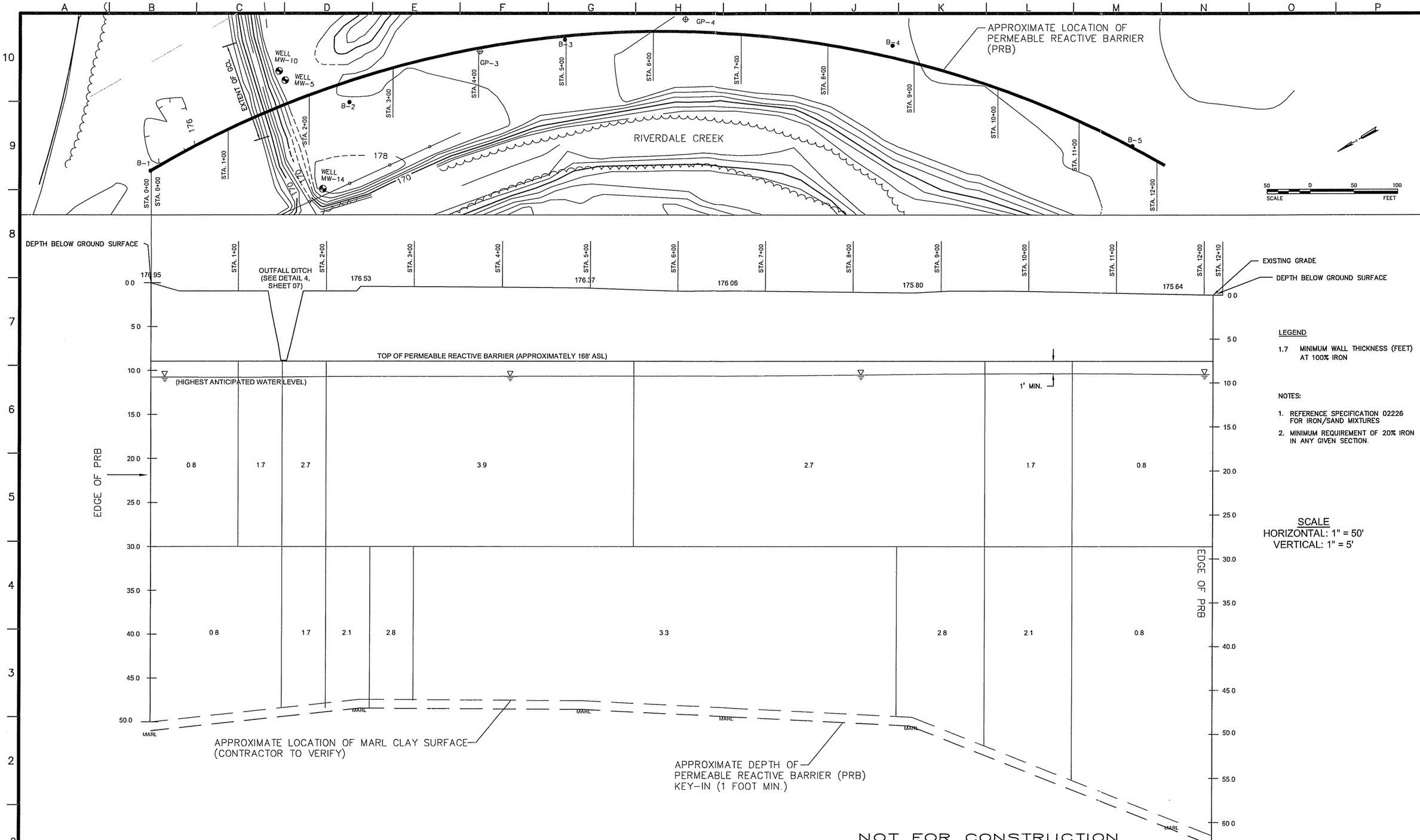
ARVIN MERITOR, INC.

PERMEABLE REACTIVE BARRIER
GROUNDWATER INTERIM MEASURE

DETAILS

PROJECT NUMBER 19071.001
DRAWING NUMBER 19071
SHEET NUMBER 08

04/07/03 1=1
19071-08



LEGEND

1.7 MINIMUM WALL THICKNESS (FEET) AT 100% IRON

NOTES:

1. REFERENCE SPECIFICATION 02226 FOR IRON/SAND MIXTURES
2. MINIMUM REQUIREMENT OF 20% IRON IN ANY GIVEN SECTION.

SCALE
HORIZONTAL: 1" = 50'
VERTICAL: 1" = 5'

BROWN AND CALDWELL

SUBMITTED: _____ DATE: _____
PROJECT MANAGER
APPROVED: _____ DATE: _____
BROWN AND CALDWELL
APPROVED: _____ DATE: _____

LINE IS 2 INCHES AT FULL SIZE (IF NOT 2"-SCALE ACCORDINGLY)

FILE 19071-09
DRAWN R. MALONEY
DESIGNED D. SHOWERS
CHECKED
CHECKED R. E. ASH

ROBERT E. ASH IV, P.E. 4/18/03
MISSISSIPPI LICENSE NO. 13005
DATE

REVISIONS					
ZONE	REV.	DESCRIPTION	BY	DATE	APP.

ARVIN MERITOR, INC.

PERMEABLE REACTIVE BARRIER GROUNDWATER INTERIM MEASURE

PERMEABLE REACTIVE BARRIER PROFILE MINIMUM IRON THICKNESS AT 100% IRON

PROJECT NUMBER **19071.001**
DRAWING NUMBER **19071**
SHEET NUMBER **09**

19071-09 04/11/03 1=50

APPENDIX C

TECHNICAL SPECIFICATIONS

PERMEABLE REACTIVE BARRIER
GROUNDWATER INTERIM MEASURE

GRENADA MANUFACTURING SITE
GRENADA, MISSISSIPPI
APRIL 2003

DIVISION 1 - GENERAL REQUIREMENTS

01010 SUMMARY OF WORK
01027 APPLICATIONS FOR PAYMENT
01035 CHANGE ORDER PROCEDURES
01040 PROJECT COORDINATION
01050 CONTRACTOR FIELD ENGINEERING
01060 REGULATORY REQUIREMENTS
01090 REFERENCES
01110 ENVIRONMENTAL PROTECTION
01120 SITE MAINTENANCE
01200 PROJECT MEETINGS AND ADMINISTRATION
01310 CONSTRUCTION PROGRESS SCHEDULE
01340 SUBMITTALS
01370 SCHEDULE OF VALUES
01380 CONSTRUCTION PHOTOGRAPHS
01390 CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS
01400 QUALITY CONTROL
01500 HEALTH AND SAFETY PLAN
01540 SECURITY
01560 DUST AND NOISE CONTROL
01600 MATERIAL AND EQUIPMENT
01700 PROJECT CLOSEOUT
01740 WARRANTIES AND BONDS

DIVISION 2 - SITE WORK

02200 EARTHWORK & MATERIALS
02226 BIOPOLYMER SLURRY EXCAVATION AND IRON PLACEMENT
02233 GEOSYNTHETICS
02721 CORUGATED METAL PIPE (CMP)
02925 TOPSOILING AND SEEDING
02931 EROSION CONTROL

DIVISION 1

GENERAL REQUIREMENTS

SECTION 01010

SUMMARY OF WORK

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall be responsible for executing the work shown on the Drawings, called for in the Specifications and other Contract Documents and as necessary for a complete installation through acceptance by the Owner. The Contractor shall furnish machinery, tools, equipment, material, and labor necessary to make the work satisfactory, complete, neat, and finished. The Contractor shall be responsible for obtaining permits required to perform the work outlined herein.

B. All incidental, minor and miscellaneous items, work, and materials for which no payment is specifically provided, and any items, work, and materials not specified or shown which are necessary to complete the indicated work and to maintain and repair the work, or which may be fairly implied as included, shall be done and furnished by the Contractor at no cost to the Owner.

C. The project consists of, but shall not be limited to, the installation of a Permeable Reactive Barrier using the biopolymer trenching technology and restructuring a portion of the outfall ditch as well as any other related work to the areas designated by the Drawings and called for herein. The design intent, as determined by the Engineer, shall govern in the case of discrepancy in or between the Drawings and Specifications. The Specifications are intended to supplement and clarify the Drawings, as sometimes work is called for in the Specifications that is not shown on the Drawings, and sometimes the Drawings indicate work that is not mentioned in the Specifications. Both Drawings and Specifications must be complied with in order to fulfill the Contract requirements, and any work called for by either is as binding as though it were called for by both. The Contractor shall take no advantage of any error or omission in the Drawings or of any discrepancy between the

Drawings and Specifications. In all cases of doubt as to the true meaning of the Drawings and Specifications, the decision of the Engineer will be final and conclusive.

1.02 REFERENCES TO OTHER SPECIFICATIONS

A. Wherever in the Contract Documents references are made to other specifications, standards, or requirements, it shall be understood that the latest editions or versions of specification, standards, or requirements are intended and shall apply, except as otherwise specified or to the extent that said specifications, standards, or requirements may be in conflict with applicable laws, ordinances, rules, and regulations.

1.03 SUPPLEMENTAL DEFINITION OF PARTIES

A. The following definitions are intended to supplement the definitions contained within **DIVISION 0 - GENERAL CONDITIONS:**

1. Owner's Representative: The Owner's Representative is the person or organization who is authorized by the Owner to make decisions as specified herein. The Owner's Representative may be an employee of the Owner or a firm hired by the Owner or both.

2. Engineer: The Engineer is the person or organization who is authorized by the Owner to make engineering decisions as specified herein. The Engineer may be the same firm as the Owner's Representative.

B. Designation of specific persons for the Owner's Representative and Engineer will be established at the preconstruction meeting.

1.04 ENUMERATION OF CONTRACT DRAWINGS

A. See Design Construction Drawing "Cover Sheet" for list of contract drawings.

1.05 CONTRACTOR USE OF SITE

A. Access to Site: Traffic routes to be used during Construction shall be coordinated with the Owner to allow access at the site.

B. Emergency Exits During Construction: Shall be as identified by the Owner's Representative during the pre-construction meeting.

C. Construction Operations: Limited to areas noted on Drawings.

D. Time Restrictions for Performing Exterior Work shall be limited to daylight hours or in accordance with local ordinances, whichever are more stringent.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01027

APPLICATIONS FOR PAYMENT

PART 1 - GENERAL

1.01 REQUIREMENTS INCLUDED

A. Procedures for Preparation and Submittal of Applications for Payment

1.02 RELATED REQUIREMENTS

A. Owner-Contractor Agreement: Contract Sum; Amounts of Progress Payments and Retainages; Times for Submittals

B. Section 01340 - Submittals

C. Section 01700 - Project Closeout

1.03 FORMAT

A. Submit application for payment in a form acceptable to the Owner. The Owner recommends that EJCDC Document No. 1910-8-E "Application for Payment" form be used for all projects unless otherwise approved. A copy of the EJCDC document is included in the Division 0 Exhibits.

B. For each item, provide a column for listing: item number; description of work; scheduled value; percentage value; previous applications; work in place and on-site stored materials under this application; authorized change orders; total completed to date of application; percentage of completion; balance to finish; and retainage.

1.04 PREPARATION OF APPLICATIONS

A. Type required information.

B. Execute certification by signature of authorized officer.

C. Use data on accepted Bid Form. Provide dollar value in each column for each line item for portion of Work performed.

D. List each authorized Change Order as an extension on continuation sheet, listing Change Order number and dollar amount as for an original item of Work.

1.05 SUBMITTAL PROCEDURES

A. Submit Application for Payment at times stipulated in Agreement, or as directed by Owner.

B. Submit under transmittal procedures specified in Section 01340.

1.06 SUBSTANTIATING DATA

A. When Owner requires substantiating information, submit data justifying line item amounts in question.

B. Provide one copy of data with cover letter for each copy of submittal. Show Application number and date, and line item by number and description.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01035

CHANGE ORDER PROCEDURES

PART 1 - GENERAL

1.01 REQUIREMENTS INCLUDE

A. Procedures for processing Change Orders.

1.02 RELATED REQUIREMENTS

A. Section 00700 - General Conditions of the Contract for Construction

B. Section 01300 - Submittals

1.03 SUBMITTALS

A. Submit name of individual authorized to accept changes and to be responsible for informing others in Contractor's employ of changes in Work.

B. Change Order Form: Form acceptable to Owner is included in Division 0 Exhibits.

1.04 CHANGES

A. The cost or credit to Owner resulting from a change in Work shall be determined by one of the methods described below and supported by sufficient substantiating data to permit evaluation.

1. By Unit Prices stated in Contract Documents or subsequently agreed upon;

2. By Lump Sum.

3. By Time and Material.

4. By Time and material with a Not-to-Exceed Limit.

B. Provide to the Owner following data to support Contractor's claim:

1. Quantities of products, labor, and equipment.

2. Taxes, insurance, and bonds.

3. Overhead and profit.

4. Justification for any change in Contract Times as defined in Section 00700, Article 1.01.

5. Credit for deletions from Contract, similarly documented.

6. Invoices and receipts for products, equipment, and subcontracts, similarly documented.

C. Provide with each claim for additional costs the following information:

1. Origin and date of claim, unless Owner has requested the additional work.

2. On a form provided by Owner, Contractor shall document Work performed, materials used, employee's names, and hours worked. Form is to be signed by authorized Owner's Representative each day.

3. Submit itemized account and supporting data after completion of change, within time limits in Conditions of Contract. Supporting data shall consist of original invoices, time cards, time records and wage rates paid, material take-off receipts, and other supportable data.

4. Subcontractor's invoices and receipts for products and time charges shall be similarly documented.

D. Owner will determine the change allowable in Contract Sum and Contract Time as provided in Conditions of the Contract.

E. Document each quotation for a change in cost or time with sufficient data to allow evaluation of quotation.

1.05 EXECUTION OF CHANGE ORDERS

A. Owner will issue a written acceptance of Change Order.

B. A single Amendment to Contract may consist of one or more Change Orders making up an Amendment to the Contract. Contractor and Owner shall together determine and agree upon frequency of Amendments to Contract.

C. Each Change Order shall provide dollar amount of change, subdivided into Labor, Materials, and Sales/Use Tax. Each Amendment to Contract will be sum total of Change Orders subdivided into Labor, Materials, and Sales/Use Tax.

1.06 CHANGE ORDER MARK-UP

A. Adjustments to Contract sum may include a percentage for mark-up as provided in Section 00700.

1.07 CORRELATION OF CONTRACTOR SUBMITTALS

A. After receipt of Amendment to Purchase Order and/or Contract promptly revise Schedule of Values and Application for Payment forms to record each authorized Change Order as a separate line item and adjust Contract Sum as shown on Change Order.

B. Promptly revise Progress Schedule to reflect any change in Contract Time, revise subschedules to adjust time for other items of Work affected by change, and resubmit.

C. Promptly enter changes in Project Record Documents.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01040

PROJECT COORDINATION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Owner

B. Owner's Representative

C. Access to Work

D. Sampling and Analyses by Owner's Representative

1.02 RELATED SECTIONS

A. Section 01500 - Health and Safety Plan (HASP)

1.03 OWNER

A. Contractor shall cooperate with Owner and Owner's Representative in all activities as necessary to ascertain compliance with the Contract Documents, including but not limited to providing data, providing working record drawings, site security, site access, and any reasonable requests for information or use of personnel and equipment at no additional cost to Owner.

1.04 OWNER'S REPRESENTATIVE

A. Owner's Representative will be at the contract work area during work activities to observe the progress and quality of the executed Work. On the basis of his work area observations, Owner's Representative will keep Owner informed of the quality of the Work and will endeavor to guard Owner against defects and deficiencies in the Work of the Contractor. Owner's Representative may disapprove Work as failing to conform to the Contract Documents. Whenever it is considered necessary or advisable for the proper execution of the intent of the Contract Documents, Owner's Representative shall have authority to require Contractor to make

special examination or testing of the Work at any stage of Work progress.

B. No matter how extensive or intensive the inspection, Owner's Representative will not be responsible for construction means, methods, techniques, sequences or procedures, or for safety precautions and programs in connection with the Work, and will not be responsible for Contractor's failure to carry out the Work in accordance with the Contract Documents. The Owner's Representative's duties, services, and work shall in no way supersede or dilute Contractor's obligation to perform Work in conformance with all Contract requirements. The Owner's Representative is empowered by Owner to act on its behalf with respect to the proper execution of the Work and to give instructions when necessary to require such corrective measures as may be necessary in the professional opinion of Owner's Representative for the proper execution of the Contract or to protect Owner's interest.

1.05 ACCESS TO WORK

A. Owner, its Representative, Engineers, Inspectors, Agents, other employees and representatives of local, State and Federal regulatory agencies shall for any purpose, and any other parties who may enter into contracts with Owner for doing Work within the area covered by the Contract shall, for all purposes which may be required by their contracts, have access to the Work and the premises used by Contractor, and Contractor shall provide safe and proper facilities therefore. The Contractor shall, whenever so requested, provide to Owner's Representative access to the proper invoices, bills of lading, etc.

1.06 SAMPLING AND ANALYSES BY THE OWNER'S REPRESENTATIVE

A. Owner's Representative may conduct independent observations or sampling and analyses for the purpose of assessing the Work by Contractor. Contractor shall fully cooperate with Owner's Representative in the collection of any such samples, and shall provide assistance (labor or equipment) as appropriate.

B. It is not Owner's intent to collect and analyze any air, water, or other samples to protect the welfare of Contractor's employees and/or agents. Any sampling and analyses necessary to protect the health and welfare of Contractor's employees and/or agents shall remain the sole responsibility of Contractor.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01050

CONTRACTOR FIELD ENGINEERING

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall retain the services of an independent registered Land Surveyor licensed in the State of Mississippi to provide survey control for construction, and to provide survey for record drawings for various components of construction. The Surveyor shall furnish all labor, materials, tools, supervision, transportation, and equipment necessary to perform the surveying work as specified herein for the Additional Groundwater Interim Measure implementation, as shown on the Drawings.

B. The work of this Section shall include, but not necessarily be limited to: establishing survey control points, stakeout, providing survey control during construction, and providing final survey documentation (as-built drawings) for all portions of the Work.

1.02 RELATED SECTIONS

A. Section 02200 - Earthwork and Materials

B. Section 02226 - Biopolymer Slurry Excavation and Iron Placement

C. Section 02672 - Well Drilling and Casing

1.03 QUALIFICATION OF SURVEYOR

A. The Contractor shall retain the services of a registered Land Surveyor licensed in the State of Mississippi and acceptable to the Owner.

B. The Surveyor, in the opinion of the Owner, shall have a proven record of successful performance on projects of similar magnitude. Prior to acceptance by the Owner, the Surveyor will be required to submit a Survey Plan describing the qualifications of the survey crew chief and other key personnel. The Plan must also provide the Surveyor's

commitment to meet the project schedule and provide the required record drawing documentation as expeditiously as possible, and in accordance with the requirements imposed by the project schedule.

1.04 SUBMITTALS

A. Submit name, address, and telephone number of the Surveyor prior to the start of site work.

B. Prior to the start of survey work, submit Survey Plan including project staffing, scheduling, the type of equipment the Surveyor intends to use in the field and in the office (i.e., instruments and computer software) to complete the project, and typical examples of final work product on similar projects if available.

C. Submit (i.e., signed and sealed drawings) documentation verifying accuracy of survey work.

D. The Surveyor shall submit to the Owner six (6) blueline copies of the record drawing documentation within fourteen days of the completion of the work. The Owner's Representative will review the record drawing documentation upon receipt from the Surveyor. The Owner's Representative will notify the Contractor as to whether the record drawing documentation demonstrates construction to the specified grades, elevations, structure location, etc.

E. A minimum of six (6) certified blueline copies of the final record drawing documentation shall be prepared within 14 days after final review and approval by the Owner's Representative. One set of the record drawings on Mylar shall be provided to the Owner. Final Record Drawings shall also be provided to the Owner on 3-1/2-inch computer disk in AutoCAD 2000.

1.05 SURVEY REQUIREMENTS

A. The Surveyor shall locate survey control points prior to starting site work. The Engineer shall be promptly notified in writing of any discrepancies discovered before or during construction.

B. The Contractor shall protect each permanent survey control point during construction. The Contractor

shall immediately report, in writing, to the Owner and Engineer any survey control point which is lost, destroyed, or requires relocation. The Contractor shall be responsible for all costs associated with reestablishing each permanent survey control point.

C. The Surveyor shall maintain lines and levels, layout, and locate the work utilizing recognized engineering survey practices. A complete and accurate log of control and survey work must be maintained. The Surveyor shall provide, at a minimum, a detailed survey for the following components:

   1. Locations and elevations of installed structures.

   2. All other items that the Contractor requires to complete his work.

   3. All other reasonable items requested by the Owner or Owner's Representative associated with this project.

D. A detailed as-built drawing including topography survey shall extend a minimum of 25 feet in all directions beyond the limits of construction.

E. The survey instruments used shall be capable of reading to a precision of 0.01 feet and with a setting accuracy of 10 seconds.

1.06 CONSTRUCTION TOLERANCES

A. Construction tolerances shall be as given in the various Sections of these Specifications, and as given below.

B. The construction tolerances shall be within plus or minus ten percent of the specified slope as calculated from the highest point of the slope (i.e., for a 3 horizontal: 1 vertical or 33.3 percent slope, the finished surface shall have a slope which measures between 30 percent and 36.3 percent between any spot and the top of the overall slope).

C. The Construction tolerances for trenches shall be within plus or minus 0.1 feet from the required elevations and widths and shall meet the Owner's approval.

D. No surveying will be allowed between one hour before sunset and one hour after sunrise, unless approved by the Engineer and Owner's Representative.

E. The Contractor shall be aware of the surveying activities and shall account for them in the construction schedule.

F. The Surveyor shall cooperate fully with the Engineer and Owner's Representative at all times.

PART 2 - RECORD DRAWINGS DOCUMENTATION

A. Record drawings documentation, signed and sealed by the Surveyor, shall be provided after construction and shall include, but not be limited to, final site topographic maps at a scale of 1 inch equal to 50 feet and a 2-foot contour interval, extending a minimum of 25 feet beyond the limits of work and showing all planimetric features; locations of all construction elements; and any other items necessary to accurately portray the extent and location of the Work.

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01060

REGULATORY REQUIREMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Performance of all on-site and off-site work in accordance with all applicable regulations.

1.02 RELATED SECTIONS

A. Section 01560 - Dust and Noise Controls

B. Section 02200 - Earthwork and Materials

C. Section 02226 - Biopolymer Slurry

D. Section 02672 - Well Drilling and Casing

1.03 ON-SITE ACTIVITIES

A. On-Site Work must comply with following environmental laws.

1. Safe Drinking Water Act: 42 U.S.C. 300f et seq. Site remediation activities must not result in groundwater or surface water contamination.

2. Federal Water Pollution Control Act (Clean Water Act): 33 U.S.C. 1251 et seq.

3. Clean Air Act: 42 U.S.C. 7401 et seq.

4. Resource Conservation and Recovery Act (RCRA): 42 U.S.C. 6901 et seq.

5. Occupational Safety and Health Administration (OSHA): 29 CFR 1910 and 1926.

6. Mississippi Department of Environment Quality Regulations.

7. Mississippi State Department of Transportation Regulations.

8. Federal Emergency management Agency Regulations.

9. US Army Corps of Engieers (Mobile District) Regulations.

1.04 OFF-SITE ACTIVITIES

A. Non-Hazardous Materials

1. State of Mississippi or local solid waste regulations.

B. Transportation

1. Transportation of any raw materials must comply with all applicable regulations including, but not necessarily limited to, the following:

a. Department of Transportation: 49 CFR 171-179.

b. USEPA: 40 CFR 263 and 40 CFR 761 for any hazardous materials disposed of off Site.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01090

REFERENCES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Reference Standards and Abbreviations

1.02 RELATED SECTIONS

A. Applicable Technical Specification Sections

1.03 REFERENCE STANDARDS AND ABBREVIATIONS

A. American Society for Testing and Materials (ASTM)

B. Underwriter's Laboratory (UL)

C. American National Standards Institute, Inc. (ANSI)

D. Occupational Safety and Health Act (Current Standards) (OSHA)

E. United States Environmental Protection Agency (USEPA)

F. National Fire Protection Association (NFPA)

G. Mississippi Department of Environmental Quality (MDEQ)

H. Mississippi Department of Transportation (MDOT)

I. Federal Emergency Management Agency (FEMA)

J. US Army Corps of Engineers (Mobile District)

1.04 DEFINITIONS

See Section 00700 General Conditions of the Contract for Construction.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01110

ENVIRONMENTAL PROTECTION

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Performance of all Work while minimizing all potential environmental impacts on, but not limited to the air, water, and land.

B. Minimization of all environmental impacts in accordance with all applicable federal, state, and local Laws and Regulations.

1.02 RELATED SECTIONS

A. Section 01060 - Regulatory Requirements

B. Section 01120 - Site Maintenance

C. Section 01500 - Health and Safety Plan (HASP)

D. Section 01340 - Submittals

E. Section 01540 - Security

F. Section 01560 - Dust and Noise Control

1.03 SUBMITTALS

A. Submit to Owner for approval, a site plan for implementation of environmental protection measures.

B. Approval of Contractor's plan for environmental protection shall not relieve Contractor of any responsibility for adequate and continuing control of potential environmental impacts.

C. Contractor shall submit a plan, in writing, for implementing the requirements for environmental protection. Specifically, Contractor must address at a minimum the following: protection of soil, protection of natural and water resources, protection of wetlands, debris disposal, dust control, and decontamination.

D. Submit to Owner a site plan indicating all proposed locations of Contractor temporary facilities and activities (e.g., trailers, parking, storing/staging areas, etc.).

E. The Environmental Protection Implementation Plan described in Part 1.03 A. through C. above shall be submitted in conjunction with the submittal requirements specified in Section 02200.

F. A spill control plan shall be submitted to Owner at least 10 days prior to the start of any Work at the site.

1.04 PROTECTION OF SOIL OUTSIDE LIMITS OF WORK

A. Once the Limit of Work has been established and the erosion controls have been installed, clearing and grubbing work can commence.

B. Soil outside the Limits of Work performed under this Contract is to be preserved in present condition to the maximum extent possible. Contractor must confine construction activities to areas defined by the Drawings or Specifications. Contractor shall assure that contaminated material (if encountered) does not migrate outside the Limits of Work.

C. Soil excavation beyond that specifically called for in the Contract Documents will not be permitted without the prior approval of the Owner. Contractor shall not perform any unauthorized excavation and shall be responsible for restoring such excavations, including handling of any wastes generated therefrom, at no additional cost to the Owner.

1.05 PROTECTION OF WATER RESOURCES AND WETLANDS

A. Contractor must not discharge contaminated waste materials, or non-hazardous waste/materials to surface water, groundwater, or wetlands except as specified in the Contract Documents. Contractor must comply with all applicable federal, state, and local laws concerning pollution of surface water, groundwater, and wetlands.

B. Spillages

All necessary measures shall be taken to ensure that no accidental contamination of the soil, groundwater, or other uncontaminated areas will occur from any of the activities required to perform the Work. All spills must be reported to Owner immediately using approved emergency response and spill containment approved in the Contractor's Health and Safety Plan as outlined in Section 01500.

C. Disposal

All waste materials generated during performance of the Work shall be disposed off site by the Contractor and at the Contractor's Expense in accordance with all applicable regulations, except as otherwise directed by the Owner or Owner's Representative. If any waste material is placed in unauthorized areas, Contractor shall immediately remove the material and restore the area to the original undisturbed condition at no additional cost to Owner.

1.06 DUST CONTROL

A. Contractor must implement dust control measures to adequately protect the public, employees of Contractor, Owner, and Owner's Representative. See Section 01560 for details.

1.07 WASTE DISPOSAL

A. No waste disposal at the site by any party.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01120

SITE MAINTENANCE

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Maintenance Requirements

B. Materials

C. Work to be Performed

D. Project Closeout

1.02 MAINTENANCE REQUIREMENTS

A. Conduct all site maintenance activities in accordance with all applicable codes, ordinances, and regulations.

1.03 MATERIALS

A. Use only cleaning materials and methods which will not create health or environmental hazards.

1.04 WORK TO BE PERFORMED

A. Execute daily cleaning of the site to collect all accumulated contaminated material, including discarded health and safety equipment.

B. Execute periodic cleaning to keep the project site free from accumulation of material resulting from Project execution.

C. Any non-hazardous daily solid wastes shall be transferred into containers and staged as approved by Owner or Owner's Representative and properly disposed of off site, unless otherwise directed by Owner or Owner's Representative.

1.05 PROJECT CLOSEOUT

A. Contractor shall conduct an inspection of all work areas and certify to Owner or Owner's Representative that the entire project area is free

of all extraneous materials generated from Work execution.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01200

PROJECT MEETINGS AND ADMINISTRATION

PART 1 - GENERAL

1.01 PRE-CONSTRUCTION MEETINGS

A. The Owner shall schedule a pre-construction meeting at the Project site or other convenient location prior to commencement of construction activities. The meeting shall be conducted to review responsibilities and personnel assignments.

B. Attendees: The Owner, Engineer, Owner's Representative, the Contractor and his superintendent, major subcontractors, manufacturers, suppliers, Surveyor, and other concerned parties shall each be represented at the conference by persons familiar with, and authorized to, conclude matters relating to the work.

C. Agenda: The agenda for the meeting should include items of significance that could affect progress including such topics as:

1. Construction schedule;

2. Critical work sequencing;

3. Designation of responsible personnel;

4. Construction Quality Assurance (CQA) procedures and protocols;

5. Procedures for processing field decisions and Change Orders;

6. Procedures for processing Applications for Payment;

7. Distribution of Contract Documents;

8. Submittal of shop drawings, product data, and samples;

9. Preparation of record documents;

10. Use of the premises;

11. Office, work, and storage areas;

12. Equipment deliveries and priorities;

13. General Construction Safety procedures;

14. Site Health and Safety Plan;

15. First aid;

16. Security;

17. Housekeeping;

18. Site restoration and protection; and

19. Working hours.

1.02 PROGRESS MEETINGS

A. Progress meetings will be held at the Project site every month. The Owner shall notify the Contractor, Engineer, and Owner's Representative of scheduled meeting dates.

B. Attendees: In addition to representatives of the Owner, Engineer, and Contractor, each subcontractor, supplier, or other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings by persons familiar with the project and authorized to conclude matters relating to progress.

C. Reporting: The Owner's Representative shall be responsible for preparing the progress meeting report no later than three working days after each progress meeting date; copies shall be distributed to each party present and to other parties who should have been present. A brief summary, in narrative form, of progress since the previous meeting shall be included in this report.

1.03 PROBLEM OR WORK DEFICIENCY MEETING

A. A special meeting shall be held when and if a problem or deficiency is present or likely to occur. At a minimum, the meeting shall be attended by the Engineer, Owner's Representative, Contractor, and any affected Subcontractors. The

purpose of the meeting shall be to define and resolve the problem or work deficiency.

B. The meeting shall be documented by the Owner's Representative and minutes shall be transmitted to affected parties.

1.04 CONSTRUCTION PROGRESS SCHEDULES

A. The Contractor shall furnish in duplicate, graphic type construction progress schedule listing trade divisions and all parts of work, and showing planned starting date and completion time for each part of work and work element interdependencies. Scheduled completion date shall conform to contract completion time. The schedule form and starting and completion dates shall be as approved. Attached to the schedule shall be the actual delivery dates of the submittals identified in Section 01340. The construction progress schedule shall be furnished no later than 10 days after the pre-construction meeting, and shall be updated at least twice monthly throughout the duration of the contract.

1.05 ADMINISTRATION OF CONTRACT

A. The Contractor shall follow the Drawings strictly and execute all work in accordance therewith, and with the kind and quality of materials set forth in the Specifications, using the figured dimensions marked on the Drawings and not scaled measurements.

B. The Specifications and Drawings shall be coordinated, so that any work shown on the Drawings and not mentioned in the Specifications, and vice-versa, shall be executed in the same manner as though mentioned in the Specifications and shown in the Drawings.

C. The Contractor shall furnish and install such work and material as may be proper and suitable preparation, basis, support, or finish for the work which is shown or specified, whether or not the same is specifically mentioned in the Specifications or shown on the Drawings. The Contractor shall be required to make plural and complete work which is shown single or partially indicated to avoid needless repetition, for the

sake of brevity, and for reasons of clarity. In all cases, the intent and meaning of the Drawings and Specifications, as defined herein, shall be followed. The Contractor shall not avail himself of any errors or omissions therein, should any exist, which may be in conflict therewith.

1.06 PROJECT RECORD DOCUMENTS

A. The Contractor shall maintain at the job site one copy of all Drawings, Specifications, Addenda, approved Shop Drawings, Change Orders, Field Orders, other Contract Modifications, Record Drawings Documentation, and other approved documents submitted in compliance with various sections of these Specifications.

B. Identification and Maintenance: Each of these Project Record Documents shall be clearly marked "Project Record Copy", maintained in good condition, available at all times for inspection by the Engineer or Owner's Representative, and not used for construction purposes.

C. Records:

1. Mark up the most appropriate Document to show:

   a. Significant changes made during the construction process.
   b. Significant detail not shown in the original Contract Documents.

2. The information given shall include, but shall not be limited to:

   a. The location of underground utilities and appurtenances, referenced to permanent surface improvements.
   b. The location of internal utilities and appurtenances, referenced to permanent surface improvements.
   c. Any relocation of concealed structural components.
   d. Other changes as directed by the Engineer or Owner's Representative.

3. Keep Project Record Documents current. Do not permanently conceal any work until the required information has been recorded.

4. Project Record Documents kept on the job site and amended as changes occur shall be returned to the Engineer as part of the project record information submission.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01310

CONSTRUCTION PROGRESS SCHEDULE

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Construction Progress Schedule

1.02 RELATED SECTIONS

A. Section 01040 - Project Coordination

B. Section 01340 - Submittals

1.03 SUBMITTALS

A. Contractor shall develop and submit the Construction Progress Schedule in accordance with this specification section.

B. The Construction Progress Schedule must be approved by the Owner before any site work proceeds.

C. Submit details of the Construction Progress Schedule for each individual system component including but not limited to:

1. Mobilization
2. Submittals
3. Permeable Reactive Barrier Installation
4. Drainage Ditch Regrading/Channel Improvement
5. Well Installation
6. Meetings
7. Final Inspection/Punchlist
8. Demobilization

1.04 DESCRIPTION

A. The Construction Progress Schedule shall include, at a minimum, the following:

1. Critical milestones on activity progression schedule (e.g., modification, selection and purchasing, assembly, construction, turnover).

2. Coordination with Owner or Owner's Representative for critical path identification and implementation.

3. Follow standards as stated in EJCDC guidelines for Gantt chart progress schedule including a bar graph schedule versus calendar dates.

B. Contractor shall update the Construction Progress Schedule as appropriate, but no less than twice monthly (if required).

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01340

SUBMITTALS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. In addition to the requirements contained in Division 0, this section includes requirements for shop drawings, operation and maintenance data, working drawings, record drawings, certificates of compliance, manufacturer's certifications, manufacturer's instructions, and other items required to be submitted by the Contractor for acceptance by the Engineer.

1.02 SUBSTITUTIONS

A. Requests for acceptance of products and/or equipment other than specified shall be submitted by the Contractor to the Owner and Engineer for approval. Request shall be submitted in triplicate.

B. An offer of a substitute article or material by the Contractor subsequent to award of the contract, not specified herein, will raise the presumption that it is for cost-saving purposes. If, in such case, the article or material is accepted, the Owner shall be given credit for: The difference in the net cost to the Contractor of the article or material submitted and the price at which he could have obtained the lowest priced article or material specified. For convenience in checking the credit, the Contractor shall submit these figures with each substitute submittal, and no article or materials will be considered without such figures.

C. If, subsequent to award of the Contract, it becomes necessary because of the inability of the Contractor to obtain any items or material as specified or the equal within a reasonable time frame, and could possibly cause future delays in the project, the Engineer, at his discretion, may authorize use of substitute items or materials of the same, greater, or less cost than those specified.

D. In such cases as described above in B and C, the Contractor shall submit, in writing, his request for permission to make a substitution and shall furnish full information as to costs of the item or material specified and the item or material to be substituted therefore. Such information shall be in such form and detail as to permit the Engineer to check, to his satisfaction, the costs involved. Upon acceptance of the substitution and provided the cost is less, the Engineer will authorize, in writing, the proper credits to be allowed to the Owner. If the costs of the accepted substitution are greater, the Engineer shall make a recommendation to the Owner to accept the substitution. Upon acceptance, the Owner will authorize in writing the proper additional payments to be made to the Contractor. Payment adjustments shall represent the difference between the net cost to the Contractor of the accepted substituted item or material and the price at which he could have obtained the lowest priced items or material specified.

E. The decisions of the Engineer, as to the proper credits to be allowed to the Owner, or substitutions to be allowed, shall be final.

1.03 IDENTIFICATION

A. All shop and working drawings shall have the following identification data contained thereon or permanently attached thereto.

1. Project Name, Proposal Number, and Contract Name.

2. Submittal Number. Shop drawings and working drawings shall be numbered sequentially in order of original submission. Resubmittals shall include the original submittal number and shall be lettered sequentially.

1.04 SHOP DRAWINGS

A. Shop drawings are generally defined as all drawings, diagrams, illustrations, brochures, product information, schedules, and other data which are prepared by the Contractor, a subcontractor, manufacturer, fabricator, supplier, or distributor, which illustrate how specific

portions of the work shall be fabricated or installed.

B. The Contractor shall submit for the Engineer's acceptance the requisite number of complete detailed shop drawings of all materials, equipment, accessories, and appurtenances specified herein or shown on the Drawings prior to the fabrication, installation, or incorporation of the specified materials, equipment, accessories, and appurtenances in the work.

C. All shop drawings shall be in conformity with the Contract Documents. All shop drawings shall be to scale, shall be accurate and distinct, and shall give all dimensions required for the fabrication, installation, and incorporation of the specified items in the work. Wherever the location of any of the materials, equipment, accessories, and appurtenances is not shown on the Drawings, the Contractor shall furnish prints of shop drawings for the purpose of giving the exact location in plan and in elevation of the said materials, equipment, accessories, and appurtenances.

D. The Contractor shall submit to the Engineer three (3) copies of the shop drawings for acceptance. One (1) additional copy shall be sent directly to the owner. At the time of submission, the Contractor shall call to the Engineer's attention, in writing, any deviations that the shop drawings may have from the requirements of the Drawings and Specifications. Shop drawings for a particular component shall be submitted complete at least 14 days prior to the anticipated start date of construction unless an alternative schedule is given elsewhere in the Specifications. Shop drawings will be reviewed and returned within 10 days unless otherwise indicated.

1.05 WORKING DRAWINGS FOR CHANGES, SUBSTITUTIONS, AND CONTRACTOR DESIGN ITEMS

A. Working drawings shall be submitted for changes to the work and substitutions requested by the Contractor, and for the Contractor design items.

B. Working drawings and calculations shall be certified by a Professional Engineer registered in the State of Mississippi and shall be accompanied

by calculations or other sufficient information to explain in complete detail the proposed method of construction.

C. Submission, number of copies, and review by the Engineer for working drawings shall be as stipulated in these specifications for shop drawings.

D. The acceptance of working drawings is not to be taken or construed that they have been examined in detail and shall not relieve the Contractor of his responsibilities under this contract. The Owner and/or Engineer will not be responsible for errors on the working drawings furnished by the Contractor even though the working drawings containing such errors are inadvertently accepted. Working drawings shall, upon acceptance by the Engineer, become a part of the Contract Documents.

1.06 ON-SITE RECORDS

A. The Contractor shall keep one record copy of all Contract Documents, shop drawings, and working drawings at the site in good order and annotated to show all changes made during the construction process. Such annotations shall be kept current. These items shall be available to the Engineer and Owner's Representative at all times.

PART 2 - PRODUCTS

NOT USED

PART 3 - SUBMITTAL SCHEDULE FOR PROJECT SPECIFICATIONS

Specification No.	Submittal	Described In	Submit When
01027	Application and Certificate for Payment Form	1.03	Prior to start of work
01027	Application for Payment	1.04, 1.05, and 1.06	As directed by Owner

Specification No.	Submittal	Described In	Submit When
01028	Individual Authorized to Accept Changes	1.03A	Prior to start of work
01028	Change Order Form	1.03B	Prior to start of work
01050	Name, Address, and Telephone Number of Surveyor	1.04A	Prior to start of work
01050	Survey Plan	1.04B	Prior to start of work
01050	Documentation Verifying Accuracy of Survey Work	1.04C	
01050	Record drawings	1.04D	Within 14 days after completion of work
01050	Record Drawings	1.04E and Part 2	Within 14 Days after Final Approval by the Owner's Representative
01110	Environmental Protection Implementation Plan	1.03A-C	14 days prior to start of work, in conjunction with Specification 02200
01110	Spill Control Plan	1.04F	10 Days prior to start of work
01310	Construction Progress Schedule	1.04 1.03	10 Days after pre-construction meeting; update twice monthly

Specification No.	Submittal	Described In	Submit When
01340	Requests for Acceptance of Products and/or Equipment other than Specified	1.02	7 days prior to bid opening
01340	Shop Drawings, Test Data, and Product Data	1.04	14 days prior to anticipated start date of work
01340	Working Drawings	1.05	14 days prior to anticipated start date of work
01370	Preliminary Contractor's Schedule of Values	1.03	With bid
01370	Final Contractor's Schedule of Values	1.03	As directed by Owner
01380	Project Photographic Documentation	1.04	Within 14 days after photographs were taken
01500	Health and Safety Plan	1.04	14 days prior to start of work
01540	Work Area Security Protocol	1.04	14 days prior to start of work
01600	Contractor Request for Substitution	1.03	Prior to installation
01700	Written Certification of Project Completion	1.01	Prior to project closeout
01700	Final Application for Payment	1.01	Prior to project closeout

Specification No.	Submittal	Described In	Submit When
01700	Record Drawings	1.03	Prior to project closeout
01740	Warranties and Bonds (includes payment and performance bonds)	1.05	See project specification
02200	Qualifications of Geotechnical Engineer and Testing Firm	1.05B	14 days prior to start of work
02200	Test Reports	1.05C	14 days prior to start of work
02200	Certification of Clean Materials	1.05D	14 days prior to start of work
02226	Written Evidence of Experience and Competence in Biopolymer Slurry Trench Construction	1.05A	With Bid
02226	Field Staff Resumes	1.05B	With Bid
02226	Slurry Wall Operating Plan	1.05C	14 days prior to start of work

[END OF SECTION]

SECTION 01370

SCHEDULE OF VALUES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. The Schedule of Values Form as described herein.

1.02 RELATED SECTIONS

A. Section 01027: Application for Payment

B. Section 00310: Bid Form

1.03 SUBMITTALS

A. Submit to Owner a Contractor's Schedule of Values allocated to various portions of Work bid as lump sum.

1. A preliminary Contractor's Schedule of Values to include units, quantity, and unit prices shall be submitted to Owner with the Bid for lump sum items. Unit prices provided by the Contractor for work items on the Schedule of Values shall be used if additional work above the bid quantity estimated is required. Schedule of values shall include specifically items associated with the Additional Groundwater Interim Measure implementation.

2. After review by Owner, the final Contractor's Schedule of Values shall be prepared and submitted to Owner.

3. Progress payments will be evaluated and made on a monthly basis or less frequently if Contractor does not submit monthly forms in a timely fashion.

B. Upon request of Owner, Contractor shall support values with data which will substantiate their correctness.

1.04 FORM AND CONTENT OF SCHEDULE OF VALUES

A. Type schedule on 8½ x 11-inch white paper; Contractor's standard forms and automated printout will be considered for approval by Owner upon Contractor's request. Identify schedule with:

   1. Title of project and location.

   2. Owner and Owner's project number.

   3. Name and address of Contractor.

   4. Contract designation.

   5. Date of submission.

B. List on Schedule installed value of component parts of Work in sufficient detail to serve as basis for computing values for progress payments during construction.

C. Follow the table of contents of these Specifications as format for listing component items.

   1. Identify each line item with number and title of respective major sections of Specifications.

D. For each major line item, list sub-values of major products or operations under item.

E. Provide separate listing of items of General Requirements (Division 1), such as but not limited to: job mobilization, field supervision and layout, construction facilities and temporary controls, contingency allowance, construction schedule, and submittals.

F. For various portions of Work:

   1. Each item shall include directly proportional amount of Contractor's overhead and profit.

   2. For items on which progress payments will be requested for stored materials, break down value into:

      a. Cost of materials, delivered and unloaded, with taxes paid.

b. Total installed value.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01380

CONSTRUCTION PHOTOGRAPHS

PART 1 - GENERAL

1.01 SUMMARY

A. Contractor shall provide all labor, camera, tripods, film, album and stamps or labels necessary to meet the photographic documentation requirements. This cost shall be included in the contract price.

1.02 RELATED SECTIONS

A. Section 01340 - Submittals

1.03 PHOTOGRAPHIC REQUIREMENTS

A. The photographic documentation report shall consist of each major construction component at the various milestone posts of construction as defined herein or as directed by the Owner's Representative.

B. The photographs shall include important features of the site prior to construction, construction activities, and appearance of individual subject areas following completion of work.

C. Supplemental photographs may be requested as part of the coordinated project meetings by the Owner or Owner's Representative.

1.04 SUBMITTALS

A. Contractor shall maintain on the job site a permanent record of photographs, as well as record the prescribed information on the back of each photograph. The photos shall be assembled in chronological order in albums with index (table of contents) for each construction component.

B. Prints shall be 3 inches by 5 inches, except where otherwise designated by the Owner's Representative. Prints shall be color, semi-glossy on single weight, white based paper.

C. The back of each print shall be labeled with the permanent record information including date, site location, direction of photo, photographer, and subject description.

D. The Contractor shall provide four copies of each print, except when otherwise requested by the Owner or Owner's Representative.

E. Prints shall be made available within fourteen (14) days of when the photographs were taken.

F. Individual albums shall contain a list of photographs and activities. The albums shall be constructed such that the descriptive information can be accessed without removing the individual photographs.

G. The negatives shall be maintained in sleeves in a notebook with adequate labeling to include the activity being documented, date, location, and cross reference to the permanent record.

1.05 OWNERSHIP

A. The negatives shall remain the property of the Contractor during construction, who shall maintain the negatives in safe storage through the date of substantial completion of the project as designated by Owner. Following substantial project completion, the photographs and negatives shall be delivered to Owner to be incorporated into the permanent record.

1.06 CONSTRUCTION MILESTONES

A. The Contractor shall photographically record the following milestones and activities (at a minimum):

1. Existing Conditions Prior to Construction
2. Slurry Trench Excavation
3. Granular Iron/Sand Mixing
4. Trench Backfill
5. Drainage Ditch restructuring/Channel Improvement

B. Additional events or milestones may be photographed as required by the Owner's Representative.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01390

CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall furnish and maintain, during construction of the project, adequate construction facilities at the site for the use of the Owner, the Engineer, the Owner's Representative, and himself as set forth below. Upon completion of the project, or as directed by the Owner, the Contractor shall remove all such temporary construction facilities and temporary controls from the site, and leave the premises in the condition required by the Contract.

B. The Contractor and his subcontractors may maintain construction facilities and temporary controls on the site in addition to those specified, as may be necessary for the proper conduct of the work. These shall be located so as to cause no interference to the Contract work. The Owner shall be consulted with regard to locations prior to placement.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 FIELD OFFICE, TELEPHONES

A. All field offices shall be provided and maintained by the Contractor. The field offices will provide adequate electrical power and telephone service for the duration of the project.

B. Locate office in a location meeting the approval of the Owner or owner's Representative.

C. Provide separate office type space for the Owner or Owner's Representative in the field trailer. Trailer shall be equipped with desks, meeting

accommodations, heat, air conditioning, telephone, facsimile, electricity, water, and lighting.

3.02 TEMPORARY SCAFFOLDS

A. The Contractor shall provide, erect, maintain, and remove when directed, all scaffolding, staging, platforms, temporary runways, temporary flooring, guards, railings, stairs, etc., as required by Local, State, and Federal codes or laws, for the protection of workmen and the public. The construction, inspection, and maintenance of the above items shall comply with all safety codes and regulations as applicable to the project.

3.03 TEMPORARY SANITARY FACILITIES

A. Contractor shall provide sanitary facilities for the Work Area.

B. The Contractor is to provide roll-off containers for normal, non-hazardous solid waste, (i.e., daily debris). The Contractor is responsible for disposal of all non-hazardous solid waste.

3.04 TEMPORARY WATER SUPPLY

A. The Contractor will be responsible for an on-site water supply for construction purposes. Contractor shall be responsible for supplying all water required for the Work.

3.05 TEMPORARY ELECTRICAL SERVICE

A. The Contractor shall make all necessary arrangements for temporary electricity and furnish, at his own expense, all temporary wiring, lamps, accessories, and current required for completion of the work. The Contractor shall obtain necessary permits and meet applicable codes. He shall also provide temporary lights and wiring for proper execution of his and his subcontractor's work at a proper lighting level that allows for correct installation of the work. Temporary wiring shall be installed so as not to interfere with construction activities or ongoing on-site business activity of the Owner.

3.06 TEMPORARY PROTECTION AGAINST THEFT, DAMAGE, AND WEATHER

A. Payment by the Owner for any materials, equipment, or labor incorporated into the work shall not be deemed to be an acceptance by the Owner. The risk of loss of such materials, equipment, or cost of labor spent to install such, shall remain with the Contractor, and the Contractor shall be fully responsible for such materials, equipment, or labor to the same extent as if the Owner had not paid for such items. The Owner will only be responsible or accept real property after final inspection and approval by Engineer. Stolen, damaged, vandalized, missing equipment or material, or weather damage shall be considered the property of the Contractor until final acceptance by Owner.

3.07 PROTECTION OF PERSONNEL, WORK, AND PROPERTY

A. The Contractor shall construct and maintain all necessary temporary drainage and do all pumping necessary to keep the work area and all other work free of water, no matter what the source. The Contractor shall collect and pump all water (rain water and groundwater) that enters into the work area prior to or during construction. Particular care should be taken to prevent construction run-off from entering Riverdale Creek.

B. The Contractor shall provide all shoring, bracing, and sheeting for safety and for the proper execution of the work, and have same removed when work is completed.

C. The Contractor shall provide and maintain guard lights at all barricades, railing obstructions, in access roads, and at all trenches or pits adjacent to access roads or otherwise accessible to any individuals working at the site.

D. Any work damaged by failure to provide protection as required above shall be removed and replaced with new work at the Contractor's expense.

3.08 TEMPORARY HEAT AND COLD WEATHER PROTECTION

A. The Contractor shall provide all temporary heating to protect and keep dry all such work during cold weather. The type of temporary heat used will be

such that will not in any manner be detrimental to finished work. The Contractor shall be responsible to determine and meet applicable codes.

B. The Contractor shall provide cold weather protection and temporary heat as necessary to carry on the work expeditiously during inclement weather, to protect all work and materials against injury from dampness and cold, and to provide suitable working conditions for the installation and curing of materials until final acceptance by the Owner. The method of heating and the type of fuel and equipment used shall be subject to approval by the Engineer. The Contractor shall be responsible to determine and meet applicable codes.

C. The Contractor shall comply with all specific requirements of the other sections of these Specifications.

3.09 CONSTRUCTION EQUIPMENT

A. The Contractor shall provide construction equipment and operating personnel necessary to perform his work.

B. The Contractor shall provide equipment with proper guys, bracing, and other safety devices as required by Local, State, or Federal codes.

C. The Contractor shall provide all scaffolding, staging, platforms, temporary flooring, railing, stairs, etc. as required by Local, State, or Federal laws and codes for the protection of workmen and the public.

3.10 PROTECTION

A. The Contractor shall replace and put in good working condition all items (e.g., existing strucutres, trees, fence) damaged or injured in carrying out the contract, unless the same shall be permanently done away with by order of the Owner as being unnecessary for the proper carrying out of the Contract.

B. The Contractor shall take all proper precautions to protect persons from injury and unnecessary interference or inconvenience, leave an unobstructed way along facility roads for

pedestrians and vehicles, and for access to hydrants.

C. The location of any construction fencing, and areas for on-site storage of equipment and other facilities required by the Contractor, shall be subject to approval by the Owner.

3.11 PUMPING

A. Whenever necessary, the Contractor shall provide pumping of groundwater or other water (i.e., rainwater) to protect any phase of the work. Groundwater or rainwater collected during construction by the Contractor shall be handled by the Contractor with prior approval by the Owner. Depending on the pumping location, groundwater, stormwater, and/or soil may be contaminated. The Contractor shall provide the Owner with a plan for handling contaminated groundwater, stormwater, or soil, should any be encountered.

B. The Contractor shall be responsible for pumping or otherwise rerouting water in the Outfall Ditch during the period when the ditch is temporarily dammed. The water level in the blocked portion of the ditch shall not exceed the culvert invert elevation. Flow in the Outfall Ditch includes discharge from the facility wastewater treatment plant (variable flow, but continuous) and stormwater runoff (estimated to be 61 cfs for a 25-year, 30-minute storm event). This water shall be pumped to Riverdale Creek and shall be filtered, if necessary in the opinion of the Owner's Representative, to minimize sediment loading to the creek. The Contractor shall pump to the creek at a rate that approximates the facility NPDES discharge to minimize impact to the creek. The Contractor shall minimize the time during which the Outfall Ditch is blocked.

3.12 ROADWAYS AND PARKING AREAS

A. The Contractor's activities shall not hinder the normal traffic at the site without prior approval by the Owner.

B. The Contractor shall construct temporary access/construction roads as necessary to complete the Work outlined in these Specifications and on

the Drawings. The road shall consist of sufficient materials to support the equipment required to complete the work and protect the site from damage. Free-draining, crushed stone shall be used to build up the temporary road(s). The source of the off-site fill must be stated and approved by the Engineer. A woven-mesh geosynthetic shall be used between the existing grade and the temporary road material for strength on soft, existing soil (see Specification 02233). It will be the responsibility of the Contractor to dismantle and remove the temporary road(s) upon completing the Work outlined in these Specifications and Drawings.

3.13 TRUCKING

A. All trucks bringing to or removing from the site earth, loose materials, or debris shall be loaded in a manner to prevent dropping of materials on streets.

B. At all points where trucks leave the project site and enter adjacent paved streets, the Contractor shall maintain an installation and crew to prevent any mud from being carried onto such adjacent paved streets.

C. Earth, loose materials, or debris deposited on the streets due to contract trucking activities shall be removed daily.

D. Handle earth materials excavated from the trenching in accordance with Section 02200.

3.14 CLEAN-UP DURING CONSTRUCTION

A. Clean-up shall be performed as required with once daily serving as the minimum to prevent accidents to personnel, protect all work in place, and to effect completion of the project in an orderly manner.

B. Construction clean-up shall consist of the removal of all mud, oil, grease, sand, gravel, dirt, trash, scrap, debris, and excess materials, from within the limit of work for the project, that may cause the tripping or sliding of workmen, ladders, or equipment. Construction cleanup shall be performed to the satisfaction of the Owner.

3.15 REMOVAL OF UTILITIES, FACILITIES, AND CONTROLS

A. Remove temporary above grade or buried utilities, equipment, facilities and materials prior to substantial completion (as defined in Section 01700).

B. Clean and repair damage caused by installation or use of temporary work.

C. Restore existing facilities used during construction to original condition or as shown on Drawings, or other Specification sections.

[END OF SECTION]

SECTION 01400

QUALITY CONTROL

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Quality control of construction and installation of equipment.

B. References

C. Field samples

D. Mock-up

1.02 RELATED SECTIONS

A. Section 01340 - Submittals

B. Section 01600 - Material and Equipment

1.03 QUALITY ASSURANCE/CONTROL OF INSTALLATION

A. Monitor quality control over suppliers, manufacturers, products, services, site conditions, and workmanship to produce work of specified quality.

B. Comply fully with manufacturers' instructions, including each step in sequence.

C. Should manufacturers' instructions conflict with Contract Documents, request clarification from the Engineer before proceeding.

D. Comply with specified standards as a minimum quality for the work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

E. Perform work by persons qualified to produce workmanship of specified quality.

1.04 REFERENCES

A. Conform to reference standard by date of issue current on date of Contract Documents.

B. Should specified reference standards conflict with Contract Documents, request clarification from the Engineer before proceeding.

C. The contractual relationship of the parties to the Contract shall not be altered from the Contract Documents by mention or inference otherwise in any reference document.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01500

HEALTH AND SAFETY PLAN (HASP)

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Health and Safety Plan

B. Key Personnel/Identification of Health and Safety Personnel

C. Task/Operation Safety and Health Risk Analysis

D. Personnel Training Requirements

E. Personal Protective Equipment to be Used

F. Medical Surveillance Requirements

G. Frequency and Types of Air Monitoring and Personnel Air Sampling

H. Site Control Measures

I. Decontamination Plan (if applicable)

J. Emergency Response/Contingency Plan

K. Spill Containment Program

L. Additional Requirements

1. The objective of these procedures is to minimize the risk of exposure to hazardous substances/conditions by identifying, evaluating and controlling potential safety and health hazards. The HASP must address those site activities and factors which impact health, safety, and the environment during the Construction period. These include without limitation site activities which can cause migration of site products such as dusts, mists, fumes, and vapors to off-site locations.

2. Contractor shall be responsible for preparing and implementing the HASP which shall apply to all personnel on site during construction including, but not limited to, the Contractor's employees, subcontractor's employees, Owner, and Owner's Representative.

1.02 REFERENCES AND STANDARDS

A. Federal OSHA Standards

1. *General Industry Standards and Interpretations*; Volumes 1 - 3- OSHA 2077; U.S. Department of Labor, Occupational Safety and Health Administration; Most current versions. Specifically Sections:

1904	Recordkeeping and Reporting of Occupational Injuries and Illnesses
1910.120	Hazardous Waste Operations and Emergency Response
1910.132	Subpart I, Personal Protective Equipment
1910.146	Permit Required Confined Space
1910.147	Control of Hazardous Energy (Lockout/Tagout)
1910.301	Subpart S, Electrical Standards
1910.1000	Air Contaminants (PELs)
1910.1001	Asbestos (if applicable)
1910.1025	Lead (if applicable)
1910.1200	Hazard Communication
1926	Safety and Health Regulations for Construction
1990	Identification, Classification and Regulation of Potential Occupational Carcinogens

2. *Hazardous Waste Inspections Reference Manual*; U.S. Department of Labor; Occupational Safety and Health Administration; 1986.

3. *OSHA Field Operations Manual*; U.S. Department of Labor; Occupational Safety and Health Administration; most recent edition.

B. Other References and Standards.

1. *A Guide to the Safe Handling of Hazardous Materials Accidents*; ASTM Manual Series, MNL10; American Society for Testing and Materials; 2nd Ed.; 1990.

2. *Air Sampling Instruments*; 6th Ed.; American Conference of Governmental Industrial Hygienists (ACGIH); 8th Ed.; 1995.

3. *Dangerous Properties of Industrial Materials*; Sax, NI; Van Nostrand Reinhold; New York; 1995.

4. *Fire Protection Guide on Hazardous Materials*; 11th Ed.; National Fire Protection Association; 1994.

5. *Fundamentals of Industrial Hygiene*, 4th Ed.; Chicago, IL; National Safety Council; 1995.

6. *Guide to Industrial Respiratory Protection*; NIOSH Publication 87-116; US Department of Health and Human Services, Public Health Service, Centers for Disease Control, NIOSH; 1987.

7. *Guidelines for the Selection of Personal Protective Equipment*; 3rd Ed.; Schwope, A.D.; American Conference of Governmental Industrial Hygienists; Cincinnati; 1987.

8. *Hazardous Waste Handbook for Health and Safety*; Martin, W.F.; Lippit, J.M.; Prothero, T.C.; Butterworth Publishers; 2nd Ed.; 1992.

9. *Hazardous Materials Emergencies Response and Control*; Cashmon, J.R.; Technomic Publishing Owner; 2nd Ed.; 1988.

10. *NIOSH/OSHA Pocket Guide to Chemical Hazards*; U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, NIOSH; 1994 or most current edition.

11. *Occupational Health Guidelines for Chemical Hazards*; NIOSH/OSHA Department of Health and Human Services (NIOSH) Publication 81-113; January 1981; Supplement 1 (1988); Supplement 2 (1989).

12. *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*; NIOSH/OSHA/USCG/EPA; U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, NIOSH Publication 85-115; 1985.

13. *Protecting Personnel at Hazardous Waste Sites*; Levine, S.P., Martin, W.F.; Butterworth-Heinemann; 2nd Ed.; 1994.

14. *Quick Selection Guide to Chemical Protective Clothing*; 2nd Edition; Forsberg, K., Mansdorf, S.Z.; Van Nostrand Reinhold; 1993.

15. Standard Operating Safety Guides; USEPA Office of Emergency and Remedial Response; OSWER Directive 9285.1-03; 1992.

16. *Threshold Limit Values and Biological Exposure Indices for 1996*; American Conference of Governmental Industrial Hygienists (ACGIH).

1.03 PLAN DESCRIPTION

A. Contractor shall provide a Health and Safety Plan (HASP) which establishes policies and procedures to protect workers and the public from the potential hazards posed by the work. The HASP must be developed before site activities proceed.

1. At a minimum the plan shall:

a. Name key personnel and alternates responsible for site safety and provide an organizational chart.

b. Describe hazards associated with each operation conducted, as well as general hazards at the site.

c. Confirm that personnel are adequately trained to perform their job responsibilities and to handle the specific hazardous situations they may encounter.

d. Describe the protective clothing and equipment to be worn by personnel during various site operations.

e. Describe medical surveillance requirements.

f. Describe the program for personnel monitoring.

g. Describe the actions to be taken to mitigate existing hazards to make the work environment less hazardous.

h. Define site control measures and include a site map depicting the work zones, decontamination areas, and the location and layout of any temporary facilities to be constructed on or near the site.

i. Establish decontamination procedures (if required) for personnel and equipment.

j. Set forth the site's Standard Operating Procedures for Health and Safety.

B. Definitions

As used in the HASP, the following terms are defined:

- Active Operations - Activities resulting in disturbance of waste, soil, buildings, or equipment at a work area.

- Authorized Personnel - Any person, such as task-specific personnel, project personnel, oversight personnel, contractors, and consultants whose presence is authorized at the Project Site by Owner.

- Contamination Reduction Zone (CRZ) - The area or corridor between the Exclusion Zone and the Support Zone. This is the area where decontamination takes place.

- Contractor/Subcontractor - Any person or firm, retained or hired by Contractor, to carry out and/or supervise any portion of the activities conducted at the Project Site.

- Exclusion Zone - The area in which all personnel entering must be directly involved in the ongoing work, have designated personal protective equipment (PPE), and meet training and medical monitoring requirements. The exclusion zone will be defined by an appropriate physical barrier, which will be suitably marked.

- MSDS - Material Safety Data Sheets, which provide information on the physical, chemical, and hazardous properties of chemical compounds.

- Oversight Personnel - Any person, designated by the State, Federal Government, or Owner, who is assigned to carry out oversight work.

- PPM - Parts per million; expressed as PPM(v) for gases and vapors.

- Project Personnel - Any person or contractor, assigned by Owner, its consultants, its contractors or subcontractors, to carry out work at the Project Site (e.g., Project Director, Project Manager, etc.).

- Project Health and Safety Officer - The designated person responsible for overall implementation of the Health and Safety Plan.

- Project Site - The area defined by a specific project Work Plan, as well as contiguous areas to which access is required for the execution of the field tasks which may be set forth in a Work Plan.

- Site Safety Officer - The person(s) designated by Contractor who is responsible for supervising the Health and Safety/Contingency Plan.

- Support Zone - The area outside the exclusion zone that is considered clean for the purpose of the Health and Safety/Contingency Plan. It is used for transfer of equipment and materials (i.e., support) into the secure area.

- Task-Specific Site Personnel - Any person or subcontractor assigned by Contractor to carry out work at the Project site.

1.04 SUBMITTALS

A. Submit plans in accordance with Section 01340.

B. In accordance with time frame outlined in Submittal Schedule:

1. Written HASP containing all (applicable) requirements under 29 CFR 1910.120. The plan shall be written to avoid misinterpretation and ambiguity, and to minimize the potential for mistakes. Submit revised HASP, if required, responding to comments by Owner, Owner's Representative, or regulatory agencies, in accordance with the Submittal Schedule.

2. HASP approvals by appropriate and qualified Contractor personnel for review by Owner, Owner's Representative, and by regulatory agencies.

3. Documentation of medical monitoring (as required).

4. Documentation of personnel training (as required).

5. Documentation of personnel respirator qualification and fit testing (as required).

C. During Construction Activities:

1. All required forms and OSHA records will be kept on site as applicable.

1.05 PRODUCT

A. Contractor shall provide a HASP consistent with the recommended format as outlined in reference No. B11, Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. Minimum HASP requirements are described according to the following sample outline:

i. Table of Contents
ii. Tables and Figures
iii. Addenda

1.0 INTRODUCTION

1.1 Scope and Applicability of the HASP

A. Identify, evaluate, and control potential health, safety and environmental hazards.

B. Provide emergency response provisions for accidents during work operations.

1.2 Definition

A. To avoid misunderstanding on site, list the following items:

1. List of terms referenced in the HASP.
2. List of term definitions.

1.3 Visitor Requirements on Site

A. Visitors may periodically visit the site. The visitors must:

1. Be able to identify the secure zone and understand procedures.

2. Know and follow sign in/sign out procedures.

3. Show documentation of appropriate training and medical monitoring (as required) which is required in secure work zones.

2.0 KEY PERSONNEL/IDENTIFICATION OF HEALTH AND SAFETY PERSONNEL

A. Identify key personnel (and alternates) and organizational responsibilities for site safety. Also identify key personnel assigned to various operations. List telephone numbers, addresses, and organizations of these people. Include response operations and governmental notification.

2.1 Key Personnel

A. List and define key project personnel on site and off site. Include names, title, and office phone number.

2.2 Site Specific Health and Safety Personnel

A. List site health and safety personnel and alternates. Include name, title, and office phone number.

2.3 Organization Responsibilities

A. Specify minimum responsibilities of key project and health and safety personnel.

3.0 TASK/OPERATION SAFETY HEALTH RISK ANALYSIS

3.1 Historical Overview of Site

A. Include a site history.
B. Include a site map to provide an understanding of the geographical area.
C. Include plans showing the location and layout of any temporary facilities to be constructed on or near the site.

3.2 Task/Risk Analysis

A. Identify and evaluate any potential physical, biological, radiological, or chemical hazards. Express potential impact on workers or the public.

B. Instructions

1. Identify chemical hazards including:

a. respirable dust
b. skin contact/absorption hazards
c. accidental ingestion

2. Identify electrical hazards including:

   a. overhead electrical lines
   b. buried electrical lines
   c. de-energize electrical lines as required

3. Identify mechanical hazards including:

   a. moving equipment and vehicles
   b. rotating machine parts
   c. lockout/tagout moving machinery, as required

4. Identify fire/explosion hazards including:

   a. gasoline powered equipment
   b. smoking
   c. flammable fumes and vapors
   d. burning and welding
   e. compressed gases (e.g., natural gas, compressed air)

5. Identify heat and cold stress hazards including:

   a. extremely hot, humid weather
   b. extremely cold, windy weather

6. Identify acoustical hazards including:

   a. noisy equipment/machinery

7. Identify physical hazards including:

   a. slippery or uneven walking surfaces
   b. tripping hazards
   c. working at elevations above floor level

8. Identify construction hazards:

   a. confined space
   b. trenching/shoring
   c. site vehicle and heavy equipment traffic
   d. overhead hazards

9. Identify hazards relating to off-site locations:

   a. migration of dusts/fumes/mists or unanticipated releases to protect the adjacent community and general public
   b. off-site vehicular traffic

10. Identify unanticipated, site-specific hazards.

NOTES:

a. The iron material is a dust nuisance and adequate personal protective equipment should be worn at all times while handling or being in close proximity to iron material. MSDS data sheets are available from the manufacturer.

b. The contractor should be aware that mixing of iron and sand might cause the temperature of the mixture to increase by several tens of degrees due to friction of the granular particles and oxidation of the iron.

4.0 PERSONNEL TRAINING REQUIREMENTS

4.1 Training and Briefing Topics

A. Pre-project briefing meeting covering the following HASP topics:

i. site characterization
ii. hazards
iii. medical surveillance requirements
iv. symptoms of overexposure to hazards
v. site control
vi. training requirements
vii. monitoring equipment

B. Have all site workers sign an acknowledgment form attesting to attendance at the pre-project meeting, understanding of safety rules and documentation and understanding of respirator fit test (as necessary).

C. Hold a daily safety meeting to be held by the designated site safety officer to discuss specific current safety issues and as a daily safety reminder.

D. Have all site workers supply documentation of appropriate training.

1. Suggested topics to be covered:

a. personal protective equipment
b. hazards
c. any injuries or close calls
d. weather related issues

5.0 PERSONAL PROTECTIVE EQUIPMENT TO BE USED

A. Define levels of protection required for work activities in terms of work location and/or work function. Define specific types of respirators and protective clothing for each level.

5.1 to 5.5 Level A, B, C and D Personal Protective Equipment

A. After review of hazards and the greatest expected exposure, select levels A-D personal protective equipment. Due to the identified contaminants, level A is not likely to be required. Describe levels of protection worn by personnel and delineate specific job functions.

5.1 Level A - worn when the highest level of respiratory, skin, and eye protection is needed.

5.2 Level B - worn when the highest level of respiratory protection is needed, but a lesser level of skin protection.

5.3 Level C - worn when the criteria for using air-purifying respirators are met based on toxins and/or air monitoring results.

5.4 Level D - worn only as work uniform and not on any site with respiratory or skin hazards.

5.5 The level of protection is selected based on:

- Type and measured concentration of the chemical substances in the ambient atmosphere and their toxicity.

- Potential for exposure to substances in air, splashes of liquids, or other direct contact with material due to work being done.

5.6 Reassessment of Protection Program

A. Levels of protection shall be upgraded or downgraded based upon changes in site conditions or later findings.

5.7 Work Mission Duration

A. The anticipated duration of the work mission is established.

B. Conditions that affect work mission duration to be addressed in this section are:

a. cold and heat
b. capacity to work in full face respirators
c. air supply consumption of SCBAs or airline respirators

5.8 Chemical Resistance and Integrity of Protective Material

A. Personal protective equipment must be specific for the tasks performed in the HASP.

B. The Quick Selection Guide to Chemical Protective Clothing provides a quick reference.

5.9 Standard Operating Procedures for Respiratory Protection Devices

A. Checklists for pre-use inspection, reinspection, and periodic inspection.

5.10 Standard Operating Procedures for Personal Protective Clothing

A. Checklists for pre-use inspection and reinspections.

5.11 Specific Levels of Protection for Site

A. Based on anticipated hazards, the specific levels of protection are listed.

1. Level A
2. Level B
3. Level C
4. Level D (or Modified Level D)

B. List all types of personal protective equipment to be used on site for each level.

6.0 MEDICAL SURVEILLANCE REQUIREMENTS

A. Develop a medical surveillance program by a Board Certified or Qualified to be a Board Certified Occupational Physician.

6.1 Baseline or Pre-assignment Monitoring

A. Document medical monitoring for all personnel working in the Secure Zone.

B. Examinations to include:

a. complete medical and work histories
b. physical examination
c. pulmonary function
d. chest X-ray
e. electrocardiogram
f. eye exam and visual acuity
g. audiometry
h. urinalysis
i. blood chemistry (hematology, serum analyses, heavy metals toxicology)

C. The medical monitoring physical must certify the ability of personnel to use air purifying respirators and to be medically able to perform specific tasks.

6.2 Periodic Monitoring

A. Perform periodic monitoring (medical physical) for personnel working in the secure zone required within the last 12 months.

B. Monitoring documentation maintained on Site.

6.3 Specific Medical Monitoring

A. Monitoring for symptoms related to the possible exposure of harmful chemical compounds.

B. Physical injuries during performance of tasks covered by HASP.

C. Visually monitor personnel for signs of heat or cold overexposure.

6.4 Exposure/Injury/Medical Support

A. Make provisions for special circumstances which may require medical attention of a physician.

7.0 FREQUENCY AND TYPES OF AIR MONITORING AND PERSONNEL AIR SAMPLING

A. The purpose is to identify and quantify airborne contaminants in order to verify and determine the level of personal protection required and to ensure non-migration of site contaminants to off-site locations.

B. Two principal methods are used:

a. Continuous air monitoring using direct reading instrument, (e.g. HNU, OVA, combustible gas/oxygen meter, dust monitors.)

b. Composite air monitoring obtained by sorbent (e.g. charcoal and silica gel tubes collected by a personal pump).

7.1 Direct-Reading Monitoring Instruments

A. Direct Reading Instruments are used in the Secure Zone.

B. Determine Direct Reading Instrument based on anticipated contaminants and confined space entry requirements.

C. Calibrate instruments each morning and each afternoon.

7.2 Personal Sampling

A. Based on contaminants, identify personal sampling pumps with collection tubes that may be used.

7.3 Specific Contaminants that may be Monitored at Site Location

A. Contaminants of concern as identified in the October 2000 groundwater sampling performed in the vicinity of the permeable reactive barrier (PRB) include the following:

Constituent	Concentration
VOCs (µg/L)	
1,1-Dichloroethene	8
1,2-Dichloroethene (total)	45,360
Tetrachloroethene	30
Toluene	380
Trichloroethene	69,000
Vinyl Chloride	1,000
SVOCs (µg/L)	
Bis-2-ethylhexyl phthalate	7.3

Metals (mg/L)	
Arsenic	0.06
Chromium (Total)	2.55

Note: In addition to the constituents listed above, there is a potential to encounter organic subsurface dense nonaqueous phase liquids (DNAPL) and light non-aqueous phase liquids (LNAPL) at the site.

Greater amounts of these substances may be present in environmental materials in the work areas.

8.0 SITE CONTROL MEASURES

8.1 Buddy System

A. Work in the Secure Zone shall be scheduled to assure no person works alone.

B. Visual contact shall be maintained at all times.

C. Buddy system shall be required when working on or near water hazards including the use of a life line and life preservers.

D. Appropriate trained personnel (authorized entrants, attendants, entry supervisors, and rescue and emergency services) for permit-required confined space.

8.2 Site Communications Plan

A. Provide a communication system which includes the following elements.

1. telephones
2. 2-way radios
3. hand signals
4. verbal communication
5. other (horns, whistles)

8.3 Work Zone Definition and Site Access

A. Work zone definition incorporates the following elements (as required):

1. Exclusion Zone

2. Secure Zone

3. Contamination Reduction Zone

4. Support Zone

5. Control procedures to prevent unauthorized access. Require a check-in and check-out system to control and record each individual and piece of equipment in each area.

6. Site security procedures - (fences, signs, sign in/sign out procedures)

B. Provide a site map and identify the following (as necessary):

1. Exclusion zone, Secure Zone, Contamination Reduction Zone, and Support Zone.

2. Indicate the sizes of zones, zone boundaries, and access control points into each zone.

3. Indicate the location of nearest roads, major topographical features, and other buildings.

8.4 Nearest Medical Assistance

A. Provide the name, address, and telephone of nearest medical assistance and location of on site medical assistance (if appropriate).

B. Provide a map to nearest medical facility.

C. Provide written directions to nearest medical facility.

8.5 Safe Work Practices

A. List safe work practices that are mandatory and enforceable at site location

8.6 Emergency Alarm Procedure

Address site emergencies or occurrences that require immediate actions to prevent additional problems or harm to responders, the public, property, or the environment.

A. Establish Site Emergency Procedures:

1. List names and emergency functions of on-site personnel responsible for emergency actions. Indicate training they have received.

2. Provide communication plan and alternate means for emergency communications.

3. List names, telephone numbers, and locations of emergency organizations that might be needed.

4. Address and define procedures for rapid evacuation of personnel.

5. List emergency equipment.

6. Address emergency medical care.

7. Advise site personnel of their duties in an emergency.

8. Provide for emergency decontamination of injured personnel.

9. Provide a map(s) with route(s) to nearby hospital(s) and pre-arrangements for emergency medical treatment.

10. Notify and coordinate with local emergency and rescue services before commencing permit required confined space entries.

9.0 DECONTAMINATION PLAN

9.1 Standard Operating Procedures

A. Establish decontamination procedures (as required) for personnel and equipment.

B. Arrange for proper disposal of contaminated material, solutions, and equipment.

Follow specifics as stated in *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*. NIOSH/OSHA/USCG/EPA; US Department of Health and Human Services, Public Health Service, Center for Disease Control, NIOSH; 1985.

9.2 Levels of Decontamination Protection Required for Personnel

A. Establish the level of decontamination based on anticipated levels of contaminants.

9.3 Equipment Decontamination

A. Establish decontamination procedures for equipment and arrange for disposal of solutions and/or equipment in accordance with the Construction Operations Plan.

9.4 Disposition of Decontamination Wastes

A. Establish decontamination waste disposal procedures. This includes solutions and/or equipment.

10.0 EMERGENCY RESPONSE/CONTINGENCY PLAN

A. Provide an Emergency Response/Contingency Plan established with the following objectives:

1. Pre-Emergency Planning

2. Personnel Roles and Lines of Authority

3. Emergency Recognition and Prevention

4. Evacuation Routes and Procedures/Safe Distances

5. Site Security and Control

6. Emergency Decontamination Procedures

7. Emergency Contact/Notification System and Alerting Procedures including alternate means of communication

8. Emergency Medical Treatment Procedures

9. Fire or Explosion Response Procedures

10. Spill or Leak Response Procedures

11. Personal Protective Equipment and Emergency Equipment

12. Rescue and Emergency Services

13. Governmental Notification Procedures

11.0 SPILL CONTAINMENT PROGRAM

A. Provide a spill containment program identifying possible spill potential and containment procedures and equipment.

1. List emergency contacts and phone numbers

2. List types and location of spill containment materials.

12.0 CONFINED SPACE ENTRY PROGRAM

A. Provide a confined space entry program identifying locations of confined spaces, potential hazards present within these spaces, personnel notification procedures, and ways to limit access into confined spaces.

B. Describe established permit-required confined space entry procedures that meet the following objectives found in 29 CFR 1910.146:

1. Applicability of this procedure

2. Definitions used in this procedure

3. General requirements

4. Contractor notification requirements

5. Methods to limit access to spaces, control and isolate hazards, evaluate acceptable entry conditions through testing to determine if acceptable entry conditions exist and are maintained during the course of entry conditions

6. Required personal protective equipment

7. Equipment calibration, air monitoring and ventilation procedures

8. Document completion of measures required in the program through the use of written, signed permits

9. Establish and document personnel training

10. Provide description of duties for entry, rescue, and support personnel

11. Describe rescue operations and equipment

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01540

SECURITY

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Project Security Control Measures and Protocol

B. Work Area Security

1.02 RELATED SECTIONS

A. Section 01340 - Submittals

B. Section 01390 - Construction Facilities and Temporary Controls

1.03 PROJECT SECURITY CONTROL MEASURES

A. Protect Work from theft, vandalism, and unauthorized entry.

1.04 SUBMITTALS

A. Develop work area security protocol and submit to Owner and Owner's Representative for review in accordance with the Submittal Schedule given in Section 01340. Include Security Protocol which addresses the following items at a minimum:

1. Personnel responsible for implementing and maintaining security measures in the work area including names and assigned functions.

2. Description of proposed daily security operations.

3. Description of proposed methods and frequency of security checks at the project site, if required.

4. Description of proposed methods for responding to the following breaches in security:

   a. Entry of unauthorized personnel into the work area.

   b. Site boundary security provisions are breached.

1.05 WORK AREA SECURITY

A. Contractor shall provide temporary security for the contract work area. Snow fences or a temporary mesh security fence or other approved means shall be installed by Contractor in order to define the restricted area and to prevent unauthorized personnel from entering that area.

B. Contractor shall be responsible for all costs associated with providing the security and access restriction features, maintaining all features during construction and removal and disposal of temporary features at the conclusion of the Project.

C. Contractor shall maintain a list of personnel allowed in the work area and at the project site and exclude entry of all others. All individuals requesting access shall be required to display identification.

D. Contractor shall maintain a current log of all visitors entering and leaving the site.

E. Contractor shall immediately notify Owner or Owner's Representative of any attempts to enter the work area by unauthorized personnel or visitors.

F. Under no circumstance shall Contractor convey project information to persons not directly involved with the project. Refer such persons to the Owner's Representative for answers to questions. Contractor shall notify Owner or Owner's Representative of any request for information by parties not directly involved in the project.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01560

DUST AND NOISE CONTROL

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Dust control shall consist of operations performed by Contractor to minimize the production of dust in the work areas.

B. Noise control shall consist of operations performed by Contractor to minimize excessive noise in the work areas.

1.02 RELATED SECTIONS

A. Section 01500 - Health and Safety Plan (HASP)

B. Section 02200 - Earthwork and Materials

C. Section 02931 - Erosion Control

1.03 DUST CONTROL

A. Contractor shall implement dust control procedures (e.g., watering) to prevent conditions under which dust is visible in the air and to prevent dust from leaving the work area. Contractor may not use water on the bulk granular iron or the iron/sand mixture to prevent dust.

B. In the event that it becomes necessary in the opinion of Owner, Owner's Representative, or Health and Safety Officer to provide additional measures to control the release of dust, such measures shall be immediately implemented by Contractor.

C. Owner shall reserve the right to suspend Work at any time if necessary due to dust generation which causes a safety or air quality problem or which may cause contamination of adjacent areas and Contractor shall not be entitled to any additional compensation for suspension of Work under such conditions.

1.04 NOISE CONTROL

A. Contractor shall implement noise control procedures to prevent excessive noise in the work area and surrounding areas as determined by Owner or by Owner's Representative.

B. Contractor shall provide necessary measures to minimize noise occurring due to after normal work hours activities. Care must be taken to prevent excessive noise such that there will be very minimal disturbance to neighboring residential or industrial sites.

C. Owner or Owner's Representative shall reserve the right to suspend Work at any time if necessary due to noise generation causing a safety or excessive vibration hazard. In the event the OSHA limit of 85 dBA is exceeded for 8 hours per day or a peak level of 140 dBA is exceeded, a hearing protection program must be implemented.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.01 DUST CONTROL

A. The Contractor shall implement dust control procedures (e.g., watering) to prevent conditions under which dust is visible in the air. Contractor may not use water on the bulk granular iron or the iron/sand mixture to prevent dust.

B. In the event that it becomes necessary in the opinion of the Owner or the Owner's Representative to provide the watering of surfaces to control the release of dust, such watering shall be immediately implemented by the Contractor.

C. The Owner or Owner's Representative shall reserve the right to suspend the Work at any time if necessary due to excessive wind velocity or adverse wind direction.

D. Calcium chloride or other chemical methods shall <u>not</u> be used for dust control. Severe dust problems

shall be controlled with mulch, gravel, or other temporary methods subject to the approval of the Owner's Representative.

[END OF SECTION]

SECTION 01600

MATERIAL AND EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Material and Equipment Incorporated into Work:

1. Conform to applicable specifications and standards.

2. Comply with size, make, type, and quality specified or as specifically approved, in writing, by the Engineer.

B. Do not use material or equipment for any purpose other than that for which it is designed or specified.

1.02 RELATED SECTIONS

A. Section 01340 - Submittals

1.03 SUBSTITUTIONS

A. Requirements for substitutions do not apply to Contractor options on materials, equipment, and construction methods. Revisions to Contract Documents, where requested by the Owner or the Engineer are "changes" not "substitutions." Contractor's determination of and compliance with governing regulations and orders issued by governing authorities do not constitute "substitutions" and do not constitute basis for change orders, except as provided for in Contract Documents.

B. The Contractor's requests for changes in materials and equipment, and methods of construction required by Contract Documents, are considered requests for "substitutions" and are subject to requirements hereof.

C. The Contractor's request for substitution will be received and considered when all of the following are satisfied:

1. When extensive revisions to Contract Documents are not required and changes are in keeping with general intent of Contract Documents;

2. When timely, fully documented, and properly submitted; and

3. When one or more of the following conditions is satisfied, as judged by the Engineer.

   a. Where requests are directly related to an "or equal" clause or other language of same effect in Contract Documents; or

   b. Where required, material, equipment, or method cannot be provided within Contract Time, but not as result of the Contractor's failure to pursue work promptly or to coordinate various activities properly; or

   c. Where required, material, equipment, or method cannot receive required approval by governing authority, and requested substitution can be so approved.

D. Request for substitution constitutes representation that the Contractor:

   1. Has investigated proposed material or equipment and determined it is equal to or superior to specified.

   2. Will provide same warranties or bonds for substitution as for material or equipment specified.

   3. Will coordinate installation of accepted substitution into Work and make such other changes as may be required to make Work complete.

   4. Waives claims for additional costs, under the Contractor's responsibility, which may subsequently become apparent.

1.04 CONTRACTOR'S OPTIONS/COMPATIBILITY

A. Options:

1. Standards, Codes, and Regulations: Where only compliance with imposed standard, code, or regulation is required, select from among products which comply with requirements of those standards, codes, and regulations.

2. "Or Equal": For materials and equipment specified by naming one or more materials or manufacturers and "or equal" the Contractor shall submit request for substitution for any material or manufacturer not named, for approval by the Engineer.

3. Two or More Materials/Manufacturers: For material or equipment specified by naming materials or manufacturers, select any one of materials or manufacturers named. Do not provide or offer to provide unnamed material or manufacturer.

4. Single Material/Manufacturer: For materials or equipment specified by naming only one material or manufacturer, and/or followed by words indicating no substitution, there is no option.

B. Compatibility:

1. Where more than one choice is available as options for the Contractor's selection of material or equipment, select option which is compatible with other equipment and materials already selected.

2. Compatibility among options is not assured by limitations within Contract Documents, but shall be provided by the Contractor.

1.05 MANUFACTURER'S INSTRUCTIONS

A. When Contract Documents require that the installation of work, materials, or equipment to be furnished shall comply with manufacturer's instructions, obtain and distribute printed copies of such instructions to parties involved in installation, including two copies to the Owner.

1. Maintain one set of complete instructions at job site during installation and until completion of Work. Submit documents in accordance with Section 01340 - Submittals.

B. Handle, install, connect, clean, condition, and adjust materials and equipment in accordance with manufacturer's written instructions and in conformity with specified requirements.

1. Should job conditions or specified requirements conflict with manufacturer's instructions, consult the Owner for further instructions.

2. Do not proceed with Work without written instructions.

1.06 TRANSPORTATION AND HANDLING

A. Arrange delivery of materials and equipment in accordance with construction progress schedules and conditions at site.

1. Deliver materials and equipment in undamaged condition, in manufacturer's original containers or packaging, with identifying labels intact and legible.

2. Immediately upon delivery, inspect shipments to assure compliance with requirements of Contract Documents and approved submittals and that materials and equipment are protected and undamaged.

B. Provide equipment and personnel to handle materials and equipment by methods recommended by manufacturer to prevent soiling or damage to materials, equipment or packaging.

1.07 STORAGE AND PROTECTION

A. The Owner assumes no responsibility for materials stored in buildings or on-site. The Contractor assumes full responsibility for damage due to storing of materials.

B. Interior Storage:

1. Store materials and equipment in accordance with manufacturer's instructions, with seals and labels intact and legible.

2. Store materials and equipment subject to damage by elements in weathertight enclosures.

3. Maintain temperature and humidity within ranges required by manufacturer's instructions.

C. Exterior Storage:

1. Store fabricated materials and equipment above ground, on blocking or skids, to prevent soiling or staining. Cover materials and equipment which are subject to deterioration with impervious sheet coverings, provide adequate ventilation to avoid condensation.

2. Store loose granular materials in a well-drained area on solid surfaces to prevent mixing with foreign matter.

3. Materials such as pipe shall be stored on pallets or racks, off the ground.

D. Arrange storage in a manner to provide easy access for inspection and inventory. Make periodic inspections of stored materials and equipment to assure that materials and equipment are maintained under specified conditions and free from damage or deterioration.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01700

PROJECT CLOSEOUT

PART 1 - GENERAL

1.01 CLOSEOUT PROCEDURES

A. Submit written certification that Contract Documents have been reviewed, work has been inspected, and that work is complete in accordance with Contract Documents and ready for Owner's and Owner's Representative's final inspection.

B. Provide record drawings documentation, all submittals of Section 01340 of these Specifications, and any other submittals required by governing or other authorities to the Owner and the Owner's Representative.

C. Submit Final Application for Payment identifying total adjusted Contract Sum, previous payments, and sum remaining due.

D. Provide written notification that punch list items have been completed. Where applicable, provide a description of how each punch list item has been addressed.

1.02 FINAL CLEANING

A. Upon completion of work and prior to final inspection, the Contractor shall remove all of his equipment, signs, facilities, construction materials, and trash, and shall perform any other reasonable clean-up activities requested by the Owner. All disturbed areas shall be restored or otherwise put into a condition satisfactory to the Owner. Finished grades shall promote positive drainage to catch basins and drainage swales and channels.

1.03 PROJECT RECORD DOCUMENTS

A. The Contractor shall maintain on site, one set of the following record documents:

1. Drawings

2. Specifications
3. Addenda
4. Change Orders and other modifications to the Contract
5. Reviewed shop drawings, product data, and samples.

B. The Contractor shall store Project Record Documents separate from documents used for construction.

C. The Contractor shall record information concurrent with construction progress.

D. Record Documents and shop drawings shall be legibly marked by the Contractor for each item to record actual construction, including:

1. Field changes of dimension and detail; and
2. Details not on original Contract Drawings.

E. The Contractor shall submit documents to the Owner with claim for final Application for Payment.

1.04 FINAL INSPECTION

A. The Contractor shall notify the Owner seven (7) days prior to completion of the work in order to schedule the final inspection date.

B. The final inspection shall be conducted with the Owner, Contractor, Owner's Representative and Engineer all present at the site.

1.05 PUNCH LIST ITEMS

A. The Contractor shall rectify punch list items identified during construction prior to final site inspection. Punch list items identified during the final inspection shall be addressed within two weeks after the final inspection and prior to final payment unless an alternate schedule is approved by the Owner.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

SECTION 01740

WARRANTIES AND BONDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Preparation and submittal

B. Time and schedule of submittals

1.02 RELATED SECTIONS

A. Section 01340 - Submittals

B. Section 01700 - Contract Closeout

C. Individual Specifications Sections: Warranties required for specific products or work.

1.03 FORM OF SUBMITTALS

A. Bind in commercial quality, 8 1/2 inch by 11 inch three-ring side binders with hardback, cleanable plastic covers.

B. Label cover of each binder with title of Project; name, address, and telephone number of Contractor and equipment supplier; and name of responsible principal.

C. Table of Contents: Neatly typed, in the sequence of the Table of Contents of the Project Manual, with each item identified with the number and title of the Specification Section in which specified, and the name of the product or work item.

D. Separate each warranty or bond with index tab sheets keyed to the Table of Contents listing. Provide full information, using separate, typed sheets as necessary. List Subcontractor, supplier, and manufacturer, with name, address, and telephone number of responsible principal.

1.04 PREPARATION OF SUBMITTALS

A. Obtain warranties and bonds, executed in duplicate by responsible Subcontractors, suppliers, and manufacturers, within ten days after completion of the applicable item or work. Except for items put into use with Owner's permission, leave date of beginning of time of warranty until the Date of Substantial Completion is determined.

B. Verify that documents are in proper form, contain full information, and are notarized.

C. Co-execute submittals when required.

D. Retain warranties and bonds until time specified for submittal.

1.05 TIME OF SUBMITTALS

A. Warranties for equipment or component parts of equipment put into service during construction with Owner's permission, submit documents within ten days after acceptance.

B. Make other warranty submittals within ten days after Date of Substantial Completion, prior to final Application for Payment.

C. For items of work when acceptance is delayed beyond Date of Substantial Completion, submit warranty within ten days after acceptance, listing the date of acceptance as the beginning of the warranty period.

D. Payment and performance (if required by the Owner) bonds to be submitted at the time of the signing of the contract.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

NOT USED

[END OF SECTION]

DIVISION 2

SITE WORK

SECTION 02200

EARTHWORK AND MATERIALS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary to perform all earthwork to the lines and grades specified herein, as shown on the Drawings, and as necessary to complete the Work.

B. The Contractor shall be prepared to perform earthwork in conjunction with other construction activities (e.g., geosynthetics installation, access road construction, etc.).

C. The work of this Section shall include, but may not necessarily be limited to: hauling, backfilling, spreading, grading, and compacting of each of the specified materials.

1.02 RELATED SECTIONS

A. Section 01040 - Project Coordination

B. Section 01050 - Field Engineering

C. Section 01120 - Site Maintenance

D. Section 01340 - Submittals

E. Section 01500 - Health and Safety Plan (HASP)

F. Section 01560 - Dust and Noise Control

G. Section 02226 - Biopolymer Slurry Excavation and Iron Placement

H. Section 02931 - Erosion Control

1.03 REFERENCES

A. The Contractor shall comply with applicable provisions and recommendations of the following, except as otherwise shown or specified.

1. Latest version of American Society for Testing and Methods (ASTM).

   a. C 136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregate

   b. D 422 Test Method for Particle-Size Analysis of Soils

   c. D 698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft^3)

   d. D 1557 Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft^3)

   e. D 2321 Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

   f. D 2487 Test Method for Classification of Soils for Engineering Purposes

   g. D 2922 Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods

   h. D 3017 Test Method for Moisture Content of Soil In Place By Nuclear Methods

   i. D 4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

2. Latest Version of State of Mississippi Department of Transportation Specifications.

1.04 QUALITY CONTROL

A. Laboratory Testing

1. The services of a qualified independent geotechnical testing laboratory will be engaged by the Contractor to perform tests and determine the suitability of the earth materials (i.e., fill material, bedding material, soil layers, structural fill, road stone, coarse aggregate, and gravel), as listed in Part 2 of this Section.

B. Permits and Regulations

1. The Contractor shall perform the required Work in compliance with applicable requirements of governing authorities having jurisdiction.

C. On-Site Testing

1. The services of a qualified independent geotechnical testing laboratory will be engaged by the Contractor to perform all on-site testing under the observation of the Owner's Representative.

1.05 SUBMITTALS

A. Prepare and submit finished grade information and drawings, as described in Section 01050.

B. Submit the name and qualifications of the independent geotechnical laboratory for approval by the Owner's Representative.

C. For each soil type specified in Part 2 of this Section, submit to the Owner's Representative for preapproval the following information and samples a minimum of 14 days prior to starting construction, unless a source has been prequalified by the Owner's Representative:

1. The proposed material source or sources.

2. The results of grain-size analyses conducted on material from each source in accordance with ASTM D 422 and a material classification in accordance with ASTM D2487.

D. Submit documentation that all earth materials to be used are certified clean materials, including:

1. Certification stating that the materials are virgin materials from a commercial or non-commercial source.

2. Bills of lading to document the source(s) of the materials, including the name of the affiant and relationship to the source, and the location where the materials were obtained, including the street, town, lot and block, county, state, and a brief source site history.

3. A statement that to the best of the affiant's knowledge and belief, the material is not contaminated pursuant to any applicable remediation standards and is free of extraneous or solid waste, and a description of the steps taken to confirm such.

4. At the request of the Owner's Representative, the Contractor may, at no cost to the Owner, be required to perform Toxicity Characteristic Leaching Potential (TCLP) chemical tests. The number of tests to be performed will be determined based on the soil borrow source in question. The Contractor shall use his equipment and work with the Owner's Representative to collect representative samples as directed by the Owner's Representative.

E. Submit information on earthwork equipment to be used on the Project.

F. Submit copies of the test reports on earth materials directly to the Owner's Representative from the testing service, with a copy to the Contractor.

1.06 EXISTING CONDITIONS

A. Approximate existing site surface conditions are indicated on the Drawings. The Contractor shall review these documents and become familiar with the site conditions.

B. The Contractor shall verify that subsurface utilities have been marked prior to performing excavation or earthwork and shall provide sufficient notification to the local Dig Safe Agency.

C. Contractor shall be responsible for generating topographic information for the proposed trench alignment, access roads, trench spoils disposal areas, and other areas of disturbance. The topographic information shall be included on the Working Drawings prepared and submitted by the Contractor.

PART 2 PRODUCTS AND EQUIPMENT

2.01 GENERAL FILL

A. The general fill material shall be used as fill above the top of the Permeable Reactive Barrier (PRB), as the berm material to contain excavated soil, and in regraded portions of the Outfall Ditch, as shown on the Drawings

B. Material Evaluation:

1. The Contractor shall employ an independent geotechnical testing laboratory approved by the Owner's Representative to carry out the following tests and shall submit the test data to the Owner's Representative. The testing frequency shall be one test per every 5,000 in-place cubic yards per source (except as noted below), but shall in no case be less than three tests per source. The Contractor shall take the testing frequency into account in planning his construction schedule.

a. Mechanical Gradation (Sieve Analysis)	ASTM D 422
b. Natural Moisture Content	ASTM D 2216
c. Compaction Test	ASTM D 1557
d. Atterberg Limits	ASTM D 4318
e. Classification	ASTM D 2487

C. The general fill layer shall consist of imported material and be clean and free of any metals, roots, trees, stumps, concrete, construction debris, or any other organic matter or deleterious material.

D. The general fill layer should be able to support vegetation and shall serve as a backfill/topsoil as the site is seeded at the end of construction.

E. The final approval of a source for the fill material shall be at the sole discretion of the Owner's Representative. Any material that does not conform to these Specifications shall be replaced by the Contractor at no cost to the Owner's Representative.

2.02 COVER SOIL LAYER MATERIAL

A. The cover soil layer material shall be used over the geosynthetic clay liner, as shown on the Drawings.

B. Cover soil material shall be free draining and have the physical characteristics of soil designated as group A-1, A-2, or A-3 under AASHTO M145, shall have properties such that it may be readily spread and compacted, and shall be satisfactory to the Owner's Representative. A maximum of 35% of the dry total weight of the material shall be capable of passing through a 0.074 millimeter, No. 200 mesh sieve. At least 40% of the dry total weight of the material shall be capable of passing through a 2 millimeter, No. 10 mesh sieve. It shall not contain any material angular or otherwise which could damage the geosynthetics and shall have a maximum particle size of one inch. The combustible or coal content of the cover soil may not exceed 12% of the dry total weight.

C. Material Evaluation:

1. The Contractor shall employ an independent geotechnical testing laboratory approved by the Owner's Representative to carry out the following tests and shall submit the test data to the Owner's Representative. The testing frequency shall be one test per every 5,000 in-place cubic yards per source (except as noted below), but shall in no case be less than three tests per source. The Contractor shall take the testing frequency into account in planning his construction schedule.

a. Mechanical Gradation (Sieve Analysis)	ASTM D 422
b. Natural Moisture Content	ASTM D 2216
c. Compaction Test	ASTM D 1557
d. Classification	ASTM D 2487
e. Hydraulic Conductivity	ASTM D 5084B

D. The cover soil layer shall consist of imported material and be well and free of any metals, roots, trees, stumps, concrete, construction debris, or any other organic matter or deleterious material.

E. The final approval of a source for the cover soil shall be at the sole discretion of the Owner's Representative. Any material that does not conform to these Specifications shall be replaced by the Contractor at no cost to the Owner.

2.03 TRENCH SAND

A. Trench sand shall be used as fill material to be mixed with the granular iron for the permeable reactive barrier (PRB) as shown on the Drawings. The sand shall consist of imported material and shall be well and free of any metals, roots, trees, stumps, concrete, construction debris, or any other organic matter or deleterious material which could impact the integrity of the material.

B. Material to be used as trench sand shall meet the requirements set forth below:

Deleterious Substances	Maximum Permissible Limits (% by Weight)
Clay lumps	0.3
Coal and lignite	0.5
Material Passing the No. 200 Sieve	2.0
Other deleterious substances such as shale, alkali, mica, coated grains, and soft and flaky particles	2.0
Total shale, coal, lignite, clay lumps, and other deleterious substances	3.0

C. The grain size and gradation of the trench sand material should be at least as coarse as the gradation of the granular iron specified in Section 02226 and as listed in the table below.

US Standard Mesh Number	mm	Weight Percent Passing
#8	2.4	95 - 100
#16	1.2	75 - 90
#30	0.6	25 - 45
#50	0.3	0 - 10
#100	0.15	0 - 5

D. The Contractor shall submit results of grain-size analyses and material classification for every 100 cubic yards of trench sand brought to site or no less than three tests per source, whichever is greater. These tests shall be conducted in accordance with the standard methods for Sieve Analysis of Fine and Coarse Aggregate (ASTM C 136) and Classification of Soils for Engineering Purposes (ASTM D 2487). The Contractor shall take the testing frequency into account in planning his construction schedule.

E. The final approval of a source for the trench sand shall be at the sole discretion of the Owner's Representative. Any material that does not conform to these Specifications shall be replaced by the Contractor at no cost to the Owner.

2.04 WORK PLATFORM AND ROAD STONE

A. The work platform and road stone shall be used to construct the work platform above the PRB, as well as the final surface for the access road from Highway 332 to the PRB, as shown on the Drawings.

B. Material Evaluation:

1. The Contractor shall employ an independent geotechnical testing laboratory approved by the Owner's Representative to carry out the following tests and shall submit the test data to the Owner's Representative. A minimum of two tests shall be performed per source. The Contractor shall take the testing frequency into account in planning his construction schedule.

   a. Mechanical Gradation (Sieve Analysis) — ASTM C 136

   b. Atterberg Limits — ASTM D 4318

   c. Compaction Test — ASTM D 698

   d. Classification — ASTM D 2487

C. The road stone shall be imported coarse aggregate and be well and free of any metals, roots, trees, stumps, concrete, construction debris, or any other organic matter or deleterious material which could impact the integrity of the material.

D. The road stone shall meet the requirements set forth in the State of Mississippi Department of Transportation Specifications, for classification as Class 5 Group C stone. Maximum particle size shall not exceed 3 inches (nominal). The Contractor may submit alternate materials for consideration by the Owner's Representative.

E. The final approval of a source for the road stone shall be at the sole discretion of the Owner's Representative. Any material that does not conform to these Specifications shall be replaced by the Contractor at no cost to the Owner.

2.05 RIPRAP

A. Riprap material shall be used to control erosion in the drainage features as designated on the Drawings. The stone shall consist of imported material and be well and free of any metals, roots, trees, stumps, concrete, construction debris, or any other organic matter or deleterious material which could impact the integrity of the material.

B. Material placed in the ditch shall meet the requirements of NSA No. R-3 stone with d_{50} = 3 inches as designated on the Drawings.

C. Sandstone or similar soft rock or relatively thin slabs will not be acceptable. The material shall be free from clay, loam, or other plastic material.

D. The Contractor shall employ an independent geotechnical testing laboratory approved by the Owner's Representative to certify that the riprap materials meet the requirements stated above. Certification shall be submitted to the Owner's Representative. The Contractor shall take the testing frequency into account in planning his construction schedule.

E. The final approval of a source for the riprap shall be at the sole discretion of the Owner's Representative. Any material that does not conform to these

Specifications shall be replaced by the Contractor at no cost to the Owner.

2.06 EQUIPMENT

A. Place, spread, and compact, as required, earth materials by using a backhoe, bulldozer, hand tamper, vibratory compactors, or similar construction equipment, as approved by the Owner's Representative.

B. Place, spread, and compact, as required, around culvert and force main using equipment to prevent damage to the culvert or force main.

PART 3 EXECUTION

3.01 FAMILIARIZATION

A. The Contractor shall perform all earthwork, to the lines and grades and to the specified depths as shown on the Drawings.

1. The Contractor shall provide the Owner's Representative with sufficient time and means to examine the areas and conditions under which earthwork is to be performed. Prior to examination by the Owner's Representative and implementing any of the work in this Section, the Contractor shall carefully inspect the installed work of all other Sections and verify that all Work is complete to the point where the work of this Section may properly commence without adverse impact.

2. Do not proceed with the Work until unsatisfactory conditions have been corrected in a manner acceptable to the Owner's Representative.

B. The Contractor shall verify that subsurface utilities have been marked prior to performing excavation or earthwork and shall provide sufficient notification to the local Dig Safe Agency.

3.02 GENERAL REQUIREMENTS

A. All material shall be placed only on unfrozen surfaces.

B. If a defective area is discovered in the earthwork, the Contractor shall immediately determine the extent and

nature of the defect at no additional cost to the Owner's Representative. If the defect is indicated by an unsatisfactory test result, the Contractor shall determine the extent of the defective area by additional tests, observations, a review of records, or other means that the Owner's Representative deems appropriate. If the defect is related to adverse site conditions, such as overly wet soil or surface desiccation, the Contractor shall define the limits and nature of the defect.

C. After the extent and nature of a defect has been determined, the Contractor shall correct the deficiency to the satisfaction of the Owner's Representative. The cost of corrective actions shall be borne by the Contractor.

D. Additional testing shall be performed by the Contractor at no cost to the Owner's Representative to verify that the defect has been corrected. This additional testing shall be performed before any additional work is allowed in the area of the deficiency.

3.03 GENERAL FILL

A. The trench and other features requiring general fill shall be constructed to the lines and grades shown on the Drawings. The backfill above the PRB shall be finished at an elevation 0.25 feet (minimum) higher on the centerline than the adjacent ground surface. The backfill shall slope evenly from the centerline such that it blends smoothly with the adjacent grade. The finished surface shall be reasonably smooth and free from irregular surface changes. The finished surface shall be free of depressed areas where water could pond.

B. The general fill shall meet the requirements of Part 2.01 of this Section.

C. The Contractor shall not operate equipment directly on the geotextile and GCL.

D. General fill is to be placed in loose lifts that result in maximum compacted lift thicknesses of one foot or the design thickness, whichever is smaller.

E. Each lift of general fill shall be compacted by the Contractor at a moisture content within plus or minus 2% of the optimum moisture content, as determined by ASTM D

1557, and to 95% of maximum dry density, as determined by ASTM D 1557, unless noted otherwise.

F. Compaction Quality Control Evaluation:

1. Moisture Content (ASTM D 3017) on a 100 foot spacing along the length of the trench or outfall ditch, per lift; and in no case less than one per loft, per day, per fill area. This test shall be calibrated by performing one lab determination of moisture content (ASTM D2216) per 10 in situ moisture content tests, and at least one laboratory test per day.

2. In situ Dry Density (ASTM D 2922) at the frequency specified in F.1. above. This test shall be calibrated by performing 1 sand-cone test (ASTM D 1556) per 10 in situ dry density tests and at least 1 sand-cone test per day.

G. The Owner's Representative may, at its sole discretion, increase the frequency of testing given above.

H. Proposed sampling locations specified in F.1. above will be preapproved by Owner's Representative.

I. A special testing frequency shall be used at the discretion of the Owner's Representative when visual observations of construction performance indicate a potential problem.

3.04 TRENCH SAND

A. Trench sand shall be mixed with the granular iron and placed in the PRB per the requirements listed in Section 02226, including the approved Operating Plan, and to the specified lines and grades shown on the Drawings.

B. The trench sand shall meet the requirements of Part 2.03 of this Section.

3.05 RIPRAP

A. Riprap shall be placed at the locations and to the specified lines, grades, and slopes shown on the Drawings.

B. The riprap shall meet the requirements of Part 2.05 of this section.

3.06 WORK PLATFORM AND ROAD STONE PLACEMENT

A. The road stone shall be placed directly on a geotextile layer placed at the ground surface, and will serve as the top layer of the access road, in accordance with the Drawings.

B. The road stone shall meet the requirements of Part 2.04 of this Section.

C. The Contractor shall not operate equipment directly on the geotextile and shall protect such materials from damage.

D. Road stone is to be placed in loose lifts that result in a compacted lift thickness of six inches.

E. Each lift shall be compacted by the Contractor at a moisture content within plus or minus 2 percent of the optimum moisture content, as determined by ASTM D 698, and to 92 percent of maximum dry density, as determined by ASTM D 698, unless otherwise noted.

F. Compaction Quality Control Evaluation:

1. Moisture Content (ASTM D 3017) on a 100 foot spacing along the length of the road, per lift; and in no case less than one per lift, per day, per fill area.

2. In Situ Dry Density (ASTM D 2922) at the frequency specified in F.1. above.

G. The Owner's Representative may, at its sole discretion, increase the frequency of testing given above.

H. Sampling locations shall be preapproved by the Owner's Representative.

I. A special testing frequency shall be used at the discretion of the Owner's Representative when visual observations of construction performance indicate a potential problem.

J. After installation of the PRB and prior to the placement of topsoil over the excavated soil and a portion of the work platform (as shown on the Drawings), the surface of the work platform shall be regraded to match final grades and act to promote positive drainage (also refer to Part 3.03A of this Section).

3.07 SURVEYING AND CONSTRUCTION TOLERANCES

A. The Contractor shall retain a surveyor who shall be responsible for all surveying associated with the Contractor's work. All surveying shall be performed in accordance with Section 01050.

B. The Contractor shall construct the cover system to the tolerances given in Sections 01050 and 02220.

C. The surveyor shall prepare record drawing documentation for all earthwork in accordance with the requirements and schedule given in Sections 01050.

3.08 PROTECTION OF WORK

A. Use all means necessary to protect all prior work, including all materials and completed work of other sections.

B. In the event of damage, immediately make all repairs and replacements necessary to the approval of the Owner's Representative and at no additional cost to the Owner.

[END OF SECTION]

SECTION 02226

BIOPOLYMER SLURRY EXCAVATION AND IRON PLACEMENT

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall furnish all labor, equipment, materials, and supervision for installation of a Permeable Reactive Barrier (PRB) using the biopolymer slurry trench method of construction. The Contractor shall perform all work necessary for the complete construction of the PRB by the biopolymer slurry trench method to meet the requirements outlined in this Specification.

B. The work shall include, but not be limited to, site preparation, supply of granular iron and sand, excavation of the trench, circulation and maintenance of biopolymer slurry, preparation of iron/sand mixture, backfilling trench with granular iron/sand mixture, management of excavated trench soils, and biopolymer slurry degradation and management of excess biopolymer slurry.

1.02 RELATED SECTIONS

A. Section 01040 - Project Coordination

B. Section 01050 - Field Engineering

C. Section 01060 - Regulatory Requirements

D. Section 01110 - Environmental Protection

E. Section 01120 - Site Maintenance

F. Section 01340 - Submittals

G. Section 01390 - Construction Facilities and Temporary Controls

H. Section 01500 - Health and Safety Plan (HASP)

I. Section 01560 - Dust and Noise Control

J. Section 01600 - Material and Equipment

K. Section 02220 - Earthwork and Materials

L. Section 02931 - Erosion Control

1.03 REFERENCES

REFERENCE	TITLE OR DESCRIPTION
API Spec 13A	American Petroleum Institute (API) Specification for Oil-Well Drilling-Fluid Materials
API RP 13B-1	API Recommended Practice Standard Procedure for Field Testing Water-Based Drilling Fluids
ASTM C 33	Standard Specification for Concrete Aggregates

1.04 QUALITY CONTROL

A. Granular Iron

1. Grain size distribution analyses are to be completed on representative samples collected every 300 tons (at a minimum) during the production run.

2. The Manufacturer shall grant all involved parties the right to visit the manufacturing facility during the production run to visually inspect the manufacturing process and collect random samples at that time. The Manufacturer shall provide reasonable assistance to obtain these samples.

B. Trench Sand

1. Material requirements for the trench sand are contained in Section 02200 - Earthwork and Materials.

2. Trench sand shall be in as dry condition as possible prior to mixing with granular iron.

1.05 SUBMITTALS

A. The Contractor shall provide written evidence of experience and competence in biopolymer slurry trench construction, especially in PRB applications.

B. The Contractor shall provide resumes of the following qualified field staff for the project:

1. Slurry Trench Manager - A competent, full-time, on-site slurry trench manager and/or superintendent with a minimum five years of experience and five successful completed projects constructing biopolymer slurry trenches (at least one of which included the use iron filings). The Slurry Trench manager shall be knowledgeable in: the proper mixing methods employed to mix biopolymer slurry; the use, degrading, testing, and control of degradable polymers as a slurry; the construction equipment used on this project; excavation and backfill operations; and testing for quality control of PRB walls constructed using biopolymer slurry. The Slurry Trench Manager's responsibility is the construction of the biopolymer slurry trench on the project. Any replacement of the Slurry Trench Manager during the project must be approved in writing by the Owner.

2. Quality Control Engineer - An on-site quality control engineer with a minimum three years experience in construction quality control and/or construction management.

3. Operator(s) - The operator(s) for the excavation equipment shall have at least three years experience with clamshells, backhoe, chisels, and other excavation equipment proposed for use on the project by the Contractor.

C. The Contractor shall submit a detailed Operating Plan describing the proposed construction methods, equipment, and schedules. This shall include, but not

be limited to, the Contractor's plan for each of the following:

1. Listing of supervisory personnel: Name and experience of the various persons, their roles and primary responsibilities.

2. Construction means and methods: Access requirements, workspace requirements, listing of equipment and capabilities, construction sequence, biopolymer slurry production, excavation, backfill placement, handling of trench spoil, drain activation (slurry degradation), ditch crossings, work platform construction and materials, maintenance and removal, management, and disposal of encountered stormwater and groundwater.

3. Incorporated Materials: Certificates of compliance with these specifications, test reports and/or catalog cuts and material safety data sheets (MSDS) provided by the manufacturers of the permanent materials that become a part of the final installation.

4. Biopolymer slurry: The name, type, and characteristics of all chemicals in the biopolymer slurry intended to be used in the construction, including any additives and breakers. The submittal shall indicate whether the slurry is natural or synthetic and any residual materials present after degradation. In addition, the Contractor shall submit an MSDS for each slurry ingredient.

5. Trench Sand: Information about the trench sand as required in Section 02200 - Earthwork and Materials shall also be included in the Operating Plan.

6. Quality Control: The contractor shall provide a written quality control plan covering all aspects of the use and degradation of the biopolymer slurry. The quality control plan shall include, but not necessarily be limited to: limits for slurry viscosity and pH, sampling methods, testing frequencies, depth measuring methods, backfill placement controls, sand and iron mixing equipment and procedures, iron content, trench widths and

depth, extraction well spacing for slurry degradation, rate and pore volumes of pumping during trench activation (slurry degradation), and corrective measures.

7. The location and screened interval of the recirculation wells for breaking bioslurry.

H. See drawing Sheet 19071-09 for the required profile of the PRB showing existing grade, finished grade, high water table, general stratigraphy, equivalent pure-iron thicknesses for each section, and confining units.

PART 2.0 - PRODUCTS AND EQUIPMENT

2.01 GRANULAR IRON SPECIFICATIONS

A. The granular iron should consist of approved dry material free from oils, greases, or other foreign organic substances.

The granular iron shall be obtained from:

- Connelly-GPM Inc., Chicago, IL
  Phone: (773) 247-7231. Product: ETICC-1004.

B. The gradation of granular iron should approximate the range specified below, and be approved by the project engineer.

US Standard Mesh Number	mm	Weight Percent Passing
#8	2.4	95 - 100
#16	1.2	75 - 90
#30	0.6	25 - 45
#50	0.3	0 - 10
#100	0.15	0 - 5

C. Granular iron should be transported and arrive on site at near ambient temperatures.

D. The granular iron shall not be directly exposed to moisture or mixed with foreign matter (other than sand mentioned below), and the size and shape shall not be altered significantly, as this can adversely

affect the performance of the granular iron for the intended application.

E. The granular iron unloaded at site should be protected from contact with water at all times. Stored granular iron should be covered with impermeable sheets anchored or tied in place, if stored outdoors. Iron should not be stored directly on the ground surface.

F. Protective packaging should not be removed from granular iron until final placement in the PRB. Unused portions of granular iron shall be returned to storage and protected in accordance with the above requirements.

G. Suppliers should be queried as to the buyback of reactive material, in the event excess material exists at end of construction.

H. The iron material is a dust nuisance and adequate personal protective equipment should be worn at all times while handling or being in close proximity to iron material. MSDS data sheets are available from the manufacturer.

2.02 TRENCH SAND

A. The requirements for the trench sand are listed in Section 02200 - Earthwork and Materials.

B. Trench sand should be in as dry condition as possible prior to mixing with the granular iron.

2.03 BIOPOLYMER SLURRY

A. Biopolymer, biodegradable slurry and bioslurry are used interchangeably in this specification.

B. Biopolymer is to be a biodegradable substance such as guar gum that when properly mixed with water will provide gel strength to support the trench excavation. The biopolymer must be capable of being naturally degraded or "broken" through the use of additives to a non-toxic water solution. Rantec G150 biopolymer or equivalent shall be used.

C. Where an alternative biopolymer other than a guar gum based biopolymer is proposed, the Contractor shall provide test data to demonstrate that the biopolymer will not breakdown prematurely or adversely affect the reactivity of the granular iron.

D. The biopolymer and any breakdown products shall not be a hazardous or toxic substance or contain hazardous or toxic substances.

E. The biopolymer must be capable of obtaining the required viscosity in the presence of granular iron.

F. The biopolymer shall not form a permanent filter cake on the trench walls or cause a permanent decrease in the transmissivity of the granular iron/sand mixture or the adjacent aquifer.

G. Additives such as dispersants, preservatives, pH adjustment agent and/or softeners may be added to the bioslurry to obtain proper stability of the bioslurry and efficient use of the biopolymer. The additives shall be subject to the approval of the Owner.

H. Breaker fluid shall be used to assist in the degradation of the bioslurry. The breaker must be effective in high pH environments. Acid or acidic water (e.g., bioslurry broken with acid) may not be placed or injected into the backfilled reactive media. Acid may be used for pH adjustment of bioslurry out of the trench (e.g., in a frac tank) provided this water is neutralized prior to reinjection into the reactive media. Rantec Liquid Enzyme Breaker LEB-H or equivalent shall be used.

2.04 WATER

A. The water used to make the slurry shall be suitable to provide slurry with adequate viscosity and useful life. Fresh water, free of excessive amounts of deleterious substances (especially bio-organisms) that adversely affect the properties of the slurry shall be used to manufacture the slurry. It is the responsibility of the Contractor to provide water meeting the above criteria and to assure that the

slurry resulting from the water shall always meet the standards of this specification.

PART 3 - EXECUTION

3.01 GENERAL

A. See drawing 19071-05 for the required profile of the PRB showing existing grade, finished grade, high water table, general stratigraphy, equivalent pure-iron thicknesses for each section, iron weight percent for each section, confining units.

B. The Contractor shall verify the required lines, levels, contours, and datum.

C. The Contractor shall maintain and protect existing utilities, which may pass through the work area.

D. The Contractor shall protect bench marks and existing structures from excavation equipment and vehicular traffic.

E. The biopolymer trench shall be laid out according to the lines and coordinates shown on the Drawings.

F. The biopolymer trench shall be excavated to at least 1-foot below the top of the "Marl" surface (estimated to be 45 to 60 feet below existing grade). See drawing 19071-05 for a profile of the trench.

G. Width - The minimum width of the biopolymer slurry trench will be determined by the width of the iron backfill required and the required excavating equipment. The width of the trench shall not exceed 5 times the equivalent pure-iron width required for each panel of the PRB. See Drawings for panel locations and exact pure-iron widths.

H. PRB top - the top of the PRB shall be constructed up to the elevations shown on the drawings.

I. Site Conditions - The site soils encountered during preconstruction investigations can generally be described as an upper silty clay layer underlain by a fine sand layer. The fine sand layer is underlain by

a marl that will serve as the lower confining layer and key-in for the PRB. The Drawings present a cross section along the proposed PRB alignment and includes the field and laboratory data collected during the preconstruction investigations. **It should be noted that flowing or running sands and low soil strength values were encountered in the initial investigations at the site. The Contractor is responsible for performing any additional investigations and analyses required to provide a stable trench.**

J. Temporary Working Platform - The Contractor shall design the working platform as shown on the Drawings to ensure that a suitable head of slurry can be achieved to maintain trench stability. The working platform shall be constructed of the materials shown on the Drawings and specified in Section 02200 - Earthwork and Materials sufficient to accomodate the excavation and support equipment without affecting the integrity of the trench. A woven-mesh geosynthetic shall be used between the existing grade and the work platform material for strength on soft, existing soil (see Specification 02233).

K. It shall be the responsibility of the Contractor to adequately reroute stormwater and wastewater flow from the Outfall Ditch that is disrupted by trench construction. (Refer to Section 01390 Part 3.11).

3.02 IRON/SAND MIXING

A. The iron and sand shall be mixed into a uniform mixture using suitable equipment. Satisfactory means, incorporating weighing or metering, shall be incorporated to assure the proper ratio of sand to granular iron is maintained. Equipment such as concrete trucks, mobile concrete mixers, or stationary concrete mixers are suitable alternatives.

B. All equipment should be clean of foreign materials (e.g., concrete mix, soil, stones, etc.) and no water should be used during mixing. Addition of water is permitted after mixing.

C. The ratio of iron to sand is dependent on the actual excavated width of the trench and the required pure-iron width required for each panel as shown on the

Drawings. The width of the trench shall not exceed 5 times the equivalent pure-iron width required for each panel of the PRB. The iron/sand ratio shall be based on dry weights. The in-place iron/sand ratio shall not be less than 20% by volume. The iron/sand ratio shall be based on the actual bulk densities for the granular iron and for the sand. The actual bulk densities must be determined by the Contractor prior to construction and approved by the Owner's representative. The iron/sand ratio shall be verified on a dry weight basis based on the actual bulk density of the trench sand and a bulk density of 150 lbs/ft^3 for the granular iron.

D. The dry weights of sand and iron mixed in each batch shall be measured with approved methods and recorded.

E. The sand and iron shall be mixed to provide a uniform mixture. The uniformity of the mixture shall be determined with a magnetic iron separation test as described in Appendix A. The results of the magnetic separation test must be within 1% of the specified ratio. Test documentation shall be provided to the field engineer upon test completion.

F. The contractor should be made aware that mixing of iron and sand might cause the temperature of the mixture to increase by several tens of degrees due to friction of the granular particles and oxidation of the iron.

G. If the iron/sand mixing is to occur off site, the mixing contractor must be made aware of iron handling and storage issues (i.e. keeping it covered and dry). The iron/sand mixture must be stored in a manner similar to the granular iron.

H. During transport and handling, care should be taken to minimize vertical drop and vibration of the finished product to prevent separation/segregation.

I. The iron and sand mixture may be stored prior to installation based on the moisture content of the mixture as follows:

Mixture Moisture Content (Weight Percent)	Iron/Sand Mixture Maximum Recommended Storage Times (hr)
0 to 3	72
3 to 6	48
6 to 9	24
greater than 9	8

J. Quality control testing of the mixed sand and granular iron materials shall be conducted on every 100 cubic yards of material to verify compliance with the specifications.

3.03 TRENCH EXCAVATION

A. The Contractor shall provide sufficient numbers and types of excavating equipment to complete the PRB trench to the final depth and complete the project within the schedule. The equipment is to be in good condition with no hydraulic leaks and decontaminated prior to mobilization to site.

B. The plant for mixing the biopolymer slurry shall include the necessary equipment including a mixer/eductor capable of producing a suspension of polymer in water plus any pumps, valves, hoses, supply lines, and all other equipment as required to adequately mix, store, and supply fresh slurry to the trench. All slurry for use in the trench shall be prepared using a suitable mixer and no slurry is to be made in the trench.

C. The Contractor shall maintain the stability of the trench excavation. The Contractor shall control surcharges from excavation and backfill equipment, soil stockpiles, backfill stockpiles, and any other surcharge loads that may affect trench stability. The amount and quality of the slurry in the trench shall be maintained at a level sufficient to maintain trench stability. The contractor shall have sufficient personnel and equipment ready to raise the slurry level during construction and on call during nights and weekends. The quality of the slurry shall be maintained at all times until the backfill is in place.

D. Loose soil, debris, or cobbles that settle out of the slurry or fall to the bottom of the trench shall be removed prior to placement of backfill.

E. The following tolerances shall apply to the PRB trench dimensions and construction. The tolerances may vary from the designed values if approved by the Owner's representative.

1. The PRB shall be essentially vertical. The working platform and/or excavating equipment should be leveled to be plumb within 1% of vertical.

2. The PRB shall be excavated to a minimum of 1 foot below the top of the clay ("marl") surface as shown on the Drawings. The Contractor shall confirm the surface of the marl by observation of the excavated soil and the relative effort of the excavator. The surface shall also be verified by the Owner's Representative. The depth of the excavation shall be measured at least every 25 feet along the length of the trench.

3. The PRB shall be measured or surveyed to within 6 inches of the desired elevation.

4. The PRB trench shall follow the designed alignment within 1 foot of the designated centerline.

5. Construction will not be permitted when severe weather conditions or cold weather may compromise the quality of the work.

F. In the event the excavated trench is more than 6 inches greater than the design trench width, the contractor may increase the percentage of sand in an iron/sand mixture to provide an equivalent iron flow-through thickness. The calculation of the iron/sand ratio shall be based on the minimum measured trench width in the section of concern. The minimum percentage of iron in an iron/sand mixture shall be 20 percent by volume. Cost for additional supply and placement of iron and sand materials and disposal of excess soil shall be the responsibility of the Contractor.

3.04 BACKFILLING

A. The iron or iron/sand mixture shall be placed into the trench via a modified tremie tube with a minimum diameter of 8 inches or other approved method. The mixture shall be poured from the top of the tremie tube. The base of the tremie tube shall be maintained a distance of not more than 4 feet above the top of the placed mixture.

B. The Contractor shall provide a means of containing, if necessary, the excess bioslurry as backfilling proceeds.

C. Samples of the iron/sand backfill are to be collected from the approximate mid-depth of the trench every 50 feet along the trench, at a minimum. The iron fraction is to be determined using the magnetic separation test as outlined in Part 3.02 and Appendix A of this Section to verify compliance with the specifications.

D. A geotextile shall be placed atop the iron/sand mixture prior to placement of the backfill. The geotextile is to extend up the sides of the excavation a minimum of 1 foot. The geotextile shall meet the requirements of specification Section 02233 Part 2.02.

3.05 BIOSLURRY DEGRADATION AND TRENCH DEVELOPMENT

A. It is the responsibility of the Contractor to incorporate in the PRB during its installation adequate means to circulate the pore volume of the trench. The Contractor shall specify how this re-circulation will be performed and submit a slurry degradation plan outlining placement of recirculation wells, recirculation well screen intervals, and method of injecting or mixing breaker fluid evenly throughout the backfilled reactive media. The recirculation wells shall be left in place, functional and capped at ground surface after completion of construction.

Two criteria shall be used to determine whether the biopolymer slurry is adequately degraded during the development of the PRB. First, the viscosity of the broken slurry shall be measured in the field using a

Marsh Funnel. Before development of the PRB is allowed to stop, the viscosity of the recirculating fluid must equal the viscosity of water obtained in the field using the Marsh Funnel. The water to be sued for this comparison shall be from the water source used in mixing the biopolymer slurry.

If, in the opinion of the Owner's Representative, it appears that the bioslurry had not been properly degraded, the Contractor shall install 4 monitoring wells in the middle of the PRB spaced evenly along the length of the PRB. The Owner's Representative will perform hydraulic testing (Slug tests) on the reactive media to access to permeability of the reactive material. If it is determined that the permeability is impacted due to the presence to unbroken bioslurry, the Contractor shall take corrective measures.

B. After backfilling, the slurry shall be degraded to water and a minute amount of residual material. Approved slurry additives may be used as necessary to destroy the viscosity of the slurry. The total pore volume of the trench shall be extracted and circulated at least 3 times to ensure degradation of the slurry. Any excess broken slurry shall be encouraged to infiltrate into the subsurface or be removed from the trench prior to final backfilling.

3.06 DISPOSAL OF EXCAVATED MATERIAL

A. The Contractor shall construct a soil berm parallel to the work platform (and connecting with the work platform as required to contain runoff) at the location shown on the Drawings. The berm shall be constructed of general fill (see Section 02200). The Contractor shall stockpile excavated materials directly adjacent to the work platform on the upgradient side of the trench between the work platform and the soil berm.

B. The combined width of the work platform and the stockpiled excavated materials shall not exceed 120 feet as shown on the Drawings.

C. The Contractor shall be responsible for sampling the excavated soil and analyzing samples for trichloroethylene (TCE). Detection limits shall be

1 mg/kg (ppm) or lower. Excavated material with concentrations exceeding 7.8 mg/kg must be disposed off-site at a permitted facility or as otherwise directed by the Owner.

D. The elevation of the height of the excavated material stockpile shall not exceed the elevation of the portion of the work platform to which it is directly adjacent. The excavated material shall be placed and graded to promote positive drainage.

E. Upon completion of the PRB installation, the Contractor shall cover all the excavated material and all but 20 feet of the work platform above the centerline of the PRB with at least 6 inches of temporarily removed topsoil or general fill (see Section 02200) and then seed and fertilize per Section 02521. Final grade of the finished area shall be sloped away from the centerline of the access road. The uncovered work platform shall constitute an access road for future inspection and monitoring (see Section 02200 Part 3.06J).

F. The Contractor is responsible for disposing of excess stormwater that collects in the excavated material stockpile area. Accumulated stormwater shall not be allowed to exceed the top height of the soil berm or work platform or be allowed to adversely impact the integrity of the work platform. Impacted excess water shall be properly characterized for off-site disposal in accordance with all applicable regulations.

Appendix A - Magnetic Separation Testing Procedure

[Note: This test shall be completed by the Contractor.]

1. A 200 gram sample of the iron sand mixture is collected from the discharge of the mixing device (e.g. shoot of a concrete mixer)

2. The sample is weighed and the weight recorded. A suitable weighing device must be used.

3. The sample is dried and weighed and the weight recorded.

4. The sample is spread out on a suitable flat surface.

5. The magnet is covered in a material (such as a plastic bag) to allow the magnetic material to be separated from the magnet.

6. The magnet is passed over the sample to remove the magnetic fraction. Care must be taken to avoid trapping sand particles within the iron grains. The magnetic fraction is removed from the magnet and placed in a container.

7. At least three passes of the magnet over the sample are completed to ensure the magnetic fraction has been removed.

8. The magnetic and non-magnetic fractions are weighed. The total weight of the magnetic and non-magnetic fractions should be the same as the weight prior to separation.

9. The dry weight percent is determined by:

   Dry weight percent = weight of magnetic material/total weight of dry sample.

[END OF SECTION]

SECTION 02233

GEOSYNTHETICS

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, incidental materials, tools, supervision, transportation, and installation equipment necessary for the installation of geosynthetic materials (i.e., a geosynthetic clay liner [GCL] and geotextile to be installed as part of the restructured Outfall Ditch and above the iron/sand mixture in the trench) as specified herein, as shown on the Drawings and as otherwise required for a complete and functional installation. The Contractor shall provide and install all geosynthetic materials.

B. Be prepared to install the geosynthetic materials in conjunction with the earthwork and other components of this project.

1.02 RELATED SECTIONS

A. Section 01050 - Field Engineering

B. Section 01340 - Submittals

C. Section 01400 - Quality Control

D. Section 02200 - Earthwork and Materials

E. Section 02226 - Biopolymer Slurry Excavation and Iron Placement

1.03 REFERENCES

A. Latest version of the American Society for Testing and materials (ASTM) standards:

1. ASTM E 946 Water Absorption of Bentonite by Porous Plate Method

2. ASTM D 1987 Test Method for Biological Clogging of Geotextile or Soil/Geotextile Fillers

3. ASTM D 3786 Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and

Nonwoven Fabric-Diaphragm Bursting Strength Test Method

4. ASTM D 4354 Practice for Sampling of Geosynthetics for Testing

5. ASTM D 4355 Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)

6. ASTM D 4439 Terminology for Geosynthetics

7. ASTM D 4491 Standard Test Method for Water Permeability of Geotextiles by the Permittivity Method

8. ASTM D 4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles

9. ASTM D 4595 Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method

10. ASTM D 4632 Standard Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)

11. ASTM D 4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile

12. ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

13. ASTM D 4873 Guide for Identification, Storage, and Handling of Geotextiles

14. ASTM D 5084 Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible-Wall Permeameter

15. ASTM D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes

16. ASTM D 5261 Test Method for Measuring Mass Per Unit Area of Geotextiles

17. ASTM D 5993 Standard Test Method for Measuring Mass Per Unit of Geosynthetic Clay Liners

1.04 RESPONSIBILITIES OF PARTIES INVOLVED

A. The following information on qualifications for the Contractor, Geosynthetics Manufacturer(s) and/or Fabricator(s), and Installer shall be submitted to the Owner's Representative as specified in Part 1.06 herein. The Owner's Representative reserves the right to waive any portion of this submittal requirement.

B. Contractor:

1. Contract the Geosynthetics Manufacturer(s) and/or Fabricator(s) to supply geosynthetic materials.

2. Contract the Geosynthetics Installer, as a Subcontractor, if the Contractor is not a qualified installer.

3. Accept and retain full responsibility for installation and be responsible for any defects in the completed work.

4. Responsible for coordination of geosynthetic installation with earthwork activities.

C. Geosynthetic Manufacturer(s) and/or Fabricator(s):

1. Responsible for the production and delivery of geosynthetics, as specified herein.

2. Responsible for the production of geosynthetic materials and shall have sufficient production capacity and qualified personnel to meet the demands (e.g., quantity, production, schedule, quality control, etc.) of this project.

D. Geosynthetics Installer:

1. The installer of the geosynthetics shall be the Geosynthetic Installer and shall be responsible for field handling, storing, deploying, seaming, temporarily restraining (against wind), maintaining temporary cover, and other site aspects of the geosynthetic materials and other components of the project.

1.05 WARRANTY

A. The Geosynthetic Manufacturer(s) and/or Fabricator(s) shall confirm in writing, prior to shipment, that the material to be furnished will meet the intent of the specifications, and shall guarantee the material to be free of defects in materials and workmanship at the time of sale and against deterioration due to the effects of ozone, ultraviolet or other normal weathering on a pro-rata basis for a minimum of 5 years from the date of acceptance.

B. The Geosynthetic Manufacturer(s) and/or Fabricator(s) shall furnish a sample warranty for review and approval prior to shipment.

1.06 SUBMITTALS

A. Qualification Information

1. Submit the following information in writing describing each geosynthetic manufacturer and/or fabricator to be used on the project:

   a. Corporate background and information

   b. Reference project descriptions that show that the company has successfully manufactured and/or fabricated a minimum of five (5) million square feet of geosynthetic materials of the type(s) specified herein. The following information shall be provided for each reference project:

      i. name, location, and purpose of facility, and date of installation;

      ii. names of Owner, Project Manager, Engineer, General Contractor, Fabricator (if any), and Installer; and

2. Submit the following information in writing describing the geosynthetics installer to be used on the project:

   a. Corporate background and information.

   b. Copy of installer's letter of approval or license by the Geosynthetic Manufacturer and/or Fabricator.

c. Installation capabilities, including:

i. information on equipment and personnel;

ii. average daily production anticipated for this project;

iii. quality control procedures; and

iv. samples of field seams, a certified list of minimum values for seam properties, and the test method employed.

d. A list of at least five similar completed facilities for which the installer has successfully installed geosynthetics as specified herein. This experience shall be available, at a minimum, at the field crew foreman level. The following information shall be provided for each facility.

i. the name and purpose of the facility, its location, and dates of installation;

ii. the names of the Owner, Project Manager, Engineer, General Contractor, Geosynthetic Manufacturer and/or Fabricator, and the name of a contact at the facility who can discuss the project;

iii. name and qualifications of the installer's supervisor(s);

iv. surface area and type of installed geosynthetics;

e. Resumes of all personnel who will perform installation operations on this project.

f. Resume of the installation supervisor to be assigned to this project. The superintendent shall have supervised the installation of a minimum of 500,000 square feet of GCL, and geotextile.

B. Prior to transporting any geosynthetic materials to the site, the Contractor shall obtain from the Geosynthetic Manufacturer(s) and/or Fabricator(s), and have available for the Owner's Representative's inspection, the following documentation on the resin and/or raw materials used to manufacture the geosynthetics.

1. Copies of quality control certificates issued by the resin and/or raw materials supplier, including the production dates and the origin of the resin and/or raw materials used to manufacture the geosynthetic materials for the project.

2. Results of tests conducted by the Geosynthetic Manufacturer(s) and/or Fabricator to verify the quality of the resin used to manufacture the geosynthetic materials rolls assigned to the project and the origin of the resin and the quality control certificates issued by the resin supplier.

C. The Contractor will obtain from the Geosynthetic Manufacturer(s) and/or Fabricator(s), and have available for the Owner's Representative's inspection, the following documentation on geosynthetic materials roll production prior to the shipment of the geosynthetic rolls.

1. Manufacturing quality control certificates for each shift's production of geosynthetic materials, signed by responsible parties employed by the Geosynthetic Manufacturer(s) and/or Fabricator(s) (such as the production manager), and notarized.

2. The quality control certificate shall include:

a. roll numbers and identification;

b. sampling procedures; and

c. results of quality control tests, including description of the test methods used.

3. The Geosynthetics Manufacturer(s) and/or Fabricator(s) quality control tests to be performed, as specified in the Manufacturing Quality Control section for each geosynthetic product.

D. Certified test results from the Manufacturer and/or Fabricator on the stock of material to be delivered to the site showing the minimum acceptable and actual test values for the physical characteristics specified in Part 2.03 of this section for the GCL material shall be submitted to the Owner's Representative at least two weeks prior to the start of installation of the GCL.

E. During the installation, the Contractor shall provide the following information on a timely basis:

1. Quality control documentation

2. Continuous subgrade acceptance certificates, signed by the Installer, for each area to be covered by the geosynthetic materials.

F. A Certificate of Calibration less than 12 months old shall be submitted for the field tensiometer referenced in Part 3.05 - C.3 of this Section.

I. Upon completion of the installation, the warranty from the Installer as specified in Part 1.05 of this section shall be submitted by the Contractor.

1.07 CONSTRUCTION QUALITY ASSURANCE BY OWNER'S REPRESENTATIVE

A. The installation of the geosynthetic materials shall be monitored and tested by the Owner's Representative as outlined in Part 3 of this Section.

B. The Contractor shall be aware of the testing activities outlined herein and shall account for these testing activities in the installation schedule.

PART 2 PRODUCTS

2.01 GENERAL

A. Manufacturing Quality Control:

1. All geosynthetics shall be manufactured with quality control procedures that meet or exceed generally accepted industry standards.

2. The Contractor shall obtain from the geosynthetics manufacturer(s) periodic sample and test results for the geosynthetics to demonstrate that the materials and fabrication practices comply with the specifications. This quality control (QC) sampling and testing shall be performed at the Contractor's expense.

3. The Contractor shall not accept or install any geosynthetics which exhibit defects.

4. In the event that any geosynthetic sample does not comply with these specifications, it will result in rejection of the roll from which that sample was obtained. The Contractor shall replace any rejected rolls at no additional cost to the Owner.

5. If a geosynthetic sample fails to meet the quality control requirements of this Section, the Owner's Representative will require sampling and testing of each roll manufactured in the same lot, or at the same time, as the failing roll. Sampling and testing of rolls shall continue until the Contractor verifies, in writing, that each and every QC problem has been identified and corrected, and that all affected rolls have been replaced; all at no additional expense to the Owner.

6. Additional sampling and testing may be performed, at the Contractor's discretion and expense, to more rapidly identify any non-complying rolls and/or to qualify individual rolls.

7. Sampling shall, in general, be performed on sacrificial portions of the geosynthetic materials, such that repair is not required. The geosynthetics shall be sampled and tested at a minimum of once for every 20,000 square feet of that material delivered to the site to demonstrate that its properties conform to these specifications.

   a. Samples taken from stored rolls shall be taken across the entire width of the roll and shall not include the first wrapping or outer layer of the roll.

   b. Samples taken at the time of manufacturing may be obtained from the end of the roll.

   c. Unless otherwise specified, samples shall be 2 ft long by the roll width.

8. The Contractor shall comply with all certification and submittal requirements specified herein before.

B. Labeling:

1. Geosynthetic materials shall be supplied by the manufacturer(s) in rolls wrapped in relatively impermeable and opaque protective covers.

2. Geosynthetics and their protective covers shall be marked or tagged by the manufacturer(s) and/or fabricator(s) with the following information:

   a. manufacturer's name
   b. product identification
   c. date of manufacture
   d. lot number
   e. roll number
   f. roll dimensions
   g. thickness of material (if applicable)

C. Transportation:

1. Transportation of the geosynthetic materials shall be the responsibility of the Contractor. The Contractor shall be liable for any and all damages to these materials prior to and/or during transportation to the site.

D. Handling and Storage:

1. Handling, storage, and care of the geosynthetics prior to, during, and following installation at the site shall be the responsibility of the Contractor. The Contractor shall be liable for any and all damages to these materials prior to final acceptance of the geosynthetics system by the Owner.

2. Each geosynthetic material shall be protected, in accordance with its manufacturer's recommendations, from moisture, excessive heat or cold, puncture, or other potentially damaging or deleterious conditions. All geosynthetics shall be stored off the ground and out of direct sunlight. Any additional storage procedures recommended by the manufacturer(s) shall be the obligation of Contractor.

2.02 GEOTEXTILE PROPERTIES (WOVEN)

A. Geotextiles to be installed for separation/stabilization under rip-rap, under the work platform and access road, and between the iron/sand mix and overlying backfill shall be woven geotextiles having properties that comply with the required following property values:

Properties	Test Method	Units	Qualifier	Specified Value
Apparent Opening Size	ASTM D 4751	mm	MARV	0.425
Puncture Strength	ASTM D 4833	lbs	MARV	120
Tensile Strength	ASTM D 4595	lb/in	MARV	200
Mullen Burst	ASTM D 3786	psi	MARV	750

B. The Geotextile Manufacturer and/or Fabricator shall furnish materials whose "Minimum Average Roll Values", meet or exceed the properties specified in Part 2.02A, as well as a certification that the material properties meet or exceed the specified values. The geotextiles shall be stock products. The Geotextile Manufacturer and/or Fabricator shall not furnish products specifically manufactured to meet the specifications of this project unless authorized by the Owner's Representative.

C. In addition to the property values specified in Part 2.02A, the geotextiles shall:

1. Retain their structure during handling, placement, and long-term service.

2. Be capable of withstanding direct exposure to sunlight for a minimum of 30 days with no measurable deterioration.

D. Manufacturing Quality Control

1. Quality control testing shall be performed as specified in Part 2.01 of this section.

E. Acceptable Manufacturers/Fabricators:

1. Synthetic Industries

2. Engineer Approved Equal

2.03 GEOSYNTHETIC CLAY LINER

A. The geosynthetic clay liner (GCL) shall be Bentomat DN™ manufactured by Colloid Environmental Technologies Company and consist of a layer of sodium bentonite clay between two non-woven polypropylene geotextiles which are needlepunched together.

B. The GCL Manufacturer shall furnish GCLs having the following property values:

GCL Property Value Requirements

Properties	Test Method	Units	Qualifier	Specified Value
Clay Mass per Area	ASTM D 5993	psf	MARV	0.75 (at 0% moisture)
Grab Strength	ASTM D 4632	lbs/in	MARV	150
Permeability	ASTM D 5084	cm/sec	Nominal	5×10^{-9}

C. The GCL shall be manufactured by mechanically bonding the geotextiles using a continuous needlepunching process to punch fibers from the geotextiles through the bentonite clay layer to integrate then into the adjoining geotextile.

D. Acceptable Manufacturers/Fabricators:

1. Colloid Environmental Technologies Company (Bentomat DN)

2. Engineer Approved Equal

PART 3 INSTALLATION OF GEOSYNTHETICS

3.01 FAMILIARIZATION

A. Prior to implementing any of the work described in this Section, the Geosynthetic Installer and Contractor, if other than installer, shall become thoroughly familiar with all portions of the work falling within this section and related sections.

B. Inspection:

1. Prior to implementing any of the work in this Section, the Geosynthetic Installer(s) and Contractor shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the work of this Section may properly commence without adverse impact.

2. If the Geosynthetic Installer has any concerns regarding the installed work of other Sections, he shall notify the Contractor and the Owner's Representative in writing prior to the start of the work of this Section. Failure to inform the Contractor and the Owner's Representative in writing will be construed as the Geosynthetics Installer's acceptance of the related work of all other Sections.

3. If the Geosynthetic Installer intends to install geosynthetics between one hour before sunset and one hour after sunrise, he shall request approval from the Owner's Representative in writing prior to the start of the work. The Geosynthetic Installer shall indicate additional precautions which shall be taken during these installation hours.

3.02 EARTHWORK

A. Surface Preparation:

1. The surface of the subgrade layer/cushion soil layer shall be smooth, firm, unyielding, and free of vegetation, construction debris, sticks, sharp rocks, void spaces, abrupt elevation changes, and standing water. Immediately prior to GCL deployment, the subgrade shall be final graded to fill in all voids or cracks and then smooth-rolled to provide the best

practicable surface for the GCL. At the completion of this activity, no wheel ruts, footprints or other irregularities shall exist in the subgrade. Furthermore, all protrusions extending more than one-half inch from the surface shall either be removed, crushed or pushed into the surface with a smooth-drum compactor.

2. The Geosynthetic Installer shall provide continuous certification in writing that the surface on which the geosynthetics is being installed is acceptable and in accordance with the Drawings and Specifications. This certification of acceptance shall be given to the Contractor and the Owner's Representative prior to commencement of geosynthetics installation in the area under consideration.

3. Special care shall be taken to maintain the prepared soil surface throughout the geosynthetic installation work.

4. No geosynthetics shall be placed onto an area which has been softened by precipitation and/or condensation or which has cracked due to desiccation. The soil surface shall be observed daily to evaluate the effects of desiccation cracking and/or softening on the integrity of the soil surface.

5. Any damage to the soil surface caused by installation activities shall be repaired at the Contractor's expense.

3.03 QUALITY ASSURANCE TESTING BY OWNER'S REPRESENTATIVE

A. Geosynthetic Materials:

1. Samples of the GCL will be selected by the Owner's Representative and sent to a geosynthetics CQA Laboratory selected by the Owner's Representative for testing to ensure conformance with the requirements of this Section.

2. Samples will be selected by the Owner's Representative. Samples will be taken at a minimum frequency of one sample per 20,000 square feet with a minimum of one sample per lot.

3. The Owner's Representative may increase the frequency of sampling in the event that test results do not comply with the requirements of Part 2.03 of this

Section. The additional testing shall be performed at the expense of the Geosynthetics Manufacturer and/or Fabricator.

4. As a minimum, tests listed in Part 2.03A of this section shall be performed on the GCL.

5. Any geosynthetics that are not certified in accordance with Part 1.06B of this Section, or that conformance testing indicates do not comply with the associated parts of this Section, will not be approved for use by the Owner's Representative. The Geosynthetic Manufacturer and/or Fabricator shall replace the rejected material with new material, at no additional cost to the Owner.

3.04 GEOSYNTHETIC INSTALLATION

1. The Contractor shall take all reasonable and appropriate precautions to avoid damage to the geosynthetics during its installation or resulting from other construction activities.

2. Equipment shall not be driven directly on the geosynthetics. Unless otherwise directed in writing by the Owner's Representative, all equipment used to spread and compact the cover soil shall comply with the following requirements.

Maximum Allowable Equipment Ground Pressure (psi)	Initial Lift Thickness of Overlying Compacted Fill (ft)
<5	0.5
<10 but >5	1.5
<20 but >10	2.0
>20	3.0

3. In heavily trafficked areas and in areas trafficked by rubber tire vehicles, the Contractor shall maintain a minimum thickness of compacted structural fill overlying the membrane of 3 feet.

3.05 GEOTEXTILE INSTALLATION

A. General:

1. Geotextiles shall be handled in such a manner as to ensure they are not damaged in any way.

2. Precautions shall be taken to prevent damage to underlying layers during placement of the geotextile.

3. After unwrapping the geotextile from its opaque cover, the geotextile shall not be left exposed for a period in excess of 30 days unless a longer exposure period is approved by the Owner's Representative, based on a formal demonstration from the Contractor that the geotextile is stabilized against UV degradation for a period in excess of 30 days.

4. If white-colored geotextile is used, precautions shall be taken against "snow blindness" of personnel.

5. Care shall be taken during placement of geotextiles not to entrap stones, excessive dust, or moisture in the geotextile during placement.

6. In the presence of wind, all geotextiles shall be weighted with sand bags or the equivalent. Such sand bags shall be installed during placement and shall remain until replaced with protective soil cover or other components of the cover system.

7. The Contractor and Geosynthetics Installer shall examine the entire geotextile surface after installation to ensure that no potentially harmful foreign objects are present. Such foreign objects shall be removed and damaged geotextile shall be replaced.

B. Seams and Overlaps:

1. Geotextiles shall be overlapped a minimum of 12 inches.

C. Repair:

1. Any holes or tears in the geotextile shall be repaired as follows:

   a. A patch made from the same geotextile shall be placed with a minimum of 2 feet overlap in all

directions. Should any tear exceed 10 percent of the width of the roll, that roll shall be removed from the slope and replaced with new material.

2. Care shall be taken to remove any soil or other material which may have penetrated the torn geotextile.

3.06 GCL INSTALLATION

A. The Contractor shall handle GCL materials/rolls in such a manner as to ensure they are not damaged in any way. Contractor shall install GCL in accordance with Manufacture's recommendations.

B. All required cuts in GCLs shall be made using a utility knife with a sharp blade. Blades shall be changed frequently to maintain suitable sharpness for cutting. Care shall be exercised to prevent alteration or damage to any underlying material during cutting.

C. During placement, care shall be taken not to entrap stones, other potentially damaging objects, or moisture under the GCL.

D. Under no circumstance shall equipment or other potentially damaging objects be dragged across exposed surfaces of the GCL.

E. Any GCL roll, panel, or portion thereof which is damaged by stones or other objects, or installation activities shall be replaced by the Contractor at no additional cost to the Owner's Representative.

F. The Contractor shall not install GCL material on a saturated subgrade or on standing water. The GCL shall be installed in a way that prevents hydration prior to covering with soil.

G. The GCL shall not be installed during precipitation or other conditions that may cause hydration of the GCL.

H. Any and all GCL which becomes hydrated, as determined by the Owner's Representative, shall be replaced by the Contractor at no additional cost to the Owner.

I. All GCL that is placed during one day shall be covered with soil before the Contractor leaves the site at the end of that day.

J. Seams in GCL Panels:

1. Horizontal seams shall not be constructed on slopes steeper than 10 percent.

2. Seams shall be overlapped a minimum of 6 inches along the sides of adjacent panels and at least 1-foot at the ends.

3. Granular bentonite shall be placed on all seam surfaces.

4. Edges of GCLs shall be pulled taught to remove any wrinkles or creases in the seam areas.

5. Seams/overlaps shall not be nailed or stapled to the subgrade.

6. Horizontal seams shall be overlapped such that the upgradient GCL is placed over the downgradient GCL.

K. Repair:

1. Holes, tears, or hydrated areas in the GCL shall be repaired by closing or removing the damaged portion and placing a GCL patch over the hole. Such patch shall overlap all edges of the damaged area by 1 foot. Accessory clay material, to be obtained from the GCL manufacturer, shall be placed between the patch and the repaired area of the GCL.

2. Prior to installation of any patch, the Contractor shall remove any soil or other material which potentially may adversely affect the bond between the patch and the underlying GCL.

3. All repairs shall be made at no additional cost to the Owner.

4. Patch materials shall not be nailed or stapled to the subgrade.

3.07 PLACEMENT OF SOIL AND EARTHEN MATERIALS

A. The Contractor or Geosynthetics Installer shall place all soil and earthen materials in such a manner as to ensure that:

1. the final grades, elevation, and surface preparation are acceptable to the Engineer and the geosynthetics manufacturer and installer;

2. the geotextile and underlying cover materials are not damaged;

3. minimal slippage occurs between the GCL and geotextile(s) and underlying geosynthetics layers; and

4. excess tensile stresses are not produced in the GCL.

B. Equipment shall not be driven directly on the GCL. Unless otherwise specified by the Owner's Representative, all equipment operating on soil material overlying the GCL shall comply with the requirements specified in Part 3.04 of this section.

C. Cover soil placement shall occur from the bottom up. Alternate methods for placing the cover soil material shall not be allowed unless approved by the Owner's Representative. Soil placement in these areas shall provide a supporting buttress on which the uphill soil is supported as placement progresses up the slope.

3.08 PRODUCT PROTECTION

A. Use all means necessary to protect all prior work and materials and completed work of other Sections.

B. In the event of damage, the Contractor shall make all repairs and replacements necessary, to the approval of the Owner's Representative and at no additional cost to the Owner.

[END OF SECTION]

SECTION 02721

CORRUGATED METAL PIPE (CMP)

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The Contactor shall furnish all labor, materials, tools, supervision, transportation, installation equipment, and incidentals required for installation of corrugated metal pipe (CMP) and fittings as specified herein, as shown on the Drawings, and as necessary to complete the work.

B. The Contractor shall be prepared to install corrugated metal pipe in conjunction with the earthwork, construction of the access roads, and other activities.

C. Work includes procurement, installation, and connection of corrugated metal pipe culverts and preparation of bedding for culverts and backfilling around and over culverts.

1.02 RELATED SECTIONS

A. Section 02200 - Earthwork and Materials

PART 2 - MATERIALS

2.01 CORRUGATED METAL PIPES

A. The corrugated metal pipe shall be made from annular or helically corrugated steel and shall comply with the requirements for Type I or Type II pipe, respectively, as described in AASHTO M36. The pipe shall be of the diameter shown on the Drawings, and shall be fabricated from 14 gage sheet. The corrugations shall be 2-2/3 inch pitch by ½ inch depth. The end section of each pipe shall be annular (instead of helical) corrugations for use in connecting adjacent sections.

B. The corrugated metal pipe shall e manufactured using aluminum coated sheet conforming to AASHTO M274.

2.01 JOINTS AND APPURTENANCES

A. Adjacent sections of pipe shall be joined suing a coupling band fabricated from the same base metal as the pipe. The coupling bands shall conform to AASHTO M36.

B. Joints shall be made watertight using a gasket or O-ring conforming to AASHTO M36.

C. Bolts, nuts, and all other hardware shall be made of galvanized or cadmium plated steel.

D. All joining shall be performed in accordance with the CMP manufacturer's recommendations.

E. All CMP pipe appurtenances, shall be of like material to the pipe, meet the same performance criteria and be fastened consistent with CMP pipe manufacturer's recommendations.

2.03 PIPE BEDDING MATERIAL

A. Pipe Bedding material shall meet the requirements of the work platform material outlined in Section 02200.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Care shall be taken in loading, transporting, and unloading to prevent damage to the pipe, joints, and joint surfaces. Pipe sections and joint materials shall not be dropped during handling. The Contractor shall examine all pipe sections and joint materials before installation. The Contractor shall not install any piece that is defective. The Engineer may reject defective pipe and joints; defective pipe and joints shall be removed and replaced with new materials at no cost to Owner.

B. The surface on which the pipe bedding material is to be placed shall be constructed in accordance with the requirements of Section 02220 prior to pipe placement. A pipe bedding layer consisting of six inches, or as otherwise shown on the Drawings, of bedding material complying with Part 2.03 of this Section shall be placed over the prepared surface and compacted as specified in Section 02200.

C. Adjacent sections of the pipe shall be connected by butting the ends of adjacent sections together and joining the section with a coupling band. Joints shall be made watertight using a gasket or O-ring.

D. After placement of the pipe in a trench, pipe bedding shall be placed in the trench in six inch lifts. The pipe bedding shall be compacted using a vibrating plate, or other method approved by the Engineer, in a manner that compacts fill adjacent to the pipe to at least 90 percent of the material's maximum modified proctor density without damaging the pipe. The pipe bedding shall be placed and compacted to a height equal to or above the springline of the pipe.

E. After compaction of the pipe bedding material, the pipe shall be covered with structural fill material meeting the requirements of Section 02200.

F. The Contractor shall use all means necessary to protect all prior work and materials and completed work of other sections.

[END OF SECTION]

SECTION 02925

TOPSOILING AND SEEDING

PART 1 - GENERAL

Not Used

PART 2 - MATERIALS

Not Used

PART 3 - EXECUTION

3.01 PREPARATION OF GROUND SURFACE

A. Equipment, in good condition and approved by the Engineer, shall be provided for the proper preparation of the ground and for handling and placing all materials.

B. Prior to any excavation work, Contractor shall strip the top 4 inches of topsoil. The topsoil shall be stockpiled for later use. Topsoil shall be distributed uniformly and spread evenly to an average thickness of 6 inches, with a minimum thickness of 4 inches after natural settlement and light rolling. Topsoil shall be spread so that seeding can proceed with minimum additional soil preparation or tillage. Surface irregularities resulting from topsoiling or other operations shall be leveled to prevent depression.

   Topsoil shall not be placed when the subgrade is excessively wet, extremely dry, excessively compacted, or in a condition detrimental to the proposed planting or grading.

3.02 SEEDING

A. Contractor shall perform seeding as required to return all disturbed areas to a pre-construction condition. Seed mix shall be as recommended by the Mississippi Department of Agriculture and Commerce, and shall be approved by the Owner's Representative prior to placement.

[END OF SECTION]

SECTION 02931

EROSION CONTROL

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, installation equipment, and incidentals required to provide erosion control during and upon completion of construction as specified herein, as shown on the Drawings, and as necessary to complete the Work.

B. The work shall include temporary erosion control (i.e., until permanent erosion control features have been established) for those areas shown on the Drawings and all areas disturbed by the Contractor. Work involves installation of silt fences, hay bale barriers, erosion control and revegetation mats, etc.

1.02 RELATED SECTIONS

A. Section 01050 - Field Engineering

B. Section 01060 - Regulatory Requirements

C. Section 01110 - Environmental Protection

D. Section 02110 - Work Area Preparation

E. Section 02200 - Earthwork and Materials

F. Section 02925 - Fertilizing and Seeding

1.03 APPLICABLE REGULATIONS

A. The Contractor and any Subcontractors shall adhere to the applicable requirements of the approved Soil Erosion and Sedimentation Control Plan. The erosion and sedimentation control plan is made up of the approved drawings, engineering calculations and technical specifications, as well as the Construction Sequencing Plan (CSP) to be submitted by the contractor as described in Part 1.04.

B. The Contractor shall conduct site activities in accordance with all applicable regulatory requirements throughout the duration of the Work.

1.04 SUBMITTALS

A. Prepare and submit a CSP showing sequence of construction activities for review and approval by the Owner's Representative. This plan shall provide sufficient detail to allow evaluation of the use of temporary and permanent erosion and sedimentation controls (drainage swales, erosion control mat, silt fence, hay bales, vegetation, etc.), both as shown on the Drawings and as may be necessary to properly complete the Work.

The plan shall also address steps to be taken by the Contractor to meet required subgrade elevations (i.e., placement of fill material, if necessary) as required in Section 02200. The plan shall address specific erosion and sedimentation controls associated with any temporary stockpile areas and displaced trench slurry.

PART 2 - PRODUCTS

2.01 Silt Fencing

A. Silt fence shall conform to silt fence with woven wire fence backing per the most recent version of the Mississippi DOT Standard Specifications and shall be installed as indicated on the Drawings and as needed to control run-off.

B. Silt fence fabric shall be MS DOT approved fabric and shall be inert to chemicals commonly found in soil.

B. Silt fence fabric shall be resistant to mildew, rot, insects, and rodent attack.

C. Silt fence fabric shall be buried a minimum of 6-inches to prevent undermining.

D. Silt fence posts shall be 4-foot long wooden posts. Silt fence fabric and fence posts shall be factory assembled. Posts shall be attached to the silt fence at a maximum of 4 feet on center.

E. Silt fence fabric shall meet the following requirements (Mississippi DOT Type II geotextile):

Property	Test Method	Average Value
Tensile Strength, lb	ASTM D 4632	90 (min.)
Elongation, %	ASTM D 4632	50 (max.)
Bursting Strength, psi	ASTM 3786	175
Retained Strength when wet, %	ASTM D 4632, 3786, 4833	100
Permittivitity, s^{-1}	ASTM D 4491	0.05
A.O.S., mm	ASTM D 4751	0.60
Tensile Strength after UV exposure, %	ASTM D 4355	70

2.02 HAY BALE BARRIERS

A. Straw bales shall consist of undecayed firmly-packed straw of nominal size 14 inches by 18 inches by 36 inches as prepared by any standard hay-bailing machine and firmly bound by at least two separate circuits of rope or band material which will withstand weathering for a minimum of three months.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Silt fencing shall be installed as shown on the Drawings and as necessary to control runoff. Silt fence material shall be embedded at least 6 inches beneath ground surface and shall extend upward at least 28 inches above the ground surface. The top edge of the fabric shall be reinforced or shall have a one-inch tuck.

B. Where two ends of a silt fence join, the ends shall be overlapped a minimum of 36 inches.

C. Straw bales shall be installed in a row with ends tightly abutting. Each bale shall be embedded in

the soil a minimum of four inches and placed so that the bale bindings are oriented horizontally. Bales shall be securely anchored in place by wood stakes, steel fence pickets, or rebars driven through the bale. Stakes shall be driven flush with the bale and shall extend at least 12 inches beneath the bale into the underlying soil.

3.02 PROVISIONS FOR EROSION CONTROL DURING CONSTRUCTION

A. The Contractor shall implement and maintain erosion control measures around all areas to be disturbed prior to disturbing ground in the area, in accordance with the approved Drawings and Specifications and to the complete satisfaction of the Owner's Representative. The Owner's Representative will periodically observe erosion control structures to confirm that the Contractor is maintaining these features.

B. The Contractor shall plan to construct and put into use permanent erosion and sedimentation controls as early in the project as possible.

C. The Contractor shall take sufficient precautions during construction to minimize the run-off of polluting substances such as silt, clay, wastes, fuels, and oils into the surface waters of Mississippi.

D. Disposal of drainage from the site shall be at a location approved by the Owner's Representative. Drainage shall not be disposed of until silt and other sedimentary materials have been removed. Particular care shall be taken to prevent the discharge of unsuitable drainage to a water supply or surface water body.

E. The temporary silt fences and other erosion and sediment control features shall be maintained in the locations shown on the Drawings.

F. Accumulated silt and debris shall be removed by the Contractor from behind the face of the silt fence as needed to provide proper silt fence operation. Clogged or damaged fabric shall be replaced immediately.

G. Accumulated silt and debris and damaged or deteriorated hay bales shall be removed by the

Contractor as required by the Owner's Representative.

H. The Contractor shall check and repair erosion control measures as necessary, at least weekly, but also within 24 hours after a rainfall of 0.5 inches or more, and daily during wet weather. The Contractor shall notify the Owner's Representative of such checks and repairs so that the work can be inspected and recorded.

I. Erosion control measures will be maintained at all times by Contractor. If full implementation of the approved plan does not provide for effective erosion control, additional erosion and sediment control measures shall be implemented to control or treat the sediment source.

[END OF SECTION]

APPENDIX D

CONSTRUCTION QUALITY ASSURANCE PLAN

CONSTRUCTION QUALITY ASSURANCE PLAN
PERMEABLE REACTIVE BARRIER
GROUNDWATER INTERIM MEASURE

GRENADA MANUFACTURING, LLC
GRENADA, MISSISSIPPI

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1.0 GENERAL

1.1 INTRODUCTION

This Construction Quality Assurance Plan (CQAP) addresses Construction Quality Assurance (CQA) and Construction Quality Control (CQC) for the Permeable Reactive Barrier Groundwater Interim Measure (Interim Measure) for the Grenada Manufacturing Site located in Grenada, Mississippi. This CQAP is divided into the following sections:

- Section 1.0 - General
- Section 2.0 - Interim Measure CQA
- Section 3.0 - Documentation

1.2 DEFINITIONS RELATING TO CONSTRUCTION QUALITY ASSURANCE

1.2.1 Construction Quality Assurance and Construction Quality Control

In the context of this plan, CQA and CQC are defined as follows:

- CQA refers to means and actions employed by the CQA Consultant and testing laboratories to assess conformity of the Interim Measure with this CQAP, the design plans, and the technical specifications. CQA is provided by a party independent from the contractor for installation of the permeable reactive barrier (PRB), geocomposite clay liner (GCL) and riprap placement, and handling and disposal of excavated material that exceeds action levels.

- CQC refers to those actions taken by Suppliers, Contractors, or Owners so that the materials and the workmanship meet the requirements of the design plans and technical specifications.

1.3 PARTIES TO CONSTRUCTION QUALITY ASSURANCE

1.3.1 Description of the Parties

OWNER

The Owner is responsible for the Project Site. In this CQAP, the term "Owner" will refer specifically to ArvinMeritor Inc.

DESIGN ENGINEER

The Design Engineer (Brown and Caldwell) is responsible for the remedial design, design plans, technical specifications, and CQAP for the Interim Measure.

CQA CONSULTANT

The CQA Consultant (Brown and Caldwell) is a party independent from the Contractor, or Supplier who is responsible for managing, coordinating, and implementing the CQA activities so that the CQA activities are performed in accordance with the CQAP, design plans and technical specifications for the various systems. The CQA Consultant is responsible for documenting the Interim Measure Construction.

CONTRACTOR

The Specialty Contractor (Contractor) is responsible for the permeable reactive barrier wall installation and channel modifications. The Contractor will also be responsible for all other specialty work performed by his subcontractor(s).

SUPPLIER(S)

The Supplier(s) is responsible for the production of materials identified in the project design plans and technical specifications to be used for the implementation of the Interim Measure. Materials will include, but not be limited to, iron filings, slurry, backfill soil, geosynthetics, and riprap.

REMEDIAL TECHNOLOGY SPECIALIST

The Remedial Technology Specialist is a party independent from the Contractor or Supplier who is responsible for providing technical support to the CQA Consultant regarding the permeable reactive barrier technology.

TRANSPORTER

The Transporter transports the materials from the Supplier(s) to the Project Site and/or from the Project Site to disposal facilities.

SOILS CONSTRUCTION QUALITY ASSURANCE LABORATORY

The Soils CQA Laboratory is independent from the Contractor, Supplier, Transporter and Engineer. The Soils CQA Laboratory is responsible for conducting tests in the laboratory on samples of slurry from excavated areas, backfill (mixture of sand and iron filings), and riprap. The Soils CQA Laboratory will collect, handle and ship samples under CQA Consultant supervision. Sample locations will be designated by the CQA consultant or CQA managing engineer.

ANALYTICAL QUALITY ASSURANCE LABORATORY

The Analytical QA Laboratory is independent from the Contractor, Supplier, Transporter and Engineer. The Analytical QA Laboratory is responsible for conducting tests in the laboratory on excavated material. Excavated material will be tested for constituent exceedence levels. If those tests indicate target level exceedence, the soil will be treated and/or disposed off site; otherwise the soil will remain on site adjacent to the PRB. The Analytical QA Laboratory will collect, handle and ship samples under CQA Consultant supervision. Sample locations will be designated by the CQA consultant or CQA managing engineer.

GEOSYNTHETIC QUALITY ASSURANCE LABORATORY

The Geosynthetic QA Laboratory is independent from the Contractor, Supplier, Transporter and Engineer. The Geosynthetic QA Laboratory is responsible for conducting tests in the laboratory on geotextile fabric and GCL collected from Supplier(s) before and after delivery

to site. The CQA Consultant will collect, handle and ship samples to Geosynthetic QA Laboratory.

CERTIFIED SURVEYOR

The Certified Surveyor (Surveyor) is a party independent from Owner, Engineer, Contractor, Supplier, Transporter, or QA Lab. At a minimum, the Surveyor is responsible for establishing survey control points, providing control during construction, and providing final record documentation for all portions of the Work.

1.3.2 Qualifications of the Parties

The following qualifications are required of parties involved with the design and CQA of the Interim Measure.

DESIGN ENGINEER

The Design Engineer should be a qualified engineer, registered as a professional engineer in the State of Mississippi. The Design Engineer should have a history which demonstrates familiarity with the project system components, including design methods and procedures.

CONSTRUCTION QUALITY ASSURANCE CONSULTANT

The CQA Consultant should be a qualified engineer, registered as a professional engineer in the State of Mississippi, or his designated representative. The CQA Consultant should have demonstrated experience in working with CQAP preparation and implementation. The Design Engineer can also serve as the CQA Consultant.

CONTRACTOR

The Contractor and/or Subcontractor(s) installing the reactive barrier wall should demonstrate a history of at least six (6) similar successful completed projects. The Contractor and/or his Subcontractor(s) installing the geosynthetics for channel modifications should demonstrate a history of at least six (3) similar completed projects for which the Contractor and/or Subcontractor(s) have successfully installed a minimum of 10,000 square-feet of GCL, and 10,000 square-feet of geotextile.

SUPPLIER(S)

Supplier(s) will be able to provide construction materials and qualified personnel to meet the demands of the project. The Supplier will be required to submit certification(s) of specified materials required in the Interim Measure. The Geosynthetic Supplier should show that he has successfully manufactured and/or fabricated a minimum of five (5) million square feet of geosynthetic materials.

REMEDIAL TECHNOLOGY SPECIALIST

The Remedial Technology Specialist shall be the party responsible for the development and treatability testing of the permeable reactive barrier technology. This party shall have extensive experience in the design and construction of similar applications. EnviroMetal Technologies, Inc. holds a patent on the application of this process, provided technical support and treatability testing during the design, and shall act as the Remedial Technology Specialist.

TRANSPORTER

All personnel responsible for the loading/unloading and transport of soil, iron filings, slurry, riprap, and geosynthetic materials must be familiar with handling and transport constraints required by the Supplier and/or disposal facility.

SOILS CONSTRUCTION QUALITY ASSURANCE LABORATORY

The Soils CQA Laboratory will have experience in soil sampling collection in related projects, meet all regulatory requirements, and be familiar with ASTM and other applicable standards. The Soils CQA Laboratory will be capable of providing test results in accordance with the technical specifications.

ANALYTICAL QUALITY ASSURANCE LABORATORY

The Analytical QA Laboratory will have experience in soil sampling in related projects, meet all regulatory requirements, and be familiar with ASTM and other applicable standards. The Analytical QA Laboratory will be capable of providing test results in accordance with the technical specifications.

GEOSYNTHETIC QUALITY ASSURANCE LABORATORY

The Geosyntehtic QA Laboratory will have experience in geosynthetic testing in related projects, meet all regulatory requirements, and be familiar with ASTM and other applicable standards. The Geosynthetic QA Laboratory will be capable of providing test results in accordance with the technical specifications.

CERTIFYING SURVEYOR

The Certifying Surveyor is retained by the Contractor and is responsible, at a minimum, for establishing survey control points, providing control points during construction, and providing final record documentation for all portions of the Interim Measure. The Certifying Surveyor will be a registered Land Surveyor in the State of Mississippi and be employed by a well-established surveying firm incorporated (or otherwise registered) in the United States.

1.3.3 Duties of Construction Quality Assurance Personnel

In this CQAP, the roles of the CQA Consultant are described below:

- The Design Engineer and CQA Managing Engineer who operate from the offices of the CQA Consultant's firm and visit the Project Site periodically; and

- The CQA Site Manager and Monitors, who are located at the Project Site.

The duties of the CQA Personnel are as follows:

DESIGN ENGINEER

The Design Engineer will be responsible for the following:

- Provide guidance on key technical issues or problems;

- Provide general oversight of the implementation of CQAP program; and

- Responsible for overseeing and reviewing the final record of construction report of construction and certifying that the remedial action has been completed in satisfaction of the requirements of the Interim Measure.

CQA MANAGING ENGINEER

The CQA Managing Engineer will be responsible for the following:

- Administers the CQA program, i.e., assigns and manages CQA personnel, reviews field reports, and provides engineering review of CQA-related issues;

- Provides quality control of the CQA personnel, including Project Site visits;

- Reviews changes to the design plans and technical specifications;

- Familiarity with design plans and technical specifications;

- Familiarity with other site-specific documentation, including bid documents, proposed layouts, soils and groundwater investigation reports, and the manufacturer's and installer's literature;

- Attends the pre-construction and any resolution meeting when requested; and

- Reviews the QA/QC documentation generated throughout the Interim Measure Construction.

- Consults with and utilizes the technical assistance of the Remedial Technology Specialist as a resource throughout the construction process as needed. Technical assistance may include submittal review, consultation by telephone or meeting, one or more site visits, or other assistance, as appropriate, at the discretion of the CQA Managing Engineer.

CQA SITE MANAGER

The CQA Site Manager will be responsible for the following:

- Acts as the on-site (resident) representative of the CQA Consultant;
- Familiarizes CQA Monitor(s) with the Project Site and the CQA Requirements for the project;
- Manages the daily activities of the CQA Monitor(s);
- Attends CQA-related meetings, i.e., resolution, pre-construction, daily, weekly, etc.;
- Oversees the ongoing preparation of the Record Drawings;
- Assigns locations for testing and sampling;
- Reviews CQA Monitor(s)' daily reports and logs;
- Reports to the CQA Managing Engineer, and logs in his daily report any relevant observations reported to him by the CQA Monitor(s);
- Prepares his own daily report;
- Reviews and reports results of laboratory data obtained from the Contractor;
- Reports unresolved deviations from the CQAP, design plans and technical specifications to the CQA Managing Engineer;
- Assists the Design Engineer and CQA Managing Engineer with the preparation of the final report;

- Checks periodically materials for defects and variability and that conformance testing is carried out;

- Reviews the work of the Contractor's equipment operators to check that proper maintenance is undertaken to protect other portions of the work;

- Establishes additional test requirements beyond those in the technical specifications, when necessary;

- Reviews the Contractor's personnel qualifications for conformance with those pre-approved for work on the Project Site; and

- Assists CQA Managing Engineer with administration of construction contract and construction schedule.

- Reviews supplier, manufacturer, and installer certifications and documentation and makes appropriate recommendations;

CQA MONITOR(S)

The duties of the CQA Monitor(s) are assigned by the CQA Site Manager and include monitoring, logging, and/or documenting appropriate operations associated with the Interim Measure.

The duties to be performed, and operations to be monitored by the CQA Monitor(s) are as follows:

- Observation and documentation of materials delivery;

- Observation and documentation of soils, slurry mixture, sand/iron mixture, riprap, and geotextile stockpiling, placement, and hauling;

- Observation and documentation of clearing and grubbing, excavation, hauling, backfill, compaction, grading, and reseed operations;

- Observation and documentation of implementation of erosion and sediment control, temporary dam for water containment, rock filter berm, and excavation support systems;

- Observation and documentation of collection, transport, and treatment/disposal of water during dewatering activities;

- Observation and documentation of sample collection for laboratory testing;

- Observation and documentation of operations to protect completed areas;

- Observation of the soil surface for signs of excessive wetting, desiccation, or other disturbance prior to placement of any backfill material, GCL, geotextile, and riprap;

- Observation and documentation of scarification, rewetting, recompaction, or proof rolling required to repair deteriorated areas.

- Observation and documentation of material unloading and on-site transport and storage;

- Observation and documentation of material loading, on-site treatment (if any), off-site transport and disposal;

- On-site conformance to verify width and depth of excavated regions;

- On-site conformance to verify areas of GCL placement;

- Observation and documentation of geotextile and riprap placement operations;

- Observation and documentation of geotextile and riprap placement operations;
- Observation and documentation of repair operations;
- Observation and documentation of surveying operations;
- Documentation of any proposed modifications to the Interim Measure;
- Observation and documentation of any approved modifications to the Interim Measure;

In addition to these specific duties, CQA Monitors will take note of any on-site activities that could result in damage to the PRB, GCL, geotextile, and riprap or other components. Any observations so noted will be reported as soon as possible to the CQA Manager. The CQA Site Manager may also serve as a CQA monitor.

1.4 SCOPE OF CONSTRUCTION QUALITY ASSURANCE

The scope of this CQAP includes the CQA of the Interim Measure and related components. This CQAP does not address CQC design guidelines, installation specifications, or selection of materials or other components. The CQC of the selection, evaluation, and testing of the various components is included in the design plans and technical specifications.

The CQA Consultant will review the Contractor's submittals for each Interim Measure component. The CQA Consultant will transmit to the Contractor and Site CQA Manager each approved submittal. Submittals not approved will be noted and given to the Contractor for resubmittal. The Site CQA Manager will observe installation and field quality control testing during the implementation of the Interim Measure.

1.5 SITE AND PROJECT CONTROL

1.5.1 Project Coordination Meetings

To provide requisite quality during construction, clear, open channels of communication are essential. To that end, meetings are critical. The remainder of this section will describe meetings to be held throughout the project to provide coordination between parties.

1.5.1.1 Pre-Construction Meetings. A pre-construction meeting will be held at the Project Site. The meeting will be attended by the Owner, Design Engineer, the Contractor, Key Subcontractors, and the CQA Consultant, (i.e., the CQA Managing Engineer, the Site CQA Manager and the CQA Monitor(s)).

Specific topics considered for this meeting will include:

- Review the responsibilities of each party;
- Review lines of authority and communication;
- Establish work area security and safety protocol;
- Review methods for documenting, reporting, and distributing documents and reports;
- Communicate to parties any change/modification in the project documents;
- Review critical design details of the project;
- Establish protocols for testing;
- Establish protocols for handling deficiencies, repairs, and retesting;

- Review the time schedule for operations;

- Outline procedures for packaging and storing archive samples;

- Establish material staging locations; and

- Conduct a Project Site walk-around to review material staging locations, limits of work, and locations of sensitive areas.

The meeting will be documented by the CQA Consultant and a summary of the highlights of the meeting will be transmitted to the involved parties.

1.5.1.2 Progress Meetings. A weekly progress meeting will be held between the Site CQA Manager, the CQA Monitor(s), the Contractor, and other concerned parties. This meeting will discuss the current progress of the project, planned activities for the next week, and any new business or revisions to the work. The Site CQA Manager will log problems, decisions, or questions arising at this meeting in daily reports. Any matter requiring action which is raised in this meeting will be reported to the appropriate parties.

1.5.1.3 Problem or Work Deficiency Meeting. A special meeting will be held when and if a problem or deficiency is present or likely to occur. The meeting will be attended by the affected Contractor, the CQA Managing Engineer, the Site CQA Manager and CQA Monitor(s). If the problem requires a design modification, the Design Engineer should also be present. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- Define and discuss the problem or deficiency;
- Review alternative solutions; and
- Implement an action plan to resolve the problem or deficiency.

The meeting will be documented by the Site CQA Manager, and minutes will be transmitted to affected parties.

1.5.2 Project Control Visits

Periodically, the construction Project Site will be visited by the CQA Managing Engineer. This visit should be coordinated with a similar visit by the Design Engineer.

1.5.3 Project Closeout

A substantial completion construction inspection (walk-through), to be attended by the Owner, Contractor and the CQA Managing Engineer, will be conducted upon preliminary completion of construction to verify the completeness of the Interim Measure. A punch list identifying outstanding items, proposed activities for resolution thereof, and schedule for final completion. Following completion of the punch list items, a final inspection will be conducted to check that items have been addressed and that full demobilization has been completed. The final inspection will be attended by the Owner, CQA Consultant, United States Environmental Protection Agency (USEPA) and the Mississippi Department of Environmental Quality (MDEQ).

2.0 INTERIM MEASURE CQA

2.1 INTRODUCTION

This section of the CQAP addresses the components of Interim Measure and outlines the CQA Program to be implemented with regard to materials selection and evaluation, laboratory test requirements, field test requirements, and treatment of problems.

2.2 CERTIFICATION SURVEYING

Certification Surveying will be performed to provide documentation for record drawings; to verify quantities of soils and aggregates; to verify that the geometric requirements of the slurry wall, GCL, geotextiles and riprap placement, and backfill placement, and erosion and sediment control measures have been met. The Contractor will be responsible for the work and coordination with the Surveyor.

2.3 INTERIM MEASURE CONSTRUCTION QUALITY ASSURANCE

2.3.1 Permeable Reactive Barrier (PRB) and Geocomposite Clay Layer (GCL)

The Contractor will be responsible for excavation and hauling, shoring, placement of bioslurry, backfill with sand/iron mixture, compaction, topsoil, and reseeding to the grades, slopes, and elevations as shown in construction drawings and in accordance with design plans and technical specifications. During construction, the Contractor will be required to maintain the level of the slurry to within 1 foot of the ground (or work platform) surface and at least 9 feet above the top of groundwater in sections of the trench with final depths of 60 feet or less. In addition, the Contractor will be required to maintain a workable and stable slurry viscosity. The Contractor will also be required to install a GCL along the Outfall Ditch and across the PRB to 1) divert groundwater flow into the PRB and 2) avoid mixing of groundwater and stormwater flow. The CQA Consultant will check that the qualified land surveyor has verified lines and grades of the PRB and GCL following project completion.

Submittals for the PRB and GCL will be in accordance with the technical specifications. The CQA Consultant will review the Contractor's submittals for compliance with the design plans and technical specifications. Installation of the PRB will not start prior to approval of the submittals.

2.3.2 Erosion and Sediment Control

The Contractor will be responsible for implementation of erosion and sediment control measures that are in accordance with design plans and technical specifications. The Contractor will be required to install 1) Two temporary construction dams upstream of the PRB for temporary storage of water during PRB construction activities, 2) A silt fence along the banks of the ditch to prevent soil erosion, 3) Riprap and geotextile cover along the GCL to prevent scour, and 4) a rock filter berm at the confluence of the Outfall Ditch and Riverdale Creek for sediment control. The CQA Consultant will check that the qualified land surveyor has verified lines and grades of the impacted areas prior to start and finish of earthwork.

Submittals for the backfill materials will be in accordance with the design plans and technical specifications. The CQA Consultant will review the Contractor's submittals for compliance with the design plans and technical specifications. Erosion and sediment control measures shall not start prior to approval of the submittals.

2.3.3 Monitoring

The CQA Consultant will monitor and document the construction work during interim measure activities. The monitoring activities consist of the following:

- Review of test data developed by the Contractor to determine the material properties, moisture content and other physical properties of the sand/iron mixture, bioslurry, GCL, riprap, and backfill materials during processing, placement, and compaction;

- Monitoring the thickness of sand/iron mixture, GCL, backfill materials, and riprap materials as loosely placed and as compacted;

- Monitoring the action of the compaction and heavy hauling equipment on the construction surface (i.e., penetration, pumping, cracking, etc.);

- Monitoring the number of passes used to compact each layer;

- Monitoring the thickness and depth of the PRB;

- Checking for sharp debris/objects which may damage the geotextile

Testing used to evaluate the suitability or conformance of soil materials will be carried out by the Soils Construction QA Laboratory in accordance with as required by the design plans and technical specifications and the current versions of the corresponding American Society for Testing and Materials (ASTM) test procedures except as noted herein.

Conformance testing of soil materials obtained from on or off site borrow sources, shall be performed by the Contractor and submitted to the CQA Consultant to check that the soil meets the requirements of the design plans and technical specifications. Testing shall be performed by the Contractor on the soil materials prior to placement, and compaction or any relevant construction activity.

The CQA Consultant will examine test results and report any nonconformance to the Design Engineer. The Design Engineer shall accept or reject the materials based on the requirements of the design plans and technical specifications.

Field testing will also be performed on the soil materials by the Contractor as required by the design plans and technical specifications. Field tests will be conducted on samples taken from the soil materials during the course of the construction work.

The sampling frequency for the field tests are outlined in the design plans and technical specifications. The CQA Consultant will examine and check test results and report any non conformances.

2.4 GEOSYNTHETIC QUALITY ASSURANCE

The CQA Consultant will be responsible for checking that the grades, slopes and elevations for the subgrade material meet the requirements of the design plans and technical specifications before the placement of the geosynthetics. The geosynthetics shall be installed according to the design plans and technical specifications.

Submittals for the geosynthetics will be as identified in the design plans and technical specifications. The CQA Consultant will review the submittal for compliance with the design plans and technical specifications. Installation of the geosynthetics will not be started prior to approval of the submittals.

The CQA Consultant will monitor and document the construction work during geosynthetic activities. The monitoring activities consist of the following:

- Inspection of labels to confirm that the manufacturer labeled the rolls according to the design plans and technical specifications;
- Observation of handling procedures for materials;
- Observation of storage conditions for the geosynthetics;
- Observation of testing procedures;
- Observation of the placement of the geosynthetics to check for compliance with the design plans and technical specifications; and

- Observation of the repairs to the geosynthetics to check for compliance with the requirements of the design plans and technical specifications.

The geosynthetics supplier will provide the CQA Consultant with a list of guaranteed properties for the type of geosynthetics to be supplied. These properties will meet or exceed the properties outlined in the deisgn plans and technical specifications. The geosynthetics supplier will also provide the CQA Consultant with a written certification signed by a responsible party that the geosynthetics actually delivered have "minimum average values" properties which meet or exceed the guaranteed properties. The CQA Consultant will examine geosynthetics supplier's certification to ensure that the property values listed on the certification meet or exceed the design plans and technical specifications. Discrepancies will be reported to the Design Engineer. Upon delivery of the rolls of geosynthetics, the CQA Consultant will check that samples are removed and forwarded to the geosynthetics CQA Laboratory for conformance testing by the Contractor as required by the design plans and technical specifications.

Conformance test results will be reviewed by the CQA Consultant and non conformance will be reported to the Design Engineer. The Design Engineer shall accept or reject the material based on the requirements of the design plans and technical specifications.

2.5 DEFICIENCIES

If a defect is discovered in the PRB installation, the Site CQA Manager will immediately assess the extent and nature of the defect. If the defect is indicated by unsatisfactory quality control data or visual observation, the Site CQA Manager will assess the extent of deficient area by additional observations, a review of records, or other means that the Site CQA Manger deems appropriate. The Design Engineer will be notified immediately by the Site CQA Manager to resolve the problem. After assessing the extent and nature of a defect, the Site CQA Manger will notify the Owner and Contractor and schedule measures to correct the work deficiency.

3.0 DOCUMENTATION

3.1 INTRODUCTION

An effective CQAP depends largely on recognition of construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished by the documentation of quality assurance activities. The CQA Consultant will document that quality assurance requirements have been addressed and satisfied.

The Site CQA Manager will provide the CQA Managing Engineer with signed descriptive remarks, data sheets, and logs to check that monitoring activities have been carried out. The Site CQA Manager will also maintain at the Project Site a file of design plans and technical specifications, CQAP checklists, test procedures, daily logs, and other pertinent documents.

3.2 DAILY RECORD KEEPING

Standard reporting procedures will include preparation of a daily report which, at a minimum, will consist of: (a) field notes, including memoranda of meetings and/or discussions with the Contractor; (b) observation logs and testing data sheets; and (c) construction problem and solution data sheets. This information will be regularly submitted to and reviewed by the CQA Managing Engineer.

3.2.1 Memorandum of Discussion with Contractor and Subcontractors. A memorandum will be prepared, as needed, summarizing discussions between the Site CQA Manager and Contractor. The memorandum will include the following information:

- Date, project name, location, and other identification;
- Names of parties to discussion;
- Relevant subject matter or issues;
- Activities planned;
- Constraints or suggestions;

- Schedule; and
- Signature of the Site CQA Manager.

3.2.2 Daily Observation Report and Testing Data Sheets. Daily observation reports and testing data sheets will be prepared daily. These reports and data sheets will include the following information:

- An identifying sheet number for cross-referencing and document control;
- Date, project name, location, and other identification;
- Data on weather conditions;
- A reduced-scale Site Plan showing proposed work areas and test locations (if appropriate);
- Description and locations of ongoing construction;
- Equipment and personnel in each work area, including subcontractors;
- Descriptions and specific locations of areas, or units, or work being tested and/or observed and documented;
- Locations where tests and samples were taken;
- A summary of test results;
- Calibrations or recalibrations of test equipment, and actions taken as a result of recalibration;
- Off-site materials received, including quality control documentation;

- Decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality; and

- The Site CQA Manager or CQA Monitor's signature.

3.2.3 Construction Problem and Solution Data Sheets. Sheets describing special construction situations will be cross-referenced with specific daily observation reports and testing data sheets, and must include the following information, where available:

- An identifying sheet number for cross-referencing and document control;

- A description of the situation or deficiency;

- The location and probable cause of the situation or deficiency;

- How and when the situation or deficiency was found or located;

- Documentation of the response to the situation or deficiency;

- Final results of any responses;

- Any measures taken to prevent a similar situation from occurring in the future; and

- The signature of the Site CQA Manager and/or CQA Monitor, and signature of the CQA Managing Engineer indicating concurrence.

The CQA Managing Engineer will be made aware of any significant recurring non-conformance with design plans and technical specifications. The CQA Managing Engineer will then assess the cause of the non-conformance and recommend appropriate changes in design and/or technical specifications. When this type of evaluation is made, the results will be documented, and any revision to design and/or technical specifications will be approved by the Owner and CQA Managing Engineer.

A summary of supporting data sheets, along with final testing results and the Site CQA Manager's approval of the work, will be required upon completion of construction.

3.3 PHOTOGRAPHIC REPORTING DATA SHEETS

Photographic reporting data sheets, where used, will be cross-referenced with daily observation reports and testing data sheets and/or construction problem and solution data sheets.

These photographs will serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain color prints; negatives will also be stored in a separate file in chronological order. These records will be presented to the CQA Managing Engineer upon completion of the project.

3.4 DESIGN AND/OR TECHNICAL SPECIFICATION CHANGES

Design and/or technical specifications changes may be required during construction. In such cases, the Site CQA Manager will notify the CQA Managing Engineer.

Design and/or technical specifications changes will be made only with the written agreement of the CQA Managing Engineer and the Owner, and will take the form of an addendum to the design and/or specifications.

3.5 PROGRESS REPORTS

The Site CQA Manager will prepare a summary progress report each week, or at time intervals established at the pre-construction meeting. This report will include the following information:

- A unique identifying progress report number for cross-referencing and document control;

- The date, project name, location, and other information;
- A summary of work activities during progress reporting period;
- A summary of construction situations, deficiencies, and/or defects occurring during the progress reporting period;
- A summary of test results, failures, and retests, and
- The signature of the CQA personnel.

3.6 FINAL RECORD REPORT OF CONSTRUCTION

At the completion of the project work, the CQA Consultant will compile the CQA documentation and prepare a Final Record Report of Construction. This report will document that the work has been performed in compliance with the design plans and technical specifications and physical sampling and testing, except as properly authorized and implemented, and that the summary document provides the necessary supporting information.

This report will include: (a) summaries of construction activities; (b) weekly progress reports; (c) construction problems and solutions data sheets; (d) changes from design and/or technical specifications; (e) Record Drawings; and (f) a summary statement sealed and signed by a Professional Engineer registered in the State of Mississippi. The Record Drawings will include scale drawings depicting the location of the Interim Measure construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, system component construction, etc.). Surveying and base maps required for development of the Record Drawings will be developed by the Contractor's licensed land surveyor. These Record Drawings will be reviewed by the CQA Consultant and included as part of the Interim Measure CQA documentation.

3.7 STORAGE OF RECORDS

Handwritten data sheet originals, especially those containing signatures, should be stored by the Owner in a safe repository. Other reports may be stored by any standard method which will allow for easy access.

APPENDIX E

PERFORMANCE MONITORING PLAN

PERFORMANCE MONITORING PLAN
PERMEABLE REACTIVE BARRIER
GROUNDWATER INTERIM MEASURE

GRENADA MANUFACTURING SITE
GRENADA, MISSISSIPPI

Prepared for:

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April 2003

19071.001

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1.0 PURPOSE AND OBJECTIVES

The purpose of this Performance Monitoring Plan is to evaluate the effectiveness of various corrective measures in meeting target cleanup levels to be established for the site constituents of concern at the Grenada Manufacturing facility (Site) in Grenada, Mississippi (see Figure E-1). In addition, this Performance Monitoring Plan addresses requirements of the United States Environmental Protection Agency (USEPA) January 30, 2003 letter to Grenada Manufacturing. Two main issues are addressed in this Plan from USEPA's letter, 1) adequacy of the monitoring well network and 2) Confirmatory Sampling for off-site releases. USEPA's concern over the adequacy of the current monitoring well network is anticipated to be resolved through the addition of new monitoring wells. Second, this proposed Performance Monitoring Plan satisfies the requirements in the facility Hazardous and Solid Waste Amendments (HSWA) permit for Confirmatory Sampling.

The Performance Monitoring Plan addresses monitoring of both groundwater and surface water. Groundwater sampling will be performed to monitor the effectiveness of interim and final corrective measures, and plume migration downgradient of the sources identified at the Site. The key purpose of the surface water sampling is to monitor the effectiveness of the various corrective measures at preventing off-site migration of impacted groundwater to surface water.

Initially, groundwater and surface water will be monitored primarily to assess the effectiveness of the permeable reactive barrier (PRB) groundwater interim measure. To accomplish this, samples will be collected before, during, and after the PRB installation. The sampling will determine short and long-term effectiveness of the PRB, in addition to other previous and on-going interim measures at the Site. Groundwater sampling will be performed in accordance with the approved Quality Assurance Project Plan (Brown and Caldwell, November 2000), which will be referred to herein as the QAPP. Surface water sampling will be performed in accordance with the procedures outlined in this document. The ongoing interim measure operations, such as non-aqueous phase liquid (NAPL) recovery, will be continued during and after the PRB construction. However, long-term

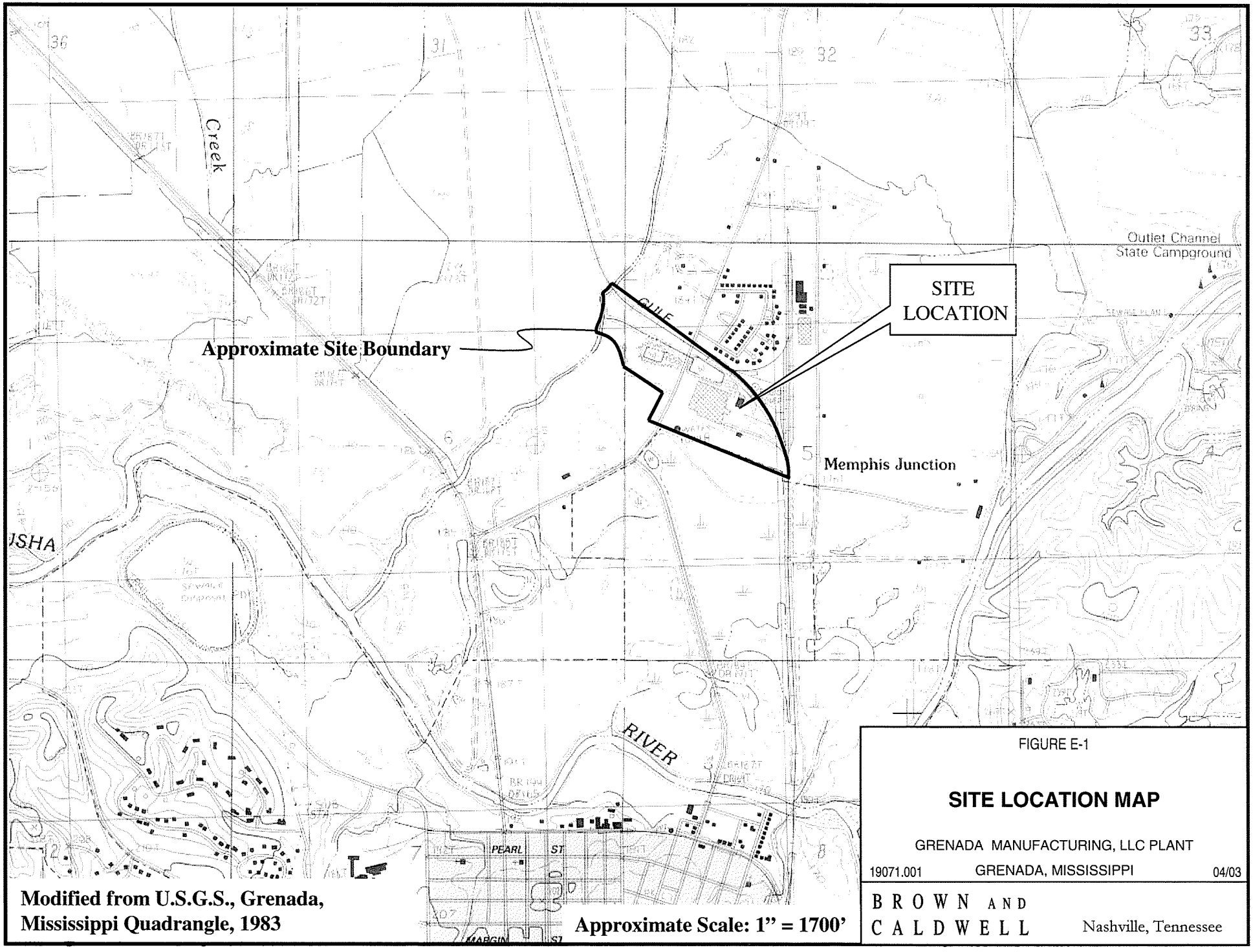


FIGURE E-1

SITE LOCATION MAP

GRENADA MANUFACTURING, LLC PLANT

19071.001 GRENADA, MISSISSIPPI 04/03

BROWN AND CALDWELL Nashville, Tennessee

NAPL recovery will be evaluated as part of the Corrective Measures Study (CMS) for the Site. Specific objectives of this Performance Monitoring Plan are as follows:

- Conduct a site-wide ("baseline") sampling event to include groundwater and surface water.
- Evaluate short-term effectiveness of the PRB by comparison of upgradient groundwater sampling and sampling of wells in the PRB.
- Evaluate long-term effectiveness of the PRB by comparison of upgradient groundwater sampling, sampling of wells in the PRB, and sampling of downgradient groundwater, as well as surface water sampling in Riverdale Creek.
- Establish a long-term sampling schedule for the Site.
- Identify surface water and groundwater sampling locations and frequency at which these locations are to be sampled.
- Identify constituents to be analyzed in surface water and groundwater samples.
- Install additional groundwater monitoring wells in the vicinity of the PRB to supplement the existing monitoring network.
- Measure and evaluate groundwater elevation data in order to confirm the groundwater seepage velocity and monitor groundwater flow direction.

2.0 SITE CONDITIONS

2.1 SITE GEOLOGY AND HYDROGEOLOGY

Based on the data collected from the RI and a recent focused geotechnical investigation, the site is determined to be underlain at the surface by approximately 8 to 15 feet of clayey silt or silty clay. Underlying this zone is a saturated fine to medium grained sand with varying amounts of silt with a thickness ranging from approximately 30 to 50 feet, which is referred to as the Upper Aquifer. Within the vicinity of the Main Plant, this sand unit is bisected by a discontinuous clay unit observed at a depth between 20 and 30 feet. This clay unit is not observed in the western portion of the site or in vicinity of the PRB. At the base of the sand unit, a thinly bedded, slightly sandy, clayey silt was encountered at depths ranging from 47 to 60 feet below the ground surface, which is referred to as the lower aquitard. This layer is approximately 16 feet thick and has been previously identified as marl and it exhibited much higher blow count values than the soil encountered above it. Below this sand unit is another sand unit, designated as the Lower Aquifer.

The Upper and Lower Aquifers are the primary horizontal transport pathways for the site. Groundwater within these units is generally under semi-confined conditions. Groundwater within the Upper Aquifer moves to the northwest toward and discharges to Riverdale Creek, which is believed to be in direct communication with the Upper Aquifer. The Upper Aquifer is confined above by the surfical confining unit and below by the lower clay unit. A significant upward gradient exists between the Upper and Lower Aquifers, thereby precluding the transport of constituents of concern to the Lower Aquifer from the site.

The site geology and hydrogeology is expanded upon in the RI Report (Brown and Caldwell January 1994). Refer to Section 4.9 of the RI Report for more information on site and regional geology and hydrogeology.

2.2 CURRENT GROUNDWATER QUALITY

Groundwater samples have been collected from a number of monitoring wells and Geoprobe® samples to assess the groundwater quality of the shallow aquifer. Various volatile organic compounds (VOCs) were detected in groundwater at the Site with trichloroethylene (TCE) and its daughter products [i.e., cis-1,2-dichloroethene (1,2-DCE), 1,1-dichloroethene (1,1-DCE), and vinyl chloride (VC)], arsenic, lead, and chromium being the constituents of greatest concern. The extent of the TCE plume and its daughter products, as of October 2000, is shown in Attachment A of the RCRA Facility Investigation (RFI) Report (Brown and Caldwell, October 2001). These plumes generally encompass the Main Plant area and extend downgradient and ultimately discharge to Riverdale Creek. Tetrachloroethene was observed, at relatively lower concentrations, in areas under the Sludge Lagoon, Equalization Lagoon, On-Site Landfill, and in the vicinity of GP-4 near Riverdale Creek. In general, the other constituents of concern, such as toluene, 1,1,2-trichloroethane (TCA), and 1,2 dichloroethane (DCA), appear in the vicinity of the Main Plant area. The plumes for the inorganics appear to be limited to the area from the Main Plant to the On-site Landfill; however, they do not appear to extend to Riverdale Creek. Additionally, sporadic detections of bis(2-ethyl-hexyl) phthalate have also been observed at isolated locations. Based on this historic data, the primary constituents of concern (particularly in the vicinity of Riverdale Creek) are TCE and its degradation products. A complete description of the extent of VOCs and other constituents of concern in the groundwater is discussed in the RFI Report (Brown and Caldwell, 2001).

3.0 GROUNDWATER MONITORING

Groundwater monitoring will consist of three components: groundwater quality, piezometric surface, and bioparameters. The groundwater quality will be measured in order to monitor the effectiveness of the various corrective measures. Piezometric surface monitoring will be used to monitor groundwater flow direction and confirm the seepage velocity through the aquifer and the relationship between the Upper Aquifer and Riverdale Creek. Seepage velocity downgradient of the PRB will determine the effective retention time of constituents in groundwater between the PRB and Riverdale Creek. The groundwater will also be analyzed for bioparameters in order to determine the extent to which natural attenuation is occurring.

In general, groundwater monitoring will consist of sampling and analysis of VOCs identified in Table 2-1 of the RFI Report (Brown and Caldwell, 2001), metals (including total and hexavalent chromium), and bioparameters. The list of parameters are provided herein as Table E-1.

3.1 INSTALLATION OF NEW MONITORING WELLS

Fourteen new monitoring wells will be installed to supplement the existing monitoring network. The purpose of the additional monitoring wells is to provide supplemental groundwater quality and groundwater elevation monitoring in areas upgradient to, within, and downgradient of the PRB. The wells will generally be installed as well couplets to allow for the monitoring of the upper and lower portions of the Upper Aquifer. The following provides the specific objectives of the individual well placement:

- Two monitoring well couplets (MW-41/MW-42 and MW-47/MW-48) will be installed downgradient of the PRB to monitor downgradient water quality. These wells will also allow for the measurement of groundwater elevations to evaluate the groundwater flow relationship between the Upper Aquifer and Riverdale Creek.

Table E-1

List of Constituents for Groundwater and Surface Water Monitoring

Grenada Manufacturing Site
Grenada, Mississippi

Constituents of Concern

METALS

Arsenic
Chromium (hexavalent and total)
Lead

VOCs

Trichloroethene (TCE)
cis-1,2-Dichloroethene (Cis-1,2-DCE)
Vinyl Chloride (VC)
Benzene
1,2-Dichloroethane
1,1,-Dichloroethene
1,1,2-Trichloroethane
Tetrachloroethene
Toluene

SVOCs

Bis(2-ethyl-hexyl)Phthalate

LAB BIOPARAMETERS

Methane, Ethane, Ethene
Iron
Manganese
Alkalinity Bicarbonate (as $CaCO_3$)
Alkalinity Carbonate (as $CaCO_3$)
Ammonia (as Nitrogen)
Nitrate + Nitrite (as Nitrogen)
Total Phosphorous
Sulfate
Total Kljedar Nitrogen
Volatile Fatty Acids
Chloride

Table E-1 (Continued)

List of Constituents for Groundwater and Surface Water Monitoring

Grenada Manufacturing Site
Grenada, Mississippi

Constituents of Concern
FIELD BIOPARAMETERS
Specific Conductivity
Temperature
Dissolved Oxygen
Manganese
Iron
Carbon Dioxide
Hydrogen Sulfide
pH
Oxidation-Reduction Potential (ORP)

- Two monitoring well couplets (MW-43/MW-44 and MW-49/MW-50) will be installed within the upper and lower portion of the PRB to monitor wall performance.

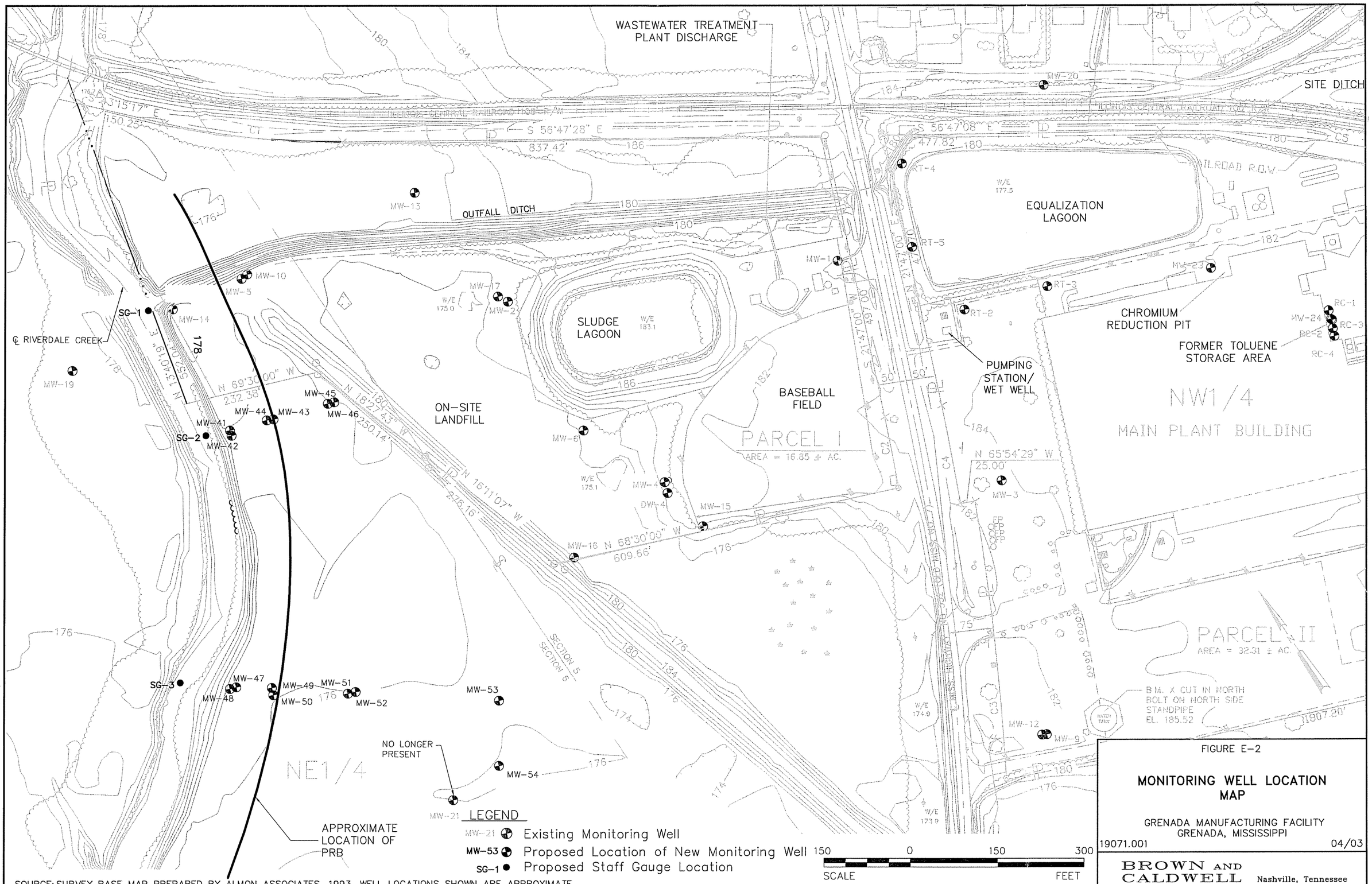
- Two monitoring well couplets (MW-45/MW-46 and MW-51/MW-52) will be installed to supplement groundwater quality and groundwater elevation monitoring upgradient of the PRB.

- One shallow monitoring well (MW-53) will be installed to monitor the side-gradient extent of the plume in the upper portion of the Upper Aquifer. The location of this well corresponds to the side-gradient extent of the plume in the upper portion of the Upper Aquifer as of the October 2000 groundwater sampling event.

- One deep monitoring well (MW-54) will be installed to monitor the side-gradient extent of the plume in the lower portion of the Upper Aquifer. The location of this well corresponds to the side-gradient extent of the plume in the lower portion of the Upper Aquifer as of the October 2000 groundwater sampling event.

The proposed new monitoring wells will be assigned the designation of MW-41 through MW-54. The proposed locations of these wells are depicted in Figure E-2. The ten upgradient and downgradient wells will be drilled using the hollow-stemmed augers method. The monitoring wells placed within the PRB will be drilled using the sonic drilling method. The drilling methods, well installation methods, and development methods are described below.

3.1.1 Hollow Stemmed Auger Method. Ten wells will be installed using the hollow stem auger method. These wells include: MW-41, MW-42, MW-45, MW-46, MW-47, MW-48, MW-51, MW-52, MW-53, and MW-54. Six of these wells (MW-41, MW-42, MW-47, MW-48, MW-53, and MW-54) will be installed as soon as practicable after approval of this Performance Monitoring Plan. The other four wells are located in close proximity to the PRB and, therefore, will be installed after construction of the PRB when the four wells in the wall will be installed (see Section 3.1.2).



SOURCE: SURVEY BASE MAP PREPARED BY ALMON ASSOCIATES, 1993. WELL LOCATIONS SHOWN ARE APPROXIMATE.

FIGURE E-2

MONITORING WELL LOCATION MAP

GRENADA MANUFACTURING FACILITY
GRENADA, MISSISSIPPI

19071.001 04/03

BROWN AND CALDWELL Nashville, Tennessee

The shallow monitoring wells will be completed in the uppermost portion of the Upper Aquifer to a depth of approximately 25 feet. Deep monitoring wells will be installed at the base of the Upper Aquifer. The anticipated depths of these wells will range from a depth of 45 to 55 feet. Initially, for each well, a soil boring will be advanced to the designated depth using 4¼-inch ID hollow stem augers. Soil samples will be collected for physical descriptions from each boring using a 2-inch diameter split-spoon sampler, driven with a 140-pound hammer, generally following the procedures of the Standard Penetration Test (ASTM Method D-1586). The soil samples will be collected at five-foot intervals and examined and classified in the field upon collection in accordance with a system modified after Burmister (1958). Because the deep monitoring well borings are adjacent to shallow borings, soil samples will only be collected below the base of the adjacent shallow monitoring well boring.

Upon completion of each shallow and deep boring (a depth of 25 feet for the shallow wells and a depth ranging from 45 to 55 feet for the deep wells), a monitoring well will be constructed through the augers with 2-inch ID PVC Schedule 40 well casing. A 10-feet length of machine slotted 2-inch diameter 0.010-inch slot Schedule 40 PVC well screen will be placed at the base of each boring. Schedule 40 PVC riser pipe will be installed from the screen to the ground surface to approximately 2 feet above the ground surface.

Clean washed silica sand, appropriately sized for the screen, will be used to fill the annulus from the base of the screen up to 2 to 3 feet above the top of the screen while retracting the augers. A bentonite seal, 2 to 3 feet in thickness, will be placed above the sand, followed by cement/bentonite grout (Type I Portland with 2 percent to 4 percent bentonite by weight; e.g., 14 to 15 pounds/gallon) to the surface.

3.1.2 Sonic Method. The monitoring wells to be installed within the PRB (MW-43, MW-44, MW-49, and MW-50) will be drilled using the sonic drilling method. This drilling method will enhance the ability to ensure that the wells are installed near vertical and within the appropriate vertical and horizontal section of the PRB. Both shallow and deep wells are to be installed within one month of PRB construction. The sonic drilling method employs a

casing advance system which advances a 5 7/8 inch OD casing. Sand/iron samples will be collected continuously to the base of the boring using the continuous sampler from within the drive casing. Upon completion of each shallow and deep boring (a depth of 25 feet for the shallow wells and a depth ranging from 45 to 55 feet for the deep wells) a monitoring well will be constructed through the drive casing with 2-inch ID PVC Schedule 40 well casing. A 5-feet length of machine slotted 2-inch diameter 0.010-inch slot Schedule 40 PVC well screen will be placed at the base of each boring. Schedule 40 PVC riser pipe will be installed from the screen to the ground surface to approximately 2 feet above the ground surface.

An appropriate sand/iron mix will be used to fill the annular space from the base of the boring to at least 1 foot above the top of the PRB. The ratio of sand/iron will be based on the final PRB design parameters for the associated wall section. That is, the sand/iron mix will match that of the surrounding wall. A bentonite seal, 2 to 3 feet in thickness, will be placed above the sand/iron, followed by cement/bentonite grout (Type I Portland with 2 percent to 4 percent bentonite by weight; e.g., 14 to 15 pounds/gallon) to the surface.

3.1.3 Surface Completions, Records, and Developments. Each monitoring well will be secured with an above grade steel protective casing with locking cap. Additionally, each well will be completed with a 3-feet by 3-feet concrete pad with bumper post in each of the four corners. Upon completion of the monitoring wells, each will be developed by surging and purging with a portable submersible pump (Grunfos Ready-Flo®) with the intent of making the discharge visually clear and free of suspended material. A minimum of five well volumes will be removed unless the well will be completely evacuated and/or slow to recharge.

3.2 GROUNDWATER ELEVATION MONITORING

Groundwater elevations will be collected from selected site wells to develop a potentiometric surface map within the Upper Aquifer. Groundwater elevations will also be used to evaluate hydraulic gradients within the vicinity of Riverdale Creek. Additionally, staff gages will be installed at three locations within Riverdale Creek (see Figure E-2). The surface water and groundwater elevations will be used to evaluate the groundwater flow relationship between

the Upper Aquifer and Riverdale Creek. The Upper Aquifer piezometric surface will also be used to confirm the seepage velocity within the vicinity of the PRB. Determining these flow characteristics will aid in the evaluation of the PRB performance and to ensure the successful capture of the plume and thereby prevent off-site migration beyond Riverdale Creek. Procedures for measuring the groundwater and surface water elevations are provided in Section 9.0 of the approved QAPP.

3.3 MONITORING WELL AND STAFF GAUGE SURVEY

Each newly installed monitoring well and staff gauge will be surveyed for horizontal and vertical control by a surveyor licensed in the State of Mississippi. Horizontal location of each well and staff gauge will be surveyed to the nearest 0.1 foot and will be referenced to the State Plane coordinate system. A vertical reference point will be selected for the wells and staff gauges. The vertical reference point for the wells will be the top of the 2-inch PVC riser and the vertical reference point for the staff gauges will be designated in the field. The reference points will be surveyed to the nearest 0.01 foot and will be referenced to National Geodetic Vertical Datum (NGVD) 83.

3.4 SITE-WIDE GROUNDWATER QUALITY MONITORING

The methods and procedures that will be followed to conduct the groundwater sampling are presented in Section 9.0 through Section 20.0 of the approved QAPP (Brown and Caldwell, November 2000), and include field sampling, laboratory analysis, sample chain of custody, quality control, and personnel certification. Decontamination of sampling equipment and proper handling of investigation-derived waste (IDW) are discussed in Section 6.0 of this Performance Monitoring Plan.

A site-wide groundwater sampling event will be conducted as soon as practicable upon the approval of this document by the USEPA. After the initial sampling or "baseline" event, the monitoring wells will be sampled biennially (once every two years) on a site-wide basis. The site-wide sampling events will supplement the existing groundwater quality database for the Site and also serve to monitor on-going interim and final corrective measures at the Site.

These samples will be analyzed for the entire list of Site constituents of concern. The monitoring wells and analytical parameters included in this site-wide sampling program are presented in Table E-2. The locations of the monitoring wells are presented on Figure E-2.

In addition, these wells will be sampled for field analysis of indicator parameters for biodegradation of VOCs to include carbon dioxide, iron (II), manganese (II), hydrogen sulfide, and dissolved oxygen. Bioparameters are measures or indicators of conditions favorable to natural attenuation and/or the extent to which natural attenuation (reductive dechlorination) is occurring. By evaluating these parameters and comparing the relative values obtained at different locations within the aquifer, insight can be gained with respect to whether conditions are continuing to be supportive of reductive dechlorination, as well as obtaining direct and indirect evidence that reductive dechlorination is occurring. By following these parameters over time, potential changes in conditions that affect reductive dechlorination can be identified.

3.5 PRB PERFORMANCE MONITORING

Three new upgradient shallow and three new upgradient deep aquifer monitoring wells, and two downgradient shallow and two downgradient deep aquifer monitoring wells will be installed to monitor the effectiveness of the PRB. In addition, two new shallow and two new deep monitoring wells will be installed in the PRB. These fourteen (14) new monitoring wells, along with three of the existing wells (MW-5, MW-10, and MW-14), will be used to monitor the performance of the PRB. The other existing monitoring wells will serve as the long-term monitoring network for the Site, but will not be used to monitor the performance of the PRB. Monitoring groundwater quality on the upgradient side of the PRB will provide information concerning expected demands on the PRB, as well as changes in aquifer flow and environmental conditions. Monitoring on the downgradient side will provide a measurement of the extent to which natural attenuation is being protective of Riverdale Creek and reducing contaminant concentrations in that portion of the aquifer. The proposed monitoring wells downgradient will serve as direct measure for natural attenuation and PRB effectiveness.

Table E-2

Biennial Site-Wide Groundwater Sampling

Grenada Manufacturing Site
Grenada, Mississippi

SAMPLE LOCATION	PARAMETERS		SHALLOW (S)/DEEP (D)
MW - 1	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 2	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 3	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 4	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 5	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 6	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 7	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 8	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 9	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 10	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D
MW - 11	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D
MW - 12	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D
MW - 13	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 14	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 15	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 16	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 17	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D
MW - 20	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 23	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 24	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 25	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
RT - 1	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
RT - 2	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
RT - 3	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
RT - 4	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S

Table E-2

Biennial Site-Wide Groundwater Sampling

Grenada Manufacturing Site
Grenada, Mississippi

SAMPLE LOCATION	PARAMETERS		SHALLOW (S)/DEEP (D)
RT - 5	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 41	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 42	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D
MW - 43	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 44	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D
MW - 45	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 46	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D
MW - 47	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 48	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D
MW - 49	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 50	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D
MW - 51	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 52	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D
MW - 53	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	S
MW - 54	Metals, VOCs, SVOCs, Lab and Field Bioparameters	(see Table E-1)	D

Monitoring wells that are part of the performance monitoring for the PRB will be sampled and analyzed initially within 1 month of completion of the PRB installation and semi-annually afterwards. The average groundwater flow velocity in the vicinity of the PRB is about 0.72 feet/day. The distance from the PRB to Riverdale Creek is about 70 to 120 feet. Therefore, groundwater will require at least 100 days to travel from the wall to the creek. In addition, before a significant change in constituent concentration can be observed in the vicinity of the creek, treated groundwater will need to pass through the impacted area 2 to 3 times. As such, a semi-annual sampling frequency is appropriate. Table E-3 presents the specific monitoring wells and the list of parameters for this monitoring program. Dissolved organic carbon will be analyzed to monitor the disappearance (breakdown) of the bioslurry. Therefore, this parameter will only be measured during the first two sampling events.

Table E-3

Semi-Annual Groundwater Sampling

Grenada Manufacutinrg Site
Grenada, Mississippi

SAMPLE LOCATION	PARAMETERS		SHALLOW (S)/DEEP (D)
MW - 5	Metals, VOCs, Field Bioparameters	(see Table E-1)	S
MW - 10	Metals, VOCs, Field Bioparameters	(see Table E-1)	D
MW - 14	Metals, VOCs, Field Bioparameters	(see Table E-1)	S
MW - 41	Metals, VOCs, Field Bioparameters	(see Table E-1)	S
MW - 42	Metals, VOCs, Field Bioparameters	(see Table E-1)	D
MW - 43	Metals, VOCs, Field Bioparameters, Dissovled Organic Carbon[a]	(see Table E-1)	S
MW - 44	Metals, VOCs, Field Bioparameters, Dissovled Organic Carbon[a]	(see Table E-1)	D
MW - 45	Metals, VOCs, Field Bioparameters	(see Table E-1)	S
MW - 46	Metals, VOCs, Field Bioparameters	(see Table E-1)	D
MW - 47	Metals, VOCs, Field Bioparameters	(see Table E-1)	S
MW - 48	Metals, VOCs, Field Bioparameters	(see Table E-1)	D
MW - 49	Metals, VOCs, Field Bioparameters, Dissovled Organic Carbon[a]	(see Table E-1)	S
MW - 50	Metals, VOCs, Field Bioparameters, Dissovled Organic Carbon[a]	(see Table E-1)	D
MW - 51	Metals, VOCs, Field Bioparameters	(see Table E-1)	S
MW - 52	Metals, VOCs, Field Bioparameters	(see Table E-1)	D
MW - 53	Metals, VOCs, Field Bioparameters	(see Table E-1)	S
MW - 54	Metals, VOCs, Field Bioparameters	(see Table E-1)	D

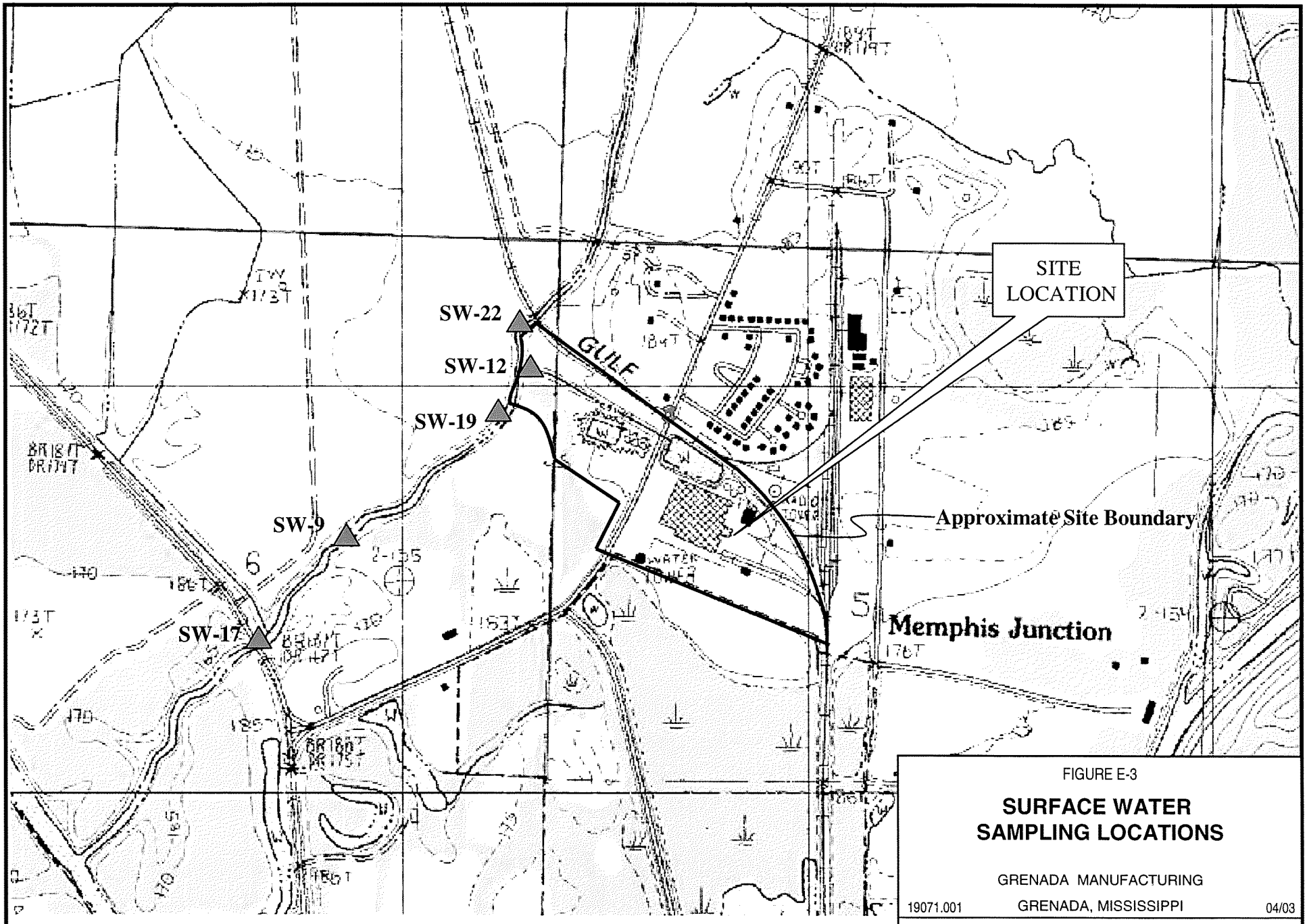
[a]Only monitored in first two sampling events.

4.0 SURFACE WATER MONITORING

In addition to the groundwater sampling, surface water sampling will be performed. The groundwater in the uppermost aquifer at the Site flows toward and discharges to Riverdale Creek. The surface water quality will be measured to monitor the effectiveness of the PRB and its ability to intercept the groundwater plume. Surface water quality will be monitored in Riverdale Creek upstream and downstream of the PRB. There will also be one sampling location parallel to the PRB in Riverdale Creek and an additional sampling point in the Outfall Ditch at its confluence with Riverdale Creek. The sections below further identify surface water sampling locations, frequency, and constituents of interest.

Surface water samples will be collected at five (5) sample locations indicated on Figure E-3. In order to compare previously gathered data, these sample locations will coincide with the previous surface water sampling event conducted during the RI. In addition, the sample designations will match those assigned in the RI. These locations include one sample collected approximately 300 feet upstream of the Outfall Ditch on Riverdale Creek, one in the Outfall Ditch, one in Riverdale Creek parallel to the alignment of the PRB approximately 400 feet downstream of the Outfall Ditch, and two downstream of the PRB. The downstream samples will consist of one sample approximately 2,000 feet downstream of the Outfall Ditch (roughly 400 feet downstream of the PRB) and the other approximately 3,000 feet downstream of the Outfall Ditch near the Highway 51 bridge.

Performance monitoring in Riverdale Creek will begin as soon as practicable upon receipt of USEPA approval of this Performance Monitoring Plan, coincidental with the first site-wide groundwater sampling event (see Section 3.3). Five (5) locations along Riverdale Creek will be sampled and analyzed for the list of constituents identified in Table E-4. After the construction of the PRB is complete, surface water will be sampled on a semi-annual basis coincidental with the PRB groundwater monitoring program. The five sampling points on Riverdale Creek will serve to monitor the performance of the PRB on a semi-annual basis. Monitoring on the upstream side of Riverdale Creek will provide the background levels for the constituents of concern. Comparison of the other sampling locations to the background concentrations and historical Site data will demonstrate the effectiveness of the PRB.



Modified from U.S.G.S., Grenada, Mississippi Quadrangle, 1983

Approximate Scale: 1" = 1000'

FIGURE E-3

SURFACE WATER SAMPLING LOCATIONS

GRENADA MANUFACTURING

19071.001 GRENADA, MISSISSIPPI 04/03

BROWN AND CALDWELL Nashville, Tennessee

Table E-4

Semi-Annual Surface Water Sampling

Grenada Manufacturing Site
Grenada, Mississippi

SAMPLE LOCATION	PARAMETERS	
SW-9	Metals, VOCs	(see Table E-1)
SW-12	Metals, VOCs	(see Table E-1)
SW-17	Metals, VOCs	(see Table E-1)
SW-19	Metals, VOCs	(see Table E-1)
SW-22	Metals, VOCs	(see Table E-1)

Surface water samples will be collected near the east bank of Riverdale Creek in an area exhibiting the greatest degree of homogeneity. Surface water samples will be collected from downstream to upstream. At each of the sample locations, a water sample will be collected that is representative of the entire depth of water. This may be accomplished in one of two ways. If the water is deeper than 24 inches, a stainless steel Kemmerer sampler will be used to collect a sample of the entire water column or from approximate mid-depth location. If the water is less than 24 inches, a stainless steel dipper will be used to collect the sample. In both instances, care will be taken not to disturb the sediment. Prior to sample collection, the sampler will be flushed with the water at that sample location.

At each sample location, water temperature, pH, and specific conductance will be measured in the field using a thermometer, portable field pH meter, and specific conductance meter. All results will be recorded in the field log book. Meter probes will be gently wiped with a tissue and then rinsed with deionized water before and after each use. The pH and specific conductivity meters will be calibrated and calibration records will be maintained in the field log book. Surface water samples will be accessed beginning at the most downstream locations and moving upstream such that sediment is not transported to unsampled locations.

5.0 REPORTING

A groundwater and surface water monitoring report will be developed and submitted annually to USEPA and MDEQ. The report will include groundwater and surface water sampling results, as well as estimates of seepage velocities and aquifer characteristics, such as groundwater flow direction and gradient. Groundwater quality data will be tabulated and comparisons made with Site cleanup goals (e.g., MCLs) and historical Site data. During years when site-wide groundwater sampling is performed, data will also be presented on isoconcentration maps and potentiometric maps. Natural attenuation will be evaluated by a review of the collected bioparameters. By evaluating these parameters and comparing the relative values obtained at different locations within the aquifer, insight can be gained with respect to whether conditions are continuing to be supportive of reductive dechlorination, as well as obtaining direct and indirect evidence that reductive dechlorination is occurring. By following these parameters over time, potential changes in conditions that affect reductive dechlorination can be identified

Surface and site-wide groundwater quality sampling and analysis will be conducted as soon as practicable after USEPA has approved this Performance Monitoring Plan. Groundwater sampling and analysis to monitor the effectiveness of the PRB will begin within a month of installation of the PRB. Thereafter, groundwater and surface water sampling will continue at the frequency specified in earlier sections of this Plan. At some future time, ArvinMeritor may wish to petition the USEPA and the MDEQ to modify this Performance Monitoring Plan. ArvinMeritor may conduct additional sampling to facilitate understanding of the surface water conditions in order to make recommendations to USEPA and MDEQ regarding environmental activities at the Site.

6.0 DECONTAMINATION AND INVESTIGATION DERIVED WASTE

6.1 DECONTAMINATION

An important aspect of quality control is the decontamination of field equipment. Improperly cleaned equipment can lead to cross-contamination and misinterpretation of data. Decontamination procedures for this project are outlined in the following paragraphs.

Water Level Indicators

Upon completion of the liquid measurements in the monitoring wells, the probe will be raised to the surface and, along with the wetted portion of the tape, will be decontaminated with the following procedure:

- Wash in potable water and laboratory detergent.
- Rinse with potable water.
- Rinse with deionized water.

For wells that are located around the perimeter of the Site and which are expected to contain relatively low concentrations of dissolved constituents with respect to historical data, only the last two steps will be performed.

Submersible Sampling Pumps

Submersible pumps will be cleaned prior to and between each use. Pump tubing will be discarded after each use. The cleaning process will consist of the following:

- The external surface will be scrubbed with a potable water/detergent solution.
- Flush laboratory detergent and potable water solution through the pump.
- Rinse the external surface of the pump.
- Flush two gallons of potable water through the pump.
- Rinse the internal and external surface of the pump with deionized water.

The power leads to the pump will be decontaminated in a similar fashion.

Miscellaneous Equipment

- Wash the external and internal surfaces with a potable water/detergent solution.
- Rinse with potable water.
- Rinse with Deionized water.

6.2 INVESTIGATION DERIVED WASTE

All purge water developed during the sampling event will be placed into DOT-approved 55-gallon drums and stored on site. Groundwater analyses will be used to characterize the purge water for transportation and disposal by a licensed waste transporter retained by ArvinMeritor. In addition to proper handling of purge water, all solid waste (i.e., soil cuttings and drilling mud) produced during the monitoring well installation will be placed into DOT-approved 55-gallon drums and stored on Site. Soil analyses will be used to characterize the solid waste for transportation. BC will provide the number of drums, estimated volume of purge water, and analytical results. Additionally, BC will clearly label each drum as to contents and date as required for proper storage. The waste transporter will develop the waste disposal manifests and deliver the manifest to ArvinMeritor for signature. The waste transporter will then properly label each drum for transport and transport the drums under manifest for proper disposal on ArvinMeritor's behalf.

7.0 HEALTH AND SAFETY

All work performed or this Performance Monitoring Plan will be conducted in accordance with an existing site-specific Health and Safety Plan (HASP), which has been developed consistent with OSHA requirements. A copy of the HASP will accompany the sampling team during conduct of these sampling events.

8.0 PROJECT MANAGEMENT

8.1 PROJECT ORGANIZATION AND MANAGEMENT

Mr. John Bozick is the Project Manager for ArvinMeritor. Mr. Bozick has the overall responsibility for coordinating work activities at the Site interfacing with Grenada Manufacturing and the BC Project Manager and communicating with the USEPA and MDEQ.

BC has been retained by ArvinMeritor to conduct the groundwater and surface water monitoring. The BC Project Manager, Dale R. Showers, P.E., will be responsible for coordinating technical activities and directing BC personnel on the project, and will be the primary BC contact. Robert E. Ash IV, P.E., of BC will act as the Principal-in-Charge with responsibility for the overall quality of the work. Project related activities will be managed by Mr. Showers from the BC Nashville, Tennessee office. BC personnel will be responsible for the establishment and monitoring of schedules, coordination of field activities, managing data, and performance of subcontractors. BC personnel will interface with subcontractors, laboratory and project personnel, and inform the Project Manager of all activities.

8.2 DOCUMENT CONTROL

Project documents will be controlled through an organized project filing system. Project and task numbers will be printed on each document. Analytical/technical files will include work products generated during the project. Field books, field observations, photographs, and other field related documents will be prepared and will also be placed in the project files. Laboratory sample results will be controlled, reviewed, and validated as defined in the QAPP, dated November 2000. Original incoming documents will be date-stamped upon arrival and will be placed in the files.

8.3 DATA MANAGEMENT

Data received from the field, analytical laboratories, subcontractors, or private sources will be tabulated on a spreadsheet or database and will be subjected to quality control procedures, including comparing raw data to the original source, verifying calculations, and confirming data summaries. Data distribution will not occur until data review has been completed. Maps or drawings created using the data will be subjected to the review process.

Work products will be checked before final use. This includes checking calculations, reports, plans, etc. with various levels of review. The Project Manager will be responsible for the review of work as an element of his project responsibilities. The Principal-In-Charge is responsible for the overall quality of the work. One or more discipline-specific Technical Directors may be assigned by the Project Manager. Further, assignments may be made outside the project team, as needed, for quality control purposes.