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DEMONSTRATION OF RIVER CROSSING TECHNOLOGY FOR INSTALLATION OF ENVIRONMENTAL HORIZONTAL WELLS: AMH-6 AND AMH-7 INSTALLATION REPORT (U)

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DISCLAIMER

CONTENTS

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF ABBREVIATIONS, ACRONYMS, AND INITIALS

BHA	Non-Magnetic Bottom Hole Assembly
CDM Federal	CDM Federal Programs Corporation
CEC	EVI Cherrington Environmental Corporation
DOE	Department of Energy
ECEC	Eastman Christensen Environmental Corporation
EMTC	Environmental Monitoring and Testing Corporation
ft-lbs	foot-pounds
ID	internal diameter
lb	pound
MD	measured depth
MGS	Magnetic Guidance System
msl	Mean Sea Level
OD	outside diameter
PCE	Tetrachloroethylene
PID	photoionization detector
ppm	parts per million
psi	pounds per square inch
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
rpms	revolutions per minute
SAIC	Science Applications International Corporation
SRS	Savannah River Site
SRTC	Savannah River Technology Center
TCE	Trichloroethylene
TVD	true vertical depth
VD	vertical depth
VOCs	volatile organic compounds
WSRC	Westinghouse Savannah River Company

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1.0 EXECUTIVE SUMMARY

The Department of Energy's (DOE) Office of Technology Development initiated an integrated demonstration of innovative technologies and systems for cleanup of volatile organic compounds (VOCs) in soils and groundwater. This drilling project is part of the directional drilling task for the integrated technology demonstration at the Savannah River Site (SRS). One of the objectives of the drilling task is the demonstration of multiple drilling technologies. The technologies can then be compared and evaluated in terms of technical performance and cost effectiveness. Petroleum horizontal well technology and utility industry horizontal well technology have been previously demonstrated at the SRS. The petroleum industry directional drilling technology was demonstrated by Eastman Christensen Environmental Corporation (ECEC). ECEC directionally drilled and installed four horizontal wells in the M Area. Charles Machine Works, working with Sandia National Laboratory, demonstrated a utility industry directional drilling technology by installing one horizontal well in the M Area. The demonstration that is the subject of this report involved river crossing horizontal well technology for the installation of two M-Area Settling Basin soil gas extraction wells.

EVI Cherrington Environmental Corporation (CEC) was chosen for this demonstration. CEC developed directional drilling expertise in the river crossing industry and is an industry leader in horizontal well installation.

Two horizontal wells were installed beneath the M-Area Settling Basin at the A/M Area of the SRS. Documented releases from the M-Area Settling Basin have contaminated the underlying vadose zone and groundwater with VOCs. The vadose zone has retained a large portion of the VOCs and now acts as a secondary source of contamination. The wells are parallel to one another and are oriented southwest to northeast. The horizontal wells were installed approximately 10 feet above the water table and were planned to have a horizontal screen underlie the width of the basin. The wells will be part of a soil vapor extraction system designed to remediate the vadose zone and act as a barrier to prevent further contamination of the groundwater.

The installation of the horizontal wells was a two-part process. Part one consisted of constructing the borehole, and part two was the horizontal well completion. Borehole construction was attempted by first directionally drilling a pilot hole with a small diameter drill pipe and a hydraulic spud-jet drilling tool. The pilot hole was expanded with a larger diameter "washover" pipe that was circumferentially drilled over the pilot drill string. The pilot drill string was retracted from the washover pipe once the washover pipe had been drilled over the entire pilot string and the borehole was complete. The well materials were then installed inside the washover pipe. The washover pipe was withdrawn from the borehole once the well materials were in the proper position.

Difficulties were encountered during construction of the borehole for AMH-6. The first attempt at constructing the borehole for AMH-6 was unsuccessful because the washover drilling pipe became stuck in the borehole and could not be removed. The second attempt at constructing the AMH-6 borehole was partially successful. Washover drilling pipe once more became stuck in the borehole. The construction of the borehole for well AMH-7 was successfully completed during the first attempt.

The installation of the two horizontal wells was successful. The borehole of AMH-6 was 20 feet short, and four-inch washover pipe left in the hole obstructed another 170 feet of the installed well screen. The result was 230 feet of effective well screen placed in the target horizon instead of 420 feet. The AMH-7 well screen was successfully placed in the target horizon and had a total horizontal well screen length of 420 feet.

The following conclusions were reached upon completion of the drilling demonstration.

1. River crossing industry type directional drilling technology is capable of successfully installing horizontal wells under the M-Area Settling Basin.

2. The drilling crew was inexperienced in installing deep (greater than 50 vertical feet) horizontal wells.

3. The hydraulic spud-jet drilling tool was inefficient. A downhole drill motor should have been used to improve drilling efficiency.

4. The washover pipe became stuck in AMH-6 because the radius of curvature of the borehole (400 feet) was not large enough to accommodate the drill pipe and the washover pipe was not of the proper strength.

5. The guar gum-based drilling fluid system was inadequate. The drilling fluid system should have been improved, or a bentonite-based drilling fluid should have been considered. The drilling crew did not keep drilling records or mud reports during this project. Therefore, the drilling crew was unprepared to adapt to the site conditions.

2.0 INTRODUCTION

The SRS is part of the United States DOE Nuclear Weapons Complex. Its main function is to produce nuclear materials for national defense. The SRS is located in south-central South Carolina and occupies an area of approximately 300 square miles (192,000 acres) (Fig. 2-1). The major physiographic feature is the Savannah River which forms the southwestern boundary of the site and is also the South Carolina-Georgia border. The SRS includes portions of Aiken, Barnwell, and Allendale Counties in South Carolina.

The DOE Office of Technology Development initiated an integrated demonstration of innovative technologies and systems for cleanup of VOCs in soils and groundwater at the SRS in 1989. The overall goal of the program is demonstration of multiple technologies and systems in the fields of drilling, characterization, monitoring, and remediation at a single test bed. Innovative technologies are compared to one another and to baseline technologies in terms of technical performance and cost effectiveness. Transfer of successfully demonstrated technologies and systems to DOE environmental restoration organizations, to other government agencies, and to industry is a critical part of the program. Directional drilling and horizontal well installation are the innovative technologies demonstrated in this task.

Directional drilling and horizontal well installation have been shown to be successful techniques for enhancing access to the subsurface where vertical wells are impractical or impossible to install. During this task two horizontal wells were installed to be used for vapor extraction of VOCs from the vadose zone beneath the M-Area Settling Basin. The task was initiated in November 1992 and completed in December 1992.

2.1 M-Area Settling Basin Background and Project Description

The M Area (3/700 Area), located in the northwestern portion of the SRS (Fig. 2-1), is the site of the metals fabrication facility where fuel targets for the reactors were fabricated. The M-Area Settling Basin was used as a settling basin for metal-rich wastes that contained solvents. Hydrologic investigations at the SRS have shown that M-Area operations have resulted in the contamination of the groundwater with VOCs near the M-Area Settling Basin (Fig. 2-2). The contamination at this site resulted from the leakage of waste solvents from the M-Area Settling Basin, now closed and capped according to Resource Conservation and Recovery Act (RCRA) guidelines, into the vadose zone with subsequent gravity-driven migration of the contaminants into the groundwater. A remedial action program consisting of groundwater pumping from eleven vertical recovery wells, followed by above-ground air-stripping in a central tower, was implemented in 1985 to address groundwater contamination in M Area.

The Savannah River Technology Center (SRTC) performed a pilot test in 1986 and 1987 to evaluate the removal of VOCs from the vadose zone in the M Area using a vacuum extraction system. The pilot test utilized three horizontal and one vertical extraction well along the process sewer line leading to the basin. In one three-week period, 1500 pounds of VOCs were extracted through the vertical extraction well. A full-scale extraction program was planned based on the results of the pilot test. The full-scale program includes two horizontal soil vapor extraction wells installed beneath the basin. This report will deal exclusively with the drilling of the horizontal boreholes and the installation of horizontal wells AMH-6 and AMH-7.

A drilling team was retained by SRTC for the design, drilling, and installation of the horizontal wells. Drilling experts from CEC designed the borehole and provided the drilling and well completion materials. Sharewell Inc. was subcontracted by CEC to provide the directional surveying equipment. Environmental Monitoring and Testing Corporation (EMTC) (New Ellenton, SC) was subcontracted by CEC to provide a South Carolina-certified driller and local access to equipment as necessary. CDM Federal Programs Corporation (CDM Federal) (Aiken, SC) was retained by the SRTC to function as the onsite SRTC representative and implement the following services: (1) provide technical oversight, (2) document project activities, and (3) generate the horizontal well completion report. SRTC provided program management.

2.2 Objectives

The objectives of the M-Area Settling Basin demonstration were: (1) to test and evaluate one technique of horizontal well installation technology adapted from the river crossing industry; (2) to drill boreholes in unconsolidated sediments (sands, gravels, and silts) and semi-consolidated clay units beneath the M-Area Settling Basin; and (3) to install two horizontal wells in the vadose zone for vapor extraction of VOCs from soil.

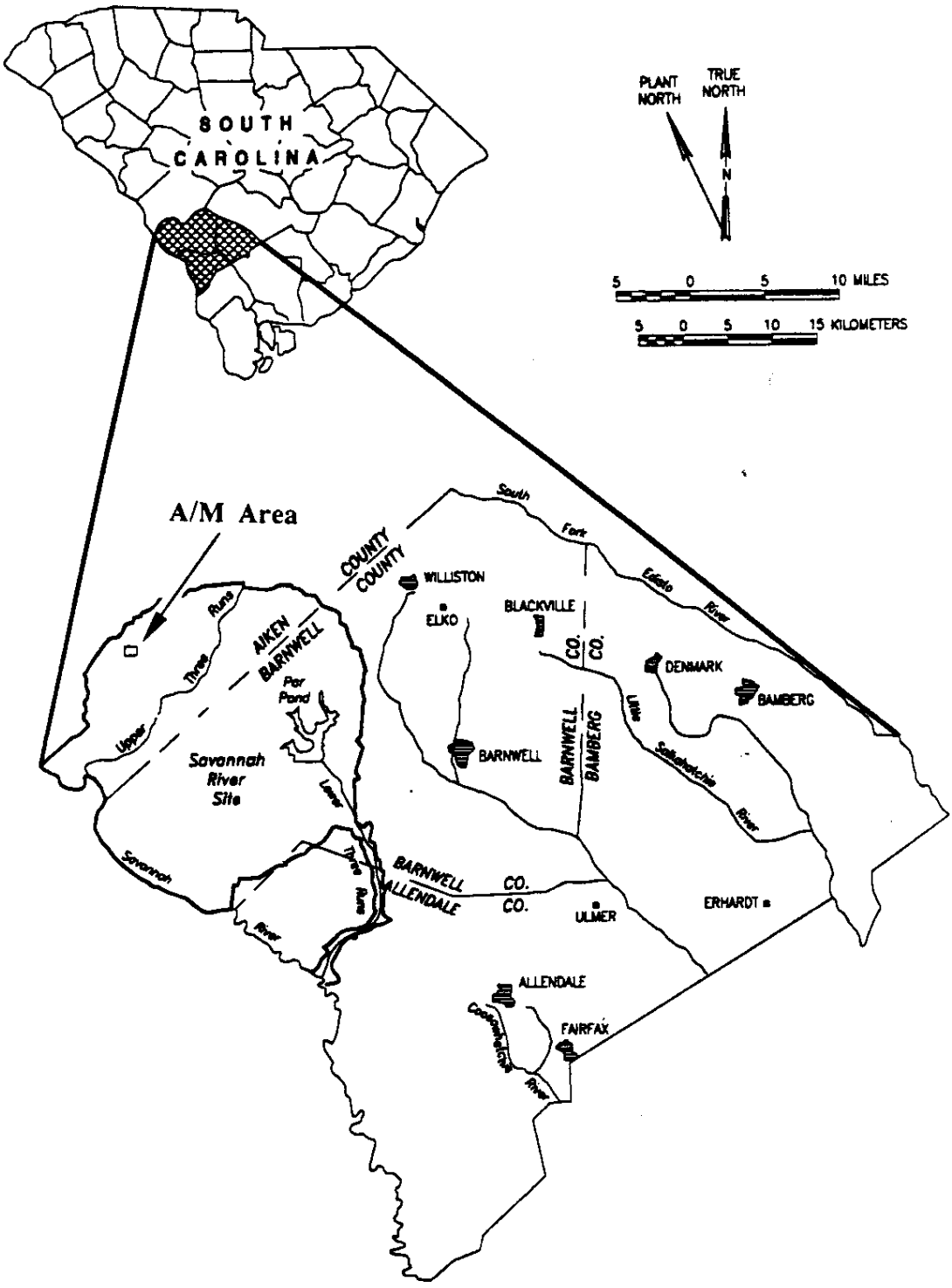


Figure 2-1. Location of the SRS in South Carolina

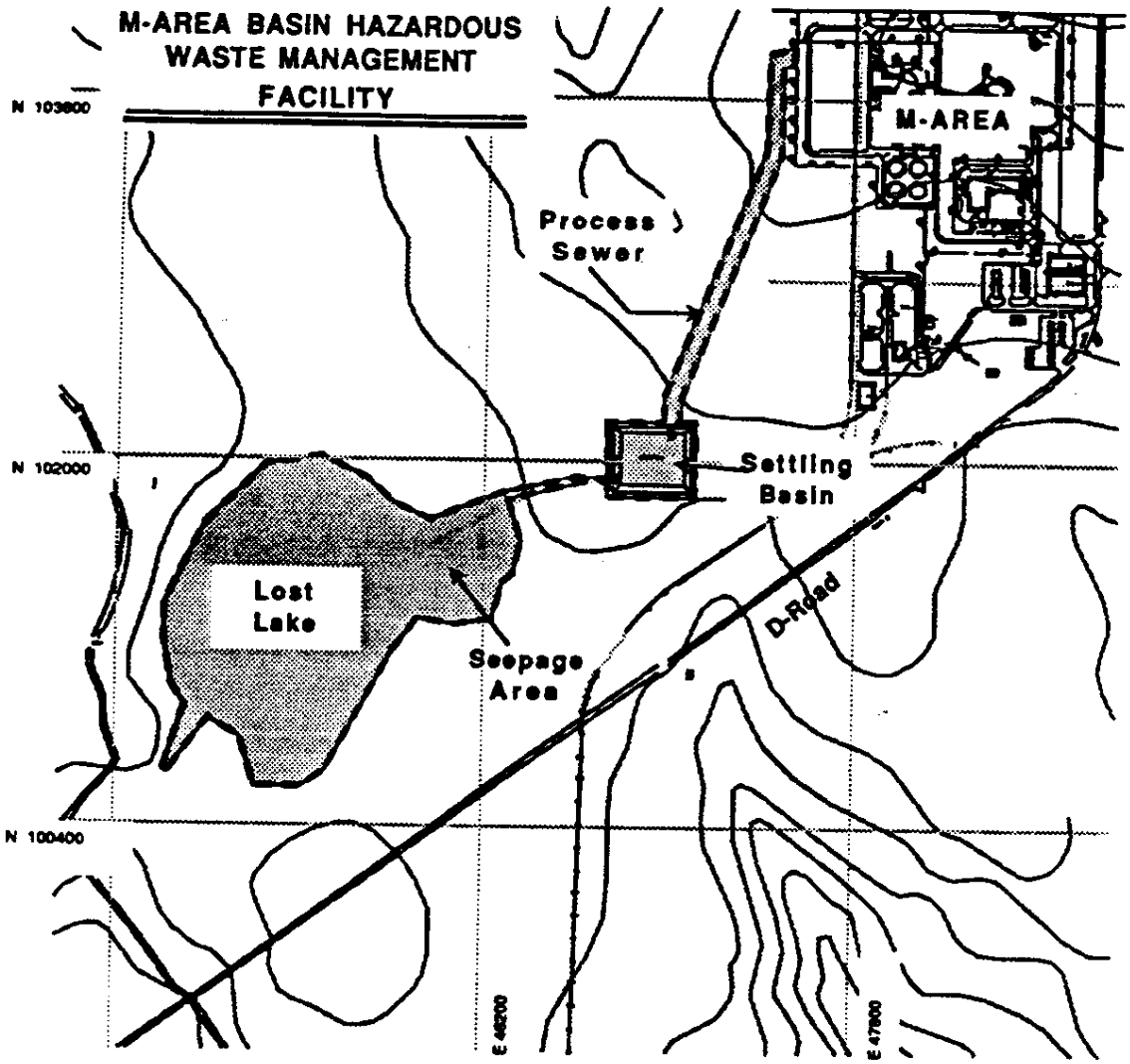


Figure 2-2. Location of M-Area Settling Basin Hazardous Waste Management Facility

3.0 GEOLOGIC SETTING

3.1 Regional Setting

The SRS is located in the Atlantic Coastal Plain Physiographic Province (Fig. 3-1). Within the Atlantic Coastal Plain Province, the SRS lies on the Aiken Plateau (Fig. 3-2) which is bounded by the Savannah and Congaree Rivers. The surface of the Aiken Plateau is dissected by streams and is characterized by broad, interfluvial areas with narrow steep-sided valleys.

The Atlantic Coastal Plain is comprised of a wedge of southeast-dipping unconsolidated and semiconsolidated sediments which increase in thickness from zero at the Fall Line to more than 4,000 feet near the Atlantic Coast. These sediments range from Late Cretaceous (100 million years) to Holocene (present) in age and extend to the seaward edge of the Continental Shelf. The Atlantic Coastal Plain sediments generally consist of strata of gravel, sand, silt, clay, and limestone, which were deposited in a variety of fluvial, deltaic, and marine depositional environments. The base of the Atlantic Coastal Plain sediments lies unconformably on top of crystalline, metamorphic and granitic rocks in the northern portion of the SRS and on top of Triassic sediments, deposited in a rift basin, in the southern part of the SRS. The Atlantic Coastal Plain sediments have been extensively studied at the SRS, and many lithologic and hydrostratigraphic names have been applied to these sediments. Figure 3-3 illustrates a comparison of chronostratigraphic, lithostratigraphic, and hydrostratigraphic units. For the purpose of this report, the A/M-Area hydrogeologic setting is described using hydrostratigraphic nomenclature, and the vadose zone, where the horizontal drilling occurred, will be described using lithostratigraphic nomenclature.

3.2 A/M Area Hydrogeologic and Hydrostratigraphic Setting

In the A/M Area, the Atlantic Coastal Plain hydrogeologic province consists of the Floridan-Midville Aquifer System which includes the McQueen Branch Aquifer, the Crouch Branch Aquifer, and the Steed Pond Aquifer (Fig. 3-4).

The majority of the monitoring wells within the A/M Area are constructed in the water-bearing sediments overlying the McQueen Branch Confining Unit. The Crouch Branch Aquifer, which overlies the McQueen Branch Confining Unit, is continuous beneath all of the A/M Area. Beneath the Integrated Demonstration Site at MSB-2, the top of the Crouch Branch Aquifer lies approximately 275 feet below land surface. The Crouch Branch Confining Unit separates the underlying Crouch Branch Aquifer from the overlying Steed Pond Aquifer. Within the central and southern portions of the A/M Area, the Crouch Branch Confining Unit, from its base to the top of the unit, can be subdivided into "lower clay" and "upper clay" confining zones separated by a "middle sand" aquifer zone. The entire Crouch Branch Confining Unit thins in a northerly direction, and when the "upper clay" confining zone is absent, the "middle sand" aquifer zone merges with the overlying Steed Pond Aquifer north of the M-Area Settling Basin to form the Hollow Creek Aquifer. Within the southern to central portions of the A/M Area, the Steed Pond Aquifer, from its base to the top of the aquifer, includes the "Lost Lake" aquifer zone, the "green clay" confining zone, and the "M-Area" aquifer zone.

Overlying the "M-Area" aquifer zone is the vadose zone. At the M-Area Settling Basin, the depth to the bottom of the vadose zone (water table) is approximately 130 feet below ground

surface. The vadose zone underlying the M-Area Settling Basin includes portions of the Santee Formation, Dry Branch Formation, Tobacco Road Formation, and the "Upland unit". AMH-6 and AMH-7 were installed completely within the vadose zone below the M-Area Settling Basin and thus the only geologic formations that will be characterized in this report are those that comprise the vadose zone. These formations are described from the base of the vadose zone to ground surface.

3.2.1 Santee Formation

In the A/M Area, the Santee Formation varies in thickness from 30 to 45 feet. Below the M-Area Settling Basin, the Santee Formation is 43 feet thick at MHT-3C, and the top of the formation lies 103 feet below land surface. It is composed of brown, tan, and yellowish orange, fine to coarse, poorly to well-sorted sands and interbedded with clayey sand, sandy clay, and clay. It is distinguished from the cleaner sands of the overlying Dry Branch Formation by a higher gamma-ray count on geophysical logs. Underlying the M-Area Settling Basin, the Santee Formation is partially saturated with a static water level of approximately 130 feet below ground surface.

Both AMH-6 and AMH-7 were screened in the Santee Formation. Figures 3-5 and 3-6 illustrate the relationship of the installed screen zones to the formations and the zone of saturation. Drilling became difficult during the installation of both AMH-6 and AMH-7 as each borehole was emerging from the radius of curvature. This point appears to correspond to the contact between the Santee Formation and the overlying Dry Branch Formation. The Santee Formation has a higher clay content and numerous clay stringers in comparison to the relatively clean sands of the Dry Branch Formation. This increase in clay content probably accounted for the difficulty in penetration of the drill bit.

3.2.2 Dry Branch Formation

The Dry Branch Formation crops out in stream valleys, and the thickness varies from 0 to 110 feet in A/M Area wells. Below the M-Area Settling Basin, the Dry Branch Formation is 35 feet thick at MHT-3C, and the top of the formation lies 68 feet below ground surface. Sand of the Dry Branch Formation probably accumulated in a shallow marine environment. Jacksonian (Late Eocene) fossils have been found in the formation in downdip SRS wells, and the specific formation was traced into the A/M Area by correlating it with lithologic and geophysical logs.

The Dry Branch Formation is composed of orange, brown, tan, and yellow, fine to coarse, poorly to well-sorted quartz sand. Pebbly layers are common, and induration is slight to moderate. The Twiggs Clay Member of the Dry Branch Formation (Fig. 3-3) is difficult to map within the A/M Area, but clay that is lithologically similar to the Twiggs Clay Member is present at various stratigraphic intervals within the Dry Branch Formation. This clay lithofacies, interbedded with sand and clayey sand, which is characterized as tan, light gray, and brown, ranges from 12 to 34 feet thick and occurs at approximately 80 feet below ground surface beneath the M-Area Settling Basin (Science Applications International Corporation [SAIC], 1992) but is not laterally continuous over long distances. It has been referred to as the "tan clay" in previous SRS reports and as the "270-ft clay" by Eddy and others (1991). The top of the Dry Branch Formation is identified on geophysical logs where a low gamma-ray count in the cleaner sand of the Dry Branch Formation sharply increases in the more

argillaceous sand of the Tobacco Road Formation. On most lithologic logs, the contact, which is probably conformable, is marked by an increase in silt and clay percentage. The Dry Branch Formation and the overlying formations are unsaturated beneath the M-Area Settling Basin.

3.2.3 Tobacco Road Formation

The Tobacco Road Formation crops out in several places in the A/M Area. The formation has a higher silt and clay content and thus a lower permeability than the Dry Branch Formation. The Tobacco Road Formation was probably deposited in a shallow marine environment and has been dated as late Jacksonian (late Late Eocene) downdip from the SRS in Georgia (Huddleston and Hetrick, 1985). Nystrom and Willoughby (1982) have traced the formation into the vicinity of the A/M Area by correlation of outcrops and have dated it as Claibornian, not Jacksonian.

Beneath the M-Area Settling Basin, the Tobacco Road Formation is 15 feet thick at MHT-3C, and the top of the formation lies 53 feet below ground surface. The top of the Tobacco Road Formation is identified where comparatively well-sorted sand is overlain by more poorly sorted sand, pebbly sand, and clay of the "Upland unit". The Tobacco Road Formation is orange, red, brown, yellow, tan, and purple. Fine to coarse, poorly to well-sorted sands compose almost the entire formation. Pebbly layers are common, especially near the base. Clay clasts are fairly common, and clay layers ranging from 2 to 10 feet thick have been identified underlying the M-Area Settling Basin (SAIC, 1992). This unit is referred to as the "300-ft clay" by Eddy and others (1991).

3.2.4 "Upland Unit"

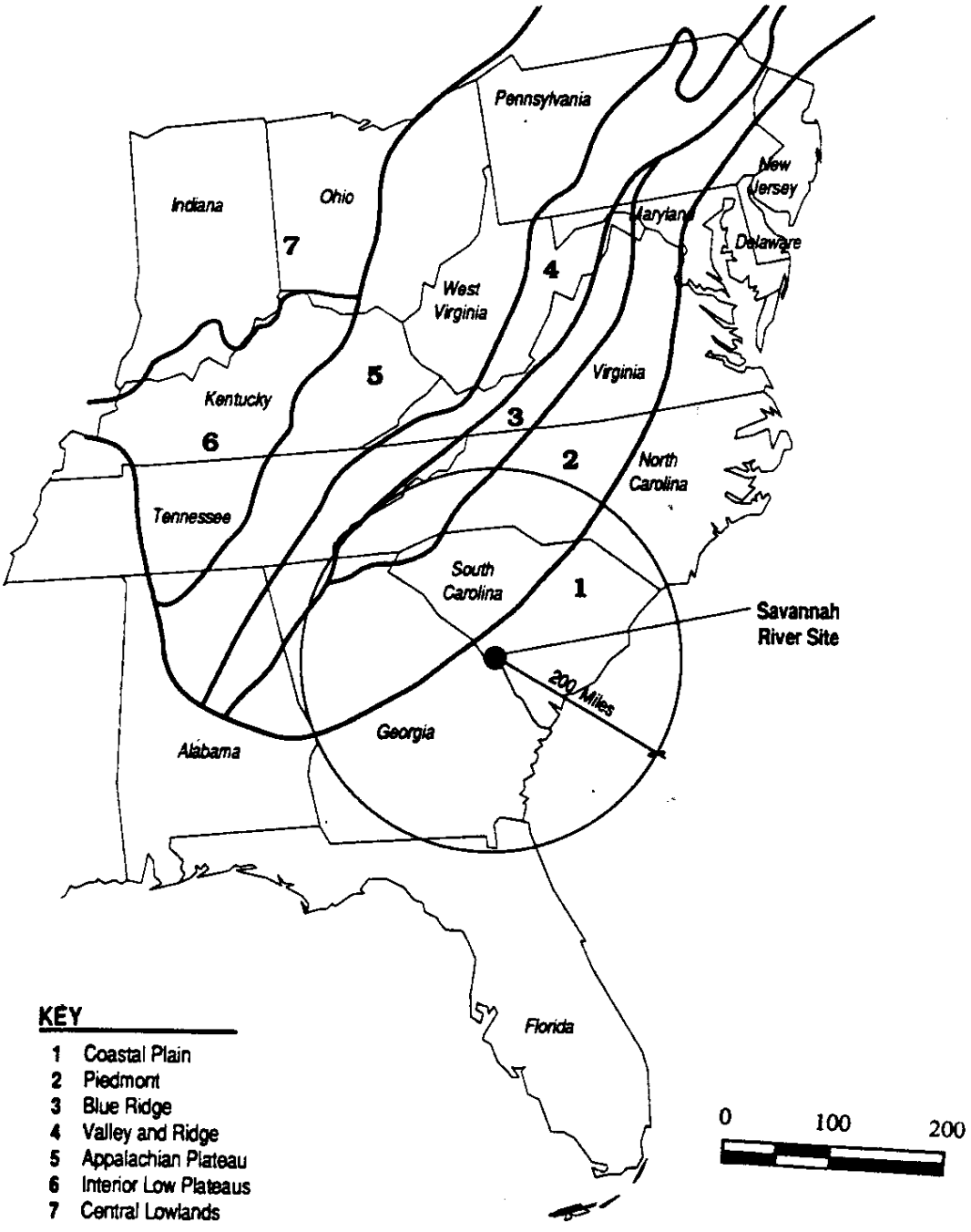
The "Upland unit" unconformably overlies the Tobacco Road Formation. The South Carolina Geological Survey has been mapping it as the informally named "Upland unit" (Nystrom and Willoughby, 1982). It partially corresponds to sediments previously mapped at the SRS as the Hawthorn Formation (Siple, 1967). The unit caps higher areas in much of the southwestern Coastal Plain of South Carolina and is a deposit of poorly-sorted, clayey, silty, pebbly, and cobbly quartz sand, conglomerate, and clay which show significant lateral and vertical variation.

In the A/M Area, these sediments are yellow, orange, purple, red, brown, and tan, mostly fine to very coarse, clayey, silty quartz sand beds. They are locally pebbly with layers of conglomerate and are very poorly to poorly sorted, moderately indurated. Weathered feldspar grains are abundant in places. Clay lenses interbedded with these sands are laterally discontinuous. Thickness of the "Upland unit" varies from 0 to approximately 60 feet. The sediments, which have low permeability, were probably deposited in high energy fluvial channels, point bars, floodplains, and abandoned channels. The "Upland unit" has not been dated paleontologically, but it may correlate with the Miocene Altamaha Formation in Georgia (Nystrom et al., 1986).

Underlying the M-Area Settling Basin, the "Upland unit" is 53 feet thick at MHT-3C. Locally the "Upland unit" is characterized as a reddish orange, brown, and purple, poorly sorted gravelly sand and clay. The sandy units have a speckled appearance (SAIC, 1992). Only a few clay layers exceed one foot in thickness. Textural evidence exists indicating that many of

the one-foot intervals logged as clay and sandy clay, in the lower portions of this unit, are cobble- to boulder-sized clasts of clay eroded from the underlying sediments or small lenticular clay lenses (SAIC, 1992).

During the installation of both AMH-6 and AMH-7, a dense, clayey horizon was encountered at approximately 25 feet below ground surface within the "Upland Unit". The density of this clay horizon slowed the spud jet penetration to nearly the point of rejection and caused both boreholes to be deflected horizontally. Figures 3-5 through 3-10 define the trace of AMH-6 and AMH-7 as installed below the M-Area Settling Basin as well as the first abandoned attempt at installing AMH-6 both in plan and in cross section.



SOURCE: Water Resources Commission Report, Number 155, 1989

Figure 3-1. Physiographic Provinces of the Eastern United States

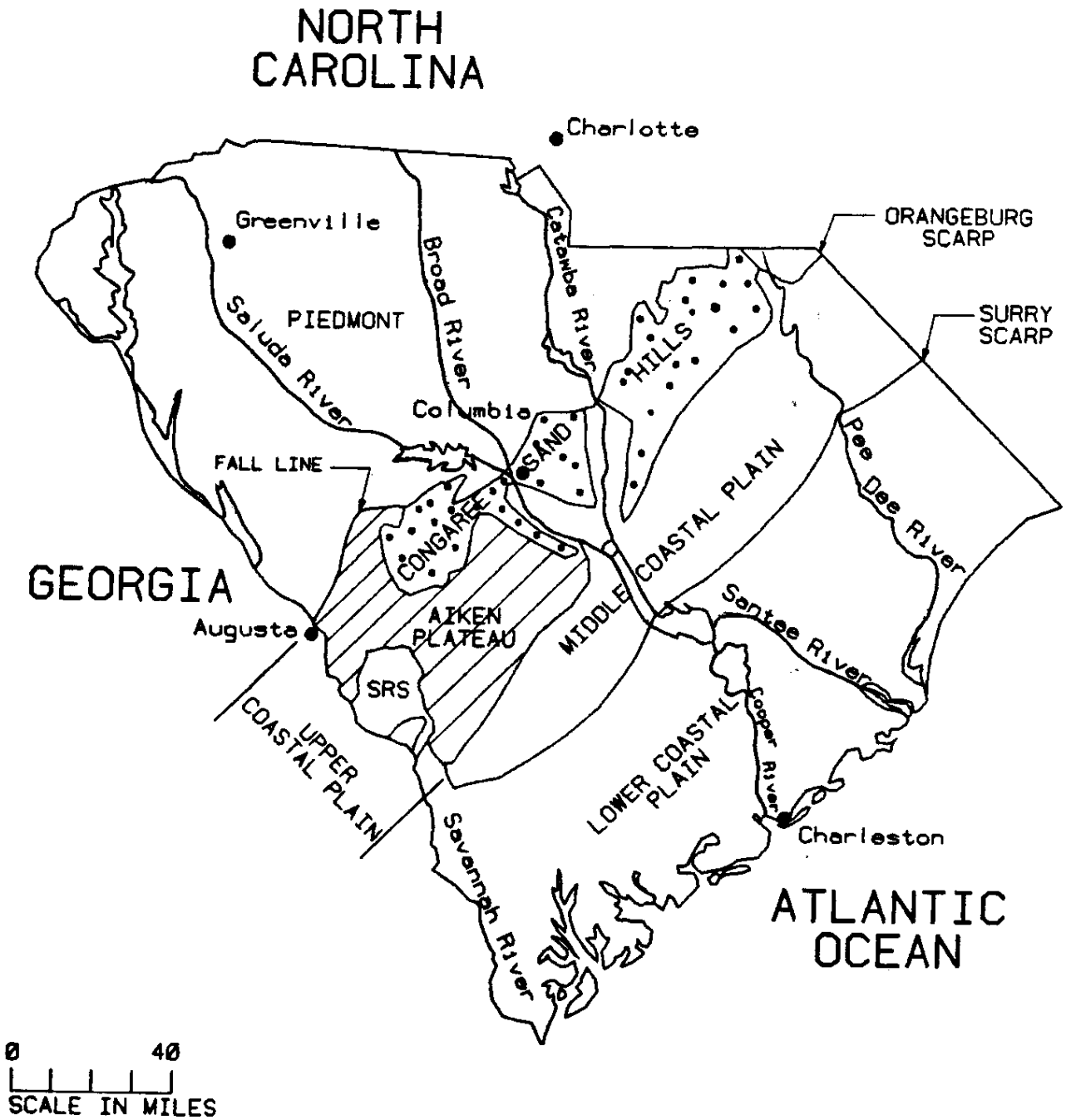


Figure 3-2. Physiographic Subprovinces of the South Carolina Coastal Plain

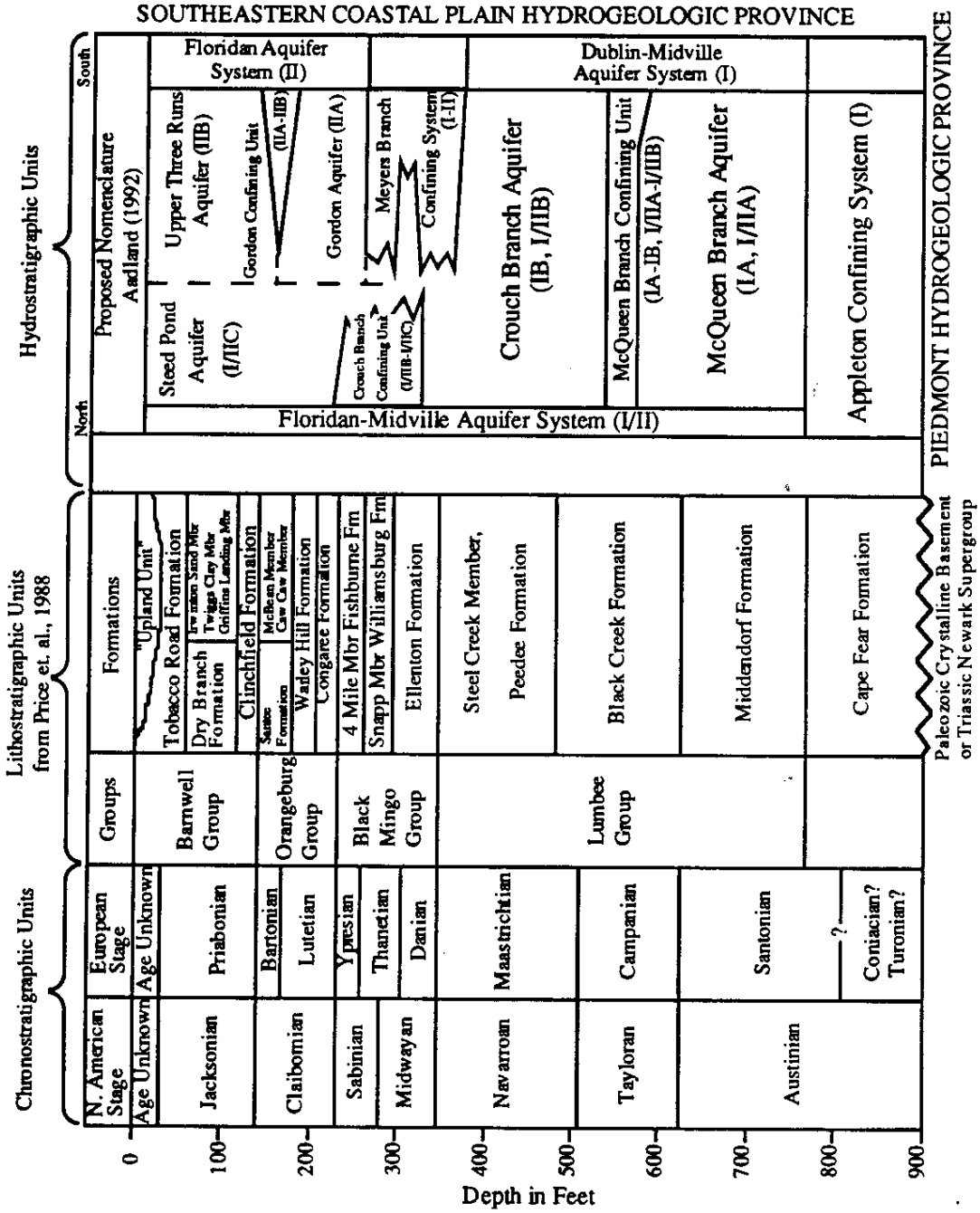


Figure 3-3. Comparison of Chronostratigraphic, Lithostratigraphic, and Hydrostratigraphic Units at the SRS

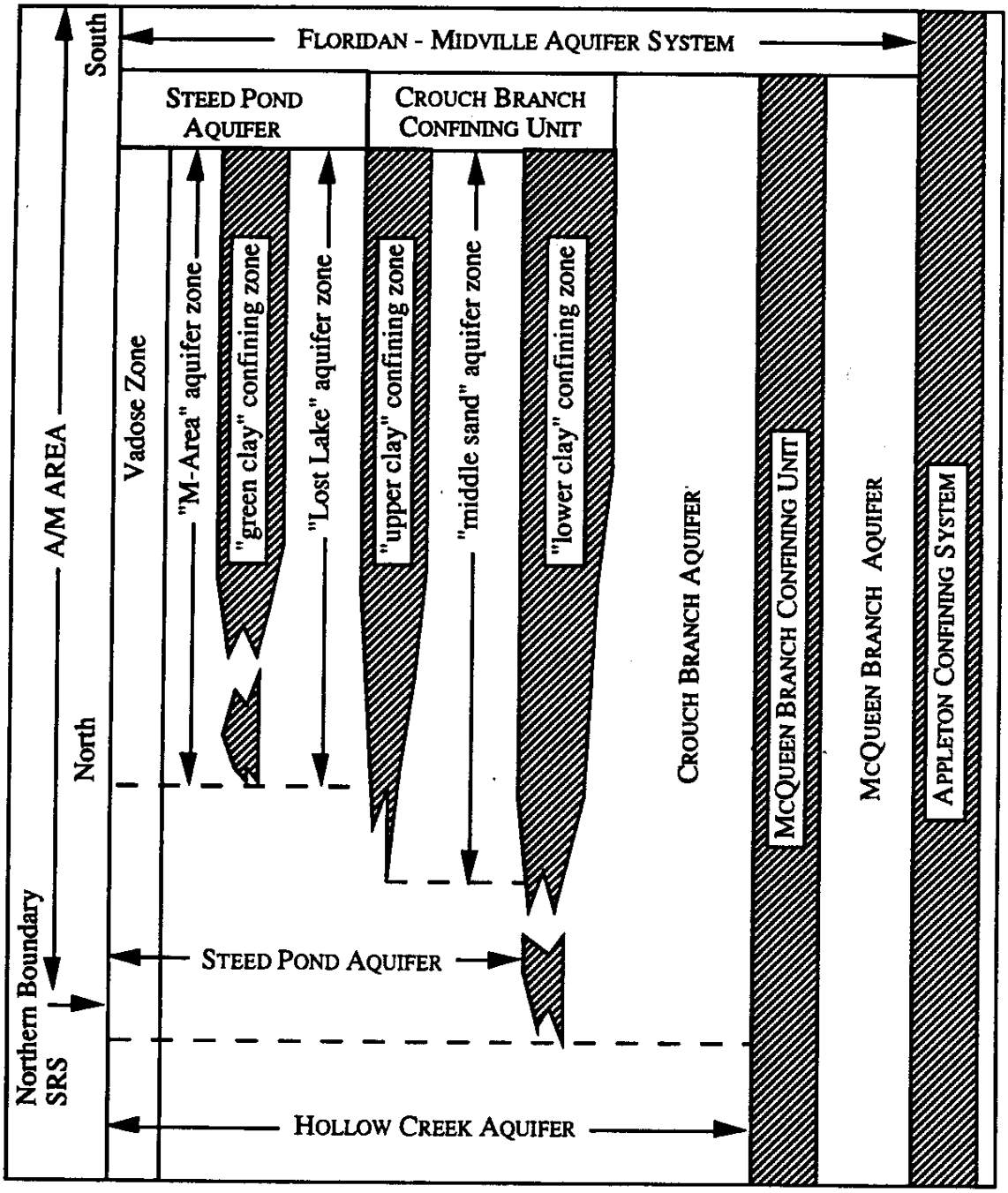


Figure 3-4. Hydrostratigraphic Chart for the A/M Area

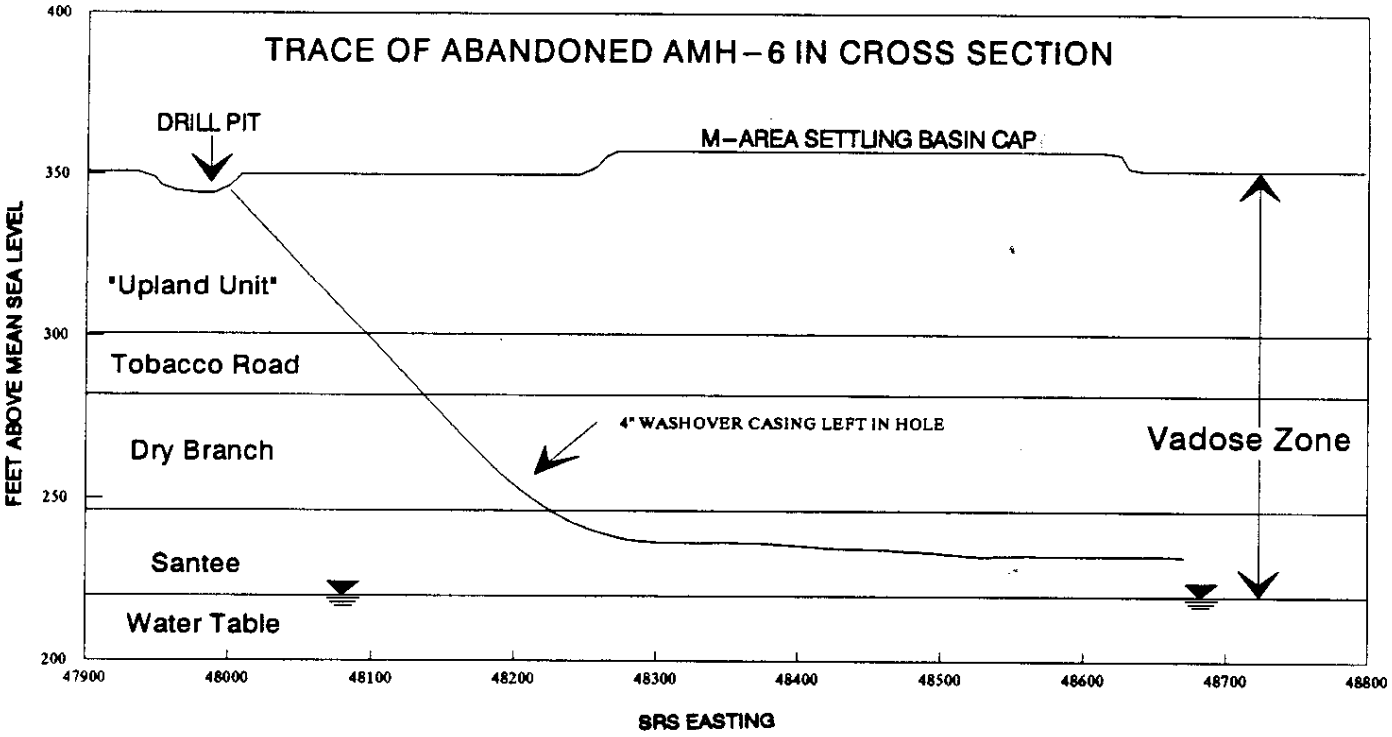


Figure 3-5. Trace of Abandoned Borehole AMH-6 in Cross Section with Relation to Geologic Units

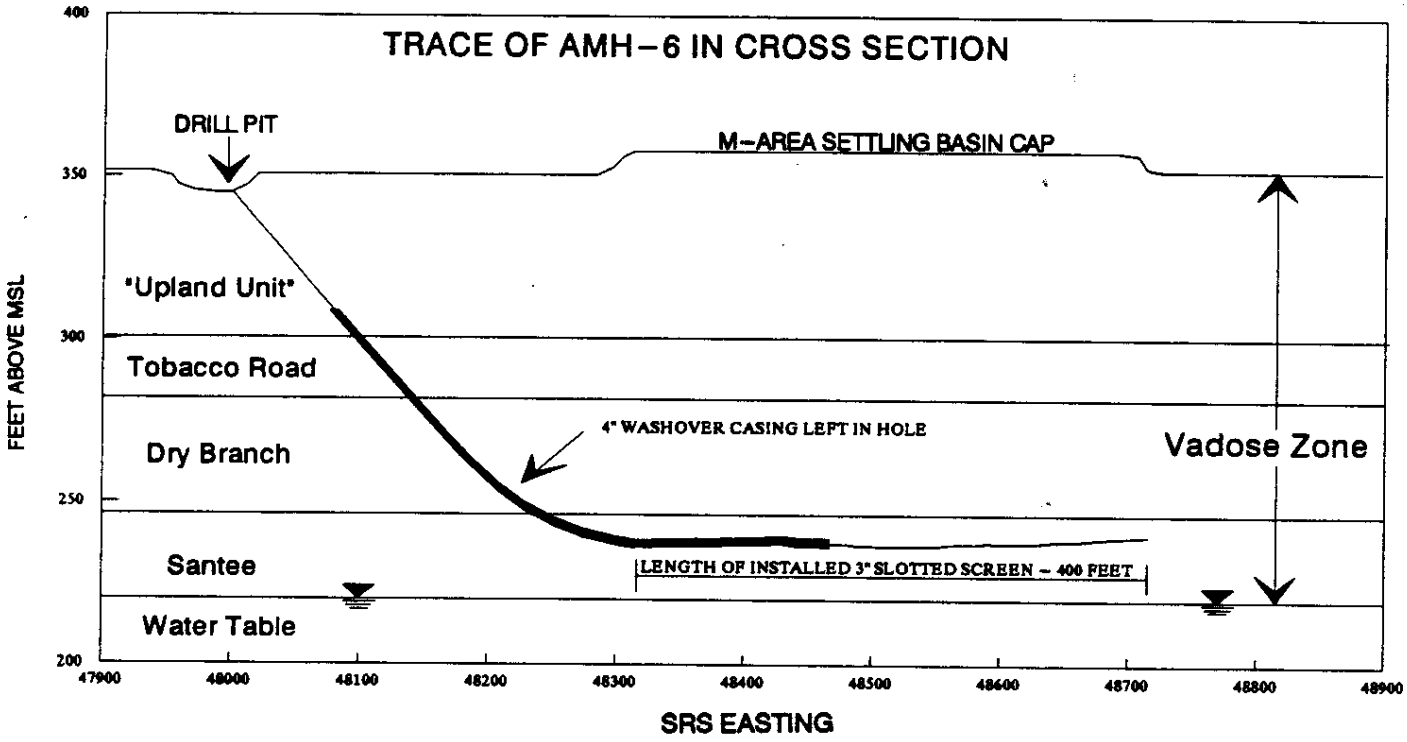


Figure 3-6. Trace of AMH-6 as Installed in Cross Section with Relation to Geologic Units

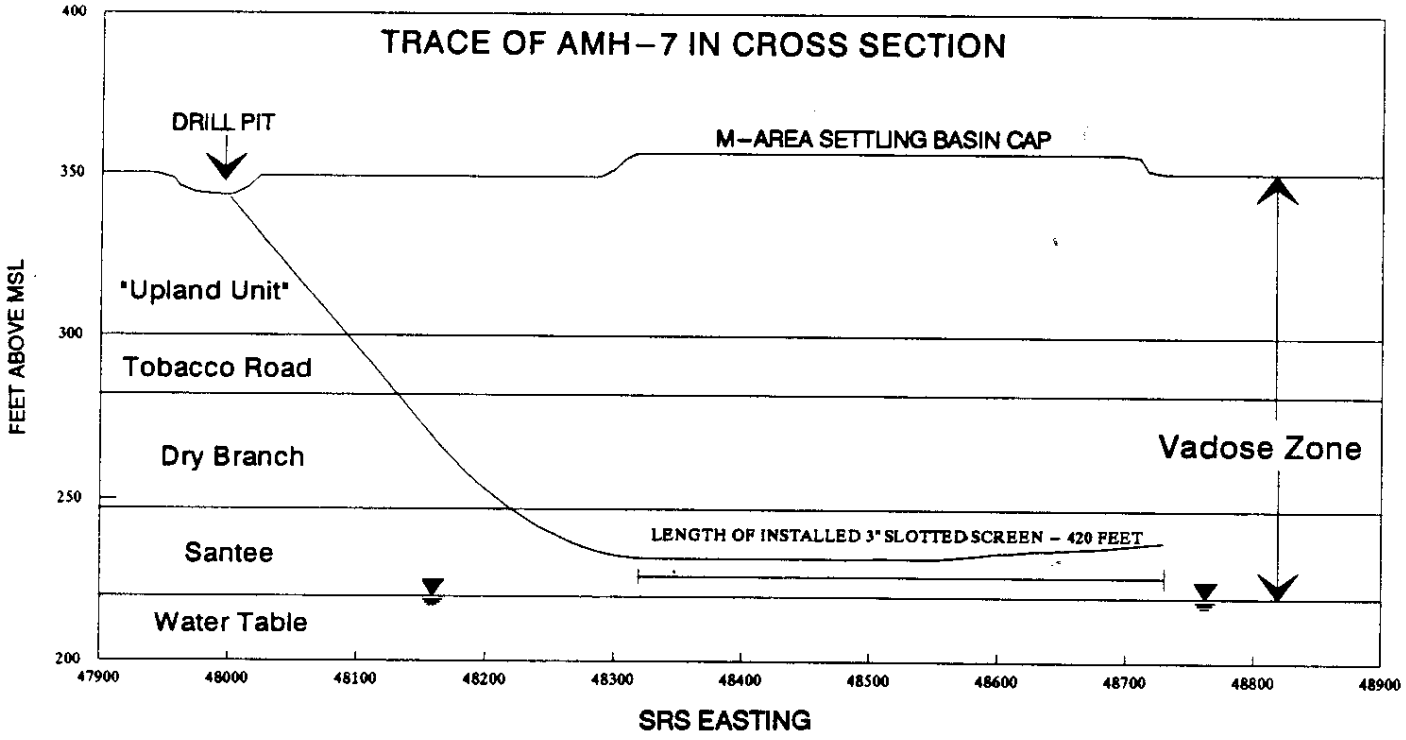


Figure 3-7. Trace of AMH-7 as Installed in Cross Section with Relation to Geologic Units

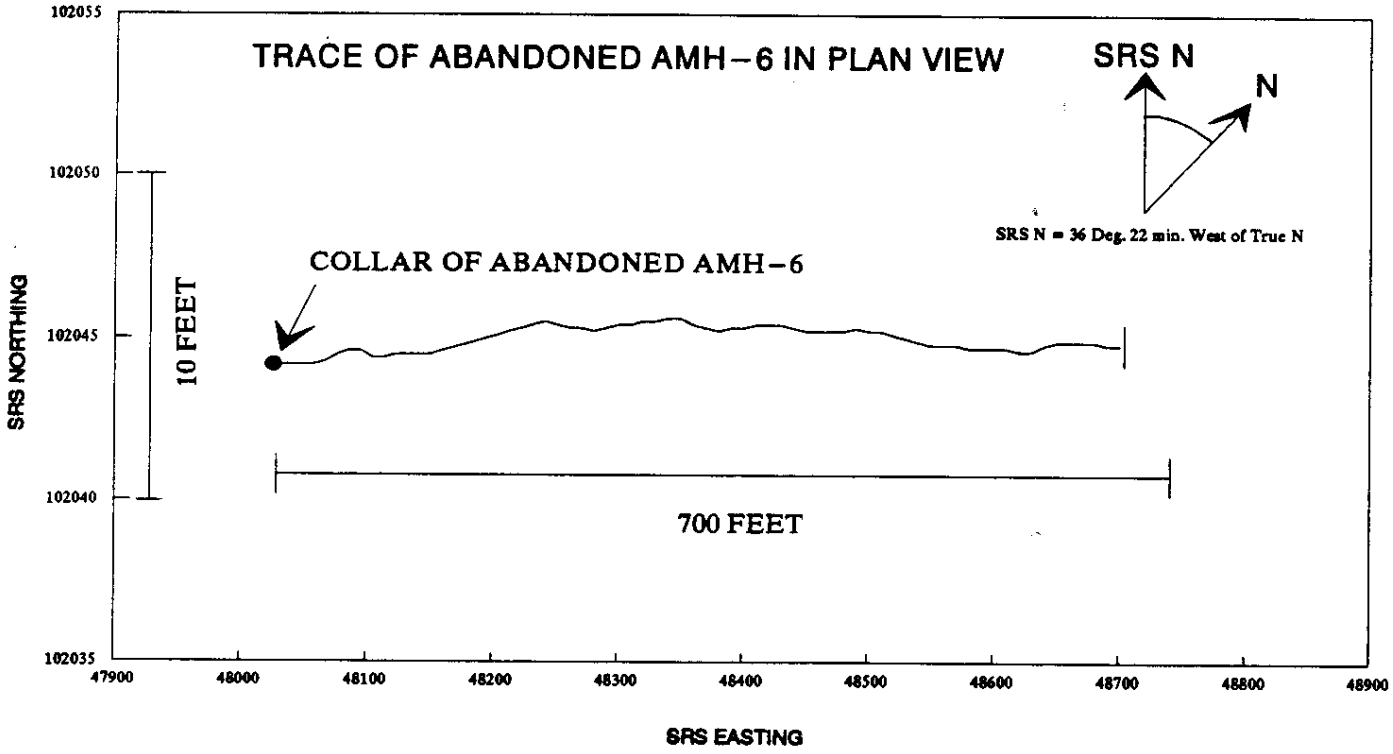


Figure 3-8. Trace of Abandoned Borehole AMH-6 in Plan View

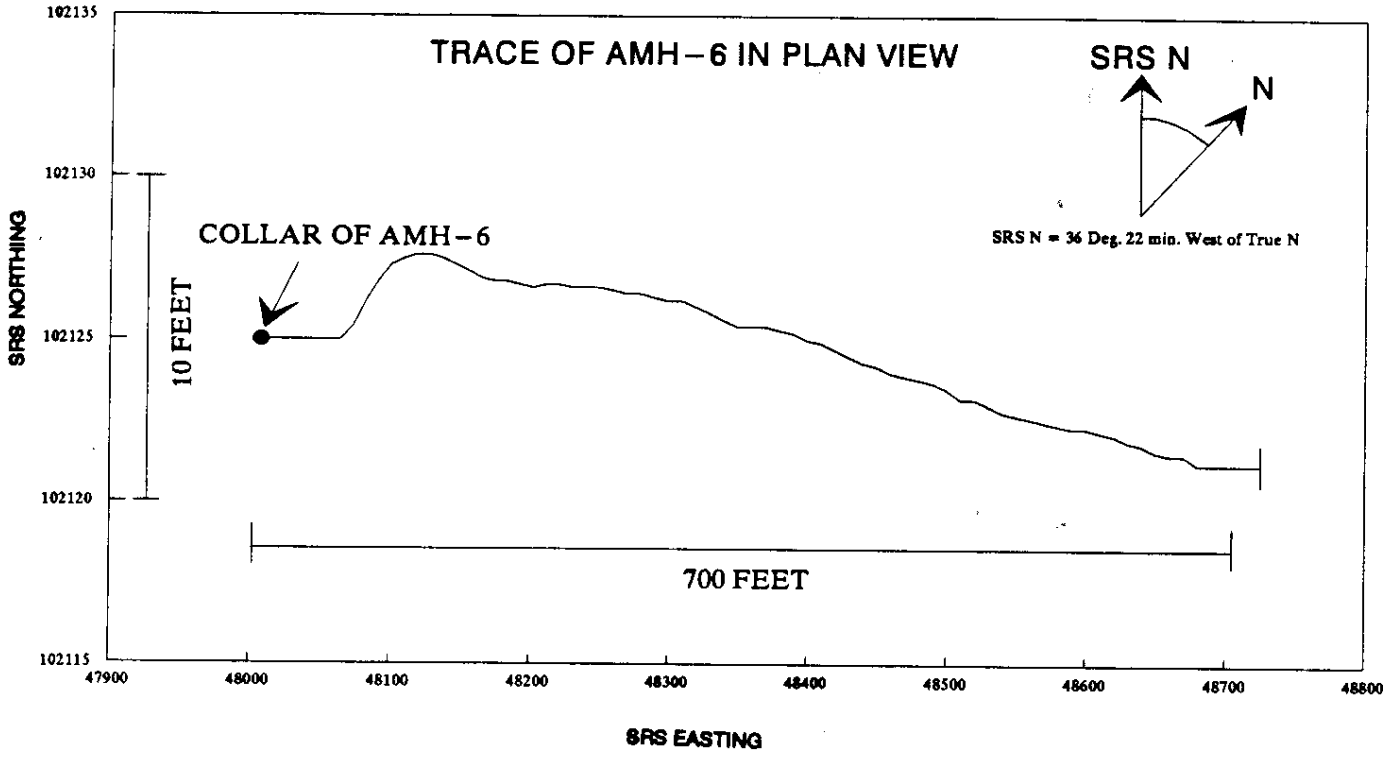


Figure 3-9. Trace of AMH-6 as Installed in Plan View

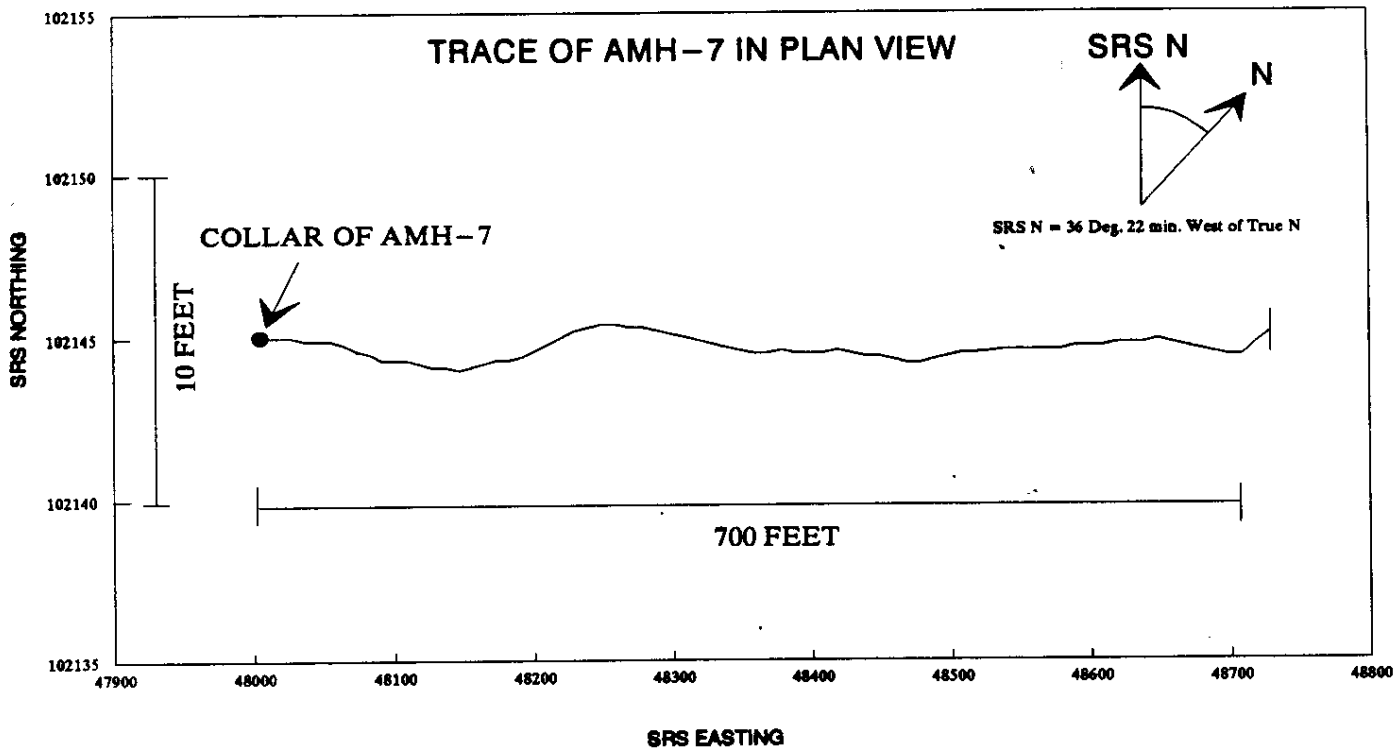


Figure 3-10. Trace of AMH-7 as Installed in Plan View

4.0 DRILLING SYSTEM

A river crossing industry directional drilling rig was used for this project. River crossing industry directional drilling rigs range in size from small trailer mounted drilling rigs that can be pulled by a pick-up truck to large semi-tractor trailer mounted drilling rigs capable of drilling large (up to 60-inches in diameter) boreholes thousands of feet. Horizontal wells AMH-6 and AMH-7 were installed using a medium-sized river crossing directional drilling rig.

4.1 Equipment Used

4.1.1 Drilling Rig

The MC-90 drilling rig (Fig. 4-1) is a top drive hydraulic mud rotary rig with a high thrust and rotational torque capacity. The maximum thrust power of the drilling rig is 47,000 pounds (lbs). The maximum pullback capacity is 120,000 lbs. The maximum spindle rotational speed of the drilling rig is 200 revolutions per minute (rpms) with a maximum spindle torque of 6,000 foot-pounds (ft-lbs). The maximum mud pressure of the power source is 2500 pounds per square inch (psi) generated from 234 horsepower. The drilling rig is able to turn drill pipe in sizes ranging from the smallest available size to 12 inches in diameter for distances of up to 2,000 feet in most soil conditions. The diameter and/or length capability may be significantly reduced where formations contain 30 percent or more gravels. The maximum drill rod length for the drilling rig is 10 feet. The drilling operations are controlled from a console mounted on the right side of the drilling rig.

The drilling rig is track driven and has two adjustable drilling platforms that allow the driller to accurately adjust the drilling angle. The track drive and the drilling platform are controlled from a console located at the rear of the drilling rig. The approximate operating weight of the rig is 8,000 lbs.

At the front of the drilling rig there is a piston-driven ram that is used to anchor the drilling rig. The drilling rig anchor is created by welding the ram to a mass of metal buried in the ground (a "dead man"). During this project the "dead man" consisted of two 10-foot sections of four-inch drill pipe driven vertically into the ground.

4.1.2 Down-Hole Drilling Assembly

The down-hole drilling assembly consists of a directional drilling tool and a steering tool contained in a non-magnetic housing (Fig. 4-2). The total length of the down-hole drilling assembly is approximately 15 feet. All components of the down-hole drilling assembly, including the closest three pieces of drill stem, are constructed of non-magnetic steel to prevent magnetic interferences with the steering tool.

Drilling Tool

CEC proposed to use one of two types of drilling tools depending on the hardness of the materials encountered. A hydraulic spud jet, designed to penetrate soft alluvial formations (sands, clayey sands, etc.) similar to the types of sediments present at the M-Area Settling

Basin, was planned as the primary drilling tool. An in-hole mud drilling motor was planned to be used if drilling conditions became too difficult for the hydraulic spud jet drilling tool.

The hydraulic spud jet drilling tool (Fig. 4-3) was equipped with a 2° bend in the housing to provide directional drilling capabilities. When the drilling tool is pushed forward without rotation, the tool deviates in the direction of the angle of the tool. To drill without deviation the drilling tool is rotated as it is pushed forward; in this way the tool face does not have a preferred orientation, and the drilling tool advances along a straight path, as in the slant or horizontal sections of the borehole. The tool face orientation is monitored by the steering system. The down-hole drilling assembly produces a hole approximately 3 1/2" in diameter.

Steering System

The orientation and location of the pilot bit was constantly monitored with a "real time" magnetic guidance system (MGS) (Fig. 4-4). This MGS enabled the driller to steer the pilot bit into place and ensure proper borehole alignment and elevation. The MGS was supplied by Sharewell, Inc., a subcontractor to CEC. The MGS enabled the driller to guide the pilot bit by providing immediate gravitational and magnetic information on tool face orientation, azimuth (horizontal location) and inclination (vertical location). These raw data were transmitted to an interface unit at the surface from a down-hole sensor located immediately above the drilling tool or drill motor via a single conductor wire. The surface interface unit displayed tool face orientation, azimuth, and inclination readings. Knowledge of the length of the drill string, azimuth, and inclination allowed the driller to calculate the location of the down-hole sensor and thus the borehole path. Tool face orientation provides information used to determine the steering direction of the drilling tool. The MGS is a proven, accurate system and is hindered only by local magnetic interferences. If magnetic interferences are observed, then a secondary survey system is used. The secondary survey system was not required for this drilling project.

4.1.3 Drill Rods and Bits

The drilling method utilizes two drill strings. A small diameter drill string (pilot drill string) is used with the down-hole drilling assembly to drill the pilot hole, and a larger diameter drill string (washover drill string) is drilled over the pilot drill string (Fig. 4-5).

The pilot drill string was used to accurately place the pilot hole in the correct location. The pilot drill string is made up of 2 3/16" outside diameter (OD), 4130 heat-treated steel BCQ drill rods adapted from the mining industry. The length of the pilot drill string rods was limited to 10 feet by the size of the drilling rig.

The washover drill string was used to maintain borehole stability during installation of the horizontal well materials. The 4 1/2" OD, 2160 heat-treated steel washover pipe was drilled circumferentially over the 2 3/16" pilot string which served as a guide for the washover pipe until the total drilling distance was achieved (Fig. 4-5). CEC utilized a nine-inch bit for drilling in the washover pipe (Fig. 4-6). The length of the washover drill string rods was limited to 10 feet by the size of the drilling rig.

4.2 Drilling Fluid System

The drilling fluid system was typical of a recirculating mud rotary drilling operation. The system included: a mixing tank where the drilling fluid was mixed, a mud pumping system to pump the mud through the hydraulic spud jet, a mud pit to mechanically settle the coarser fraction of suspended drilling solids as it exits from the borehole, and a mud settling tank and desander to remove the finer sand remaining in suspension (Fig. 4-7).

The drilling fluid consisted of processed guar gum beans, ground into colloidal particles and mixed with water through a standard mixing jet hopper. Guar gum is a natural polymer that acts to increase the viscosity of the drilling fluid. With bentonite-based drilling fluids, the gel strength or carrying capacity (the size of particles remaining in suspension) is directly related to the viscosity of the drilling fluid. However, with a guar gum-based drilling fluid the gel strength is not directly related to viscosity. Therefore, the carrying capacity of a guar gum-based drilling fluid cannot be predicted by its viscosity. To increase the gel strength of the guar gum-based drilling fluid, the natural polymers must be linked together by an additive. The additive most commonly used is Borax. During this drilling project the guar gum carrying capacity was not enhanced with Borax and therefore drill cuttings were left in the borehole. The drilling fluid needed periodic reconditioning due to the length of the drilling program and was reconditioned by simply adding more guar gum. Guar gum-based drilling fluids biodegrade naturally within approximately two days.

4.3 Drilling Procedures

The drilling procedures consisted of setting up the drilling rig, drilling the borehole, and installing the horizontal well.

Setting Up the Drilling Rig

Setting up the drilling rig involved surveying the direction (azimuth) of the horizontal well, calibrating the steering tool along the azimuth of the horizontal, and setting up the drilling rig and mud system. The well entry locations were surveyed, and the azimuth of each horizontal well was delineated on the ground surface with stakes and cords. The steering tool was lined up on the horizontal well azimuth and calibrated to ensure proper orientation of the borehole.

Plastic sheeting (0.010 millimeter thick) was placed on the ground at the entry point and the drilling rig was then moved into place and lined up on the horizontal well azimuth (Fig. 4-8). The drilling platform was tilted to the proper entry angle, and a mud pit was constructed at the entry point. Plastic sheeting was also placed in the mud pit. The down-hole drilling assembly was placed on the drilling rig and drilled into the ground.

Drilling the Borehole

The borehole was constructed using a technique named "over-washing". The procedure required a pilot drill string and a washover drill string. The pilot drill string was advanced in stages and then drilled over (over-washed) by the washover drill string. The length of the stages were dictated by the drilling conditions; generally the length of the stage was from 100 feet to 200 feet. The one exception was the section between the kick-off point and the end of

the curve. The pilot hole was always completely drilled in the curved section before the washover casing was advanced. Once the pilot hole reached the target measured depth and the washover drill string was advanced to the total measured depth, the pilot drill string was removed.

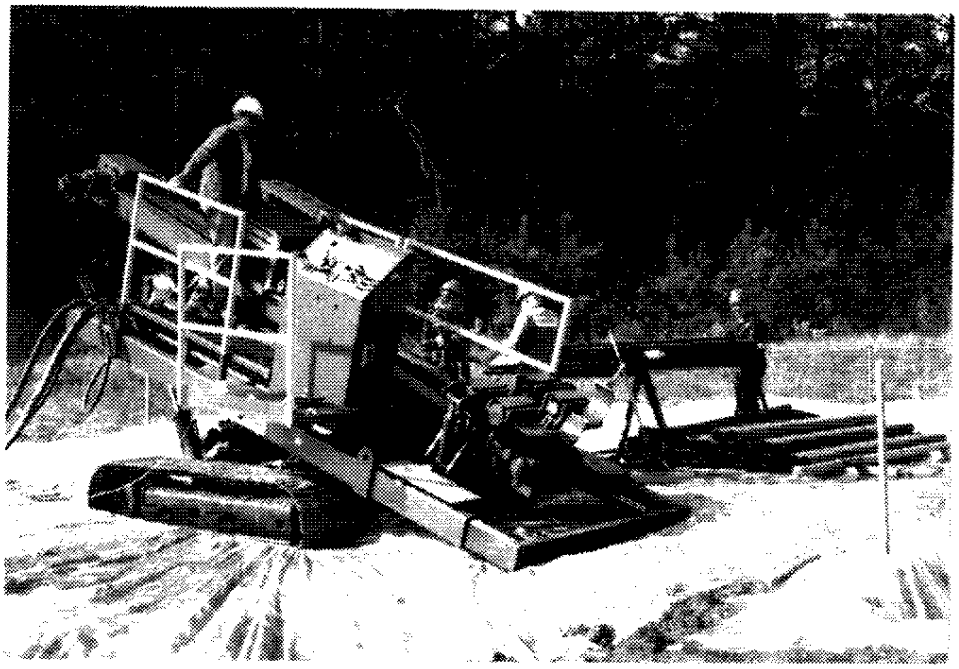
Installing the Horizontal Well Materials

The horizontal well string (the riser casing and well screen) was installed by screwing 20-foot sections together and advancing them down inside the washover drill string by hand. Hydraulic pressure (drilling fluid) or mechanical pressure (the drilling rig) was used to advance the well string when resistance to the manual installation became too great to advance the well string. Once the well string was in place the washover drill string was retrieved, and the horizontal well was grouted and developed. Well development consisted of volume water flushing and air lifting drilling fluid and cuttings from the well until all cuttings were removed from the well screen.

4.4 Operating Conditions

The drilling plan called for the use of two crews with operations running 24 hours per day, seven days per week, as long as drill rods were in the ground. Approximately 30 minutes of shift overlap was allowed for crew shift transition. The night crew was informed they could work at a slower pace, if they felt it deemed necessary, to prevent safety hazards due to limited visibility.

The two extraction wells were designed to pass directly below the M-Area Settling Basin, above the water table in the vadose zone. Because the vadose zone below the basin contains various amounts of VOCs, namely trichloroethylene (TCE) and tetrachloroethylene (PCE), it was necessary to monitor the cuttings coming out of the ground. The SRTC representative utilized a hand-held photoionization detector (PID) for determining the amount of ambient VOCs within the drilling area. The health and safety plan designated worker clothing as Level D (hard hats, steel toe boots, coveralls). If PID readings for VOCs exceeded 10 parts per million (ppm), then the workers would be advised to move up to safety Level C (respirator) while working in these areas. If VOCs readings reached 25 ppm, the workers would be required to move up to Level C protection. Readings were collected usually once a shift or as often as deemed necessary by the technical oversight. No VOC readings were recorded above 3 ppm, with average readings less than or equal to 1 ppm, for the duration of the project.



Oblique view of MC-90 drilling rig .

Figure 4-1. Oblique View of MC-90 Drilling Rig

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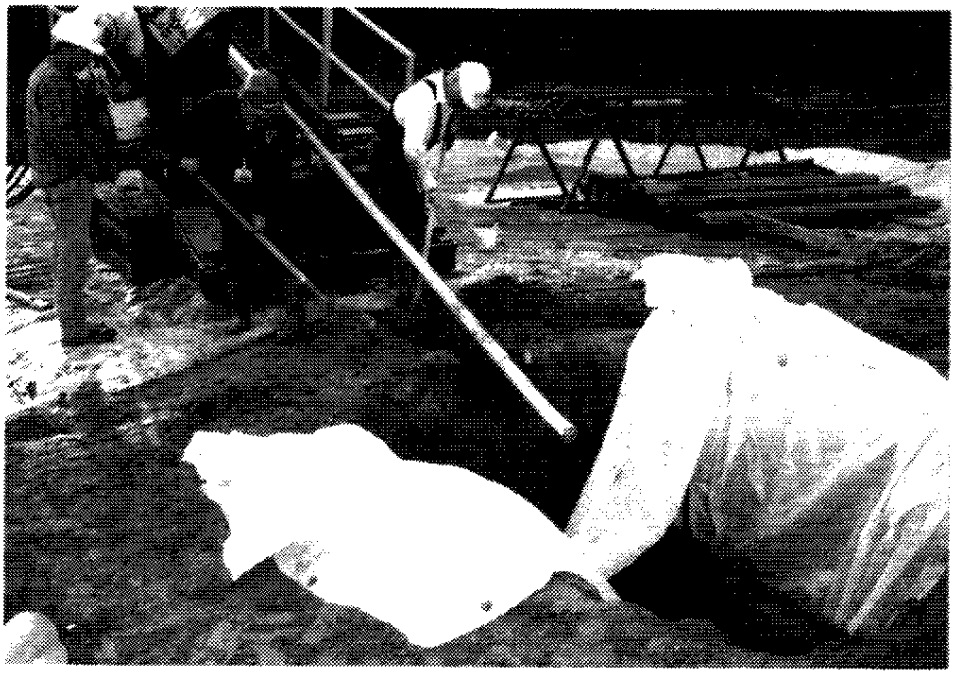

The down-hole drilling assembly is shown on the drilling rig. The hydraulic spud-jet and bent sub-assembly are at the end of the down-hole assembly. The steering tool is located in the housing just behind the bent sub-assembly. The drill sump is in the foreground.

Figure 4-2. Down-Hole Drilling Assembly

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This hydraulic spud-jet drilling tool was used throughout the duration of the project.

Figure 4-3. Directional Drilling Tool

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The Magnetic Guidance System (MGS) is shown in the foreground.
The tool is inserted into the Borehole Drilling Assembly.
The wire attached to the top connects the MGS to the computer.

Figure 4-4. Magnetic Guidance System

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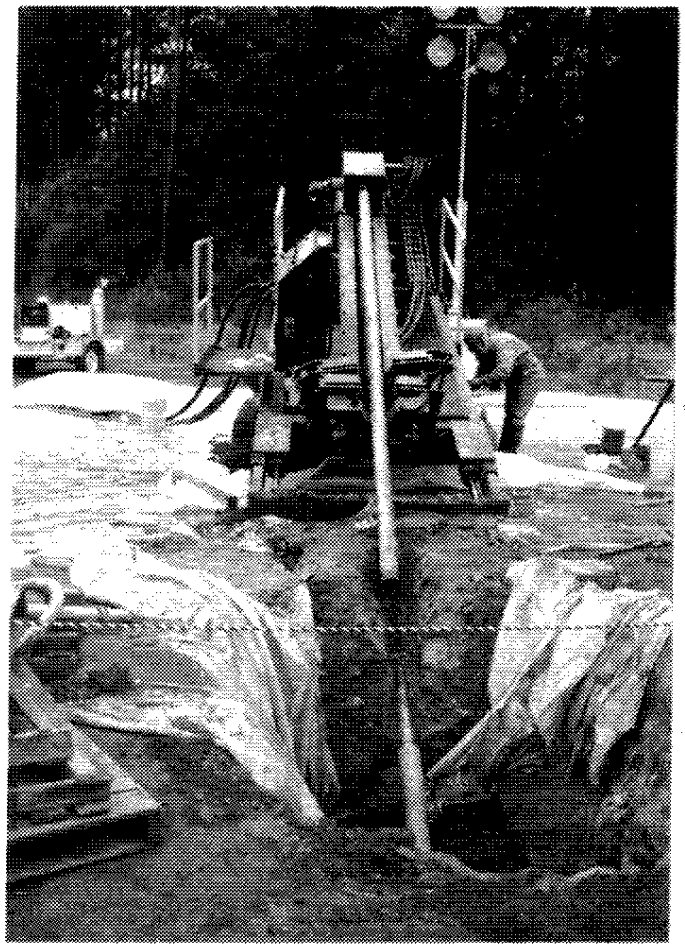

The four-inch washover pipe can be seen protruding at the base of the drill pit and attached to the drilling rig. The two-inch pilot string can be seen projecting out of the washover pipe.

Figure 4-5. Drill String Assembly

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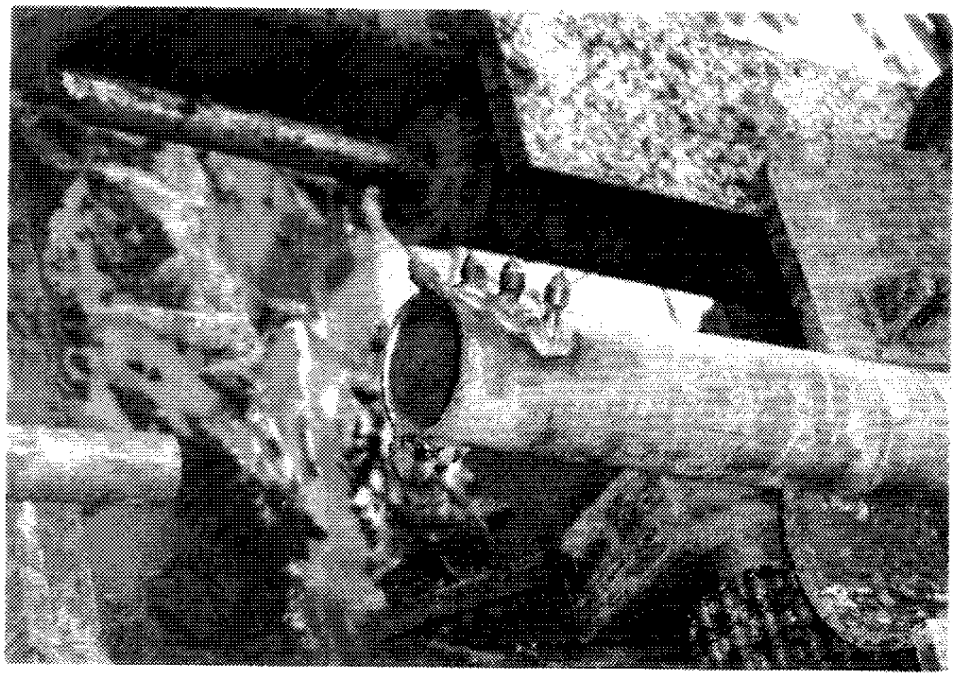

The nine-inch drill bit consists of carbide tips welded to a four-inch washover coupling.

Figure 4-6. Nine-Inch Drill Bit Attached to Washover Pipe

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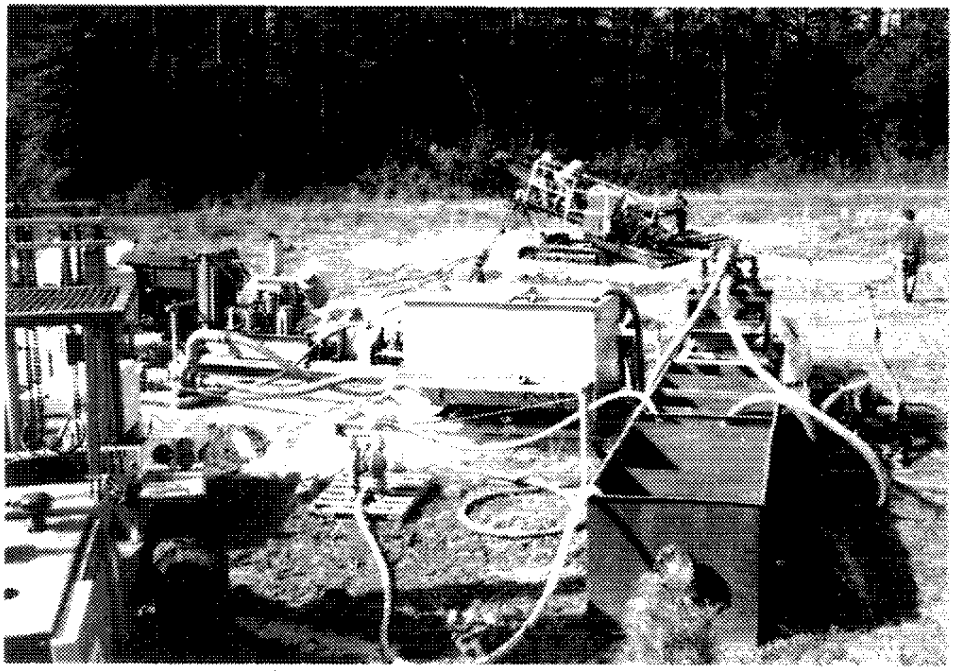

The light green tank in the foreground is the mixing tank.
The mud pumping system is to the left of the mud mixing tank.
The mud pit is directly in front of the drilling rig in the background.
The mud settling tank/desander is the light brown tank in the right foreground.

Figure 4-7. Mud System Set-Up

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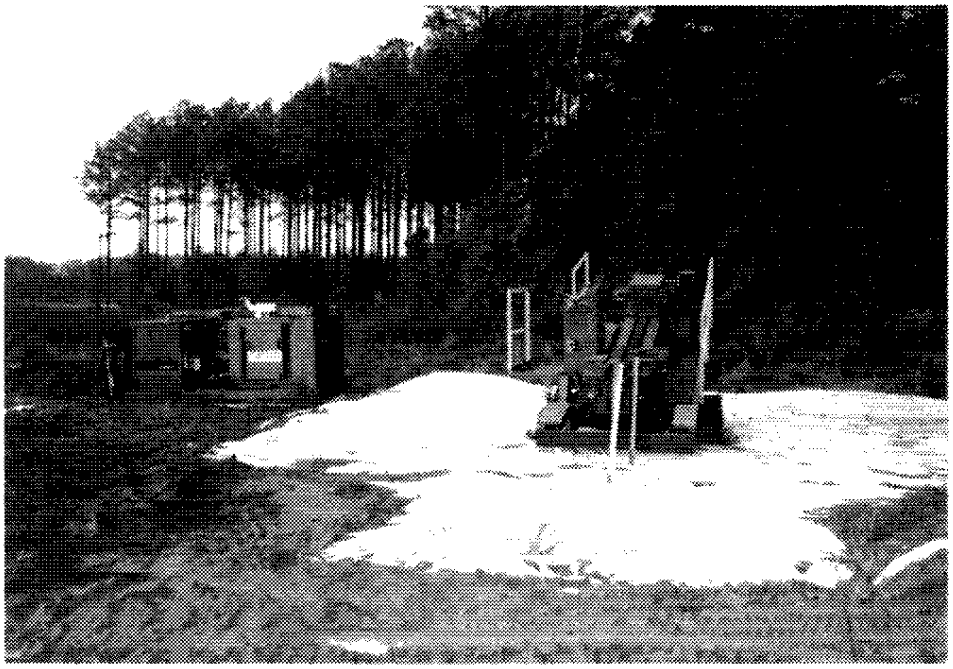

The drill site is lined with 0.010 millimeter-thick plastic sheeting. The plastic extends under the drilling rig and down into the mud pit.

Figure 4-8. Drill Site Set-Up with Lined Drill Pad and Sump

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5.0 TECHNICAL APPROACH

One of the objectives of the project was to install two identical and parallel horizontal wells beneath the M-Area Settling Basin and to demonstrate river crossing directional drilling and horizontal well installation technology. The horizontal wells will be part of a soil gas extraction system designed to remediate the vadose zone beneath the M-Area Settling Basin and prevent further migration of VOCs downward into the groundwater. SRTC decided to install the wells approximately 10 to 15 feet above the water table in a clayey sand horizon at an elevation of 240-245 feet above mean sea level (msl). The horizon was chosen because it appeared to be a permeable zone close to the water table. During operation of the soil gas extraction system air will pass from the surface through the vadose zone to the horizontal wells. Aerating the vadose zone in this manner will maximize the removal of the VOCs. The wells were planned to be constructed 100 feet apart (Fig. 5-1) beneath one half of the basin.

Borehole Path – Plan 1

The directional drilling and horizontal well installation plan was devised by the drilling contractor, CEC, and approved by SRTC. The methodology is described in Section 4.0. The directional drilling plan was based on the need to construct a 430-ft-long borehole at the target depth below the basin. A diagram used for calculating the borehole path is shown in Figure 5-2; the pertinent borehole path data were:

Target Elevation:	243 feet msl
Entry Elevation:	353 feet msl
Total Vertical Depth (TVD):	110 feet
Radius of Curvature:	300 feet (19°/100 feet)
Approach Angle:	25° from the horizontal
Step-off Distance:	302.7 feet
Kick-off Point:	194.1 feet Measured Depth (MD), 82.0 feet Vertical Depth (VD)
Length of Curve:	130.9 feet
End of Curve:	324.3 feet MD
Total Measured Depth:	754.3 feet MD

Borehole Path – Plan 2

The first borehole path plan was abandoned after the first attempt to drill a borehole with the above specifications failed. It was believed at the time that the radius of curvature was too short and therefore the radius of curvature was increased to 400 feet. The well separation was decreased to 80 feet. A diagram used for calculating the borehole path is shown in Figure 5-2; the pertinent borehole path data were:

Target Elevation:	243 feet msl
Entry Elevation:	353 feet msl
Total Vertical Depth:	110 feet
Radius of Curvature:	400 feet (14.4°/100 feet)
Approach Angle:	25° from the horizontal
Step-off Distance:	325.9 feet
Kick-off Point:	173.2 feet MD, 73.2 feet VD

Length of Curve:	173.6 feet
End of Curve:	346.8 feet MD
Total Measured Depth:	776.8 feet MD

Horizontal Well Installation Plan

The boreholes were constructed using a dual drill pipe system as described in Section 4.0. Once the pilot drill string attained the total measured depth and the washover pipe was drilled to the total measured depth, the pilot string was retrieved from the borehole. The well materials were then pushed into the washover pipe until the well screen was placed in the entire horizontal section beneath the basin. The well materials were chosen by SRTC and CEC. The well screen was 0.010-inch slotted three-inch internal diameter schedule 40 polyvinyl chloride (PVC) pipe. The riser casing was solid three-inch internal diameter schedule 40 PVC pipe.

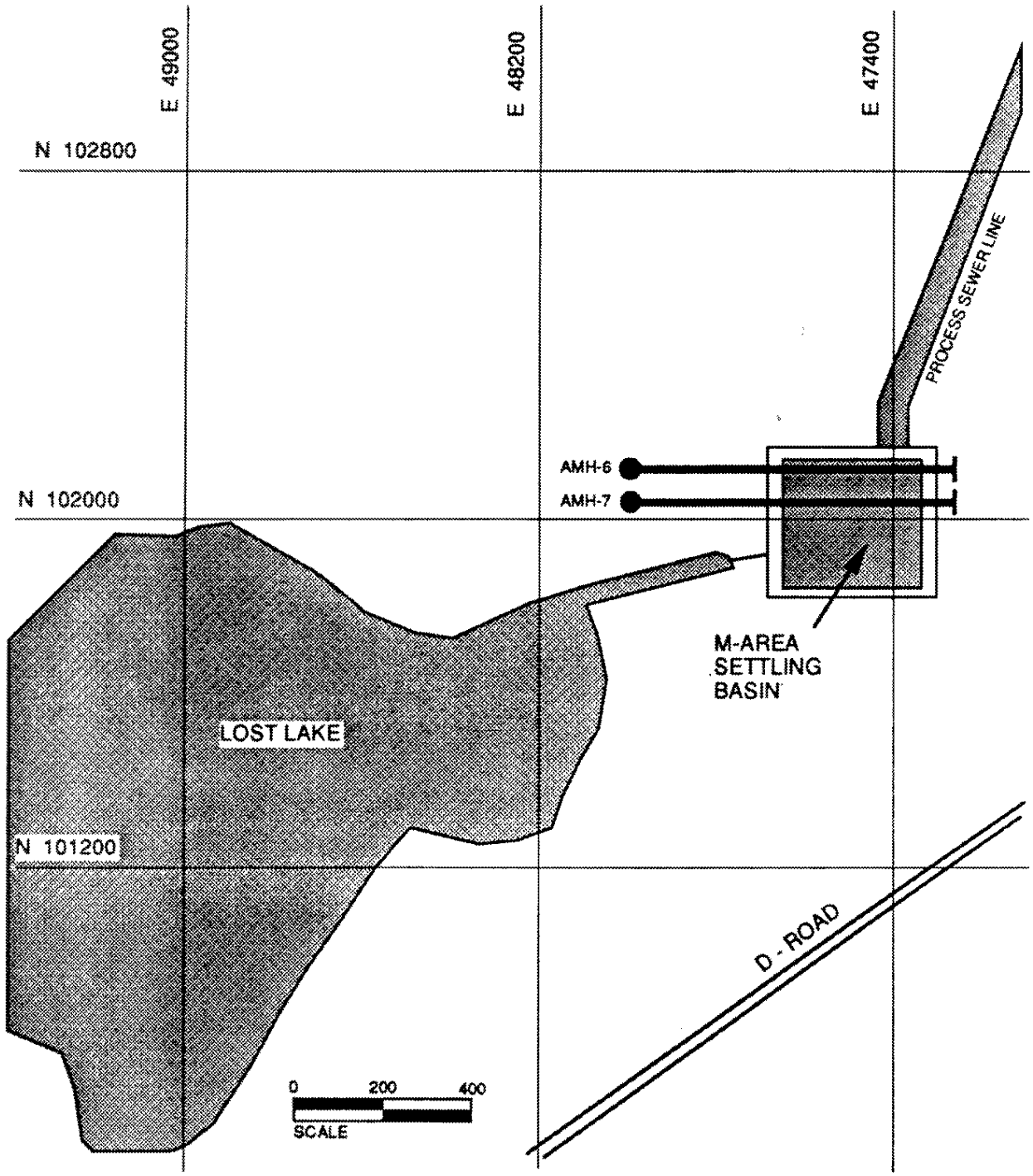
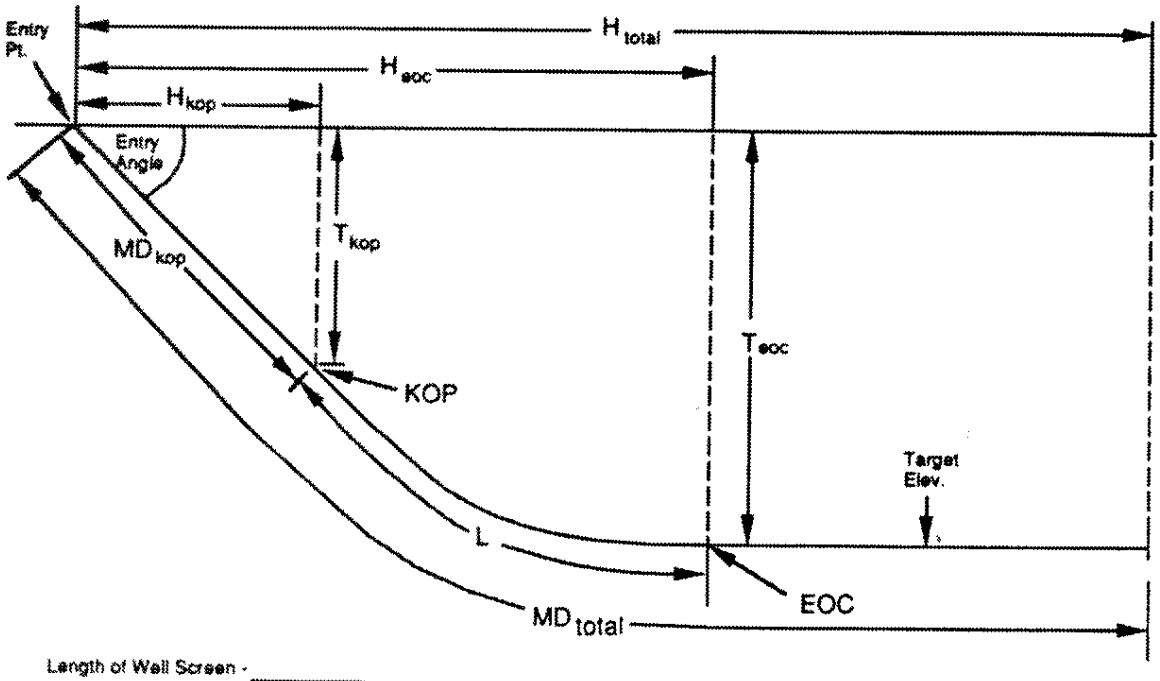


Figure 5-1. Proposed Path (Plan View) of Horizontal Wells in M Area



Length of Well Screen - _____

Elevation of Entry - _____

Elevation of Target - _____

Entry Angle - _____

Depth to Target - _____

Radius of Curvature - _____

L = Length of Curve = sin (1) * entry angle * radius of curvature

EOC = End of Curve

K_1 = Constant for degrees / ft = (1 / sin (1)) * 100 = 5730

BUR = Build Up Rate = 2*arcsin (50/radius of curvature)

KOP = Kick Off Point

T_{kop} = Vertical Depth to Kick Off Point = Depth to Target - K_1 / BUR * (sin (90) - sin (90 - entry angle))

H_{kop} = Horizontal Distance to Kick Off Point = T_{kop} / tan (entry angle)

H_{eoc} = Horizontal Step Off Distance from End of Curve = H_{kop} + K_1 / BUR * (cos (90 - entry angle) - cos (90))

T_{eoc} = Vertical Depth to End of Curve or Depth to Target Horizon = T_{kop} + K_1 / BUR * (sin (90) - sin (90 - entry angle))

MD_{kop} = Measured Depth to the Kick Off Point = T_{kop} / sin (entry angle)

MD_{eoc} = Measured Depth to the End of the Curve = MD_{kop} + ((Pi * K_1) / 180) * (entry angle / BUR) or (MD_{kop} + L)

MD_{total} = Measured Depth to the End of the Borehole = MD_{eoc} + horizontal distance required for well screen

H_{total} = H_{eoc} + horizontal distance required for well screen

Figure 5-2. Diagram (in Cross Section) of Horizontal Well Layout

6.0 WELL CONSTRUCTION SUMMARY

Directional drilling and horizontal well installation activities began on November 11, 1992 and continued until December 25, 1992. This section contains a description of the activities for this period. Appendix A contains a detailed account of drilling and fishing activities. Appendix B contains the Daily Activity Reports for this period. Appendix C contains photographs of the drilling activities for this period. Appendices D and E contain well construction diagrams and as-built diagrams, respectively. Appendix F provides specific information on the Guar Gum drilling additive utilized for this task.

A health and safety orientation meeting was conducted during the morning of November 11, 1992 by the SRTC representative. The items discussed during the meeting were the health and safety plan, the objectives of the drilling program, and the drilling plans. After the meeting CEC personnel began preparing the site for drilling operations. Inclimate weather and equipment break-downs forced site preparation activities to continue until the afternoon of November 13, 1992. Site preparation normally does not take that long to complete.

The SRTC representative calibrated the PID unit at the beginning of drilling and on a daily basis thereafter.

6.1 AMH-6 Borehole Construction – First Attempt

Preliminary Work

Preliminary work included setting up the drilling rig, setting up the mud system, and setting up the downhole drilling assembly. The drilling rig was set up on the AMH-6 location and oriented on the proper azimuth and entry angle. The drilling rig power pack and the mud system were set up between the AMH-6 and AMH-7 drilling locations. A mud pit was excavated at the entrance site of AMH-6 to accumulate and contain drilling fluids. The downhole drilling assembly was assembled and a line of sight survey of the proposed borehole path was performed. As discussed in Section 5.0, the planned paths of the boreholes passed directly below the basin and between several clusters of monitoring wells. It was imperative that the survey tracking be closely monitored to ensure that the existing monitoring wells were not damaged. Sharewell Inc. personnel calibrated the steering tool along the line of site survey to ensure the accuracy of the borehole.

Drilling the Slant

AMH-6 borehole construction began during the afternoon of November 13, 1992. The pilot drill stem entered the ground at the prescribed 25° approach angle. As the downhole drilling assembly was initially being advanced (within ten feet of ground surface), drilling fluid was observed discharging out of the subsurface approximately 25 feet from the drill collar. The pilot drill stem was advanced 40 feet into the ground, and 20 feet of washover pipe were installed. The drilling fluid then stopped discharging to the surface.

At 25 feet VD (55 feet to 65 feet MD), an extremely hard layer was encountered. This layer was likely the "325-ft clay" of the "Upland unit" as mentioned in Section 3.2.4.

The pilot drill string was advanced to 195 feet MD (initial point for beginning the curve). The washover pipe was then advanced to a depth of 160 feet MD. Mud pressures during this portion of the drilling stayed around 300 psi. Mud returns were generally good during this initial portion of the hole with some fluid loss at 140 feet MD.

Drilling the Curve

Once the slant portion of the borehole was complete, the pilot hole of the curved section of the borehole was drilled. The pilot drill stem was drilled with a constant build rate of 19° per 100 feet of borehole through the curve.

The curve was drilled to 262 feet MD (245 feet msl) when a hard layer was encountered. This hard layer deflected the drill bit up approximately two feet. Pilot string installation continued, and drilling fluid circulation was lost around 290 feet MD. The drillers decided to pull the pilot stem back to the point of encountering the hard layer and correct the deflection in the radius of curvature. The drillers were concerned that this deflection would make the radius of curvature too small and jeopardize the integrity of both the pilot drill stem and the washover pipe. The drillers were successful in re-entering the hard layer at the correct build rate for the curve. The pilot hole was drilled through the curve and into the horizontal portion of the borehole to 363 feet MD. Drilling fluid circulation was regained at 330 feet but was on the whole sporadic. Losses of drilling fluid to the formation during this period were estimated at 2000 gallons. Because of the difficulty in penetrating the formation at the target horizon, the target elevation for the well was moved down from 245 to 243 feet msl.

Once the pilot string was drilled through the radius of curvature, drilling switched back to washover pipe installation. The washover pipe was advanced to 340 feet MD. Drilling fluid circulation was intermittent while the washover pipe was advanced through the curve. At least another 1000 gallons of drilling fluid was lost to the formation during this period.

Drilling the Horizontal

The pilot drill stem was advanced to 570 feet MD where drilling became too difficult to advance any further. From 363-570 feet MD the drilling was intermittently hard and soft, and drilling fluid returns were good. The elevation of the downhole drilling assembly at 570 feet MD was 239.5 feet msl.

The washover pipe installation resumed at 340 feet MD. However, at 350 feet MD the drilling fluid circulation was lost to the formation. The drillers continued advancing the washover pipe to 530 feet MD, until drilling became too difficult to advance the washover pipe. It is estimated that 11,000 gallons of drilling fluid were lost to the formation during the 12 hours it took to drill the washover pipe through the section of the well from 340 to 530 feet MD. The washover pipe could not be advanced past 530 feet MD, and the driller decided to advance the pilot drill stem.

The pilot drill stem was advanced to 700 feet MD. Drilling was intermittently hard and soft. Drilling fluid returns were good. Once again the drillers attempted to advance the washover pipe past 530 feet MD and failed. The decision was made to retract the washover pipe to determine if the pipe had broken. The drillers pulled off only 32 joints of washover pipe

before encountering the end of the drill string. The washover drill string had broken off at the box joint of a washover pipe. Twenty-one pieces (210 feet) of washover pipe were left down hole with the top of the broken section at approximately 310 feet MD. On November 15, 1992, at 2100 hours, drilling was halted until a recovery (fishing) tool could be flown in to extract the broken pipe.

Drill Pipe Recovery Activities

The recovery activities lasted from November 17, 1992 to November 21, 1992 and were ultimately unsuccessful in recovering all the washover pipe and the borehole. The downhole drilling assembly and pilot drill stem were recovered. Drill pipe recovery activities are presented in Appendix A. During the recovery activities, approximately 19,000 gallons of drilling fluid were lost to the formation.

AMH-6 Drilling Summary – First Attempt

The salient observations that were made during this attempt were that 31,000 gallons of drilling fluid were lost to the formation and the washover pipe broke. No mitigating actions were taken to prevent drilling fluid loss other than thickening the drilling fluid by mixing the guar gum at a rate that prevented total dissolution of the guar gum in the drilling fluid. The result was clumps of guar gum powder (known as "fish eyes") that float in the drilling fluid. The purpose of the fish eyes was to flow into and plug any cavities in the area of the borehole that were experiencing the fluid loss. CEC personnel determined later in the drilling project that the washover pipe was not the proper grade and strength for this drilling technique. Another observation that was made was that the desander in the drilling fluid system did not perform efficiently. The drilling fluid had a high fine sand and silt content and therefore the carrying capacity of the drilling fluid was greatly reduced.

The washover pipe had broken at the first attempt to advance it past 530 feet MD. However, the driller failed to recognize the situation and continued to drill the pilot hole. The time and effort spent drilling the 130 feet of extra pilot hole was wasted. The abandoned borehole remained open until the drilling project was completed. The borehole was then grouted from total depth to the surface.

6.2 AMH-7 Borehole Construction

Preliminary Work

Preliminary work included setting up the drilling rig, setting up the mud system, and setting up the downhole drilling assembly. The drilling rig was set up on the AMH-7 location and oriented on the proper azimuth and entry angle. Because of the problems encountered in drilling AMH-6, the decision was made to move the collar of AMH-7 back to the south approximately 25 feet to increase the radius of curvature on the hole from 300 feet to 400 feet (see Section 5.0). The new location was surveyed in by Sharewell Inc. personnel and reviewed by the SRTC representative. To assist in anchoring the drilling rig to the ground, the drillers utilized a backhoe to push two 10-foot sections of four-inch diameter drill steel into the ground in front of the drilling rig and welded the steel to the rig frame. This allowed for much

greater stability during pushing or pulling on the drill rods. The drilling rig power pack and mud system were already set up between the AMH-6 and AMH-7 drilling locations.

A mud pit was excavated at the entrance site of AMH-7 to accumulate and contain drilling fluids. The downhole drilling assembly was assembled, and a line of sight survey of the proposed borehole path was performed. Sharewell Inc. personnel calibrated the steering tool along the line of site survey to ensure the accuracy of the borehole.

Drilling the Slant

AMH-7 drilling activities began at 0800 hours on November 21, 1992. Initial drilling of the pilot string progressed smoothly until 110 feet MD. At this point the steering tool control wire broke at the downhole drilling assembly. The crew installed washover pipe down to 100 feet and extracted the pilot drill stem and the downhole drilling assembly. The crew reattached the broken wire, reinstalled the pilot stem down to 110 feet, and resumed drilling.

Drilling the Curve

The pilot hole was drilled from 110 feet MD, through the curve and into the horizontal section, to 360 feet MD. The build rate in the curve was 14.4° per 100 feet drill stem. A soft horizon was encountered at approximately 239 feet msl. The elevation of the end of the curve was 237.5 feet msl. The washover pipe was then advanced to 300 feet MD. Approximately 3000 gallons of drilling fluid were lost to the formation up to this point in drilling AMH-7.

Drilling the Horizontal

The drilling conditions at 370 feet MD (237.5 msl) indicated a very dense clay horizon. Drilling fluid pressure was increased to 750 psi, and the pilot string advanced slowly to 400 feet MD. Drilling efforts then switched back to washover pipe installation to ensure that the two-inch pilot string was not getting bound up by drill cuttings. The extreme push pressure on the washover pipe caused the drilling rig to separate from the four-inch steel support pilings. The anchors were reattached. Mud returns to this point were good, and fluid losses to the formation were minimal. The decision was made to drill up two feet to reach the soft horizon encountered at 239 feet msl. The driller did drill upwards, but the drilling did not become easier.

A very hard zone was encountered between 580 and 590 feet MD. This zone deflected the downhole drilling assembly up 2.4° in a ten-foot length. The borehole deviation was too great to accommodate the washover pipe; therefore, the pilot stem was retracted to approximately 560 feet MD, and the washover pipe was advanced. The cutting ability of the rotary bit on the washover pipe opened up the borehole at the point of deflection, and the downhole drilling assembly returned to the proper trajectory.

Drilling continued, alternating approximately every 50 feet between the pilot string and the washover pipe installation. The drilling was extremely difficult, and cuttings coming back up the annulus indicated that the formation being penetrated was a tan green clay with very little to no sand. At 740 feet MD drilling reached the point of rejection. The decision was made to pull the pilot string back to approximately 710 feet MD and drill the washover pipe to the total depth

of the well (770 feet MD). The washover pipe was then retracted forty feet and the pilot string advanced to the end of the well to collect survey information. The drillers completed surveying the well and retracted the pilot drill stem and prepared for installation of the well materials inside the washover pipe.

AMH-7 Drilling Summary

During the borehole construction, 9,000 gallons of drilling fluid were lost to the formation. No mitigating actions were taken to prevent drilling fluid loss other than thickening the drilling fluid by mixing the guar gum at a rate that prevented total dissolution of the guar gum in the drilling fluid.

6.3 AMH-7 Well Installation

The well materials for AMH-7 consisted of:

- One six-inch long, 3-inch diameter, schedule 40 PVC cap.
- 21 pieces of 20-ft long, flush threaded, 3-inch nominal inside diameter (ID), 0.010-inch slotted schedule 40 PVC screen in the horizontal section below the basin.
- 16 pieces of 20-foot long and 2 pieces of 10-foot long, flush threaded, 3-inch nominal ID, schedule 40 PVC riser above the screen.

The slotted screen was easily installed by hand to 250 feet MD. However, at this depth the buoyancy of the screen within the drilling fluid in the borehole created a frictional force that exceeded the driller's ability to push the screen by hand. Drilling mud was pumped inside the screen to decrease the buoyancy. Once filled with mud, the screen and casing were easily pushed by hand down to approximately 600 feet MD. Sand, built up in front of the screen, made it necessary to use the drilling rig to advance the well casing to the end of the borehole. A cap was placed over the end of the well casing, and the rig drill head pushed slowly on the pipe until the section was near ground level. Once the section of well pipe was installed the cap was removed, another section of pipe added, and the process was repeated. The total installed depth of well AMH-7 was 760.5 feet (750.5 feet below ground surface and 10 feet of casing above the ground surface).

Once the well materials were installed, the washover pipe was extracted. The well installation was completed on November 25, 1992 at 1400 hours. The well would be grouted and developed upon completion of drilling and installation of AMH-6. Drilling and well installation for AMH-7 took just over four days.

6.4 AMH-6 Borehole Construction – Second Attempt

Preliminary Work

Preliminary work included setting up the drilling rig, setting up the mud system, and setting up the downhole drilling assembly. Because of the problems encountered in drilling the first attempt at AMH-6, the decision was made to move the entry site of AMH-6 back to plant west approximately 25 feet to increase the radius of curvature on the hole from 300 feet to 400 feet (see Section 5.0) and to plant south approximately 20 feet, to prevent physical and magnetic

interference from the broken section of washover pipe left in the first abandoned attempt on AMH-6. The new location was surveyed in by Sharewell Inc. and reviewed by the SRTC representative. The drilling rig was set up on the AMH-6 location and oriented on the proper azimuth and entry angle. A drilling fluid return pit was constructed at the entry point, and two 10-foot sections of four-inch diameter drill steel were pushed into the ground in front of the drilling rig and welded to the rig frame to anchor the drilling rig. The drilling rig power pack and the mud system were already set up between the AMH-6 and AMH-7 drilling locations.

Drilling the Slant

Drilling began on AMH-6 on November 25, 1992 at 2100 hours. Initial drilling of the pilot string progressed to 161 feet MD before switching over to install the initial sections of washover pipe. The steering tool experienced magnetic interference near the surface that resulted in an azimuth error and a subsequent borehole deviation of 2.3 feet to the right of the proposed borehole path. A standard practice is to "plug" the proposed azimuth into the steering tool software where there is a possibility of magnetic interferences (such as near the ground surface). The Sharewell Inc. survey operator did not plug the proper azimuth. The difference in azimuth was not crucial to the completion of the well. Drilling continued, and the borehole was brought back on the correct path (see Figure 3-9).

Washover installation continued to 140 feet MD (approximately 290 feet msl). Based on the previous attempt at installing AMH-6, SRTC and CEC made the decision to move the target elevation of the well to 245 feet msl. The crew switched to installing the pilot string and began building the angle at 161 feet MD.

Drilling the Curve

Installation of the pilot string continued to 301 feet MD (approximately 250 feet msl). Washover pipe was installed to 260 feet MD, and then the pilot string was drilled through the curve. At 351 feet MD the end of the curve was reached, and drilling became very difficult. A visual analysis of the cuttings indicated that the bit was penetrating a clayey zone.

Drilling the Horizontal – Stage 1

Drilling of the pilot hole proceeded smoothly to 511 feet MD (244 feet msl). The borehole was within a couple of feet of the projected elevation. The steering tool appeared to have experienced no magnetic interference from the broken section of washover pipe that remained in the abandoned borehole left from the first attempt at drilling AMH-6. The drilling, within the horizontal section below the basin, alternated between hard and soft indicating a possible variable clay content in the horizon. To this point, returns for all drilling in this borehole were good, and there appeared to be minimal losses in drilling fluids to the formation. At 511 feet MD, drilling became difficult, and the crew switched to installing the washover pipe. Washover pipe installation began at 250 feet MD and proceeded to 340 feet MD where drilling reached the point of rejection. The decision was made to retract the washover pipe to inspect the drill bit for wear. The crew moved the pilot string to ensure it was not stuck in the hole and then proceeded to pull the washover pipe.

The washover pipe was found to have broken at 270 feet MD; 60 feet of washover pipe remained between 270 and 330 feet MD. The break occurred between the #6 and #7 washover pipe above the downhole drilling assembly. The box of joint #6 was still attached to the pin of joint #7. This relationship of the box breaking off on the pin of the previous pipe is the same for each of the washover pipe failures for this project.

Recovery Activities

The drillers retracted the pilot drill stem and recovered the downhole drilling assembly. A detailed account of the recovery activities may be found in Appendix A. The washover pipe was recovered with a simple hook attached to the pilot drill stem.

Drilling the Horizontal – Stage 2

The pilot stem with the downhole drilling assembly was re-installed to 511 feet MD, and the washover pipe was re-installed to 330 feet MD. Drilling began again on the washover pipe and proceeded to 405 feet MD where the point of rejection was reached. It appeared that the washover pipe had again broken at some point in the curve.

The drillers retracted the pilot drill stem and recovered the downhole drilling assembly. The pilot drill stem was replaced with a "dummy string" to 511 feet MD. The dummy string consisted of the pilot drill stem without the down-hole drilling assembly. The washover pipe was retracted. The break occurred at 325 feet MD, between washover joints #8 and #9 above the drill bit. The box of joint #8 was still attached to the pin of joint #9. Eighty feet of washover pipe was left in the hole between 325 and 405 feet MD.

Recovery Activities

A detailed account of the recovery activities may be found in Appendix A. The washover pipe was recovered with a simple hook attached to the pilot drill stem. The total down time for retrieving the broken washover pipe was 24 hours.

Drilling the Horizontal – Stage 3

The pilot drill stem with the down-hole drilling assembly was re-installed in the borehole to 511 feet MD, and the washover pipe was re-installed to 405 feet MD. Because there was a major concern that the washover pipe had been weakened by the cumulative stresses of the previous drilling activities, the drillers decided to use lower rotational speed and push force to put less strain on the joints of washover pipe as they rotated through the curved section of the borehole. CEC and the SRTC representative agreed that the rotational speed would not exceed 30 rpms.

Drilling of the washover pipe resumed and mud losses to the formation became significant. The crew completed pushing the washover pipe to 490 feet MD; however, fluid losses to the formation had reached 1000 gallons per twenty feet of borehole drilled.

The pilot drill stem was drilled 611 feet MD. At this point the drillers took a 30-minute break for dinner. Upon returning from dinner break, all of the drilling mud had drained out of the

mud pit and presumably into the formation. The borehole took an entire tank of drilling mud just to regain circulation. Mud losses to the formation appeared to have begun while drilling the washover pipe between 420 to 440 feet MD. Circulation could be maintained as long as mud was being pumped down the borehole. However, if the drilling stopped, the thick mud would visibly flow back down the hole and into the formation by the hydrostatic head pressure of the drilling mud alone. Analysis of the potential causes for these fluid losses will be discussed in Section 7.0.

Pilot string installation continued to 631 feet MD. While drilling 620 to 630 feet MD, the directional drilling tube was pointed up but the inclination of the borehole (as indicated on the survey tool) dropped down 4°. This indicated that the downhole drilling assembly encountered very soft material or an open void. Approximately 1000 gallons of drilling fluid were used to drill this ten feet of borehole. The amount of drilling fluid running out of the mud pit and into the formation under hydrostatic pressure alone was estimated by observing that the fluid level in the 10 ft. × 6 ft. mud pit was dropping 1 inch per minute. The estimated rate of fluid loss was 5 cubic feet or 40 gallons per minute.

The drilling crew decided to advance the washover pipe to the end of the pilot drill stem to mitigate the drilling fluid loss. However, the washover pipe would not advance further. The crew then pulled on the washover pipe until it jerked suddenly. The jerk indicated that the washover pipe had broken downhole. The washover pipe was extracted. The break in the washover pipe occurred at 80 feet MD, between washover joints #42 and #41 above the drill bit. The box of joint #41 still attached to the pin of joint #42. The 400 feet of washover pipe remaining in the borehole was between 80 and 480 feet MD.

Recovery Activities

The recovery activities are described in Appendix A. The washover pipe was not recovered from the horizontal section of the borehole.

Drilling the Horizontal – Stage 4

CEC proposed to SRTC that they would drill 270 feet past the end of the broken section of washover pipe and install the well materials in an open borehole. The result would be 270 feet of open screen beneath the M-Area Settling Basin. SRTC decided to accept the well if CEC could install 250 to 280 feet effective screen below the basin. The SRTC decision was made because of their concern of the massive fluid losses to the formation. A replacement well would be drilled only if all other attempts at salvaging the current borehole failed.

The pilot drill stem was advanced to 745 feet MD. The pilot borehole was sized to a larger diameter to facilitate the installation of the well materials. The open borehole was between 480 feet MD to 745 feet MD.

AMH-6 Drilling Summary – Second Attempt

Approximately 34,000 gallons of drilling fluid were lost to the formation during this attempt, the washover pipe broke numerous times, and the well was not completed to the original specifications. No mitigating actions were taken to prevent drilling fluid loss other than

thickening the drilling fluid by mixing the guar gum at a rate that prevents total dissolution of the guar gum in the drilling fluid. CEC personnel determined that the washover pipe was not the proper grade and strength for this drilling technique. The desander in the drilling fluid system did not perform efficiently. The drilling fluid had a high fine sand and silt content and therefore the carrying capacity of the drilling fluid was greatly reduced. Many days were spent trying to extract washover pipe that was stuck in the borehole. The end result was that the washover pipe remained in the borehole and that the well screen was not the originally proposed length.

6.5 AMH-6 Well Installation

The well construction materials for AMH-6 consisted of:

- One six-inch long, 3-inch diameter, schedule 40 PVC cap.
- Twenty pieces of 20-ft long, flush threaded, 3-inch nominal ID, 0.010-inch slotted schedule 40 PVC screen in the horizontal section below the basin.
- Eight pieces of 20-foot long and 16 pieces of 10-foot long, flush threaded, 3-inch nominal ID, schedule 40 PVC riser above the screen.

The slotted screen was easily installed by hand to a MD depth of 295 feet; however, at this depth the buoyancy of the screen within the drilling mud exceeded the driller's ability to push the screen by hand. A cap was attached to the top of the well pipe, but the drilling rig was unable to push the well materials downhole without the possibility of breaking the PVC pipe. The crew thinned out the drilling mud to allow easier penetration by the well material, but this did not work. The two-inch pilot drill stem was installed inside the well material to push the well material from the bottom of the screen. This technique proved successful, and the well was advanced to 710 feet MD.

At 710 feet MD, the well material would not advance any further. The drillers felt they had pushed the cap off of the end of the screen. Well installation could proceed no further. The result was that there was a total of 230 feet of well screen open to the formation. SRTC personnel decided to accept the well length although the length was 20 feet less than the minimum length agreed upon earlier. SRTC personnel wanted to prevent further damage to the target horizon.

A plug, designated as a "one way pig", was installed to within five feet of the end of the screen to reseal the end of the well. The plug consisted of a 6" long, 3.25" diameter polypropylene plug. The total installed depth of well AMH-6 was 720 feet (710 feet below ground surface and 10 feet above ground). The total effective screen installed beyond the broken section of washover pipe in AMH-6 is 225 feet (710 feet MD minus 480 feet for the broken washover pipe and 5 feet for the plug).

The drillers attempted to remove the extra washover pipe that had been installed from the surface down to the top of the broken section; however, the pipe would not move. Sand had apparently settled in around the splayed end of the washover pipe, preventing it from being extracted. Instead of risking damage to the installed well, the drillers rotated the washover pipe counterclockwise to unscrew as much of the pipe as possible. Only 6 sections of washover

pipe were extracted, leaving 420 feet of washover casing down the hole from 60 to 480 feet MD.

6.6 AMH-6 and AMH-7 Well Completion

Well completion was accomplished by: installing sand by tremmie pipe in the annulus above the well screen; installing a bentonite plug in the annulus above the sand; and filling the annulus with grout from the bentonite plug to the surface (see Appendix D for Horizontal Well Construction Diagrams). Both wells were completed on December 9, 1992. The total time for installation of the two horizontal wells was 26 days.

6.7 AMH-6 and AMH-7 Well Development

The well materials were installed using hydraulic pressure supplied by the drilling fluid system. The drilling fluid used during the installation of AMH-7 had a significant silt and fine sand fraction. Therefore, AMH-7 had a significant amount of sand in the well screen after well installation was complete. The drilling fluid used to install AMH-6 did not have a significant silt and sand fraction and therefore AMH-6 did not contain a significant amount of sand in the well screen.

AMH-6 Well Development

Development of AMH-6 began on December 12, 1992. The crew installed 330 feet of two-inch PVC tremmie pipe with a perforated six-inch pointed plug on the end (Fig. 6-1) into the well. The perforations consisted of approximately eight 1/4" angled holes. The purpose of the holes was to force water and air back uphole to wash sediment from the screen.

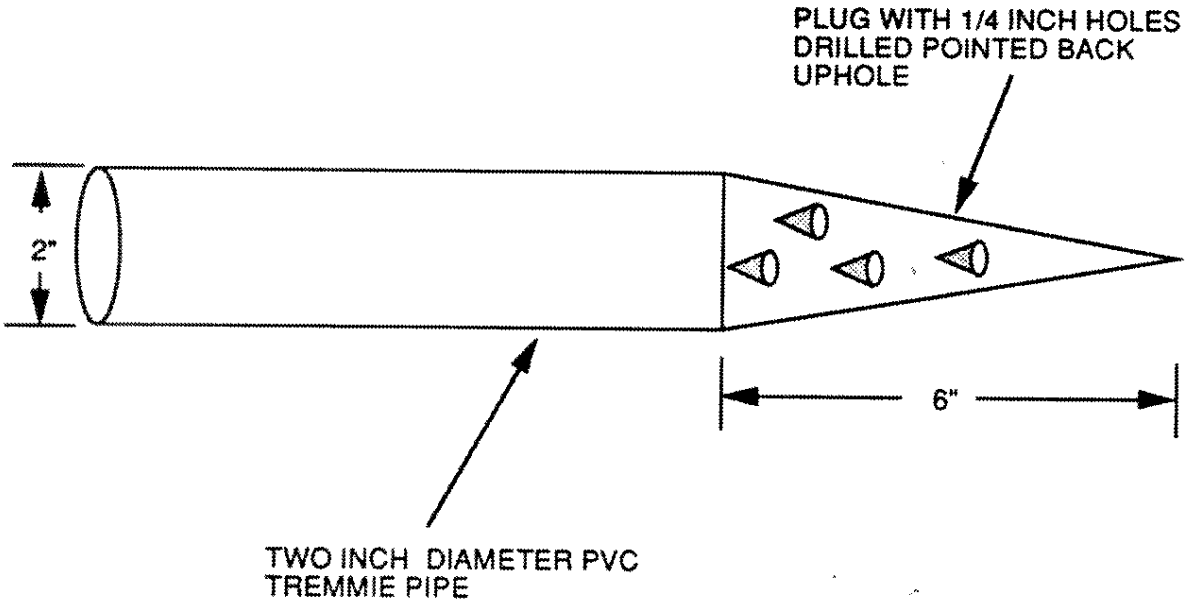
When the tremmie pipe reached 330 feet MD, water was injected as each 10-foot section of pipe was added. The tremmie pipe was push to 635 feet MD, at which time the crew could no longer advance the pipe. Approximately 2500 gallons of fresh water was pumped down the well during the four hours of tremmie pipe installation between 330 feet and 635 feet MD; however, no returns came to the surface (with all the drilling fluid lost, no returns were expected).

Apparently the water (and whatever sand) in the well was blowing back uphole but the pump was not strong enough to force the sand and water to the surface. The tremmie pipe was extracted from AMH-6, several more holes drilled in the plug, and the pipe reinserted into the well. The plan was to: insert the tremmie pipe into the well until the first sand was encountered; pump water; and then air lift to see if any fluids and/or cuttings returned to the surface. The tremmie pipe was installed to 360 feet before the first sand was encountered. Approximately 200 gallons of water were pumped down the hole before the crew began blowing air down the tremmie pipe. No returns were observed at the surface.

The driller decided to advance the tremmie pipe to the end of the well and blow with air as the pipe was being extracted, forcing the sand out laterally into the walls of the borehole. Tremmie pipe was installed to 705 feet MD, and the air development technique was applied. The technique was successful, and the well screen was cleared of sediments.

AMH-7 Well Development

AMH-7 well development proceeded with the same techniques used to develop AMH-6. Development of AMH-7 began on December 14, 1992. The crew installed 735 feet of two-inch PVC tremmie pipe with the perforated plug on the end into the well. The tremmie pipe was installed easily by hand to 610 feet before water was needed to assist in advancing the pipe. At 735 feet, the sand remaining in the screen zone had either been forced out into the formation or compressed into the last 15 feet of the screen zone, making the effective screen length of AMH-7 405 feet. Several hundred gallons of water were pumped down the well over a three-hour period with no returns at the surface. The crew began continuously injecting air into the well while extracting the tremmie pipe, forcing the sand and silt laterally out of the screen into the formation. This technique was applied until all tremmie pipe was extracted from the well. Development on AMH-7 was completed on December 15, 1992.



A six-inch long, two-inch diameter plug was perforated with 1/4" holes for blowing water and/or air down inside the three-inch well for cleaning sand and mud out during well development.

Figure 6-1. Two-Inch Diameter Perforated PVC Plug for Well Development

7.0 DISCUSSION

The directional drilling and horizontal well installation technology used by CEC appears to be a sensible approach to horizontal well installations. However, the implementation of that technology was flawed by the inexperience of the drilling crew and therefore the technology cannot be fully evaluated.

7.1 Analysis of the Drilling Program

Factors which controlled the drilling performance are discussed below and include the following:

- Inexperience of the drilling crew.
- Ineffective drilling fluid system.
- Specific geologic conditions (clay percentage and highly permeable zones) and fluid losses.
- Deficient washover pipe.
- Other factors.

These factors will be discussed below.

7.1.1 The Drilling Crew

The CEC drilling crew consisted of two crews. The night crew worked from 7:00 pm to 7:00 am. The night crew chief was the Vice President of Operations for CEC. The day crew worked from 7:00 am to 7:00 pm. The day crew chief was operating the drilling rig for the first time. It was not a coincidence that the washover pipe usually broke when the day crew chief was drilling. Both crews were relatively inexperienced in deep (greater than 50 feet vertical depth) environmental well installation.

The inexperience of the drilling crews was demonstrated in their inability or reluctance to adapt their drilling methods to the site-specific drilling conditions. Two aspects of their drilling method which needed to be adapted for this drilling project were washover pipe installation and the drilling fluid system.

CEC claims that the washover pipe was deficient (discussed below). The joints of the washover pipe were too weak to withstand the oblique stresses experienced while the pipe was rotated and/or pushed through the curved section of the borehole. After the first attempt at constructing the AMH-6 borehole failed, the radii of curvature of the borehole paths were increased from 300 feet to 400 feet. The increased radius of curvature was supposed to decrease the oblique stresses experienced by the joints of the washover pipe. No other changes were made in the drilling operation to prevent the washover pipe joints from breaking until well into the project after the washover pipe had broken numerous times. Changes that were made included rotation of the washover pipe slowed to approximately 30 rpms and the push pressure reduced. By that time, the washover pipe was well worn and more fragile, and the changes did not significantly improve the drilling performance.

Drilling fluid circulation was often lost during the drilling project. The drilling crew used the following methods to mitigate the fluid loss:

1. The drill crew thickened the drilling fluid by quickly mixing the guar gum at a rate that prevents total dissolution of the guar gum in the drilling fluid. The result was clumps of guar gum powder (known as "fish eyes") that float in the drilling fluid. The purpose of the fish eyes was to flow into and plug any cavities in the area of the borehole that were experiencing the fluid loss.

2. The drill crew drilled the washover pipe past the zone where drilling fluid was being lost. This method only regains fluid circulation while drilling the pilot drill stem and is not effective if fluid loss occurs while advancing the washover pipe.

These two methods of drilling fluid loss mitigation may work at some drilling sites; however, they did not work at this site. The crew kept trying the above listed methods over and over again, regardless of the efficacy of their efforts. Alternate drilling fluid loss mitigation methods are discussed below.

The ineffectiveness of the drilling crews to deal with these two drilling challenges resulted in many additional man hours of drilling, loss of drilling fluids to the formation, and because drilling fluid loss caused the washover pipe to become stuck in the borehole, loss of drilling materials.

7.1.2 The Drilling Fluid System

CEC uses a guar gum-based drilling fluid on all their environmental horizontal well installation drilling projects. CEC distributes information on guar gum in their informational brochures (Appendix F). Guar gum-based drilling fluid is a natural organic polymer additive which overcomes problems associated with conventional drilling fluids. Guar gum-based drilling fluid systems have the following advantages. Formation damage is minimized because the fluid does not introduce clays to the borehole and formation. Drilling tool penetration rates are increased because the fluid reduces friction on the drilling tool.

A guar gum-based drilling fluid also has disadvantages. A guar gum-based drilling fluid has virtually no gel strength. Gel strength is a measure of the ability of the drilling fluid to maintain cuttings in suspension. When fluid circulation is stopped or lost, drill cuttings will settle to the bottom of the borehole. Once cuttings settle out of the fluid they will remain at the bottom of the borehole until the fluid velocity becomes great enough to once again entrain the cuttings in the fluid. The drilling fluid velocity can be increased by increasing the fluid pressure at the drilling tool.

A second disadvantage is at high temperatures a guar gum-based drilling fluid tends to "break down" or lose viscosity more quickly. This is in part due to the growth of certain microorganisms which are most prolific at 80° to 120°F (27-49°C). Enzymes produced by these organisms in addition to those inherent in the guar gum-based drilling fluid can cause the breakdown of guar gum-based drilling fluid to be accelerated. Where such microorganisms or soil bacteria are likely to be present, precautions should be taken. If the mud pit is earthen, it should be lined with plastic. The mix water should be disinfected by chlorinating to 100 ppm. During the project, the mud pit quickly lost its plastic liner, and the mix water was not disinfected.

A third disadvantage is that if the guar gum-based drilling fluid has penetrated into a very permeable formation it will temporarily reduce the well's efficiency which could result in inaccurate test pumping data. To remove this fluid, the well should be developed by high velocity horizontal jetting with 1,000 ppm chlorine solution which will break down the guar gum-based drilling fluid. The wells installed during this project were not developed in this manner.

The drilling fluid system was inefficient for two reasons: (1) the drilling system was inefficient in removing drill cuttings, and (2) the guar gum-based drilling fluid was inefficient in maintaining fluid circulation. These two items are discussed below.

Removal of Drill Cuttings

The drilling system was inefficient in removing drill cuttings because the carrying capacity of the drilling fluid was not sufficient to remove drill cuttings from the borehole. The carrying capacity of the drilling fluid was affected by the gel strength of the fluid, the velocity of the fluid, and the fine sediment content of the fluid.

The crew increased the viscosity of the guar gum-based drilling fluid to increase the gel strength of the fluid and to stop fluid loss (described below). However, the gel strength of the guar gum-based drilling fluid remained less than the gel strength of a bentonite-based drilling fluid with the same viscosity. Whenever drilling fluid circulation stopped, the larger fractions of the entrained cuttings settled from the fluid to the bottom of the borehole. Because the borehole was either horizontal or at a low angle the cuttings remained in the borehole until the fluid velocity became great enough to erode the cuttings from the bottom of the borehole. The SRTC representative suggested to CEC personnel that the fluid velocity should be increased to remove cuttings. The CEC drilling crew did not increase the fluid velocity to remove drill cuttings from the borehole.

The drilling fluid system contained one small desander that early in the drilling project proved ineffective in removing fine sediments from the drilling fluid. The purpose of the desander was to remove fine sediments from the drilling fluid as it circulated from the borehole to the mud mixing tank. Drilling activities were stopped numerous times to allow the drilling crew to remove fine sand from the mud mixing tank that should have been removed by the desander. The desander was not replaced and remained inefficient throughout the drilling project. The results of the ineffectiveness of the desander were that the carrying capacity of the drilling fluid was greatly reduced and drill cuttings remained in the borehole. The drill cuttings remaining in the borehole quite possibly contributed to the washover pipe sticking and breaking numerous times. Cuttings that remain in the borehole will form a bridge between the drill pipe and the borehole wall. The bridge will act as a wedge when the drill pipe turns, and the drill pipe will become stuck.

Loss of Drilling Fluid Circulation

Two methods are available to stop drilling fluid loss. The first method requires an extremely viscous guar gum-based drilling fluid, 120 Marsh funnel seconds or more. A mass of this freshly mixed highly viscous guar gum-based drilling fluid must be spotted in the hole opposite the lost circulation zone. Enough of this guar gum-based drilling fluid to twice fill the borehole

annulus should be mixed in a separate tank or pit and pumped through the drill pipe to this zone. The drill pipe is then pulled back allowing the viscous guar gum-based drilling fluid to migrate into the permeable zone, thus sealing it off. After about 30 minutes, the viscosity of the remaining fluid can be reduced, and normal drilling can resume. The drill crew used a similar approach to mitigate fluid loss. The drill crew did mix a viscous guar gum drilling fluid (described above), but they did not have a Marsh funnel to measure viscosity, and they did not pull back the drill pipe to the loss circulation zone and pump the viscous drilling fluid into the permeable zone.

The second method to mitigate drilling fluid loss involves mixing Borax with the guar gum-based drilling fluid to create a dense, rubbery plugging material. Onsite experimentation with a few quarts of fluid is useful to determine mix ratios but generally one can proceed as follows:

1. Mix one cup of "20 Mule Team Borax" in 5 gallons of water, then pour the borated water directly into the drill stem.
2. Mix a pit of highly viscous guar gum-based drilling fluid – about 120 Marsh funnel seconds.
3. Raise the pH of this fluid to 9.0 to 9.5 by adding soda ash as needed. Start by dissolving a cupful of soda ash per 1,000 gallons of water and slowly add to circulating fluid system at the pump suction. System pH should be checked periodically while circulating and should be kept below 10 to avoid polymer destruction.
4. Mix additional borated water at the ratio of one cup borax per 5 gallons of water.
5. Place bottom of drill stem opposite lost circulation zone.
6. Raise pump suction to near pit surface level.
7. Activate pump at idling speed and when the drilling fluid starts to flow, pour borated water into the pit near the pump suction. Continue pumping until borated gel appears at ground surface in the annulus between drill stem and bore. It will be a thick, gelled mass.
8. Shut pump down immediately to prevent gel from reaching pit.
9. Pull drill stem back one or two lengths and wait 30 minutes for gel to cure.
10. Resume drilling operation with pump operating at reduced speed until several feet of new formation has been penetrated.
11. Repeat entire operation if necessary. If used in an aquifer where a screen has been set, it may be necessary to develop the well by high velocity jetting with a 1,000 ppm chlorine solution.

The gelled fluid may be returned to its starting viscosity by reducing the pH to 7 or lower. Reducing the amount of guar gum-based drilling fluid or Borax used or using a pH above 7 but less than 9 will weaken the chemical cross-linking bond of the guar gum polymer and produce a partially gelled, stringy mass that can be easily pumped or circulated. This partially cross-linked gel can be used where excessive fluid loss is a problem as, for example, when encountering coarse sand and gravel or other highly permeable zones.

The SRTC representative strongly suggested to CEC that they should try this method to stop drilling fluid loss. The CEC drill crew did not apply this method.

7.1.3 Specific Geologic Conditions and Fluid Losses

The specific geologic conditions that created difficulties during drilling were the clay content of sediments and sporadic, high permeability zones within the target horizon. The geologic cross section provided to CEC by SRTC showed that the target horizon was generally silty sand to silty, clayey sand. The drilling plan submitted to SRTC by CEC acknowledged the possibility of the presence of clay and/or clayey silt/sand horizons. The drilling plan provided for the use of a down-hole drilling motor if drilling conditions became too difficult for the hydraulic spud-jet drill bit. CEC did not bring a downhole drill motor to the site nor did they send for one when drilling conditions became too difficult for the hydraulic spud-jet. While drilling the AMH-7 borehole, the drilling rate was as slow as 10 feet of pilot hole drilled per 90 minutes. The reluctance of CEC to adapt to drilling conditions added many hours to the drilling project.

The nature of the high permeability zones within the target horizon is unclear. Regardless of the cause of the loss of drilling fluid circulation, the fact remains that CEC did not adapt their drilling method or fluid system to meet site conditions.

7.1.4 Drill Rod Type

The 4130 heat-treated two-inch steel pilot drill pipe used proved to be adequate for drilling in the coastal plain sands and clays. However, the 2160 washover pipe (used by mistake instead of 4130 pipe) proved to be inadequate. This type of washover pipe broke on several occasions with the box of the downhole pipe breaking off on the pin of the pipe above it. Later in the drilling project, 4130 washover pipe was shipped to the drill site and used to extract the broken sections of 2160 pipe. No problems were encountered with any of the new 4130 washover pipe.

7.1.5 Other Factors

Drilling Tool

The Task Management Plan provided by CEC stated that a drill motor and hydraulic spud-jet system would be used on this project. CEC chose to provide only a hydraulic spud-jet system at the site. However, the clayey nature of the target horizon dictated that a drill motor was required. These wells could have been completed more efficiently by using the drill motor.

Steering System

The steering system is the most accurate system available. The survey crew must calibrate the tool before drilling begins. The drilling method used by CEC required that the control wire that connects the downhole steering probe with the surface control unit be spliced twice at the beginning of each ten-foot run. Normal drilling operations require only one splice. The second splice added more time to the drilling operation and provided another weak spot in the wire. The wire will break at weak spots and cause failure of the steering system. System failure required extracting the pilot string from the borehole, resulting in significant drilling delays.

Drilling Rig Anchorage

Anchors were placed at the front of the drilling rig by driving two 10-foot sections of four-inch diameter washover pipe into the ground and welding them to the frame of the drilling rig. The drilling rig anchors became loose due to excessive pushing and pulling and had to be periodically welded back to the frame. The standard anchor system for the drilling rig consisted of a hydraulic ram and a "dead man" (Section 4.1.1). The standard anchor system was never employed by CEC.

7.2 Analysis of the Well Installation Method

The well installation method is described in Sections 6.3 and 6.5. While this method is intuitively simple, it does put stress on the well materials. At any given time each section or joint in the well string experiences the following components of stress:

Compression – Compression is exerted on the well materials when the drilling rig must be used to push the well construction material from the surface. This technique is necessary to overcome downhole frictional forces. If too much force is exerted, the screen may collapse.

Weight – The weight of the well string is dependent on the mass of the well materials and upward or downward forces in the borehole. An example of upward force is buoyancy caused by fluid in the borehole. An example of a downward force is the weight of the well string.

This installation method is easy and efficient. The implementation of the method during this drilling project was flawed. Drilling mud was used to install the well materials in AMH-7. The drilling fluid contained a large fraction of fine sediments. The sediments remained in the well after the materials were pushed into place and well development was difficult. A clean, low viscosity, chlorinated drilling fluid should have been used to supply the hydraulic pressure needed to install the well materials.

There appeared to be no problems associated with installation of the sand, bentonite, and grout well seals in the wells.

7.3 Well Development

Well development for a soil vapor extraction well is difficult because there is no formation water to aid in flushing out the drilling mud. As discussed above, if a clean, low viscosity, chlorinated drilling fluid was used to apply hydraulic pressure to the well materials during well installation (instead of drilling fluid that contains abundant drill cuttings), then there would have been less sediments in AMH-7, and the guar gum-based drilling fluid would have been rendered biologically inactive. A water-flushing treatment of the well may have been deemed unnecessary if the well installation had been done properly. However, water-flushing of the well was performed. The water was not chlorinated and biological activity induced by the guar gum-based drilling fluid may cause reduction in formation permeability.

8.0 CONCLUSIONS

The following conclusions were reached upon completion of the river crossing directional drilling demonstration.

1. Two horizontal wells were successfully installed at 24±5 feet msl (under the M-Area Settling Basin. Well AMH-7 was installed with a screen of 420 feet; well AMH-6 was installed with an effective screen of 230 feet (190 feet short of the proper length due primarily to the washover casing left in the borehole).

2. Formation damage could have been minimized by:

   - Controlling fluid loss to the formation during borehole drilling.
   - Using clean, chlorinated drilling fluid during well installation.
   - Using clean, chlorinated water during well development.

3. The drilling crew was inexperienced in installing deep (greater than 50 vertical feet) horizontal wells. The crew's inexperience was demonstrated by their inability to: deal with adverse site specific drilling conditions; deal with loss of drilling fluid circulation; deal with an ineffective desander in the drilling fluid system.

4. A downhole drill motor would have improved drilling efficiency.

5. The drilling crew did not ensure that washover pipe of the proper strength was used during the drilling project. The radii of curvature of the boreholes (400 feet) were not large enough to ensure stability of the washover pipe.

6. The guar gum-based drilling fluid system was inadequate. The drilling fluid system should have been improved or a bentonite-based drilling fluid should have been considered. The drilling crew did not keep drilling records or mud reports during this project. Therefore, the drilling crew was unprepared to adapt to the site-specific drilling conditions.

7. The directional drilling and horizontal well installation method used during this project cannot be fully evaluated because the implementation of the method was flawed. However, at this time the method should be considered as an appropriate technology for installing horizontal wells.

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9.0 RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE ACTIVITIES

9.1 Recommendations

The following are major recommendations for consideration if future projects of this nature are planned.

1. The drilling contractor should provide an experienced drilling crew. The drilling crew should be experienced in the following:

   - Installation of a horizontal well in conditions similar to that found at the proposed drilling site.
   - The use of all equipment used to install the horizontal well.

2. The drilling crew should make every effort to control the loss of drilling fluid circulation. Loss circulation zones should be plugged when they are encountered.

3. When using a guar gum-based drilling fluid, a chlorine additive should be used in the drilling fluid mix water and development water to disinfect the drilling fluid and inhibit bacterial growth. If the state Health Department does not allow a disinfectant to be introduce to the subsurface, then an alternate drilling fluid (such as a bentonite-based drilling fluid) should be used.

4. If hydraulic pressure is used to install the well materials, a clean, chlorinated, drilling fluid should be used. A clean drilling fluid would not introduce drill cuttings into the well materials that would increase well development efforts.

5. Drilling crews should be required to keep detailed daily records of drilling activities and drilling fluid properties. The records can be used to adapt drilling methods to site conditions.

6. Radii of curvature for the boreholes should be large enough to accommodate the drilling materials. Future drilling projects that use similar washover pipe should be designed to have a borehole with a radius of curvature greater than 400 feet.

7. Longer drill pipe and a wireless drilling survey system would greatly decrease the drilling time.

9.2 Suggestions for Future Activities

Based on the results of this field demonstration, the following suggestion is made regarding the future of horizontal wells AMH-6 and AMH-7. The efficiency of the horizontal wells are scheduled to be evaluated during the soil vapor extraction tests. If the horizontal well evaluations demonstrate a lower than expected soil gas permeability, then the wells should be developed with chlorinated water to destroy bacterial growth in the formation.

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APPENDIX A

SUMMARY OF BROKEN WASHOVER PIPE RECOVERY ACTIVITIES

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A. SUMMARY OF BROKEN WASHOVER PIPE RECOVERY ACTIVITIES

Section 6.0 of this report provides detailed drilling activities for AMH-6 and AMH-7. This appendix provides a detailed account of the broken washover pipe recovery activities during the two attempts to install AMH-6. Refer to Appendices B and C for Daily Activity Reports for the period of November 11, 1992 to December 15, 1992 and for drilling photographs, respectively.

A.1 First Attempt at Drilling of AMH-6 and Subsequent Fishing Activities

Drilling began on Hole #2 (AMH-6) on November 13, 1992. The pilot drill stem was advanced to 570 feet MD and the washover pipe to 350 feet MD before significant drilling fluid losses began to occur. Installation of the washover pipe continued until washover pipe #54 (540 feet MD) could not be advanced and the decision was made to trip out the washover pipe to determine if the washover pipe had broken. The driller pulled off only 32 joints of washover pipe before encountering the end of the drill string. The washover pipe had broken off at the box of joint #22, leaving 21 joints (210 feet) of washover pipe down hole with the top of the broken section approximately 310 feet MD down hole.

On November 15, 1992 at 2100 hours, drilling was halted until a fishing tool could be flown in to extract the broken pipe. The fishing tool (Fig. A-1) arrived on November 17, 1992 at 0700 hours. The fishing tool, designed as an overshot barrel, was attached to the end of the washover pipe. This device was then advanced over the broken section of washover pipe and rotated to grind off any anomalous metal from the end of the broken pipe. A sleeve within the fishing tool locks on to the broken section of pipe for extraction.

The drillers attempted to push the fishing tool down to the broken section of washover pipe; however, the hole was too tight to detect when the tool encountered the broken string. The drillers tripped out the fishing tool, went back into the hole with a nine-inch rotary bit to widen the borehole, and advanced it down to within two feet of the broken string. The rotary bit was tripped out and the fishing tool reinserted. On November 18, 1992 at 0430 hours, the fishing tool was successfully attached to the broken washover pipe; however, the drilling rig was unable to move or rotate the washover pipe. The decision was made to pull the two-inch drill string, with the Non-Magnetic Bottom Hole Assembly (BHA) resting approximately 80 feet past the end of the broken washover pipe. The BHA was retracted into the broken string until it reached the fishing tool but would move no further. The opening in the fishing tool was too small for the BHA to pass, so the BHA was advanced back down past the broken string. At 1500 hours on November 18, 1992 the decision was made to order a vibrating hammer and a spare BHA.

The vibrating hammer (Fig. A-2) arrived on site November 24, 1992 at 1040 hours. The crane provided by EMTC was not capable of lifting the hammer off the truck. A new crane was ordered and arrived at 1600 hours. The hammer was attached, and the rig began attempting to move the washover pipe. Utilizing both the pulling power of the drilling rig and the vibration of the hammer, the pipe began to move. The fishing tool appeared at the collar of the borehole, but no washover pipe was attached. Now that the fishing tool was out of the way, the BHA was extracted and the hole abandoned. The crew pulled all of the two-inch pilot string with the BHA out of the hole and moved to Hole #1 (AMH-7).

The total estimated drilling fluid lost to the formation during the first attempt at installing AMH-6 was 31,000 gallons. This volume was unacceptable, and attempts were made during the drilling of AMH-7 to minimize this loss.

A.1 Second Attempt at Drilling of AMH-6 and Subsequent Fishing Activities

Drilling began on AMH-6 on November 25, 1992 at 2100 hours. Pilot hole drilling proceeded to 511 feet MD and washover pipe to 350 feet MD before the washover pipe again broke downhole.

The washover pipe had broken between joints #6 and #7 downhole (270 feet MD) with the box of joint #6 still attached to the pin of joint #7. This relationship of the box breaking off on the pin of the previous pipe has been the same for each of the pipe failures for this project. The broken section of six washover pipes rested between 270 and 330 feet MD. The driller tripped out the BHA and replaced it with a two-inch dummy string to 510 feet. The washover pipe was then advanced down to the top of the broken section with a nine-inch drill bit to increase the diameter of the hole for installation of the fishing tool. Because the broken section of washover pipe was encountered a few feet shallower than expected, the driller felt that it may be loose and decided to use a hook instead of the fishing tool to retrieve the pipe. The two-inch dummy string was tripped out of the hole, and the hook (Fig. A-3) was attached to the end. The hook was then pushed back downhole and passed out the end of the broken string. To grab the broken section of pipe, the hook was pulled back slowly past the estimated point of the end of the broken washover pipe and by placing a hand on the two-inch pipe as it was retracted, contact with the broken section could be felt. If the hook was retracted beyond the estimated downhole end of the pipe, then it was advanced back down past the end of the pipe and rotated 90° and the process repeated.

Contact with the broken string was achieved, and the crew began pulling the pipe back. Every time a section of the two-inch retrieving pipe was removed from the rig, the driller would push the hook back down the hole approximately two feet and begin pulling slowly again until contact with the broken washover pipe was felt. This process continued until the hook reached 160 feet MD. During the attempt to pull joint #16 no contact could be felt with the broken string. The driller decided to continue pulling the hook, but there was no broken washover pipe attached when it reached the surface. The hook was advanced back down the hole, past the broken string and reattached to the end of the broken string. Extraction resumed and when the broken section emerged at the surface, the hook was attached to the outside of the broken string.

The crew proceeded to reinstall the pilot string with the BHA back down to 511 feet MD and the washover pipe to 330 feet MD. Drilling began again on the washover pipe and proceeded to 405 feet MD where the point of rejection was reached. It appeared that the washover pipe had again broken at some point in the curve.

The crew decided to trip out the two-inch pilot string and reinstall the two-inch string with the hook, using the washover pipe as a guide to the bottom. Once the hook was installed, the washover pipe was pulled to determine the location of the separation. The break occurred between washover joints #8 and #9 (325 feet MD) with the box of joint #8 still attached to the pin of joint #9. The eight joints left in the hole were between 325 and 405 feet MD. The drill

crew used the same technique described above for removal of the broken washover pipe. The broken string was removed without incident.

The driller tripped the two-inch pilot string with the BHA back into the hole to 511 feet MD and the washover pipe to 405 feet MD. The drillers decided to use lower rotational speed and pull down force to put less strain on the washover pipe. The rates agreed on by CEC and the SRTC representative were that pull down force not exceed 800 lbs and rotational speed not exceed 30 rpms. At this point, a major concern was the amount of strain that had previously been put on the washover pipe was a major concern for the rest of the drilling program.

Drilling of the washover pipe resumed with mud losses to the formation becoming significant. The drill crew completed pushing the washover pipe to 490 feet MD; however, fluid losses to the formation reached 1000 gallons per twenty feet drilled or approximately 1000 gallons every 40 minutes. Drilling efforts again shifted to the pilot string and progressed to joint # 61 (611 feet MD).

The drill crew attempted to move the washover pipe #63 (631 feet MD), but it was stuck. The rig continued to pull on the washover pipe until it moved suddenly. This indicated that the washover pipe had probably broken downhole. The break occurred between washover joints #42 and #41 (80 feet MD) with the box of joint #41 still attached to the pin of joint #42. The 40 joints left in the hole were between 80 and 480 feet MD. If the well could be drilled out to the end of the original project distance, then even if the washover casing was left in the hole there could be 270 feet of effective screen below the basin. SRTC personnel were informed of the massive fluid losses and the broken washover pipe. The decision was made by SRTC personnel to accept the well with 250 to 280 feet of effective screen below the basin if the washover casing could not be removed. Because of the massive fluid losses to the formation and the problems with the integrity of the washover pipe, a replacement well would be drilled only if all other attempts at salvaging the current borehole failed.

The drill crew tripped out the two-inch pilot string with the BHA and reinstalled the hook to pull on the downhole end of the broken string. They also reinstalled the fishing tool to attach to the upper end of the broken string. In retrospect, it was not a good idea to use both of these tools together. Once the fishing tool was attached to the upper end of the broken string, it became impossible to retract the hook back through the fishing tool. The drill crew began pulling on the two-inch hook in an attempt to move the pipe; however, the hook broke off downhole from the two-inch string. The two-inch string was extracted to determine where the break occurred. All of the sections of two-inch pipe emerged from the borehole with the exception of the four-inch long hook. The driller felt a two-inch pipe with a plug on the end could be pushed downhole and the broken hook either pushed to the end of the hole or laterally into the borehole wall. The crew tripped a dummy two-inch string back down the borehole, past the end of the broken washover pipe, to act as a guide. The drill crew prepared to hook up the vibrating hammer to the four-inch washover pipe.

The hammer was engaged, and the coupling on the washover pipe directly below the hammer began to separate. The drill crew cut in half a two-foot long section of four-inch steel washover pipe and welded it over the coupling to stabilize the link. The vibrator was again engaged, but the plate attaching the hammer to the four-inch washover pipe broke. The drill

crew decided to stop work for the night and ordered a D-8 bulldozer for the morning to provide added pulling capabilities.

The D-8 bulldozer arrived on site at 1000 hours the next morning. The drill crew hooked the winch of the bulldozer up to the four-inch washover pipe and began to pull. The pipe began to move until ten feet of washover pipe was exposed. The section of pipe was removed, and the string reattached to the drilling rig. The rig could not advance the string, even with the assistance of the bulldozer. The hammer was reattached and engaged, but the washover pipe broke apart four joints below the surface. Because the fishing tool was still downhole, the drill crew had to stop work for the day and order another fishing tool. Work was stopped on December 1, 1992 at 1600 hours.

The new fishing tool arrived late in the afternoon of December 2, so work resumed at 0700 hours of December 3. The fishing tool reached the broken washover pipe at 46 feet MD. Pulling was initiated at 1000 hours utilizing both the drilling rig and the bulldozer together. The pipe failed to move after three hours of continuous pulling. A second D-8 bulldozer was ordered and arrived at 1420 hours. The drilling rig and the two bulldozers in tandem pulled on the pipe for one hour before the washover pipe broke. The crew retracted the washover pipe and recovered both fishing tools and 13 joints of washover pipe below the lower fishing tool. At this point 28 joints of washover pipe remained in the ground between 200 and 480 feet MD. The drill crew reinstalled the fishing tool, attached to the broken washover pipe, and began pulling and hammering with the drilling rig and the two bulldozers in tandem. The plate that attaches the washover pipe to the hammer broke, and a new plate was fabricated. The new plate was attached and pulling resumed, but the pipe broke again. This time the box of the fishing tool broke off on the pin of the washover pipe, leaving no surface for attaching another fishing tool.

The drill crew attached a spear to the washover pipe and advanced it down into the broken fishing tool. Several attempts were made at pulling the broken string out of the borehole with the spear, but the drilling rig could never advance the spear far enough into the fishing tool to get a solid link. The drillers decided to try to disengage the fishing tool from the broken string by rotating the spear counterclockwise and pulling with light force. This effort was successful, and the fishing tool was removed from the borehole.

The drill crew reattached the BHA and began pushing the pilot string back down the borehole. Upon reaching the top of the broken section of the washover pipe (approximately 200 feet MD), the BHA would not pass in to it. A splayed coupling was prepared from a section of washover pipe to fit over the broken end downhole. This provided a guide to allow the BHA to pass. The pilot string passed out of the broken washover pipe but encountered the remains of the hook. The driller was successful in pushing the hook laterally into the wall of the borehole. A major concern was the possibility of the hook washing out of the wall of the borehole and preventing the extraction of the BHA. The BHA was extracted, and the well was installed.

After well installation, the drill crew attempted to remove the extra washover pipe that had been installed from the surface down to the top of the broken section; however, the pipe would not move. Sand had apparently settled in around the splayed end of the washover pipe, preventing it from being extracted. Instead of risking damage to the installed well, the drill crew rotated

the washover pipe counterclockwise to unscrew as much of the pipe as possible. Only 6 sections of washover pipe were extracted, leaving 420 feet of washover casing down the hole from 60 to 480 feet MD.

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Oblique view of the fishing tool used as an overshot to attach on to the broken section of four-inch washover pipe.

Figure A-1. Fishing Tool for Extraction of Broken Washover Pipe

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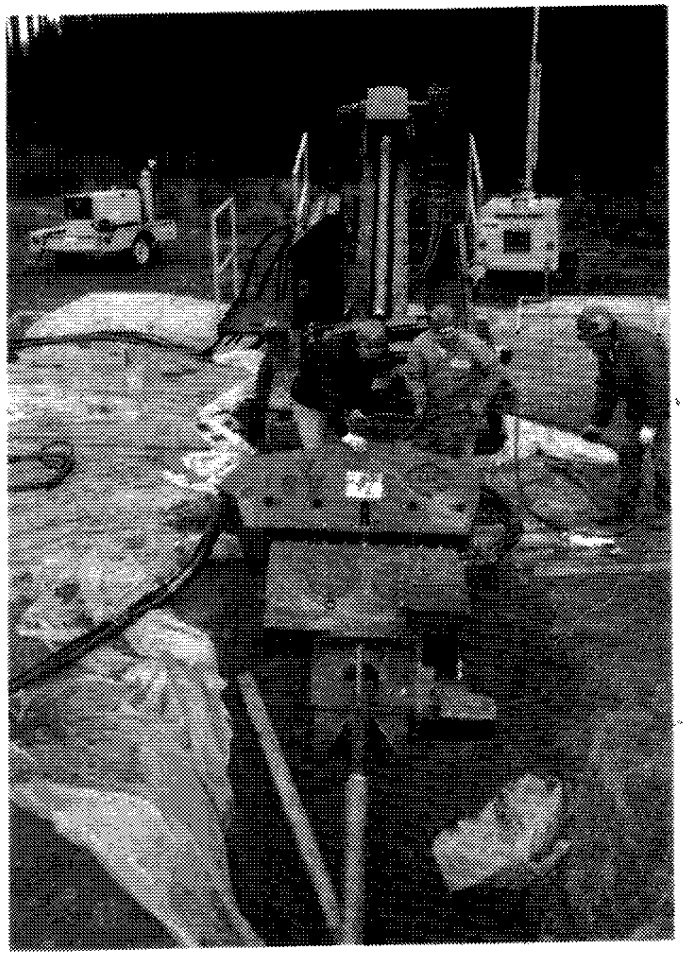

Vibrating hammer was attached to the washover pipe and vibrated with a pushing and pulling motion.

Figure A-2. Vibrating Hammer for Extraction of Broken Washover Pipe

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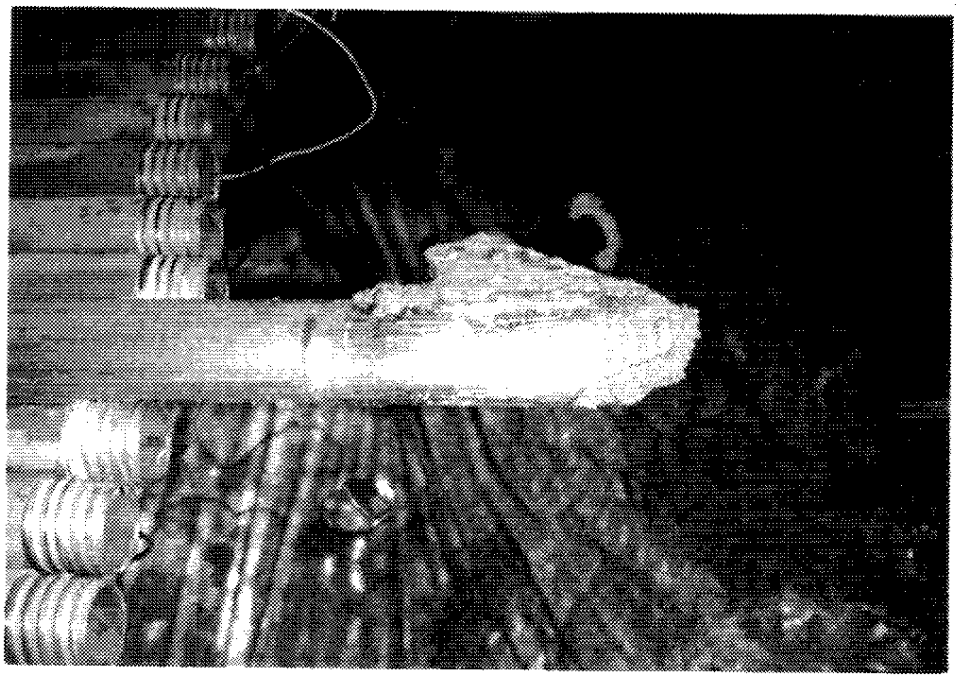

This hook was advanced down the inside of the four-inch washover pipe attached to the two-inch pilot string. The hook was passed out the end of the broken washover pipe and retracted until the hook latched on to the downhole end of the broken section of pipe.

Figure A-3. Two-Inch Diameter Hook for Extraction of Broken Washover Pipe

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APPENDIX B

DAILY ACTIVITY REPORTS

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OBR 30-2 (Rev 12-88)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6 — TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS / REID OLSON	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: MAREA SETTLING BASIN	DATE: 11/11/92 — PAGE: 1 OF 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
	0910	arrived on-site - Discussed target elevation with Ray
		Abercrombie.
1000	1030	Kick-off meeting
		Attendees:
		Westinghouse: Bechtel:
		Dawn Kaback } they arrived late — Ken Lombard
		Miles Denham } — Shirely Burdick
		CDM/FPC — Sharewell
		Dave Wilson — Tracy Moncour
		Dave Watkins — George Kowalczyk
		Reid Olson
		CEI Cherrington — Not present:
		Ray Abercrombie — Richard Mullens (Sharewell)
		Charles Reeves — Frank Cooper }
		Mike Jones — Gary Moore } EATL Drillers
		Rennie Commack
		Jerry Brantley
		Larry Gilbert
		Items discussed
		① Health & Safety
		- SRS HP will monitor site for radionuclides twice a day
		once in the morning & once in the afternoon
		- CDM will monitor VOC's - CDM will use 10ppm action
		level, WSRC will use 25ppm
		② Work schedule
		- 2 - 12 hour shifts
		- can work slower at night

TECHNICAL OVERSIGHT SIGNATURE David R. Watkins DATE 11/11/92

DSR 30-2 (Rev 12-88)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6 — TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS, REID OLSEN	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SETTLING BASIN	DATE: 11/11/92 — PAGE: 2 OF 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
		(3) Target zone is from 241'-246' MSL
	1110	The drill pipe is 2 3/4 OD Q wireline drill rod, 4130 heat treated. Over wash is 4½" OD heat treated flush thread
	1420	Ken Lombard showed CDM where to put the drilling spoils. The spoils will be place about 150' north of the northeast corner of M-area basin.
	1525	- EATC finally showed up with a backhoe to clear the site so EVI they can set up the drill rig.
	1531	Surveyed elevations of Well 1 - 350.19
	~~1620~~	Well 2 - 351.87
	1630	Dave Wilson left the site.

TECHNICAL OVERSIGHT SIGNATURE: Dave R. Watkins DATE: 11/11/92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombie/Mike Jones
WELL NUMBER: AMH-6 — TECHNICAL OVERSIGHT: Dave Wilson / David Watkins, Reid Olsen	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Settling Basin	DATE: 11/12/92 — PAGE: 1 of 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0730		Dave Wilson arrived on-site - weather is rainy + foggy.
0735		Well #2 will be drilled first.
		Entry Elev. 351.7' MSL
		Target Elev. 243.5' MSL
		Measured Depth (MD) to kick off point (KOP) - 190.5'
		MD to end of curve (EOC) - ~~[illegible]~~ 311.4'
		MD total = 311.4' + 500' = 811.4'
0810		D. Wilson left site to pick up J. Koelsch + D. Oakley of NAZWRAP at the visitors center
0900		returned to site with J. Koelsch + D. Oakley.
0930		Dave Wilson J. Koelsch + D. Oakley left site
1015		Dave Wilson returned to site - Drillers are still setting up equipment.
1108	1130	Dawn Kaback on site
1230	1310	Dave Wilson left site, upon return the drillers had left because Ken Lombard told them to. It had been raining + Ken L. was concerned about the site conditions deteriorating because of the rain and site activities.
1320		Dave Wilson left the site.

TECHNICAL OVERSIGHT SIGNATURE: David R. Watkins DATE: 11/12/92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Wilson/David Watkins, Reid Olsen
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Settling Basin	DATE: 11/13/92
	PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0700		Dave Wilson arrives on site - weather clear & cool, crew is setting up equipment
0911		Dan Oakley on site
1057	1150	Dan Oakley & Dave Wilson leave site.
1150		The drill crew is continuing to prepare the site for drilling
1252	1330	Drill crew breaks for lunch.
		The Day Shift will consist of: / Night Shift:
		EVI Cher. - Mike Jones / Ray Abercrombie
		Rennie Connell / Charles Reeves
		Larry Gilbert / Jerry Brantley
		Sharewell Tracy Moncrief / Richie Mullon
		EMTC Frank Cooper / Barry Moore
		CDM Fed. Reid Olsen / Dave Wilson
1410		The bottom hole assembly consists of:
		4' drill bit
		2 x 10' non magnetic drill collars
		0.6' pipe adapter
		24.6'
1500		HNu calibration - 11.7 eV lamp
		69 ppm @ 4.62 span
1503		Background HNu reading 0.4 ppm
1625		Tim Turner of CDM on site
1625		The bit ~~18'~~ is in the ~~ground~~ [above: upper] ground. The steering tool ~~[vice] 84' 25'~~ is at the ground surface, 4' of BHA (bit) is below the ground surface, 8' of BHA is between ground surface & vice on rig
1655		Reid Olson of CDM on site
1700		Dave Wilson leaves the site

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/13/92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6 — TECHNICAL OVERSIGHT: Dave Wilson / David Watkins, Reid Olson	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Settling Basin	DATE: 11/13/92 — PAGE: 2 of 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1725		The drill crew dug a slit trench to the mud pit to collect drilling fluid fracturing out at the surface ~25' in front of the drill rig.
1805		Tim Turner left site - drill having hard time penetrating at hard clay layer ~25' depth.
1845		Rickie Mullens + George Kowalczak on site
1920		HNu reading above mud pit. 0.4ppm
1955		Good mud returns up to drill rod 10 (115' MD).
2030		Day crew off-site, Night crew working on mud pump
2055		Drilling resumed
2155		Mud pump pressure 300 psi - minimum return pressure up to this time
2320		18 drill rods (including BHA) have been installed (183.8' MD). Washover pipe will now be installed.

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/13/92

SSR 30-2 (Rev 12-90)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight

DRILLING SUBCONTRACTOR: Cherrington Environmental

DRILLER: [illegible] Mercanne / Mike Jones

WELL NUMBER: AMH-6

TECHNICAL OVERSIGHT: Dave Wilson / [illegible] Reid Olsen

OVERSIGHT FIRM: CDM Federal

LOCATION: M-Area Settling Basin

DATE: 11/14/92

PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0005		Approximately 1-50lb bag of guar gum used in drilling
0155		HNu reading in mud tank 0.3ppm, above borehole - 0.3ppm
0200		1 more bag of guar gum used
0220		Mud pressure doesn't register on gauge. Some fluids lost to
		the formation at 140' MD with wash pipe.
0315	0345	Driller take lunch break.
0345		Drilling resumes, mud pressure about 300 psi. The driller
		is making the mud thicker to help stop fluid loss. The
		crew resumed drilling the pilot hole at 0345.
0426		Drill fluid is returning up hole through & around the wash
		pipe.
0500		Dave Wilson on site - Reid Olsen off site
0517		Drilling difficult on joints 21-22 ([illegible] 203-223' MD)
0615		HNu Readings
		- Background - 2.6 ppm
		- mud pit - 2.6 ppm
		- Drill rig - 2.6 ppm
0625		The drilling is hard (262'-272' MD)
0653		The day shift arrives on-site
0720		The night crew leaves the site.
0800		The drilling gets easy 292-297' MD.
0844		The drilling gets hard at 297'-302' MD. Drilling fluid has
		lost circulation.
0857		The hard layer encountered by the drill has deflected the
		drill up.
0946		The fluid loss has used up the mud, more mud is being mixed.
		The driller will try to drill the angle a little straighter.
1025		We have lost 1000 gal of fluid in the last 30 min.

TECHNICAL OVERSIGHT SIGNATURE [illegible] DATE 11/14/92

OBR 30-2 (Rev 12-88)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6; TECHNICAL OVERSIGHT: Dave Wilson / David Watkins / Reid Olsen	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Settling Basin	DATE: 11/14/92; PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1130		The driller successfully redrilled the curve at the correct angle. Drilling Fluids returned to the surface.
		Mike Denham on-site
1144		Drilling Fluid returns are very good on joint #33 (332')
1155		The wire was lost down the drill stem - They will now trip out to find it.
1240		The wire was found after tripping out 6 joints.
1311		Drilling new borehole has resumed.
1318		Drilling returns good
1325	1345	Miles Denham left site. Crew breaks for lunch
1348		Drilling resumes and is hard at 323-333' MD
1419		Drill cuttings consist of yellow + white clay with little or no sand while drilling 343-353' MD.
1430		HNu calibrated at 69 ppm at 5.0 span
1436		HNu reading
		- Background 0.6 ppm - mud tank 0.6 ppm
		- mud pit 0.6 ppm - desander 2.0 ppm
		- wash pipe 0.6 ppm - desander tank 2.0 ppm
1439		The drilling is hard on joint #31 (363' MD). Returns show yellow + white clay. Elevation of drill bit is ~~MSL~~ 245.5 MSL, which is in the middle of the target zone.
1510		Dave Wilson leaves site. Tim Turner, CDM Fed. on-site. Drilling wash over pipe begins
1653		HNu reading
		- background 1.2 ppm
		- mud pit 2.0 ppm
		- wash pipe 1.0 ppm
		- mud tank 1.0 ppm

TECHNICAL OVERSIGHT SIGNATURE: [signature] DATE: 11/14/92

OGR 30-3 (Rev 12-88)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Art Abercrombie / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Wilson / Ronald Watkins Reid Olsen
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Settling Basin	DATE: 11/14/92 PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1535		HNu readings
		- Background 1.2 ppm
		- mud pit 2.6 ppm
		- Breathing zone 2.6 ppm
		- mud tank 2.2 ppm
1851		Tim Turner leaves site, Reid Olsen on-site.
2005		HNu readings
		Background 2.6 ppm
		mud tank 0.6 ppm
		mud pipe 1.0 ppm
2025		Day shift off-site at R45 - Night shift on-site at 1900
2130		Dave Wilson on-site - Direction from Down to back in ~~to go~~ that
		the driller can go below 241' MSL. Dave Wilson says not
		to go below 238' MSL.
2145		Dave Wilson off-site.
2150		3000 gallons of water has been used to mix mud since
		~1900 hrs.
2347		Drilled joint #40 - elev. at 243.1 MSL

TECHNICAL OVERSIGHT SIGNATURE: David R. Watkins DATE: 11/14/92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT	DRILLING SUBCONTRACTOR
HORIZONTAL DRILLING TECHNICAL OVERSIGHT	CHARRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE/MIKE JONES

WELL NUMBER	TECHNICAL OVERSIGHT	OVERSIGHT FIRM
AMH-6	DAVE WILSON/DAVID WATKINS REID OLSON	CDM FEDERAL

LOCATION	DATE	PAGE
M-AREA SETTLING BASIN	11/15/92	7

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0010		HNu calibrated at 69 ppm at 5.0 gpm.
0016		HNu readings
		-Background 2.1 ppm
0030		-wash pipe 0.8 ppm
		-mud tank 0.4 ppm
0050	0125	Drillers take lunch break
0230		Drilling joint #46 w/mud pressure of 300 psi. While in the
		horizontal section it appears as though we are drilling through
		alternating hard + soft zone, returns are moderate. Bit elev.
		is 241.5' MSL
0250		HNu readings
		-Background -1.4 ppm
		-mud tank -1.0 ppm
		-wash pipe -1.0 ppm
0355		Drilling on joints 47-49 (462'-482' MD) has been hard.
		joint # 49 is drilling easier
0430		Joint # 51 (503-513) encountered a hard zone. Mud returns
		are good w/moderate solids content; some sand is being
		recovered.
0508		Good returns good moderate to high in solids. Reid Olson
		OFF-site. Dave Wilson on-site.
0715		Drilled in joint #57 - the drilling has been alternating
		hard + soft
0723		Started to advance workover pipe.
0858		Drilling wash pipe # 42, there weren't any mud returns
		since wash pipe #38
0910		The crew is mixing up a new batch of mud.
0847	1004	Crew stopped drilling to do minor repairs.

TECHNICAL OVERSIGHT SIGNATURE Dal R. Valk DATE 11/15/92

OSR 30-7 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal well drilling technical oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Mercomar / Mike Jones
WELL NUMBER: AMH-6 — TECHNICAL OVERSIGHT: Dave Wilson / David Watkins, Reid Olson	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Settling Basin	DATE: 11/15/92 — PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1056		- stopped advancing casing.
1126		- The lack of mud returns may be affecting the drilling
		- The wash pipe became "tight" on pipe #53, that is
		why they stopped advancing the pipe.
		- When they tried to turn the drill pipe they found that
		it was hard to turn.
		These two observations do not bode well for the drilling.
1133		Drilling the borehole resumed - there are good returns coming
		out of the wash pipe.
1138		Mud returns appear to be coming back through the annulus
		and the wash pipe. Rod #58 went in fairly quickly.
1148		The crew is going to pull wash pipe to loosen it up.
1203		The drill pipe appears to be moving with the wash pipe.
		They may be cuttings bound up between the wash pipe
		and drill pipe. The crew will try to clear the
		wash pipe of cuttings.
1220	1244	Crew took a lunch break
1255		Drilling pilot hole resumed on joint #59
1332		HNu readings
		Background 0.6 ppm wash pipe 1.0 ppm
		desander 0.6 ppm
		Mud tank 1.0 ppm
1411		Hooked on to wash pipe to turn it.
1750		Drilling 2" rod #69 will put wash ~~pipe~~ on pipe on - Dave Watkins
		relieved Dave Wilson at 1525
1800		Began installing wash pipe - #53 went downhole (past the vise
		on the rig).
1822		The night shift arrived

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/15/92

OSHA 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cleanwater Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Watkins / Mario Watkins / Reid Olsen
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Settling Basin	DATE: 11/15/92
	PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1622		Mixing mud.
1635		Started pulling work pipe because it was tight.
1706		Reid Olsen relieved Dave Watkins.
1807	2015	Pulled work pipe #49 to #22 and found that the remaining work over pipe remained in the borehole.
2045		Shut down operation
2050		Reid Olsen left the site.

TECHNICAL OVERSIGHT SIGNATURE: D A Watkins DATE: 11/15/92

OSR 30-3 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY HOERCHNER / MIKE JONES
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS, REID QUINN	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SETTLING BASIN	DATE: 11/16/92 PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0959	1530	The crew spent the down time cleaning up the site. Dave Wilson talked to Dawn Kaback and the following was discussed.
		① The wash over pipe broke 310' MD, 220' of casing was left in the borehole.
		② The crew is ordering a fishing tool.
		③ The crew will stay on 24hr work days.
		④ The fishing will begin on 11/17/92 at 0700 hrs.
		⑤ The well screen doesn't have to be 500' long (per Dawn Kaback) as long as it goes the length of the basin.

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/16/92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technology Oversight
DRILLING SUBCONTRACTOR: Cherokee Environmental
DRILLER: Ray Beauchamp / Mike Jones
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: Dave Wilkes / Reid Olson, David Watkins / Bill Bales
OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-Area Seepage Basin
DATE: 11/17/92
PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0730		Greg Powers arrives on site, Drillers working on fishing tool, 3½ IO w/ API Tapered threads
0745		Drillers start to modify ends to make crossover (air arrived @ 9:00pm on 11-16-92, Picked up @ 6:00 am on 11-17-92)
0800		HNU readings: Background @ trailer - 1.0 ppm, East side of rope barricade - 0.5ppm, @ drill collar - 0.25 ppm, @ mud hopper - 0.2 ppm
0830		Drillers continue to make crossover sub API / HW casing, SRS
		Workers staking areas around scrap oaks @ drill site
		Plan for fishing attempt: ① run in fishing tool over 2° pilot string until broken casing is reached, ② grind down irregularities with fishing tool, ③ tap into casing w/ fishing tool, ④ circulate mud through tool and broken casing to help loosen string
0900	0910	Dennis Coldea (EMTC) on site for short visit, Drillers assembling fishing tool
0915		Joint #1 attached to fishing tool, 44 washover joints on site, not including broken joints and the one just put on rig
0900	0930	Crew also working on dead battery for mud pump
1000		Started mud pump, need stronger battery, Jannelle Jansen and Sandy Rigsby on site (both USRC personnel, Jannelle is Geologist @ well house, Sandy is USRC Procurement contract officer) David Watkins on site
1015		USRC personnel leave site, Add joints #2 #3, Push casing, Add joint #4, Add joints #5 - #11, Drill Pressure 1000 lbs
1045		HNU readings: Background @ trailer - 1.0 ppm, @ mud pit - 2.0 ppm, @ drill - 1.0 ppm, @ drill collar - 2.0 ppm
1050		Add joints #12 - #14
1110		HNU readings: Background @ trailer - 1.0 ppm, @ mud pit - 1.0 ppm, @ drill collar - 1.0 ppm, Add joints # 15 & 16

TECHNICAL OVERSIGHT SIGNATURE: D. R. Watkins DATE: 11/17/92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight
DRILLING SUBCONTRACTOR: Cherrington Environmental
DRILLER: Ray Mackenzie / Mike Jones
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: Dale Watkins / Reid Olson, David Watkins / Greg Powers
OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin
DATE: 11/12/92
PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1120		DESANDER PUMP running HOT, STOP PUMP AND DRILLING TO ADD
		WATER TO TANK
1130		START DRILLING W/O DESANDER, ADD JOINT #17
1135		START DESANDER PUMP (PUMP VERY HOT, NOT LIKELY TO LAST) ADD #18
1145		ALL MWD READINGS NORMAL (1-2 BAR), DRILLING TIGHT, POOR RETURNS,
		ADD JOINT #19
1200	1220	STOP DRILLING FOR LUNCH
1220		WATER TRUCK ARRIVES (1000 GAL)
1300		WORK CONTINUES ON DESANDER PUMP
1325		DESANDER PUMP RUNNING AGAIN
1335		DAVID WATKINS ARRIVES ON SITE, GREG POWERS SIGNS OVER LOG BOOK
1340		ADDING JOINT #20, GREG POWERS OFF SITE
1345	1348	STOP DRILLING TO COOL DESANDER PUMP
1355		COMPLETE JOINT #20
1410		ADD JOINT #21, FLUID RETURN GOOD
1517		JOINT #22 COMPLETE ADDING #23, DRILLING TIGHT
1530		DRILLERS DECIDE TO STOP PUSHING FISH TOOL TO PULL ALL CASH
		OVER CASING, ADD AN 8" DIAMETER BIT (FISH TOOL IS 7¼" DIAMETER)
		TO INCREASE SIZE OF HOLE, BECAUSE HOLE IS TIGHT IT WOULD BE
		DIFFICULT TO PULL WHEN CONTACT W/ BROKEN STRING WAS MADE
1532	1602	PULLED JOINTS #23 - #17
1607		BELT THAT HOLDS MAKE UP VICE ON DRILL RIG HAS BROKEN, PROCEEDING
		TO BREAK JOINTS MANUALLY
1611	1656	PULLED JOINTS #16 - #1, COMPLETE FABRICATING 8" BIT
1710		WASH PIPE #1 RE-INSTALLED W/ 8" BIT
1711	1810	ADDED WASH PIPE JOINTS #2-#17
1812		MWD READING: 1.0 BAR @ DRILL COLLAR
1814	1906	ADDED JOINTS #18 - #26, REID OLSON ON SITE @ 1906

TECHNICAL OVERSIGHT SIGNATURE: Dale A. Watkins DATE: 11/12/92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight

DRILLING SUBCONTRACTOR: Cherrington Environmental

DRILLER: Ray [illegible] / Mike Jones

WELL NUMBER: AMH-6

TECHNICAL OVERSIGHT: Dave Wilson / Reid Olson, David Watkins / [illegible] Powers

OVERSIGHT FIRM: CDM Federal

LOCATION: M-Area Seepage Basin

DATE: 11/17/92

PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1907		David Watkins signs log book over to Reid Olson
1910	1928	Add wash joints # 27 - # 30
1930		Drillers take break, day shift offsite, borehole has been reamed out to 5" down to within 10' of break, will now trip out 5" bit and reinstall fish tool
2007	2219	Tripping out joints #30 - #12, HNU readings; calibrated @ 5 span - 69 ppm, @ trailer (background - 1.8 ppm), @ mud tank - 1.8 ppm @ desander - 1.8 ppm, primary mud mixing tank - 2.2 ppm, mud pit - 2.0 ppm, work area - 2.0 ppm, desander clogging due to increased mud viscosity
2225	2250	Break in drilling to clean desander pump, allow to cool
2250	2316	Trip joints #11 - #1
2320		Drillers prepare fish tool string
2337		Drillers take short break, washover pipe count, tiers 2+3 = 33

11/17/92

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/17/92

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DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT
DRILLING SUBCO: CHERRIN
DRILLER: LAY AGE
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: DAVE WILSON / REID OLSON, DAVID WATKINS / GREG POWERS
OVERSIGHT FIRM: CDM
LOCATION: M-AREA SEEPAGE BASIN
DATE: 11/18/

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0001	0112	RESUME TRIPPING IN FISH TOOL - JOINTS
		MUD RETURNS
0115		MIXING MORE MUD TO INCREASE VISCOSITY
0135		DRILLING @ END OF JOINT # 24 IS HARD, MU
0150		MUD PUMP CLOGGED, WORKING TO UNCLOG PU
0142	0315	DRILLING WASH RIGS # 25 - # 30
0332		FISHING TOOL HAS REACHED BROKEN CASING
		ATTACHING, PLAN TO CONTINUE ATTEMPTING
0400		BREAK OFF JOINT # 31 TO SEE IF 2" PILOT
		WILL NOT TURN, REATTACH JOINT # 31
0430		SEEM TO HAVE CONNECTED TO BROKEN SECTI
		BE WELL TO ROTATE, NOT GETTING CIRCU
0500		DAVE WILSON ON SITE, REID OLSON SIGN
0540		THE OVERWASH PIPE HAS NOT MOVED YET, CRE
		THEY WILL NOW BREAK OFF WASH PIPE TO PULL
		RECOMMEND THEY PULL THE 2" BACK TO THE
		IT FROM GETTING STUCK
0550		CREW PULLED ON 2" AND IT MOVED WITH A
		HOOKING UP SURVEY CABLE TO SEE IF PIPE
0559		STEERING TOOL IS STILL CONNECTED, PIPE
0604	0700	PULLING 2" RIGS, JOINTS # 60 - # 48
0705	0730	DAY CREW ON SITE, NIGHT CREW OFF SITE
0754		THE RIG IS NOW MOVED TO JOINT # 32 RH

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT | DRILLING SUBCO: CHERRIN
DRILLER: RAY ADA
WELL NUMBER: AMH-6 | TECHNICAL OVERSIGHT: DAVE WILSON/REID OLSON DAVID WATKINS/GREG POWERS | OVERSIGHT PER: CDM
LOCATION: M-AREA SEEPAGE BASIN | DATE: 11/18/

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0001	0112	RESUME TRIPPING IN FISH TOOL - JOINTS
		MUD RETURNS
0115		MIXING MORE MUD TO INCREASE VISCOSITY
0135		DRILLING @ END OF JOINT # 24 IS HARD, MU
0150		MUD PUMP CLOGGED, WORKING TO UNCLOG PU
0142	0315	DRILLING WASH PIPES # 25 - # 30
0312		FISHING TOOL HAS REACHED BROKEN CASING
		ATTACHING, PLAN TO CONTINUE ATTEMPTING
0400		BREAK OFF JOINT # 31 TO SEE IF 2" PILOT
		WILL NOT TURN, REATTACH JOINT # 31
0410		SEEM TO HAVE CONNECTED TO BROKEN SECTI
		OF WELL IN ROTATE, NOT GETTING CIRCU
0500		DAVE WILSON ON SITE, REID OLSON SIGN
0540		THE OVERWASH PIPE HAS NOT MOVED YET, CRE
		THEY WILL NOW BREAK OFF WASH PIPE TO PULL
		RECOMMEND THEY PULL THE 2" BACK TO THE
		IT FROM GETTING STUCK
0550		CREW PULLED ON 2" AND IT MOVED WITH A
		HOOKING UP SURVEY CABLE TO SEE IF PIPE
0559		STEERING TOOL IS STILL CONNECTED, PIPE
0604	0700	PULLING 2" PIPES, JOINTS # 60 - # 48
0705	0730	DAY CREW ON SITE, NIGHT CREW OFF S.T.
0754		THE RIG IS NOW HOOKED TO JOINT # 32. BH

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT
DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: DAVE WILSON / REID OLSON / DAVID WATKINS / GABE POWERS
OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN
DATE: 11/18/92
PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0001	0112	RESUME TRIPPING IN FISH TOOL - JOINTS # 4 - # 24, 6000
		MUD RETURNS
0115		MIXING MORE MUD TO INCREASE VISCOSITY, TRAILER LOCATION RIG SERVICE
0135		DRILLING @ END OF JOINT # 24 ; HARD, MUD PUMP IS SLOW
0150		MUD PUMP CLOGGED, WORKING TO UNCLOG PUMP
0142	0315	DRILLING WASH PIPES # 25 - # 30
0332		FISHING TOOL HAS REACHED BROKEN CASING, UNSUCCESSFUL IN
		ATTACHING, PLAN TO CONTINUE ATTEMPTING CONNECTION.
0400		BREAK OFF JOINT # 31 TO SEE IF 2" PILOT WILL TURN W/ PIPE WRENCH,
		WILL NOT TURN, REATTACH JOINT # 31
0430		SEEM TO HAVE CONNECTED TO BROKEN SECTION, CANNOT PULL OUT
		OF WELL OR ROTATE, NOT GETTING CIRCULATION BACK
0500		DAVE WILSON ON SITE, REID OLSON SIGNS OVER LOG BOOK
0540		THE OVERWASH PIPE HAS NOT MOVED YET, CREW TAKING SHORT BREAK,
		THEY WILL NOW BREAK OFF WASH PIPE TO PULL ON 2" STEM. I
		RECOMMEND THEY PULL THE 2" BACK TO THE WASHPIPE TO PREVENT
		IT FROM GETTING STUCK
0550		CREW PULLED ON 2" AND IT MOVED WITH A JERK, THEY ARE
		HOOKING UP SURVEY CABLE TO SEE IF PIPE IS STILL INTACT
0559		STEERING TOOL IS STILL CONNECTED, PIPE (2") IS NOT BROKEN
0604	0700	PULLING 2" PIPES, JOINTS # 60 - # 48
0705	0730	DAY CREW ON SITE, NIGHT CREW OFF SITE, CONTINUE PULLING 2"
0754		THE RIG IS NOW HOOKED TO JOINT # 32, BHA IS NOT COMING OUT
		OF THE OVERWASH
0826		IT IS DETERMINED THAT THE BHA WILL NOT PASS THROUGH FISH TOOL
0930		MIKE JONES CONTACTED RAY ABERCROMBIE AND HAVE DECIDED TO TRIP
		DRILL STEM BACK IN PAST WASHOVER PIPE AND PUMP MUD TO LOOSEN WASHOVER,
		I CONTACTED DAVE KABACH AND EXPLAINED SITUATION

TECHNICAL OVERSIGHT SIGNATURE: David B. Watkins DATE: 11/18/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT

DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL

DRILLER: RAY [illegible] / MIKE JONES

WELL NUMBER: AMH-6

TECHNICAL OVERSIGHT: DAVE WILSON / REID OLSON, DAVID WATKINS / GREG POWERS

OVERSIGHT FIRM: CDM FEDERAL

LOCATION: M-AREA SEEPAGE BASIN

DATE: 11/17/92

PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1907		DAVID WATKINS SIGNS LOG BOOK OVER TO REID OLSON
1910	1928	ADD WASH JOINTS # 27 - # 30
1930		DRILLERS TAKE BREAK, DAY SHIFT OFFSITE, BOREHOLE HAS BEEN REAMED OUT TO 8" DOWN TO WITHIN 10' OF BREAK, WILL NOW TRIP OUT 8" BIT AND REINSTALL FISH TOOL
2007	2219	TRIPPING OUT JOINTS #30 - #12, HNU READINGS; CALIBRATED @ 5 SPAN - 69 PPM, @ TRAILER (BACKGROUND - 1.8 PPM), @ MUD TANK - 1.8 PPM, @ DESANDER - 1.8 PPM, PRIMARY MUD MIXING TANK - 2.2 PPM, MUD PIT - 2.0 PPM, WORK AREA - 2.0 PPM, DESANDER CLOGGING DUE TO INCREASED MUD VISCOSITY
2225	2250	BREAK IN DRILLING TO CLEAN DESANDER PUMP, ALLOW TO COOL
2250	2316	TRIP JOINTS #11 - #1
2320		DRILLERS PREPARE FISH TOOL STRING
2337		DRILLERS TAKE SHORT BREAK, WASH OVER PIPE COUNT, TIERS 2+3 = 33

11/17/92

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/17/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHARRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERNATHY / MIKE TOWES
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: DAVE WILSON / GREG POWERS / DAVID WATKINS
	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/18/92 PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1030		INVENTORY: WASHOVER - 59 on GROUND, 31 on FISH, 22 STUCK
		2" DRILL STEM - 29 on GROUND, 51 CANNOT BE USED on ONE on RACK
1051		DAVE WILSON LEFT SITE FOR SRTC OFFICE
1115		ARRIVED @ SRTC OFFICE TO LOOK @ GEOLOGIC X-SECTS, IN MSB-3B: CLAYEY SAND 245-260, CLAY STRINGERS 251-254 & 268-266, NO RECOVERY 247-245, SAND < 245', WATER @ 227.5'
1230		LEFT SRTC OFFICE
1240		ARRIVE ON SITE, INSTALLING 2" PIPE #52
1250	1338	DINNER BREAK
1339		CREW HAS HOOKED UP TO WASHPIPE AND IS PULLING ON IT
		MUD PRESSURE 200 lbs
1345		OUT OF MUD
1359		THEY HAVE HOOKED THE BACKHOE UP TO THE WASHPIPE WITH A CHAIN AND USING TO PULL ALSO
1445		GREG POWERS ON SITE
1510		PLAN IS TO: ① CIRCULATE MUD AND PULL, ② ORDER A HAMMER, ③ IF HAMMER WILL TAKE ALONG TIME TO ARRIVE, DRILLERS WILL MOVE AND SET UP ON HOLE #1, ④ ORDERING ANOTHER BHA AND MORE 2" DRILL PIPE
1516		DAVE WILSON SIGNS LOG BOOK OVER TO GREG POWERS
1520		WATER TRUCK ARRIVES, NO ACTIVITY EXCEPT MUD MIXING
1600		SHUT DOWN EQUIPMENT TO CHECK OIL + FLUIDS
1615	1630	MILES PENHAM ON SITE FOR SHORT VISIT, GREG POWERS BRIEFS ON RECENT DRILLING EVENTS
1636		START EQUIPMENT AND BEGIN PULLING ON WASHOVER PIPE
1650		WATER TRUCK LEAVES TO FILL UP
1730		NO ACTIVITY @ DRILL SITE EXCEPT FOR MINOR MAINTENANCE, LIGHTS ON, WATER TRUCK NOT BACK YET

TECHNICAL OVERSIGHT SIGNATURE: Dale A. Wilson DATE: 11/18/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHEARINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: REID OLSON / GREG POWERS
	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/18/92 — PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1735		WATER TRUCK ARRIVES ON SITE
1745		BEN VOLK (WESTINGHOUSE HANFORD) ON SITE TO OBSERVE DRILLING
1840		NIGHT SHIFT ON SITE
1850		REID OLSON ON SITE, GREG POWERS SIGNS OVER LOG BOOK
1900		DRILLERS PUMPING MUD AND PULLING IN ATTEMPT TO FREE OVERWASH
1910		PARTIAL MUD RETURNS, MUD PRESSURE MINIMAL, NOT REGISTERING
2100		BEN VOLK OFF SITE, BEN MAY BE INTERESTED IN CDM FEDERAL
		DOING HORIZONTAL DRILLING OVERSIGHT WORK @ HANFORD.
		DRILLERS HAVE BEEN REPAIRING HYDRAULIC HOSE LEAKS, ETC..
2215		SHAREWELL NIGHT SHIFT OFF SITE, DRILLERS STILL WORKING ON
		REPAIRING HYDRAULIC HOSES IN THE CONTROL BOX ON RIG,
		ONCE COMPLETED DRILLERS WILL CIRCULATE MORE MUD DOWN HOLE
2240		DRILLERS WORKING ON THE MUD PRESSURE CONTROL, IT APPEARS
		THAT THE PRESSURE CONTROL WILL NOT ALLOW MAXIMUM PRESSURE TO
		BE DELIVERED. IT IS SOMEHOW BEING REGULATED
2250		REGULATOR OR CONTROL DEVICE REMOVED BECAUSE IT WAS
		LEAKING AND WAS BYPASSED, HOWEVER, THIS DID NOT SOLVE PROBLEM
2310		DRILLERS REINSTALLING PRESSURE REGULATOR AFTER GOING
		THROUGH IT
2358		PRESSURE REGULATOR PROBLEM SOLVED

11/18/92

TECHNICAL OVERSIGHT SIGNATURE Del A. Lobb DATE 11/18/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6 — TECHNICAL OVERSIGHT: DAVE WILSON / REID OLSON / DAVID WATKINS / GREG POWERS	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/19/92 — PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0100		BEGIN CIRCULATING MUD
0105		GETTING GOOD CIRCULATION, STOP FOR THE NIGHT
0110		REID OLSON OFFSITE, DRILLERS OFFSITE
0820		DAVE WILSON ARRIVES ON SITE, NO DRILL CREW, TOLD
		FRANK C. TO HAVE CREW CALL D. WILSON @ CDM FEDERAL
		OFFICE AND TELL ME IF HAMMER WILL BE IN TODAY
0828		LEFT SITE TO FIND CREW
0930		ARRIVED ON SITE, NO CREW ON SITE
0936		CREW ARRIVES ON SITE - HAMMER WILL ARRIVE IN A.M.
		TOMORROW 11/20/92 W/ NEW BHA
0943		DAVE WILSON OFFSITE

[signature] 11/19/92

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/19/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ASKEW/MIKE JONES
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: DAVE WILSON/DAVID WATKINS
	OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/20/92 PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0820		DAVE WILSON ARRIVES ON SITE, TALKED TO DAWN KAMACK AND
		SHE SAID THAT SRTC WILL SUPPLY EQUIPMENT ON EMERGENCY BASIS
		ONLY, JUST TO SAVE TIME, BEN VOLK ON SITE
0855	0902	HP ON SITE FOR SHORT VISIT, THEN OFF SITE
1015		DAY CREW HAS SET UP DRILL RIG ON THE RELIEF HOLE, THIS HOLE
		WILL BE DRILLED ALONG THE TOP OF THE CASING TO THE POINT WHERE
		THE WASHPIPE IS STUCK. CREW WILL THEN JET AROUND PIPE TO FREE IT.
		SPARTANBURG CREW HAS ORDERED A SECOND BHA FOR THE RELIEF HOLE
		AND IT WILL BE ON SITE TOMORROW MORNING 11/21/92. THE SHIPMENT
		DELAY WAS DUE TO THE CONSTRUCTION TIME OF THE BARRELS.
		HAMMER HAS ARRIVED THIS MORNING. AT THIS POINT IT IS UNCLEAR
		IF HAMMER WILL BE UTILIZED BEFORE THE RELIEF HOLE IS COMPLETE.
1040		HAMMER HAS ARRIVED ON SITE
1125		PUMPED 500 GAL OF MUD W/ "FISH EYES" DOWN THE HOLE
		TO PLUG THE FORMATION
1130		CRANE ARRIVES TO UNLOAD THE HAMMER
1132		BEGINNING TO RAIN INTERMITTENTLY
1148		PLAN IS TO: (1) PUMP SOME THICK MUD DOWN THE BOREHOLE
		ANNULUS (COMPLETED), (2) RIG UP THE VIBRATING HAMMER TO THE
		4" WASH PIPE AND TRY TO LOOSEN IT, (3) IF THE HAMMER DOES NOT
		WORK THEN CREW WILL DRILL THE RELIEF HOLE TOMORROW WITH
		2" STEM AND WILL FOLLOW THE BOREHOLE BETWEEN THE 4" WASH
		PIPE AND THE ANNULUS (4) ONCE THE RELIEF HOLE IS DRILLED
		THE HAMMER WILL BE TRIED AGAIN (5) IF ALL OF THE ABOVE
		FAIL THEN THE BHA MAY BE RECOVERED BY DRILLING
		OUT THE OTHER SIDE OF THE BASIN
1210	1245	LUNCH BREAK
1325		CREW PREPARING TO PUT HAMMER ON R.G

TECHNICAL OVERSIGHT SIGNATURE: D. A. Watkins DATE: 11/21/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCRUMBE / MIKE JONES
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/20/92 / PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1350	1353	HP ON SITE, NOTHING NEW TO MONITOR
1412		THE CRANE IS NOT CAPABLE OF LIFTING THE HAMMER SO
		THEY WILL NEED TO GET ANOTHER CRANE
1445		KEN LOMBARD ON SITE
1505	1535	JANELLE JANSEN + DAN WELLS (WSRC WELL HOUSE FOR BITH)
		SHORT VISIT TO SITE
1549		STILL WAITING FOR THE NEW CRANE - CREW POLICING SITE
1615		THE NEW CRANE HAS ARRIVED ON SITE, KEN LOMBARD OFF SITE
1634		THE VIBRATOR IS OPERATING
1649		THE WASH PIPE MOVED UP HOLE
1655		CREW HOOKING UP THE WASH PIPE TO START PULLING
1700		ATTEMPTING TO PULL THE PIPE
1709		THE WASH PIPE HAS NOT MOVED UP HOLE UNDER RIG POWER
1716		CREW TAYING THE VIBRATOR AGAIN
1734		CREW PULLED ~ 2' OF PIPE UPHOLE WITH VIBRATOR ATTACHED
1737	1740	PULLED 4' OF WASH PIPE
1802	1812	PULLED OFF 2 JOINTS
1815		DAVE WILSON SIGNS LOG BOOK OVER TO DAVID WATKINS
1817	1830	PULLED JOINTS #29 - #26
1835		ATTEMPTING TO MOVE WASHPIPE JOINT #25 BUT CASING IS
		STUCK, ROCKING DRILL AND PULLING, PIPE MOVING A FEW INCHES
1842		BOLTS IN FLANGE HOLDING OVERWASH PIPE TO DRILL HEAD ARE
		PULLING LOOSE, ALLOWING MUD TO SPRAY OUT, DRILLERS STOP
		PULLING WASHPIPE TO TIGHTEN BOLTS
1852		DRILL STRING BEGINS TO MOVE
1857	2003	PULLED WASHPIPE JOINTS #25 - #3
2005		PULLED JOINT #2, FISH BARREL APPEARS @ DRILL COLLAR IN SUMP,
		NO PIPE ATTACHED TO FISH

TECHNICAL OVERSIGHT SIGNATURE: David R. Watkins DATE: 11/20/92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight
DRILLING SUBCONTRACTOR: Cherrington Environmental
DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: Dave Wilson / Mario Watkins
OVERSIGHT FIRM: COM Federal
LOCATION: M-Area Seepage Basin
DATE: 11/20/92
PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
2010		Drillers will now attempt to pull 2" pilot string and move to another spot to begin drilling a new replacement hole
2016	2211	Pulled 2" rods #50-#1
2225		Begin mobilizing rig to new hole
2315		Decided to move drill rig to hole #1, hole will be set 25' back to the south from the surveyed point to increase the radius of curvature, decided not to drill the replacement well for #2 at this time because of the possible influence of grout from the old hole, grout will be installed on Sat. 11/21/92. Replacement hole for #2 will also be set back 25' south and also 20' east of original hole. Hole #1 cannot be moved 20' east, to keep separation between wells the same, because it would appear to project directly into well cluster at seepage basin
2340		Drillers have set up rig for hole #1

11/20/92

TECHNICAL OVERSIGHT SIGNATURE Dal R. Lutts DATE 11/20/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNOLOGY DEMONSTRATION
DRILLING SUBCONTRACTOR: CHEROKEE ENVIRONMENTAL
DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-7
TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN
DATE: 11/21/92
PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0035	0115	CREW BREAKS FOR DINNER
0115		CREW DIGGING SUMP FOR DRILL COLLAR
0135		MOBILIZATION CONTINUES, MOVING DRILL STEEL
0315	0325	DRILLERS ON COFFEE BREAK
0325		CREW MOVING LIGHT PLANTS
0440		DRILL RIGGED UP AND READY TO DRILL, FUELING UP
		ALL VEHICLES
0455		DRILLERS SHUTING DOWN FOR NIGHT, DAVID WATKINS OFF SITE
0650		DAVE WILSON ARRIVES ON SITE, ATTEMPT ON WELL #2 HAS
		BEEN ABANDONED, THE BOREHOLE WILL BE GROUTED TODAY, ALL
		INFORMATION REGARDING THE FIRST ATTEMPT ON WELL #2
		AND THE SET UP ON WELL # 1 IS RECORDED IN LOGBOOK 10-1
0707		IT HAS STARTED RAINING, TRACEY M. ON SITE, 108 PIECES OF 2" PIPE ON SITE
0734		ALL DAY CREW ON SITE PLUS RITCHIE M. THE FOLLOWING ACTIVITIES
		WILL BE COMPLETED PRIOR TO DRILLING: ① DRILL RODS WILL
		BE NUMBERED, ② ROPE ANNULUS BACKED ③ DRAW NEW BOREPATH
0747		WELL # 1 INFORMATION:
		ELEVATION OF ENTRY - 358.5 - 8.0 = 350.5
		ENTRY ANGLE - 25°
		TARGET DEPTH - 118.5'
		TARGET ELEV. - 240.0'
		RADIUS OF CURVATURE - 400'
		LENGTH OF CURVE = 0.01745 * RADIUS * ANGLE
		FT/° OF ANGLE = 0.01745 * RADIUS
0857		DRILLERS BEGIN DRILLING, PUSH JOINTS #2 - #4, HOOKING ON #4,
0956		CREW STOPS DRILLING TO SET ANCHORS FOR THE RIG, THE ANCHORS
		WILL BE 2 - 4' WASH PIPES DRIVEN VERTICALLY INTO THE GROUND IN FRONT
		OF RIG, THEN WELD THEN TO THE RIG

TECHNICAL OVERSIGHT SIGNATURE Dale R. Lacy DATE 11/21/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL [illegible] OVERSIGHT	DRILLING SUBCONTRACTOR: [illegible]
	DRILLER: LEE ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-7	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
	OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/21/92
	PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1040		DRILLING RESUMES ON PILOT JOINT #4, COMPLETE
		JOINTS #4 & #5
1115		CREW INSTALLING 3 SECTIONS OF WASH PIPE TO CONTROL MUD
1152		CREW TAKING A BREAK. THE RUN IS STEADY AND HAS BEEN
		MOST OF THE MORNING. THE SITE IS GETTING SLOPPY
1225		DRILLING RESUMED ON JOINT #6. I ASKED MIKE JONES IF
		RAY ABERCROMBIE HAD DISCUSSED WAYS TO MINIMIZE FLUID
		LOSSES. IT WAS APPARENT THAT HE HADN'T. SHOULD
		REACH AREA OF LOSSES WHEN R. ABERCROMBIE IS ON SHIFT TOMORROW.
1231		THE AMOUNT OF FLUID LOSS EXPERIENCED ON WELL #2 WAS
		UNACCEPTABLE. I WILL CHECK THE CONTRACT TO SEE IF
		I CAN STOP DRILLING (WITHOUT A PENALTY) IF THEY BEGIN
		EXPERIENCING SIMILAR FLUID LOSS.
1247	1310	CREW BREAKING FOR LUNCH, CONTRACT DOES NOT SPECIFICALLY
		ADDRESS CONTINGENCIES FOR MAJOR FLUID LOSSES
1310		DRILLING RESUMES, THEY ARE GOING TO REAM JOINT #10
1410		THERE HAVE BEEN GOOD RETURNS UP TO JOINT #9
1457		THE STEERING TOOL WIRE BROKE DOWNHOLE, THEY WILL NEED TO WASH
		OVER THE DRILL STRING AND TRIP OUT THE 2" DRILL STEM. THE
		WIRE BROKE AT THE BHA. THEY WILL RUN SIX WASH PIPES DOWN HOLE
1510		RETURNS HAVE BEEN GOOD UP TO DRILL JOINT #11.
1510	1540	CREW ON BREAK
1620		THEY HAVE STOPPED OVERWASHING AND WILL NOW TRIP OUT DRILL STEM.
1700		THE BHA IS AT THE SURFACE
1723		TRACY AND MIKE REWIRED THE STEERING TOOL. THEY HAD
		TO TAKE THE TOOL OUT OF THE MONEL TO REATTACH WIRE
1752		DAVE WILSON SIGNS LOG BOOK OVER TO DAVID WATKINS.
		FLUID LOSS WILL MOST LIKELY OCCUR AT JOINT #4 AND ± JOINTS # 30-33

TECHNICAL OVERSIGHT SIGNATURE D O R Watkins DATE 11/21/92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ARGENBRIGHT / MIKE JONES
WELL NUMBER: AMH-7	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/21/92
	PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1835		2" DRILL STEEL HAS BEEN REINSTALLED AND READY FOR
		CONTINUED DRILLING (10 RODS ON R.G)
1837		SECOND SHIFT ON SITE
1855		DRILLING ON HOLE # 1 RESUMES
2022		GETTING 6000 RETURNS ON 2" DRILL ROD #16, RETURN
		HAS BEEN 6000 AROUND ANNULUS ON ALL RODS TO THIS POINT
2046		DRILLING ON JOINT #17, BEGINNING CURVE
2100	2108	DRILLERS TAKING SHORT COFFEE BREAK
2110		AN INSPECTION OF THE PLOTTED DRILL TRACING REVIEWS
		THE HOLE IS ON TARGET THROUGH 2" JOINT #18
2241		DRILLING JOINT #24, RETURNS ARE 6000 AND HAVE BEEN
		SINCE BEGINNING OF SHIFT
2310	2315	RAINING HARD NOW, DRILLERS BREAKING FOR COFFEE
2315		DRILLERS BACK ON R.G, STILL GETTING 6000 RETURNS ON JOINT #25

David R. Watkins 11/21/92

TECHNICAL OVERSIGHT SIGNATURE David R. Watkins DATE 11/21/92

OSR 30-3 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHARRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-7	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/22/92 PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0026		INSTALLED JOINT #27, BUT LOST SIGNAL FROM DOWN HOLE
		DIRECTIONAL TOOL, DRILLERS CHECKING CONNECTIONS
0040		DRILLER ATTEMPTING TO BY-PASS WIRING SYSTEM AND CONNECT
		DIRECTLY TO WIRES COMING OUT OF DRILL PIPE TO SEE IF THE
		PROBLEM IS DOWNHOLE OR BETWEEN THE RIG AND THE TRAILER,
		DETERMINED THAT THE PROBLEM WAS IN THE CONNECTION
		OF THE WIRE IN THE LAST PIPE INSTALLED (JOINT #27)
0045	0115	DRILLERS BREAK FOR DINNER
0115		DRILLERS RETURN FROM DINNER, BEGIN TO PUMP MUD BACK
		DOWN HOLE, MUD HOSE FITTING ON DRILL HEAD IS LEAKING
0130		LEAK IN COUPLING HAS BEEN FIXED, DRILLING RESUMES ON JOINT #27
0217		WATER TRUCK LEAVES TO FILL UP, 1ST TIME SINCE SPUD IN
0221		BEGINNING TO RAIN VERY HARD
0310		RAIN SUBSIDING
0315	0320	DRILLERS ON COFFEE BREAK, CONTINUE DRILLING ON JOINT #32
0445		STOP DRILLING PILOT STRING AT 351' (JOINT #35) TO BEGIN
		PUSHING MORE WASHOVER PIPE, 351' IS JUST PAST END OF CURVE
0520		DRILLING STOPS TO UNCLOG PUMP THAT PUSHES MUD FROM
		THE DRILL PIT TO THE DESANDER, DISASSEMBLING PUMP
0526		DRILLERS HAVE UNCLOGGED PUMP, REASSEMBLING, PUSHING WASHOVER PIPE
0540		HAVE RETURNS @ MUD PIT = 1,000 gpm
0547		HAVE BEEN GETTING GOOD RETURNS ON DRILL MUD DURING
		PUSHING OF WASHOVER PIPE
0550		DAVE WILSON ON SITE
0555		DAVID WATKINS SIGNS LOG BOOK OVER TO DAVE WILSON
0611		MUD RETURNS ARE GOOD ON WASHPIPE #18
0643		TRACY M. ON SITE
0656		TRACY M. MEASURES DISTANCE TO BASIN AS 410'+10' = 420'

TECHNICAL OVERSIGHT SIGNATURE: Dale R. Wilson DATE: 11/22/92

DSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHARRINGTON ENVIRONMENTAL
	DRILLER: RAY ARRACHMAE / MIKE JONES
WELL NUMBER: AMH-7	TECHNICAL OVERSIGHT: DAVE WILSON
	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/22/92
	PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0701		DAY CREW ON SITE
0713		NIGHT CREW OFF SITE - DRILLING RESUMES. I TALKED
		TO RAY ARRACHMAE BEFORE HE LEFT THE SITE AND ASKED
		HIM ABOUT THE DRILLING FLUID LOSS MITIGATION PLAN.
		THE PLAN IS TO THICKEN THE MUD WITH GUAR GUM UNTIL
		"FISH EYES" APPEAR, THEN CONTINUE DRILLING
0732		THE DRILLERS ARE PURPOSELY DRILLING THE WASHPIPE SLOWLY
		TO ENSURE THAT THE ANNULUS BETWEEN THE WASHPIPE
		AND THE FORMATION REMAINS CLEAR OF EXCESSIVE
		CUTTINGS - THIS IS A GOOD IDEA
0801		GOOD RETURNS ON WASHPIPE UP TO JOINT # 26
0809		ANU CALIBRATED @ 6900ppm - 4.45 SPAN
0815		HNU READINGS: BACKGROUND - 0.4ppm, MUD PIT - 0.2ppm,
		MUD TANK - 0.4ppm
0828		GOOD MUD RETURNS ON WASHPIPE UP TO JOINT # 29
0845		COMPLETED DRILLING WASHPIPE #30, SETTING UP FOR 2" PILOT DRILLING
		48 PIPES ON RACK - 47 ON RACK WITH 1 ON R'G ABOVE VICE
0901		THERE IS A DISCREPANCY IN THE ROD COUNT. WE HAVE ONE TOO
		MANY ON THE RACK. IF WE ARE OFF BY ONE JOINT OR 10'
		THEN THE DEPTH MAY BE INCORRECT. WE WILL KNOW WHEN WE
		INSTALL THE WELL - RETURNS REMAIN GOOD UP TO WASHPIPE # 30
0917		DRILLING IS HARD ON DRILL STEM # 36, GOOD RETURNS FROM
		BOTH THE ANNULUS AND THE WASHPIPE
0931		MUD PRESSURE IS 750 PSI
0932		THE DRILL PIPE COUNT ~~HAS~~ NOW HAS BEEN RESOLVED. IT APPEARS
		AS THOUGH THE (EPC) NIGHT SHIFT DROPPED A ROD IN THE
		ROD COUNT
0939		MUD PRESSURE IS @ MAXIMUM, ARE'S ARE TO PULL WITH ANY MORE POWER

TECHNICAL OVERSIGHT SIGNATURE: Dale A. Wilson DATE: 11/22/92

DSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight
DRILLING SUBCONTRACTOR: Cherrington Environmental
DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-7
TECHNICAL OVERSIGHT: Dave Wilson / David Watkins
OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-AREA Seepage Basin
DATE: 11/22/92
PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1010		Drilling is real slow. The drillers helpers are lounging (except for Fred). If I were Mike J. I would have them cleaning up the site.
1105		It looks like they broke a seal on the mud system.
1126		The mud system is ok. They sent a drill rod and will replace it. They will add a slick pipe up to the rig to prevent the drill rod from flexing too much.
1151		The crew had trouble with the 4" sub on the drill motor. It is fixed now. Crew breaking for lunch.
1200		Crew only took a short break. Will take lunch later. Resume drilling
1245		Crew is working on the desander pump
1304		Pump fixed. Lunch break
1328		Crew back from lunch
1330		Drilling on wash pipe # 37. Crew will finish installing the pipe and resume pushing the pilot stem. Returns very good.
1418		Pushing is very hard. A weld broke on one of the 4" casing pilings
1421		The second piling's weld broke from rig.
1505		Drilling resumes on 2" rod # 39, returns good, rig well anchored.
1520		I called Greg Powers to ask if there is any rock in the subsurface. Greg said that limestone stringers are present but rare, when they are present, they tend to be silicified. The stringers are thin and not laterally extensive.
1537		Drilling resumes with presumably a higher mud pressure
1558		Returns are good, sticking coming out both annulars and wash pipe
1601		mud pressure 750 psi
1628		I asked Mike J. to have crew put the rock bypass back up.

TECHNICAL OVERSIGHT SIGNATURE: D. A. Watkins DATE: 11/22/92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Mercadante / Mike Jones
WELL NUMBER: AMH-7	TECHNICAL OVERSIGHT: David Wilson / David Watkins
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 11/22/92
	PAGE: 4

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1737		STARTING TO OVERREAM
1801		DAVE WILSON SIGNS LOG BOOK OVER TO DAVID WATKINS
1809		AN INTERESTING OBSERVATION IS THE OFFSET BETWEEN MSB-62 AND MSB-4 SHOWN ON A/M AREA CROSS SECTION D-D', COULD BE A FAULT (SOURCE OF FLUID LOSS IN 1ST WELL (#2))
1905		RAY MERCADANTE INDICATES THAT DRILLING APPROX. 2' HIGHER THAN THEY ARE NOW DRILLED EASIER, DRILLERS WILL MOVE HOLE UP 2' TO 241.5' MSL.
1908		DRILLERS PUSHING LASHOVER JOINT #29, ADDING JOINT #30
1957		PUSHING LASHOVER JOINT #30, RETURNS ARE GOOD
2012	2030	COFFEE BREAK FOR CREW
2111		COMPLETED INSTALLATION OF LASHOVER PIPE DOWN TO 430', BACK TO PILOT DRILLING
2113		CHECKED ROD COUNT ON 2" DRILL STEM, 37 ON RACK
2230		ANOTHER OBSERVATION ON PASS STRUCTURE BELOW M-AREA BASIN, UPON ANALYSIS OF CROSS SECTIONS A-A', D-D', AND E-E', TWO OF WHICH PASS DIRECTLY OVER THE M-AREA BASIN, IT APPEARS THAT THE OFFSET EXISTS ≈ 200-300' SOUTHWEST OF MSB-4. THIS IS WHERE THE DRILLING IS OCCURRING. BASED ON INTERP. OF THE X-SECTS A-A', D-D' AND E-E', IT APPEARS THE STRIKE OF THE FEATURE IS ≈N35-40°W
2325	2335	DRILLERS ON COFFEE BREAK
2335		DRILLERS PUSHING ROD #50, RETURNS GOOD

David A Watkins 11/22/92

TECHNICAL OVERSIGHT SIGNATURE David A Watkins DATE 11/22/92

OSR 30-2 Rev 12-89

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT
DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
DRILLER: RAY ABERCROMBIE / MIKE TOVE
WELL NUMBER: AMH-7
TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN
DATE: 11/23/92
PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0034		BEGINS TO RAIN HEAVILY, 1ST RAIN OF SHIFT
0105	0205	CREW BREAKS FOR DINNER
0205		CREW BACK TO DRILLING ON DRILL STEM # 53
0413		HNU READING TAKEN @ DRILL COLLAR W/ GOOD FLOW OF
		MUD RETURNS - 0.4 PPM
0528		DRILLING PILOT ROD # 60, RETURNS GOOD @ ANNULUS AND WASHOVER
0538		DRILLING ON JOINT # 60 IS VERY HARD, RAY A. FEELS IT IS HARDER
		THAN SANDY CLAY
0540		RAY A. DECIDES TO PULL 2" JOINT # 60 BACK OFF AND RUN WASHOVER
0545		DAVE WILSON ON SITE
0552		DAVID WATKINS SIGNS LOG BOOK OVER TO DAVE WILSON
0600		THE DRILLERS ARE TRYING TO MOVE WASHPIPE, NOT MOVING BACK OR FORWARD
0603		WASHPIPE MOVING BACK, MOVED @ FIRST WITH JERKS
0606		ABLE TO ADVANCE WASHPIPE
0612	0630	MIXING MUD
0644		MUD RETURNS VERY GOOD SINCE START OF SHIFT
0658		DAY SHIFT ON SITE
0713		NIGHT SHIFT OFF SITE
0815		HNU READINGS: BACKGROUND - 0.6 PPM, MUD PIT - 0.4 PPM,
		MUD TANK - 0.4 PPM
0843		THE CREW RAN WASH PIPE FROM 0600 UNTIL NOW, NOW SWITCHING
		OVER TO PILOT STEM. THEY ARE GOING TO PULL BACK ≈ 2 JOINTS
		AND TRY TO DRILL OVER THE HARD LAYER THE BIT IS IN NOW.
0930		MILES DENHAM ON SITE
1018		THE CREW IS TRYING TO SMOOTH OUT THE ANGLE OF THE HOLE @ JOINTS #58
		AND #59. THE NIGHT CREW HIT SOMETHING HARD THAT DEFLECTED THE BIT
		UP ≈ 2.4° THAT BEND IS TOO HIGH FOR 10 PIPE. TRYING TO CUT THE HOLE
		LOWER TO LESSEN ANGLE. THIS IS SLOW, FORMATION IS VERY HARD.

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/23/92

OER 30-2 (Rev 12-88)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-7 / TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/23/92 / PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1037		THE CREW IS GOING TO CUT #59 WASH PIPE IN THE HOLE AND THEN WASH OVER IT TO ENLARGE THE HOLE AND FORM A LIP THEY CAN JET AGAINST. FIRST THEY WILL CHANGE THE MUD OUT
1059		MILES DENNAN OFF SITE.
1101	1315	DAVE WILSON OFF SITE AND RETURNS
1315		THE CREW HAS BEEN EMPTYING MUD TANK, STILL HAVE A FEW FEET OF SAND LEFT TO GO. MIKE T THINKS THAT REMOVING THE SAND WILL INCREASE THE EFFICIENCY AND THE PRESSURE OF THE MUD SYSTEM.
1322		HNU READINGS: BACK GROUND - 1.0 ppm, BOTTOM OF MUD TANK - 1.0 ppm
1346		ATTACHED WASH PIPE #56 TO ATTEMPT TO MOVE WASH PIPE
1348		VIDEO CREW ON SITE. THE CREW IS GETTING THE MUD SYSTEM READY FOR DRILLING. THEY ARE GOING TO TRY ADVANCING THE 2" STEM AGAIN. THEY THINK THE MUD SYSTEM WILL HAVE MORE PRESSURE AND MAY BE ABLE TO CUT THE FORMATION. IF IT WON'T CUT THE FORMATION THEY WILL USE THE WASHPIPE TO CUT A LIP TO PUSH AGAINST.
1426		DRILLING RESUMES WITH 2" STEM, RETURNS GOOD, THE MUD HAS AN OLIVE GREEN TINT TO IT
1435		MILES DENNAN ON SITE. SURVEYING WILL NOT BE NEAR UNTIL NEXT WEEK.
1457		THE WIRE HAS BROKEN @ AROUND JOINT #30
1520		HNU READING: BACKGROUND - 1.0 ppm, WASH PIPE - 1.0 ppm
1601		THEY FOUND THE WIRE IN JOINT # 28
1640	1700	KEN LOMBARD ON SITE
1934		THE CREW IS STILL TRIPPING BACK INTO THE HOLE, THEY HAVE 21 more JOINTS TO GO TO THE ADVANCING WASHPIPE. LAST ADVANCE @ 1346 TODAY.

TECHNICAL OVERSIGHT SIGNATURE D L A [illegible] DATE 11/23/92

DSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT		DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
		DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-7	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN		DATE: 11/23/92 — PAGE 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1747		DAVID WATKINS ON SITE
1750		DAVE WILSON SIGNS LOG BOOK OVER TO DAVID WATKINS
1855		NIGHT CREW ON SITE
1910		DAY CREW OFF SITE
2012		FINISHED PILOT ROD INSERTION TO JOINT #57, ADDED WASHPIPE #57 AND PIPE TURNED FREELY
2031		DRILLERS ATTEMPTING TO PUSH PILOT JOINT #57 TO ADJUST FOR THE 2.4° UPWARD WARPING OF THE HOLE
2130		DRILLING PILOT ROD #58, DRILLING EXTREMELY HARD AND SLOW, THE OLIVE TAN COLOR OF THE MUD ALONG WITH THE ABUNDANT SMALL WHITE FLEKS OF CLAY IN THE CUTTINGS WOULD INDICATE DRILLING IS CURRENTLY CUTTING A DENSE CLAY, POSSIBLY THE "TAN CLAY" OF THE DRY BRANCH FORMATION, RAY A. FEELS THAT THE DENSITY OF THE CLAY COULD ALMOST BE A "SHALE", ALTHOUGH THERE ARE NO TRUE "SHALES" @ THE SRS, THERE ARE LENSES OF DENSE, FISSLE CLAY WITHIN THE "TAN CLAY" UNIT OF THE DRY BRANCH FORMATION
2237		COMPLETED PILOT ROD #60, CLAY STILL EXTREMELY HARD, DRILL RIG HAS BROKEN BOTH WELDS THAT ATTACHED IT TO THE 4" CASING PILINGS
2244		DRILLERS WRAPPING CHAIN AROUND PILINGS TO SECURE RIG.

[signature] 11/23/92

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/23/92

OSR 30-3 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ASHCRAMBE / MIKE JONES
WELL NUMBER: AMH-7	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 4/24/92
	PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0047		COMPLETED PILOT JOINT #62, CHANGING TO PUSH WASHPIPE
0055		WASHPIPE NOT MOVING
0058		WASHPIPE BEGINS TO MOVE, CONTINUE PUSHING WASHPIPE, COMPLETE #58
0100	0135	DRILLERS ON DINNER BREAK
0135		BACK TO DRILLING ON WASH JOINT # 57
0236		COMPLETED WASHPIPE JOINT # 59, SWITCHING BACK TO PILOT ON JOINT # 63
0330		HNU READING @ WASHPIPE ANNULUS - 0.6ppm
0511		COMPLETED DRILLING PILOT STEM #66, PREPARING TO PUSH WASH PIPE #59
0542		DAVE WILSON ON SITE
0595		DAVID WATKINS SIGNS LOG BOOK OVER TO DAVE WILSON.
0547		DAVID WATKINS OFF SITE
0603		IT HAS BEGAN TO RAIN LIGHTLY
0620		THE DRILLING HAS BEEN VERY HARD.
0630		CREW SWITCHING OVER TO NEW DRILL PIPE.
0648		DAY CREW ON SITE.
0707		NIGHT CREW OFF SITE. DRILLING PILOT STEM RESUMES.
0707		THE MUD RETURNS HAVE NO DISCERNABLE SAND GRAINS, RED-BR. in color
0732		IT TOOK ≈ 30 MINUTES TO DRILL ROD # 67.
0834		PREPARING TO DRILL WASHPIPE
0852		WASH PIPE IS MOVING BACKWARD AND FORWARD
0928		THEY DRILLED 4 JOINTS OF WASHPIPE DAW AND ARE SWITCHING TO PILOT
0938		RESUME DRILLING PILOT
1017		DRILLING JOINT # 69 VERY HARD DRILLING, MUD RETURNS HAVE VERY FINE BROWN SAND
1044		FINISHED JOINT # 69, TOOK ≈ 60 MIN. TO DRILL IT.
1122		DRILLING JOINT # 70, RAIN INTERMITTENT AND LIGHT
1134		FINISHED # 70, TOOK 33 MIN, SWITCHING TO NEW WASH PIPE.

TECHNICAL OVERSIGHT SIGNATURE: Del R Watkins DATE: 11/24/92

DSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHEARFOW ENVIRONMENTAL
	DRILLER: RAY ASHCRAFT / MIKE JONES
WELL NUMBER #: AMH-7	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/24/92
	PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1142		BEGAN TRYING TO MOVE WASHPIPE.
1144		WASHPIPE IS MOVING.
1204	1251	CREW TAKING LUNCH BREAK, @ 1239-RAINING HARD
1251		RAIN EASES UP, CREW BACK FROM LUNCH
1308		RESUME DRILLING WASH PIPE ON JOINT #69
1320		SETTING UP TO DRILL 2" PILOT STEM
1337		BEGIN DRILLING 2" PILOT, LAST MUD SAMPLE TAKEN WHILE DRILLING
		JOINT # 70 @ ± 1130, DID NOT FLOW OUT OF THE STRAINER DURING
		2 HRS. THE MUD WAS THICK WITH CLAY AND FINE SAND
1429		RAINING HARD
1437		LIGHTNING AND THUNDER, WORK IS HALTING
1449		DRILLING RESUMES ON JOINT # 71
1508		THEY FINISHED DRILLING JOINT # 71, NOW SETUP TO RUN WASH PIPE
1516		TRACEY M. AND I MEASURED THE LENGTH OF THE BASIN WITH
		A 100' TAPE AND DETERMINED THAT IT IS 407' LONG.
1531		THE MD OF THE WELL MATERIALS WILL BE 347' + 407' = 754',
		THEREFORE WE NEED TO DRILL AT LEAST 75 JOINTS AND INSTALL
		75 JOINTS OF PVC.
1536		THEY HAVE NOW DRILLED IN WASH PIPE #69 AND ARE PREPARING
		TO DRILL PILOT STRING
1559		DRILLING PILOT HOLE WITH JOINT # 72 RESUMES.
1629		IT TOOK 30 min. TO DRILL MD # 72.
1709		THE WIRE SHORTED WHILE DRILLING MD # 73.
1732		THEY THOUGHT THAT THEY HAD THE SHORT FIXED AND STARTED
		DRILLING AGAIN ONLY TO HAVE THE SHORT OCCUR ONCE MORE.
		TRACY THINKS THAT THE SHORT IS AT THE PROBE.
1734		THEY ARE GOING TO RUN WASH PIPE UNTIL RAY ASHCRAFT
		ARRIVES FOR THE NIGHT SHIFT.

TECHNICAL OVERSIGHT SIGNATURE: David A Watkins DATE: 11/24/92

OBR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT
DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
DRILLER: RAY ABLACAMBE / MIKE JINES
WELL NUMBER: AMH-7
TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN
DATE: 11/24/92
PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1747		BEGIN TRYING TO MOVE WASHPIPE - IT IS MOVING
1750		DAVID WATKINS ON SITE.
1755		DAVE WILSON SIGNS LOG BOOK OVER TO DAVID WATKINS.
1806		PULLED WASHOVER JOINT #71 BACK OFF, INSTALLED PILOT JOINT #73
1845		DRILLING ON ROD #73 FOR PILOT HOLE IS EXTREMELY HARD,
		ROD HAS MOVED ≈ 3 FEET IN 45 MINUTES
1849		NIGHT SHIFT CREW ON SITE
1902		DAY SHIFT CREW OFF SITE
1958		COMPLETED PILOT JOINT #73, PUTTING WASHOVER JOINT #71 ON
2055		DRILLERS INSTALLING WASHOVER JOINT #74 TO DRILL PAST PILOT
		BIT TO THE END OF THE HOLE, WASHOVER WILL THEN BE PULLED BACK
		TO PUSH THE PILOT ROD TO THE END OF THE HOLE FOR A SURVEY.
2241		FINISHED RUNNING WASHPIPE TO 770 FEET
2327		PULLED OFF WASHPIPE BACK TO JOINT #73, ATTACHING
		PILOT JOINT #74 TO PUSH 10' AND TAKE SURVEY
2355	0018	DRILLERS BREAK FOR DINNER

[signature] 11/24/92

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/24/92

OSR 30-2 (Rev 13-89)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY AGUILCHINGE / MIKE JONES
WELL NUMBER: AMH-7	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/25/92
	PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
2355	0018	DINNER BREAK
0025	0225	SURVEYING OF HOLE IS COMPLETE, BEGINNING TO PULL ALL
		2" PILOT STEM, PULLING COMPLETE
0245		DRILLERS MOVING WASHOVER PIPES # 75 AND # 76 BACK INTO
		HOLE, PREPARING TO INSTALL SCREEN, MOVING SUPPLIES
0310	0407	BEGIN WELL INSTALLATION, INSTALLED 21 JOINTS OF
		20' PVC SCREEN + CAP = 420.5' CUMULATIVE LENGTH
0436	0445	INSTALLED 3 JOINTS OF 20' CASING (PVC) - CUM. LENGTH 480.5'
0445		HAVE READING @ MUD PIT @ DRILL COLLAR - 1.0 PPM, A.R. - 1.0 PPM
0448	0542	INSTALLED CASING (PVC) JOINTS #4 - #16, ALL 20' LONG, CUM.
		LENGTH INSTALLED = 740.5'
0547	0552	INSTALLED 2 SECTIONS OF 10' PVC CASING, CUM LENGTH = 760.5',
		10 FEET IS STICKING ABOVE GROUND
0602		DAVID WATKINS SIGNS LOG BOOK OVER TO DAVE WILSON
0606		CREW BEGINS PULLING WASH PIPE
0607		THE FUEL TRUCK GOT STUCK IN THE PIT THAT THEY DUG TO
		RECOVER FRAC FLUIDS
0613	0635	TRUCK IS FREE, CREW TAKING WELL DESERVED BREAK
0635		BREAK OVER - BACK TO PULLING WASH PIPE, RAY A. WANTS
		TO PULL ENOUGH WASH PIPE TO MAKE SURE THE PVC STAYS
		IN THE HOLE. I DISCUSSED THE FOLLOWING ISSUES WITH RAY A.:
		- DEVELOPMENT - THE FLUIDS NEED TO BE CONTAINED
		- SURVEY - THE CONTRACT CALLS FOR A DIRECTIONAL
		SURVEY AFTER WELL COMPLETION
0644		IT APPEARS AS THOUGH THEY ARE DUMPING MUD WHILE THEY ARE
		PULLING BACK. WE WILL NEED TO BE SURE TO DEVELOP THE WELL
		SUFFICIENTLY TO REMOVE THE DRILL CUTTINGS. I THINK WE SHOULD WAIT
		UNTIL THE GUAR GUM HAS A CHANCE TO DEGRADE.

TECHNICAL OVERSIGHT SIGNATURE: Dale B. Watkins DATE: 11/25/92

GSR 30 2 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY MCELROMBE / MIKE JONES
WELL NUMBER: AMH-7	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/25/92
	PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0712		DAY SHIFT ON SITE.
0754		THEY HAVEN'T PULLED WASHPIPE SINCE 0705. CREW NEEDS BETTER DIRECTION FROM MIKE JONES. NIGHT CREW LEFT @ 0740.
0803		RESUMED PULLING WASHPIPE
0806		MILES DENHAM ON SITE. I ASKED HIM TO:
		- FIND OUT IF WE NEED TO CONTAINERIZE DRILLING DEVELOPMENT FLUIDS
		- FIND OUT IF A CONFIRMATORY WELL SURVEY IS NEEDED AFTER WELLS ARE COMPLETE.
		- I TOLD HIM THAT THE CREW WILL TRY TO GROUT THE ABANDONED HOLE TODAY AND HE SAID THAT VADOSE ZONE WELLS ARE REGULATED AS STRICTLY AS GROUNDWATER WELLS.
0845		MIKE JONES HAS DECIDED TO WAIT TO GROUT THE ABANDONED HOLE BECAUSE OF TIME CONSTRAINT AND BECAUSE THE GROUND IS TOO SOFT TO HOLD THE TRUCK. I TOLD HIM THAT WAS "UP TO HIM".
0945	1010	DENNIS CORDER (YANKEE) ON SITE - YANKEE TALKED TO MIKE J. AND DECIDED THAT CHERRINGTON WILL GROUT IN THE OPEN HOLE ON FRIDAY, THEY CAN GET A GROUT TRUCK ON FRIDAY FROM A LOCAL COMPANY, THAT WILL GIVE THEM TIME TO SET UP TODAY AND START DRILLING WELL #2
1225		LAST WASH PIPE OUT OF THE HOLE, 78 PIECES INCLUDING THE 9.7
1230	1330	LUNCH BREAK
1345		THE CREW IS PREPARING THE SITE TO DRILL WELL #2, WELL #1 WILL BE GROUTED ON 11/27/92
1401	1552	DAVE WILSON OFF SITE.
1716		WE'RE STILL A COUPLE OF HOURS AWAY FROM DRILLING

TECHNICAL OVERSIGHT SIGNATURE: [signature] DATE: 11/25/92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombie/Mike Jones
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: Dave Wilson/David Watkins	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 11/25/92 / PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES: REMARKS
1752		David Watkins on site, Dave Wilson signs over log book
1915		Drillers assembling directional drill tool
1920		Night shift on site
2122		Drillers begin to push pilot hole
2149		Drilling stops due to lightning, National Weather
		Service has issued a tornado watch for the SRS
		area until 12 midnight
2235		Rain stops, lightning appears to have passed, Drillers
		back to work
2359	0032	Drillers break for dinner

David R. Watkins 11/25/92

TECHNICAL OVERSIGHT SIGNATURE David A. Watkins DATE 11/25/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNOLOGY OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6 · TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/26/92 · PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0032		DRILLERS RETURN TO WORK AFTER DINNER BREAK,
		BEGIN DRILLING ON PILOT STEM PIPE # 6
0117		RAIN BEGINS TO PICK UP, LIGHTNING STOPS WORK
0207		RAIN BEGINS TO LET UP, LIGHTNING STILL VISIBLE IN
		DISTANT THUNDERSTORM, DRILLERS RETURN TO WORK PUSHING
		PILOT STEM JOINT # 8
0540		DRILLING OF PILOT STEM HAS CONTINUED TO THIS TIME
		AND ARE WORKING ON JOINT #16, DAVE WILSON ARRIVES TO RELIEVE
		DAVID WATKINS, LOG BOOK SIGNED OVER TO DAVE WILSON
0620		THE PLOT OF THE BORE HOLE TO JOINT # 16 PLOTS UP 5.5'
		OFF TO THE WEST, ALSO ALITTLE HIGH, DRILLERS WILL ADJUST, BEGIN
		WASHING DOWN WASH PIPE FROM SURFACE TO 140'
0740		DAY CREW ARRIVES ON SITE AND ADJUSTS AZIMUTH TO DETERMINE
		HOLE IS ACTUALLY 2.3' WEST OF THE TARGET AZIMUTH, THE PROBLEM
		ARRIVING WHEN RITCHIE DID NOT ENTER THE TRUE AZIMUTH INTO THE
		COMPUTER WHEN THE DRILL STEM WAS NEAR THE SURFACE AND EXPERIENCING INTERFERENCE
0806		RAY WANTS TO CHANGE KOP TO ~~ELEVATION~~ DAW DEPTH OF 160' AND TARGET
		ELEVATION OF ≈ 245'
0819		MUD RETURNS GOOD, BEGINNING TERRAIN, DRILLING WASH PIPE # 11
0851		INSTALLATION OF WASH PIPE COMPLETE TO 140', DRILLERS RIGGING FOR PILOT
0902		DRILLERS STOP DRILLING TO CLEAN MUD SYSTEM
1127 DAW		DRILLING OF PILOT STEM RESUMES
~~1140~~ ~~1144~~	~~1314~~ ~~1154~~	LUNCH FOR DRILLERS
1444		HNU CALIBRATED @ 69 PPM - BACKGROUND 0.6 PPM, MUD PIT 0.6 PPM,
		WASH PIPE 0.6 PPM, MUD TANK 0.6 PPM
1631		DRILLING OF PILOT STEM CONTINUED TO JOINT # 30, CHANGE TO
		WASH PIPE,
1845		DAVID WATKINS ON SITE, LOG BOOK SIGNED OVER FROM DAVE WILSON

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/26/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT
DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
DRILLER: RAY ASER CHARGE/MIKE JONES
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: DAVE WASSIL/DAVID WATKINS
OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN
DATE: 11/26/92 (CONT.)
PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1912		COMPLETED RUNNING WASH PIPE TO 260', SWITCHING BACK TO 2" PILOT STEM
1922		NIGHT CREW ARRIVES ON SITE
2142		DRILLING 2" JOINT # 35, THE LAST JOINT OF THE CURVE BEFORE LEVELING @ 245' ELEV, BECOME HARD, DRILLING MUST HAVE HIT THE "TAN CLAY" HORIZON, DRILLERS WILL TRY TO BRING THE ELEVATION UP A COUPLE OF FEET IN NEXT COUPLE OF JOINTS
2330		COMPLETED DRILLING PILOT POINT # 40

11/26/92

TECHNICAL OVERSIGHT SIGNATURE D. L. R. [illegible] DATE 11/26/92

DAILY ACTIVITIES REPORT

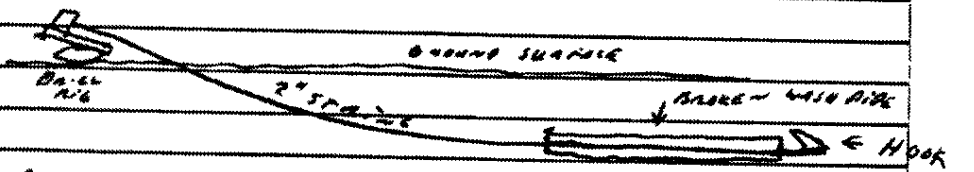
PROJECT: Horizontal Drilling TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE/MIKE JONES
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: DAVE WILSON/DAVID WATKINS
	OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/27/92 PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0005		COMPLETED DRILLING 2" PILOT STEM JOINT # 41
0010	0048	DRILLERS BREAKING FOR DINNER
0048		DRILLERS BACK TO WORK PUSHING PILOT STRING, INTERMITTENT RAIN.
0235		DRILLING JOINT # 47 OF PILOT STEM, NO SIGNIFICANT DRILLING FLUID LOSSES SINCE BEGINNING OF HOLE, RAINING STEADILY
0413	0425	DRILLERS TAKE BREAK ON JOINT # 48
0510		RAIN LIGHTENS UP
0535		DAVE WILSON ON SITE, LOG BOOK SIGNED OVER FROM DAVID WATKINS
0605		THE BOREHOLE IS WITHIN 1.3 FEET OF THE PROJECTED AZIMUTH AND AT ELEVATION 249' ABOVE MSL @ JOINT # 51
0631		CREW RIGGING UP TO DRILL WASH PIPE AT JOINT # 27
0745		DAY CREW ON SITE.
0806		MUD RETURNS HAVE BEEN GOOD UP TO WASH PIPE # 31 AND DRILL ATEMS1
0925		CREW ADVANCING WASH PIPE WITH GOOD MUD RETURNS TO JOINT # 35 ENCOUNTERED HARD ZONE TO THE POINT OF REFUSAL, NOW PULLING OFF JOINT # 35 AND ATTEMPT TO MOVE PILOT STRING
1011		THE PILOT STRING IS CLEAR AND IN ONE PIECE, TRIPPING OUT WASH PIPE
1148		WASH PIPE COMES OUT OF THE HOLE BUT IS BROKEN OFF BETWEEN JOINTS 46 AND 47, THE BOX OF JOINT # 46 WAS BACKED AND ON # 47 PIN
1212		THE BROKEN STRING OF WASH PIPE IS LOCATED BETWEEN 270'-330' MD.
1234		THE PLAN IS TO: ① TRIP BHA OUT OF THE HOLE, ② GO BACK INTO THE HOLE WITH A DUMMY 2" STRING TO TD, ③ DRILL FISHING TOOL DOWN ON END OF WASH PIPE AND ATTACH TO BROKEN STRING, ④ ONCE THE BROKEN STRING HAS BEEN REMOVED WASH BACK OVER DUMMY 2" STRING WITH WASH PIPE TO 341'
1226	1434	DAVE WILSON TO COM FEDERAL OFFICE TO GET MORE DAILY LOG FORMS

TECHNICAL OVERSIGHT SIGNATURE David R. Watkins DATE 11/27/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNOLOGY DEMONSTRATION
DRILLING SUBCONTRACTOR: CHEARINGTON ENVIRONMENTAL
DRILLER: RAY MCCLENAHAN / MIKE JONES
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN
DATE: 11/27/92 (CONT.)
PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1438		THE BHA HAS BEEN REMOVED FROM THE HOLE AND DRILLERS ARE TRIPPING BACK in WITH DUMMY 2" STRING
1633		CREW HAS COMPLETED INSTALLING 52 JOINTS OF 2" PIPE
1635		CREW WILL NOW OPEN THE HOLE TO 8" BY DRILLING DOWN
		TO 2901 FEET WITH A CUTTER TO ALLOW THE FISH TOOL TO GAIN
		EASE OF MOBILITY DOWN HOLE, BEGIN WASHING DOWN HOLE
1730		RAIN STOPPED EARLY THIS AM, AND SKIES WERE CLEAR IN P.M.
1745		DAVID WATKINS ON SITE, LOG BOOK SIGNED OFF FROM DAVE WILSON
1929		WASHOVER PIPE HAS REACHED BROKEN STRING ON JOINT #29
1945		NIGHT CREW ON SITE, BEGIN PULLING WASHOVER PIPE WITH
		BIT TO INSTALL FISH TOOL, DECIDE NOT TO PULL WASH PIPE,
		INSTEAD TO PULL DUMMY STRING AND ATTACH A HOOK TO 2"
		PIPE TO ADVANCE DOWN WASH PIPE, PAST BROKEN SECTION, AND
		PULL OUT FROM THE BACK SIDE, WASH PIPE WILL ACT AS A
		GUIDE, ONCE 2" PIPE IS PAST BROKEN SECTION, DRILL WASH
		PIPE WILL BE PULLED OUT, DRILLERS FEEL BROKEN SECTION IS LOOSE
		Diagram of Tool
		
2125		CREW PULLING DUMMY STRING, ALLOWED ± 100' OF 2" PIPE TO SLIDE BACK
		DOWN HOLE, DRILLERS SHOULD HAVE BEEN HOLDING PIPE WITH CLAMP
2158		2" PIPE REATTACHED, PULLING OF 2" DUMMY STRING CONTINUES
2243		2" DUMMY TRIPOUT COMPLETE, INSTALLING HOOK, TRIPPING BACK in
2359		INSTALLATION OF 35 JOINTS OF 2" PIPE WITH HOOK COMPLETE
		AND ATTEMPTING TO ENGAGE HOOK ON BROKEN PIPE

TECHNICAL OVERSIGHT SIGNATURE: Dave R. Watkins DATE: 11/27/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT
DRILLING SUBCONTRACTOR: CHERRY POINT ENVIRONMENTAL
DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN
DATE: 11/28/92
PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0000		DRILLERS PREPARING TO PULL WASHOVER PIPE OUT FROM ABOVE
		BREAK
0046	0130	DRILLERS BREAK FOR DINNER
0130		CREW BEGINS PULLING WASH PIPE
0210		CREW COMPLETES PULLING WASHPIPE (23 JOINTS), BEGINS PULLING
		OUT 2" HOOK
0425		HOOK EMERGES FROM HOLE BUT WASH PIPE WAS NOT ATTACHED,
		COULD "FEEL" BROKEN SECTION OF END OF HOOK AS EACH JOINT
		WAS PULLED UNTIL ATTEMPTING TO PULL JOINT #16, GOING BACK
		IN WITH HOOK TO AROUND 180' TO REATTACH HOOK, REATTACHMENT
		APPEARS TO BE SUCCESSFUL
0551		DAVE WILSON ON SITE, LOG BOOK SIGNED OVER BY DAVID WATKINS
0608		HOOK COMES OUT OF HOLE WITH 4" WASHOVER PIPE IN TOW, 2"
		HOOK WAS ON THE <u>OUTSIDE</u> OF THE BROKEN WASHPIPE
0625		BROKEN SECTION HAS BEEN REMOVED, CREW TAKING WELL
		DESERVED BREAK
0725		NIGHT CREW OFF SITE
0755		DAY CREW ON SITE, THE PLAN IS TO: ① TRIP BACK IN WITH
		BHA, ② OVERWASH AS THEY GO, ③ TRY TO HAVE ALL DRILL
		MATERIALS RE-INSTALLED AND READY FOR NIGHT SHIFT
0818		CREW IS RIGGING UP THE BHA AND BEGINNING TO TRIP BACK
		INTO HOLE
0820		FOOD FOR THOUGHT: ① THE WASH PIPE BROKE TWICE AT A JOINT
		WHILE COMING TO THE END OF THE CURVE, ② THE JOINTS ARE THE
		WEAKEST POINTS ON THE 4" PIPE, WEAKEST AT EITHER THE PIN OR
		THE BOX, SO FAR BOTH BREAKS HAVE BEEN @ THE BOX, ③ A 400'
		RADIUS CURVE IS APPARENTLY TOO SHARP OF A CURVE TO BE
		ACCOMODATED BY THIS 4" PIPE

TECHNICAL OVERSIGHT SIGNATURE: Dave A. Wilson DATE: 11/28/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT
DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
DRILLER: RAY ABERCROMBIE/MIKE JONES
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: DAVE WILSON/DAVID WATKINS
OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN
DATE: 4/28/92 (cont.)
PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0903		CREW BEGINS TAPPING IN 2" PILOT STRING WITH BHA
1311		CREW HAS COMPLETED TAPPING IN PILOT STRING DOWN TO
		JOINT #51, CREW WILL NOW RIG UP FOR RUNNING WASH
		PIPE AND BREAK FOR LUNCH, DAVE WILSON OFF SITE
1313	1400	DAVE WILSON AT SUPPLIER
1414		CREW HAS RIGGED UP TO RUN WASH CASING, MIXING MUD
1419		CREW BEGIN TAPPING IN WASH PIPE
1646		CREW HAS COMPLETED DRILLING WASH PIPE #35, THIS
		PUTS DRILLING ≈ 5' FURTHER THAN WHEN WASH PIPE
		BROKE 33 HOURS AGO
1725		DAVID WATKINS ON SITE, DAVE WILSON SIGNS OVER LOG BOOK
		DRILLING OF WASH PIPE CONTINUES
1810		CREW DRILLING WASH PIPE #42 APPEARS TO HAVE HIT SOMETHING
		HARD, HOPE WASH PIPE HAS NOT BROKEN AGAIN, ROD #42
		IS ≈ 5' FROM BEING DRILLED DOWN, WASH PIPE MAY HAVE BROKEN
		IN SAME PLACE AS BEFORE
1830		REATTACHING SURVEY WIRE TO SEE IF SURVEY TOOL IS STILL
		FUNCTIONING AND PILOT STRING IS STILL INTACT
1846		SURVEY TOOL STILL FUNCTIONING
1847		THERE MUST BE A RELATIVELY LOCAL, SEVERE KINK IN THE HOLE WHICH
		MUST PUT STRESS ON EVERY JOINT AS IT PASSES KINK
1905		DAY SHIFT WAITING FOR THE ARRIVAL OF THE NIGHT SHIFT TO ASK
		RAY ABERCROMBIE WHAT APPROACH HE WOULD LIKE TO TAKE. I WOULD WAGER
		THE STRING IS BROKEN WITHIN 20' OF JOINT #27. IT APPEARS THAT THE
		DESIGN OF THE 4" WASH PIPE IS SUCH THAT THE COUPLING IS THE WEAKEST
		POINT ON THE RODS
1925		NIGHT CREW ON SITE
1955		DRILL CREW MIXING MUD AND PIPE DOPE, GENERAL SITE CLEAN UP

TECHNICAL OVERSIGHT SIGNATURE: Dale R. Watkins DATE: 11/28/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT		DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL	
		DRILLER: RAY ABERCROMBIE/MIKE JONES	
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: DAVE WILSON/DAVID WATKINS	OVERSIGHT FIRM: CDM FEDERAL	
LOCATION: M-AREA SEEPAGE BASIN		DATE: 11/28/92 (CONT.)	PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
2105		DRILLERS DECIDE TO TRIP OUT 2" PILOT STEM FIRST,
		BEGIN PULLING 2" PIPE
2220		CREW COMPLETES TRIPPING OUT 2" PIPE
2247		CREW PREPARING TO GO BACK INTO HOLE WITH 2" PIPE WITH
		HOOK ON END, WILL TRIP 2" BACK IN BEFORE PULLING
		WASH PIPE SO IT WILL GUIDE 2" PIPE THROUGH BROKEN SECTION
2350		COMPLETED INSTALLATION OF 2" PIPE WITH HOOK DOWN TO
		JOINT #42, JUST PAST THE END OF THE BROKEN STRING
2352		PREPARING TO PULL WASH PIPE OUT FROM ABOVE BREAK
2359		CREW BREAKS FOR DINNER

[signature] 11/28/92

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/28/92

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNOLOGY
DRILLING SUBCONTRACTOR: CHARLESTON ENVIRONMENTAL
DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN
DATE: 4/29/92
PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0047		CREW RETURNS FROM LUNCH BREAK, BEGINS TRIPPING OUT WASH PIPE
0210		BROKEN END OF WASH PIPE APPEARS AT COLLAR OF HOLE, BREAK OCCURRED BETWEEN JOINTS #8 AND #9 AT THREADS, BOX OF #8 WAS ATTACHED TO PIN OF #9, LEFT 8 JOINTS IN HOLE FROM 325-405 MD
0216	0250	DRILLERS TAKING BREAK
0250		DRILLERS BACK FROM BREAK, MANAGE TO UTILIZE HOOK TO GRAB BROKEN SECTION ON 1ST ATTEMPT, BEGIN PULLING 2" PIPE
0413		BROKEN WASH PIPE APPEARS IN HOLE AT COLLAR
0440		ALL 2" STEM WITH HOOK HAS BEEN REMOVED, DRILLERS TAKING BREAK, STILL NEED TO TRIP OUT THE 8 SECTIONS OF WASH PIPE
0455		CREW BACK TO TRIPPING BROKEN WASH PIPE
0539		COMPLETE TRIP OF WASH PIPE
0540		DAVE WILSON ON SITE, DAVID WATKINS SIGNS OVER LOG BOOK
0605		CREW AND DAVE WILSON LEAVE SITE FOR MOTEL, RAY ABERCROMBIE THINKS THAT THE WASH PIPE IS BEING ROTATED AT TOO HIGH AN RPM AND IS BEING PUSHED TOO HARD AS IT ADVANCES THROUGH THE CURVE. RAY A. IS GOING TO TELL MIKE JR. TO DRILL SLOW AND EASY THROUGH THE CURVE
0816		I MET WITH RAY A. AND MIKE J. AT SHONEYS IN AIKEN. THE PLAN IS TO: ① TRIP THE 2" RDD WITH BHA TO TD, ② TRIP IN THE OVERWASH PIPE WHILE TRYING TO USE THE NEWEST, MOST UNUSED PIPE THROUGH THE CURVE, DRILL SLOW, ROTATE SLOW FOR THE REST OF THE HOLE, ③ REMOVE THE BIT ON THE WASH PIPE SINCE THE PRESENT BIT HAD NO TEETH PROTRUDING FORWARD, ④ IF WE BREAK THE WASH PIPE AGAIN THEN WE WILL LIKELY STOP WORK AND ORDER MORE NEW PIPE

TECHNICAL OVERSIGHT SIGNATURE: D L Wilson DATE: 11/29/92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington for Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Wilson / David Watkins
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Sage Gage Basin	DATE: 11/29/92
	PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0840		2" rod count on rack: 25 bottom row, 24 on 2nd row,
		23 on 3rd row, 6 on top row for a total of 78
0853		Crew begins tripping 2" rod with BHA
1030		Miles Denham on site
1108		Miles Denham off site, he said any water (i.e.
		development water) needs to be containerized
1345		Have tripped in 51 joints of 2" pipe including
		BHA, now preparing to run wash pipe
1415		They are going to use the newest wash pipe first
1606		We now have installed 41 joints of wash pipe in the
		hole, we are now back to where we were last night
1645		Crew stops to mix mud
1702		Mud returns are low, losing some to the formation
1750		David Watkins on site, Dave Wilson signs over log book
1945		Drillers stop pushing wash pipe @ joint #49, preparing for drill stem
2005		Day crew takes over, night crew takes over
2135		Drillers pushing joint #54 but are using ± 1000 gal. of mud
		per 2 stems drilled, breaking to mix mud, losses are exceeding
		drill times, drilling is down waiting on mud
2152		Crew back drilling 2" joint #54
2346		Completing drill joint #60
2357	0027	Drillers breaking for dinner

11/29/92

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 11/29/92

OMB 30-3 Rev 12-88

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE/MIKE JONES
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: DAVE WILSON/DAVID WATKINS	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/30/92 / PAGE: 1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
2357	0027	DRILLERS ON DINNER BREAK
0027		DRILLERS BACK TO WORK PUSHING PILOT ROD #61
0050		LOSS OF DRILLING FLUID HAS BECOME CRITICAL. AFTER RETURNING FROM DINNER, IT TOOK AN ENTIRE TANK OF DRILL MUD JUST TO REGAIN CIRCULATION. ONCE CIRCULATION IS RESTORED AND DRILLING STOPS THE THICK MUD VISIBLY FLOWS BACK DOWN THE HOLE AND OUT EITHER INTO AN EXTREMELY PROLIFIC SAND UNIT OR EITHER A VOID BELOW THE SEEPAGE BASIN. EXAMINATION OF THE GEOLOGIC CROSS SECTIONS FOR THE M/m AREA APPEAR TO SUGGEST DISPLACEMENT OF STRATIGRAPHIC HORIZONS ON SEVERAL OF THE SECTIONS. IF THESE DISPLACEMENTS ARE LINED UP, THEY PROJECT DIRECTLY BELOW OR JUST SLIGHTLY SOUTH OF THE M-AREA SEEPAGE BASIN. (EXACTLY WHERE PROBLEMS IN THE WELL DRILLING HAVE OCCURRED).
0052		DRILLING HAS STOPPED PENDING THE RETURN OF THE WATER TRUCK AND MIXING OF MUD. FORMATION IS TAKING MUD AS FAST AS IT IS BEING PUMPED.
0118		IF A STRUCTURE EXISTS @ THE M-AREA SEEPAGE BASIN IT WOULD NOT BE ADVISEABLE TO PLUG UP THE FAULT WITH GROUT AS THE FAULT IS A LIKELY PREFERENTIAL PATHWAY FOR THE VERTICAL, DOWNWARD MIGRATION OF CONTAMINANTS. BECAUSE THE WELL IS ABOVE THE WATER TABLE, THERE IS NO GROUNDWATER TO PROVIDE HYDROSTATIC HEAD RESISTANCE TO THE DRILL MUD FLOWING OUT INTO THE CRACKS OR FISSURES. BECAUSE STRATIGRAPHICALLY, WE ARE DRILLING IN THE AREA OF THE "TAN CLAY", WHICH CAN BE AS MUCH AS 5-10' THICK, NORMAL FAULTING OF THE CLAY CAN PRODUCE VOIDS. NORMALLY, IF THE FAULTING IS IN SAND, THE SAND CAN FLOW BACK IN TO FILL THE VOID; HOWEVER, IN CLAYEY UNITS

TECHNICAL OVERSIGHT SIGNATURE: D. R. Watkins DATE: 11/30/92

DSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Wilson / David Watkins
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 11/30/92
	PAGE: 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0118 (cont.)		sand may not always fill the void. This is especially
		true in the Vdoose Zone where there is no superasaturation
		of sediments.
0143		water truck returns (1000 gal), preparing to mix
		mud. It is unclear where major fluid loss began
		to occur; however, it appears to have been around
		wash pipe joints # 42-#44
0151		Upon examining the apparent trend of the structure
		outward from the M-Area seepage basin based on the
		cross sections, the structure to the southeast appears
		to possibly be reflected at the surface topographically
		by a well developed, relatively straight drainage pathway.
		This surficial expression may suggest Holocene age
		(recent) movement, or at least movement younger
		than the "upland unit"
0210		water truck leaves to get another load, Drillers
		mixing mud
0246		water truck returns, preparing to mix more mud, drilling
		will resume when mud is ready.
0306		Drillers back to drilling after mixing mud. This batch
		may only fill up the drill column, it appears that
		the Drillers may not be able to mix mud fast enough
		to keep up with losses.
0325		water truck returns (1000 gal)
0333		completed pilot joint # 62, survey tool dropped down
		4° in last 5' of drill rod even though the directional
		tool was pointed up. Ray A. feels there is an open void at
		this point, used entire tank of mud to drill 10'.

TECHNICAL OVERSIGHT SIGNATURE D. R. [illegible] DATE 11/30/92

OMB 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT		DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL	
		DRILLER: RAY ABERCROMBIE / MIKE JONES	
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS	OVERSIGHT FIRM: CDM FEDERAL	
LOCATION: M-AREA SEEPAGE BASIN		DATE: 11/30/92	PAGE: 3

START	STOP	DESCRIPTION OF ACTIVITIES: REMARKS
0338		ALTHOUGH DRILL PIT AT ANNULUS HAS FILLED WITH MUD,
		WHILE DRILLING IS STOPPED I CAN VISUALLY SEE THE LEVEL OF FLUID
		IN THE PIT DROPPING. IN 1 minute FLUID LEVEL DROPPED
		1", THAT IS 1" X 10' X 6' = 5 CUBIC FEET PER MINUTE OF
		FLUID MOVING OUT INTO THE FORMATION BY HYDROSTATIC
		HEAD ALONE.
0345		RATE OF MUD LOSS @ PIT NOT LETTING UP, ≥ 1" PER minute.
0750		DRILLERS BREAKING TO MIX MUD
0353		WATER TRUCK LEAVES TO FILL UP
0423		WATER TRUCK RETURNS (500 GAL)
0435		DRILLERS WAITING FOR EMTC EMPLOYEE TO COME AND PULL
		OIL OUT OF FUEL TRUCK. BOTH WATER TRUCKS ARE NOW
		FULL, BUT THEY NEED OIL FOR THE PUMP. NO ONE HERE CAN
		ACCESS OIL IN THE FUEL TRUCK. DENNIS CORDER is coming
		TO ACCESS FUEL TRUCK
0545		DAVE WILSON ARRIVES ON SITE. DAVID WATKINS SIGNS OVER LOG BOOK.
0710		THE DRILL CREW HAS PUT OIL IN THE MUD PUMP. (DENNIS
		CORDER SHOWED UP @ ≈ 0605) THEY ARE NOW GOING TO
		ATTEMPT TO MOVE THE WASHPIPE.
0745		DAY CREW ON SITE. WASH PIPE APPEARS TO BE STUCK.
0755		THE WASH PIPE MAY BE BROKEN.
0800		THE WASH PIPE IS BROKEN.
0810		I HAVE TRIED TO REACH WSRC FOLKS WITH NO SUCCESS.
0819		I HAVE REACHED Tim Jarosch AND EXPLAINED THE
		FOLLOWING FACTS TO HIM:
		(1) WSRC will HAVE TO EITHER ACCEPT FLUID LOSS AND FINISH THE
		BOREHOLE @ A RATE OF 100 GAL / FT WITH DW OR ACCEPT THE BOREHOLE
		AND ANGLE W/ 250' OF SCREEN.

TECHNICAL OVERSIGHT SIGNATURE: D. A. Watkins DATE: 11/30/92

GSR 30-2 (Rev 12-90)

DAILY ACTIVITIES REPORT

SUBJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: DAVE WILSON / DAN WATKINS
	OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/30/92
	PAGE: 4

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0819 (Cont.)		(2) THE WASH PIPE IS BOTH STUCK AND BROKEN. THE CREW
		DOES NOT HAVE ENOUGH WASH PIPE TO FINISH A 740' MD
		HOLE. HOWEVER, IF THEY WERE ABLE TO GET UNSTUCK THEY
		WOULD HAVE ENOUGH ONSITE TO COMPLETE A 3620' MD HOLE.
0845		THE BREAK OCCURRED BETWEEN WASH PIPES #42 AND #41
		(#8 AND #9) DOWNHOLE. THE BREAK OCCURRED AT THE SAME
		LOCATION ON THE JOINT ~~AS~~ DAN AS THE OTHER BREAKS; AT
		THE BOTTOM THREAD ON THE BOX.
0941		BRIAN LOONEY, CARL ECOY, AND MILES DENHAM CAME
		ON SITE AND I DISCUSSED WITH THEM OUR DIFFERENT OPTIONS.
		WE HAVE DECIDED TO TAKE ONE OPTION AT A TIME.
		THEY (BRIAN LOONEY) HAVE DECIDED THAT THE PILOT HOLE
		IS NOW LONG ENOUGH AND THAT THEY WILL ACCEPT A WELL
		WITH 250-280' OF SCREEN BELOW THE BASIN. THEY
		REALIZE THAT THE WASH PIPE MAY NOT COME OUT OF THE
		HOLE. IF IT DOESN'T WE WILL FACE THOSE NEW ISSUES THEN.
0945		THE DRILL CREW IS NOW TRIPPING THE 2" PILOT STEM OUT OF
		THE HOLE TO RECOVER THE BHA. THEY WILL THEN RUN THE
		2" BACK IN WITH THE HOOK AND THEN RUN THE OVER-SHOT
		FISH TOOL IN AND USE BOTH TOGETHER (ALTERNATELY).
1000		DAVE WILSON LEFT SITE TO MEET WITH RAY ABERCROMBIE.
1115		RETURNED TO SITE. I SPOKE TO RAY A. AND RELAYED
		INFORMATION TO HIM FROM BRIAN LOONEY THAT THE PILOT
		HOLE IS LONG ENOUGH. THE DRILL CREW IS ALMOST
		FINISHED TRIPPING OUT THE 2" PILOT STEM.
1135		THE BHA IS OUT OF THE HOLE. CREW STILL NEEDS TO GET
		THE BOOM TRUCK AND TAKE IT OFF THE RIG.
1205	1240	CREW BREAKS FOR LUNCH.

TECHNICAL OVERSIGHT SIGNATURE: Dan R. Watkins DATE: 11/30/92

GSA 340-3 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
	OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/30/92
	PAGE: 5

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1300		THE CREW BEGINS TRIPPING IN 2" PIPE WITH FISH HOOK.
		THEY WILL TRY TO HOOK THE FAR END OF THE BROKEN 4" ARC
		AND VIBRATE IT LOOSE. THEN PULL ON THE BROKEN STRING
		WITH THE OVER-SHOT FISHING TOOL.
1400		THEY HAVE COMPLETED TRIPPING IN THE 2" AND ATTACHED HOOK.
1430		MILES OEHMAN ON SITE.
1710		THE CREW HAS PREPARED THE MAIN SITE FOR THE RECOVERY
		OF THE FISH. THEY HAVE DUG OUT THE MUD PIT SO THE MANAGER
		WILL FIT IN IT. THEY ARE NOW ATTACHING THE FISHING
		TOOL TO THE 4" PIPE AND WILL RUN IT DOWN HOLE TO
		CATCH THE BROKEN 4" PIPE.
1737		DAVID WATKINS ON SITE.
1745		DAVE WILSON SIGNS LOG BOOK OVER TO DAVID WATKINS
1807		DRILLERS TRIPPING BACK INTO HOLE WITH 4" WASHPIPE AND
		FISH TOOL TO HOOK BROKEN STRING.
1815		REACH BROKEN STRING WITH FISH TOOL AND 8 RODS.
1819		FISH TOOL APPEARS TO BE ATTACHED ON BROKEN STRING
1821		BRINGING UP BOOM TRUCK TO HOOK UP VIBRATOR
1840		PREPARING TO PULL 2" PIPE TO FIND OUT WHERE IT BROKE.
1841		IF 2" HOOK IS BROKEN @ WELD IT WILL COME THROUGH THE
		FISH TOOL. IF IT IS BROKEN ON PIPE THEN IT WILL STILL
		COME THROUGH FISH TOOL. THE FIRST THING TO DETERMINE IS
		WHERE IS BREAK ON 2" PIPE.
1953		END OF 2" STRING APPEARS AT COLLAR OF HOLE. ALL
		2" PIPE CAME OUT WITH THE EXCEPTION OF THE 2" SUB
		WITH THE HOOK WELDED ON IT. RAY A. FEELS THIS WILL NOT
		CAUSE A PROBLEM. THEY WILL SIMPLY TAKE 2" PIPE WITH
		PLUG ON THE END AND PUSH THE BROKEN SUB DOWN TO

TECHNICAL OVERSIGHT SIGNATURE Dan A. Vogt DATE 11/30/92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6 — TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 11/30/92 — PAGE: 6

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1955 (CONT.)		THE END OF THE HOLE. DRILLERS WILL NOW TRIP BACK
		DOWN THE HOLE TO THE END WITH A 2" DUMMY STRING IN
		CASE THE WASHPIPE BREAKS DURING HAMMERING.
2045		CREW WELDING PLATE ONTO 4" PIPE FOR VIBRATING,
		CONTINUE TRIPPING IN 2" DUMMY PIPE.
2143		COMPLETED TRIPPING IN 2" DUMMY PIPE.
2148		CONNECTING 4" WASHPIPE TO TRY AND PULL FREE.
2155		PREPARING TO HOOK UP THE VIBRATOR.
2230		BEGIN UTILIZING VIBRATOR TO BREAK WASHPIPE LOOSE.
2300		COUPLING ON WASHPIPE JUST BELOW VIBRATOR IS BEGINNING
		TO BREAK. DRILLER WELDING COUPLING OVER JOINT
		TO KEEP SECTIONS TOGETHER.

[signature] 11/30/92

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 11/30/92

DAILY ACTIVITIES REPORT

SUBJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: DAVE WILSON / DAVID WATKINS
	OVERSIGHT FIRM: CDM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 12/1/92
	PAGE: 1 / 2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0740		Dave Wilson arrived on site. D. Wilson got a call from
		David Watkins last night and D. Watkins said that work would
		not start today until the day shift arrived.
0805		Day shift drillers arrive on site.
0840		D. Wilson + driller ask. Shirley Burdick to get a D8 dozer
		for the job. Ken Lombard OKayed it.
0918		Mike Jones said that Ray Abercrombe would be on site
		at 1200 hrs.
0930		Water level in MSB-3D = 130.98' TOC
0935		water level in MSB- = 130.46' TOC
0948		D. Wilson suggests that the crew slope back the sides of
		the entrance pit to conform with OSHA regulations.
1000	1016	Terry Walton and Col. Gallagher on site for visit
1018		Ray Abercrombe and K. Lombard on site
1055		K. Lombard said that the crew needs to slope back the
		sides of pit and to put a barricade around it.
1151		The dozer is hooked up and they will try to pull
		the pipe at noon.
1210		The dozer tried to wrench the pipe out however it
		Failed. The crew will now attach the vibratory hammer.
1228		The crew pumps mud down the bore hole before starting
		the hammer.
1130	1230	Chuck Fanning and Mike Berry of SRS on site
1240		The crew is straightening the pull point on the pipe
		D. Wilson breaks for lunch.
1328		D. Wilson returns from lunch. Crew is pulling pipe again.
1341		≈10' of pipe came out (TSP) out of the hole.
1354		The crew unhooks the dozer and they will try to pull the

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12/1/92

DSR 30-3 (Rev 12-88)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Wilson / Dan Watkins
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/1/92
	PAGE: 2/2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1354		pipe with the rig.
1411		the drill rig was not able to pull the pipe.
1437		The crew hooks up the dozer to the pipe again.
1458		The dozer can't pull the pipe either and the crew
		hooks up the vibratory hammer again.
1514		John Walker of CDM Federal arrives on site. The crew
		starts the hammer and the pipe appears to break.
1600		The wash pipe broke ≈ 4 joints are down hole. The
		crew orders 2 more fishing tools and will remove
		remaining pipe tomorrow.
1700		D. Wilson leaves site

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-1-92

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: CHERRINGTON ENVIRONMENTAL
	DRILLER: RAY ABERCROMBIE / MIKE JONES
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: DAVE WILSON / DAWN KABECK
	OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 12/2/92
	PAGE: 1/2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0720		D. Wilson arrives on site. He meets with Ray Abercrombe and arranges to meet with him and Dawn Kabeck for lunch.
		D. Wilson states the following.
		(1) The used pipe needs to be washed.
		(2) The pit need to be dressed up - sloped back some more
		(3) The crew needs to cement wells #1 and the abandoned well #2. The abandoned well was not grouted because it was too muddy to get a truck in to grout it. It has been affirmed that the crew may grout in the drill pipe in the abandoned well.
0835		Miles Denham on site
0854		Mike Jones off site. The crew has pumped 4 bags of filter sand down well #1
		60 ft 3 x 100 lb bags
		50 ft 2 x 100 lb bags
		3/8" Hole Plug - bentonite (Barpid)
		40 ft - 1 bag 50 lbs
		- Waiting for cement mixer
1103		D. Wilson is informed that the fishing tools have been lost in shipment.
1135		The fishing tools have been located in Atlanta, they should arrive in Augusta at 1420 hrs.
1225		D. Wilson met with Ray Abercrombe and Dawn Kabeck and Miles Denham. Dave and Ray updated them on the status of the well. Dawn suggested that Miles and Dave go to the core lab and see what if they could find what
	1315	was causing the fluid loss.

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-2-92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: HORIZONTAL DRILLING TECHNICAL OVERSIGHT	DRILLING SUBCONTRACTOR: CHEMNIZOTON ENVIRONMENTAL
	DRILLER: RAY ABERNATHY / MIKE JONES
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: DAVE WILSON / ANTONIATTIS
	OVERSIGHT FIRM: COM FEDERAL
LOCATION: M-AREA SEEPAGE BASIN	DATE: 12/2/92
	PAGE: 2/2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1330	1530	D. Wilson went to the core lab with M. Denham.
1535		Returned to the site
1650		The fishing tool will not arrive in Augusta until
		1820 hrs. The drillers will not do any work until
		tomorrow
1718		D. Wilson leaves the site
		Core Lab Notes
		MHT 1C
		100'-102' clayey sand. some loose - some very hard
		102'-104' loose sand - white clay lumps
		104'-106' loose sand with clay
		106'-108'
		108'-120' Very hard clay some sand
		Well Basin Location
		MSB 57D - SE
		MSB 1A-C - S
		MSB 60D - SW
		MSB 4 - W
		MSB 59D - NW
		MSB 22 - N
		MSB 3B - N
		MSB 58D - NE

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-2-92

OMB 30-1 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Charrington Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Wilson / Dan Watkins
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/3/92
	PAGE: 1 / 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0703		D. Wilson arrives on site. The crew is preparing the fishing tool.
0741		There was a hydraulic leak of the drill rig. The fluid leaked on the plastic. The drill crew will pump the leaked fluid into a 55-gal drum. Miles Denham is on site.
0902		The hydraulic fluid is still not picked up but it is on the plastic. EMTC is bringing out a 55-gal drum and absorbant. The rig is working again and the crew should begin the retrieval efforts soon. M. Denham leaves site.
0930		Retrieval efforts begin.
1036		The mud pump engine was inoperable up to this time. The crew has gotten the engine running and are not continuing fishing operations
1055		The fishing tool hooks up to the broken pipe at about 46'. The crew now is going to set up to pull with hammer and dozer.
1124		Recovery operations continue. The hammer + dozer are hooked up to the pipe.
1130		After vibrating and pulling for a couple of minutes, the crew decides to cut off the anchor casings at the rig. The anchor casing are the 4" washover pipes that the crew drove into the ground to anchor the rig.
1132		Pulling resumes.
1150		No luck so far. Drillers break for lunch.
1212		Resume work. Larry Gilbert is operating the dozer. Ray Abercrombe told D. Wilson that EVI operation of the dozer is acceptable to the dozer operators.
1235		Chuck Fanning + Assoc. of SRC is on site

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-3-92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Wilson / David Watkins
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/3/92
	PAGE: 2/3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1255		The crew is going to get another dozer to help pull the pipe
1324		Resume pulling with 1 dozer
1335		The crew stops (RD) stops pulling. They will pump mud down the hole and wait for additional dozer.
1353		M. Denham on site
1400		M. Denham leaves site
		Hank Kenhison Buch Carlson } WSRC personnel on site Wilson Wheelstone
1420		2nd dozer arrives on site
1430		Crew starts pulling with 2 dozers
1535		Wash pipe breaks
1553		Crew pulls broken pipe and upper fishing tool out.
1612		The crew has recovered the lower fishing tool.
1715		They have recovered 13 joints below the lower fishing tool. There are 28 joints left in the hole
1730		The crew begins tripping in fishing tool again.
1742		David Watkins arrives on site.
1754		D. Wilson signs over log to D. Watkins
1821		Fishing tool reaches broken stem at ≈215'. Drillers hook fishing tool to (RD) pipe. They attempt to move pipe with drill rigs however the pipe is still stuck.
1841		No movement of pipe yet. The crew hooks up pump to pump all mud out of the Drill Pit. They also prepare to hook up vibratory hammer.
1845		Crew takes short break while pump pumps (RD) out drill pit.

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-3-92

OSR 36-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Technical oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Wilson / Anderson
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12-3-92
	PAGE: 3/3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1858		Mud pit dry
1905		Crew digs out loose mud from pit
1925		Pulled joints 19, 20, and 21. Rig is moved to hook up dozers.
1930		Driller attempting to pull off top section of 2" pipe has broken loose 2" pipe. At least 4-5 joints are in the ground. Driller attempts to screw pipe back together by hand.
1945		2" pipe reattached. Drillers hook up vibrator and 2 - D8 dozers in tandem.
2015		Begun pulling on pipe. The pipe breaks at the coupling where plate connects to pipe. Driller break for dinner.
2045		Crew back at work. They are fabricating a new pull plate.
2135		Crew hooks up new pull plate and reattaches the vibrator.
2140		Begin pulling and vibrating the pipe again.
2157		The pipe gives suddenly and it appears that it has broken off slightly below the surface.
2205		Drillers stop work for the night. D. Watkins leaves site.

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-3-92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: Dave Wilson / David Watkins / Tim Turner	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/4/92 / PAGE: 1 / 3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0730		Dave Wilson arrives on site.
0750		Crew begins pulling wash pipe from hole.
0821		The break occured at the joint between the bent wash pipe and the fishing tool. In other words, they lost the fishing tool. At this time, there are 28 pieces of wash pipe and 1 fishing tool left in the hole. The box joint of the fishing tool broke off on to the pin of the wash pipe.
0830		They are going to see if they can spear the fishing tool with the 3rd fishing tool.
0845		Crew begins pulling 2" pipe from hole.
0939		David Watkins arrives on site. Dave Wilson signs over log to David Watkins.
1020		Finish pulling 2" Dummy String.
1030		David Watkins, Dave Wilson, and Ray Abercrombe talked to Dawn Kaback on the phone. They decide to do the following:
		① Retreive the fishing tool and any wash pipe that comes with it.
		② Go back in with drill tool on 2" pipe and push the hole out ≈ 260 feet past the end of the broken string.
		③ Install 3" pvc screen and casing down the hole such that at a minimum, 240 feet of screen must project down past the casing left down the hole.
1054		Drillers go back down hole with the spear.
1137		Spear reaches fishing tool. Drilles tap spear into fishing tool

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-4-92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Wilson / David Watkins / Tim Turner
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/4/92
	PAGE: 2/3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1147	1225	Break for lunch
1225		Drillers pull on pipe to with drill rig to see if
	1258	spear is secure. The spear appears to be attached.
1258		Preparing to break off 2 sections of wash pipe
		to hook up dozer and shaker.
1312		Hooking up dozer only to pull on pipe.
1320		Begin pulling on pipe
1327		Pipe separates down hole. Unsure of where
		separation occurred.
1340		Drillers reattach spear with drill rig.
1350		Drillers move rig. The dozers are hooked back up to
		the pipe. The dozer operators said that they had put
		very little pressure on the pipe when it pulled out
		the last time.
1400		Dozer begins pulling on pipe. Pipe breaks loose
		down hole. More pressure was put on line this time
		than last. It is unclear if the spear pulled loose
		or if pipe below the spear broke. Either way, a
		coupling broke, entire pipe did not move, release
		was too abrupt.
1410		Drillers move rig back into position.
1412		Tim Turner arrives on site
1420		Drillers have reattached spear to fishing tool and are
		attempting to back the fishing tool off the broken
		section.
1430		Drillers appear to have success in backing off fishing tool.
		The begin pulling tools
1515		All wash pipe above and including the fishing tool are

TECHNICAL OVERSIGHT SIGNATURE: Tim Turner DATE: 12-4-92

DOE 30-3 (Rev. 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Technical Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Wilson / David Watkins / Tim Turner
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/4/92 PAGE: 3/3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1515		out of hole
1530		Miles Denham on site. D. Watkins discuss the drilling plan with him.
1555		Driller grouts well #1. He uses 8 bags of sand, 1 bag of bentonite, and 6 bags of cement. Estimated density of grout 14.2.
1600		David Watkins signs over log to Tim Turner
1630		Drillers begin tripping down the hole. They hook up the initial directional piece and start adding drill rod.
1715		8 rods in the ground. water truck leaves site for water.
1800		17 rods in the ground. water truck returns.
1820		19 rods in the ground. The drill rods have reached the top of the old washover pipe. The drillers are trying to push the rods into the washover pipe. Depth is approximately 195'.
1840		Drillers can't get rod to fit into the washover pipe. They will try again tomorrow. End for the day.

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-4-92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: David Watkins / Tim Turner
	OVERSIGHT FIRM: COM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/5/92
	PAGE: 1/2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0700		Tim Turner arrives on site
0730		Drillers set up equipment etc. They plan to install overwash pipe down to the old overwash pipe that is in the ground. They have made a washover pipe with a bell shaped end which will be used to fit over the end of the old pipe in the ground. The new overwash pipe will act as a guide for the drill wash rods and eventually for the well screen + casing.
0745		Drillers start adding washover pipe.
0835		18 rods (TRT) wash over pipes in the ground. Drillers stop to get water.
0845		Water truck returns. Drillers resume pushing the washover pipes. (TRT)
0915		Driller thinks that washover pipe has made contact with old washover pipe in the ground. Drillers now try to push drill rods. [19 washover pipes are in the ground]
0930		Driller determines that the washover pipe has not made contact with the old pipe. They remove 1 drill rod and suspend the others with a cable. They add an additional washover (in the hole) (TRT) pipe to try to make contact with the old washover pipe. (TRT)
1025		The first additional washover pipe is added.
1050		Drillers only push washover pipes about 1-2 ft. and they think that they are at the top of the old pipe again. They will try to push drill rods into old pipe again.
1130		Drill rods again meet resistance. Drillers do not

TECHNICAL OVERSIGHT SIGNATURE T R DATE 12-5-92

OSR 30-3 (Rev 12-88)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: David Watkins / Tim Turner
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/5/92
	PAGE: 2/2

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1130		think that the TAR new washover pipe has reached the
		old washover pipe in the ground. They will add more
		washover pipe and try to reach the old pipe.
1145		Drillers add the 1st additional washover pipe.
1245		20 washover pipes are in the ground. Drillers think that
		they have made contact with the old washover pipe.
		They will try to push the drill wash rod.
1305		Drillers are successful on this attempt and get past
		the top of the old washover pipe. They take a
	1320	short lunch break.
1320		Drillers return from break. They start pushing drill rod.
1635		Drill rods are near the end of the old washover pipe.
		49 rods are in the ground. Water truck leaves site for water
1650		Drill wash rod; hit an obstruction. It is probably the
		hook that broke off during the washover pipe retrieval
		efforts. The driller is trying to wash the obstruction
		out of the way.
1700		Drillers get past the obstruction. Tim Turner signs
		log over to David Watkins.
1707		water truck returns.
1709		Although the drill bit is past the obstruction, the
		possibility exists that the hook could wash back into the
		hole and block the removal of the bit from the hole. This is
		because the BHA is 3.5" in diameter and the drill rod is 2".
1730		Drillers stopping work for the day. will start tomorrow at 7:00 am
		Drill bit is sitting at the end of the wash pipe so it should
		not get stuck.
1735		David Watkins leaves site.

TECHNICAL OVERSIGHT SIGNATURE Tim Turner DATE 12-5-92

OSR 30-3 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Tech. Oversight

DRILLING SUBCONTRACTOR: Cherrington Environmental

DRILLER: Ray Abercrombe / Mike Jones

WELL NUMBER: AMH-6

TECHNICAL OVERSIGHT: David Watkins / Tim Turner

OVERSIGHT FIRM: CDM Federal

LOCATION: M-Area Seepage Basin

DATE: 12/6/92

PAGE: 1/5

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0700		Drillers arrive on site
0705		David Watkins arrives on site
0715		Crew starting up and warming up equipment.
		Temp ≈ 24° F clear skies
0825		Drilling begins. Drillers start by pushing rod #49 back down the hole. (TRT)
0912		55 rods in the ground. Calculations - if 28 wash pipe sections are broken off in ground, and 20 sections of new pipe were added to complete the section, Then 480 ft of wash pipe is in the ground. Therefore, to get the 240 ft minimum screen length past the wash pipe, the drilling must advance to a minimum depth of 720 ft below the ground collar
0959		Drill bit reaches joint #63 or 645 ft down hole. All drilling was very easy as this is where the (TRT) previous drilling had stopped. Drillers Fabricated new clamp for where survey wire is connected to drill head on rig. clamp is leaking mud.
1020		Drilling resumes on joint #63
1025		Signal from survey tool has stopped. Drillers attempt to locate source of service interruption.
1028		Loose connection found. Drilling resumes.
1058		640 ft in ground. stopped drilling because of lack of drilling mud. Waiting on water truck (Drillers attempted to aquire an extra water truck from EMTC on 12/5/92 evening but none were available. Lack of mud could become a major problem today in Finishing this hole)

TECHNICAL OVERSIGHT SIGNATURE: T. Turner DATE: 12-6-92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

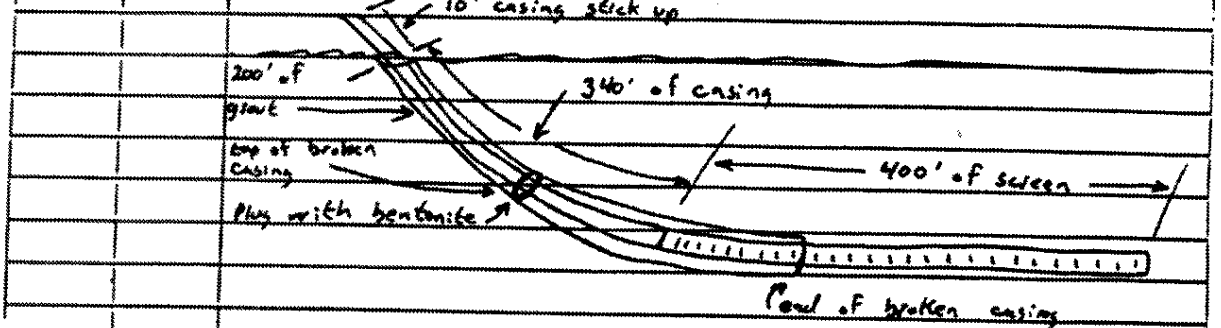
SUBJECT: Horizontal Drilling Tech. Oversight
DRILLING SUBCONTRACTOR: Cherrington Environmental
DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: David Watkins / Tim Turner
OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin
DATE: 12/6/92
PAGE: 2/5

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1116		Water truck returns. Begin mixing mud
1129		Water truck empty. Truck leaves to get more water.
		Drillers resume drilling.
1200		Water truck returns. 66 rods in the ground.
1248	1310	68 rods in the ground. Drillers break for lunch.
1310		Drillers return to drilling. Water truck leaves to
		get water.
1345		Water truck returns. Drillers layout 3" PVC screen +
		casing.
1350		Inventory of screen and casing.
		1 - 0.5' sump plug (3")
		7 + 13 - 3" PVC well screen (20' lengths) = 400 ft
		8 - 3" PVC casing (20' lengths) = 160 ft
		19 - 3" PVC casing (10' lengths) = 190 ft
		750 ft
		* Adding (TR) 140' +20' of screen for getting casing to surface.
1400		The plan for well installation is as follows:
		① Complete drilling to 74 joints (755 ft)
		② Install 400' of 3" screen (260 ft will extend beyond the 4" wash over pipe.)
		③ Install 350' of 3" casing (10' will stick up above the ground) for a total of 750 ft of well screen + casing (* Note: screen will be 140' back into the broken casing because (TR) there is only 350' of a 3" PVC casing on site and it would take days to get more.)
		④ Plug the top of the broken casing with bentonite

TECHNICAL OVERSIGHT SIGNATURE: Tim Turner DATE: 12-6-92

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Tech Oversight
DRILLING SUBCONTRACTOR: Cherrington Environmental
DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: David Watkins / Tim Turner
OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin
DATE: 12/6/92
PAGE: 3 / 5

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1400		and grout the remaining hole to the surface
		
1430		Spoke with Ray Abercrombe about location of fluid loss when drilling wash pipe. He said that loss of fluid occured due to a void at about joint #43 of wash pipe. As per D. Watkins note of 0143 on 11/30/92, D. Watkins estimated that based on water usage, the structure was between joints #42 - #44. This agrees with what Ray says. Also Ray said that the loss of fluid occured on almost the same joint (#43) in all of the holes drilled for this project. This agrees with a theory of D. Watkins that a structure passed between the drill collar and the M-Area seepage basin perpendicular to the trace of well borings and in proper locations.
1435		71 rods in the ground. water truck returns.
1437		It has been proposed that a horizontal gravelly layer is responsible for the fluid loss; however, WSRC personnel monitoring nearby vertical wells have been checking the wells daily for drill muds to show up. D. Watkins proposes that if a vertical structure does exist below the M-Area seepage

TECHNICAL OVERSIGHT SIGNATURE: Tim Turner DATE: 12-6-92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: David Watkins / Tim Turner	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/6/92 / PAGE: 4/5

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1437		Basin, the fluids pumped into the vadose zone at this location would move laterally out along the structure and little migration into the surrounding sediments would occur. If the structure were vertical, then it is unlikely that any vertical wells close to the basin have penetrated it. ~~I suggest~~ (TRT) D. Watkins suggests that the estimated trace of the structure be plotted on a map and then see if any clusters, within a resonable distance of the basin, penetrate the estimated trace.
1450		Current temperature is ≈ 47°. Begining to rain lightly
1510		Completed drilling joint #72 add joint #73 this is the last joint before completion of well.
1517		73 joints will put hole about 745' from bottom of hole to drill vice (vice ≈ 5' above ground level) or 740' from drill collar. Broken 4" wash casing bottom is at ≈ 480' and this means that if the well screen is pushed to the end of the hole, it would be 260' beyonnd the end of the broken off wash casing.
1530		Raining steadily
1537		Complete drilling hole #2 at 745 ft. Drillers begin tripping out 2" ~~pilot~~ (TRT) pilot stem.
1850		Tripping out pilot stem continues. Steady rain.
1921		BHA reaches top of hole. Drillers break off BHA. Prepare to run PVC screen + casing down the hole.
1956		Pushing first 14 - 20' screens went quickly (less than 1 per minute). However the pushing came to a stop at screen #15 (≈295' down hole).

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-6-92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: David Watkins / Tim Turner	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/6/92 / PAGE: 5/5

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
2008		Crew can't push screen any further even with drill rig. Crew will now take the following approach:
		① Drill hole in 3" PVC cap and put screw rebar into cap to tie PVC into head so the screen will not slip down hole.
		② Reattach a piece of 4" wash pipe and pump in an attempt to wash mud around the screen.
2016		Cap is attached to well screen (TRT) At this point, it looks unlikely that pvc screen will go down the hole.
2044		Drillers complete washing around 3" PVC screen and add another joint of screen to see (TRT) if washing helped.
2050		Trying to push joint #15 with rig but it is stuck (TRT) stuck. Steady rain. Temperature is ≈ 36° F.
2100		Drillers considering running dummy 2" rod down center of screen to help push screen down hole. Drillers
	2130	break for dinner.
2130		Drillers return from break. continuous rain. Very
		slippery conditions.
2135		Drillers will thin out mud with fresh water to see if
		reduced hydrostatic resistance will help move pipe.
2140		Added joint #16 of PVC screen. Drillers have not yet
		employed thinned mud or 2" dummy rod. They try to push
		with drill head.
2144		Pushing screen very slowly. moved only 2' in 5 min.
2210		Drillers stop work for tonight. They tie off screen so it won't slide down hole.
2215		Drilling will resume at 8:00 am tomorrow. D. Watkins off site.

TECHNICAL OVERSIGHT SIGNATURE Tim Turner DATE 12-6-92

DER 20-3 (Rev 13-89)

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: David Watkins / Tim Turner
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/7/92
	PAGE: 1 / 4

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0900		D. Watkins arrived on site. Drillers arrived at 0815 and have been starting up diesel equipment.
0910		Drillers mix mud.
0915		Begin pumping mud down hole to fill up casing. Begin pushing screen FRP #16. Need to push screen down hole by at least 10' so crew can add a washover pipe to pump thinned mud down around and below the screen.
0930		Still pushing joint #16. Pumping more PHPA mud down screen. Crew cleans up site.
0938		End of screen is at ≈ 310 ft. This is where the BHA was right coming out of the hole (within 20') It could be that this is where sand settles out at the base of the curve. This is where there have been numerous problems with the hole. D. Watkins believes that the curve is very tight here (small radius of < 300') for a limited distance. Suggest we gather survey data and plot with computer instead of by hand. (simple Lotus graph, X-Y, can display both horizontal and vertical movement)
0953		The 3" screen is not moving. Drillers still must push another 3ft before washover pipe can be added. Drillers decide to run 2" dummy rods down PVC screen to push. Drillers must be extremely careful not to push the well plug off the end of the screen.
1000		Drillers begin tripping in 2" dummy rods. There are 96 rods on the rack and 32 rods will be needed to reach the bottom of the well screen.
1020		Still tripping in dummy rods. D. Watkins leaves site to

TECHNICAL OVERSIGHT SIGNATURE: T. M. Turner DATE: 12-7-92

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: David Watkins / Tim Turner
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/7/92
	PAGE: 2/4

START	STOP	DESCRIPTION OF ACTIVITIES: REMARKS
1020		go to Ken Lombard's office to call Dawn Kabeck to give her a status report.
1025		Arrive at K. Lombard's office. D. Kabeck's phone is busy. D. watkins calls CDM Federal office to see if D. Kabeck had called but she has not called.
1040		D. watkins call D. Kabeck again but she has left her office.
1044		D. watkins arrives back on site. Drillers are still tripping down the dummy rods. 23 rods in the hole.
1104		2" Dummy rod reaches bottom of screen. 32 joints are in the ground and 1 joint is sticking out of screen. Drillers take short coffee break. Rain has stopped. It has been raining all morning. Temperature is about 40°F. Forecast is to clear in the afternoon.
1123		Drillers back to work. Rigging up to add 4" washover to pump mud down hole. Pulled 3" screen joint #16 back off.
1202		Added screen joint #16 back on.
1347		Break for lunch. Just added 3" screen #20 for a total of 400 ft.
	1410	
1410		Drillers go back to work.
1435		All of the screen has been installed. Drillers now add PVC casing.
1516		Halfway through joint #24. End of screen passing end of casing.
1548		Miles Denham on site. D. watkins informed M. Denham of Drilling status. 510' of screen + casing is in the ground
1604		Tim Turner is on site. D. watkins signs over to TT

TECHNICAL OVERSIGHT SIGNATURE: [signature] DATE: 12-7-92

OSR 30-3 (Rev 12-89)

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Tech. Oversight
DRILLING SUBCONTRACTOR: Cherrington Environmental
DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: David Watkins / Tim Turner
OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin
DATE: 12/7/92
PAGE: 3/4

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1604		log book to Tim Turner
1830		Pushing the well casing is very hard. Drillers are at
		≈ 700' and will attempt to push at least 30 more feet.
1900		Drillers make 2 attempts at pushing last 10' (from
		710' to 720') however the pipe wrenches used to push
		the casing slip after pushing only 5'. The well
		casing is compressed and when the wrenches slip the
		~~pipe~~ casing (ART) springs back to its original position. The drillers
		can advance the well no further.
1905		T. Turner calls Dawn Kabeck and tells her of
		the situation. She says that it is OK to end
		the well at 230' past the end of the broken washover
		pipe instead of the 240' as originally planned.
1910		Drillers trip out washover pipe.
1915		Washover pipe is stuck. Drillers rotate washover pipe and
		decide to leave a portion of the pipe in the hole.
		They pull out as many pieces of pipe as they can and
		it turns out that 15 pieces of pipe are left in the
		hole in addition to the (R) washover pipe which had
		broke in the hole. They decided to leave the pipe
		in the hole to avoid damaging the PVC well screen +
		casing already in the hole during extensive retrieval
		attempts. The additional pipe in the ground should
		not be any problems since this portion of the well
		will be grouted.
1940		Finish removing all but 15 pieces of the new washover
		pipe.
1950		Drillers trip out drill wash rods.

TECHNICAL OVERSIGHT SIGNATURE: T T R DATE: 12-7-92

OSER 30-5 (Rev. 12-88)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: David Watkins / Tim Turner
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/7/92
	PAGE: 4 / 4

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
2025		Drillers ~~finish~~ stop (TRT) removing drill wash rods. End work for the day. Tim Turner off site.

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-7-92

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: David Watkins / Tim Turner
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/8/92
	PAGE: 1/1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0830		David Watkins on site. Crew begining clean up operations.
		They are preparing to bentonite and grout hole #2.
		Because they left some additional washover casing down hole,
		they will put bentonite at both the top of the
		casing break and at the top of the section they
		left in the ground. They will use 3/8" bentonite
		chips. They are currently tripping out 2" dummy
		pilot string.
0925		Miles Denham on site
0940		M. Denham off site
0947		D. Watkins calls Dawn Kabeck however she is at a
		meeting.
1015		Drillers complete tripping out of 2" dummy pilot string.
1025		Crew begins site demobilization.
1100		Crew loads vibrator and power plant onto flatbed truck
		with crane. Truck moves to decon area for steam
		cleaning.
1135		D. Watkins leaves site to call D. Kabeck.
1138		D. Kabeck is still in meeting.
1140		D. Watkins arrives on site. Crew begins decon of vibrator.
1158		D. Watkins off site.
1330		D. Watkins on site. Mike Jones leaves site to take Larry to
		airport. Crew places tremie down hole.
1500		Tremie in place at 200' down hole.
1645		Crew installs 5 bags of bentonite at 200' (a 3 bags was got stuck in tremie)
1712		crew installed 1 bag of bentonite at 58'. They will place more
		tomorrow morning.
1730		Drillers end for the day. D. Watkins off site

TECHNICAL OVERSIGHT SIGNATURE: T. Turner DATE: 12-8-92

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: David Watkins / Tim Turner
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/9/92
	PAGE: 1/1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0730		Tim Turner arrives on site. Drillers are placing sand from about 50' to 25' below where the casing unscrewed (50') Blew 8 bags of sand (2 per 10' extra to above screw then 8-10 bags).
0830		Drillers place 3 bags of bentonite from about 45' below ground surface.
0930		Bentonite placement is complete. Drillers hydrate bentonite with about 10 gallons of water. Cement truck will be on site to grout the hole at 1:00pm today. T. Turner returns to CDM FPC office.
1330		T. Turner returns to site.
1345		Cement truck arrives on site. Drillers have set up tremie in abandoned well hole. They pump grout into the abandoned well. Hole tagged at ±200' Drillers estimate grout weight at 15-17 lb/gal.
1445		Complete grouting of abandoned well hole. Used ≈5 yds of cement grout. Drillers move to well #2 and start grouting. Hole tags at 240' below ground surface.
1555		Complete grouting of well #2. Holes are grouted up to the bottom of the drill pits.
1615		Well #2 topped off with remaining grout. Hole grouted up to about 4' below ground surface. Drillers end for day after cleaning up site. They expect to begin well development on Saturday 12-12-92. Tim Turner leaves site.

TECHNICAL OVERSIGHT SIGNATURE T J R Turner DATE 12-9-92

GSR 30-3 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: David Watkins / Tim Turner	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/10/92 / PAGE: 1/1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1530		D. Watkins on site. Crew is cleaning up site, deconing equipment and demobilizing. D. Watkins speaks to Mike Jones about the plans for well development. M. Jones says they had been deconing + demobing all day today. The plan for the next few days will be as follows:
		① Friday 12/11/92. Continue to decon + demob. D Watkins will check on them in the afternoon to check progress.
		② Saturday 12/12/92. Crew will begin pad construction on one of the wells and develope the other well. D. Watkins will be onsite.
		③ Sunday 12/13/92 Crew will construct pad at developed well and will develope the other well.
		④ M. Jones said that there are several techniques that they could use to develope the wells. D. Watkins suggested that they pump fresh water down the well and blow out with air. This is the technique that they will use.
1555		D. Watkins leaves site.

TECHNICAL OVERSIGHT SIGNATURE _____ DATE 12-10-92

OMB 30-3 Rev 12-88

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: David Watkins / Tim Turner
	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/11/92
	PAGE: 1/1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1600		D. Watkins arrives on site to check progress of drill crew. Plan is still to start well development tomorrow morning. D. Watkins will be on site ≈ 7:00 a.m.
1620		D. Watkins leaves site

TECHNICAL OVERSIGHT SIGNATURE T J R T DATE 12-11-92

GSR 30-3 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: David Watkins / Tim Turner	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/12/92 / PAGE: 1/3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0720		David Watkins on site. Crew is already on site dressing out. Mike Jones has left site to find PVC tremie to reach the bottom of the wells. He will probably get it from EMTC.
0814		M. Jones returns with tremie PVC pipe. Drillers planning to develope both wells today and set the forms tomorrow.
		⊛ one problem is that muddy soil was used to fill in the drill sumps. The soil was saturated from all of the recent rains. It would be unwise to build the concrete pads over the soft ground.
		⊛ water removed from the well during development will be containerized for disposal.
		⊛ Crew will push a 6" polypropylene 'pig' down hole #2 to plug end of well where screen cap was pushed out.
0910		Crew begins placing tremie down well #1
1020		Drillers have installed 580' of 2" pvc down hole. Once pipe has reached 330' down hole, crew began pumping fresh water with each joint added. End of 2" tremie has a pointed plug on end with ¼" holes drilled into it and angled back up the hole
		
		2" pipe → 6" pointed plug
		The angled holes will serve both to pressurize water as it comes out, thus cleaning the screen, and will force water back up hole (TRT) as air is injected. Once pipe reaches end of the hole air will be forced in and the pipe will be extracted. As of 580 ft

TECHNICAL OVERSIGHT SIGNATURE T. R. Turner DATE 12-12-92

OSR 30-3 (Rev 12-88)

DAILY ACTIVITIES REPORT

SUBJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: David Watkins / Tim Turner	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/12/92 / PAGE: 2/3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1020		no water has come back out of the well. Crew has pumped 1000 gallons down hole. Stopped to fill water truck.
1045		Water truck returns. Resume well development.
1136		Drillers trip pipe back to 580 ft and pump again.
1210		Crew trips all of tremie out of well #1 because plug end may be clogged.
1225		complete tripping out of hole. Water truck leaves to refill (¼ tank TRT or 500 gallons of water was used) so far a total of 1500 gal has been used.
1230		Crew is tripping in the tremie with an extra 5' joint attached to the end with extra perforations (¼" holes) drilled into it.
~~1256~~ TRT		
1252		Water truck returns, 33.5 joints of tremie down the hole. Begin pumping water.
1335		Stopped pushing tremie at 595' so water truck can get more water (2500 gal used so far)
1400		Water truck returns continue pumping tremie.
1425		Drillers break for lunch. During last down time, waiting for water, sand being forced back up the well apparently settled back down around the TRT tremie. The tremie is now stuck when work resumed. There appears to be more sand TRT in the well than the pump has pressure to flush out because there are no returns flowing to the surface.
1430		During lunch, M. Jones is examining the options to the current mode of development. In retrospect, drillers should have run

TECHNICAL OVERSIGHT SIGNATURE T. Turner DATE 12-12-92

OSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombie / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: Dave Watkins / Tim Turner
	OVERSIGHT FIRM: COM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/12/92 PAGE: 3/3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1430		2" drill stem to the bottom of the well as soon as it was installed and flushed with fresh water until return water was clear.
1440		Drillers back to work.
1505		Tremie at 61 joints (615') still no returns. D. Watkins suggests the possibility of using a Gruen submersible pump attached to the end of the 2" tremie, pushed down the well, TRT sucking mud up the center while fresh water is pumped down the outside of the tremie. They will likely need a hose up the tremie for water to travel in it to maintain velocity. Drillers are now trying to blow tremie with air to see if any returns come back.
1520		Drillers trip out tremie at 635'
1522		M. Jones pulls (TRT) will pull out all of the tremie and stop for the day. He will call Ray Abercrombe for his opinion and give D. Watkins a call tonight.
		(*) Note: At this point it appears that simply blowing water down the well and forcing the fine sand out into the formation is not the answer. The sand will simply come back in. We need either a centralized vacume system or a stronger pump than the Weldon currently being used. A third option would be to turn the Weldon pump around and have it draw water out of the well starting at the top of the screen and working down while water flows down the outside of the tremie by gravity feed.
1545		All tremie out of hole. David Watkins off site.

TECHNICAL OVERSIGHT SIGNATURE: Tim Turner DATE: 12-12-92

DSR 30-2 (Rev 12-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6 — TECHNICAL OVERSIGHT: David Watkins / Tim Turner	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basin	DATE: 12/13/92 — PAGE: 1/1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
		No oversight today. Drill crew is spending the day setting up forms for concrete pads.

TECHNICAL OVERSIGHT SIGNATURE [signature] DATE 12-13-92

OSR 30-3 (Rev 12-88)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6 / TECHNICAL OVERSIGHT: David Watkins / Tim Turner	OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basins	DATE: 12/14/92 / PAGE: 1/3

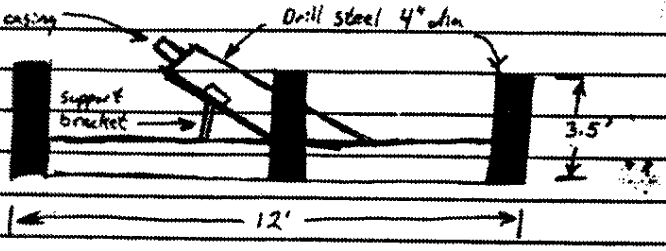
START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0720		David Watkins on site. Crew setting up to run tremie back down hole #1. ① They will push tremie until they reach sand and pump 10' of water and attempt to blow with air to see if any returns come back. ② Move and try the same at hole #2. ③ Call for concrete truck or get EMTC to construct pads ④ Ray Abercrombe will discuss options with Dawn Kabeck this morning.
0750		D. Watkins attempted to call D. Kabeck this morning but she was not in yet.
0755		Drillers reinstall tremie in hole #1. Crew did not finish constructing concrete pads on Sunday 12/13/92 due to in adequate pump.
0812		Crew has installed tremie to 360'. They will try to blow sand out here.
0824		D. Watkins tried to call D. Kabeck but she is not in her office.
0826		Crew ready to blow air in hole #1
0834		No returns, Air is forcing water and sand out of screen but not up the hole.
0840		Crew preparing to trip tremie out of hole #1 and will try the same in hole #2. ④ Note: when crew sets up on hole #2. They will not attempt to push the 'pig' (TRT) ~~Screen~~ until the screen has been ~~Attempt~~ (TRT) cleaned.
		The pads are 6' x 12' x 6" and are surrounded by 6 posts made of 4" drill steel. The crew inserted a section of 4" drill steel over the well casing to

TECHNICAL OVERSIGHT SIGNATURE: T. Turner DATE: 12-14-92

OSR 30-3 (Rev 11-89)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight
DRILLING SUBCONTRACTOR: Cherrington Environmental
DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6
TECHNICAL OVERSIGHT: David Watkins / Tim Turner
OVERSIGHT FIRM: CDM Federal
LOCATION: M-Area Seepage Basins
DATE: 12/14/92
PAGE: 2/3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0840		provide support to (for) PVC. Also, the drillers added a steel support bracket.
		
0946		Crew has inserted 360' of tremie down hole #2
		They begin pumping water down the hole.
0951		Crew blows air down the tremie. No returns.
1005		D. Watkins leaves the site to call D. Kabeck.
1010		D. watkins talks to D. Kabeck and told her of the situation.
		D. watkins suggested using a pumping system (Ground Fos 2" Pump). D. Kabeck said that Graves has this kind of pump.
		D. watkins said that Ray Abercrombe would call her and he left to tell Mike Jones of the possible solution.
1025		D. watkins leaves the site for the office. M. Jones will call him when he gets an answer from R. Abercrombe.
1430		M. Jones calls D. Watkins and tells him that he and R. Abercrombie have talked to D. Kabeck. The plan is to push the pig in hole #2 down to 705 ft then blow air on the way back out with the tremie.
1500		D. watkins arrives back on site. M. Jones has pushed the pig down to 400' and is proceeding to 705'. M. Jones asks if EMTC can complete the well pads. D. watkins leaves site to call D. Kabeck.
1510		D. Kabeck OKs EMTC completing the pads in the middle of

TECHNICAL OVERSIGHT SIGNATURE: Tim Turner DATE: 12-14-92

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6	TECHNICAL OVERSIGHT: David Watkins / Tim Turner
	OVERSIGHT FIRM: COM Federal
LOCATION: M-Area Seepage Basins	DATE: 12/14/92
	PAGE: 3/3

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
1510		next week. D. Watkins returns to the site.
1515		Crew has pushed 'pig' down to 645 ft. out of water. Water truck leaves
1545		water truck returns.
1550		Crew resumes pushing tremie and pumping water down the hole to help advance the 'pig'.
1610		'Pig' is down to 675' with 30' left to go. 'Pig' is moving slowly but is still advancing. The weldon pump has stopped working. Frank with EMTC leaves the site to see if he can find another pump.
1615		Drillers continue to push the 'Pig'.
1622		Drillers reach 705' with the 'pig.' They trip out the tremie and blow air the entire way out to help clean the screen.
1735		Driller complete tremie removal. They blew air the entire way. No sand came out of well.
1745		D. Watkins and Drillers end for the day. They leave site.

TECHNICAL OVERSIGHT SIGNATURE T. Turner DATE 12-14-92

OSR 30-2 (Rev 12-90)

DAILY ACTIVITIES REPORT

PROJECT: Horizontal Drilling Tech. Oversight	DRILLING SUBCONTRACTOR: Cherrington Environmental
	DRILLER: Ray Abercrombe / Mike Jones
WELL NUMBER: AMH-6 & 7 area	TECHNICAL OVERSIGHT: David Watkins / Tim Turner
	OVERSIGHT FIRM: COM Federal
LOCATION: M-Area Seepage Basins	DATE: 12/15/92
	PAGE: 1/1

START	STOP	DESCRIPTION OF ACTIVITIES; REMARKS
0740		D. Watkins on site. Crew is on site and are setting up Eremite at Hole #1. Crew will go in with Eremite and pump fresh water as far as possible.
0815		Crew begins tripping in Eremite.
0840	0845	Crew takes short break.
0845		Crew begins pushing Eremite
0850		Tremie reaches 610 ft and hole gets very tight.
		Drillers begin pumping water.
0907		Tremie reaches 735 ft (745 with above ground stickup), bottom of hole. Crew will now trip out Eremie while blowing air.
1010		Tremie is out of ground. Hole #1 is complete.
1130		D. Watkins leaves site.

TECHNICAL OVERSIGHT SIGNATURE: T. Turner DATE: 12-15-92

APPENDIX C

M AREA HORIZONTAL DRILLING PHOTOGRAPHS

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Oblique View of the MC-90 Drilling Rig with two-inch drill steel in foreground. This view displays the difficulties encountered with operating under spotlights.

Figure C-1. Night Shift Drill Set-Up

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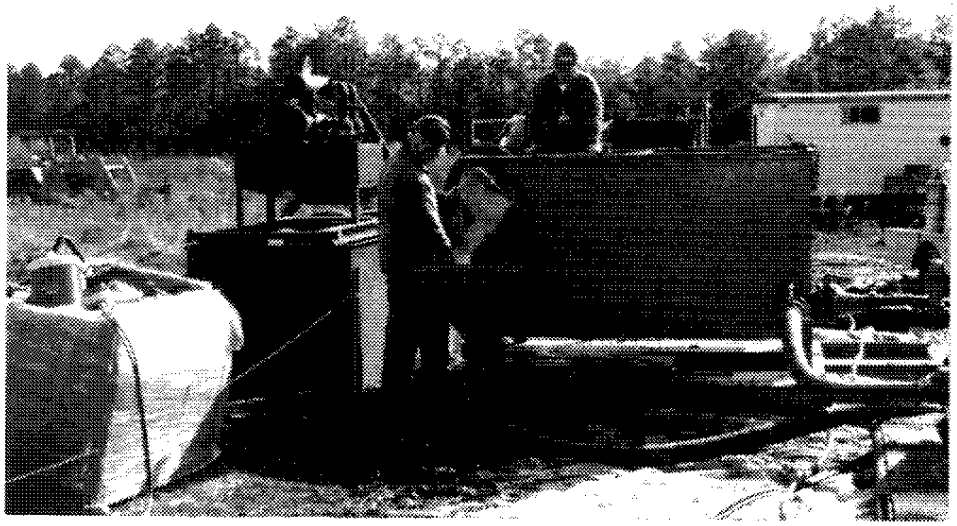

View of mud mixing system with helper adding a bag of guar gum into the hopper to be mixed into the drilling mud.

Figure C-2. Close-Up of Mud System

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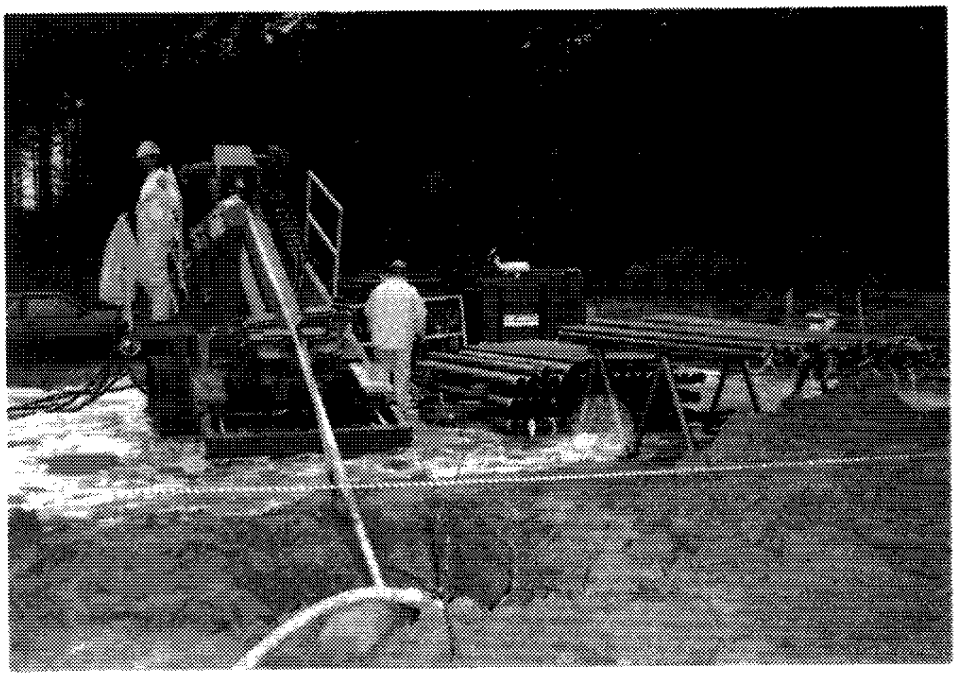

Layout of four-inch and two-inch drill steel on racks. Each layer is numbered sequentially for tracking rod counts. Note the two-inch drill pipe has sections of white survey wire inserted, allowing for easier and faster survey tool connection.

Figure C-3. Drill Steel Racks

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Close-up of the broken end of a section of four-inch washover pipe with quarter for scale. Note how the end is rounded where the driller attempted to advance the pipe after separation. The box of this pipe was left attached to the pin of the pipe below it.

Figure C-4. Broken End of Four-Inch Washover Pipe

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View of fishing tool attached to the end of the four-inch washover pipe.

Figure C-5. Fishing Tool Preparing to be Installed

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The 12" x 16" piece of 3/4 " thick steel is welded onto a section of four-inch washover pipe. This device is then screwed into the four-inch washover string and the vibrating hammer is clamped onto the flat surface.

Figure C-6. Plate for Attaching Hammer to Four-Inch Washover Pipe

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A crane had to be brought in to lift the hammer off of the flat bed truck and place it in the drill pit for installation.

Figure C-7. Crane for Moving Vibrating Hammer

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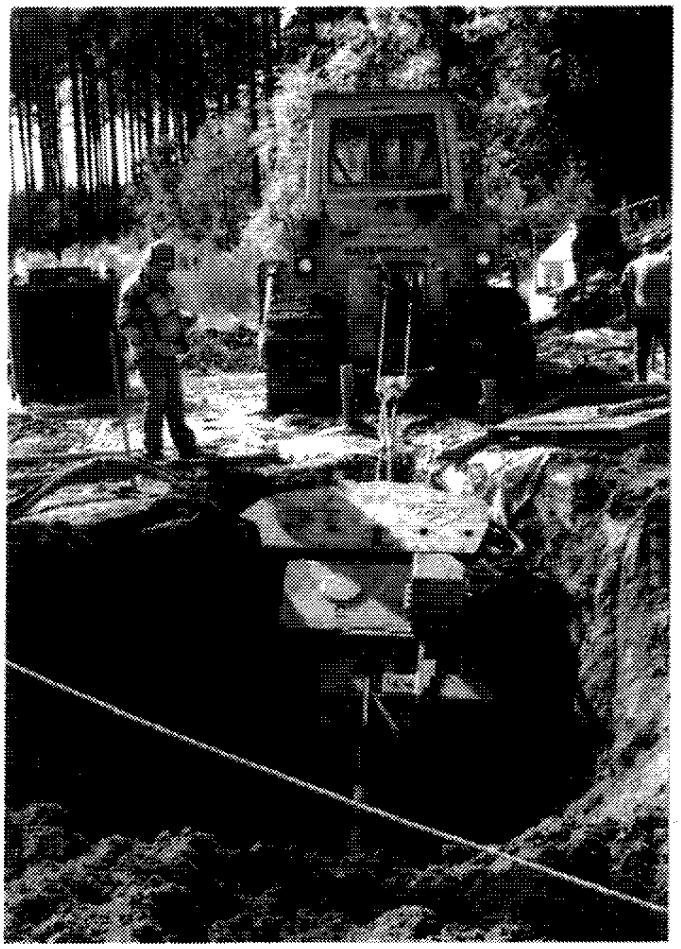

View of the drill pit with the four-inch washover pipe in the foreground attached to the vibrating hammer. The D-8 Bulldozer is pulling on the assembly with little success.

Figure C-8. D-8 Bulldozer Pulling on Stuck Washover Pipe

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The crew had little success pulling on the stuck washover pipe with one bulldozer so a second was brought in. Both machines pulled on the pipe in tandem and succeeded in moving several sections of pipe before the string broke again downhole.

Figure C-9. Two D-8 Bulldozers Pulling in Tandem on Stuck Washover Pipe

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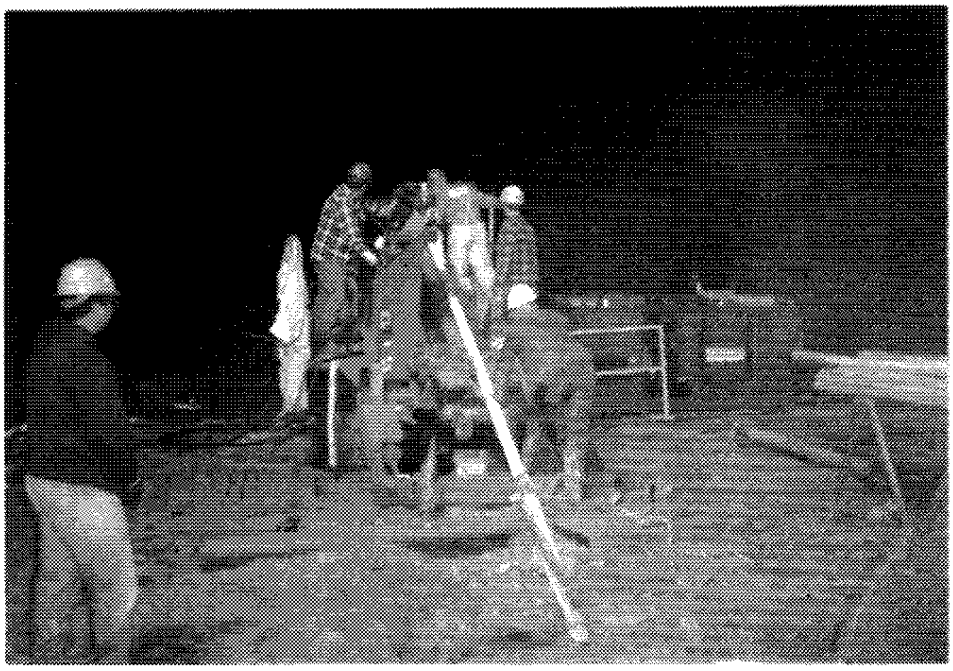

The three-inch PVC screen and casing was installed by hand until the string could no longer be advanced through manpower alone. The drill head on the rig was then used both to pump drilling mud down the screen to reduce hydrostatic resistance and to apply slight pressure on the PVC pipe to advance it down the hole.

Figure C-10. Crew Installing Three-Inch PVC Well Screen in Hole

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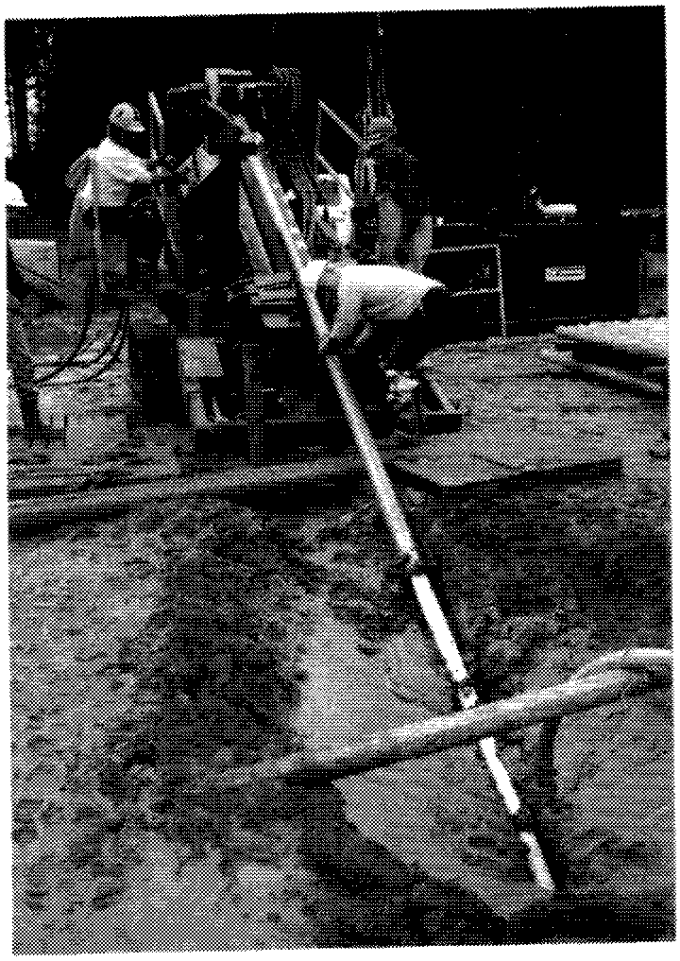

Once the three-inch PVC screen and casing were installed to the end of the borehole, the washover pipe was carefully extracted. On AMH-6, the washover pipe became stuck and the decision was made to leave the pipe in the hole instead of chancing damage to the installed well.

Figure C-11. Four-Inch Washover Pipe Being Extracted from Over Installed Well

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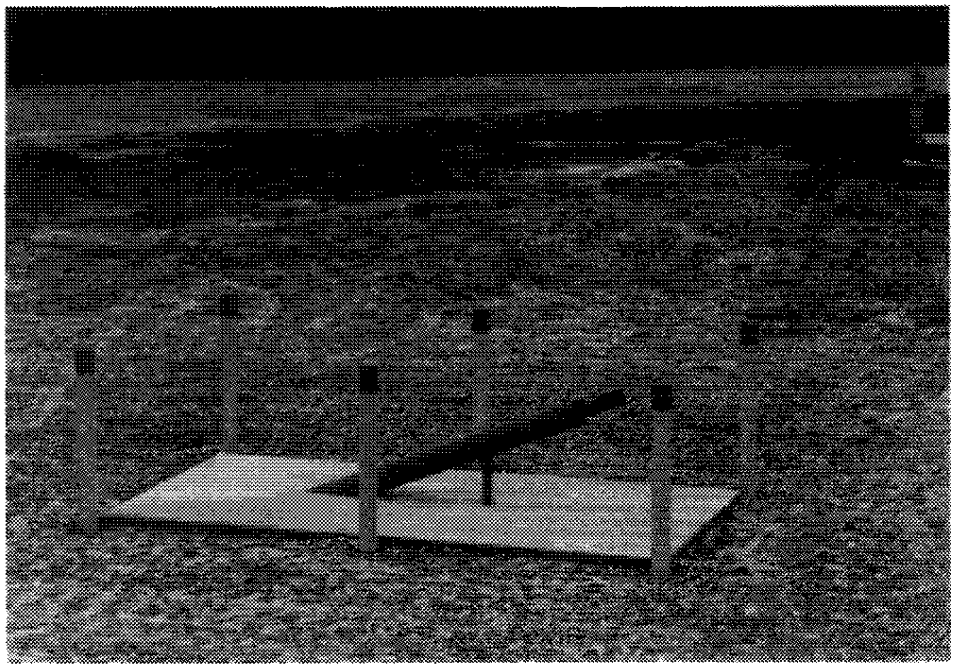

Once all drill steel was removed from the well, the annulus around the casing was grouted to the surface. A 10-foot section of four-inch washover pipe was advanced down the hole, over the PVC Casing for stability and a 3 " thick concrete pad was constructed around the well. A locking cap was then welded to the washover pipe. Six sections of washover pipe were advanced into the ground around the pad and filled with concrete. All steel was subsequently painted for visibility.

Figure C-12. Example of Completed Horizontal Well Pad

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APPENDIX D

HORIZONTAL WELL CONSTRUCTION DIAGRAMS

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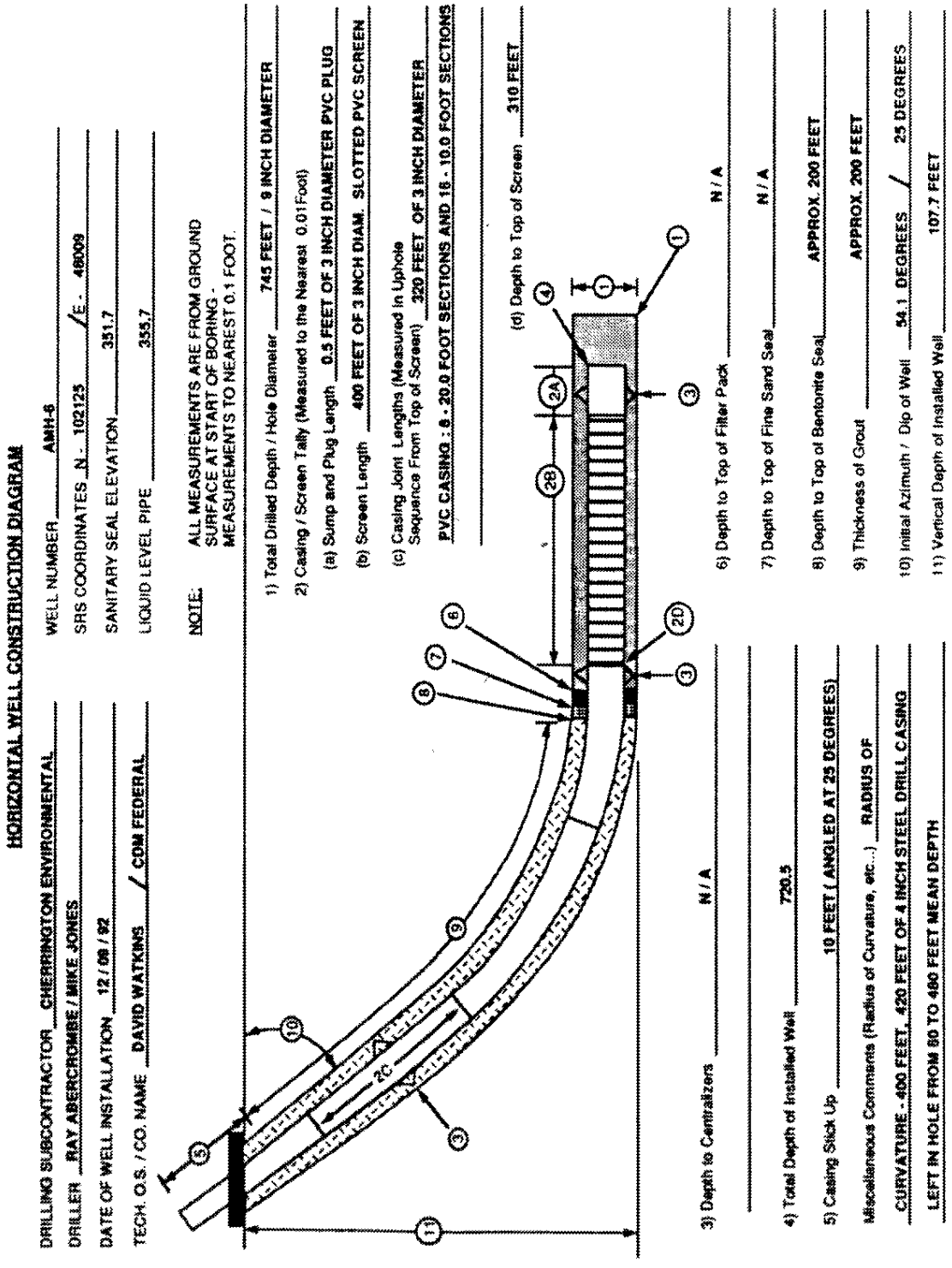

Figure D-1. AMH-6 Horizontal Well Construction Diagram

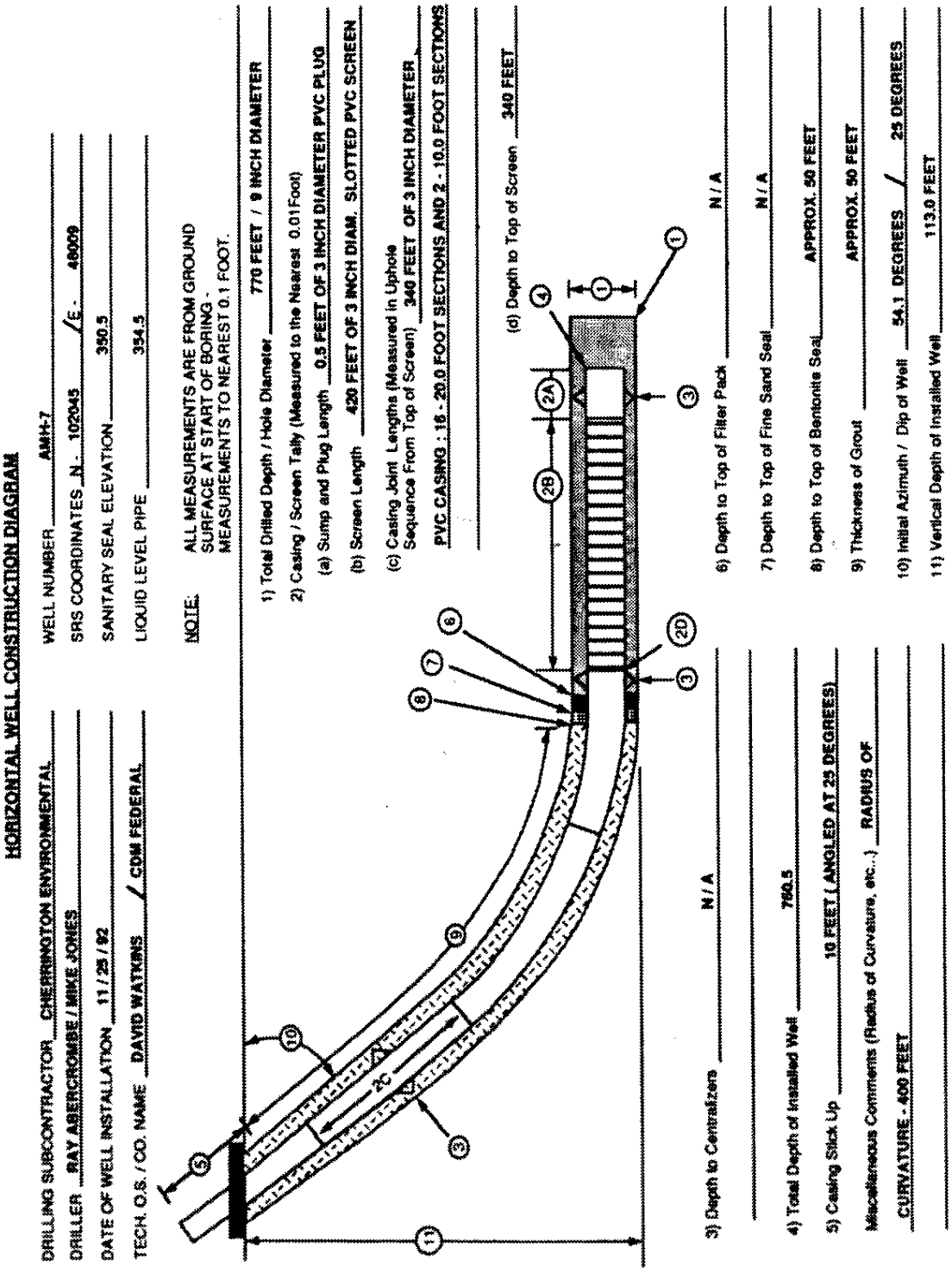

Figure D-2. AMH-7 Horizontal Well Construction Diagram

APPENDIX E

HORIZONTAL WELL AS-BUILT DIAGRAMS

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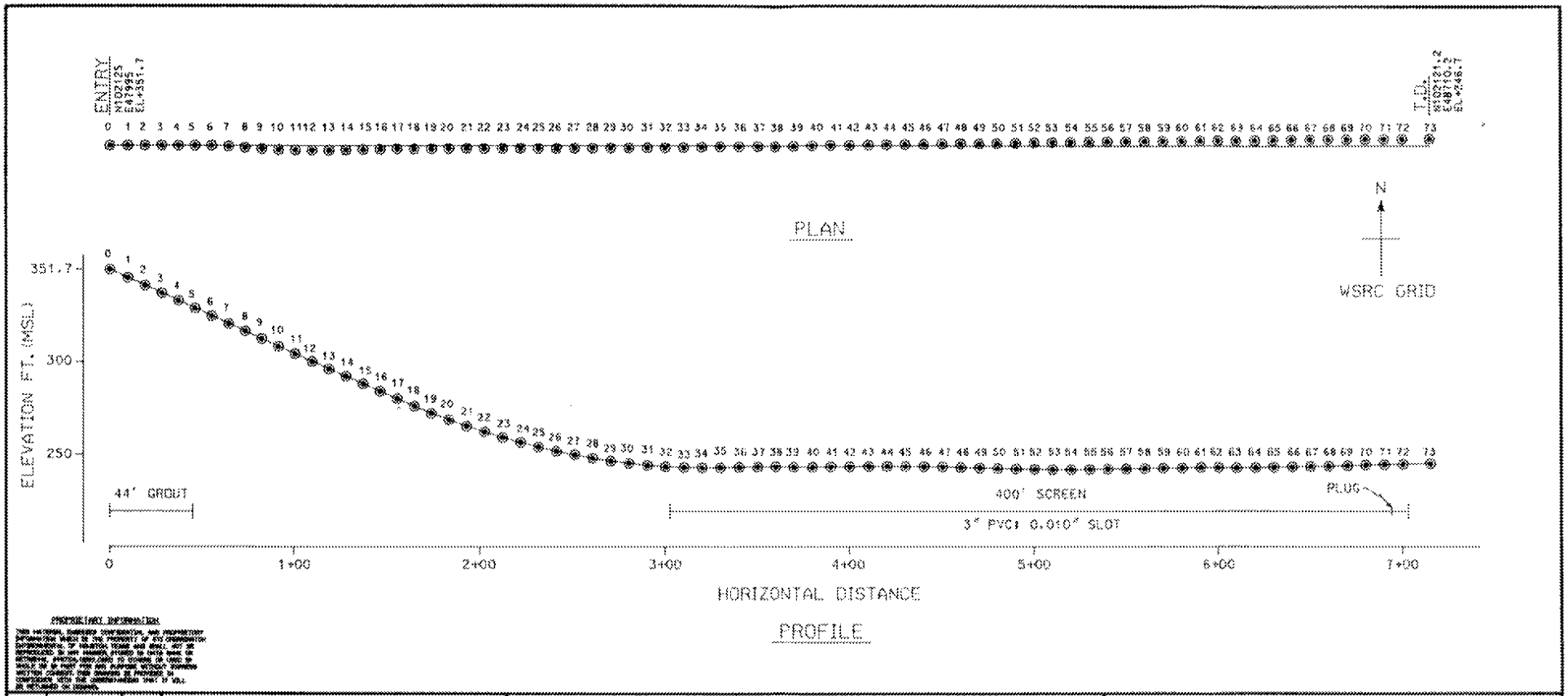


NO.	DATE	BY	DESCRIPTION
0	01-22-93	LG	AS-BUILT
1	01-25-93	LHF	REVISED SCREEN LENGTH
	- -		
	- -		

DATE	REFERENCE
- -	
- -	
- -	

EVI CHERRINGTON ENVIRONMENTAL
1055 CONARO SAUER DRIVE, HOUSTON, TEXAS 77043

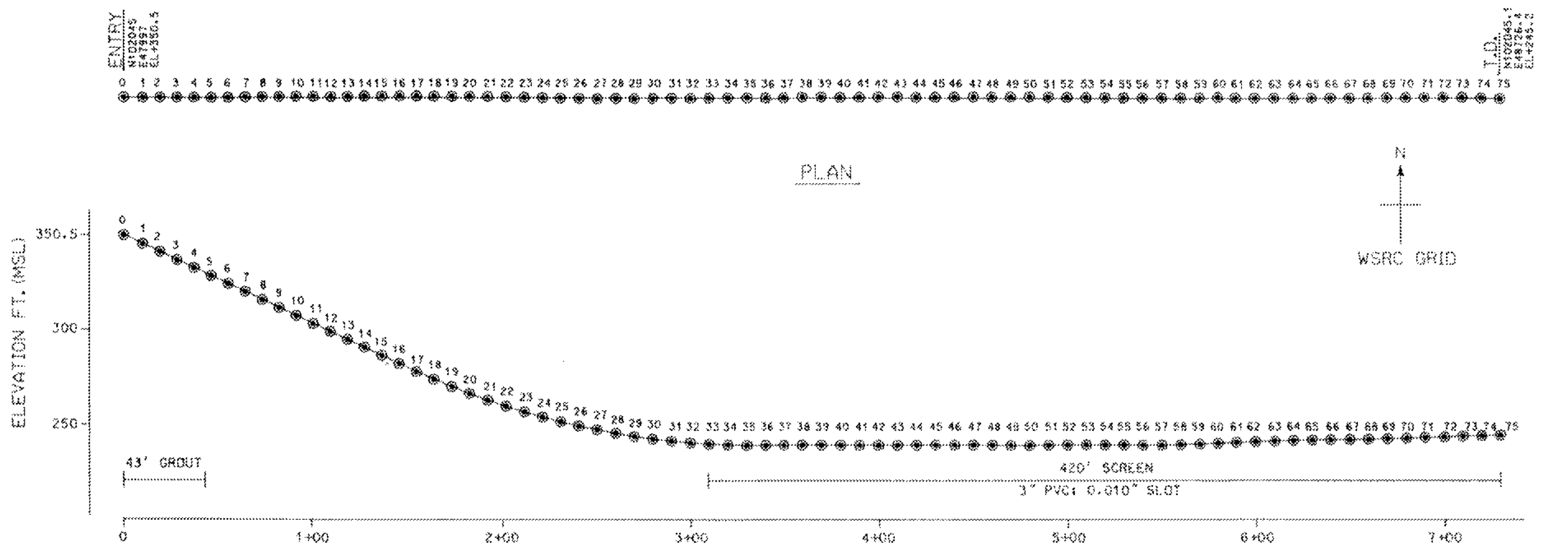
PREPARED FOR

WESTINGHOUSE SAVANNAH RIVER COMPANY

TITLE
HORIZONTAL WELL AMH6
AS-BUILT

DWN.	CKD.	APP.	SHEET NO.	DATE
LG		LHF	1 of 3	01-22-93

JOB NO.	DWG. NO.	SCALE	REV.
92-06	9206-3-2	AS NOTED	1



NO.	DATE	BY	DESCRIPTION
0	01-22-93	LG	AS-BUILT
1	01-25-93	LHF	REVISED SCREEN LENGTH
	- -		
	- -		

DATE	REFERENCE
- -	
- -	
- -	

EVI CHERRINGTON ENVIRONMENTAL
1055 CONARD SAUER DRIVE, HOUSTON, TEXAS 77043

PREPARED FOR

WESTINGHOUSE SAVANNAH RIVER COMPANY

TITLE
HORIZONTAL WELL AMH7
AS-BUILT

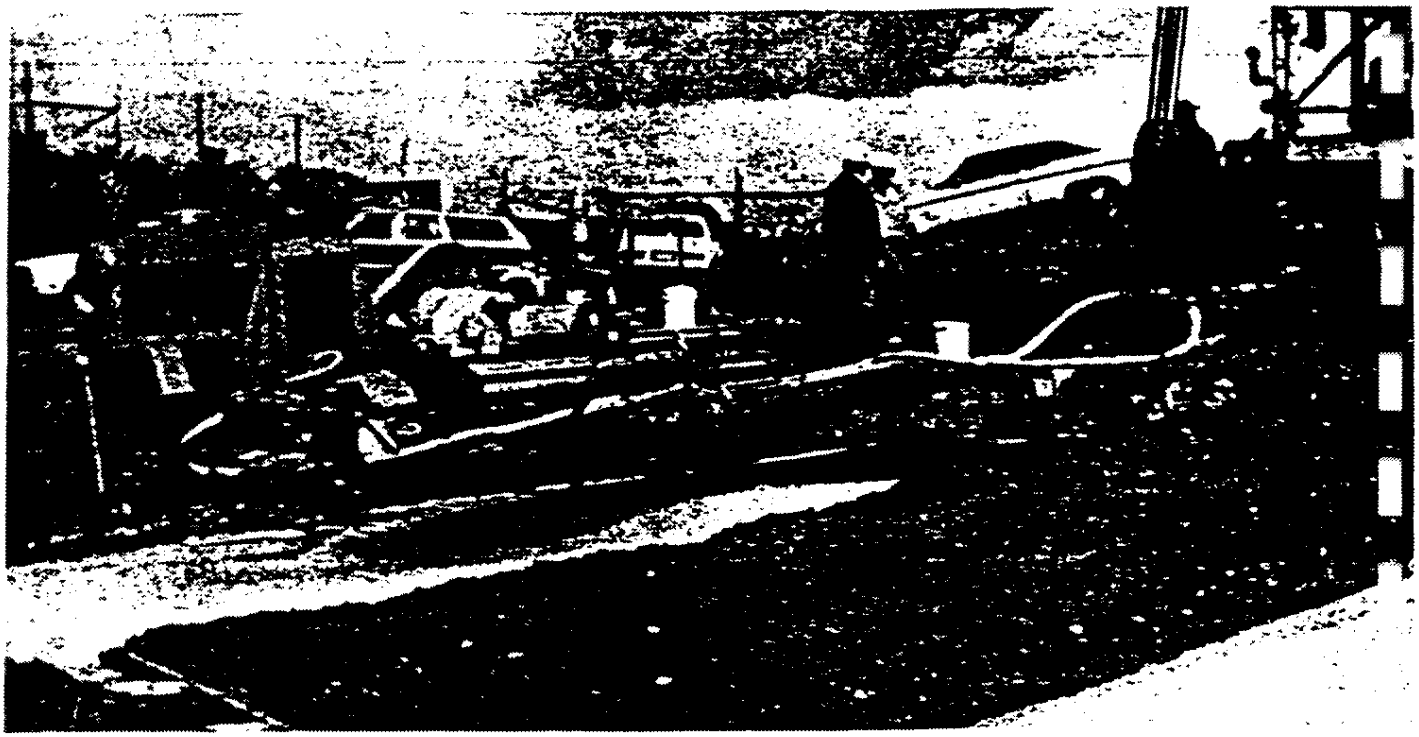
DWN.	CKD.	APP.	SHEET NO.	DATE
LG		LHF	1 of 3	01-22-93

JOB NO.	DWG. NO.	SCALE	REV.
92-06	9206-3-1	AS NOTED	1

APPENDIX F

SPECIFIC INFORMATION ON GUAR GUM DRILLING ADDITIVE

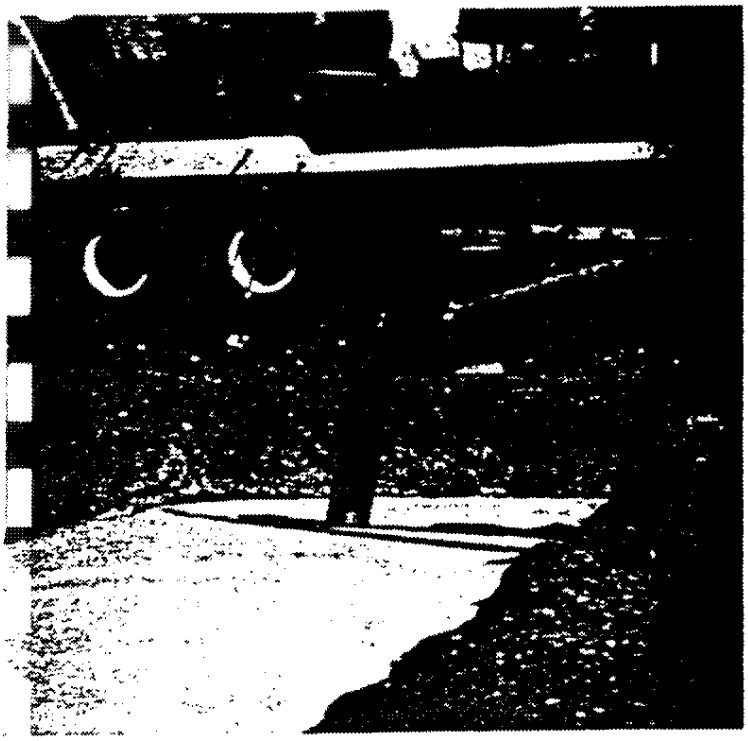
(INFORMATION PROVIDED BY EVI CHERRINGTON ENVIRONMENTAL)



Revert is a natural organic polymer additive which overcomes problems associated with conventional drilling fluids.

Revert drilling fluid systems have the following advantages:

- **Formation damage is minimized.** When drilling fluids are forced into the formation during drilling, the aquifer permeability is reduced if the drilling fluid is not completely removed during well development. With conventional fluid systems, an almost impermeable mud cake can also be formed on the borehole wall. Since Revert's viscosity can be reduced to nearly that of plain water, its removal during well developments is facilitated.
- **Caving, swelling and squeezing problems are overcome.** Revert encapsulates or coats clays to prevent these problems which occur when certain clays and shale strata are wetted. Clean, uniform-gauge holes are obtained more easily than is possible with bentonite-based mud.
- **Better samples are produced.** Because clay does not mix readily with Revert, samples are not contaminated by extraneous clay materials. Native clays penetrated by the bit appear as separate and distinct lumps or particles—an essential consideration in test drilling or sampling.
- **Cuttings settle out in the pit much faster.** Abrasive sands and other cuttings circulating in the mud system can obscure samples and, more seriously, cause abrasive wear on mud pump sleeves and other parts. Revert's lower gel strength allows these cuttings to settle faster.
- **Penetration rates are increased.** The lower density Revert radically reduces fluid friction in the circulating systems. This makes available increased energy in the drilling fluid at the drill bit where it is needed. Larger, deeper holes can be drilled faster.
- **Power and fuel are more efficiently used.** Lower density and reduction in fluid friction also means more efficient use of power. Reductions in hydraulic head loss in pipe flow of 60% or more are easily attained by using only small amounts



of Revert. Tests and experience show Revert uses at least 30% less power than conventional drilling muds.

- **Less Revert is needed to do the job.** Revert has 8 to 10 times the viscosity-building capacity of bentonite. This means that a Revert fluid has only one eighth to one tenth the amount of solids as conventional muds of the same viscosity thus resulting in a lighter weight drilling fluid.
- **Brackish or saline waters pose no problems.** Revert, unlike bentonite or native clays, mixes well in these waters. No change in the mud system is needed when saline water is encountered during drilling.
- **Electric logging of the borehole is improved.** Aquifers containing fresh water tend to have higher resistivity than other water bearing subsurface formations. Since drilling fluid enters these permeable zones during drilling, it is important that the drilling fluid not interfere with this resistivity difference. Bentonite has a low resistivity which has a masking effect making reading resistivity differences more difficult. The high resistivity of Revert combined with the aquifer's high resistivity causes a marked shift in the resistivity curve thus aiding in electric log interpretation.

MIXING REVERT

Revert is as easy to mix as any conventional drilling fluid. A jet-type mixer is typically used for on-site preparation of the fluid. Other tools common to conventional mud mixing such as a Marsh funnel and cup and mud balance to measure viscosity and weight of the mixed fluid will also be needed. The system's pH can be checked periodically with pH test paper or meter.

As with bentonitic materials, the Revert cannot be dumped unmixed into the mud pit or fed too fast into the mixer or it will tend to "gumball" in lumps because of incomplete hydration.

A typical feeding rate of 250 lb/hr with a standard jet-type mixer should produce complete wetting of all Revert particles. For small jobs, dry Revert can be sprinkled into a barrel of water in which a paddle mixer or small pump provides needed turbulence. A barrel of fluid thus mixed can be sufficient for a cable tool, auger or jetting operation. Hydration rates vary with local conditions but generally a suitable viscosity is reached about 1/2 to 3/4 hour after mixing.

FACTORS AFFECTING VISCOSITY

The viscosity produced by a given amount of Revert in water can be affected by several conditions such as the temperature, pH and salinity of the mix water. The higher the temperature of the water, the more Revert is needed to achieve a given viscosity. Similarly, the higher the water's pH (more alkaline) the longer the hydration time and the lower the viscosity will be from a given amount of Revert. Mixing with saline water rather than fresh water will also result in a lower viscosity Revert fluid.

Most natural ground water has a pH in the range of 5.5 to 8.0. Within that range Revert mixes readily to form a serviceable fluid when used in the ratios described in Figure 1.

After mixing, the drilling fluid's viscosity should be measured with a Marsh funnel. At that point, adjustments can be made either by adding more

Material Drilled	Desired MFV (Seconds)	LB. Revert Per 100 Gal. at Mixing Water Temp of...		
		45°	60°	85°
Fine Sand	40	2.8	3.5	4.2
Med. Sand	50	4.2	4.7	5.6
Coarse Sand	60	4.9	5.5	6.5
Gravel	70	5.5	6.1	7.0
Coarse Gravel	80	6.0	6.5	7.4

Figure 1. A suitable viscosity of Revert drilling fluid can be obtained for various combinations of temperatures and formation materials.

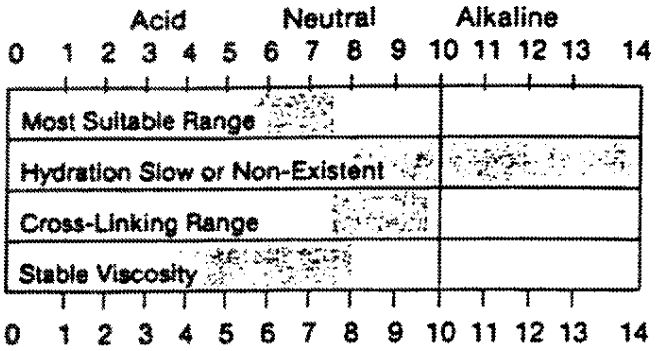


Figure 2. Revert system's pH must be maintained below 10 at all times. For most applications, a neutral to slightly acid pH is best.

Revert or more water. Normally only small amounts of Revert will be needed to account for variations in salinity, pH or water temperature.

SPECIAL FIELD CONDITIONS

Rarely, some of the constituents of the water used to mix Revert will have an effect on the mixing rate and the final viscosity of the drilling fluid. This may happen, for example, when freshly placed cement grout is drilled which contaminates the drilling fluid causing the pH to become extremely high. In this case, the Revert will not hydrate and the drilling fluid will gain no viscosity. In this case, the system must either be wasted or the pH must be reduced. This can be done by adding hydrochloric (muriatic) acid, Johnson's Nu-Well® or some other acid to the system.

If the mix water is high in iron—more than 3ppm (3 mg/l)—it can form a complex iron compound with the Revert resulting in a fluid with less than normal viscosity. Treating the water with about 1.3 lb 100 ppm. of calcium hypochlorite (HTH) powder per 1,000 gallons of water will disinfect the water and oxidize dissolved iron. This effect can also be obtained by using 2 gallons sodium hypochlorite (5%) per 1,000 gallons of mix water resulting in a 100 ppm chlorine solution.

A third condition involves chemical constituents such as heavy metals which can cause Revert drilling fluids to gel or can inhibit hydrating of the Revert. Gelled fluids are resistant to flow and might be difficult to handle. Here, the system must be chlorinated as described above to oxidize the metals if present. It must also have the pH lowered if necessary by acid treatment as described earlier.

In general, the mix water should be chlorinated if any of the above constituents are suspected to be in the water, if the character of the water is unknown, or if the mix water is from an untreated surface source. Before mixing and during drilling the pH should be maintained near neutral and carry a measurable free chlorine residual.

VISCOSITY CONTROL

The length of time Revert will maintain a given viscosity under typical conditions is described in Figure 3.

At high temperatures, Revert tends to "break down" or lose viscosity more quickly. This is in part due to the growth of certain microorganisms which are most prolific at 80° to 120°F (27-49°C). Enzymes produced by these organisms in addition to those inherent in the Revert can cause the breakdown of Revert to be accellerated. Where such microorgamisms or soil bacteria are likely to be present, precautions should be taken. If the mud pit is earthen, it should be lined with plastic. The mix water should be disinfected by chlorinating to 100 ppm. For other special techniques to use in dealing with premature fluid breakdown, consult Johnson technical service personnel.

On some occasions it may be desirable to accellerate the breakdown of the fluid. One technique involves adding ammonium persulfate $(NH_4)_2S_2O_8$ and ferrous sulfate ($FeSO_4$) directly to the mud pit in the ratio of one pound of each to each 25 pounds of dry Revert in the fluid system. This fluid is circulated until breakdown occurs—usually within 10-20 minutes after mixing. If viscosity extenders have been used in the fluid, it may be necessary to increase the ratio of these two chemicals to two pounds or more per each 25 pounds of dry Revert.

If the Revert fluid has penetrated into a very permeable formation it will temporarily reduce the well's efficiency which could result in inaccurate test pumping data. To remove this fluid, the well should be developed by high velocity horizontal jetting with 1,000 ppm chlorine solution which will break down the Revert. This has the added benefit

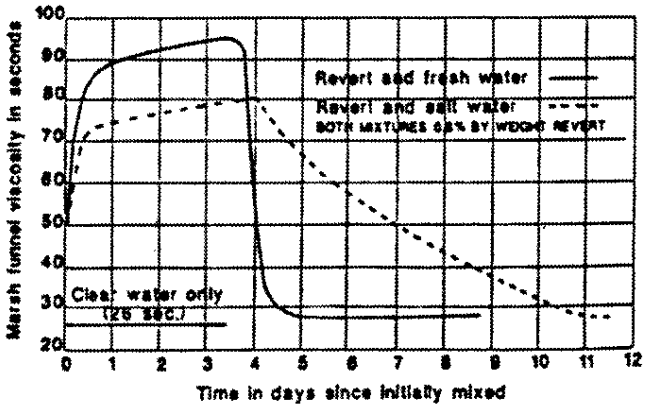


Figure 3. Revert mixes well with either fresh or salt water. Curves show the change in fluid viscosity with time in a typical drilling fluid of 0.8% Revert by weight at 70°F.

Sodium hypochlorite				
Available Chlorine	PPM (in 1,000 Gal. of Water)			
	50	100	500	1,000
3%	1.7 gal.	3.3 gal.	16.7 gal.	33.3 gal.
5	1.0 gal.	2.0 gal.	10.0 gal.	20.0 gal.
10	0.5 gal.	1.0 gal.	5.0 gal.	10.0 gal.
15	0.3 gal.	0.7 gal.	3.3 gal.	6.7 gal.
Calcium hypochlorite (Cl load)				
65%	0.6 lb.	1.3 lb.	6.4 lb.	12.8 lb.

Figure 4. The above quantities of chlorine compounds added to 1,000 gallons of water will produce the most commonly used concentrations of chlorine in a drilling fluid. Note that sodium hypochlorite is measured in gallons; calcium hypochlorite in pounds.

of disinfecting the well. See Figure 4 for mixing chlorine compounds.

When using high chlorine concentrations, it is sometimes beneficial to use sodium hypochlorite (liquid bleach) instead of calcium hypochlorite. This is especially true in fine-grained formations where the formation water pH is higher than 7 and might also contain a significant amount of calcium.

	NaCl		$CaCl_2$	
Fluid Weight (Lb/Gal)	Lb/1000 Gal	Freeze Point (F°)	Lb/1000 Gal	Freeze Point (F°)
8.33	-	32	-	32
8.5	-	29	-	
8.7	531	26	-	
8.8	725	23	-	
9.0	1031	19	925	23
9.2	1356	14	1136	18
9.4	1828	8	1587	13
9.6	2106	2	1828	7
9.8	2531		2075	0
10.0	2926		2363	-5
10.2	-		2750	-15
10.4	-		3104	-25
10.6	-		3625	-35
10.8	-		3784	
11.0	-		4174	
11.2	-		4486	
11.4	-		5156	
11.65	-		5554	

Figure 5. Conditions may require that Revert drilling fluid be weighted. Solution weighting may be accomplished by adding salts in the approximate ratios shown. Note that salt also has the effect of lowering the fluid freezing point.

A 1,000 ppm solution of calcium hypochlorite will contain approximately 280 ppm calcium. Calcium has a tendency to precipitate at about 300 ppm. Thus, if the combined calcium levels exceed approximately 300 ppm, the precipitation of calcium hydroxide could occur in the formation necessitating a follow-up acid treatment to restore the original permeability.

Other conditions may make it difficult to accelerate viscosity breakdown such as the presence of gelled mud or saturated salt mud. These should be handled by the chlorination process described above, but if special problems arise, Johnson technical service personnel are available for assistance.

CONTROLLING FLUID WEIGHT

The fluid weight of Revert is only slightly higher than that of water—about 8.4 lbs per gal. When dealing with artesian pressures it may be necessary to increase the fluid weight to control water flow into the borehole from the formation and prevent caving. Revert is most effectively weighted by adding salt—calcium chloride or sodium chloride—either before or after mixing the fluid. This produces a solution-weighted fluid as distinct from suspension-weighted bentonitic fluids. Solution weighting is necessary because a Revert fluid does not have the gel strength required to suspend weighting particles when it is not being circulated. Figure 5 shows recommended approximate ratios of salt to fluid volume to achieve a desired fluid weight.

SPECIAL APPLICATIONS FOR REVERT

Revert drilling fluids can be applied as "problem solvers" in special circumstances and to enhance other conventional drilling procedures.

CONTROLLING FLUID LOSS

One problem often encountered by drillers is lost circulation in which drilling fluid is lost in a highly permeable zone. Two methods are available to solve this problem:

The first method requires an extremely viscous Revert fluid—120 Marsh funnel seconds or more. (The friction reducing properties of Revert allow this to be circulated without special equipment.)

A mass of this freshly mixed highly viscous Revert must now be spotted in the hole opposite the lost circulation zone. Enough of this Revert fluid to twice fill the borehole annulus should be mixed in a separate tank or pit and pumped through the drill pipe to this zone. The drill pipe is then pulled back allowing the viscous Revert to migrate into the permeable zone, thus sealing it off. After about 30 minutes, the viscosity of the remaining fluid can be reduced and normal drilling can resume.

The second method involves mixing Borax with Revert to create a dense, rubbery plugging material. Rig-side experimentation with a few quarts of fluid is useful to determine mix ratios but generally one can proceed as follows: (1) Mix one cup of "20 Mule Team Borax" in 5 gallons of water, then pour the borated water directly into the drill stem. (2) Mix a pit of highly viscous Revert—about 120 Marsh funnel seconds. (3) Raise the pH of this fluid to 9.0 to 9.5 by adding soda ash as needed. Start by dissolving a cupful of soda ash per 1,000 gallons of water and slowly add to circulating Revert system at the pump suction. System pH should be checked periodically while circulating and should be kept below 10 to avoid polymer destruction. (4) Mix additional borated water at the ratio of one cup borax per 5 gallons of water. (5) Place bottom of drill stem opposite lost circulation zone. (6) Raise pump suction to near pit surface level. (7) Activate pump at idling speed and when Revert starts to flow, pour borated water into the pit near the pump suction. Continue pumping until borated Revert appears at ground surface in the annulus between drill stem and bore. It will be a thick, gelled mass. (8) Shut pump down immediately to prevent gel from reaching pit. (9) Pull drill stem back one or two lengths and wait 30 minutes for gel to cure. (10) Resume drilling operation with pump operating at reduced speed until several feet of new formation has been penetrated. (11) Repeat entire operation if necessary. If used in an aquifer where a screen has been set, it may be necessary to develop the well by high velocity jetting with a 1,000 ppm chlorine solution. (Extreme care must be used when handling high concentrations of chlorine.)

The gelled fluid may be returned to its starting viscosity by reducing the pH to 7 or lower.

EXCESSIVE FLUID LOSS

Reducing the amount of Revert or Borax used or using a pH above 7 but less than 9 will weaken the chemical cross-linking bond of the Revert polymer and produce a partially gelled, stringy mass that can be easily pumped or circulated. This partially cross-linked gel can be used where excessive fluid loss is a problem as, for example, when encountering coarse sand and gravel or other highly permeable zones.

REVERT IN CABLE TOOL DRILLING

Revert can be used in any situation where clay slurries are used in cable tool drilling. It provides superior lubrication to facilitate driving the casing. It can also be used to support the hole when casing has been driven to refusal and it is necessary to drill open hole beyond the casing bottom. The fluid also reduces friction between borehole and tool string which increases cable tool efficiency and speeds penetration rates.

It can be used to pressurize a formation to control heaving sands. (See the section in this bulletin on controlling fluid weight.)

REVERT IN REVERSE CIRCULATION DRILLING

Revert is also useful in reverse circulation drilling to greatly increase drilling efficiency allowing larger, deeper holes to be drilled more quickly. As little as 5 pounds of Revert per 1,000 gallons of water can decrease friction loss in the fluid system by as much as 60 per cent. Revert may be periodically added to chlorinated drilling water at the pump suction during drilling to reduce friction.

A more viscous Revert fluid such as used in conventional rotary drilling can also be used to control fluid losses, lost circulation, swelling and caving shales and clays and other common reverse circulation problems.

REVERT IN AIR FOAM DRILLING

Small amounts of Revert added to the injected foam-producing agent will make a tough, stable foam with very good water-lifting, cutting-carrying and particle suspension properties. Using one pound of Revert (about 26 oz. dry measure) per 100 gallons of injection fluid will permit excellent hole cleaning at low annular velocities and air delivery rates. The other beneficial properties of Revert help reduce sloughing and caving, lubricate the bit and protect the permeability of the formations penetrated. As in other Revert applications, the fluid can be broken down when desired with a chlorine solution.

COLD WEATHER DRILLING

Adding salt to Revert drilling fluid has the effect of lowering the fluid freezing point. Figure 5 indicates approximate amounts of salt to achieve a desired result.

REVERT IN PIEZOMETER WELLS

Hydraulically efficient piezometer and observation wells can be more quickly and easily installed with Revert than with clay additive drilling fluid. Since small piezometer wells are often not developed, the damage to hydraulic conductivity caused by clay-based fluids is unrepaired.

If several test holes are planned close to one another it may be advantageous to mix the Revert in portable tanks which can be skidded from one site to another. Alternatively, the Revert can be pumped from one site to the next.

REVERT IN WELL RECONSTRUCTION

Often, a sand-pumping well can be salvaged by

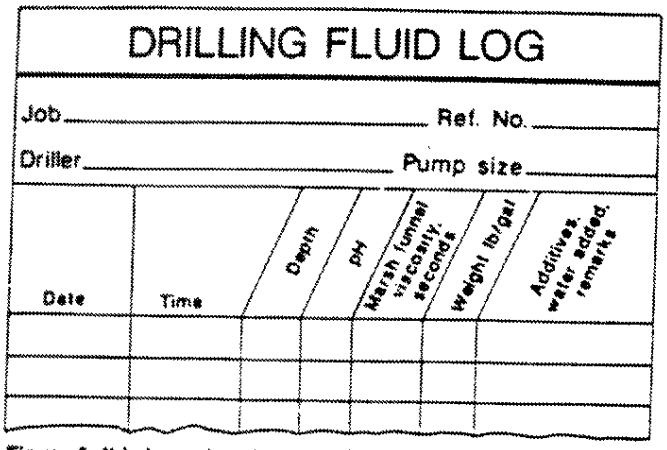


Figure 6. It is important to maintain an accurate log throughout the entire drilling job taking note of the fluid system's pH, weight, viscosity, and any other variables such as additives used or unusual conditions encountered. Such logs serve as a record of work performed and as a potentially useful reference for future jobs.

placing a screen liner in a slotted-pipe well. During this process, the existing slotted casing is ripped almost to destruction before the screen is placed. Chlorinated Revert fluid placed in the hole will provide the support necessary during this and subsequent steps in the well reconstruction. After the Revert fluid viscosity is broken, removal of the fluid and development of the well can proceed quickly and thoroughly. This same basic process can be used when pulling and replacing screens in wells.

PLACING GRAVEL PACK WITH REVERT

Revert fluid is ideal for placing gravel pack by the reverse circulation method. This may be done equally well in new wells or in old wells that were originally completed as open hole and later require a screen and gravel pack combination to stop sand pumping.

REVERT AND BACTERIA

Revert does not contain or produce any harmful bacteria. Tests on water samples during well development or test pumping may show a high bacteria count. These are not, however, disease-producing bacteria since the organisms in Revert consist of -yeast, mold and lactobaccilli which naturally occur in such foods as flour and milk. These non-pathogenic organisms are also naturally present in food-grade guar. Their presence is not an indication that the well water contains coliform, Salmonella or other disease-producing germs. In fact, subsequent tests such as the methyl red differential or the eosin methylene blue agar will show that only harmless bacteria are present.

APPLICATIONS ASSISTANCE WITH REVERT

Johnson technical personnel are available to help with Revert applications assistance. Contact your Johnson representative.