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DEPARTMENT OF ENERGY
National Nuclear Security Administration
Los Alamos Site Office
Los Alamos, New Mexico 87544

OCT 28 2004

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NMED Hazardous Waste Bureau

Mr. John Young
NMED-Hazardous Waste Bureau
2905 Rodeo Park Drive East,
Building 1
Santa Fe, NM 87505-6333

Dear Mr. Young:

Subject: Drill Plan for Intermediate Wells in Mortandad Canyon

Enclosed are two copies of the Drill Plan for Intermediate Wells in Mortandad Canyon. If you have any questions regarding this matter, feel free to contact me at (505) 665-5046 or Tom Whitacre at (505) 665-5042.

Sincerely,

Mat Johansen
Groundwater Program Manager

EM:3TW-002

Enclosure

cc w/o enclosure:
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Drill Plan
for
Intermediate Wells
Mortandad Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico
October 2004

KLEINFELDER

Project No. 49436

WHITACRE

FINAL DRILLING PLAN FOR INTERMEDIATE WELLS MORTANDAD CANYON LOS ALAMOS NATIONAL LABORATORY LOS ALAMOS, NEW MEXICO PROJECT NO. 49436

PREPARED FOR:

THE UNITED STATES DEPARTMENT OF ENERGY AND THE NATIONAL NUCLEAR SECURITY ADMINISTRATION THROUGH THE UNITED STATES ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

PREPARED BY:

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October 2004

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October 2004

Kleinfelder Review and Approvals:

Program Manager	Paul Fensterer	10/12/04 Date
Deputy Program Manager	Barbara Everett	10/13/04 Date
Technical Manager/Lead Geologist	for Mark Everett	10/13/04 Date

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1. INTRODUCTION

This Drill Plan (DP) provides guidance for site preparation, drilling, sampling, installation, testing, and site restoration activities associated with Intermediate Wells (I-1, I-3, I-4, I-5, I-6, I-8, and I-10) to be installed in Mortandad Canyon located at Los Alamos National Laboratory (LANL), New Mexico. Wells I-2, I-7, and I-9 may be added as funding and Data Quality Objectives (DQOs) become available.

A map of the Los Alamos area showing the location of the Intermediate wells (I-wells) is presented in Figure 1. This plan has been prepared to comply with the scope of work set forth in U.S. Army Corps of Engineers (USACE) Delivery Order W91238-04-F-0096.

The following sections provide an overview of the program management and operations topics including project staff, quality practices, health and safety, security, training, schedule, and permits, as well as plans for well installation and dust control.

2. PROGRAM MANAGEMENT AND OPERATIONS

Kleinfelder Inc.'s (Kleinfelder) proposed management personnel and their respective roles are detailed in Table 1 and in Kleinfelder's Project Management Plan (PMP) (Kleinfelder, Inc. 2003). A list of Key Personnel involved in the project with roles and phone numbers is presented in Table 2. The overall project organization is shown schematically in Figure 2.

This project is being performed for the United States Department of Energy (DOE) Project Manager with contractual assistance provided by the USACE. The end-users of the data collected from this project will be for the Remediation Services Project, DOE, New Mexico Environment Department (NMED), and the general public. The LANL Field Operations Logistical Advisor will assist with obtaining the necessary LANL-required permits and assist with scheduling and logistical issues.

2.1 PROJECT STAFF

2.1.1 PROJECT MANAGEMENT TEAM

The Kleinfelder Management Team consists of the Program Manager (PM), Deputy Program Manager (DPM), Program Hydrogeologist, Technical Manager (TM), and Health and Safety Manager. The Management Team reviews all task order work plans; supervises compliance with environmental, safety and health plans; and performs project audits of ongoing work. The Team confirms that all work is planned, executed, and completed in the best and most compliant manner possible.

The Project Management Team will also provide technical assistance to the Field Team members in the form of the Program Hydrogeologist and the Health and Safety Officer. The Program Hydrogeologist will act as a technical resource for the entire Program Team as well as the client

to assist with problem-solving activities. He will provide technical guidance to the field and technical teams as well as quality control for well materials and field procedures.

The Health and Safety Officer will provide health- and safety-related technical assistance and senior review of all project-specific safety plans. He will conduct periodic jobsite safety inspections and oversee the Team's staff of safety professionals.

2.1.2 FIELD TEAM

The Field Team will consist of the Field Manager (FM) and Field Geologists (FGs). The FM will provide oversight and review ongoing operations as they relate to this DP and assist the FGs and drillers with technical, operational, or other project related issues. A FG will be present during all field activities. The FG will:

- Provide guidance for site setup
- Maintain geologic logs (to be performed in the field)
- Package and document core and/or cuttings
- Track drilling methodologies
- Perform well development oversight
- Record general drill site activities

Additional qualified and experienced staff (existing and new) may be added after submittal of this DP for performance of the work. Additional staff members will be identified and their roles assigned before commencement of their services.

2.1.3 DRILLING SUBCONTRACTORS

The drilling will be completed in two phases, the first will be core collection and the second will be drilling and well installation. Spectrum Exploration will be performing the Phase I core collection and WDC Exploration & Wells will be performing the Phase II drilling, well installation, and well development. The drilling subcontractors will be responsible for the timely completion of the work schedule, consistent and adequate sample recovery, and proper well installation. They will also ascertain that equipment is in proper working order, that personnel are properly trained in equipment use, and that daily driller's logs are maintained.

2.1.4 SITE PREPARATION/RESTORATION SUBCONTRACTOR

EnviroWorks, Inc. will be the subcontractor responsible for the timely preparation of each drill site. The site preparation/restoration subcontractor will assist the FG with the installation of sediment and erosion control structures, leveling and grading of areas necessary for site access, necessary road improvements, installation of drill pads, and general labor and heavy equipment assistance to the project. In addition, the site preparation/restoration subcontractor will be

responsible for moving waste containers and performing final site restoration activities. The FM will coordinate the required work with the site preparation/restoration subcontractor.

2.2 QUALITY PRACTICES

All staff will be trained to the PMP, Standard Operating Procedures (SOPs), the Contractor Quality Management Plan (CQMP), Work Instructions (WI), and quality procedures that are appropriate to their assigned roles. A listing of SOPs can be found in the CQMP.

Copies of the DP, SOPs, and WIs will be maintained at active sites. The FM will visit the sites regularly to ascertain that quality procedures and requirements are being met and to provide coordination of the field crews.

Daily reviews of field documents are conducted to check for consistency, completeness, and legibility. Additionally, quality assurance (QA) audits occur weekly in accordance with the CQMP.

2.3 GENERAL HEALTH AND SAFETY

All staff will be trained to the Project Health and Safety Plan (HASP), the Site-Specific Health and Safety Plan (SSHASP), and health and safety practices that are appropriate to their assigned roles. Addenda to the SSHASP will address steep slopes, Radiological Work Permits (RWP), flash flooding, security issues, and other site-specific issues. The FM will visit the sites regularly to ascertain that the DP, HASP, SSHASP, and RWP requirements are being met and to provide coordination of the field crews.

All personnel are responsible for working safely. In support of this, the following safety related activities will be conducted:

- A safety tailgate meeting will be conducted every shift. All site personnel are required to attend and sign the acknowledgement sheet. If not present during the meeting, personnel must review the tailgate meeting form and sign the acknowledgement sheet before entering the work zone.
- Heavy equipment inspections will be conducted and documented once per day.
- Site safety inspections will be conducted and documented once per day.
- A qualified safety professional will conduct and document weekly site walk-downs.
- Kleinfelder's corporate Health and Safety Manager will conduct site walk-downs monthly.
- A DOE Health and Safety representative will perform an independent weekly site inspection.

Material Safety Data Sheets (MSDSs) for all of the chemicals being used for this project can be found in Appendix A. A current physician's release and Health Insurance Portability &

Accountability Act (HIPAA) Release Form for work for all field personnel will be in the project file.

2.4 RADIATION SURVEY

The following radiation survey procedures will be implemented at each site:

- A LANL Radiological Control Technician (RCT) will perform screening of drill sites before work is performed at a site and on an as needed basis.
- An RCT will screen support and drilling equipment both before it enters a drill site and before removal. In addition, field samples will be screened before leaving a drill site. The FG will schedule screening through the LANL Field Operations Support Lead at least 48 hours before removing equipment or samples (see Table 2, Key Personnel Phone List, for contact numbers).
- ARS (RADVAN samples) will screen core samples before the Sample Management Office (SMO) ships samples to off-site laboratories for analyses.
- A beta/gamma radiation meter will be available to screen personnel and borehole materials at drill sites.
- Onsite personnel will wear dosimeters to monitor for exposures to radiation.

See the Mortandad Canyon Site Specific Health and Safety Plan (SSHASP) for further details. Screening results will be maintained in the project files and recorded in the field logbook. In addition, the HSR-1 screening paperwork is required for submittal of core for final disposition to the Field Support Facility (FSF). If at any time the site-specific action levels are reached or exceeded, work will stop and a RCT will be contacted at 667-5185.

2.5 TRAINING

Staff will receive training by Kleinfelder or LANL that will be specific to the duties they will be performing. Training will be documented in the project file. Examples of specified training requirements are provided below.

2.5.1 KLEINFELDER PROJECT TRAINING

Kleinfelder personnel responsible for project training include the document control manager, quality control (QC) specialist, geologic data manager, and lead field geologists. Field staff training occurs both in the classroom and in the field.

- Occupational Safety and Health Act (OSHA) 29 Code of Federal Regulations (CFR) 1910.120 40-hr HAZWOPER
- First Aid/CPR
- Documentation Training
- WI and SOP Training

2.5.2 LANL TRAINING

- General Employee Training (GET) – Training required for any individual that will be working at LANL for a period of time greater than 10 days in a year
- Radworker II – Training to satisfy the requirements of the RWP (necessary for work performed in Mortandad Canyon)
- Fire Watch – Training required for individuals that will be on worksites that are considered to have fire risks or have the potential of using a fire extinguisher
- Fire Extinguisher – Training qualifying a worker to properly use an emergency fire extinguisher

2.6 SECURITY

No wells are located within a high security area. Although not in a secured area, access from Pajarito Road requires that at least one person in each vehicle must have a current LANL badge. Kleinfelder personnel and subcontractors shall maintain current LANL badges and follow the directions of security personnel.

2.7 SCHEDULE

Shifts are planned to be 12-hours long. Drilling is scheduled to occur primarily during the day shift. Coring operations may operate on a 24-hour schedule to meet project deadlines. The overall project schedule will be monitored and modified on a well-by-well basis by the PM, DPM, FM, and TM. Drilling is anticipated to begin in October 2004.

See Table 3, Intermediate Well Sequence and Data Table, for the sequence of Intermediate Wells to be drilled and installed.

2.8 PERMITS

Kleinfelder will obtain National Pollutant Discharge Elimination System (NPDES) Construction General Permit (including the Storm Water Pollution Prevention Plan) and spark/flame permits when necessary. DOE will obtain LANL excavation, archaeological, and ecological permits; program 401/404 determinations; and stream/river access, air quality, and property access permits. No work will begin at a site before the necessary permits are obtained.

In accordance with the requirements of the NPDES Construction General Permit (Subparts 3.10 and 9.C.1.c), sediment and erosion control structures, also called Best Management Practices (BMPs), of the I-well sites will be inspected as follows:

- At least once every 14 calendar days; or
- monthly during seasonal arid periods, during winter conditions when runoff is unlikely (e.g. when a site is covered with snow, ice or the ground is frozen), and/or when the entire site is temporarily stabilized; or

- within 24 hours of the end of a storm event of 0.5 inch or greater.

Inspections may be waived when land disturbance activities have ceased and frozen conditions are expected at a site for more than one month. In the Los Alamos area, frozen conditions typically exist from December through February. If waived, inspections will resume one month before thawing conditions are expected to result in a discharge. If repairs are required to the erosion control structures, the person performing the inspection will notify the FM.

3. DRILLING AND WELL INSTALLATION

Drilling and well installation will involve a number of site tasks. These tasks include site preparation, drilling and well installation, water and core sampling, geologic logging, geophysical logging, well development, hydrologic testing, and site restoration. As stated previously, the drilling and well installation will be performed in two phases. The first phase will consist of collecting continuous core within the upper portion of the borehole. Drilling and well installation will be performed during the second phase.

Once well installation is completed, the locations and elevations of the I-wells will be surveyed by a State of New Mexico licensed Professional Land Surveyor. The following sections detail activities to occur at the well sites.

3.1 SITE PREPARATION

This task includes the construction of the drill pad and road improvements necessary along the access roads. A LANL-provided RCT will screen sites before ground disturbance occurs. Figure 3 shows the generalized site plan for the Intermediate Wells. The FG must communicate with HSR-1 (RCT pool) personnel at least 48 hrs before ground disturbance to schedule radiological screening. An RCT can be scheduled by contacting Steve Pearson at 667-3005.

The pads (approximately 150 ft x 150 ft) will be cleared of brush and small trees, and leveled. Best Management Practice (BMP) erosion control materials will be placed around the drill pad. Pad size and shape may be modified due to site constraints. Approximately four inches of base coarse will be spread on the pad and wheel-rolled. A cuttings collection pit will be excavated or built above ground depending on depth to bedrock. Each pit will be approximately 60 ft x 40 ft x 7 ft and lined with HDPE.

Clearing for the road improvements may be necessary but will be limited as much as possible. Any felled timber and brush produced from the access road improvements and pad construction will be neatly stacked and left onsite. Some of these materials may be used in erosion control and/or site restoration. Before site or road modifications, the area will be wet down and vegetation removed to minimize the fire potential of a site. An exception to this will be in areas where removal may impact cultural resources. In these areas, gravel will be laid over the vegetation to prevent fires.

In the event that a tree must be removed or branches trimmed, the FM will be contacted to obtain the necessary approvals. In no case shall the removal of trees greater that eight inches in diameter be allowed without prior LANL approval.

Water for dust suppression, fire prevention, and drilling will be obtained from a fire hydrant located in TA-52 along the access road into Mortandad Canyon. Contact the FM for the exact location of the hydrant.

3.2 DRILL AND INSTALL INTERMEDIATE WELLS

Field operations will be guided by the Mortandad Canyon Groundwater Work Plan Revision 1 dated January 2004 (LA-UR-0165, ER2004-0019). Drilling and well installation will be performed in accordance with:

- LANL ER-SOP-04.01, REV.2, Drilling Methods and Drill Site Management
- LANL ER-SOP-01.08, REV.1, Field Decontamination of Drilling and Sampling Equipment
- LANL ER-SOP-05.01, REV. 3 attachments, Well Construction
- American Society for Testing and Materials (ASTM) Guides D5092-02, D4044-96, D6282-98, D1452-80, 5299-92, 5782-95, and D5876-95.

3.2.1 PHASE I DRILLING

Spectrum Exploration (Spectrum) will perform the Phase I soil coring under the guidance of Kleinfelder. Spectrum will provide a Delta Base 540 drill rig mounted on a tracked carrier. This rig has HQ and Geo-Barrel® Coring, Hollow Stem Auger (HSA), and Tubex capabilities.

The data quality objectives for the I-wells are documented in Table 4 of this document. Table 3 includes the proposed drilling methods, core depths, sampling frequency, and hydrologic testing for each well. Core is to be continuously sampled with HQ wireline and dry drilling methods. To prevent collapse, boreholes will be cased using a Tubex Under-reamer system following coring. Wet drilling methods may become necessary at depth.

Lexan tubes will be loaded into the sample tube before placement in the core barrel. Before removal of the lexan tubes from the sampler, the percent recovery will be noted. After the tubes are removed from the sampler, the lithology will be described on boring logs in accordance with LANL SOP 12.01. End caps will be placed on the lexan tube and sealed with tape.

A Kleinfelder geologist will be present during activities to collect, log, and package cores; oversee well installation and sampling; and generally manage site operations.

3.2.2 CORE HANDLING, SAMPLING, AND ANALYSES

A corehole will be advanced at each I-well except I-4 and I-5, which are adjacent to the MCOBT-4.4 corehole and to R-15, respectively. Core collected from Phase I drilling will be handled per LANL Environmental Restoration (ER) SOP 6.26 using appropriate sample containers (plastic bags and ProtecCore™). Samples will be submitted to the SMO using the LANL ER Chain of Custody documentation.

Samples collected will be analyzed for anions, cations, moisture content, tritium, radionuclides, and stable isotopes. Description of sample preparation, depth of collection, and quantities can be

found in Table 5A-5D. This information is adapted from the Mortandad Canyon Groundwater Work Plan, Revision 1.

After sampling, remaining HQ-size core will be placed in lay-flat plastic tubing, labeled, and stored in standard LANL ER core boxes. The core boxes will be labeled with the well name, box number, and the footage range for the box. The core boxes will be transported to the Field Support Facility (FSF) for archiving and storage after the borehole is completed in accordance with LANL SOP 12.02.

The Phase I borehole will be plugged and abandoned by filling the hole with hydrated bentonite chips or pellets to within 75 ft of ground surface. Bentonite chips will be tremied and tagged in 10-ft lifts to confirm depth. The volume of each 10-ft lift of bentonite chips will be confirmed through calculations.

The remainder of the borehole will be grouted to ground surface using a mixture of 95% cement and 5% bentonite powder. Grout will be tremied in place.

3.2.3 PHASE II DRILLING

WDC Exploration & Wells (WDC) will perform the Phase II drilling and well installation under the guidance of Kleinfelder. Phase II boreholes will be offset a minimum of 50 feet from Phase I boreholes and will be a nominal 12 ¼-in. diameter. Either a permanent 16-in. outer diameter (OD) surface conductor or a 13 ⅜-in. OD temporary drive casing will be set to a depth of approximately 50 ft bgs.

The proposed method for drilling the Phase II boreholes is direct air-rotary with foam assist. Each borehole will be advanced with a mill tooth tricone bit until penetration rates decrease significantly. This will likely occur at the top of the Cerros del Rio basalt. Below this depth a down-the-hole (DTH) hammer will be used.

3.2.3.1 Drilling Additives

Drilling additives will be available for use if needed. Only approved drilling products will be used at drill sites during the drilling and completion of these wells. Bentonite will be used only if all other methods have failed. Material Safety Data Sheets (MSDS) for these products are included in Appendix A. Potential drilling additives and a brief description of each follows:

1) **AQUAGEL GOLD SEAL®** – 25-50lbs/100gals. This pure bentonite provides a viscous fluid that forms the basis for increasing the surface tension of the foam mix to create stiff foam. It is also used in mud rotary drilling.

2) **EZ-MUD REGULAR®** – 0.5-1.75 lbs/100 gals. EZ-MUD® is a synthetic polyacrylamide suspension that provides additional colloidal material to further increase the surface tension of the foam mix. It is also used in mud rotary drilling.

3) **PAC®-L** – 3-7 lbs/100 gals, added to fresh or salt water in order to stabilize a water sensitive formation; 0.5-2 lbs/100 gals, in order to reduce torque and lower circulating pressure. It is also used in mud rotary drilling.

4) **POTASSIUM CHLORIDE** – 25-50 lbs/100 gals. Clay inhibitor to be used if swelling clays are encountered. It is also used in mud rotary drilling.

6) **QUIK-FOAM®** – 0.5-1.0% by volume. QUIK-FOAM® provides the surfactant necessary for foam formation.

7) **SODA ASH** – 0.5-1.0 lbs/100 gals. Soda ash softens the water by removing hardness. Additions of soda ash will also raise the pH to 8.5-9.0, which maximizes the yield of bentonite. It is also used in mud rotary drilling.

3.2.3.2 Drilling Contingencies

Kleinfelder will attempt to drill each borehole with the methods described above. However, drilling conditions may require the conversion to alternative drilling methods. Loss of circulation exceeding five (5) hrs combined with reduced penetration rates of less than 2 ft per hour may necessitate the use of casing. Kleinfelder will consult with DOE, USACE, NMED, and LANL before modifying the above-referenced drilling techniques.

- If the borehole begins to cave, one possible modification is to lower an 11 ¾-in. or 9 ⅝-in. OD drill casing into the 12 ¼-in. borehole; the borehole would then be advanced past the bottom of the casing. The casing will keep the upper part of the hole from caving around the drill bit.

  Another possible modification may be to use the Air Rotary Casing Hammer (ARCH) system or under-reaming with a STRATEX system.

- Permanent conductor casing may be used when unstable conditions exist and removal of the casing could compromise the final well completion design. Mud-rotary methods may be employed when flowing sand conditions inhibit borehole advancement and DQOs dictate that greater borehole depths are required. Both options will be available on-site and will be deployed only after consultation between DOE, USACE, NMED, LANL, and Kleinfelder.

- In the event that a borehole must be abandoned, the drill rig will be repositioned and a new borehole advanced. Depending on the conditions that led to the abandonment of the borehole, a casing advance (i.e., ARCH) system or a mud rotary system may be considered. The abandoned borehole will be backfilled with a bentonite/sand mix to within 75 ft of ground surface. See the MSDSs in Appendix A for further information on backfill materials. The bentonite placed above the regional aquifer will be hydrated after placement. Cement with 2% bentonite will be used to fill the borehole to ground surface. This option will be deployed only after consultation with DOE, USACE, NMED, LANL, and Kleinfelder.

3.2.4 SAMPLE COLLECTION

3.2.4.1 Perched Water

Kleinfelder will attempt to identify the presence of perched water in the I-well coreholes and boreholes. In the event that perched water occurs, a static water level measurement will be attempted. If perched water occurs in the targeted interval, a monitoring well will be constructed.

3.2.4.2 Perched Water Detection

In order to assess the presence of perched groundwater in the vadose zone that may not be clearly observed during drilling activities, two techniques may be used. The first method is direct observation during drilling and coring. The drill rig operator and field geologist will both watch the discharge for indications of fluid. Additionally, the drill pipe used in the Phase II drilling will be tripped out at the end of each shift to check for overnight water accumulation in the borehole. A video inspection of the borehole each morning may be conducted to verify the presence of groundwater. Particular care will be taken at the top and bottom of the basalt.

3.2.4.3 Perched Water Sampling

If significant perched water is encountered, a sample will be collected from the discharge line as drilling proceeds, or by bailing. Water will be collected with sand catcher disposable bailers, stainless steel bailers, or Kemmerer Bottles. Up to one gallon will be collected, as practical, at each perched zone encountered. The collected groundwater will be placed in appropriate containers (see Table 6) and delivered to the sample management office (SMO) for preservation. Once the SMO generates the appropriate chain of custody documentation, the anions/metals sample will be delivered to the EES-6 analytical laboratory.

3.2.4.4 Targeted Perched Interval Measurement and Sampling

Drilling will continue until a perched zone associated with the Cerros del Rio Basalts or the base of the basalts is encountered. The exception to this will be I-1. I-1 is targeting potential perched water in the Guaje pumice or dacite lava. If perched water is encountered, drilling will stop and water level measurements will be recorded. Water level data will be collected until three consecutive readings taken 15 minutes apart are within 0.5 foot of the same depth or as specified by a USACE and DOE approved alternate method. A groundwater sample will then be collected, if practical, and processed in accordance with the methods discussed in Section 3.2.4.3.

3.2.4.5 Post-Completion Groundwater Sampling

Groundwater samples will be collected following well development and at the end of the aquifer test and processed in accordance with the methods discussed in Section 3.2.4.3.

3.2.4.6 Geophysical Logging

The decision to perform geophysical logging for coring boreholes and well boreholes will depend on site conditions and will be made based on discussions among DOE, LANL, and

Kleinfelder staff. The suite of geophysical logging tools, if any, that may be used at a site are listed in Table 7. Alternatively, LANL-owned natural gamma and induction tools may be run.

To confirm if suspected perched water is present, coring boreholes may be logged using video and possibly natural gamma and induction geophysical tools. If zones of interest are encountered during drilling that need to be documented, Kleinfelder will provide a senior geologist experienced in performing borehole geophysical and video logging operations with the LANL equipment.

For I-well boreholes (Phase II), Schlumberger will provide the geophysical tools. The tools that may be used for I-well boreholes are listed in Table 7. A Kleinfelder field staff member will be present during geophysical logging operations to oversee logging runs and calibration checks. Schlumberger will process the geophysical logs and provide a preliminary log interpretation upon completion of logging. If drill or conductor casing is used in the boreholes, an additional contracted logging run may be conducted before the casing is installed.

3.2.5 INTERMEDIATE WELL INSTALLATION AND COMPLETION

Well materials and construction procedures are subject to the guidance documents and regulations of the State New Mexico. Well installation details will be recorded on a well installation record form.

I-wells will be completed with a single-screened interval. Wire-wrap screens will be used with a 5.38-in stainless steel 20-slot (0.020-inch opening). The screen lengths will be up to 20 feet. The proposed placement of well screens is within perched water associated with the Cerros del Rio basalts or the Guaje/dacite lava at I-1. Before installation of well screens, the final placement and length will be approved by DOE, LANL, and NMED. A typical single-screened well completion diagram is presented as Figure 4. Stainless steel centralizers will be placed at the top, middle, and bottom of the screen to keep the screen in the center of the boring. One additional centralizer will be placed 100 ft above the uppermost screen.

Wells will be constructed with 5-in OD stainless steel casing. The proposed casings lengths vary for each well as follows: I-1, 750 feet; I-3, 720 feet; I-4, 467 feet; I-5, 710 feet; I-6, 710 feet; I-8, 750 feet; and I-10, 950 feet.

The filter pack material placed around the well screen will be selected to be compatible with the screen slot size (10/20 sand for 0.020-inch slot size). The filter pack material will extend a minimum of 10 feet below and above the screen. The filter pack material will be placed with water using a tremie pipe. The top of the filter pack will be measured after every lift. When the filter pack is brought to the maximum height above the top of the screen, a surge block will be run inside the casing within the screen interval to augment settling and fill any voids that may remain in the filter pack. If settling occurs, additional filter pack material will be added.

A 2-ft layer of fine sand (20/40) will be placed above the filter pack. The fine sand will be tremied into place with water. A seal of ⅜-in bentonite chips will be placed above the fine sand layer. The bentonite chips will be placed using a mixture of silica sand and water. The tremie

will be used until the level of the bentonite chips exceeds the top of the perched water table. The top of the bentonite chips will be confirmed by tagging. Volumetric calculations will be performed to confirm that bridging of bentonite chips within the borehole is not occurring. The bentonite seal will be hydrated every 60 feet with a minimum of 10 gallons of potable water per foot of bentonite chips. This seal will be brought up to 75 ft bgs. Grout consisting of mechanically blended Portland cement, bentonite, and water will fill the remaining boring annulus. The grout will be tremied into place. During construction, the end of the tremie pipe will be within 10 feet of the top of the emplaced grout. The placement of grout will be uninterrupted, with minimal time between the mixing of grout batches.

See the MSDSs in Appendix A for further information on backfill materials.

3.2.6 WELL DEVELOPMENT

Well development may consist of bailing, swabbing, jetting, brushing, surging, chemical treatment, and/or pumping of the screened interval(s). Where applicable, LANL ER-SOP-06.02, REV. 2, Field Analytical Measurements of Groundwater and ASTM D5092-02 will be followed. Well conditions (e.g., fluids used, initial turbidity) will dictate the methods used and the order in which the methods are utilized. The criteria for satisfactory development are a turbidity reading that is at or below 5 Nephelometric Turbidity Units (NTU) and stable pH, temperature, and conductivity readings. In addition, a total organic carbon (TOC) concentration of less than 2.0 mg/l must be achieved. In the event that the turbidity reading cannot be achieved, an alternative standard consisting of three consecutive, repeated measurements (within 5% of the previous measurement) of temperature, conductivity, and pH may be used to determine sufficient development. Development water will be containerized and managed as described below in Section 3.3, Investigation Derived Waste (IDW), with approval from DOE.

To monitor development with respect to drilling fluids (e.g., EZ-MUD® and QUIK-FOAM®), water samples will be collected daily and transferred to EES-6 for TOC and anion analysis. Samples will include a 40-ml septum vial and 250-ml poly bottle, both non-acidified and non-filtered.

Groundwater samples will be collected following well development and hydrologic testing. See Table 6 for the proposed analytical suite, requested sample volumes, and sample containers. Samples will be kept on ice and delivered to the SMO for processing. All samples must be transferred under chain-of-custody.

When samples are taken, Keith Greene at SMO (665-9966), Dale Counce at EES-6 analytical chemistry lab (667-1224), and Pat Longmire (665-1264) will be notified that sample(s) have been collected and will be submitted to SMO. If sampling occurs during non-working hours, Keith Greene will be called to schedule processing.

3.2.7 HYDROLOGIC TESTING

Once development is complete, an aquifer test will be designed with input from DOE, LANL, and the NMED. Hydrologic testing may be performed using pump-to-evacuation, slug, or

constant-rate pumping methods depending on the hydrologic characteristics of the well (see Table 3). Where applicable, LANL ER-SOP-07.04, REV. 2, Pumping Tests, will be followed. The preferred testing method is the constant rate pump test. However, pump-to-evacuation or slug tests may be appropriate in low-transmissivity zones. If selected, testing in the low-transmissivity zones would consist of several short-duration tests conducted over one day. Other factors that could influence test selection include water storage capacity, discharge area availability, and groundwater analytical results. It is assumed that constant rate pumping tests will be performed for the I-wells.

Regardless of test type, a transducer/data logger will be set and allowed to stabilize for approximately 24 hours before beginning the test. If multiple short-duration tests are performed, the aquifer will be allowed to return to the static water level between each test. The static water level will be considered recovered when 95% of the initial static water level (+/- 5% of the originally measured depth from ground surface) has been obtained. The water level will be confirmed with an electronic water level meter before and after each test.

3.2.8 SAMPLING SYSTEM INSTALLATION

Intermediate wells are proposed as single-completion wells. The pump system will include a submersible pump as used in previous well completions (e.g., R-21). In the case of a low-producing well, an alternative sampling system such as Barcad may be used. The final system is to be determined by Kleinfelder, DOE, USACE, and NMED. Kleinfelder and WDC will install the system using a Pulstar P12000 development rig.

3.2.8.1 Submersible Pump System

Kleinfelder proposes to use a Grundfos™ environmental retrofitted submersible pump or equivalent, which would provide a low-flow (less than 3 gallons per minute) discharge at the surface. All materials that contact the groundwater sample consist of either stainless steel or Teflon®. To measure water levels in the wells, a 1-in. ID pipe will be installed to sufficient depth to set a dedicated transducer below the measured static water level. A weather-resistant pump control box will be installed next to each wellhead.

3.2.8.2 Alternative Sampling System

Conditions surrounding a specific site might warrant the use of an approved alternative sampling system. The system will be designed by the manufacturer and will be approved by the DOE Project Manager before installation.

One alternative sampling system for low-producing wells is Barcad. Barcad uses compressed gas to lift the water sample to the surface. All materials in contact with the water will be either stainless steel or Teflon®. Barcad systems, if used, will be filled with a dedicated fiber optic transducer.

3.2.9 SURFACE COMPLETION

The wellhead completion will include an outer casing to protect the stainless steel monitoring well. The top of the protective casing will be fitted with a tamper-proof well cover plate. The protective casing will be set in a 5 ft x 5 ft x 6-in.-thick reinforced concrete pad. A weep-hole will be drilled in the bottom of each protective casing. A set of four safety bollards will be placed around the pad to protect the well from traffic. One of the four bollards will be designed for easy removal to allow access during well or sampling system maintenance.

3.3 INVESTIGATION-DERIVED WASTE

Duratek has provided a Waste Management Plan (WMP, Appendix B) to handle the IDW generated from the project. The anticipated IDW will include drill cuttings, contact wastes, decontamination water, and sample and development water. Duratek has reviewed existing site-specific data and has prepared the Waste Characterization Strategy Form (WCSF, Appendix C).

Field personnel will follow the WMP as the guideline for handling and storage of IDW. In general, storage of IDW will be centrally located at each site. Drill cuttings will be placed in either one cubic yard capacity recycled nylon sacks, previously containing bentonite chips, or 55-gallon drums and stored on pallets. Decontamination water and development water will be placed in 30 to 55-gallon drums, sealed, and labeled.

IDW produced during drilling, well development, and testing will be sampled and analyzed for the suite of constituents as agreed to between DOE and NMED. The number of samples to be collected and the analytical suite will be provided in the WCSF and the WMP. Waste will be characterized based on borehole characterization analytical results and waste characterization analytical results and disposed of accordingly.

Drill cuttings that are approved for non-regulated disposal will be used to backfill the cuttings pit or thin-spread at the location of the drill site. Contact wastes obtained from drill locations that are approved for non-regulated disposal will be disposed of at a sanitary landfill.

Drilling and development water approved for discharge will be applied to the land surface or used for dust suppression on access roads or the drill site in accordance with the terms and conditions of the original NOI (August 2, 2001).

Petroleum leaks, spills, etc. are considered New Mexico Special Waste and must be managed according to the regulations. These wastes will be stored in secure, labeled drums. The drums will be placed on a pallet and labeled as New Mexico Special Waste. When assessing the site conditions, all drip pads, absorbents, and petroleum-contaminated soils will be stored according to New Mexico Special Waste guidelines. Non-contact waste, such as food containers, empty bentonite bags, etc. will be disposed of at a sanitary landfill.

3.4 SITE RESTORATION

Restoration of sites will be limited to removal of site litter, silt control fencing, other BMPs (unless instructed to leave in place), temporary water lines, and revegetation of disturbed areas

(if any) outside of the road and drilling pad area. The road improvements and drilling pad will be left in place to facilitate future well sampling and maintenance. The drill pad will be reduced in size by approximately 50% during site restoration. Erosion control and revegetation will be accomplished in accordance with LANL's BMP guidance and seeding specifications.

4. DUST CONTROL

Dust control measures will be implemented at drill sites and on access roads by EnviroWorks.

4.1 DRILL PADS AND ROADS

Dust suppression at the drill pads and on access roads will be accomplished by application of water to areas where dust is created. The applied water will be either potable water or development water approved for use by NMED and DOE.

4.2 DRILLING

The drill rig may generate dust during "dry" drilling operations. For dust suppression during "dry" Phase I drilling operations, the LANL Dust Suppression System will be employed. For "dry" Phase II drilling operations, dust will be controlled by applying a potable water mist at the air discharge.

5. REFERENCES

American Society for Testing and Materials (ASTM), 1980, 2000. Standard Practice for Soil Investigation and Sampling by Auger Borings. Designation: D 1452-80. West Conshohocken, Pa: ASTM Committee D18 and Subcommittee 18.02.

American Society for Testing and Materials (ASTM), 1997, 2002. Standard Test Method (Field procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers. Designation: D 4044-96. West Conshohocken, Pa: ASTM Committee D18 and Subcommittee 18.21.

American Society for Testing and Materials (ASTM), 2002. Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers. Designation: D 5092-02. West Conshohocken, Pa: ASTM Committee D18 and Subcommittee 18.21.

American Society for Testing and Materials (ASTM), 1993. Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities. Designation: D 5299-92. Philadelphia, Pa: ASTM Committee D18 and Subcommittee 18.21.

American Society for Testing and Materials (ASTM), 1995. Standard Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices. Designation: D 5782-95. West Conshohocken, Pa: ASTM Committee D18 and Subcommittee 18.21.

American Society for Testing and Materials (ASTM), 1996, 2000. Standard Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices. Designation: D 5876-95. West Conshohocken, Pa: ASTM Committee D18 and Subcommittee 18.21.

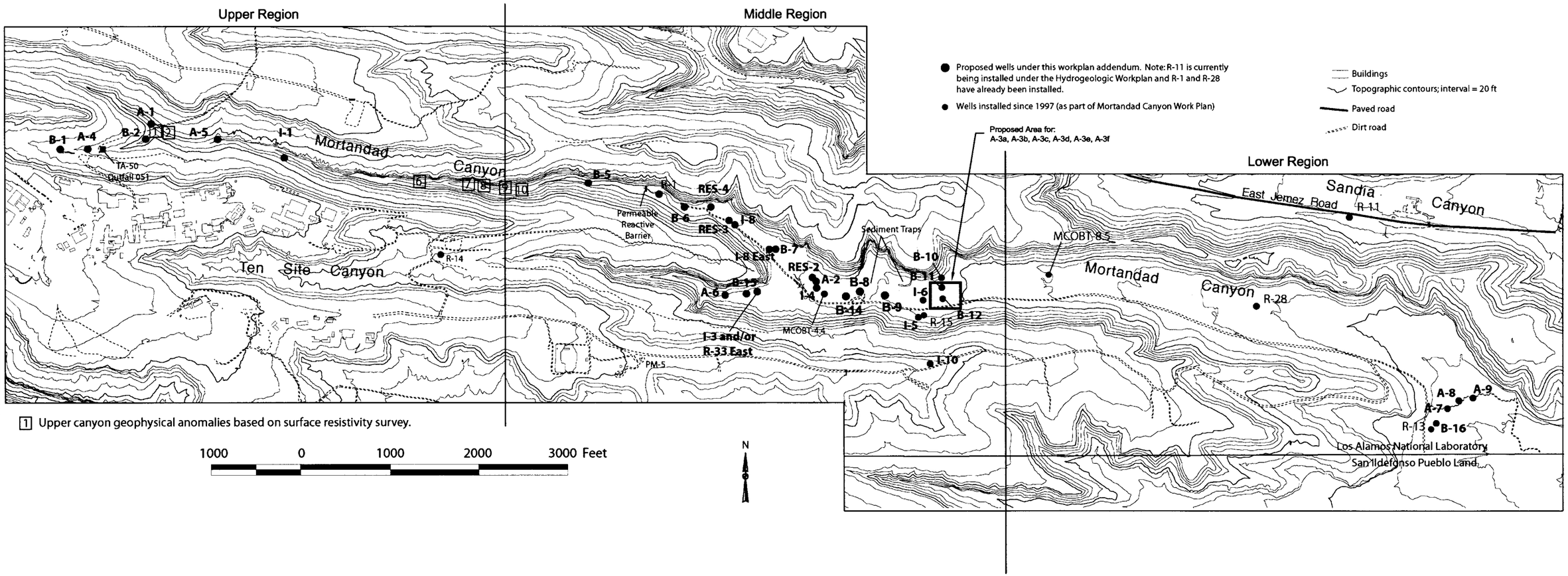
American Society for Testing and Materials (ASTM), 1999. Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations. Designation: D 6282-98. West Conshohocken, Pa: ASTM Committee D18 and Subcommittee 18.21.

Kleinfelder, Inc., 2003. Project Management Plan for DOE Monitoring Well Installation at Los Alamos National Laboratories, Contract Number 03-0029L-033-1009, Los Alamos, New Mexico, October 29, 2003.

Kleinfelder, Inc., 2003. Final – Contractor's Quality Management Program, Revision 1, Monitoring Well Installation, Los Alamos National Laboratory, Los Alamos, New Mexico, USACE Task Order DACW05-03-F-0090, Contract GS-10F-0029L, November 24, 2003.

Notice of Intent to Purchase No. W91238-04-N-0001 for Monitoring Well Installation, Los Alamos National Laboratory, Los Alamos, New Mexico

Mortandad Canyon Groundwater Work Plan Revision 1 dated January 2004 (LA-UR-0165, ER2004-0019).



[1] Upper canyon geophysical anomalies based on surface resistivity survey.

KLEINFELDER		Mortandad Canyon Well Location Map Mortandad Canyon Los Alamos National Laboratory Los Alamos, New Mexico	FIGURE 1
Drawn By: C. Landon	Date: September 2004		
Project No.: 49436	Revision: 1		

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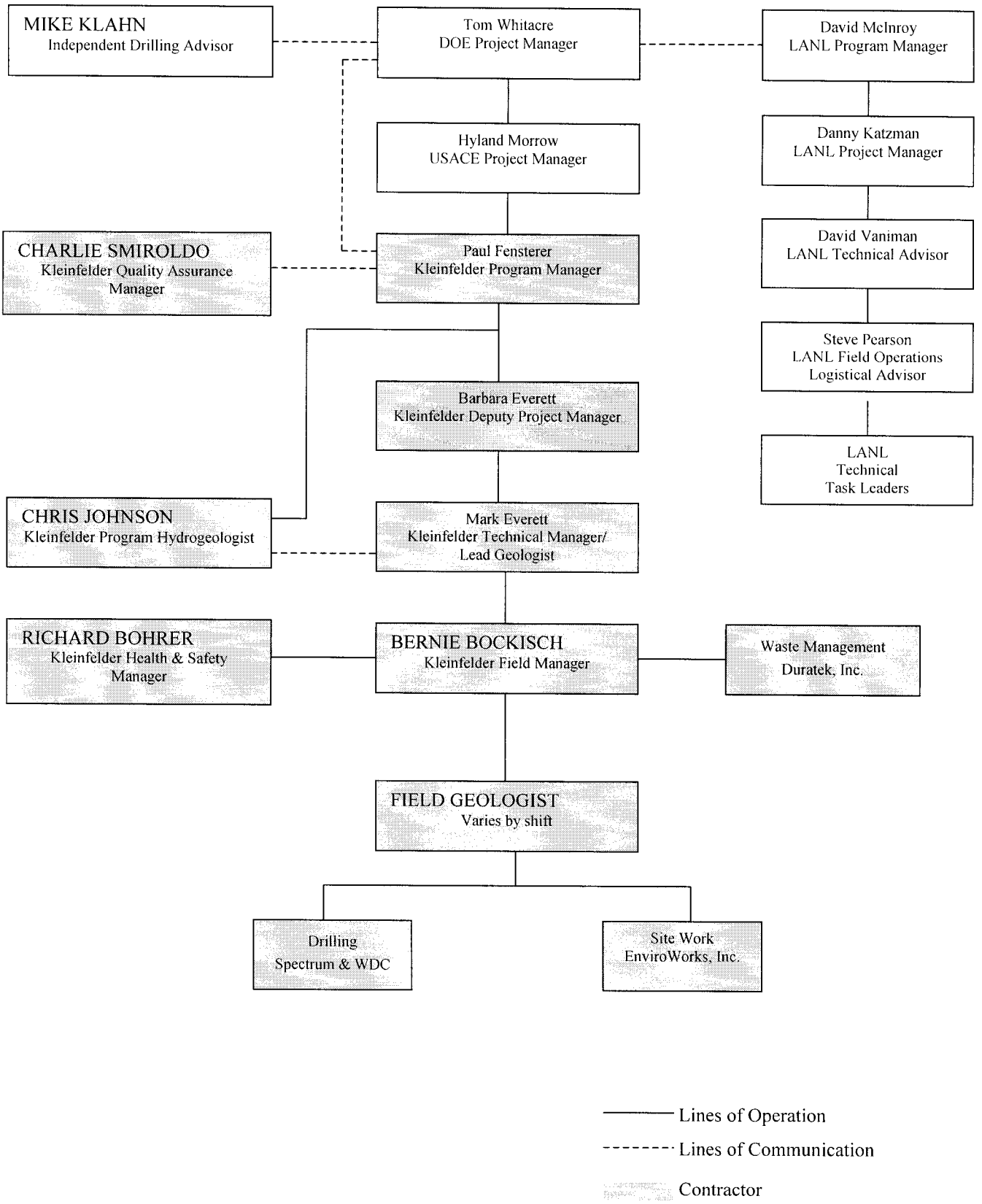
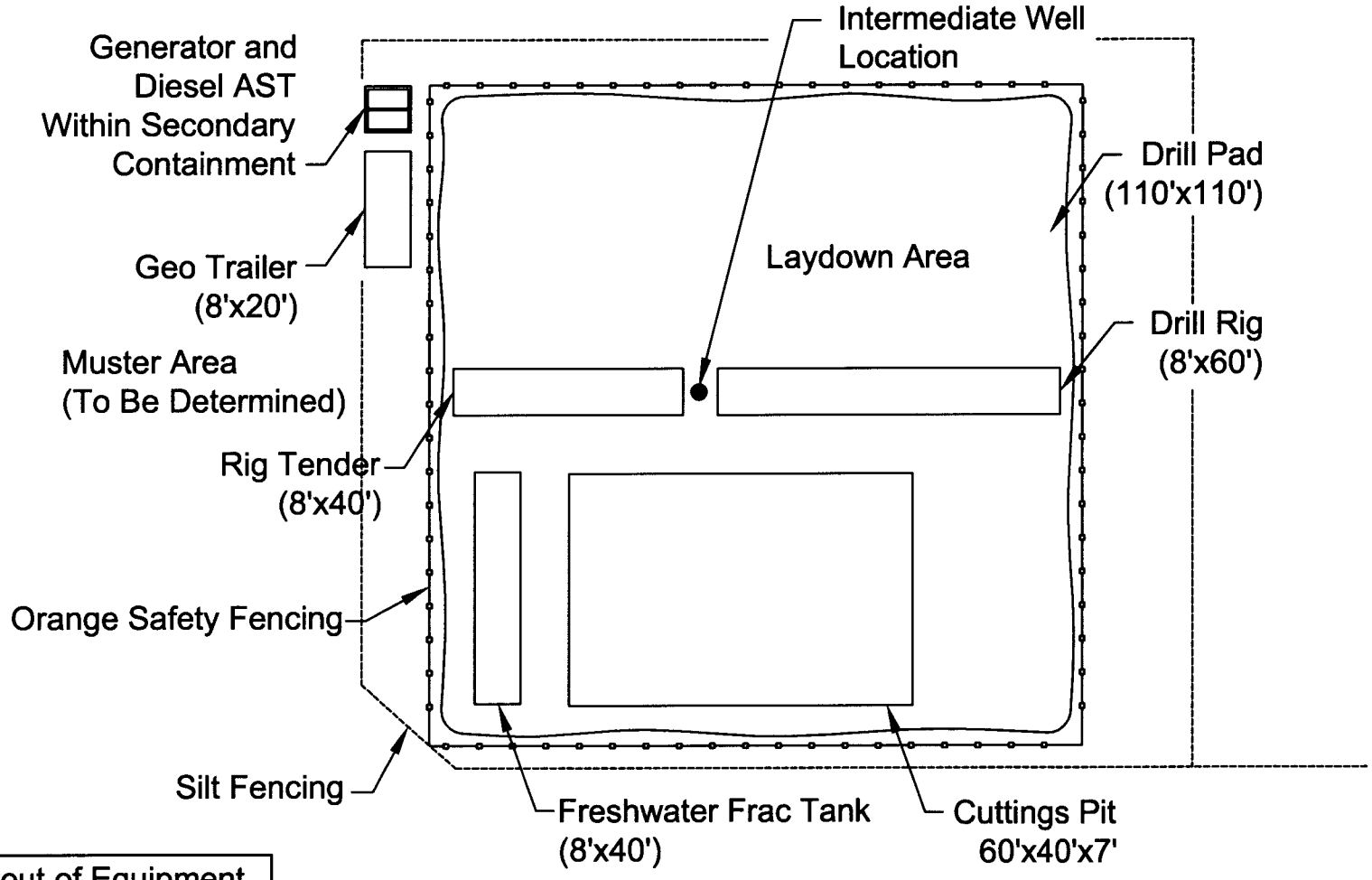


Figure 2. Project Organization Chart



Exact Layout of Equipment to be Determined Based on Actual Site Conditions

30 0 15 30

SCALE: 1 inch =30 ft.
All Locations are Approximate

KLEINFELDER

Drawn By: C. Landon
Project No.: 49436

Date: September 2004
Filename: Figure 3.dwg

GENERALIZED SITE PLAN
Intermediate Wells
Mortandad Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

FIGURE
3

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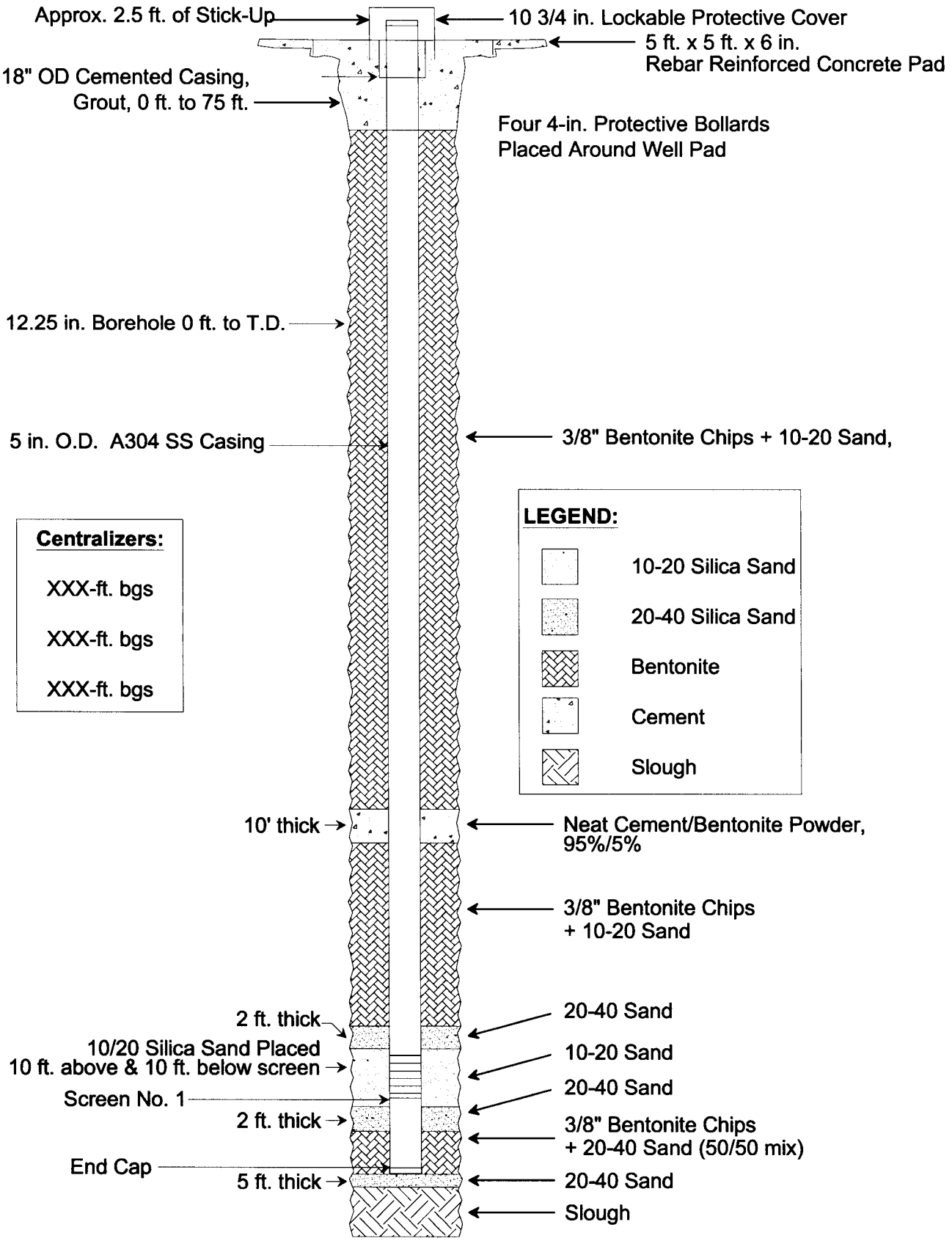
Kleinfelder, Inc. 2004



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Drawn By: C. Landon
Project No.: 49436

Date: September 2004
Filename: Figure 4.dwg

TYPICAL INTERMEDIATE WELL CONSTRUCTION DIAGRAM
Mortandad Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

FIGURE
4

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Table 1
Roles and Responsibilities

Name	Role	Responsibility
Paul Fensterer	Program Manager	Project management, budget, resource commitments, DOE/USACE interaction
Barbara Everett	Deputy Program Manager	Assist Program Manager in overall project management, budget, resource commitments, DOE/USACE interaction, daily activity management
Christopher Johnson	Program Hydrogeologist	Technical hydrogeology oversight
Richard Bohrer	Health & Safety Manager	SSHASP and compliance
Charlie Smiroldo	Quality Assurance Director	Develop, implement, manage, and continuously improve the Quality Assurance Program
Bernie Bockisch	Field Manager	Daily logistics and site management, subcontractor coordination, SSHASP, security
Mark Everett	Technical Manager/ Lead Geologist	Schedule management, LANL interaction, technical training, CQMP, reports, geophysics
Robert Helton	Drilling Manager (Spectrum)	HSA drilling, coring management, and technical support

Table 2
Key Personnel Phone List

Role	Name	Affiliation	Phone #	Cell #
Program Manager	Paul Fensterer	Kleinfelder	344-7373	
Deputy Program Manager	Barbara Everett	Kleinfelder	344-7373	328-4844
Project Manager	Mark Everett	Kleinfelder	344-7373	681-5333
Field Manager	Bernie Bockisch	Kleinfelder		401-1955
H&S Manager	Rich Bohrer	Kleinfelder	(916) 366-1701	
Program Hydrogeologist	Chris Johnson	Kleinfelder	(559) 486-0750	(559) 779-4051
Spectrum Manager	Rob Helton	Spectrum	797-0803	681-6546
Enviroworks Field Manager	Vern Cates	E-Works		362-0183
Enviroworks Manager	Sean Grossetete	E-Works	765-5887	362-1050
DOE Project Manager	Tom Whitacre	DOE/NNSA	665-5042	699-2308
DOE H&S Manager	David Barber	DOE/NNSA	667-3818	
Drilling Advisor	Mike Klahn	Independent		231-2409
LANL Project Manager	Danny Katzman	LANL	667-6333	699-1042
LANL Field Ops Support	Steve Pearson	LANL	667-3005	699-3684
LANL Technical Lead	David Broxton	LANL	667-2492	699-0950
LANL Geochemistry Lead	Pat Longmire	LANL	665-1264	699-1987
LANL Geology Lead	David Vaniman	LANL	667-1863	699-1079
LANL Chemist	Dale Counce	LANL	667-1224	
SMO	Keith Greene	LANL	665-9966	
Core Submittal	Mike Clevenger	LANL	665-6809	
RCT Pool	Larry Pacheco	LANL	667-5185	
FMU 8 Contact	Charles Trujillo	LANL	667-0491	
Rad Source Control	Gilbert Estrada	LANL	665-5298	
Training Center	Staff	LANL	667-0059	

TABLE 3A - INTERMEDIATE WELL DRILLING SEQUENCE AND DATA TABLE - Drilling Methods, Target Unit, Depth and Hydrogeologic Testing

Intermediate Well No.	Proposed Well Sequence	Est. Well Depth (ft)	Target Unit	Drilling Method	Hydraulic Testing
I-1	6	800	base of dacitic lavas	Air/foam rotary proposed. Down-the-hole hammer may be used in Cerros Del Rios Basalt	Constant rate pumping preferred with slug-in or pump-to-evacuation as options.
I-3[1]	7	770	base of Cerros del Rio	Air/foam rotary proposed. Down-the-hole hammer may be used in Cerros Del Rios Basalt	Constant rate pumping preferred with slug-in or pump-to-evacuation as options.
I-4	2	517	base of upper Puye	Air/foam rotary proposed. Down-the-hole hammer may be used in Cerros Del Rios Basalt	Cross-hole pump test using MCOBT-4.4
I-5	1	760	base of Cerros del Rio	Air/foam rotary proposed. Down-the-hole hammer may be used in Cerros Del Rios Basalt	Constant rate pumping preferred with slug-in or pump-to-evacuation as options.
I-6	3	760	base of Cerros del Rio	Air/foam rotary proposed. Down-the-hole hammer may be used in Cerros Del Rios Basalt	Constant rate pumping preferred with slug-in or pump-to-evacuation as options.
I-8	4	750	base of Cerros del Rio	Air/foam rotary proposed. Down-the-hole hammer may be used in Cerros Del Rios Basalt	Constant rate pumping preferred with slug-in or pump-to-evacuation as options.
I-10	5	1000	base of Cerros del Rio	Air/foam rotary proposed. Down-the-hole hammer may be used in Cerros Del Rios Basalt	Constant rate pumping preferred with slug-in or pump-to-evacuation as options.

[1] I-3 may not be drilled since no perched water was seen in R-33.

TABLE 3B - INTERMEDIATE CORE DRILLING SEQUENCE and DATA TABLE

Intermediate Well No.	Proposed Coring Sequence	Core Depth (ft)	[1, 2] Core Sampling Suite
I-1	6	550	B/CDF
I-3	1	550 [2]	B
I-5	3	500	B
I-6	2	500	B
I-8	4	530	B
I-10	5	300 to 800	B

[1] Core Sampling Suite (see Table 5A-5D for sampling frequency):

A = Analysis of leachates for anions, cations, Al, Fe, and Mn by LANL; 3H by an external lab; analysis of core for moisture content by LANL and of radionuclides (isotopes of Am, Pu, U, Cs, and Sr) by an external lab.

B = Analysis of leachates from core as in A, plus stable isotopes (H,O,N).

C = Petrographic analysis by LANL.

D = Quantitative X-ray diffraction (QXRD) by LANL.

E = Clay mineral separation and analysis by LANL

F = X-ray fluorescence analysis by LANL

G = Moisture analysis by LANL

Kd = Radionuclide distribution coefficient

[2] I-3 may not be drilled since no perched water was seen in R-33. Core depth for I-3 may be modified to 450 feet bgs.

Table 4
Data Quality Objectives for Intermediate Wells in Mortandad Canyon

	Well I-1	Well I-3	Well I-4	Wells I-5, I-6	Well I-8	Well I-10
Conceptual Model Uncertainty	Determine whether contaminant-bearing perched zones occur within ~1000 ft of the confluence of Effluent and Mortandad Canyons Satisfies objectives of this work plan if no saturation encountered	Determine whether perched zones occur beneath lower Ten Site Canyon Determine whether contaminant contents indicate any component of lateral migration from Mortandad Canyon Satisfies objectives of this work plan if no saturation encountered	Replace MCOB-4.4, which encountered a perched zone with ^3H, ClO_4, U, and NO_3 Replacement well to be used to monitor this zone	Provide a more complete record of the contaminated perched zone sample when regional well R-15 was drilled (1-5) Provide constraints on how this contaminant zone extends toward the axis of Mortandad Canyon (I-6; see well I-10 for extent to the south) Satisfies objectives of this work plan if not saturation encountered	Determine if perched zones occur upstream of the confluence of Mortandad Canyon and Ten Site Canyon Define nature and extent of contamination in basalt Use Contaminant signatures in I-8 to test possibility of perched-zone contamination between I-8 and I-3 Satisfies objectives of this work plan if no saturation encountered	Determine whether the perched contaminated zone discovered at R-15 extends southward beneath the mesa and toward PM-5 (see wells I-5 and I-6 for extent to the north) Satisfies objectives of this work plan if not saturation encountered
Projected Depth	800 ft; penetrate to base of dacitic lavas	770 ft; penetrate to base of Cerros del Rio basalt	517 ft; penetrate to base of upper Puye Formation	760 ft; penetrate to base of Cerros del Rio basalt	750 ft; penetrate to base of Cerro del Rio basalt	1000 ft; penetrate to base of Cerros del Rio basalt
Geology	Determine thickness of Bandelier Tuff and Cerro Toledo interval, upper Puye Formation, and dacitic lavas 0.25 mi east of TA-50 discharge	Determine thickness of alluvium; Bandelier Tuff and Cerro Toledo interval; upper Puye Formation; and Cerro del Rio lavas Determine distribution of basalts (potential fast pathways) hosting perched zone(s)	None: Characterized during installation of MCOBT-4.4	Determine thickness of alluvium; Bandelier Tuff and Cerro Toledo interval; upper Puye Formation; and Cerro del Rio basalt Determine distribution of basalts (potential fast pathways) hosting perched zone(s)	Determine thickness of alluvium/colluvium; Bandelier Tuff and Cerro Toledo interval; upper Puye Formation; and Cerro del Rio basalt Determine distribution of basalts (potential fast pathways) hosting perched zone(s)	Determine thickness of Bandelier Tuff and Cerro Toledo interval; upper Puye Formation; and Cerro del Rio basalt Determine distribution of basalts (potential fast pathways) hosting perched zone(s)
Hydrology	Determine hydraulic gradient, flow direction, discharge, recharge, and extent of saturation in the Guaje Pumice Bed or above dacitic lavas 0.25 mi east of TA-50 discharge	Determine hydraulic gradient, flow direction, discharge, recharge, and extent of saturation in the Cerros del Rio basalt in Ten Site Canyon southeast of TW-8	Determine hydraulic gradient, flow direction, discharge, recharge, and extent of saturation in the upper Puye Formation at MCOBT-4.4	Determine hydraulic gradient, flow direction, discharge, recharge, and extent of saturation in the Cerros del Rio basalt in Mortandad Canyon at R-15 (I-5) and north of R-15 (I-6)	Determine hydraulic gradient, flow direction, discharge, recharge, and extent of saturation in the Cerros del Rio basalt in Mortandad Canyon west of MCOBT-4.4 near MCO-6	Determine hydraulic gradient, flow direction, discharge, recharge, and extent of saturation in the Cerros del Rio basalt south of Mortandad Canyon near R-15
Geochemistry	Evaluate hydrochemistry of Cerro Toledo interval, Guaje Pumice Bed, or above dacitic lavas 0.25 mi east of TA-50 discharge	Evaluate hydrochemistry of Cerros del Rio basalt Evaluate effect of releases from TA-35 on water quality in perched groundwater	Evaluate hydrochemistry of upper Puye Formation Evaluate effect of releases from TA-50 and TA-35 on water quality in perched groundwater	Evaluate hydrochemistry of Cerros del Rio Basalt Evaluate effect of releases from TA-50 and TA-35 on water quality in perched groundwater	Evaluate hydrochemistry of Cerros del Rio Basalt Evaluate effect of releases from TA-50 and TA-35 on water quality in perched groundwater	Evaluate hydrochemistry of Cerros del Rio Basalt Evaluate effect of releases from TA-50 and TA-35 on water quality in perched groundwater
Vadose Zone Sampling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling	None: samples collected during drilling and subsequent sampling of MCOBT-4.4 Collect water samples if perched water is encountered during drilling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling
Core Needs	Collect core samples from **surface to core refusal (550 ft)** for contaminant, metal, and anion analyses	Collect core samples from **surface to core refusal (560 ft)** for contaminant, metal, and anion analyses	**None**: samples collected during drilling of MCOBT–4.4	Collect core samples from **surface to core refusal (500 ft)** for contaminant, metal, and anion analyses	Collect core samples from **surface to core refusal (530 ft)** for contaminant, metal, and anion analyses	Collect core samples **from 300 to 800 ft** for contaminant, metal, and anion analyses
Hydrologic Testing	Constant rate pumping preferred. Slug test and/or pump-to-evacuation as option. Completely below the perched water table.	Constant rate pumping preferred. Slug test and/or pump-to-evacuation as option. Completely below the perched water table.	Possibly use cross-hole pumping tests between existing well MCOBT-4.4 and well I-4 if geochemical sampling not compromised	Constant rate pumping preferred. Slug test and/or pump-to-evacuation as option. Completely below the perched water table.	Constant rate pumping preferred. Slug test and/or pump-to-evacuation as option. Completely below the perched water table.	Constant rate pumping preferred. Slug test and/or pump-to-evacuation as option. Completely below the perched water table.
Geophysical Testing	Suite and timing of geophysical logging to depend on borehole conditions (suite of possible logs provided in Table 7) Laboratory borehole video camera to be used when open-hole conditions in the vadose zone are favorable for logging	Suite and timing of geophysical logging to depend on borehole conditions (suite of possible logs provided in Table 7) Laboratory borehole video camera to be used when open-hole conditions in the vadose zone are favorable for logging	None: geophysical logs were collected during the installation of MCOBT-4.4	Suite and timing of geophysical logging to depend on borehole conditions (suite of possible logs provided in Table 7) Laboratory borehole video camera to be used when open-hole conditions in the vadose zone are favorable for logging	Suite and timing of geophysical logging to depend on borehole conditions (suite of possible logs provided in Table 7) Laboratory borehole video camera to be used when open-hole conditions in the vadose zone are favorable for logging	Suite and timing of geophysical logging to depend on borehole conditions (suite of possible logs provided in Table 7) Laboratory borehole video camera to be used when open-hole conditions in the vadose zone are favorable for logging
Number of Well Screens	One in Guaje Pumice Bed or dacite lava flows	One in Cerros del Rio basalt	One in upper Puye Formation	One in Cerros del Rio basalt	One in Cerros del Rio basalt	One in Cerros del Rio basalt

Note: Intermediate wells I-2 (upper Ten Site Canyon near R-14), I-7 (on the bench south of GS-2), and I-9 (1500 ft of PM-5) will be evaluated for relocation and drilling after the other I- and R-wells are drilled.

Table 5A
Borehole I-1

Analyte Suite	Moisture/ Anions (EES-6)	Nitrogen Isotopes (EES-6)	Tritium (offsite)	δ^2H and $\delta^{18}O$ (offsite)	Rad Screening (ARS)	Rad Suite (Sr, Cs, Pu, Am, U) (offsite)	Cations (EES-6)
Sample Priority	1	2	3	4		5	6
Core Length and Container	Pre-Weighed Glass Bottles	0.5 ft in capped lexan in core protect foil	0.5 ft in capped lexan in core protect foil	0.5 ft in capped lexan in core protect foil	~5 grams in Bag	500 ml poly	125 ml poly
Sample Depth (ft)							
75	1	1	1	1	1	1	1
85	1	1	1		1	1	1
95	1	1	1		1	1	1
105	1	1	1		1	1	1
115	1	1	1		1	1	1
125	1	1	1	1	1	1	1
135	1	1	1		1	1	1
145	1	1	1		1	1	1
155	1	1	1		1	1	1
165	1	1	1		1	1	1
175	1	1	1	1	1	1	1
225	1	1	1		1	1	1
275	1	1	1	1	1	1	1
325	1	1	1	1	1	1	1
375	1	1	1	1	1	1	1
425	1	1	1	1	1	1	1
475	1	1	1	1	1	1	1
at TD	1	1	1	1	1	1	1
Totals	18	18	18	9	18	18	18

Notes:

1 Sample intervals and analyte list provided by LANL scientists 10/4/05. This list supercedes DQOs from the Mortandad Canyon Groundwater Work Plan Revision 1 (Jan. 2004, LA-UR-0165, ER2004-0019).

2 Core filled Lexan™ tubes are to be cut in 0.5 ft pieces, caps placed on each end, and sealed with core protect foil immediately upon core collection.

3 Rad suite and cations sample collection (shaded area) will be transferred from the Lexan™ tubes to the appropriate container after exact interval has been selected by LANL scientists while core is being described in the core trailer or FSF.

Table 5B
Borehole I-6

Analyte Suite	Moisture/ Anions (EES-6)	Nitrogen Isotopes (EES-6)	Tritium (offsite)	δ^2H and $\delta^{18}O$ (offsite)	Rad Screening (ARS)	Rad Suite (Sr, Cs, Pu, Am, U) (offsite)	Cations (EES-6)
Sample Priority	1	2	3	4		5	6
Core Length and Container	Pre-Weighed Glass Bottles	0.5 ft in capped lexan in core protect foil	0.5 ft in capped lexan in core protect foil	0.5 ft in capped lexan in core protect foil	~5 grams in Bag	500 ml poly	125 ml poly
Sample Depth (ft)							
10	1	1	1		1	1	1
20	1	1	1		1	1	1
30	1	1	1		1	1	1
40	1	1	1		1	1	1
50	1	1	1	1	1	1	1
60	1	1	1		1	1	1
70	1	1	1		1	1	1
80	1	1	1		1	1	1
90	1	1	1		1	1	1
100	1	1	1	1	1	1	1
120	1	1	1		1	1	1
140	1	1	1		1	1	1
150				1	1		
160	1	1	1		1	1	1
180	1	1	1		1	1	1
200	1	1	1	1	1	1	1
220	1	1	1		1	1	1
240	1	1	1		1	1	1
250				1	1		
260	1	1	1		1	1	1
280	1	1	1		1	1	1
300	1	1	1	1	1	1	1
320	1	1	1		1	1	1
340	1	1	1		1	1	1
350				1	1		
360	1	1	1		1	1	1
380	1	1	1		1	1	1
400				1	1		
430	1	1	1		1	1	1
450				1	1		
480	1	1	1		1	1	1
at TD	1	1	1	1	1	1	1
Totals	27	27	27	10	32	27	27

Notes:

1 Sample intervals and analyte list provided by LANL scientists 10/4/05. This list supercedes DQOs from the Mortandad Canyon Groundwater Work Plan Revision 1 (Jan. 2004, LA-UR-0165, ER2004-0019).

2 Core filled Lexan™ tubes are to be cut in 0.5 ft pieces, caps placed on each end, and sealed with core protect foil immediately upon core collection.

3 Rad suite and cations sample collection (shaded area) will be transferred from the Lexan™ tubes to the appropriate container after exact interval has been selected by LANL scientists while core is being described in the core trailer or FSF.

Table 5C
Borehole I-8

Analyte Suite	Moisture/ Anions (EES-6)	Nitrogen Isotopes (EES-6)	Tritium (offsite)	δ^2H and $\delta^{18}O$ (offsite)	Rad Screening (ARS)	Rad Suite (Sr, Cs, Pu, Am, U) (offsite)	Cations (EES-6)
Sample Priority	1	2	3	4		5	6
Core Length and Container	Pre-Weighed Glass Bottles	0.5 ft in capped lexan in core protect foil	0.5 ft in capped lexan in core protect foil	0.5 ft in capped lexan in core protect foil	~5 grams in Bag	500 ml poly	125 ml poly
Sample Depth (ft)							
10	1	1	1		1	1	1
20	1	1	1		1	1	1
30	1	1	1		1	1	1
40	1	1	1		1	1	1
50	1	1	1	1	1	1	1
60	1	1	1		1	1	1
70	1	1	1		1	1	1
80	1	1	1		1	1	1
90	1	1	1		1	1	1
100	1	1	1	1	1	1	1
120	1	1	1		1	1	1
140	1	1	1		1	1	1
150				1	1		
160	1	1	1		1	1	1
180	1	1	1		1	1	1
200	1	1	1	1	1	1	1
220	1	1	1		1	1	1
240	1	1	1		1	1	1
250				1	1		
260	1	1	1		1	1	1
280	1	1	1		1	1	1
300	1	1	1	1	1	1	1
320	1	1	1		1	1	1
340	1	1	1		1	1	1
350				1	1		
360	1	1	1		1	1	1
380	1	1	1		1	1	1
400				1	1		
430	1	1	1		1	1	1
450				1	1		
480	1	1	1		1	1	1
500				1	1		1
530	1	1	1		1	1	
at TD	1	1	1	1	1	1	1
Totals	28	28	28	11	34	28	28

Notes:

1 Sample intervals and analyte list provided by LANL scientists 10/4/05. This list supercedes DQOs from the Mortandad Canyon Groundwater Work Plan Revision 1 (Jan. 2004, LA-UR-0165, ER2004-0019).

2 Core filled Lexan™ tubes are to be cut in 0.5 ft pieces, caps placed on each end, and sealed with core protect foil immediately upon core collection.

3 Rad suite and cations sample collection (shaded area) will be transferred from the Lexan™ tubes to the appropriate container after exact interval has been selected by LANL scientists while core is being described in the core trailer or FSF.

Table 5D
Borehole I-10

Analyte Suite	Moisture/ Anions (EES-6)	Nitrogen Isotopes (EES-6)	Tritium (offsite)	δ^2H and $\delta^{18}O$ (offsite)	Rad Screening (ARS)	Rad Suite (Sr, Cs, Pu, Am, U) (offsite)	Cations (EES-6)
Sample Priority	1	2	3	4		5	6
Core Length and Container	Pre-Weighed Glass Bottles	0.5 ft in capped lexan in core protect foil	0.5 ft in capped lexan in core protect foil	0.5 ft in capped lexan in core protect foil	~5 grams in Bag	500 ml poly	125 ml poly
Sample Depth (ft)							
300	1	1	1	1	1	1	1
310	1	1	1		1	1	1
320	1	1	1		1	1	1
330	1	1	1		1	1	1
340	1	1	1		1	1	1
350	1	1	1	1	1	1	1
360	1	1	1		1	1	1
370	1	1	1		1	1	1
380	1	1	1		1	1	1
390	1	1	1		1	1	1
400				1	1		
440	1	1	1		1	1	1
450				1	1		
490	1	1	1		1	1	1
500				1	1		
540	1	1	1		1	1	1
550				1	1		
590	1	1	1		1	1	1
600				1	1		
640	1	1	1		1	1	1
650				1	1		
690	1	1	1		1	1	1
700				1	1		
740	1	1	1		1	1	1
750				1	1		
790	1	1	1		1	1	1
at TD	1	1	1	1	1	1	1
Totals	19	19	19	11	27	19	19

Notes:

1 Sample intervals and analyte list provided by LANL scientists 10/4/05. This list supercedes DQOs from the Mortandad Canyon Groundwater Work Plan Revision 1 (Jan. 2004, LA-UR-0165, ER2004-0019).

2 Core filled Lexan™ tubes are to be cut in 0.5 ft pieces, caps placed on each end, and sealed with core protect foil immediately upon core collection.

3 Rad suite and cations sample collection (shaded area) will be transferred from the Lexan™ tubes to the appropriate container after exact interval has been selected by LANL scientists while core is being described in the core trailer or FSF.

Table 6
Sampling and Analysis of Intermediate Well Groundwater

Estimated Number of Water Samples/ Borehole [a]	Analysis	Container	Preservation	Filtered Through Acetate 0.45 Micrometer	Volume of Each Sample (L)	Collect Archival Sample	Archival Sample Volume (L)
4	Metals (dissolved)	100 ml plastic	HNO_3 to pH 2, 4°C	Yes	0.25	none	
4	Anions (dissolved)	100 ml plastic	No preservation [c]	Yes	0.25	none	
4	γ spec, ^{241}Am, ^{137}Cs, $^{238,239,240}Pu$, $^{234,235,238}U$, ^{90}Sr	1 gal. plastic	HNO_3 to pH 2, 4°C	No	3.78	X	3.78
4	Stable isotopes ($^{18}O/^{16}O$, D/H)	30 ml glass w/ poly-seal cap	Ambient temperature	No	0.03	X	0.03
4	Stable isotopes ($^{15}N/^{14}N$)	1 gal. plastic	HCl or H_2SO_4 to pH 2, 4°C	No	3.78	X	3.78
4	Tritium [b]	500 ml poly	Ambient temperature	No	0.5	X	0.5
4	Tritium (low-level or direct-counting) [b]	500 ml poly	Ambient temperature	No	0.5	X	1
4	Gross α, ß ,γ (for off-site shipping)	500 ml poly	Ambient temperature	No	0.5	X	0.5
4	TKN	1 L poly	H_2SO_4 to pH 2, 4°C [c]	No	1	X	1
4	ClO_4	250 ml poly	Ambient temperature [c]	Yes	0.25	X	0.25
Total volume of each sample event: filtered and non-filtered					10.84		10.84
Part of total volume to be filtered					0.75		

[a] Samples to be collected include one grab sample from a perched zone, one grab sample from borehole at TD, one sample after well development, and one sample after aquifer testing.

[b] Initially analyze tritium using liquid scintillation. If activity is less than 300 pCi/L, analyze archival sample using direct counting or electrolytic enrichment at University of Miami.

[c] No preservation for ClO_4^-, Br^-, Cl^-, F^-, NO_3^-, NO_2^-, SO_4^{2-}, and PO_4^{3-}

Table 7
Typical Wire-Line Geophysical Logging Tools

Tool	Cased Hole	Open Hole	Uncased Hole
Array Induction Tool (AIT)		X	Measures open-hole formation conductivity with multiple depths of investigation at varied vertical resolution
Triple-detector Litho-density (TLD)	X	X	Evaluate formation porosity where grain density can be estimated
Combinable Magnetic Resonance (CMR)		X	Provides information on water content and relative abundance of hydrous minerals and capillary-bound versus mobile water
Gross Gamma Ray (GR)	X	X	Used to distinguish lithologies by their gross gamma signature; also used to calibrate depth of other geophysical tool readings
Natural Gamma Spectroscopy (NGS; also called the spectral gamma tool)	X	X	Used to distinguish lithologies where formations vary in relative and overall concentrations of potassium, thorium, and/or uranium
Epithermal Compensated Neutron Tool (CNT)	X	X	Measures moisture content in unsaturated conditions and porosity in saturated conditions
Caliper		X	Measures rugosity of borehole well
Formation Micro-Imager (FMI)		X	Provides high-quality image of borehole based on electrical properties; used to determine lithologies, bedding attitudes, fracture characteristics, and borehole deviation. Only works in fluid-filled borehole.
Elemental Capture Spectroscopy (ECS)	X	X	Determined formation lithology from bulk geochemistry; primary use in determining elemental concentrations of H, S, Si, Ca Cl, K, Fe+Al, Ti and Gd

APPENDIX A
MATERIAL SAFETY DATA SHEETS

AQUAGEL GOLD SEAL®

Premium Untreated Sodium Bentonite

Description

AQUAGEL GOLD SEAL is a premium, high-yielding Wyoming sodium bentonite that contains no polymer additives or chemical treatments of any kind. AQUAGEL GOLD SEAL is a 200 mesh dry-powdered clay that can be added directly to fresh water or freshwater drilling fluids. AQUAGEL GOLD SEAL functions as a viscosifier and filtrate reducer in freshwater drilling fluids.

Applications/Functions

- Viscosify freshwater drilling fluids
- Reduce filtration by forming a thin filter cake with low permeability
- Improves hole cleaning capabilities
- Promote hole stability in poorly consolidated formations

Advantages

- Naturally-occurring clay mineral without chemical additives
- ANSI/NSF Standard 60 certified
- Ideal for geotechnical drilling and environmental monitoring well drilling applications
- Develops gel structure for cuttings suspension
- Quality controlled and manufactured to exceed API Specification 13A, section 5
- Filter cake easily removed from formation by the back flow
- Provides lubricity in drilling fluids

Typical Properties

Appearance	Variable-colored powder (gray to tan)
Bulk density, lb/ft^3	68 to 72 (as packaged)

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Rev 6/2001 IDP 003

Because the conditions of use of this product are beyond the seller's control, Baroid suggests that the purchaser make its own test to determine the suitability for the purchaser's application. Purchaser assumes all risks of use and handling of this product. This product will be replaced if defective in manufacture or packaging. Except for such replacement, seller is not liable for any damages caused by this product or its use. EXCEPT AS EXPRESSLY PROVIDED FOR ABOVE, THIS PRODUCT IS PROVIDED "AS-IS", AND BAROID MAKES NO OTHER WARRANTIES WITH RESPECT TO THE PRODUCT. BAROID DISCLAIMS ALL OTHER EXPRESS OR IMPLIED WARRANTIES INCLUDING ANY WARRANTIES OF MERCHANTABILITY ACCURACY OF DATA, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT

Recommended Treatment

Mix slowly through a jet mixer or sift slowly into the vortex of a high-speed stirrer.

Approximate Amounts of AQUAGEL GOLD SEAL® Added to Fresh Water or to Freshwater Drilling Fluids			
Application/Desired Result			
Added to Fresh Water	**lb/100 gal**	**lb/bbl***	**kg/m^3**
Under normal drilling conditions	30-50	13-22	35-60
To stabilize caving formations	60-80	25-35	70-100
To stop circulation loss	70-95	30-40	85-110
Added to Freshwater Mud	**lb/100 gal**	**lb/bbl***	**kg/m^3**
Under normal drilling conditions	10-25	4-10	11-28
To stabilize caving formations	20-45	9-18	25-50
To aid in control of lost circulation	25-50	10-20	28-56

- 1 bbl = 42 U.S. gallons

Packaging

AQUAGEL GOLD SEAL premium bentonite is packaged in 50-lb (22.7 kg) or 100-lb (45.4 kg) multiwall paper bags.

Availability

AQUAGEL GOLD SEAL can be purchased through any Baroid Industrial Drilling Products Distributor. To locate the Baroid IDP distributor nearest you contact the Customer Service Department in Houston or your area IDP Sales Representative.

Baroid Industrial Drilling Products,
A Product and Service Line of Halliburton Energy Services, Inc.
3000 N. Sam Houston Pkwy. E.
Houston, TX 77032

Customer Service	(800) 735-6075 Toll Free	(281) 871-4612
Technical Service	(877) 379-7412 Toll Free	(281) 871-4613

EZ-MUD®

Polymer Emulsion

Description

EZ-MUD, a liquid polymer emulsion containing partially hydrolyzed polyacrylamide/polyacrylate (PHPA) copolymer, is used primarily as a borehole stabilizer to prevent reactive shale and clay from swelling and sloughing. EZ-MUD is also added to low-solids drilling fluids to increase lubricity, fluid viscosity, and to improve carrying capacity of air/foam injection fluids.

Applications/Functions

- Stabilize reactive shale and clay formations
- Improve borehole stability
- Enhance slurry rheological properties
- Alleviate mud rings, bit balling and booting-off in clay formations
- Reduce drill pipe torque and pumping pressure
- Minimize rod chatter in diamond core drilling
- Create "stiff-foam" and maintain foam integrity
- Flocculate non-reactive solids in reserve pit at low concentrations

Advantages

- Mixes easily with minimum shear in fresh water
- Provides effective clay and shale stabilization with lower viscosity
- Imparts high degree of lubricity
- Non-fermenting
- Breaks down chemically with bleach (sodium hypochlorite)
- ANSI/NSF Standard 60 Certified

Typical Properties

Appearance	Thick, opaque white liquid
Density	8.5 lb/gal (1.02 g/cm^3)
pH (1 quart per 100 gallons water)	8.5
Flash point, PMCC °F, °C	>200 (>93.3)
Thermal stability, °F, °C	250 (121)

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BORE-GEL is a trademark of Halliburton Energy Services, Inc.

Rev 5/2001 IDP 008

Because the conditions of use of this product are beyond the seller's control, Baroid suggests that the purchaser make its own test to determine the suitability for the purchaser's application. Purchaser assumes all risks of use and handling of this product. This product will be replaced if defective in manufacture or packaging. Except for such replacement, seller is not liable for any damages caused by this product or its use. EXCEPT AS EXPRESSLY PROVIDED FOR ABOVE, THIS PRODUCT IS PROVIDED "AS-IS", AND BAROID MAKES NO OTHER WARRANTIES WITH RESPECT TO THE PRODUCT. BAROID DISCLAIMS ALL OTHER EXPRESS OR IMPLIED WARRANTIES, INCLUDING ANY WARRANTIES OF MERCHANTABILITY, ACCURACY OF DATA, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT

Recommended Treatment

Approximate Amounts of EZ-MUD® Added to Drilling Fluid System			
Drilling Application/Desired Property	**Quarts/ 100 gal**	**Pints/bbl**	**Liters/m³**
Added to fresh water (To formulate a clay-free drilling fluid)			
• To stabilize reactive clay and shale	0.5 - 2.0	0.5 - 1.75	1.25 - 5.0
• To retard rod vibration, reduce torque and pumping pressure	1.0 - 2.0	1.0 - 1.75	2.5 - 5.0
Added to QUIK-GEL® or BORE-GEL™ Drilling Fluids			
• To retard reactive shale and clay and enhance lubricity	0.5 - 1.0	0.5 - 1.0	1.25 - 2.5
Added to injection liquid in air/foam drilling applications			
• To improve foam performance and hole conditions	0.5 - 1.0	0.5 - 1.0	1.25 - 2.5

Notes:

- Make-up water used to mix EZ-MUD should meet the following quality:
  total chloride less than 1500 ppm (mg/L)
  total hardness less than 150 ppm as calcium
  total chlorine less than 50 ppm
  water pH between 8.5-9.5
- Reduce total hardness of make-up water by adding soda ash (sodium carbonate) at 0.5 to 1 pound per 100 gallons (0.6 - 1.2 kg/m³) of make-up water.
- EZ-MUD can be chemically broken down with liquid bleach in regular household concentration (5% sodium hypochlorite). Use one gallon of liquid bleach per 100 gallons (10 liters/m³) of fluid formulated with EZ-MUD. Do not use perfumed liquid bleach or solid calcium hypochlorite.

Packaging

EZ-MUD is packaged in 5-gal (19-liter) and 1-gal (3.8-liter) plastic containers

Availability

EZ-MUD can be purchased through any Baroid Industrial Drilling Products Distributor. To locate the Baroid IDP distributor nearest you contact the Customer Service Department in Houston or your area IDP Sales Representative.

Baroid Industrial Drilling Products,

A Product and Service Line of Halliburton Energy Services, Inc.

3000 N. Sam Houston Pkwy. E.
Houston, TX 77032

Customer Service	(800) 735-6075 Toll Free	(281) 871-4612
Technical Service	(877) 379-7412 Toll Free	(281) 871-4613

PAC™-L

Modified Natural Cellulosic Polymer

Description

PAC-L, modified natural cellulosic polymer, provides filtration control in most water-based drilling fluids without substantially increasing viscosity. PAC-L, when added to a QUIK-GEL® or BORE-GEL™ slurry, yields a drilling mud system suitable for drilling in sandy formation. PAC-L can be added to vegetable or mineral oil to provide an oil-based fluid suspension, which can be poured into drill string directly.

Applications/Functions

- Provide filtration control in fresh or brackish water-based drilling fluids
- Reduce fluid loss without significantly increasing fluid viscosity
- Encapsulate shale to prevent swelling and disintegration
- Promote borehole stability in water sensitive formations
- Minimize rod chatter, rotational torque and circulating pressure
- Improve hole cleaning and core recovery

Advantages

- Effective in fresh water, salt water and brackish water-based drilling fluids
- Effective in small quantities for filtration control
- Non-fermenting
- Compatible with other Baroid drilling fluid additives
- Resistant to harsh environments and contaminants

Typical Properties

Appearance	White, free-flowing powder
pH (1% aqueous solution)	7.75

Recommended Treatment

- Using a Venturi Mixer, or into vortex of a high-speed stirrer, add slowly and uniformly to the entire circulating system.

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BORE-GEL and PAC are trademarks of Halliburton Energy Services, Inc.

Rev. 6/2001 · IDP 059

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Recommended Treatment

Approximate Amounts of PAC™-L Added to Water Based Fluids		
Desired Condition/Result		
Added to fresh or salt water	**lb/100 gal**	**kg/m³**
• To stabilize water sensitive formation	3 – 7	4 – 8.5
• To reduce torque and lower circulating pressure	0.5 - 2	0.6 – 2.4
Added to QUIK-GEL® slurry (25 lb/100 gallons) or (30 kilograms per m³)	**lb/100 gal**	**kg/m³**
• To reduce filtration rate and improve borehole stability	0.5 - 2.0	0.6 – 2.4
Added to BORE-GEL™ slurry (35 lb/100 gallons) or (42 kilograms per m³)	**lb/100 gal**	**kg/m³**
• To reduce filtration rate and improve borehole stability	0.5 – 2.0	0.6 – 2.4

Note:
Very salty waters may require twice as much PAC-L as fresh water. Preferably, PAC-L should be mixed in fresh water before it is added to very salty water.

Packaging

PAC-L is packaged in 50-lb (22.7 kg) bags.

Availability

PAC-L can be purchased through any Baroid Industrial Drilling Products Distributor. To locate the Baroid IDP distributor nearest you contact the Customer Service Department in Houston or your area IDP Sales Representative.

Baroid Industrial Drilling Products
A Product and Service Line of Halliburton Energy Services, Inc.
3000 N. Sam Houston Pkwy. E.
Houston, TX 77032

Customer Service	(800) 735-6075 Toll Free	(281) 871-4612
Technical Service	(877) 379-7412 Toll Free	(281) 871-4613

HALLIBURTON

MATERIAL SAFETY DATA SHEET

PAC®-L

Revision Date: 10/17/2001

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: PAC®-L
Synonyms: None
Chemical Family: Carbohydrate
Application: Fluid Loss Additive

Manufacturer/Supplier
Baroid Drilling Fluids
a Product Service Line of Halliburton Energy Services, Inc.
P.O. Box 1675
Houston, TX 77251

Telephone: (281) 871-4000
Emergency Telephone: (800) 666-9260 or (713) 676-3000

Prepared By
Product Stewardship
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substance	Weight Percent (%)	ACGIH TLV-TWA	OSHA PEL-TWA
Cellulose derivative	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview
May cause eye, skin, and respiratory irritation. Airborne dust may be explosive.

4. FIRST AID MEASURES

Inhalation
If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin
Wash with soap and water. Get medical attention if irritation persists.

Eyes
In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion
Under normal conditions, first aid procedures are not required.

Notes to Physician
Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	430
Flash Point/Range (C):	221
Flash Point Method:	Not Determined
Autoignition Temperature (F):	752
Autoignition Temperature (C):	400
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards
Organic dust in the presence of an ignition source can be explosive in high concentrations. Good housekeeping practices are required to minimize this potential.

Special Protective Equipment for Fire-Fighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0

HMIS Ratings: Flammability 0, Reactivity 0, Health 0

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures
Avoid creating and breathing dust.

Environmental Precautionary Measures
None known.

Procedure for Cleaning/Absorption
Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions
Avoid creating or inhaling dust. Avoid dust accumulations. Slippery when wet.

Storage Information
Store away from oxidizers. Store in a dry location. Product has a shelf life of 12 months

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls
A well ventilated area to control dust levels. Local exhaust ventilation should be used in areas without good cross ventilation.

Respiratory Protection
Not normally needed. But if significant exposures are possible then the following respirator is recommended. Dust/mist respirator. (95%)

Hand Protection
Normal work gloves.

Skin Protection
Normal work coveralls.

Eye Protection
Wear safety glasses or goggles to protect against exposure.

Other Precautions
None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Powder
Color:	White to off white
Odor:	Odorless
pH:	6.5-9 (1% solution)
Specific Gravity @ 20 C (Water=1):	1.6
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	40-55
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Forms gel
Solubility in Solvents (g/100ml):	Not Determined
Solubility in Sea Water (g/100ml):	Forms gel
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C	

(centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data: Stable

Hazardous Polymerization: Will Not Occur

Conditions to Avoid
None known.

Incompatibility (Materials to Avoid)
Strong oxidizers.

Hazardous Decomposition Products
Carbon monoxide and carbon dioxide.

Additional Guidelines
Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure
Eye or skin contact, inhalation.

Inhalation
May cause mild respiratory irritation.

Skin Contact
May cause mild skin irritation.

Eye Contact
May cause mild eye irritation.

Ingestion
None known

Aggravated Medical Conditions
None known.

Chronic Effects/Carcinogenicity
No data available to indicate product or components present at greater than 1% are chronic health hazards.

Other Information
None known.

Toxicity Tests

Oral Toxicity:	LD50: 1260 mg/kg (Rat)
Dermal Toxicity:	Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect: Not determined

Carcinogenicity
Not determined

Genotoxicity: Not determined

Reproductive/Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)
Not determined

Persistence/Degradability
Readily biodegradable

Bio-accumulation
Not Determined

Ecotoxicological Information
Acute Fish Toxicity:
TLM96: > 500 mg/l (Golden orfe)
Acute Crustaceans Toxicity:
Not determined
Acute Algae Toxicity:
Not determined

Chemical Fate Information
Not determined

Other Information
Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method
Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging
Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT

Not restricted

Canadian TDG

Not restricted

ADR

Not restricted

Air Transportation

ICAO/IATA

Not restricted

Sea Transportation

IMDG

Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory
All components listed on inventory.

EPA SARA Title III Extremely Hazardous Substances
Not applicable

EPA SARA (311,312) Hazard Class
None

EPA SARA (313) Chemicals
This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).

EPA CERCLA/Superfund Reportable Spill Quantity For This Product
Not applicable.

EPA RCRA Hazardous Waste Classification
If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.

California Proposition 65
All components listed do not apply to the California Proposition 65 Regulation.

MA Right-to-Know Law
Does not apply.

NJ Right-to-Know Law
Does not apply.

PA Right-to-Know Law
Does not apply.

Canadian Regulations

Canadian DSL Inventory
All components listed on inventory.

WHMIS Hazard Class
Non-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information
For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Product Stewardship at 1-580-251-4335.

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **Potassium Chloride**

Revision Date: 10/01/2002

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: Potassium Chloride
Synonyms: None
Chemical Family: Inorganic Salt
Application: Additive

Manufacturer/Supplier
Baroid Drilling Fluids
a Product Service Line of Halliburton Energy Services, Inc.
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (800) 666-9260 or (713) 676-3000

Prepared By
Product Stewardship
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Potassium chloride	7447-40-7	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview May cause eye, skin, and respiratory irritation.

4. FIRST AID MEASURES

Inhalation If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin Wash with soap and water. Get medical attention if irritation persists.

Eyes In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 1, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 1

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	Prevent from entering sewers, waterways, or low areas.
Procedure for Cleaning/Absorption	Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions	Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.
Storage Information	Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use in a well ventilated area.
Respiratory Protection	Dust/mist respirator. (95%)
Hand Protection	Normal work gloves.
Skin Protection	Normal work coveralls.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White to gray
Odor:	Odorless
pH:	9.2
Specific Gravity @ 20 C (Water=1):	1.99
Density @ 20 C (lbs./gallon):	Not Determined

Bulk Density @ 20 C (lbs/ft3):	72.8
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	25.5
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	74.5

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	None known
Hazardous Decomposition Products	None known.
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	May cause respiratory irritation.
Skin Contact	May cause skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	None known
Aggravated Medical Conditions	None known.
Chronic Effects/Carcinogenicity	No data available to indicate product or components present at greater than 1% are chronic health hazards.
Other Information	None known.

Toxicity Tests

Oral Toxicity:	LD50: 2430 mg/kg (Rat)
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Not determined

Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	All components listed do not apply to the California Proposition 65 Regulation.
MA Right-to-Know Law	Does not apply.
NJ Right-to-Know Law	Does not apply.
PA Right-to-Know Law	Does not apply

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	Un-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Product Stewardship at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

QUIK-FOAM®

High Performance Foaming Agent

Description

QUIK-FOAM, a proprietary blend of alcohol ethoxy sulfates (AES) which are biodegradable, is an effective foaming agent. QUIK-FOAM can be added to fresh, brine, or brackish water for air/foam, air/gel-foam, or mist drilling applications.

Applications/Functions

- Enhance the rate of cuttings removal
- Increase the ability of lifting large volumes of water
- Improve hole-cleaning capability of the airstream
- Reduce the sticking tendencies of wet clays, thereby eliminating mud rings and wall packing
- Reduce erosion of poorly consolidated formations
- Provide a technique for drilling in zones with lost circulation
- Increase borehole stability
- Reduce air-volume requirement
- Suppress dust during air drilling operation

Advantages

- ANSI/NSF Standard 60 Certified
- High quality, high expansion foam with a consistency similar to shaving foam
- High stability with excellent retention time
- Versatile and compatible with various types of make-up water
- Readily undergoes primary and ultimate (>99%) biodegradation
- Proven product for multi-discipline application

Typical Properties

Appearance	Light yellow, transparent liquid
Specific gravity	1.03
pH (0.5% solution)	7.1
Flash point, PMCC °F, °C	82, (28)
Pour point, °F, °C	0, (-18)

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Rev. 6/2001 · IDP 010

QUIK-FOAM, EZ-MUD, QUIK-TROL, and QUIK-GEL are registered trademarks of Halliburton Energy Services, Inc.

Because the conditions of use of this product are beyond the seller's control, Baroid suggests that the purchaser make its own test to determine the suitability for the purchaser's application. Purchaser assumes all risks of use and handling of this product. This product will be replaced if defective in manufacture or packaging. Except for such replacement, seller is not liable for any damages caused by this product or its use. EXCEPT AS EXPRESSLY PROVIDED FOR ABOVE, THIS PRODUCT IS PROVIDED "AS-IS", AND BAROID MAKES NO OTHER WARRANTIES WITH RESPECT TO THE PRODUCT. BAROID DISCLAIMS ALL OTHER EXPRESS OR IMPLIED WARRANTIES, INCLUDING ANY WARRANTIES OF MERCHANTABILITY, ACCURACY OF DATA, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT.

Recommended Treatment

Approximate Amounts of QUIK-FOAM® Added to Injection Water			
Application	**Amount/100 gal**	**Amount/bbl**	**Liters/m^3**
Dry-air drilling (as a dust suppressant)	0.5 - 1 pints	0.2 - 0.5 pints	0.5 - 1.5
Mud-mist drilling in sticky clays	1 - 2 quarts	1 - 2 pints	2.5 - 5
Foam and gel-foam drilling	0.5 - 2 gallons	1.5 - 7 pints	5 - 20
As a slug to clean the annulus	1 pint*	0.5 pints*	0.5**

* in drill pipe, followed by 3 to 5 gallons of water; ** followed by 20 liters of water

Note:

Close product container immediately after use to avoid gelation of remaining QUIK-FOAM.

Product Make-ups for Air Drilling Injection Slurries				
Main Ingredient of Injection Slurry	**Water (gallons)**	**QUIK-GEL® viscosifier (pounds)**	**QUIK-TROL® polymer (pounds)**	**QUIK-FOAM foaming agent (% by volume)**
Foam Drilling System	100	...	...	0.02 - 3.0
Mixing/Injection Procedure Add QUIK-FOAM to injection water. Inject into the air stream at a rate necessary to maintain hole stability and penetration rate. Increase amount of QUIK-FOAM as required to compensate for downhole water dilution				
Firm-Foam Drilling System	100	...	0.5 - 1	0.1 - 2.0
Mixing/Injection Procedure Mix polymer with water before adding QUIK-FOAM. 1-2 pints of EZ MUD® may be used as a substitute for QUIK-TROL. Inject into the air stream at a rate necessary to maintain hole stability and penetration rate.				
Mud-Mist Drilling System	100	25	...	0.3 - 1.0
Mixing/Injection Procedure Mix viscosifier with water before adding QUIK-FOAM. Inject into the air stream at a rate necessary to maintain hole stability and penetration rate. Resulting viscosity is 32-40 sec/qt as measured by Marsh Funnel.				
Gel-Foam Drilling System	100	12 - 15	1	0.3 - 1.0
Mixing/Injection Procedure Mix viscosifier and polymer with water before adding QUIK-FOAM. Inject into the air stream at a rate necessary to maintain hole stability and penetration rate. Resulting viscosity is 32-40 sec/qt as measured by Marsh Funnel.				

Note:

In some states, it is illegal to discharge any foreign substance into the water shed due to potential contamination of ground water. After use, the foam mixture must be localized in an earthen pit or some type of containment and allowed to biodegrade naturally.

Packaging QUIK-FOAM® is packaged in 5-gal (19-liter) plastic containers or in 55-gal (208 liter) drums.

Availability QUIK-FOAM can be purchased through any Baroid Industrial Drilling Products Distributor. To locate the Baroid IDP distributor nearest you contact the Customer Service Department in Houston or your area IDP Sales Representative.

Baroid Industrial Drilling Products,

A Product and Service Line of Halliburton Energy Services, Inc.

3000 N. Sam Houston Pkwy E.

Houston, TX 77032

Customer Service	(800) 735-6075 Toll Free	(281) 871-4612
Technical Service	(877) 379-7412 Toll Free	(281) 871-4613

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1. PRODUCT AND COMPANY IDENTIFICATION

Product Code	00379
Trade Name	QUIK-FOAM®
Generic Description	SURFACTANT BLEND
Manufacturer/Supplier	Baroid
Address	P.O. Box 1675 Houston, TX 77251
Phone Number	(281) 871-5900
Emergency Phone Number	(281) 871-5900
Chemtrec Number	(800) 424-9300
MSDS first issued	12 March 1999
MSDS data revised	

2. COMPOSITION/INFORMATION ON THE COMPONENTS

Hazardous Components in Preparation for US

Component Name	Codes	Concentration
ISOPROPYL ALCOHOL	67-63-0	13.00 - 15.00
ETHANOL	64-17-5	4.00 - 5.00

3. HAZARD IDENTIFICATION

Routes of Entry	- Eye contact - Ingestion - Inhalation - Skin contact
Carcinogenic Status	Not considered carcinogenic by NTP, IARC, and OSHA.
Target Organs	- Eye - Lung - Skin - Central Nervous System - Liver - Kidney
Health Effects - Eyes	Liquid, mist or vapor may cause slight transient irritation. Serious damage may result if treatment is delayed.
Health Effects - Skin	Material will cause irritation. Repeated or prolonged contact may produce defatting of the skin leading to irritation and dermatitis.
Health Effects - Ingestion	A large dose may have the following effects: - irritation of mouth, throat and digestive tract - damage to the central nervous system - liver damage - kidney damage
Health Effects - Inhalation	Exposure to vapor may have the following effects: - irritation of nose, throat and respiratory tract

4. FIRST AID MEASURES

First Aid - Eyes	Immediately flood the eye with plenty of water for at least 15 minutes, holding the eye open. Obtain medical attention immediately.
First Aid - Skin	Wash skin thoroughly with soap and water. Contaminated clothing should be washed or dry-cleaned before re-use.
First Aid - Ingestion	Wash out mouth with water. Induce vomiting. Obtain medical attention immediately.
First Aid - Inhalation	Remove from exposure. If there is difficulty in breathing, give oxygen. If breathing stops or shows signs of failing, give artificial respiration. Obtain medical attention.

4. FIRST AID MEASURES

Advice to Physicians	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Extinguishing Media	Keep containers and surroundings cool with water spray. Use water spray, foam, dry chemical or carbon dioxide.
Special Hazards of Product	Flammable liquid, can release vapors that form flammable mixtures at temperatures at or above the flashpoint.
Protective Equipment for Fire-Fighting	Wear full protective clothing and self-contained breathing apparatus.

6. ACCIDENTAL RELEASE MEASURES

Spill Procedures	Contain and absorb using earth, sand or other inert material. Transfer into suitable containers for recovery or disposal. Spills will create a fire hazard.
Personal Precautions	Wear appropriate protective clothing. Wear respiratory protection.
Environmental Precautions	MODERATELY TOXIC TO FISH. DO NOT USE, SPILL OR DISCARD WHERE IT MAY LEACH, SPILL OR RUN OFF INTO WATERWAYS. Prevent the material from entering drains or water courses. Notify authorities if spill has entered water course or sewer or has contaminated soil or vegetation.

7. HANDLING AND STORAGE

Handling	Use in well ventilated area. Avoid inhaling vapor Avoid contact with eyes, skin and clothing. Keep container tightly closed when not in use.
Storage	Store away from sources of heat or ignition. Storage area should be: - cool - dry - well ventilated - out of direct sunlight - away from incompatible materials

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Occupational Exposure Standards

ISOPROPYL ALCOHOL	ACGIH: TLV 400ppm 8h TWA.
ETHANOL	UK EH40: OES 1000ppm (1900mg/m3) 8h TWA. ACGIH: TLV 1000ppm (1880mg/m3) 8h TWA. A4 - not classifiable as a human carcinogen. OSHA: PEL 1000ppm (1900mg/m3) 8h TWA.
Engineering Control Measures	Exposure to this material may be controlled in a number of ways. The measures appropriate for a particular worksite depend on how the material is used and on the potential for exposure.
Respiratory Protection	Respiratory protection if there is a risk of exposure to high vapor concentrations.
Hand Protection	Chemical resistant gloves

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Eye Protection	Chemical goggles.
Body Protection	Wear: - long sleeves
Protection During Application	During application, adequate ventilation must be provided.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State	Liquid
Color	Light Yellow
Odor	Alcoholic
pH	Range between 7.3 to 7.8.
Specific Gravity	1.02
Flash Point (PMCC) (°C/F)	27-32/80-90
Explosion Limits (%)	Not determined.
Density	8.5 lbs/gal
Solubility in Water	Completely soluble

10. STABILITY AND REACTIVITY

Stability	Stable under normal conditions.
Conditions to Avoid	- High temperatures
Materials to Avoid	- Oxidizing agents - Strong bases
Hazardous Polymerization	Will not occur.
Hazardous Decomposition Products	Incomplete combustion will generate: - oxides of carbon - short chain hydrocarbons - oxides of sulfur - ammonia

11. TOXICOLOGICAL INFORMATION

Acute Toxicity	Acute toxic effects are unlikely to occur in practice because of the warning provided by irritant effects.

12. ECOLOGICAL INFORMATION

Mobility	No relevant studies identified.
Persistence/Degradability	The product is readily biodegradable.
Bio-accumulation	Product is not expected to bioaccumulate.
Ecotoxicity	The product is rated as moderately toxic to aquatic species.

13. DISPOSAL

Product Disposal	Dispose of in accordance with all applicable local and national regulations.
Container Disposal	Labels should not be removed from containers until they have been cleaned. Dispose of containers with care. Containers should be cleaned by appropriate methods and then re-used or disposed of by landfill or incineration as appropriate. Contaminated

13. DISPOSAL

containers must not be re-used. Do not cut, puncture or weld on or near to the container.

14. TRANSPORT INFORMATION

DOT CFR 172.101 Data	Not Regulated
UN Proper Shipping Name	Flammable liquid, n.o.s.
UN Class	Flammable
UN Number	1993
UN Packaging Group	III
IATA - Proper Shipping Name	Flammable liquid, N.O.S.
IATA - Class	3
IATA - Packaging Group	III

15. REGULATORY INFORMATION

TSCA Listed	Yes.
MA Right To Know Law	Listed.
PA Right To Know Law	Listed
NJ Right to Know Law	Listed
California Proposition 65	This product does not contain materials which the State of California has found to cause cancer, birth defects or other reproductive harm.
SARA Title III Sect. 302 (EHS)	Not listed.
SARA Title III Sect. 311/312 Categorization	Immediate (Acute) Health Hazard Delayed (Chronic) Health Hazard Flammable
SARA Title III Sect. 313	This product does not contain a chemical which is listed in Section 313 at or above de deminis concentrations.

16. OTHER INFORMATION

NFPA Ratings	NFPA Code for Health 1 NFPA Code for Flammability 3 NFPA Code for Reactivity 0
Abbreviations	® Registered trademark of Halliburton Energy Services Inc. (TM) Trademark of Halliburton Energy Services N/A: Denotes no applicable information found or available CAS#: Chemical Abstracts Service Number ACGIH: American Conference of Governmental Industrial Hygienists OSHA: Occupational Safety and Health Administration TLV: Threshold Limit Value PEL: Permissible Exposure Limit STEL: Short Term Exposure Limit NTP: National Toxicology Program IARC: International Agency for Research on Cancer R: Risk S: Safety LC50: Lethal Concentration 50%

16. OTHER INFORMATION

LD50: Lethal Dose 50%
BOD: Biological Oxygen Demand
KoC: Soil Organic Carbon Partition Coefficient

Prepared By: Environmental Services

All information recommendations and suggestions herein concerning our product are based on tests and data believed to be reliable, however, it is the user's responsibility to determine the safety, toxicity and suitability for his own use of the product described herein. Since the actual use by others is beyond our control, no guarantees, expressed or implied, is made by Baroid as to the effects of such use, the results to be obtained, or the safety and toxicity of the product nor does Baroid assume any liability arising from the use, by others, of the product referred to herein. Nor is the information herein to be construed as absolutely complete since additional information may be necessary or desirable when particular or exceptional conditions or circumstances exist or because of applicable laws or government regulations.

HALLIBURTON

MATERIAL SAFETY DATA SHEET

SODA ASH

Revision Date: 06/28/2001

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: SODA ASH
Synonyms: None
Chemical Family: Carbonate
Application: Buffer

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431

Emergency Telephone: (800) 666-9260 or (713) 676-3000

Prepared By
Product Stewardship
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substance	Weight Percent (%)	ACGIH TLV-TWA	OSHA PEL-TWA
Sodium carbonate 497-19-8	60 - 100%	Not applicable	Not applicable

3. HAZARDS IDENTIFICATION

Hazard Overview
May cause eye, skin, and respiratory irritation.

4. FIRST AID MEASURES

Inhalation
If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes

difficult.

Skin
Wash with soap and water. Get medical attention if irritation persists.

Eyes
In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion
Do not induce vomiting. Slowly dilute with 1-2 glasses of water or milk and seek medical attention. Never give anything by mouth to an unconscious person.

Notes to Physician
Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Lower (oz./ft3):	Not applicable
Flammability Limits in Air - Upper (%):	Not Determined
Flammability Limits in Air - Upper (oz./ft3):	Not applicable

Fire Extinguishing Media
Water fog, carbon dioxide, foam, dry chemical.

Special Exposure Hazards
Decomposition in fire may produce toxic gases.

Special Protective Equipment for Fire-Fighters
Full protective clothing and approved self-contained breathing apparatus required for fire fighting personnel.

NFPA Ratings:	Health 2, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 2

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures
Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures
Prevent from entering sewers, waterways or low areas.

Procedure for Cleaning/Absorption
Scoop up and remove.

7. HANDLING AND STORAGE

Handling Precautions
Avoid contact with eyes, skin, or clothing. Avoid creating or inhaling dust.

Storage Information
Store away from acids. Store in a cool, dry location.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls
Use in a well ventilated area. Localized ventilation should be used to control dust levels.

Respiratory Protection
Dust/mist respirator. (95%)

Hand Protection
Normal work gloves.

Skin Protection
Normal work coveralls.

Eye Protection
Dust proof goggles.

Other Precautions
Eyewash fountains and safety showers must be easily accessible.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Odorless
pH:	11.4
Specific Gravity @ 20 C (Water=1):	2.5
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	53.8
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Soluble
Solubility in Solvents (g/100ml):	Not Determined
Solubility in Sea Water (g/100ml):	Soluble
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	105.99

10. STABILITY AND REACTIVITY

Stability Data: Stable

Hazardous Polymerization: Will Not Occur

Conditions to Avoid
None anticipated

Incompatibility (Materials to Avoid)
Strong acids.

Hazardous Decomposition Products
Carbon monoxide and carbon dioxide.

Additional Guidelines
Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure
Eye or skin contact, inhalation.

Inhalation
May cause respiratory irritation.

Skin Contact
Prolonged or repeated contact may cause skin irritation.

Eye Contact
May cause eye irritation.

Ingestion
Irritation of the mouth, throat, and stomach.

Aggravated Medical Conditions
None known.

Chronic Effects/Carcinogenicity
No data available to indicate product or components present at greater than 1% are chronic health hazards.

Other Information
None known.

Toxicity Tests

Oral Toxicity: LD50: 4220 mg/kg (Rat)

Dermal Toxicity: Not determined

Inhalation Toxicity: Not determined

Primary Irritation Effect: Not determined

Carcinogenicity
Not determined

Genotoxicity: Not determined

Reproductive/Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)
Not determined

Persistence/Degradability
Not applicable

Bio-accumulation
Not Determined

Ecotoxicological Information
Acute Fish Toxicity:
TLM24: 385 mg/l (Lepomis macrochirus)
Acute Crustaceans Toxicity:
Not determined
Acute Algae Toxicity:
Not determined

Chemical Fate Information
Not determined

Other Information
Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method
Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging
Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT

Not restricted

Canadian TDG

Not restricted

ADR

Not restricted

Air Transportation

ICAO/IATA

Not restricted

Sea Transportation

IMDG

Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory
All components listed on inventory.

EPA SARA Title III Extremely Hazardous Substances
Not applicable

EPA SARA (311,312) Hazard Class
Acute Health Hazard

EPA SARA (313) Chemicals
This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).

EPA CERCLA/Superfund Reportable Spill Quantity For This Product
Not applicable.

EPA RCRA Hazardous Waste Classification
If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.

California Proposition 65
All components listed do not apply to the California Proposition 65 Regulation.

MA Right-to-Know Law
Does not apply.

NJ Right-to-Know Law
Does not apply.

PA Right-to-Know Law
Does not apply.

Canadian Regulations

Canadian DSL Inventory
All components listed on inventory.

WHMIS Hazard Class
Non-Controlled

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information
For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Product Stewardship at 1-580-251-4335.

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **SAND - ARIZONA SILICA**

Revision Date: 11-Feb-2002

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: SAND - ARIZONA SILICA
Synonyms: None
Chemical Family: Sand
Application: Proppant

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (800) 666-9260 or (713) 753-3000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Crystalline silica, quartz	14808-60-7	60 - 100%	0.05 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation

If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin	Wash with soap and water.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	None - does not burn.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 0*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Product has a shelf life of 36 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.

Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Tan
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	2.65
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	100
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	65

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact

None known.

Eye Contact

May cause mechanical irritation to eye.

Ingestion

None known

Aggravated Medical Conditions

Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information

For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined

Reproductive / Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air) Not determined

Persistence/Degradability Not applicable

Bio-accumulation Not Determined

Ecotoxicological Information

Acute Fish Toxicity: Not determined
Acute Crustaceans Toxicity: Not determined
Acute Algae Toxicity: Not determined

Chemical Fate Information Not determined

Other Information Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials (Crystalline silica)

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **SILICA FLOUR**

Revision Date: 19-Jun-2002

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: SILICA FLOUR
Synonyms: None
Chemical Family: Sand
Application: Proppant

Manufacturer/Supplier
Halliburton Energy Services
P.O. Box 1431
Duncan, Oklahoma 73536-0431
Emergency Telephone: (800) 666-9260 or (713) 753-3000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Crystalline silica, quartz	14808-60-7	60 - 100%	0.05 mg/m^3	10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation

If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin	Wash with soap and water.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Not Applicable

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	None - does not burn.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 0*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Store in a cool, dry location. Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Product has a shelf life of 36 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.

Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	White
Odor:	Odorless
pH:	Not Determined
Specific Gravity @ 20 C (Water=1):	2.63
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	70
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	0
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	60.1

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None known.
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.

Inhalation

Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact

None known.

Eye Contact

May cause mechanical irritation to eye.

Ingestion

None known

Aggravated Medical Conditions

Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity

Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information

For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined

Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not applicable
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials (Crystalline silica)

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335.
Disclaimer Statement	This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: **MUD-GEL®**

Revision Date: 05/17/2002

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: MUD-GEL®
Synonyms: None
Chemical Family: Mineral
Application: Weight Additive

Manufacturer/Supplier
Baroid Drilling Fluids
a Product Service Line of Halliburton Energy Services, Inc.
P.O. Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (800) 666-9260 or (713) 676-3000

Prepared By
Product Stewardship
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Bentonite	1302-78-9	60 - 100%	Not applicable	Not applicable
Crystalline silica, quartz	14808-60-7	1 - 5%	0.05 mg/m³	$\frac{10\ mg/m^3}{\%SiO2 + 2}$
Crystalline silica, cristobalite	14464-46-1	0 - 1%	0.05 mg/m³	$1/2 \times \frac{10\ mg/m^3}{\%SiO2 + 2}$
Crystalline silica, tridymite	15468-32-3	0 - 1%	0.05 mg/m³	$1/2 \times \frac{10\ mg/m^3}{\%SiO2 + 2}$

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD
May cause eye and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD
Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media.
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 0*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning/Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions	This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.
Storage Information	Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container. Product has a shelf life of 12 months.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls	Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.
Respiratory Protection	Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product.
Hand Protection	Normal work gloves.
Skin Protection	Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.
Eye Protection	Wear safety glasses or goggles to protect against exposure.
Other Precautions	None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Powder
Color:	Tan to Gray
Odor:	Mild earthy
pH:	8-10
Specific Gravity @ 20 C (Water=1):	2.6
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	50 (uncompacted); 73 (compacted)
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data:	Stable
Hazardous Polymerization:	Will Not Occur
Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A). Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).
Skin Contact	May cause mechanical skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	None known
Aggravated Medical Conditions	Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.
Chronic Effects/Carcinogenicity	Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis. Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2). There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information

For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels:	None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials (Crystalline silica)

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information	For additional information on the use of this product, contact your local Halliburton representative. For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Product Stewardship at 1-580-251-4335.

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

HALLIBURTON

MATERIAL SAFETY DATA SHEET

BENTONITE PELLETS 3\{8 Inch

Revision Date: 02/25/2002

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: BENTONITE PELLETS 3\{8 Inch
Synonyms: None
Chemical Family: Mineral
Application: Weight Additive

Manufacturer/Supplier
Baroid Drilling Fluids
a Product Service Line of Halliburton Energy Services, Inc.
P.O. Box 1675
Houston, TX 77251

Telephone: (281) 871-4000
Emergency Telephone: (800) 666-9260 or (713) 676-3000

Prepared By
Product Stewardship
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

Substance	Weight Percent (%)	ACGIH TLV-TWA	OSHA PEL-TWA
Crystalline silica, cristobalite 14464-46-1	0 - 1%	0.05 mg/m3	1/2 x 10 mg/m3 / %SiO2 + 2
Crystalline silica, tridymite 15468-32-3	0 - 1%	0.05 mg/m3	1/2 x 10 mg/m3 / %SiO2 + 2
Bentonite 1302-78-9	60 - 100%	Not applicable	Not applicable
Crystalline silica, quartz 14808-60-7	1 - 5%	0.05 mg/m3	10 mg/m3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview

CAUTION! - ACUTE HEALTH HAZARD

May cause eye and respiratory irritation.

DANGER! - CHRONIC HEALTH HAZARD

Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease.

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation
If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.

Skin
Wash with soap and water. Get medical attention if irritation persists.

Eyes
In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.

Ingestion
Under normal conditions, first aid procedures are not required.

Notes to Physician
Treat symptomatically.

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media
All standard firefighting media.

Special Exposure Hazards
Not applicable.

Special Protective Equipment for Fire-Fighters
Not applicable.

NFPA Ratings: Health 0, Flammability 0, Reactivity 0

HMIS Ratings: Flammability 0, Reactivity 0, Health 0*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures
Use appropriate protective equipment. Avoid creating and breathing dust.

Environmental Precautionary Measures
None known.

Procedure for Cleaning/Absorption
Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions
This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.

Storage Information
Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls
Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.

Respiratory Protection
Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product.

Hand Protection
Normal work gloves.

Skin Protection
Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.

Eye Protection
Wear safety glasses or goggles to protect against exposure.

Other Precautions

None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Various
Odor:	Odorless
pH:	8-10
Specific Gravity @ 20 C (Water=1):	2.55
Density @ 20 C (lbs./gallon):	62
Bulk Density @ 20 C (lbs/ft3):	71
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
Solubility in Sea Water (g/100ml):	Insoluble Sinks
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data: Stable

Hazardous Polymerization: Will Not Occur

Conditions to Avoid
None anticipated

Incompatibility (Materials to Avoid)
Hydrofluoric acid.

Hazardous Decomposition Products
Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).

Additional Guidelines
Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure
Eye or skin contact, inhalation

Inhalation
Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A).

Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).

Skin Contact
May cause mechanical skin irritation.

Eye Contact
May cause eye irritation.

Ingestion
None known

Aggravated Medical Conditions
Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.

Chronic Effects/Carcinogenicity
Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis.

Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2).

There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information
For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined

Carcinogenicity
Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).

Genotoxicity: Not determined

Reproductive/Developmental Toxicity: Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)
Not determined

Persistence/Degradability
Not determined

Bio-accumulation
Not Determined

Ecotoxicological Information
Acute Fish Toxicity:
Not determined
Acute Crustaceans Toxicity:
Not determined
Acute Algae Toxicity:
Not determined

Chemical Fate Information
Not determined

Other Information
Not applicable.

13. DISPOSAL CONSIDERATIONS

Disposal Method
Bury in a licensed landfill according to federal, state, and local regulations.

Contaminated Packaging
Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT

Not restricted

Canadian TDG

Not restricted

ADR

Not restricted

Air Transportation

ICAO/IATA

Not restricted

Sea Transportation

IMDG

Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory
All components listed on inventory.

EPA SARA Title III Extremely Hazardous Substances
Not applicable

EPA SARA (311,312) Hazard Class
Acute Health Hazard
Chronic Health Hazard

EPA SARA (313) Chemicals
This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).

EPA CERCLA/Superfund Reportable Spill Quantity For This Product
Not applicable.

EPA RCRA Hazardous Waste Classification
If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.

California Proposition 65
The California Proposition 65 regulations apply to this product.

MA Right-to-Know Law
One or more components listed.

NJ Right-to-Know Law
One or more components listed

PA Right-to-Know Law
One or more components listed.

Canadian Regulations

Canadian DSL Inventory
All components listed on inventory.

WHMIS Hazard Class
D2A Very Toxic Materials
(Crystalline silica)

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information
For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Product Stewardship at 1-580-251-4335.

Disclaimer Statement
This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

*****END OF MSDS*****

HALLIBURTON

MATERIAL SAFETY DATA SHEET

Product Trade Name: HOLEPLUG® 3/8

Revision Date: 25-Feb-2002

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Trade Name: HOLEPLUG® 3/8
Synonyms: None
Chemical Family: Mineral
Application: Fluid Loss Additive

Manufacturer/Supplier
Baroid Drilling Fluids
a Product Service Line of Halliburton Energy Services, Inc.
P.O Box 1675
Houston, TX 77251
Telephone: (281) 871-4000
Emergency Telephone: (800) 666-9260 or (713) 676-3000

Prepared By
Chemical Compliance
Telephone: 1-580-251-4335

2. COMPOSITION/INFORMATION ON INGREDIENTS

SUBSTANCE	CAS Number	PERCENT	ACGIH TLV-TWA	OSHA PEL-TWA
Bentonite	1302-78-9	60 - 100%	Not applicable	Not applicable
Crystalline silica, quartz	14808-60-7	0 - 5%	0.05 mg/m^3	10 mg/m^3 / %SiO2 + 2
Crystalline silica, tridymite	15468-32-3	0 - 1%	0.05 mg/m^3	1/2 x 10 mg/m^3 / %SiO2 + 2
Crystalline silica, cristobalite	14464-46-1	0 - 1%	0.05 mg/m^3	1/2 x 10 mg/m^3 / %SiO2 + 2

More restrictive exposure limits may be enforced by some states, agencies, or other authorities.

3. HAZARDS IDENTIFICATION

Hazard Overview	**CAUTION! - ACUTE HEALTH HAZARD** May cause eye and respiratory irritation. **DANGER! - CHRONIC HEALTH HAZARD** Breathing crystalline silica can cause lung disease, including silicosis and lung cancer. Crystalline silica has also been associated with scleroderma and kidney disease. This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposures below recommended exposure limits. Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product. Review the Material Safety Data Sheet (MSDS) for this product, which has been provided to your employer.

4. FIRST AID MEASURES

Inhalation	If inhaled, remove from area to fresh air. Get medical attention if respiratory irritation develops or if breathing becomes difficult.
Skin	Wash with soap and water. Get medical attention if irritation persists.
Eyes	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes and get medical attention if irritation persists.
Ingestion	Under normal conditions, first aid procedures are not required.
Notes to Physician	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Flash Point/Range (F):	Not Determined
Flash Point/Range (C):	Not Determined
Flash Point Method:	Not Determined
Autoignition Temperature (F):	Not Determined
Autoignition Temperature (C):	Not Determined
Flammability Limits in Air - Lower (%):	Not Determined
Flammability Limits in Air - Upper (%):	Not Determined

Fire Extinguishing Media	All standard firefighting media
Special Exposure Hazards	Not applicable.
Special Protective Equipment for Fire-Fighters	Not applicable.
NFPA Ratings:	Health 0, Flammability 0, Reactivity 0
HMIS Ratings:	Flammability 0, Reactivity 0, Health 0*

6. ACCIDENTAL RELEASE MEASURES

Personal Precautionary Measures	Use appropriate protective equipment. Avoid creating and breathing dust.
Environmental Precautionary Measures	None known.
Procedure for Cleaning / Absorption	Collect using dustless method and hold for appropriate disposal. Consider possible toxic or fire hazards associated with contaminating substances and use appropriate methods for collection, storage and disposal.

7. HANDLING AND STORAGE

Handling Precautions

This product contains quartz, cristobalite, and/or tridymite which may become airborne without a visible cloud. Avoid breathing dust. Avoid creating dusty conditions. Use only with adequate ventilation to keep exposure below recommended exposure limits. Wear a NIOSH certified, European Standard En 149, or equivalent respirator when using this product. Material is slippery when wet.

Storage Information

Use good housekeeping in storage and work areas to prevent accumulation of dust. Close container when not in use. Do not reuse empty container.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Engineering Controls

Use approved industrial ventilation and local exhaust as required to maintain exposures below applicable exposure limits listed in Section 2.

Respiratory Protection

Wear a NIOSH certified, European Standard EN 149, or equivalent respirator when using this product.

Hand Protection

Normal work gloves.

Skin Protection

Wear clothing appropriate for the work environment. Dusty clothing should be laundered before reuse. Use precautionary measures to avoid creating dust when removing or laundering clothing.

Eye Protection

Wear safety glasses or goggles to protect against exposure.

Other Precautions

None known.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	Solid
Color:	Various
Odor:	Odorless
pH:	8-10
Specific Gravity @ 20 C (Water=1):	2.12
Density @ 20 C (lbs./gallon):	Not Determined
Bulk Density @ 20 C (lbs/ft3):	51
Boiling Point/Range (F):	Not Determined
Boiling Point/Range (C):	Not Determined
Freezing Point/Range (F):	Not Determined
Freezing Point/Range (C):	Not Determined
Vapor Pressure @ 20 C (mmHg):	Not Determined
Vapor Density (Air=1):	Not Determined
Percent Volatiles:	Not Determined
Evaporation Rate (Butyl Acetate=1):	Not Determined
Solubility in Water (g/100ml):	Insoluble
Solubility in Solvents (g/100ml):	Not Determined
VOCs (lbs./gallon):	Not Determined
Viscosity, Dynamic @ 20 C (centipoise):	Not Determined
Viscosity, Kinematic @ 20 C (centistrokes):	Not Determined
Partition Coefficient/n-Octanol/Water:	Not Determined
Molecular Weight (g/mole):	Not Determined

10. STABILITY AND REACTIVITY

Stability Data: Stable

Hazardous Polymerization: Will Not Occur

Conditions to Avoid	None anticipated
Incompatibility (Materials to Avoid)	Hydrofluoric acid.
Hazardous Decomposition Products	Amorphous silica may transform at elevated temperatures to tridymite (870 C) or cristobalite (1470 C).
Additional Guidelines	Not Applicable

11. TOXICOLOGICAL INFORMATION

Principle Route of Exposure	Eye or skin contact, inhalation.
Inhalation	Inhaled crystalline silica in the form of quartz or cristobalite from occupational sources is carcinogenic to humans (IARC, Group 1). There is sufficient evidence in experimental animals for the carcinogenicity of tridymite (IARC, Group 2A). Breathing silica dust may cause irritation of the nose, throat, and respiratory passages. Breathing silica dust may not cause noticeable injury or illness even though permanent lung damage may be occurring. Inhalation of dust may also have serious chronic health effects (See "Chronic Effects/Carcinogenicity" subsection below).
Skin Contact	May cause mechanical skin irritation.
Eye Contact	May cause eye irritation.
Ingestion	None known
Aggravated Medical Conditions	Individuals with respiratory disease, including but not limited to asthma and bronchitis, or subject to eye irritation, should not be exposed to quartz dust.
Chronic Effects/Carcinogenicity	Silicosis: Excessive inhalation of respirable crystalline silica dust may cause a progressive, disabling, and sometimes-fatal lung disease called silicosis. Symptoms include cough, shortness of breath, wheezing, non-specific chest illness, and reduced pulmonary function. This disease is exacerbated by smoking. Individuals with silicosis are predisposed to develop tuberculosis. Cancer Status: The International Agency for Research on Cancer (IARC) has determined that crystalline silica inhaled in the form of quartz or cristobalite from occupational sources can cause lung cancer in humans (Group 1 - carcinogenic to humans) and has determined that there is sufficient evidence in experimental animals for the carcinogenicity of tridymite (Group 2A - possible carcinogen to humans). Refer to IARC Monograph 68. Silica, Some Silicates and Organic Fibres (June 1997) in conjunction with the use of these minerals. The National Toxicology Program classifies respirable crystalline silica as "Known to be a human carcinogen". Refer to the 9th Report on Carcinogens (2000). The American Conference of Governmental Industrial Hygienists (ACGIH) classifies crystalline silica, quartz, as a suspected human carcinogen (A2). There is some evidence that breathing respirable crystalline silica or the disease silicosis is associated with an increased incidence of significant disease endpoints such as scleroderma (an immune system disorder manifested by scarring of the lungs, skin, and other internal organs) and kidney disease.

Other Information	For further information consult "Adverse Effects of Crystalline Silica Exposure" published by the American Thoracic Society Medical Section of the American Lung Association, American Journal of Respiratory and Critical Care Medicine, Volume 155, pages 761-768 (1997).

Toxicity Tests

Oral Toxicity:	Not determined
Dermal Toxicity:	Not determined
Inhalation Toxicity:	Not determined
Primary Irritation Effect:	Not determined
Carcinogenicity	Refer to IARC Monograph 68, Silica, Some Silicates and Organic Fibres (June 1997).
Genotoxicity:	Not determined
Reproductive / Developmental Toxicity:	Not determined

12. ECOLOGICAL INFORMATION

Mobility (Water/Soil/Air)	Not determined
Persistence/Degradability	Not determined
Bio-accumulation	Not Determined

Ecotoxicological Information

Acute Fish Toxicity:	Not determined
Acute Crustaceans Toxicity:	Not determined
Acute Algae Toxicity:	Not determined
Chemical Fate Information	Not determined
Other Information	Not applicable

13. DISPOSAL CONSIDERATIONS

Disposal Method	Bury in a licensed landfill according to federal, state, and local regulations.
Contaminated Packaging	Follow all applicable national or local regulations.

14. TRANSPORT INFORMATION

Land Transportation

DOT
Not restricted

Canadian TDG
Not restricted

ADR Not restricted

Air Transportation

ICAO/IATA
Not restricted

Sea Transportation

IMDG
Not restricted

Other Shipping Information

Labels: None

15. REGULATORY INFORMATION

US Regulations

US TSCA Inventory	All components listed on inventory.
EPA SARA Title III Extremely Hazardous Substances	Not applicable
EPA SARA (311,312) Hazard Class	Acute Health Hazard Chronic Health Hazard
EPA SARA (313) Chemicals	This product does not contain a toxic chemical for routine annual "Toxic Chemical Release Reporting" under Section 313 (40 CFR 372).
EPA CERCLA/Superfund Reportable Spill Quantity For This Product	Not applicable.
EPA RCRA Hazardous Waste Classification	If product becomes a waste, it does NOT meet the criteria of a hazardous waste as defined by the US EPA.
California Proposition 65	The California Proposition 65 regulations apply to this product.
MA Right-to-Know Law	One or more components listed.
NJ Right-to-Know Law	One or more components listed.
PA Right-to-Know Law	One or more components listed.

Canadian Regulations

Canadian DSL Inventory	All components listed on inventory.
WHMIS Hazard Class	D2A Very Toxic Materials (Crystalline silica)

16. OTHER INFORMATION

The following sections have been revised since the last issue of this MSDS
Not applicable

Additional Information

For additional information on the use of this product, contact your local Halliburton representative.

For questions about the Material Safety Data Sheet for this or other Halliburton products, contact Chemical Compliance at 1-580-251-4335

Disclaimer Statement

This information is furnished without warranty, expressed or implied, as to accuracy or completeness. The information is obtained from various sources including the manufacturer and other third party sources. The information may not be valid under all conditions nor if this material is used in combination with other materials or in any process. Final determination of suitability of any material is the sole responsibility of the user.

END OF MSDS

APPENDIX B
WASTE MANAGEMENT PLAN

Waste Management Plan

for

Mortandad Canyon

Surface Water and Groundwater Characterization

Los Alamos National Laboratory

Draft

September 17, 2004

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1.0 INTRODUCTION

This Waste Management Plan (WMP) addresses the processes and procedures for the management of waste materials derived from the borings and well installations during surface water and groundwater characterization activities in Mortandad Canyon.

The materials addressed in this plan include:

- drill cuttings;
- decontamination water;
- investigation derived waste (IDW);
- municipal solid waste (MSW);
- petroleum-contaminated soil (PCS); and
- petroleum-contaminated absorbent materials.

2.0 BACKGROUND

2.1 Site Description and History

Mortandad Canyon extends 9.8 miles from near Diamond Drive in Technical Area (TA-)3 east southeast to the Rio Grande and has a total watershed area (excluding Canada del Buey) of about 6 square miles (LANL 1997, 56835; LANL 1999, 62777, p. 1-3).

Proposed borehole and well locations in Mortandad Canyon are provided in Figure 2 from the Mortandad Canyon Groundwater Work Plan, Revision 1 (Attachment A).

2.2 Project Description

The activity involves the drilling and installation of boreholes and wells in Mortandad Canyon as part of the surface water and groundwater investigations per the Mortandad Canyon Groundwater Work Plan, Revision 1 (ER2004-0019, January 2004). Resistivity, alluvial, characterization, and intermediate borings/wells (approximately 37 total) will be drilled and sampled in Mortandad Canyon ranging in depth from < 5 feet to 1000 feet. A detailed description of the activity is given in Table 2, 3, and 7 of the Mortandad Canyon Groundwater Work Plan, Revision 1 (Attachment A).

3.0 PERSONNEL

Personnel involved in the waste management activities include the following:

Waste Management Coordinator (WMC)
Waste management coordinator responsibilities include understanding the waste disposal process, oversight of waste minimization, oversight of waste collection, labeling and staging, performing waste area inspections on a routine basis, maintaining records, providing waste containers, and providing additional waste management guidance as needed.

Field Team Leader (FTL)
Field team leader responsibilities include overseeing WMP implementation by field team members by ascertaining that waste is properly segregated, containerized, and staged according to the Waste Characterization Strategy Form (WCSF) and WMP requirements.

Site Safety Officer (SSO)
Site safety officer responsibilities include ensuring field team members comply with the Site Specific Safety and Health Plan requirements while they are segregating, containerizing and staging waste.

4.0 WASTE GENERATION

Several steps will be executed during waste generation. These steps include the following:

4.1 Generation of Drill Cuttings

Approximately 100 cubic yards of drill cuttings will be generated during drilling operations. Kleinfelder will store dry cuttings in nylon sacks and wet cuttings in 55-gallon drums. The sacks and drums will be stored on pallets inside sheet plastic secondary containment with a straw bale berm. A plastic tarp will cover the sacks to protect them from weather. All cuttings that are determined to be nonhazardous will be used for site restoration.

4.2 Generation of Decontamination Water

Approximately 3,700 gallons of decontamination water will be generated during the decontamination of drilling equipment. Decontamination water will be stored in 55-gallon drums, which will be placed on pallets.

4.3 Generation of IDW

Approximately 10 cubic yards of IDW will be generated during drilling operations. IDW will be stored in plastic trash bags at each borehole location.

4.4 Generation of MSW

Approximately five cubic yards of MSW will be generated during drilling operations. MSW will be stored in plastic trash bags at each borehole location.

4.5 Generation of PCS and Petroleum-Contaminated Absorbent Material

Approximately one cubic yard of PCS and Petroleum-Contaminated Absorbent Material may be generated during drilling operations. PCS will be stored in an approved 55-gallon drum and properly managed as New Mexico Special Waste.

5.0 WASTE MINIMIZATION

Waste minimization means reducing the amount of waste generated or eliminating waste generation altogether. The goal of waste minimization is to preserve natural resources and reduce the need to treat, store, or dispose of waste. Minimization can be accomplished by elimination, substitution, segregation, and recycling.

The generation of waste during drilling activities will be controlled so that no unnecessary waste will be generated.

Waste will be minimized by the following practices:

- Through a combination of administrative and engineering controls, waste will be segregated as it is generated. Through this practice material is kept clean and mixtures of different waste streams are avoided, thus reducing the overall volume of waste.
- Waste will be generated and characterized in accordance with the Waste Characterization Strategy Form for Surface Water and Groundwater Investigations in Mortandad Canyon.

6.0 WASTE MANAGEMENT

Waste management describes the process of controlling each waste stream after it is generated, including temporary storage, segregation, transportation and disposal. Waste management during drilling operations will be conducted in accordance with RCRA, DOE orders, and LANL's rules and regulations. The New Mexico Hazardous Waste Management Act will be followed along with the applicable rules of the U.S. Department of Transportation. Waste streams will be managed in accordance with appropriate procedures.

6.1 Waste Characterization

The waste streams generated during drilling operations will be characterized by direct sampling of waste and borehole characterization sampling.

6.2 Waste Streams

6.2.1 Drill Cuttings

Approximately 100 cubic yards of drill cuttings will be generated during drilling operations. Kleinfelder will store dry cuttings in nylon sacks and wet cuttings in 55-gallon drums. The sacks and drums will be stored on pallets inside plastic sheeting secondary containment with a straw bale berm. A plastic tarp will cover the sacks to protect them from weather. It is anticipated that cuttings will be characterized as solid waste, nonhazardous and nonradioactive. All cuttings that are determined to be nonhaz/nonrad will be used for site restoration. The regulatory classification of drill cuttings will be determined through site characterization and by direct sampling of the cuttings. Kleinfelder will obtain one composite sample of cuttings material from each of the three distinct drilling areas. The composite samples will be analyzed using the Volatile Organic Constituents, TCLP metals, and TCLP organics test methods.

6.2.2 Decontamination Water

Approximately 3,700 gallons of decontamination water will be generated during the decontamination of drilling equipment. Decontamination water will be stored in 55-gallon drums, which will be placed on pallets.

It is anticipated that the decontamination water will be characterized as nonhazardous and nonradioactive waste, suitable for discharge under the existing NOI(8/2/01).

The regulatory classification of decontamination water will be determined through site characterization and by direct sampling of the water. Kleinfelder will obtain one composite sample of decontamination water from each of the three distinct drilling areas. The composite samples will be analyzed using the following test methods:

- Volatile Organic Constituents
- TAL Metals
- Gross Alpha/beta/gamma
- Tritium
- Gamma spec
- isotopic plutonium and uranium
- total uranium
- Sr-90
- Am-241

6.2.3 IDW

Approximately 10 cubic yards of IDW will be generated during drilling operations. IDW will be stored in plastic trash bags at each borehole location. Since the IDW generated during drilling operations will be associated with the cuttings and decontamination water, it will be characterized based on the regulatory classification of those waste streams and managed accordingly.

6.2.4 MSW

Approximately five cubic yards of MSW will be generated during drilling operations. MSW will be stored in plastic trash bags at each borehole location. MSW will be segregated from all other waste streams, and will be managed as nonhazardous, nonradioactive waste.

6.2.5 PCS and Petroleum-Contaminated Absorbent Material

Approximately one cubic yard of PCS and Petroleum-Contaminated Absorbent Material may be generated during drilling operations. PCS will be stored in an approved 55-gallon drum and properly managed as New Mexico Special Waste. The regulatory classification of PCS will be determined by existing documentation (MSDS) and will be characterized as New Mexico Special Waste. Depending on the disposal facility used, PCS may require additional sampling to determine the total concentration of petroleum hydrocarbons using the Total petroleum hydrocarbons (TPH) test method.

6.3 Temporary Storage

It is anticipated that Kleinfelder and Duratek Federal Services, Inc. will set up the waste storage areas, which must be free of obstacles and free of ignitable sources. Typical waste storage areas will include plastic sheeting on grade with a straw bale or earth berm. Pallets for staging nylon sacks containing drill cuttings and drums containing decon water. The sacks containing cuttings will be covered with plastic tarps to protect against damage from weather.

6.4 Labeling

All waste containers will be immediately and properly labeled. Labels shall have the following information:

- Site,
- Date,
- Type of waste, and
- Constituents of waste.

The site-specific label will be placed in a waterproof, sealable pouch and affixed to the outside of the drum. If the material is awaiting characterization, then an additional label should be placed outside the drum stating "pending analysis".

6.5 Empty Containers

As defined by RCRA, containers of 110 gallons or less, holding less than 3% by weight of the total capacity, are considered empty. Empty containers are not hazardous waste. However, containers that once held an element or compound considered acutely hazardous are considered hazardous waste regardless of the volume of the residual product.

6.6 Packaging and Transportation

Containers holding waste from drilling operations may be transported within the boundaries of Mortandad canyon without shipping documents, labels or special containers. Outside of Mortandad canyon, wastes and suspect wastes will be transported in compliance with DOT requirements.

Waste materials will be packaged according to DOT rules and regulations and in compliance with 49 CFR 173. The proper materials will be used for containers, the proper size of container will be utilized and the proper strength of packaging will be implemented.

6.7 Waste Storage Area Inspections

The waste storage areas will be inspected once per week or as conditions require. Personnel inspecting waste storage areas will look for and record wear and/or damage to plastic tarps, plastic sheeting secondary containment, berms, pallets, containers and labels. Inspections will be conducted weekly or as conditions such as severe weather require.

7.0 ACRONYMS

ACM	Asbestos Containing Material
AR	Administrative Requirement
CFR	Code of Federal Regulations
CWDR	Chemical Waste Disposal Request
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
HMTF	Hazardous Materials Transfer Form
KOP	Knowledge of Process
LANL	Los Alamos National Laboratories
NMHWMR	New Mexico Hazardous Waste Management Regulations
NMSWA	New Mexico Solid Waste Act
NMWQCC	New Mexico Water Quality Control Commission
OSHA	Occupational Safety and Health Administration
OU	Operational Unit
PCOC	Potential Contaminants of Concern
PPE	Personal Protective Equipment
RCRA	Resource Conservation and Recovery Act
RSWD	Radioactive Solid Waste Disposal
TA	Technical Area
TCLP	Toxicity Characteristic Leaching Procedure
TSCA	Toxic Substances Control Act
WAC	Waste Acceptance Criteria
WMC	Waste Management Coordinator
WPF	Waste Profile Form

APPENDIX C
WASTE CHARACTERIZATION STRATEGY FORM

Waste Characterization Strategy Form

For instructions regarding this form, see Section 8 of LANL ER-SOP-01.10, R1.

Project Title	Surface Water and Groundwater Investigations in Mortandad Canyon
Operating Unit #	OU 1049 RES-2, 3, 4 A-1, A-2, A-3(a-f), A-4, A-5, A-6, A-7, A-8, A-9 B-1, B-2, B-5, B-6, B-7, B-8, B-9, B-10, B-11, B-12, B-14, B-15, B-16 I-1, I-3, I-4, I-5, I-6, I-8, I-10
PRS #	NA
Activity Type	Borehole Drilling and Well Installation
Field Team Leader	Mark Everett
Waste Generator	Tom Whitacre
Waste Management Coordinator	Victor Garde
Completed by	Tom Benson
Date	October 13, 2004

Description of activities:
The activity involves the drilling and installation of boreholes and wells in Mortandad Canyon as part of the surface water and groundwater investigations per the Mortandad Canyon Groundwater Work Plan, Revision 1 (ER2004-0019, January 2004). Resistivity, alluvial, characterization, and intermediate borings/wells (approximately 37 total) will be drilled and sampled in Mortandad Canyon ranging in depth from < 5 feet to 1000 feet. A detailed description of the activity is given in Table 2, 3, and 7 of the Mortandad Canyon Groundwater Work Plan, Revision 1 (Attachment A).

Acceptable Knowledge

Site history and description: Mortandad Canyon extends 9.8 miles from near Diamond Drive in Technical Area (TA) -3 east southeast to the Rio Grande and has a total watershed area (excluding Canada del Buey) of about six square miles (LANL 1997, 56835; LANL 1999, 62777, p. 1-3).

Proposed borehole and well locations in Mortandad Canyon are provided in Figure 2 of the Mortandad Canyon Groundwater Work Plan, Revision 1 (Attachment A).

Previous Investigation Activities: The Laboratory began monitoring sediments, surface water and groundwater in Mortandad Canyon and its tributaries in the early 1960s. Contaminants have been identified in alluvial and perched intermediate groundwater and in

the regional aquifer within Mortandad Canyon. Historically, the following constituents have been detected in surface water and alluvial groundwater: americium-241; cesium-137; plutonium-238 and plutonium-239, 240; strontium-90; tritium; uranium-234, 235, 236, 238; nitrate; perchlorate; chloride; sulfate; fluoride; and total dissolved solids ([TDS] ESP 1999, 68661; ESP 2001, 71301; ESP 2002, 73876).

Mortandad Canyon and its tributaries have received effluents from the Laboratory since the early 1950s. These effluents, discharged from TA-3, TA-35, TA-48, and TA-50, have contained a variety of contaminants including nitrate, perchlorate, tritium, cesium-137, strontium-90, americium-241, and several isotopes of uranium and plutonium (LANL 1997, 56835). Active outfalls discharging into Mortandad Canyon include TA-3 and TA-50.

Characterization Strategy:

Separate waste streams are anticipated:

- #1-Borehole Cuttings;
- #2- A-Wells, B-Borings, and RES-Borings Decontamination and Development Water;
- #3-Intermediate Well Decontamination and Development Water;
- #4-Investigation Derived Waste (IDW);
- #5-Municipal Solid Waste (MSW);
- #6-Petroleum-Contaminated Soil (PCS)(potential);
- #7-Petroleum-Contaminated Absorbent Material (potential).

Waste # 1: Borehole Cuttings

Waste type: Soil from the subsurface that is generated from drilling activities.

Anticipated Regulatory Status: Non-RCRA hazardous, non-radioactive, solid waste.

Characterization Approach: The waste characterization will be based on borehole characterization results and direct sampling of the waste for volatile organics, TCLP organics and TCLP metals, not included in the borehole sampling. Three composite samples will be collected representing three distinct areas of drilling. See Characterization Table for analytical testing parameters. LANL RCTs will conduct radiological surveys on all samples collected.

Storage and Disposal Method: It is anticipated that the waste will be stored in recycled nylon sacks, previously containing bentonite chips, and staged on pallets. Drums (30 or 55-gallon) may be used to contain cuttings if saturated with water. The waste is expected to be non-RCRA hazardous, non-radioactive solid waste and used onsite for site restoration.

Waste # 2: A-Wells, B-Borings, and RES-Borings Decontamination and Development Water

Waste Type: Decontamination water from decontamination of drilling equipment. A laboratory grade soap (Alconox) and water will be used to decontaminate the drilling equipment.

Anticipated Regulatory Status: Non-RCRA hazardous, non-radioactive.

Characterization Approach: The decontamination water will be characterized based on direct waste characterization sampling for volatile organics, metals, and a radiological suite. Three composite samples will be collected representing three distinct areas of drilling. See Characterization Table for analytical testing parameters

Storage and Disposal Method: The anticipated storage method will be 30-gallon or 55-gallon drums on pallets for A-wells, B-borings, and RES borings. The waste is expected to be non-RCRA hazardous, non-radioactive waste and will be applied to the land surface or used for dust suppression on access roads or the drill site in accordance with the terms and conditions of the original NOI (August 2, 2001).

Waste # 3: Intermediate Well Decontamination and Development Water

Waste Type: Groundwater from well development activities.

Anticipated Regulatory Status: Non-RCRA hazardous, non-radioactive.

Characterization Approach: The development water will be characterized based on groundwater characterization results and direct waste characterization sampling for volatile organics. Three composite samples will be collected representing three distinct areas of drilling. See Characterization Table for analytical testing parameters

Storage and Disposal Method: The anticipated storage method will be containment pits for the I-wells. The waste is expected to be non-RCRA hazardous, non-radioactive waste and will be applied to the land surface or used for dust suppression on access roads or the drill site in accordance with the terms and conditions of the original NOI (August 2, 2001).

Waste # 4: Investigation-Derived Waste (IDW)

Waste type: IDW includes spent PPE (gloves, coveralls, etc.), sampling supplies (plastic baggies, and sampling jars), decontamination trash (paper towels, plastic sheeting, brushes, etc.) and plastic sheeting from secondary containment that contacts potentially contaminated environmental media or equipment.

Anticipated Regulatory Status: Municipal Solid Waste (MSW).

Characterization Approach: This waste is considered MSW, pending analytical results from waste steams #1 and #2 to determine final waste characterization. The "100 times rule" will be used to assume the IDW is 100 times less than the analytical results from waste streams #1 and #2.

Storage and Disposal Method: The anticipated storage method will be 30 or 55-gallon drums. If analytical results for waste streams #1 and #2 determine the environmental media to be acceptable for onsite reuse or NOI discharge, then IDW will be disposed as MSW. If any of the environmental media is determined to be low-level radioactive or other than MSW, then the IDW will be managed appropriately.

Waste # 5: Municipal Solid Waste (MSW)

Waste type: MSW will consist of non-contact trash and debris.

Anticipated Regulatory Status: MSW.

Characterization Approach: MSW will be characterized based on acceptable knowledge. MSW will be segregated from all other waste streams.

Storage and Disposal Method: It is anticipated that the waste will be stored in a plastic-lined trash container, and then disposed of at the County of Los Alamos Landfill.

Waste # 6: Petroleum-Contaminated Soil (PCS) (Potential)

Waste Type: PCS from the release of commercial products such as hydraulic fluid, motor oil, or diesel fuel.

Anticipated Regulatory Status: New Mexico Special Waste (NMSW) based on the MSDS for the released product.

Characterization Approach: The PCS will be characterized based on the Material Safety Data Sheets (MSDS) for the product and direct waste characterization sampling. LANL RCTs will conduct radiological surveys on all PCS.

Storage and Disposal Method: It is anticipated that the waste will be stored in 30 or 55-gallon drums, staged in a designated NMSW storage area, and disposed of offsite at an NMSW-permitted facility.

Waste # 7: Absorbent Material (Potential) and PPE

Waste Type: Absorbent material includes pads, paper towels, or other material used to contain released commercial products considered to be NMSW.

Anticipated Regulatory Status: NMSW based on the MSDS for the released product.

Characterization Approach: The absorbent material will be characterized based on the MSDS for the released product and direct waste characterization sampling. LANL RCTs will conduct radiological surveys on all absorbent material.

Storage and Disposal Method: It is anticipated that the waste will be stored in 30 or 55-gallon drums in a designated NMSW storage area, and disposed of offsite at a NMSW-permitted facility.

CHARACTERIZATION TABLE

WASTE DESCRIPTION	Waste #1 Borehole Cuttings	Waste #2 A-wells, B-borings, RES-wells Decon and Develop. Water	Waste #3 I-Well Decon and Develop. Water	Waste #4 IDW	Waste #5 MSW	Wastes #6/#7 PCS/ Absorbent Material
Volume (estimate)	**100 cubic yard (cy)**	**7,400 gal**	**270,900 gal**	**10 cy**	**5 cy**	**1cy**
Packaging	**Nylon sack (recycled bentonite chips container) or 30 or 55-gal drum if wet cuttings**	**30 or 55-gal drum**	**Contain-ment pits**	**30 or 55-gal drum or rolloff bin**	**30-gal plastic-lined trash can**	**30 or 55-gal drum**
REGULATORY CLASSIFICATION						
Solid	X	X	X	X	X	
RCRA						
TSCA						
New Mexico Special						X
CHARACTERIZATION METHOD						
AK: Existing Data/Documentation						**MSDS**
AK: from Site Characterization	X	X	X	**Waste #1&#2**		
Direct Sampling of Containerized Waste	X	X	X			
ANALYTICAL TESTING						
Volatile Organic Constituents EPA 8260-B	**3 composites**	**3 composites**	**3 composites**			
Semivolatiles EPA 8270-C						
Organic Pesticides EPA 8081-A						

Waste Characterization Strategy Form

WASTE DESCRIPTION	Waste #1 Borehole Cuttings	Waste #2 A-wells, B-borings, RES-wells Decon and Develop. Water	Waste #3 I-Well Decon and Develop. Water	Waste #4 IDW	Waste #5 MSW	Wastes #6/#7 PCS/ Absorbent Material
ANALYTICAL TESTING						
Organic Herbicides EPA 8151-A						
PCBs EPA 8082						
Total Metals EPA 6010-B		**3 composites**				
Total Cyanide EPA 9012-A						
High Explosives Constituents EPA 8330						
Asbestos						
TPH EPA 8015						
TCLP Metals (EPA 1311/6010-B)	**3 composites**					
TCLP Organics (EPA 1311/8260 & 1311/8270)	**3 composites**					
TCLP Pest. & Herb. (EPA 1311/8081/1311/8151-A)						
Gross Alpha (alpha counting)		**3 composites**				
Gross Beta (beta counting)		**3 composites**				
Gross Gamma (gamma counting)		**3 composites**				
Tritium (liquid scintillation)		**3 composites**				
Gamma spectroscopy		**3 composites**				
Isotopic plutonium (chem. Separation/alpha spec.)		**3 composites**				
Isotopic uranium (chem. Separation/alpha spec.)		**3 composites**				
Total uranium (6020 ICPMS)		**3 composites**				
Strontium-90 (beta proportional counting)		**3 composites**				
Americium-241 (chem. separation/alpha spec.)		**3 composites**				
Waste Profile Form #	**TBD**	**TBD**		**TBD**	**TBD**	**TBD**

Waste Characterization Strategy Form

SIGNATURES	DATE
DOE Project Manager (Print name and then sign below.) _____	
Kleinfelder Field Team Leader (Print name and then sign below.) _____	
Duratek Waste Management Coordinator (Print name and then sign below.) _____	

ER-SOP-01.10, R1	Los Alamos Environmental Restoration Project

Attachment A

Table 2
DQO Matrix for Alluvial Wells in Mortandad Canyon

	Well A-1	Well A-2	Well A-3a–f	Wells A-4, A-5	Well A-6	Wells A-7, A-8, and A-9
Conceptual Model Uncertainty	Define the limits on baseline/contaminant content in alluvial groundwater upstream of confluence with Effluent Canyon Constrain location and rate of effluent infiltration in the upper portion of Mortandad Canyon	Provide data on the alluvial system where moderately adsorbing contaminants (e.g., strontium) are accumulated. Constrain location and rate of effluent infiltration in the middle portion of Mortandad Canyon and the extent of saturation in the alluvium between MCO-6 and MCO-7	Install piezometers to reduce uncertainty in hydraulic gradients and provide data on alluvial hydrology for modeling contaminant transport Constrain location and rate of effluent infiltration	Define location and rate of infiltration within Effluent Canyon (A-4) and location and rate of infiltration in Mortandad Canyon just below the confluence with Effluent Canyon (A-5) Replace wells that are not usable: MCO-2 (A-4) and MCO-3 (A-5)	Located in an area that may be a "hydrological sink" or a zone of enhanced infiltration. Determine whether adsorptive contaminants released into Ten Site Canyon have accumulated in the alluvium Help constrain location and rate of effluent infiltration	Provide a check on whether nonadsorptive contaminants (e.g., ^{3}He, ClO_4) migrate over large distances in periodically saturated alluvium Help constrain location and rate of effluent infiltration
Projected Depth	12 ft; penetrate 5 ft into Bandelier Tuff	90 ft; penetrate 20 ft into Bandelier Tuff	45 ft; penetrate to base of alluvium	2-3 ft at A-4 and 10 ft at A-5; penetrate to base of alluvium	90 ft; penetrate to base of alluvium	90 ft for each well; penetrate to base of alluvium and/or colluvium
Geology	Determine thickness and composition of alluvium in upper Mortandad Canyon west of confluence with Effluent Canyon	Determine thickness, reactive phases, and composition of alluvium between MCO-6 and MCO-7	Determine thickness and composition of alluvium and/or colluvium between MT-3 and MT-4	Determine thickness and composition of alluvium at MCO-2 and MCO-3	Determine thickness and composition of alluvium in Ten Site Canyon 1000 ft west of confluence with Mortandad Canyon	Determine thickness and composition of alluvium and/or colluvium near MCO-13
Hydrology	Determine hydraulic gradient, hydraulic conductivity, flow direction, and extent of saturation in alluvium	Determine hydraulic gradient, hydraulic conductivity, flow direction, and extent of saturation between MCO-6 and MCO-7	Determine vertical and horizontal gradients, hydraulic conductivity, flow direction, and extent of saturation between MT-3 and MT-4	Determine hydraulic gradient, hydraulic conductivity, flow direction, and extent of saturation at MCO-2 and MCO-3	Determine hydraulic gradient, hydraulic conductivity, flow direction, and extent of saturation 1000 ft west of confluence with Mortandad Canyon	Determine hydraulic gradient, flow direction, and extent of saturation in the alluvium and/or colluvium near MCO-13 Act as characterization wells, if saturation is encountered

Table 2 (continued)

	Well A-1	Well A-2	Well A-3a–f	Wells A-4, A-5	Well A-6	Wells A-7, A-8, and A-9
Geochemistry /Contaminant Chemistry	Evaluate hydrochemistry of alluvium in upper Mortandad Canyon west of confluence with Effluent Canyon	Evaluate attenuation of strontium-90 between MCO-6 and MCO-7 Characterize mineralogy that controls migration of strontium-90 and other contaminants	None	Evaluate hydrochemistry of alluvium at MCO-2 and MCO-3	Evaluate hydrochemistry of alluvium in Ten Site Canyon	Evaluate hydrochemistry of alluvium and/or colluvium near MCO-13
Saturated Zone Sampling	Collect and analyze water samples after well development	Collect and analyze water samples after well development	None	Collect and analyze water samples after well development	Collect and analyze water samples after well development	Collect and analyze water samples after well development
Core Needs	None	Collect core samples from surface to total depth (90 ft) for radionuclide, metal, and anion analyses	Collect core samples from surface to total depth Use selected core for moisture analysis and determining spatial distributions of radionuclides, metals, and anions	None	None	None
Hydraulic Testing	Slug tests	Slug tests	Slug tests	Slug tests	Slug tests	Slug tests
Geophysical Testing	None	Gamma induction	Gamma induction	Gamma induction	Gamma induction	Gamma induction
Number of Well Screens	One	One	Install one per well (total 6) placed at different depths to determine vertical gradients	One per well	One	One per well

Table 3
DQO Matrix for Intermediate Wells in Mortandad Canyon

	Well I-1	Well I-3	Well I-4	Wells I-5, I-6	Well I-8	Well I-10
Conceptual Model Uncertainty	Determine whether contaminant-bearing perched zones occur within ~1000 ft of the confluence of Effluent and Mortandad Canyons Satisfies objectives of this work plan if no saturation encountered	Determine whether perched zones occur beneath lower Ten Site Canyon Determine whether contaminant contents indicate any component of lateral migration from Mortandad Canyon Satisfies objectives of this work plan if no saturation encountered	Replace MCOBT-4.4., which encountered a perched zone with ^3H, ClO_4, U, and NO_3 contamination Replacement well to be used to monitor this zone	Provide a more complete record of the contaminated perched zone sampled when regional well R-15 was drilled (1-5) Provide constraints on how this contaminant zone extends toward the axis of Mortandad Canyon (I-6; see well I-10 for extent to the south) Satisfies objectives of this work plan if no saturation encountered	Determine if perched zones occur upstream of the confluence of Mortandad Canyon and Ten Site Canyon Define nature and extent of contamination in basalt Use Contaminant signatures in I-8 to test possibility of perched-zone contamination between I-8 and I-3 Satisfies objectives of this work plan if no saturation encountered	Determine whether the perched contaminated zone discovered at R-15 extends southward beneath the mesa and towards PM-5 (see wells I-5 and I-6 for extent to the north) Satisfies objectives of this work plan if no saturation encountered
Projected Depth	800 ft: penetrate to base of dacitic lavas	770 ft: penetrate to base of Cerros del Rio basalt	517 ft: penetrate to base of upper Puye Formation	760 ft: penetrate to base of Cerros del Rio basalt	750 ft: penetrate to base of Cerros del Rio basalt	1000 ft: penetrate to base of Cerros del Rio basalt
Geology	Determine thickness of Bandelier Tuff and Cerro Toledo interval, upper Puye Formation, and dacitic lavas 0.25 mi east of TA-50 discharge	Determine thickness of alluvium, Bandelier Tuff and Cerro Toledo interval, upper Puye Formation, and Cerros del Rio lavas Determine distribution of basalts (potential fast pathways) hosting perched zone(s)	None: Characterized during installation of MCOBT-4.4	Determine thickness of alluvium, Bandelier Tuff and Cerro Toledo interval, upper Puye Formation, and Cerros del Rio basalt Determine distribution of basalts (potential fast pathways) hosting perched zone(s)	Determine thickness of alluvium/colluvium, Bandelier Tuff and Cerro Toledo interval, upper Puye Formation, and Cerros del Rio basalt Determine distribution of basalts (potential fast pathways) hosting perched zone(s)	Determine thickness of Bandelier Tuff and Cerro Toledo interval, upper Puye Formation, and Cerros del Rio basalt Determine distribution of basalts (potential fast pathways) hosting perched zone(s)
Hydrology	Determine hydraulic gradient, flow direction, recharge, discharge, and extent of saturation in the Guaje Pumice Bed or above dacitic lavas 0.25 mi east of TA-50 discharge	Determine hydraulic gradient, flow direction, recharge, discharge, and extent of saturation in the Cerros del Rio basalt in Ten Site Canyon southeast of TW-8	Determine hydraulic gradient, flow direction, recharge, discharge, and extent of saturation in the upper Puye Formation at MCOBT-4.4	Determine hydraulic gradient, flow direction, recharge, discharge, and extent of saturation in the Cerros del Rio basalt in Mortandad Canyon at R-15 (I-5) and north of R-15 (I-6)	Determine hydraulic gradient, flow direction, recharge, discharge, and extent of saturation in the Cerros del Rio basalt in Mortandad Canyon west of MCOBT-4.4 near MCO-6	Determine hydraulic gradient, flow direction, recharge, discharge, and extent of saturation in the Cerros del Rio basalt south of Mortandad Canyon near R-15

Table 3 (continued)

	Well I-1	Well I-3	Well I-4	Wells I-5, I-6	Well I-8	Well I-10
Geochemistry	Evaluate hydrochemistry of Cerro Toledo interval, Guaje Pumice Bed, or above dacitic lavas 0.25 mi east of TA-50 discharge	Evaluate hydrochemistry of Cerros del Rio basalt Evaluate effect of releases from TA-35 on water quality in perched groundwater	Evaluate hydrochemistry of upper Puye Formation Evaluate effect of releases from TA-50 and TA-35 on water quality in perched groundwater	Evaluate hydrochemistry of Cerros del Rio basalt Evaluate effect of releases from TA-35 and TA-50 on water quality in perched groundwater	Evaluate hydrochemistry of Cerros del Rio basalt Evaluate effect of releases from TA-35 and TA-50 on water quality in perched groundwater	Evaluate hydrochemistry of Cerros del Rio basalt Evaluate effect of releases from TA-35 and TA-50 on water quality in perched groundwater
Vadose Zone Sampling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling	None: samples collected during drilling and subsequent sampling of MCOBT-4.4 Collect water samples if perched water is encountered during drilling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling
Core Needs	Collect core samples from surface to core refusal (550 ft) for contaminant, metal, and anion analyses	Collect core samples from surface to core refusal (560 ft) for contaminant, metal, and anion analyses	None: samples collected during drilling of MCOBT-4.4	Collect core samples from surface to core refusal (500 ft) for contaminant, metal, and anion analyses	Collect core samples from surface to core refusal (530 ft) for contaminant, metal, and anion analyses	Collect core samples from 300 to 800 ft for contaminant, metal, and anion analyses
Hydraulic Testing	Conduct slug test and/or injection/straddle packer test in the screen completely below the perched water table	Conduct slug test and/or injection/straddle packer test in the screen completely below the perched water table	Possibly use cross-hole pumping tests between existing well MCOBT-4.4 and well I-4 if geochemical sampling not compromised	Conduct slug tests and/or injection/straddle packer test in the screen completely below the perched water table	Conduct slug tests and/or injection/straddle packer test in the screen completely below the perched water table	Conduct slug tests and/or injection/straddle packer test in the screen completely below the perched water table
Geophysical Testing	Suite and timing of geophysical logging to depend on borehole conditions (suite of possible logs provided in Table 14) Laboratory borehole video camera to be used when open-hole conditions in the vadose zone are favorable for logging	Suite and timing of geophysical logging to depend on borehole conditions (suite of possible logs provided in Table 14) Laboratory borehole video camera to be used when open-hole conditions in the vadose zone are favorable for logging	None: geophysical logs were collected during the installation of MCOBT-4.4	Suite and timing of geophysical logging to depend on borehole conditions (suite of possible logs provided in Table 14) Laboratory borehole video camera to be used when open-hole conditions in the vadose zone are favorable for logging	Suite and timing of geophysical logging to depend on borehole conditions (suite of possible logs provided in Table 14) Laboratory borehole video camera to be used when open-hole conditions in the vadose zone are favorable for logging	Suite and timing of geophysical logging to depend on borehole conditions (suite of possible logs provided in Table 14) Laboratory borehole video camera to be used when open-hole conditions in the vadose zone are favorable for logging
Number of Well Screens	One in Guaje Pumice Bed or dacite lava flows	One in Cerros del Rio basalt	One in upper Puye Formation	One in Cerros del Rio basalt	One in Cerros del Rio basalt	One in Cerros del Rio basalt

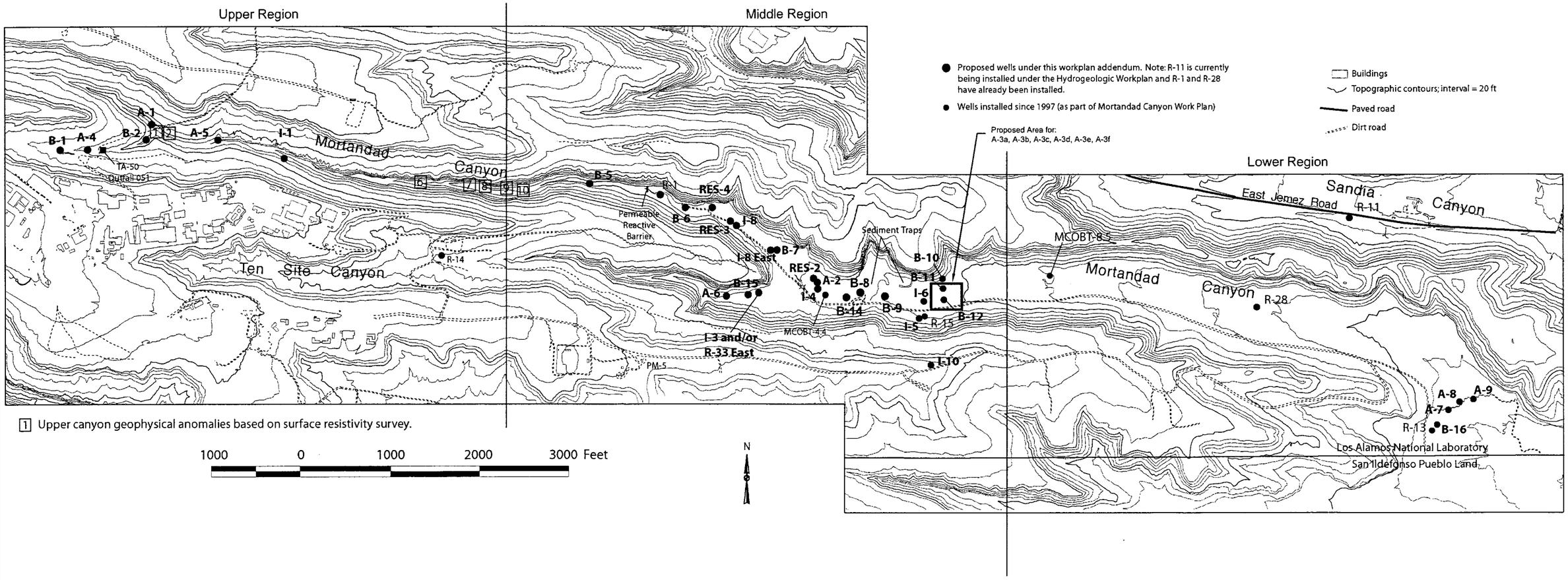
Note: Intermediate wells I-2 (upper Ten Site Canyon near R-14), I-7 (on the bench south of GS-2), and I-9 (1500 ft of PM-5) will be evaluated for relocation and drilling after the other I- and R-wells are drilled.

Table 4
DQO Matrix for Regional Aquifer Wells in Mortandad Canyon

	Well R-1	Well R-28	Well R-33	Well R-34
Conceptual Model Uncertainty	Located at the critical area where Mortandad Canyon widens and the alluvial aquifer gradient changes significantly Possible enhanced infiltration of alluvial water containing contaminants Important well for contaminant monitoring at the regional aquifer Replace TW-8 that may be allowing movement of contaminated alluvial water along the well bore to the regional aquifer	Provide a contaminant analysis and monitoring point for comparison with regional wells R-15 (upstream Mortandad), R-11 (to the north in Sandia Canyon), and R-13 (to the southeast in downstream Mortandad Canyon)	Provide sentinel contaminant monitoring for supply well PM-5 along with R-14 and R-15. Site well north of PM-5 south of Mortandad Canyon Known contamination of nitrate, perchlorate, and tritium in perched groundwater in this section of Mortandad Canyon Groundwater probably provides a source of recharge to the regional aquifer Drill and sample this well after R-1 and R-28 are drilled	R-34 will help constrain the nature and extent of potential contamination in the regional aquifer in the eastern (lower) portion of Mortandad Canyon. It may be used to provide a credible monitoring point for San Ildefonso Pueblo between R-13 and R-22 Drill and sample after R-1, R-28, and R-33 are drilled
Projected Depth	1095 ft: penetrate to a depth of 100 ft below the regional water table	950 ft: penetrate to a depth of 100 ft below the regional water table	1300 ft: penetrate to a depth of 100 ft below the regional water table	1100 ft: penetrate to a depth of 100 ft below the regional water table
Geology	Confirm stratigraphic contacts identified in the TW-8 lithologic log	Identify contacts for Bandelier Tuff and Cerro Toledo interval, Cerros del Rio basalt, Puye fanglomerates, and Totavi Lentil for sitewide models	Identify contacts for Bandelier Tuff and Cerro Toledo interval, Cerros del Rio basalt, Puye fanglomerates, and Totavi Lentil for sitewide models	Identify contacts for Bandelier Tuff and Cerro Toledo interval, Cerros del Rio basalt, Puye fanglomerates, and Totavi Lentil for sitewide models
Hydrology	Determine hydraulic gradient, hydraulic conductivity, and extent of saturation in Puye Formation. Conduct cross-hole pumping test with TW-8 if needed Evaluate localized flow patterns in the regional aquifer	Determine hydraulic gradient, hydraulic conductivity, flow direction, and extent of saturation in Puye Formation Evaluate localized flow patterns in the regional aquifer	Determine hydraulic gradient, hydraulic conductivity, flow direction, and extent of saturation in upper Puye Formation Evaluate localized flow patterns in the regional aquifer	Determine hydraulic gradient, hydraulic conductivity, flow direction, and extent of saturation in upper Puye Formation Evaluate localized flow patterns in the regional aquifer
Geochemistry	Evaluate effect of releases from TA-48, TA-50, and other surface release sites on water quality in the regional aquifer Constrain location and rate of percolation from vadose zone to regional aquifer Evaluate groundwater chemistry in Mortandad Canyon in relationship to R-14, R-15, and R-13	Evaluate effect of releases from TA-48, TA-50, and other surface release sites on water quality in the regional aquifer Constrain location and rate of percolation from vadose zone to regional aquifer Evaluate groundwater chemistry in Mortandad Canyon in relationship to R-14, R-15, and R-13	Evaluate effect of releases from TA-48, TA-35, TA-50, and other surface release sites on water quality in the regional aquifer Evaluate groundwater chemistry in Mortandad Canyon in relationship to PM-5, R-14, R-15, and R-13	Evaluate effect of releases from TA-48, TA-50, and other surface release sites on water quality in the regional aquifer Evaluate groundwater chemistry in Mortandad Canyon in relationship to R-14, R-15, and R-13

Table 4 (continued)

	Well R-1	Well R-28	Well R-33	Well R-34
Vadose Zone Sampling	Collect core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water encountered during drilling	Collect vadose zone core and analyze for anions, metals, radionuclides, and stable isotopes Collect water samples if perched water is encountered during drilling	Collect water samples if perched water encountered during drilling	Collect water samples if perched water encountered during drilling
Core Needs	Collect core samples from surface to core refusal (target 580 ft) for contaminant, metal, and anion analyses Identify contacts for Bandelier Tuff and Cerro Toledo interval, Cerros del Rio basalt, Puye fanglomerates, and Totavi Lentil for site-wide models	Collect core samples from surface to core refusal (target 300 ft) for contaminant, metal, and anion analyses	None	None
Regional Aquifer Sampling	Collect screening water samples during drilling at the top of the regional aquifer Install well screen to collect water quality data for the regional aquifer	Collect screening water samples during drilling at the top of the regional aquifer Install well screen to collect water quality data for the regional aquifer	Collect screening water samples during drilling at the top of the regional aquifer Install well screen to collect water quality data for the regional aquifer	Collect screening water samples during drilling at the top of the regional aquifer Install well screen to collect water quality data for the regional aquifer
Hydraulic Testing	Conduct slug test and/or injection/straddle packer test in the screen completely below the regional water table Conduct cross-hole pumping test with TW-8 if appropriate	Conduct slug test and/or injection/straddle packer test in the screen completely below the regional water table	Conduct slug test and/or injection/straddle packer test in the screen completely below the regional water table	Conduct slug tests and/or injection/straddle packer test in the screen completely below the regional water table
Geophysical Testing	Run cased hole geophysical suite, including neutron log, in TW-8 prior to plugging and abandonment In replacement borehole, suite and timing of geophysical logging to depend on borehole conditions (see Table 14 for suite of possible logs) In replacement borehole, laboratory borehole video camera to be used when open hole conditions in the vadose zone are favorable for logging	Suite and timing of geophysical logging to depend on borehole conditions (see Table 14 for suite of possible logs) Laboratory borehole video camera to be used when open hole conditions in the vadose zone are favorable for logging	Suite and timing of geophysical logging to depend on borehole conditions (see Table 14 for suite of possible logs) Laboratory borehole video camera to be used when open hole conditions in the vadose zone are favorable for logging	Suite and timing of geophysical logging to depend on borehole conditions (see Table 14 for suite of possible logs) Laboratory borehole video camera to be used when open hole conditions in the vadose zone are favorable for logging
Number of Well Screens	One in the Puye Formation	One in the Puye Formation	To be determined	One in the Puye Formation



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Drawn By: C. Landon	Date: September 2004
Project No.: 49436	Revision: 1

Mortandad Canyon Well Location Map
Mortandad Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

FIGURE
1

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