TA-00

Department of Energy
National Nuclear Security Administration
Los Alamos Site Office
Los Alamos, New Mexico 87544

Ms. Carolyn Cooper
Permits Management Program
NMED – Hazardous Waste Bureau
2905 Rodeo Park Dr E Bldg 1
Santa Fe, NM 87505-6313

Dear Ms. Cooper:

Subject: Transmittal Of Drilling Plan For R-2, R-4, R-11 And R-26

For your information, enclosed is a copy of the drilling plan for the regional aquifer wells R-2, R-4, R-11, and R-26. If you have questions, please contact Tom Whitacre, 665-5042 or Bob Enz, 667-7640.

Sincerely,

Mat Johansen
Groundwater Compliance
Program Manager

cc:
C. Nylander, RRES-GP, LANL, MS-M992
J. McCann, RRES-WQH, LANL, MS-M992

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KLEINFELDER DRILLING PLAN FOR CHARACTERIZATION WELLS R-2, R-4, R-11, AND R-26 FINAL
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO
PROJECT NO. 33220

September 2, 2003

Prepared for: **United States Department of Energy and the National Nuclear Security Administration Through the United States Army Corps of Engineers, Sacramento District**

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Kleinfelder Drilling Plan for Characterization Wells R-2, R-4, R-11, and R-26 FINAL

This plan provides guidance for the site preparation, drilling, sampling, installation, testing and site restoration activities associated Characterization Wells R-2, R-4, R-11, and R-26 project. Guidance in this plan is in compliance with the scope of work set forth in US Army Corps of Engineers Task Order DACW05-03-F-0090.

PROJECT STAFF

Kleinfelder's proposed project staff and their respective roles are detailed in Table 1. The overall project organization is shown schematically in Figure 1.

Table 1: Roles and Responsibilities

NAME	PROJECT ROLE	RESPONSIBILITIES	EXPERIENCE
Paul Fensterer	Program Manager	Program Management Controls, Client Interaction	Civil Engineering, Operations Management
Chris Johnson, RG	Chief Technical Leader	Technical Oversight and QA	Hydrogeology, Well Design, Deep Well Drilling
Alan Kuhn, PE, PG	Quality Manager	Quality Assurance	Quality Assurance, Engineering Geology
Richard Bohrer, CIH	Health and Safety Manager	Kleinfelder Health & Safety (H&S) Plan and Compliance	Industrial Hygiene
Mark Everett, PG	Project Manager	Project Cost Controls & Field Oversight	Geosciences and Geology, LANL Deep Well Program
Bernie Bockisch	Field Manager	Drilling Oversight, Field Geology, Subcontractor Coordinator	Geologic Engineering, Field Investigations, Environmental Sciences
Bryan Bondy, Steven Woodall, Brian Peck, & Others	Field Geologist/FTL	Drill Oversight, Field Geology, Sampling	Geology and Geochemistry, Field Investigations

Additional qualified and experienced staff (existing and new) may be added after submittal of this drilling plan for performance of the work. These staff will be identified and their roles assigned prior to commencement of their services. All staff will be trained to the Site Specific Health and Safety Plan (SSHASP), Standard Operating Procedures (SOPs), and applicable quality procedures. A current physician's release for work for all field personnel will be in the Project file. Hazardous and/or radioactive materials are not anticipated to be present at the drill sites, but the possibility of their presence cannot be eliminated. Therefore, Occupational Safety and Health Act (OSHA) 29 Code of Federal Regulations (CFR) 1910.120 (HAZWOPER 40-hr) training will be required for all field personnel and documentation will be in the project file. Radworker II, a LANL training course will not be required for these wells.

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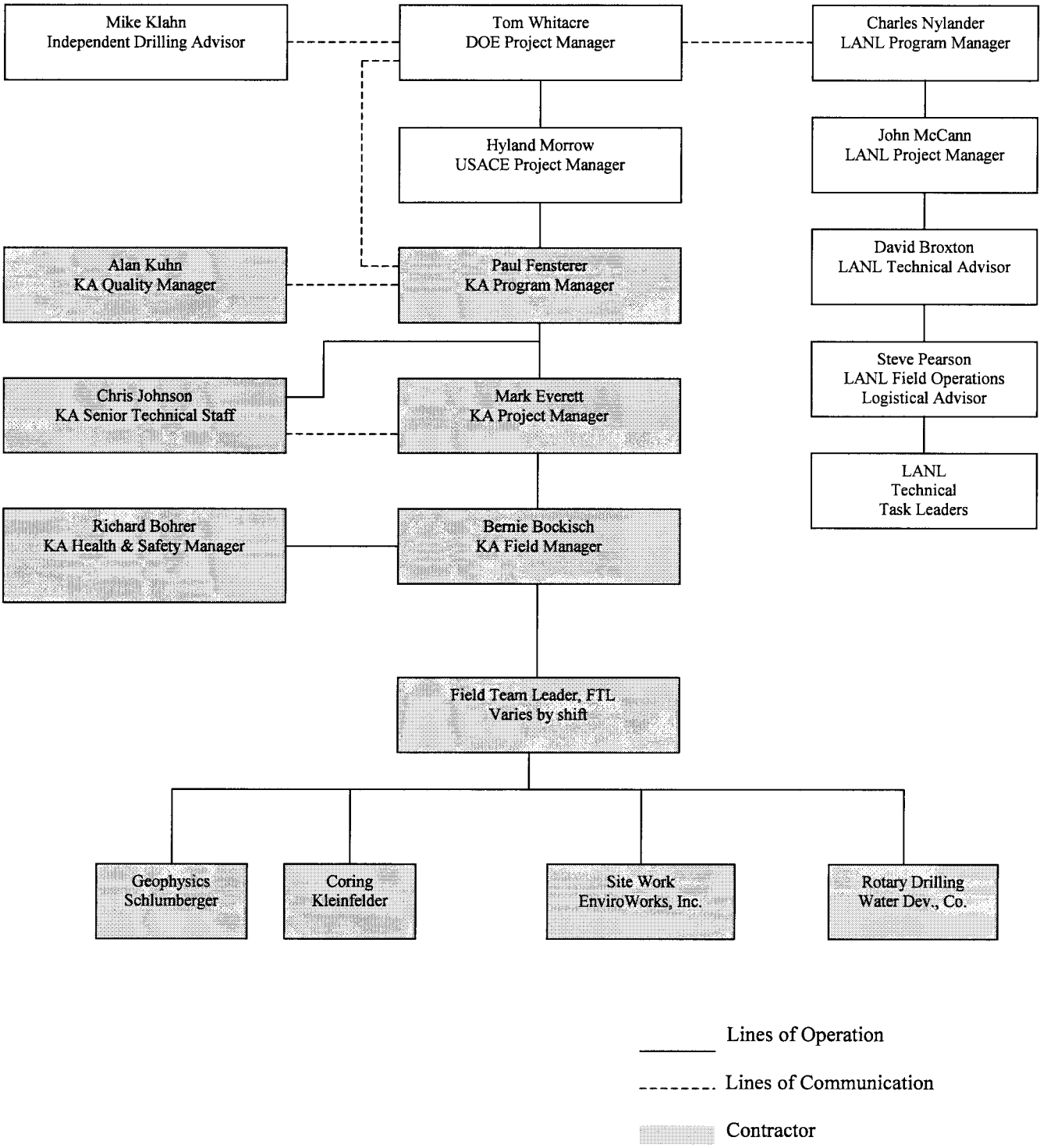

Figure 1. Project Organization Chart

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The field manager will visit the sites regularly to ensure that the Project Plan and SSHASP requirements are being met and to provide continuity amongst the field geologist crews. The field manager will provide oversight and review ongoing operations as they relate to this work plan and the SAP; and assist the drilling team with any technical, operational, or other project related issues. Drilling and completing the 4 wells in this plan, including well development, is anticipated to take 15 weeks (see Project Schedule, Appendix A).

Drilling is scheduled to occur only during daylight hours. Possible conditions that could require longer operational days may include delays in project schedule or poor down-hole stability. The overall project schedule will be monitored and possibly modified on a well by well basis. Alternatively, if unstable borehole conditions are encountered and longer operational days are required, immediate steps will be taken.

SITE PREPARATION

This task includes the construction of the drill pad, lay down areas, and road improvements necessary along the access roads. Environmental permit applications filed for this work include 401/404 flood plain crossings (access road to R-2 and R-4), Storm Water Pollution Prevention Plans (R-2, R-4, R-11, and R-26), and a wetlands assessment (R-2). No work will begin before all necessary permits are obtained. A map of the Los Alamos area showing the well locations is presented in Figure 1.

The pads will be cleared of vegetation and leveled. Approximately 4-inches of base coarse will be spread on the pad and rolled. Base coarse will also be used along access roads as necessary. Equipment necessary for the completion of the drilling project will be situated around the work site to provide a safe, secure work site (Figure 2a-d). Orientation and placement of equipment will depend on physical constraints at each drill site.

Potable water will be brought in by truck and stored in clean frac-tanks for wells R-2 and R-4. The proposed water supply is municipal supply water stored in the water tank near Los Alamos supply well Otowi 1. For R-11, water will be trucked from the municipal water standpipe located near the Los Alamos Transit Mix on Jemez Road. A waterline will be run from a fire hydrant approximately 0.25 miles to the R-26 drill site.

Clearing for the road improvements may be necessary and 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 on site with approval from the Facility Manager. Some of these materials may be used in erosion control and/or site restoration. The road to R-2 will require the most extensive improvements. At one sharp bend, the existing road may need to be rerouted. The dead-standing trees may be felled and the road temporarily aligned to allow passage of large vehicles such as the drill rig and frac-tanks. A decision on a final solution to this issue will be agreed to amongst Kleinfelder, DOE, and Los Alamos County.

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DRILL AND INSTALL CHARACTERIZATION WELLS

Field operations will be guided by the Sampling and Analysis Plan (SAP) for the Drilling and Testing of Characterization Wells R-2, R-4, R-11, and R-26. Kleinfelder has elected to mobilize multiple drill rigs to meet the project schedule. Coring will be performed by Kleinfelder with a StrataStar SS-15. Two drill rigs from Water Development Company (WDC) are proposed to advance the deep wells; a Dresser T70W and a SpeedStar 50K. Alternative rigs with similar capacity may be used. At each site, the cored boring will be offset from the main boring. The cored and main borings will be as close to one another as possible, but no more than 100 feet. Offsetting the core holes from the boreholes will allow the drill rigs to operate on independent schedules, expediting the completion of the program. In addition, WDC will provide a Smeal 5-T rig or equivalent to develop the wells and set the permanent ground water sampling systems.

Once drilling is completed, both the abandoned core holes and completed wells will be surveyed by a New Mexico licensed Professional Land Surveyor. Data provided by the surveyor will include NAD83 State Plane Coordinates, latitude and longitude, and elevation in relation to mean sea level (NGVD29).

CORED BORING

Kleinfelder will provide in-house drilling services, including equipment and labor, for the continuously cored boring to a maximum depth of 350 feet as specified in the SAP. During this task, two Kleinfelder geologists will be on site. The coring will be completed using hollow stem auger and Geobarrel (HQ-size) coring. Coring will proceed without the addition of fluids other than air. The augers will be advanced to refusal after which the HQ system will be advanced. The depth of the target perched layer will determine total depth as specified in the SAP.

Lexan tubes will be loaded into the sample tube prior to placement in the auger. Prior to removal of the lexan tubes from the sample tube, the percent recovery will be noted. After the tubes are removed from the sampler, the lithology will be logged on the boring log. End caps will be placed on each end of the lexan tube and sealed with tape. Nipple length on the Geobarrel will be dependent on the formation hardness. In softer material (e.g. Otowi Member of the Bandelier Tuff) a core catcher will be placed in the core barrel. Approximate depth intervals of proposed coring methods are presented in Table 2 on the following page.

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Table 2: Proposed Coring Methodology

Well ID	Auger Interval (ft)	HQ-coring Interval (ft)
R-2	0-50	50-300, or until upper perched zone in the Puye is fully penetrated, whichever occurs first.
R-4	0-50	50-300, or until upper perched zone in the Puye is fully penetrated, whichever occurs first.
R-11	0-300	300-350, or until penetration 50 ft into the Cerros del Rio basalt is achieved.
R-26	0-250	N/A

Core collected will be handled per LANL Environmental Restoration (ER) SOP 6.26; using sample containers (plastic bags and ProtecCore™). Samples will be submitted to the Sample Management Office (SMO) using the LANL ER Chain of Custody documentation. Samples will be collected at the following intervals: 10, 20, 30, 40, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325, and 350 ft. Samples collected will be analyzed for anions, cations, moisture content, tritium, radionuclides, and stable isotopes. Description of sample preparation and analytical laboratories to be used can be found in Table 3 which is adapted from Sampling and Analysis Plan for the Drilling and Testing of Characterization Wells R-2, R-4, R-11, and R-26.

After sampling, all 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.

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Table 3: Sample Collection Activities for Cuttings and Core

Sample Description	Analyte	Sample Size	Container	Sample Frequency	Preferred Laboratory
Coring					
Core	Anions, cations, and moisture content	0.4 ft of 2-in.-diameter core	8-oz preweighed glass jar	Target depths: 10, 20, 30, 40, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325, and 350 ft. In R-2 and R-4, the core target depth is 200 ft with the goal of completely penetrating the uppermost intermediate perched groundwater zone; however, coring will not exceed 300 ft. In R-11, coring to terminate after penetrating the top 50 ft of Cerros del Rio basalt, but will not exceed 350 ft. In R-26, core target depth is 250 ft.	EES-6[a]
Core	Tritium	0.5 ft of 2-in.-diameter core	Sealed plastic bag wrapped with tape and core protected	Target depths: 10, 20, 30, 40, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325, 350 ft. In R-2 and R-4, the core target depth is 200 ft with the goal of completely penetrating the uppermost intermediate perched groundwater zone; however, coring will not exceed 300 ft. In R-11, coring to terminate after penetrating the top 50 ft of Cerros del Rio basalt, but not to exceed 350 ft. In R-26, no tritium samples will be collected.	GEL[b]
Core	Radiological screening for gross alpha, beta, and gamma (for off-site transport of samples)	0.2 ft of 2-in.-diameter core	Sealed plastic bag	Every 50 ft	ARS[c] in Los Alamos

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Table 3: Sample Collection Activities for Cuttings and Core (continued)

Sample Description	Analyte	Sample Size	Container	Sample Frequency	Preferred Laboratory
Coring					
Core	Radionuclides	0.5 ft of 2-in.-diameter core	Sealed plastic bag and core protected	Target depths: 10, 20, 30, 40, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325, and 350 ft. In R-2 and R-4, the core target depth is 200 ft with the goal of completely penetrating the uppermost intermediate perched groundwater zone; however, coring will not exceed 300 ft. In R-11, coring to terminate after penetrating top 50 ft of Cerros del Rio basalt, but not to exceed 350 ft. In R-26, no radionuclide samples will be collected.	GEL
Core	Stable isotopes	0.5 ft of 2-in.-diameter core	Place samples into two sealed plastic bags and core protected	Target depths: 10, 20, 30, 40, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325, and 350 ft. In R-2 and R-4, the core target depth is 200 ft with the goal of completely penetrating the uppermost intermediate perched groundwater zone; however, coring will not exceed 300 ft. In R-11, coring to terminate after penetrating the top 50 ft of Cerros del Rio basalt, but not to exceed 350 ft. In R-26, the core target depth is 250 ft.	Socorro[d] for δD and $\delta^{18}O$ and Coastal Sciences for $\delta^{15}N$
Core	Laboratory hydrologic tests	1 ft of 2-in.-diameter core	None	For R-26 only; up to 8 samples to be selected for testing. This selection will be made by LANL staff at a later date.	To be determined
Drilling					
Cuttings	Bulk cuttings systematically collected for archival purposes and for supplemental sample needs	500–700 mL	Plastic ziplock bag	One sample every cuttings run (nominally every 5 ft), beginning at bottom of core hole. If main borehole is drilled before coring takes place for operational reasons, cuttings will be collected from the surface to TD.	n/a[e]

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Table 3: Sample Collection Activities for Cuttings and Core (continued)

Sample Description	Analyte	Sample Size	Container	Sample Frequency	Preferred Laboratory
Coring					
Cuttings	Sieved cuttings for lithologic description and binocular microscope examination	Enough to partly fill trays	Plastic chip trays	One sample every cuttings run (nominally every 5 ft), including over-drilling the core hole. Normally, an unsieved sample, a >10 mesh sample, and a >35 mesh sample every cuttings run.	n/a
Cuttings	Sieved cuttings for XRD[f], XRF[g], petrography	200–300 mL sieved, or bulk if necessary	Plastic ziplock bag	One >10-mesh sample every cuttings run (nominally every 5 ft); finer sizes or bulk split will be substituted where >10-mesh size cannot be obtained.	EES-6
Cuttings	Radiological	2 L of cuttings	Plastic ziplock bag	Up to 5 samples for the entire borehole within water-bearing zones; sample location to be determined by the geochemistry lead	GEL

Note: Priority of sample core collection when recovery is less than 100% should be anions, moisture content, and stable isotopes, radionuclides and tritium, and radiological screening.

[a] EES-6 = Earth and Environmental Sciences Hydrology, Geochemistry, and Geology Group.
[b] GEL = General Engineering Laboratory.
[c] ARS = American Radiation Services of New Mexico.
[d] New Mexico Institute of Mining and Technology.
[e] n/a = Not applicable.
[f] XRD = x-ray diffraction spectroscopy.
[g] XRF = x-ray fluorescence.

(FSF) for archiving and storage after the borehole is completed. Samples from R-26 may be selected for future laboratory hydrologic testing.

The core hole will be plugged and abandoned by filling the hole with hydrated bentonite chips or pellets to within 75 feet of ground surface. Above the standing water level, a minimum of 10 gallons of potable water will be added to the hole after each 10-foot lift of bentonite is placed. The remaining hole will be filled with cement containing approximately 2% bentonite. All materials will be tremied in except the water, which will be poured in the annular space between the tremie and borehole wall. The cement/bentonite slurry will be tremied in unless conditions require it to be pumped. The abandoned hole will be marked for surveying.

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FOAM/ROTARY BORING

During the foam/rotary boring task, two field geologists will be present for each 12-hour shift. The field geologists will maintain geologic logs, track down-hole tool types and lengths, track fluids used and fluids produced, and record general drill site activities.

The deep characterization boreholes will be offset from the core holes at each site and will be a nominal 12 ¼-inch diameter. A 16-inch surface conductor will be set inside a minimum 24-inch borehole to approximately 50 feet. The proposed method for drilling the deep characterization boreholes is direct air-rotary with foam assist. Kleinfelder will attempt to identify and sample perched water. If perched water is encountered, a sample will be submitted for rapid turn-around screening results. If contamination is suspected, Kleinfelder will discuss drilling options with DOE and USACE before penetrating the regional aquifer.

The proposed methodology with drill bit selection for each well follows.

R-2

A 12 ¼-inch down-the-hole (DTH) hammer and bit will advance the hole to the total anticipated depth of 910 feet. If flowing sands are encountered in the Totavi Lentil, for instance, then an air-rotary casing-hammer (ARCH) system may be used. If swelling clays are encountered, potassium chloride will be added as an inhibitor.

R-4

A 12 ¼-inch down-the-hole (DTH) hammer and bit will advance the hole to the total anticipated depth of 820 feet. Since the Totavi Lentil is anticipated to be above the regional aquifer in this location, the use of a casing advance system is not anticipated but will be available, if needed.

R-11

A 12 ¼-inch mill tooth tri-cone bit will advance the borehole until penetration rates decrease significantly. This will likely occur at the base of the Guaje Pumice Bed (257 ft bgs) or the base of the Puye above the Cerros del Rio basalt (297 ft bgs). Below this depth a DTH hammer system will be utilized.

R-26

A 12 ¼-inch mill tooth tri-cone bit will advance the borehole until penetration rates decrease significantly. This will likely occur at the base of the Guaje Pumice Bed (818 ft bgs). Below this depth a DTH hammer system will be utilized.

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Drilling Additives

Drilling additives will be available for use if needed. Only approved Baroid drilling products will be used during the drilling and completion of these wells. Potential Baroid drilling additives and a brief description of each follows. Product sheets for these products are included as Appendix B.

1). **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.

2). **AQUAGEL GOLD SEAL®** - 25-50lbs/100gals. This pure bentonite provides a viscous fluid which forms the basis for increasing the surface tension of the foam mix.

3). **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.

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

5). **POTASSIUM CHLORIDE** - 25-50 lbs/100 gals. Clay inhibitor to be used if swelling clays are encountered.

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) hours combined with reduced penetration rates below 2 feet per hour may necessitate the use of casing. Kleinfelder will consult with DOE and USACE prior to modifying the above referenced drilling techniques.

- If the borehole begins to cave in, one possible modification could be to lower an 11 ¾-inch OD drill casing into the 12 ¼-inch borehole and drill through the bottom of the casing. The 11 ¾-inch casing will keep the upper part of the hole from caving in around the drill bit. The inside of the casing shoe will be milled out to 10 5/8-inch diameter which allows a sufficient diameter hole to be drilled below. Another possible modification is the ARCH system mentioned above 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 could be employed when flowing sand conditions inhibit borehole advancement and DQOs dictate greater depths be attempted. Both options will be available on-site and will only be deployed after consultation amongst DOE, USACE, NMED, and Kleinfelder.

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- If down-hole conditions warrant, then a borehole may be abandoned, the drill rig repositioned, and a new boring advanced. The abandoned boring will be filled with a bentonite/sand mix to within 75 feet of ground surface. The bentonite placed above the regional aquifer will be hydrated after placement. Cement with 2% bentonite will be used to fill the remaining borehole. This option will only be deployed after consultation amongst DOE, USACE, and Kleinfelder.

The following drilling techniques may be implemented adjacent to the abandoned borehole. The new borehole may be advanced using 13 3/8-inch OD drive casing. If necessary, a second string of 11 ¾-inch outside diameter drive casing may be inserted into the 13 3/8-inch and "telescoped" to continue drilling. If target depth is reached with this string, the well will be constructed inside the second drive casing string, and then both strings will be removed in reverse order during well construction. If necessary, a third drive casing string (9 5/8-inch) will be available to complete the borehole.

Sample Collection

Sample collection and handling activities will be conducted in accordance with the SAP.

Ground Water

If significant perched water is encountered, a sample will be collected from the discharge line as drilling proceeds. Up to 7.0 gallons will be collected, as practical, at each perched zone encountered. The collected ground water will be placed in appropriate containers and delivered to EES-6 for filtering and preservation. Ground water samples will be kept cool and delivered to EES-6 within two hours of collection or the following morning if sampling occurs late in the day. After filtering and preservation, Kleinfelder will then submit the samples to the Sample Management Office for processing. After processing, Kleinfelder will transport a subset of the ground water samples back to EES-6 for analysis. EES-6 will provide rapid turn-around analyses for non-sorbing potential contaminants (e.g. ClO4, NO3); these screening analyses will be used to evaluate whether perched water zones should be isolated with drill casing before the regional aquifer is penetrated. Drilling will continue until a depth of approximately 40 feet into the regional zone of saturation is reached. At this point, 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 or USACE and DOE approve an alternate. A ground water sample will then be collected, if practical, and processed in accordance with referenced perched water guidelines. Drilling with foam or other drilling methods, as needed, shall continue to the maximum target depth. A ground water sample will also be collected at the bottom of the borehole, if practical, and processed as above.

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Cuttings

A subset of unsieved and sieved samples will be collected from each cuttings run, as practical, and stored in plastic chip trays labeled with the well name and cuttings depth ranges (Table 3). Unsieved and sieved cuttings will be placed in individual tray bins and labeled by footage and sieve size range. Sieve sizes will typically be >10 and >35 mesh, but will be >35 and >60 mesh for finer grained materials. Lost-circulation zones (no cuttings returns) will be indicated by empty trays labeled, "no returns" or equivalent. If foam or mud is used during drilling, cuttings return delay time will be accounted for. Up-hole velocities will be calculated based on borehole size and fluid volumes used. Physical measurements of up-hole travel time may also be made. To do this, the borehole will be circulated clean, a six-inch interval drilled, and up-hole travel time measured.

Additionally, about 200 to 300 ml of >10 mesh cuttings will be collected from each cuttings run (nominally every 5.0 ft) and stored in sealed plastic bags labeled with the well name and footage range representing the depth interval at which the cuttings were derived. Finer sieve sizes or bulk cuttings will be collected when >10 mesh materials are absent. These samples will be transferred to the LANL Geology Task Leader.

Well Completion

The characterization wells will be completed with a single-screened interval with the exception of R-26. R-26 is proposed as a two-screened interval completion. Wells R-2, R-4, and R-11 will have a 20-foot screen set below the top of the regional aquifer targeting any high permeability zones encountered. R-26 is proposed to have a 20-foot screen set in the perched interval possibly in the 300 to 700 foot depth range and an additional 20-foot screen set below the top of the regional aquifer targeting any high permeability zones encountered. Final placement of the screens will be based on discussions amongst DOE, Kleinfelder, LANL, and NMED. All four wells will be constructed of 5-inch OD stainless steel casing with stainless steel 20-slot (0.020-inch opening) wire-wrap screens. A 10-slot (0.010-inch opening) pipe-based screen will be used in the perched zone at R-26. The tensile strength of the pipe-based screen will be required for the perched interval in R-26 and since 10-slot pipe-based screen has already been fabricated, DOE and Kleinfelder agreed to use the available material.

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A bentonite seal will be placed below each screened interval and allowed to hydrate for 1 hour to prevent mixing. A two-foot interval of fine grained (30/70) transition sand will be placed above and below each primary filter pack. The primary filter pack (20/40 sand) will extend from 5 feet below each screened interval to 5 feet above. Multi-screen completions (e.g. R-26) will have intervals of sand filter pack around each screen separated by bentonite seals. A bentonite chip and sand mix will then be used to fill the annulus to within 75 feet of ground surface. The mix will be hydrated in place every 100 feet. Cement with 2% bentonite will be used to fill the remaining annulus. Below the standing water level, all materials will be emplaced with tremie pipe. Above the standing water level, backfill materials may be poured directly into the annulus from the ground surface. The depths of annular materials will be measured between each lift of annular fill to ensure that the materials are settling properly. Potable water will be used to transport the materials down-hole. If plugging of the tremie becomes a problem, a low concentration EZ-MUD/water solution will be used to place bentonite. Figure 3 presents a typical one-screen completion. Any modifications to this well completion design will be approved by DOE, USACE, and NMED.

Well Development

Well development may consist of bailing, swabbing, jetting, brushing, surging, chemical treatment, and pumping of the screened interval(s). Well conditions (e.g. fluids used, initial turbidity) will dictate the methods used and the order in which the methods are utilized. The target for development is a turbidity at or below 5 NTU (Nephelometric Turbidity Units). An alternative standard of three consecutive, repeated measurements (within 5% of the previous measurement) of temperature, conductivity, and pH may be used to determine sufficient development.

All water produced during the drilling and development of the wells will be containerized, sampled, and evaluated for compliance with NM WQCC Regulation 3103 ground water standards and applicable RCRA regulatory limits before any discharge occurs. Decisions regarding the discharge of drilling and development water will be made in accordance with the "Workplan NOI Decision Tree" (Revised-7/15/02) and in coordination with NMED. Drilling and development water approved for discharged 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).

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

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Well Test

Once development is complete, an aquifer test will be designed with input from the NMED. Possible test methods include injection, slug, or pumping. The test method selection will be based upon well design and data needs. Injection or slug tests may be appropriate in low transmissivity zones. If selected, these would consist of several short duration tests conducted over one day. Alternatively, a pumping test may be appropriate in zones that have been determined, during the well development, to produce sufficient water for such a test. Duration of a pumping test would be determined after the well has been developed. Other factors that could influence test selection include water storage capacity, discharge area availability, and ground water analytical results.

Regardless of test type, a transducer/datalogger 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 95% of the original static water level before testing began. Water level will be confirmed with an electronic sounder both before and after each test(s). All testing will be conducted under the direct supervision of a qualified hydrogeologist. Data collected and results will be included in the Well Completion Report.

Sampling System Installation

For the single completion wells R-2, R-4, and R-11 a dedicated sampling system will be installed. The system could either be a submersible pump as used in previous completions (e.g. R-21) or a BARCAD gas-driven water sampler.

Kleinfelder proposes to use a Grundfos™ 5S20-39 2HP submersible pump or equivalent which would provide approximately 3 gallons per minute (gpm) at 900 feet through stainless steel discharge pipe. This is a sufficient flow rate for sampling all three single-completion wells. All materials that contact the ground water sample will be either stainless steel or Teflon. To measure water levels in the wells, a 1-inch inside diameter 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 the wellhead.

Alternatively, the BARCAD water sampling system may be used. The BARCAD provides a low flow discharge rate of 0.17 gpm from 900 feet. The sample intake port is isolated from the standing water above with an inflatable packer. Water is lifted to the ground surface by introduction of an inert gas (e.g. nitrogen) down-hole forcing the ground water up through a small diameter collection line. A dedicated pressure transducer will be coupled with the sampling system to provide ground water elevation data. The sampling system will be constructed of stainless steel and Teflon. The combination of low flow purge and sampling coupled with the isolation packer could provide an efficient low maintenance option to the traditional submersible pump.

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For R-26, a Westbay™ MP55 multi-port sampling system will be installed. R-26 will be completed with a single 5-inch OD stainless steel casing string. The two screened intervals will be separated outside of the casing with bentonite seals. Inside the casing, a series of inflatable packers will isolate the screened intervals. Installation will include sampling and purging ports at each zone and pressure transducers for monitoring ground water levels.

Down Hole Geophysics

The geophysical logs to be collected for these wells will be similar to those collected in previous wells at LANL (Table 4). The geophysical logging operation will include one mobilization after reaching the target depth for each well. A Kleinfelder field staff member will be present on site during all logging operations to oversee logging runs and calibration checks. Schlumberger will process the geophysical logs and provide a preliminary log interpretation within 24 hours of completion. If drill or conductor casing is used in the boreholes (for example R-2, as described in the foam/rotary boring section above), an additional contracted logging run may be conducted. This additional logging run would be conducted before the conductor is installed.

Table 4: Contracted Geophysical Logging Suite

TOOL	CASED	UNCASED
Natural Gamma	X	X
Natural Gamma Ray Spectrometer	X	X
Epithermal Compensated Neutron Log	X	X
Caliper		X
Formation Micro-imager (FMI)		X
Array Induction Imager Tool		X
Triple LithoDensity	X	X
Combinable Magnetic Resonance (CMR)		X
Elemental Capture Sonde (ECS)	X	X

Video logging, and possibly additional geophysical logging, will be performed with LANL supplied equipment. If zones of interest are encountered that need to be documented, but do not warrant a Schlumberger mobilization, Kleinfelder will provide a senior geologist experienced in performing borehole geophysical and video-logging operations with the LANL equipment. LANL will mobilize the trailer to the desired well location.

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Surface Completion

The well head 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 feet x 5 feet x 6 inch thick reinforced concrete pad. A set of 4 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. A weatherproof control box will be mounted on a pedestal next to each well.

Investigation Derived Waste

Fluids produced during drilling, well development, and testing will be sampled and analyzed for the suite of constituents as agreed to between DOE and NMED. No water will be discharged until permission is granted through the approval process outlined in the Well Development section above. In addition, drill cuttings will be used in site restoration upon approval from NMED.

SITE RESTORATION

Restoration to be provided is limited to removal of site litter, silt control fencing (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. The site excavations (cuttings pits) will be backfilled or contoured. Erosion control and revegetation will be accomplished in accordance with LANL's Best Management Practices (BMP) guidance and seeding specifications.

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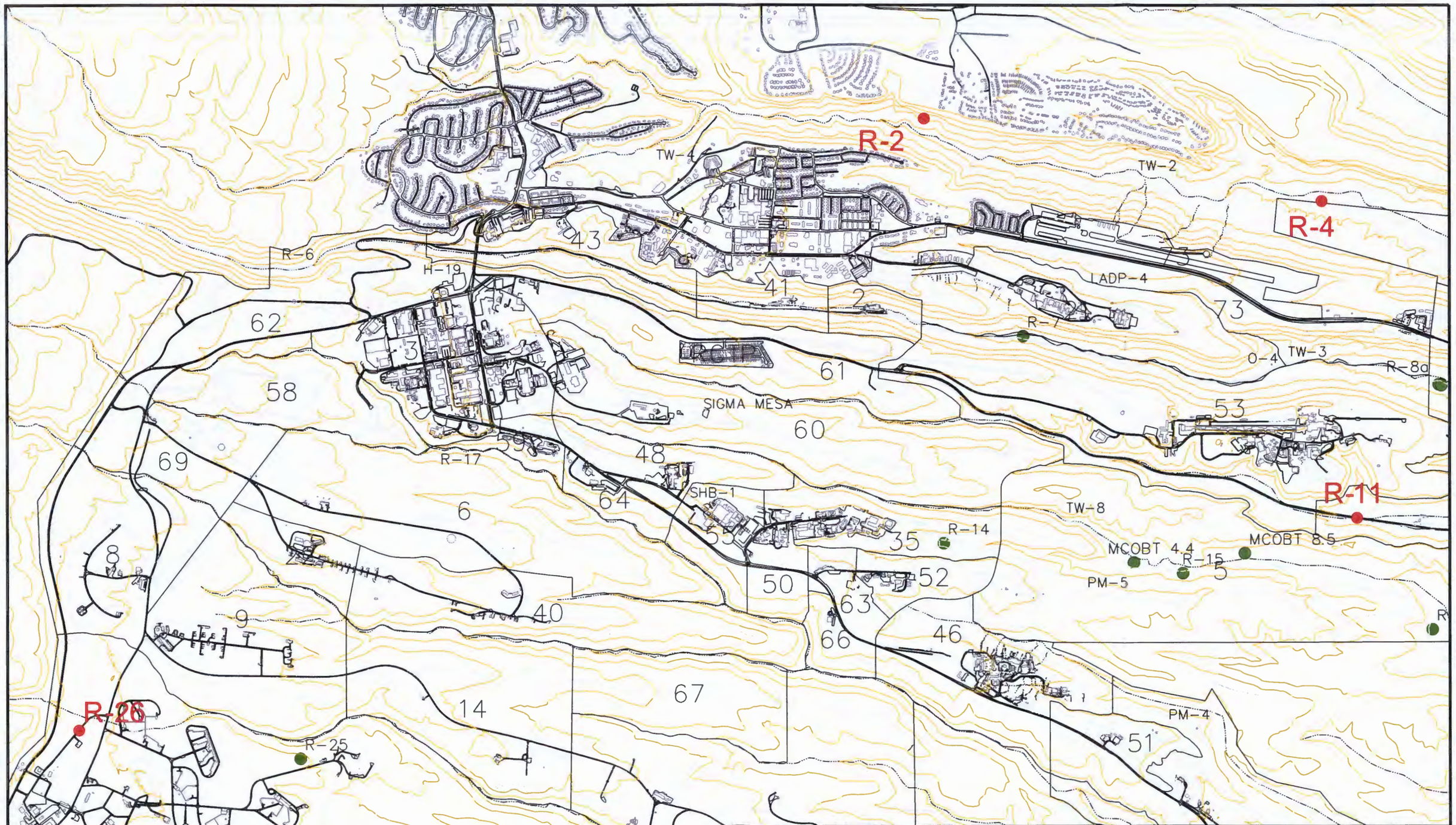


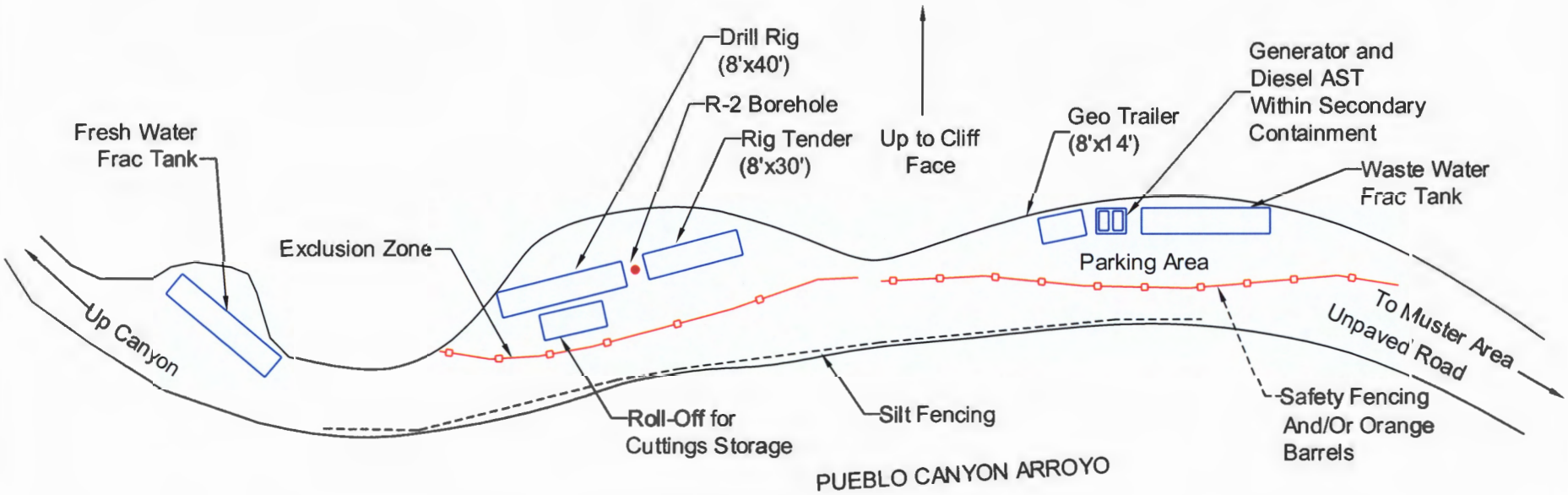
CHARACTERIZATION WELL LOCATIONS

KLEINFELDER

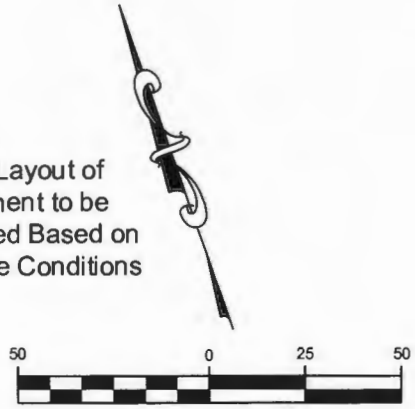
Drawn By: B. Bockisch	Date: August 2003
Project No.: 33220	Filename: character.dwg

SITE LOCATION MAP
R-2, R-4, R-11, R-26 Characterization Wells
E. Jemez Road
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure
1



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



SCALE: 1 inch =50 ft.
All Locations are Approximate

KLEINFELDER

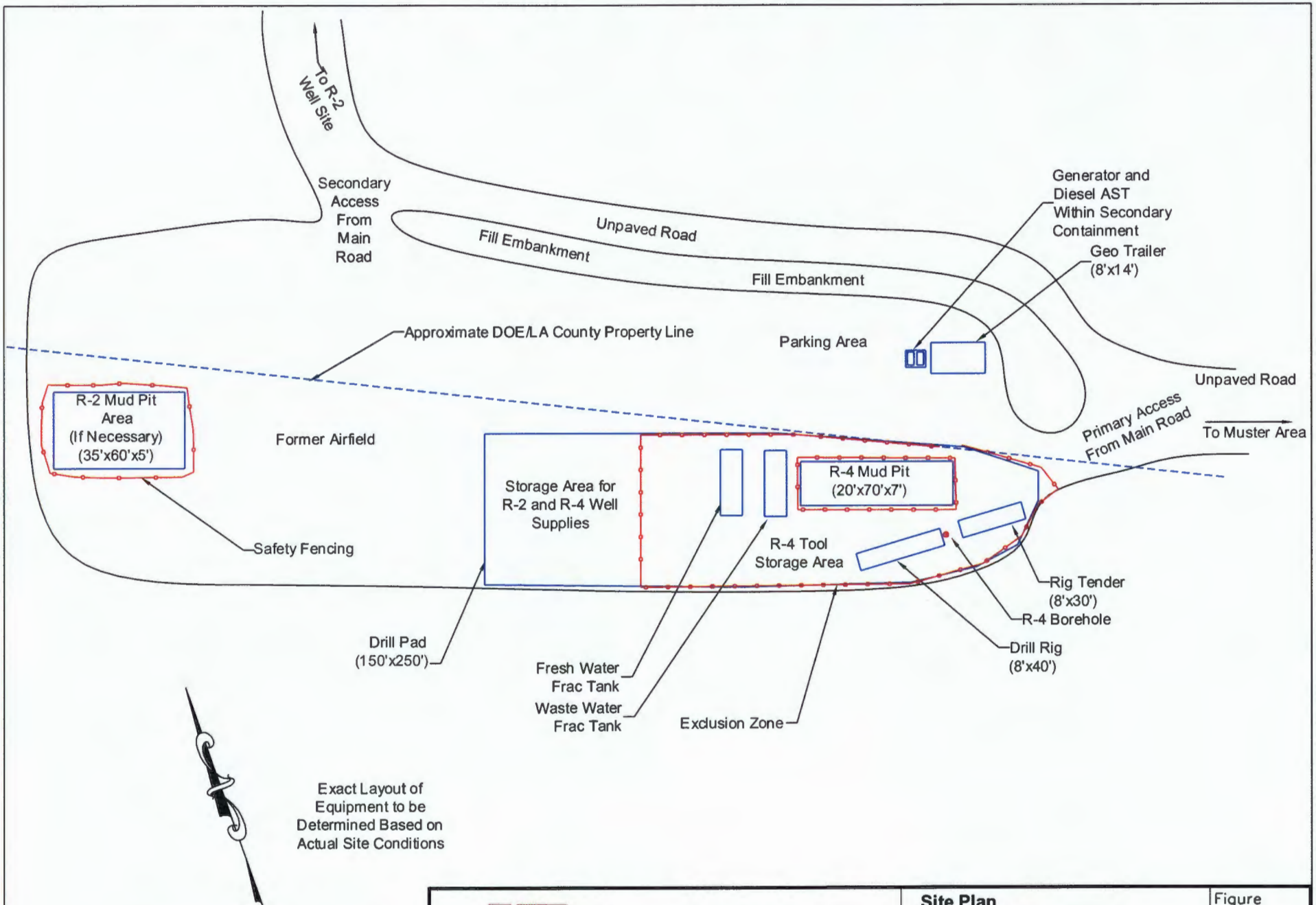
Drawn By: B. Bockisch	Date: July/August 2003
Project No.: 33220	Filename: 1A R2 Siteplan

Site Plan
R-2 Monitor Well
Pueblo Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure
2A

U:\DOE_LANL Well Program\Project Plans\SSHASP\Drilling Plan\Figure_1A_R2_Siteplan.dwg

Kleinfelder, Inc. 2000



KLEINFELDER

Drawn By: B. Bockisch
Project No.: 33220
Date: August 2003
Filename: Fig1BR4Siteplan

Site Plan
R-4 Characterization Well
Pueblo Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure
2B

U:\DOE_LANL Well Program\Project Plans\SSHASP\Health & Safety\Figure_1B_R4_Siteplan.dwg

Kleinfelder, Inc. 2000

Approximate Location of TA-72 Firing Range

Roadway Shoulders

E. JEMEZ ROAD (TRUCK BYPASS ROAD)

Drill Rig (8'x40')

R-11 Borehole

Rig Tender (8'x30')

Parking

Traffic Turn-off Area

Muster Area

Culvert

Exclusion Zone

Waste Water Frac Tank

Drill Pad (100'x40')

Fresh Water Frac Tank

Existing Two-Track Unpaved Road

Generator and Diesel AST Within Secondary Containment

Cuttings Pit

Safety Fencing

Geo Trailer (8'x14')

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

60 0 30 60

SCALE: 1 inch = 60 ft

All Locations are Approximate

KLEINFELDER

Drawn By: B. Bockisch

Project No.: 33220

Date: August 2003

Filename: 1C R11 Siteplan

Site Plan

R-11 Characterization Well

E. Jemez Road

Los Alamos National Laboratory

Los Alamos, New Mexico

Figure

2C

U:\DOE_LANL Well Program\Project Plans\SSHASP\Drilling Plan\Figure_1C_R11_Siteplan.dwg

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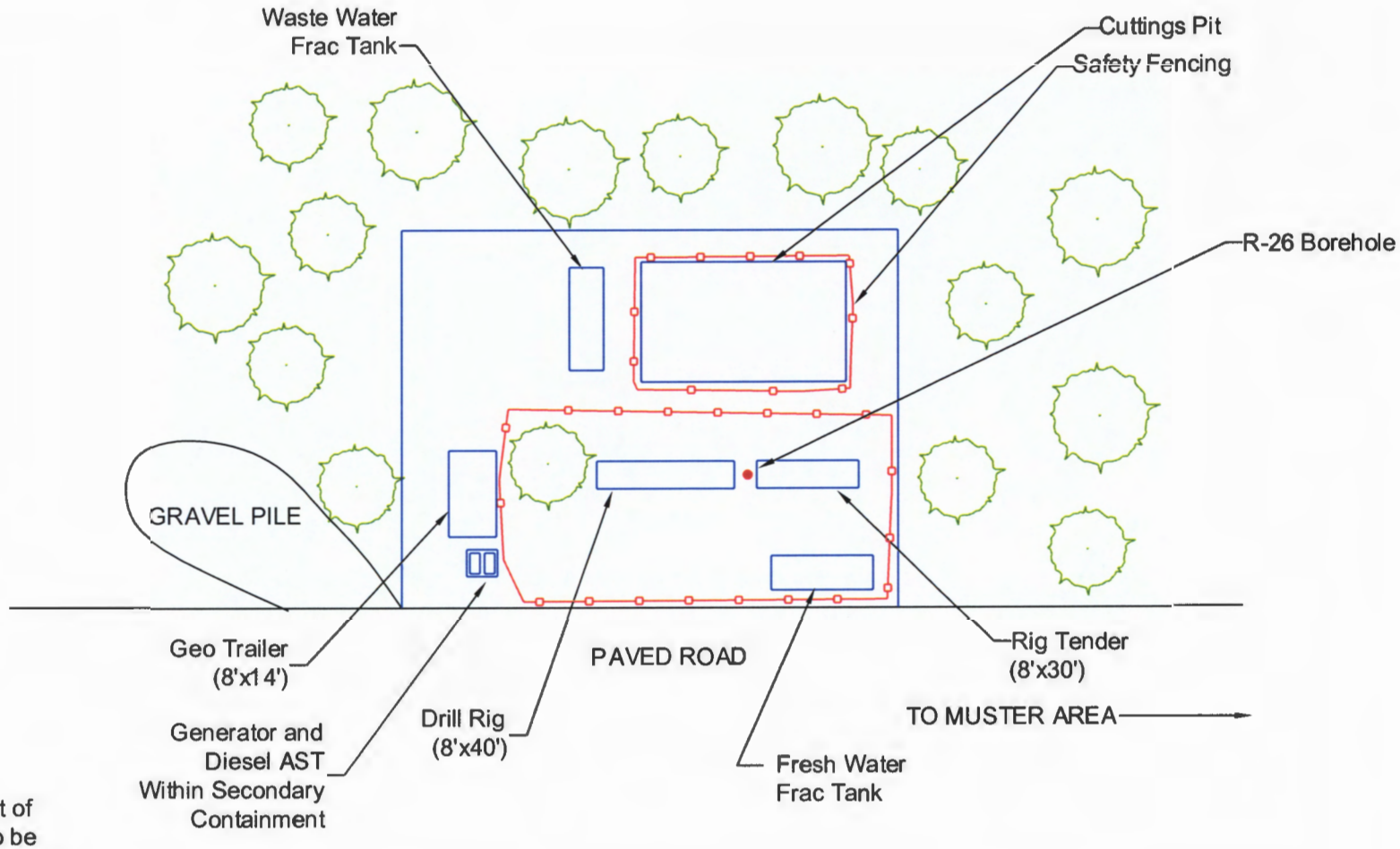


Exact Layout of Equipment to be Determined Based on Actual Site Conditions

50 0 25 50

SCALE: 1 inch =50 ft.
All Locations are Approximate

KLEINFELDER

Drawn By: B. Backisch
Project No.: 33220

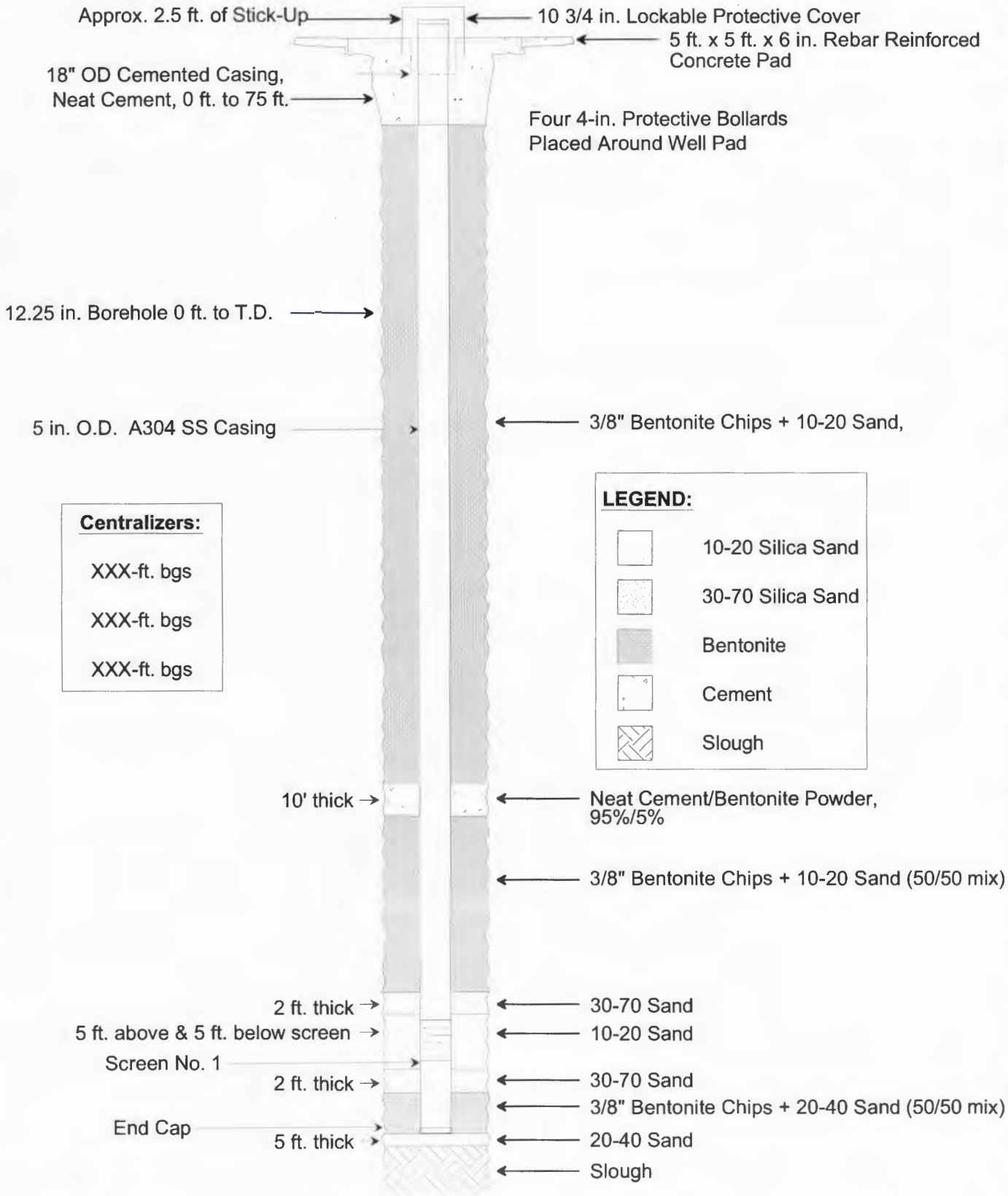
Date: August 2003
Filename:Fig1DR26Siteplan

Site Plan
R-26 Characterization Well
E. Jemez Road
Los Alamos National Laboratory
Los Alamos, New Mexico

Figure
2D

U:\DOE_LANL Well Program\Project Plans\SSHASP\Health & Safety\Figure_1D_R26_Siteplan.dwg

Kleinfelder, Inc. 2000



KLEINFELDER

Drawn By: C. Landon
Project No.: 33220

Date: August 2003
Filename: 33220_05_0.dwg

Schematic Diagram of Characterization Well

LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO

FIGURE 3

ID	Task Name	Duration	Start	Finish
1	LANL Deep Well Installation Project	112 days	Mon 7/21/03	Mon 12/29/03
2	Notice to Proceed	1 day	Mon 7/21/03	Mon 7/21/03
3				
4	1. Project Kick-off, Planning and Management	15 days	Tue 7/22/03	Mon 8/11/03
23	1.5 Security Plans	10 days	Tue 7/22/03	Mon 8/4/03
25				
26	Mobilization	19.5 days	Tue 7/22/03	Mon 8/18/03
40				
41	2.0 Meetings	102.25 days	Tue 7/22/03	Tue 12/16/03
51				
52	5.7 Monitoring Well R-4	103 days	Tue 7/22/03	Tue 12/16/03
53	7.1 Well R-4 Drilling Plan	20 days	Tue 7/22/03	Mon 8/18/03
80				
81	7.2 Monitoring Well Kick-Off Meeting	0 days	Mon 8/18/03	Mon 8/18/03
82	7.3 Site Preparation Road Improvements	4 days	Mon 8/11/03	Thu 8/14/03
83	7.4 Geologic Coring	5 days	Wed 8/27/03	Wed 9/3/03
84	7.4.1 Core Sampling	5 days	Wed 8/27/03	Wed 9/3/03
85	7.5 Drill and Install MW R-4	23 days	Tue 8/19/03	Sat 9/20/03
86	7.5.1 Mob to Site	1 day	Tue 8/19/03	Tue 8/19/03
87	7.5.2 Drill Borehole	20 days	Wed 8/20/03	Thu 9/11/03
88	7.5.3 Standby for Logging	2 days	Fri 9/12/03	Sat 9/13/03
89	7.5.4 Standby for Well completion Brief	1 day	Sun 9/14/03	Sun 9/14/03
70	7.5.5 Well Construction	5 days	Mon 9/15/03	Fri 9/19/03
71	7.5.6 Demobilization	1 day	Sat 9/20/03	Sat 9/20/03
72	7.6 Sampling	30 days	Tue 8/19/03	Sat 9/20/03
73	7.7 Geophysical Logging	2 days	Fri 9/12/03	Mon 9/15/03
74	7.11 Well Completion Briefing	0.5 days	Tue 9/16/03	Tue 9/16/03
75	7.8 Well Development	6 days	Sun 9/21/03	Fri 9/26/03
76	Pump Installation	2 days	Mon 9/29/03	Tue 9/30/03
77	7.7.1 Submit Geophysical Report	1 day	Tue 10/7/03	Tue 10/7/03
78	7.9 IDW Sampling and Disposal	12 days	Fri 9/26/03	Mon 10/13/03
62	7.10 Site Restoration	5 days	Thu 10/9/03	Mon 10/13/03
63	Fact Sheet Submittal	1 day	Mon 10/20/03	Mon 10/20/03
64	7.12 Well Completion Report	55 days	Mon 8/25/03	Tue 12/16/03
91				
92				
93	5.6 Monitoring Well R-2	105 days	Tue 7/22/03	Thu 12/18/03
94	6.1 Well R-2 Drilling Plan	20 days	Tue 7/22/03	Mon 8/18/03
99				
100	6.2 Monitoring Well Kick-Off Meeting	0.5 days	Tue 8/19/03	Tue 8/19/03
101	6.3 Site Preparation Road Improvements	4 days	Fri 8/29/03	Thu 9/4/03
102	6.4 Geologic Coring	5 days	Fri 9/5/03	Thu 9/11/03
103	6.4.1 Core Sampling	5 days	Fri 9/5/03	Thu 9/11/03
104	6.5 Drill and Install MW R-2	25 days	Sun 9/21/03	Sun 10/26/03
105	6.5.1 Mob to Site	2 days	Sun 9/21/03	Mon 9/22/03
106	6.5.2 Drill Borehole	25 days	Tue 9/23/03	Fri 10/17/03
107	6.5.3 Standby for Logging	2 days	Sat 10/18/03	Sun 10/19/03
108	6.5.4 Standby for Well completion Brief	1 day	Mon 10/20/03	Mon 10/20/03
109	6.5.5 Well Construction	5 days	Tue 10/21/03	Sat 10/25/03
110	6.5.6 Demobilization	1 day	Sun 10/26/03	Sun 10/26/03
111	6.6 Sampling	36 days	Sun 9/21/03	Sun 10/26/03
112	6.7 Geophysical Logging	2 days	Mon 10/20/03	Tue 10/21/03
113	6.11 Well Completion Briefing	0.5 days	Wed 10/22/03	Wed 10/22/03
114	6.7.1 Submit Geophysical Report	1 day	Wed 11/12/03	Wed 11/12/03
115	6.8 Well Development	2 days	Mon 10/27/03	Tue 10/28/03
116	Pump Installation	5 days	Wed 10/29/03	Tue 11/4/03
117	6.8.1 Well Survey	3 days	Sat 11/8/03	Mon 11/10/03
118	6.9 IDW Management	17 days	Wed 10/29/03	Thu 11/20/03
122	6.10 Site Restoration	5 days	Fri 11/14/03	Tue 11/18/03
123	Fact Sheet Submittal	1 day	Wed 11/19/03	Wed 11/19/03
124	6.12 Well Completion Report	38 days	Wed 10/29/03	Thu 12/18/03
129				
130				
131				
132	5.8 Monitoring Well R-11	91 days	Tue 7/22/03	Wed 11/12/03
133	8.1 Well R-11 Drilling Plan	20 days	Tue 7/22/03	Mon 8/18/03
138				
139	8.2 Monitoring Well Kick-Off Meeting	0 days	Mon 8/18/03	Mon 8/18/03
140	8.3 Site Preparation/Road Improvements	5 days	Mon 8/11/03	Fri 8/15/03
141	8.4 Geologic Coring	5 days	Tue 8/19/03	Mon 8/25/03
142	8.4.1 Core Sampling	5 days	Tue 8/19/03	Mon 8/25/03
143	8.5 Drill and Install MW R-11	25 days	Fri 8/22/03	Sun 9/28/03
144	8.5.1 Mob to Site	1 day	Fri 8/22/03	Fri 8/22/03
145	8.5.2 Drill Borehole	22 days	Tue 8/26/03	Fri 9/19/03
146	8.5.3 Standby for Logging	2 days	Sat 9/20/03	Sun 9/21/03
147	8.5.4 Standby for Well completion Brief	1 day	Mon 9/22/03	Mon 9/22/03
148	8.5.5 Well Construction	5 days	Tue 9/23/03	Sat 9/27/03
149	8.5.6 Demobilization	1 day	Sun 9/28/03	Sun 9/28/03
150	8.6 Sampling	35 days	Fri 8/22/03	Sun 9/28/03
151	8.7 Geophysical Logging	2 days	Mon 9/22/03	Tue 9/23/03
152	8.11 Well Completion Briefing	0.5 days	Wed 9/24/03	Wed 9/24/03
153	8.7.1 Submit Geophysical Report	1 day	Wed 10/15/03	Wed 10/15/03
154	8.8 Well Development	2 days	Mon 9/29/03	Tue 9/30/03
155	Pump Installation	7 days	Wed 10/1/03	Tue 10/7/03
156	8.9 IDW Sampling and Disposal	14 days	Tue 9/30/03	Sun 10/19/03
160	8.10 Site Restoration	5 days	Mon 10/13/03	Fri 10/17/03
161	Fact Sheet Submittal	1 day	Wed 10/22/03	Wed 10/22/03
162	8.12 Well Completion Report	31 days	Wed 10/1/03	Wed 11/12/03
167				
168				
169				
170				
171	5.13 Monitoring Well R-28	111 days	Tue 7/22/03	Mon 12/29/03
172	13.1 Well R-28 Drilling Plan	20 days	Tue 7/22/03	Mon 8/18/03
177				
178	13.2 Monitoring Well Kick-Off Meeting	1 day	Tue 8/19/03	Tue 8/19/03
179	13.3 Site Preparation Road Improvements	4 days	Mon 8/25/03	Thu 8/28/03
180	13.4 Geologic Coring	5 days	Mon 9/15/03	Fri 9/19/03
181	13.4.1 Core Sampling	5 days	Mon 9/15/03	Fri 9/19/03
182	13.5 Drill and Install MW R-28	30 days	Mon 9/29/03	Fri 11/7/03
183	13.5.1 Mob to Site	1 day	Mon 9/29/03	Mon 9/29/03
184	13.5.2 Drill Borehole	30 days	Tue 9/30/03	Wed 10/29/03
185	13.5.3 Standby for Logging	2 days	Thu 10/30/03	Fri 10/31/03
186	13.5.4 Standby for Well completion Brie	1 day	Sat 11/1/03	Sat 11/1/03
187	13.5.5 Well Construction	5 days	Sun 11/2/03	Thu 11/6/03
188	13.5.6 Demobilization	1 day	Fri 11/7/03	Fri 11/7/03
189	13.6 Sampling	39 days	Mon 9/29/03	Thu 11/6/03
190	13.7 Geophysical Logging	2 days	Thu 10/30/03	Fri 10/31/03
191	13.11 Well Completion Briefing	0.5 days	Sat 11/1/03	Sat 11/1/03
192	13.7.1 Submit Geophysical Report	1 day	Sat 11/22/03	Sat 11/22/03
193	13.8 Well Development	4 days	Sat 11/8/03	Tue 11/11/03
194	Install Pump	5 days	Wed 11/12/03	Tue 11/18/03
195	13.9 IDW Sampling and Disposal	16 days	Wed 11/12/03	Fri 12/5/03
199	13.10 Site Restoration	5 days	Tue 12/2/03	Mon 12/8/03
200	Fact Sheet Submittal	1 day	Fri 12/5/03	Fri 12/5/03
201	13.12 Well Completion Report	51 days	Wed 11/12/03	Mon 12/29/03

Project: LANL MW Install SCHEDULE V1
Date: Fri 8/29/03

Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary

AQUAGEL GOLD SEAL®

Premium Untreated Sodium Bentonite

THE *Original* DRILLING FLUIDS COMPANY.

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 which can be added directly to fresh water or freshwater drilling fluids. AQUAGEL GOLD SEAL functions as a viscosifier, gellant, and filtrate reducer in freshwater drilling fluids.

Applications/Functions

- Viscosify freshwater drilling fluids
- Improve hole cleaning
- Reduce filtration by forming a low permeability, thin filter cake
- Reduce seepage type of loss circulation
- Promote hole stability in poorly consolidated formations
- Aid in application of loss circulation materials

Advantages

- Naturally-occurring clay mineral without chemical additives
- 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
- Minimal abrasive content

Typical Properties

• Appearance	variable-colored (gray to tan)
• Bulk density, lb/ft^3	68 to 72 (as packaged)
• Volume per one 50-lb sack	0.685 ft^3
• Dry screen analysis	80% through 200-mesh (74 microns)

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 Premium Bentonite Added to Fresh Water or to Freshwater Drilling Fluids			
Application/Desired Result	**lb/100 gal**	**lb/bbl***	**kg/m³**
Added to Fresh Water			
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			
Under normal drilling conditions	10-25	4-10	11-28
To stabilize caving formations	20-45	9-18	25-50
To stop circulation loss	25-50	10-20	28-56

* 1 bbl = 42 U.S. gallons

Note: This product has been certified by the National Sanitation Foundation (NSF) to contribute no adverse health problems when used as the manufacturer recommends for the construction of potable water wells.

Packaging

AQUAGEL GOLD SEAL premium bentonite is packaged in multiwall, water-resistant paper bags containing 50 pounds (22.7 kg) or 100 pounds (45.4 kg). In Canada, the product is supplied in bags containing 40 kilograms.

Availability

AQUAGEL GOLD SEAL can be purchased through any QUIK-GEL® distributor, or by contacting the Customer Service Department in Houston.

Baroid Drilling Fluids, a Halliburton Company

Industrial Drilling Products

3000 N. Sam Houston Pkwy E.

Houston, TX 77032

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

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AQUAGEL GOLD SEAL and QUIK-GEL are registered trademarks of Baroid Technology, Inc.

Because the conditions of use of this product are beyond the seller's control, the product is sold without warranty either express or implied and upon condition that purchaser make its own test to determine the suitability for purchaser's application. Purchaser assumes all risk of use and handling of this product. This product will be replaced if defective in manufacture or packaging or if damaged. Except for such replacement, seller is not liable for any damages caused by this product or its use. The statements and recommendations made herein are believed to be accurate. No guarantee of their accuracy is made, however.

EZ-MUD®

Polymer Emulsion

THE *Original* DRILLING FLUIDS COMPANY.

Description

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

Applications/Functions

- EZ-MUD clay-free drilling fluid and QUIK-GEL®/EZ-MUD drilling mud system are applicable to all types of drilling operations.
  - Water wells
  - Diamond coring
  - Minerals exploration
  - Seismograph shot holes
  - Geo-construction
  - Horizontal directional drilling (HDD)
  - River crossing
  - Blast holes
- Stabilize water sensitive 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
- Reduce water loss effectively when added to pre-mixed QUIK-GEL® slurry and other drilling mud systems

---

Advantages

- Mixes easily with minimum shear in fresh water
- Develops viscosity rapidly
- Rapid settling of cuttings in pit - aids in preventing recirculation of drilled cuttings back into the wellbore
- Non-fermenting and non-toxic
- Cost effective - small amounts produce desired results
- Chemically degradable

Typical Properties

• Appearance	thick, opaque white liquid
• Density	8.7 lb/gal
• pH (1 quart per 100 gallons water)	8.5
• Flash point, PMCC °F	>200
• Thermal stability, °F	250

Recommended Treatment

For best results, mix through a jet or mechanical hopper with fresh water at a rate no faster than two minutes per gallon of product. Pretreat calcium hardness with soda ash (one half to one pound per 100 gallons water). Avoid water solutions having pH over 11.0. Always premix the bentonite before adding EZ-MUD.

Approximate Amounts of EZ-MUD® Added to Drilling Fluid System

Drilling Application/Desired Result	Quarts/ 100 gal	Pints/bbl	Liters/m^3
Added to fresh water			
(To formulate a clay-free drilling fluid)			
• To stabilize water-sensitive formations	1.0	1.0	2.5
• To stop rod vibration, reduce torque and pumping pressure, and increase hole stability	1.5	1.25	3.75
Added to QUIK-GEL® bentonite drilling mud (25 lb/100 gal)			
(To improve performance properties)			
• To improve hole cleaning, increase hole stability and minimize thickness of filter cake	1.0	1.0	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 - 2.50

Notes:

- 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 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-L) and 1-gal (3.8-L) pails.

Availability

EZ-MUD can be purchased through any QUIK-GEL® distributor, or by contacting the Customer Service Department in Houston.

Baroid Drilling Fluids, a Halliburton Company

Industrial Drilling Products

3000 N. Sam Houston Pkwy E.

Houston, TX 77032

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

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Because the conditions of use of this product are beyond the seller's control, the product is sold without warranty either express or implied and upon condition that purchaser make its own test to determine the suitability for purchaser's application. Purchaser assumes all risk of use and handling of this product. This product will be replaced if defective in manufacture or packaging or if damaged. Except for such replacement, seller is not liable for any damages caused by this product or its use. The statements and recommendations made herein are believed to be accurate. No guarantee of their accuracy is made, however.

QUIK-FOAM®

High Performance Foaming Agent

THE *Original* DRILLING FLUIDS COMPANY.

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
- Counteract 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
- Provide a technique for drilling in environmental sensitive areas

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Advantages

- High quality, high expansion foam with a consistency similar to shaving foam
- High stability with long half-life (retention time)
- Versatile and compatible with various types of make-up water
- Readily undergoes primary and ultimate (>99%) biodegradation
- Non-toxic, non-irritating to the skin

Typical Properties

Appearance	light yellow, transparent liquid
Specific gravity	1.03
pH (0.5% solution)	7.1
Flash point, PMCC °F	82
Pour point, °F	0

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 (5.3 gallons) of water

Note: Close product container immediately after use to avoid gellation of remaining QUIK-FOAM.

Product Make-ups for Air Drilling Injection Slurries					
Main Ingredient of Injection Slurry	Water (gallons)	QUIK-GEL® gellant (pounds)	QUIK-TROL® organic polymer (pounds)	QUIK-FOAM® foaming agent (% by volume)	Mixing/Injection Procedure
Foam Drilling System	100	---	---	0.02 - 3.0	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	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	Mix gellant 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	Mix gellant 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-L) plastic pails or in metal drums containing 55 gallons (208 liters).

Availability

QUIK-FOAM can be purchased through any QUIK-GEL® distributor, or by contacting the Customer Service Department in Houston.

Baroid Drilling Fluids, a Halliburton Company

Industrial Drilling Products

3000 N. Sam Houston Pkwy E.

Houston, TX 77032

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

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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*****

Soda Ash

Specialty Chemical

Description

Soda Ash is a white, granular powder primarily used to condition and soften make-up water and raise pH

Applications/Functions

- Treat out hardness due to calcium in make-up water
- Raise pH

Advantages

- Eliminate calcium ions by removing them as insoluble calcium carbonate
- Maximize the performance of bentonite and polymer product

Typical Properties

Appearance	Variable-colored powder (gray to tan)
pH of 5% solution	11.5
Bulk density, lb/ft^3	57-65

Recommended Treatment

- Hardness and pH levels of make-up water should be checked prior to addition of Soda Ash.
- Addition of Soda Ash should always be done prior to addition of bentonite or polymer to the fluid system.
- Soda Ash should not be added at the same time as other drilling fluid components.
- When treating make-up water pH ranges should be maintained between 8.5 – 9.5

General Treatment:

- 1-2 pounds per 100 gallons of make-up water or 1.2-2.4 kilograms per cubic meter of make-up water.
- Use as required to remove calcium ions but do not add in excess as overtreatment can lead to detrimental effects and reduced performance of the drilling fluid components and/or system.
- Mix slowly through a jet mixer or sift slowly into the vortex of a high-speed stirrer.

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Packaging

Soda Ash is packaged in 50-lb (22.7 kg) or 100-lb (45.4 kg) multiwall paper bags.

Availability

Soda Ash 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