# Los Alamos
NATIONAL LABORATORY

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*Los Alamos, New Mexico 87545*

Date: July 16, 1999
In Reply Refer To: ESH-18/WQ&H:99-0273
Mail Stop: K497
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JUL 1999
RECEIVED

Mr. John Kieling
New Mexico Environment Department
Hazardous and Radioactive Materials Bureau
Santa Fe, New Mexico 87504

**SUBJECT: INFORMATION REGARDING R-25 WELL**

Dear Mr. Kieling:

At the end of the Los Alamos National Laboratory's (Laboratory) Groundwater Integration Team (GIT) Quarterly Meeting on June 23, 1999, Mr. James Bearzi read a list of issues regarding the status of the R-25 well, the proposed plan for repair of the well's No. 3 screen, lessons learned by the Laboratory during the well's construction, and prospective changes that the Laboratory would make to improve the over-all implementation of the Hydrogeologic Workplan. In raising these issues, Mr. Bearzi stated that he had heard information during the Quarterly Meeting that addressed 90% of his questions and issues. However, he expressed the desire that the Laboratory respond to his issues in writing.

In response to Mr. Bearzi's questions and issues, I met with you and John Young the following day, and you handed me the attached "Homework Assignment" prepared by Mr. Bearzi which listed a number of requests for information. In response, the following information is provided in the order of the bulleted items in the "Homework Assignment".

The first bulleted item requests a recovery plan for R-25. A complete recovery plan is included as Attachment 1 to this letter. In summary, the collapsed portion of screen 3 in R-25 will be cemented and drilled through in order to provide a borehole of sufficient diameter to accommodate the WESTBAY equipment. This operation is commonly employed in the oil industry and our consulting drilling experts expect this to be successful. If the recovery plan works as expected, the screen 3 interval will be usable and all of the DQOs for the R-25 will be met. The recovery plan includes a description of the contingency plans that will be invoked if the implementation of the R-25 recovery plan is not successful.

The second bulleted item requests an R-25 Lessons Learned Report. This report is included as Attachment 2 to this letter. The report provides a chronology of activities at R25, identification of issues identified in the R-25 drilling, construction and development, and a description of what has been learned from these issues and how the drilling program will be changed to learn from the issues. It should be noted that the primary cause of the delay in completing R-25 is the geologic conditions that locked up the drilling system and cause problems with air circulation. About 75% of the R-25 drilling phase was spent overcoming the geologic conditions. Managing the drilling in these conditions has been a valuable lesson that will be used to improve the remainder of the drilling program.

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The third bulleted item requests a plan for ensuring that personnel with appropriate experience will be used in the drilling program. This issue is addressed in the R-25 Lessons Learned Report (Attachment 2). In summary, the importance of maintaining the experienced crew is recognized. However, additional crews will be needed as the number of wells being drilled concurrently increases. A number of actions are planned to address this issue. This first is to have all drilling crews supplied by a single contractor to ensure that experience and information can flow freely between crews. Secondly, potential crew members will be screened for past drilling, well construction, and well completion experience. Thirdly, each new member will be assigned to work with an experienced crew member for a specified length of time. Finally, a careful evaluation of the impact of introducing new equipment on the crew operations will be made before moving ahead with those types of changes.

The fourth bulleted item is in regards to the report being prepared by the External Advisory Group (formerly the External Evaluation Group). This group is an independent group performing a peer review function for the groundwater characterization program. The Groundwater Integration Team (GIT) does not provide direction to the EAG. The bulleted item was provided to Dr. Robert Charles as a comment on the Draft EAG report, which was made available to NMED in June. The EAG will respond to the comment as they consider appropriate in finalizing the report. The final report will be provided to you as soon as it is received.

The final bulleted item requests assurance that the original intent of the Hydrogeologic Workplan has not been lost in academic research or in plume chasing. The Data Quality Objective (DQO) process was used in developing the Hydrogeologic Workplan to ensure that the data collected will be adequate for resolving decisions on groundwater. It also serves to focus the characterization on collecting only that data needed for adequate characterization. As the program is implemented, and new data are available, the DQO process is applied to ensure the focus of the program stays on characterization adequate to resolve decisions. The adherence to this process is the Lab's assurance that that data collection and analysis are to resolve decisions, not to add to academic research.

Over the past two years, the GIT has remained focused on carrying out the scope of the Hydrogeologic Workplan, which is hydrogeologic characterization and does not include "plume chasing". Despite concerns expressed by NMED representatives at several meetings, the GIT has adhered to the Hydrogeologic Workplan and has continued to discuss the appropriate timing for delineating contaminants detected in the regional wells. The development of a strategy to respond to detection of contaminants in regional aquifer wells has been admittedly slow in coming, but is expected to be available for discussion in the near future. Once a mutually accepted response strategy for detection of contaminants is in place, that will be the provided assurance that the original intent of the Hydrogeologic Workplan will be carried out.

In closing, we appreciate the opportunity to address issues and hope to continue a dialogue that will lead to improvements in the groundwater characterization program. If you have further comments or questions, please do not hesitate to contact me at (505) 665-4681.

Sincerely,

Ken Mullen for Charles Nylander

Charles Nylander
Water Quality and Hydrology Group

CN/em

Attachments: a/s

Cy: Denny Erickson, ESH-DO, w/att., MS K491
Steven Rae, ESH-18, w/att., MS K497
Ken Mullen, ESH-18, w/att., MS K497
Tom Gunderson, DLD-OPS, w/att., MS A100
Jim Holt, NW-IFC, w/att., MS F629
Tom Baca, EM-DO, w/att., MS J591
Julie Canepa, EM-ER, w/att., MS M992
Allyn Pratt, EES-13, w/att., MS M992
David Broxton, EES-1, w/att., MS D462
Steve Bolivar, EES-13, w/att., MS H865
Joseph Vozella, DOE/LAAO, w/att., MS A316
Gene Turner, DOE/LAAO, w/att., MS A316
WQ&H File, w/att., MS K497
CIC-10, w/att., MS A150

**LOS ALAMOS GROUNDWATER INTEGRATION TEAM**

**HOMEWORK ASSIGNMENT FROM NMED**

**JUNE 24, 1999**

- **Provide to NMED a schedule and detailed plan of how the project team intends to fix R-25, and how, despite the problems that have been encountered, the original implementation plan (e.g., Westbay system) and data quality objectives will be maintained. Provide decision tree identifying critical points (e.g., screen three repair) and all options, ending with a functional or plug and abandoned well. Schedule must result in resolution of R-25 by August 1, 1999. Due date – July 2, 1999.**

- **Provide to NMED a Corrective Action Plan showing the "lessons learned" and how LANL is ensuring that a fiasco like R-25 will not happen again. Include institutional controls implemented, and which previous R-25 "disasters" each control addresses. Due date – July 9, 1999.**

- **Provide plan and template to NMED showing the assurances LANL will provide in the future that the project team, particularly the drilling team, contractors, and subcontractors, have demonstrated experience with the proposed equipment, completion techniques, well material specification, and environmental work (e.g., Barber Rig, Westbay). Due date – July 9, 1999**

- **Provide to NMED the EEG's Final Report, with important points (e.g., screen mis-specified) de-sanitized and expounded upon in greater detail than in the Draft. ~~Due Date – July 9, 1999~~**

- **How can LANL assure NMED that the original intent of the Hydrogeologic Workplan has not been lost in an academic research project, or in "plume-chasing"?**

# ATTACHMENT 1

# WELL R-25 RECOVERY PLAN

## 1.0 INTRODUCTION

The purpose of this recovery plan for Well R-25 is to provide documentation and a schedule of how screen #3, which was damaged during well completion activities, will be repaired and the well completed to meet the Data Quality Objectives (DQOs). This plan revisits the DQOs, presents the chronology of drilling activities, discusses the options for recovering screen #3 and provides the implementation plan and schedule for completion of the well.

## 2.0 WELL R-25 DATA QUALITY OBJECTIVES

The primary purpose of Well R-25 was to provide geologic and hydrologic characterization in a portion of the laboratory where this type of characterization was needed in order to better understand the hydrogeologic conceptual model for the Pajarito Plateau. A secondary purpose was to provide downgradient monitoring for operations at TA-16.

## 3.0 CHRONOLOGY OF R-25 ACTIVITIES

Figure 3-1 depicts the chronology of drilling activities for R-25.

## 4.0 OPTIONS FOR RECOVERY

Options for recovering screen #3 were investigated by the GIT drilling subcommittee including two members of the EAG. Table 4-1 provides a matrix of the options investigated for recovering screen #3. A brief description is given along with the pros and cons for each method.

## 5.0 SELECTION OF PREFERRED OPTION

The options for recovering screen #3 were discussed among the GIT drilling subcommittee. Of the options discussed, the GIT prefers plugging a section of the screen and redrilling to the gauge required for installing the WESTBAY system.

This option was selected based on its expected success. The collapsed section of the screen would be permanently repaired with no chance of collapsing again in the future. Plugging the collapsed section with cement would eliminate the possibility of causing further damage to the screen during repair, which would potentially release the fill material from the entire screened section into the well and thereby render the entire screened section unusable. This approach would also have minimal impact on the other screens in the well.

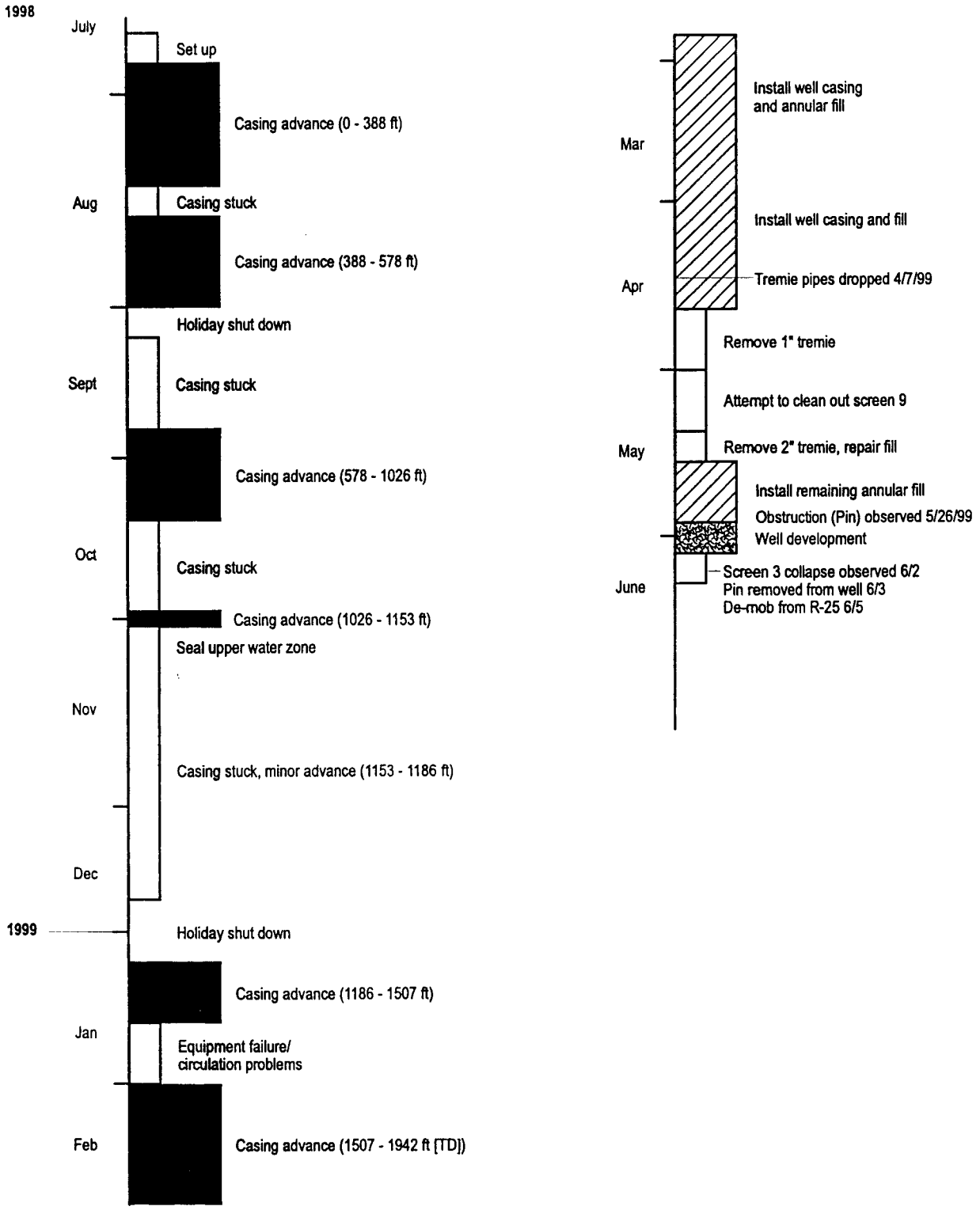



**Figure 3-1. Chronoloy of Drilling and Well Completion Activities at R-25**

Table 4-1. Options for recovering screen #3 in Well R-25.

| RECOVERY METHOD | TECHNIQUE | DESCRIPTION | COMPANIES CONTACTED | PROS | CONS |
|---|---|---|---|---|---|
| Push out the screen | Mechanical Swedge | Tapered swedging tool raised and lowered to "hammer" out collapsed screen | Star Tool Company | • Simplest, cheapest technology<br>• Readily available<br>• Could salvage most of the screen | • Hammering nature directs force vertically and may compromise other screens<br>• Might not work on compressional nature of damaged screen<br>• Screen may collapse again in future<br>• Possibility of permanent and catastrophic damage to screen during repair |
| Push out the screen | Mechanical Swedge | Roto-Cam rotating swedge tool pushes out collapsed screen | Houston Engineers | • Directs force laterally instead of vertically<br>• Could salvage most of the screen | • Tool would have to be fabricated.<br>• Might not work on compressional nature of damaged screen<br>• Screen may collapse again in future<br>• Possibility of permanent and catastrophic damage to screen during repair |

| RECOVERY METHOD | TECHNIQUE | DESCRIPTION | COMPANIES CONTACTED | PROS | CONS |
|---|---|---|---|---|---|
| Push out the screen | Hydraulic Swedge | 4-arm tool uses hydraulic oil to expand and push out collapsed screen | Welenco | • Directs force laterally instead of vertically<br>• Could salvage most of the screen | • Oil could be introduced into well through leakage from, or damage to, tool<br>• Tool would have to be fabricated.<br>• Might not work on compressional nature of damaged screen<br>• Screen may collapse again in future<br>• Possibility of permanent and catastrophic damage to screen during repair |
| Push out the screen | Hydraulic Swedge | 4-arm tool uses water to expand and push out collapsed screen | Longmire | • Hydraulic fluid is water, not oil<br>• Directs force laterally instead of vertically<br>• Could salvage most of the screen | • Tool would have to be fabricated.<br>• Might not work on compressional nature of damaged screen<br>• Screen may collapse again in future<br>• Possibility of permanent and catastrophic damage to screen during repair |

| RECOVERY METHOD | TECHNIQUE | DESCRIPTION | COMPANIES CONTACTED | PROS | CONS |
|---|---|---|---|---|---|
| Push out the screen | High pressure packers | Packers placed at collapsed screen and filled with air to push out the section | Baski<br>Tam | • No fluids used<br>• Directs force laterally instead of vertically<br>• Could salvage most of the screen | • Not expected to work on compressional nature of damaged screen<br>• Screen may collapse again in future |
| Plug section and redrill | Sectional cement plug | Retrievable packer, sand and bentonite are placed below collapsed screen, screen and sand pack cemented and then redrilled with diamond bit to gauge | | • Packers readily available<br>• Bit easily fabricated<br>• Collapsed screen easily drilled out to gauge needed<br>• No lateral or vertical forces exerted on casing string<br>• Could salvage about half of screen<br>• Permanent fix to screen, no future collapse | • Would plug about half of the screen<br>• Question of bottom casing string holding its integrity once screen cut through with bit<br>• Would introduce cement into sampling zone and affect pH, and certain analyses (not HE) |

This option was presented to stakeholders at the 3rd Quarterly GIT Meeting (June 23, 1999). The option has been presented to, and discussed with, EAG members with drilling and well construction knowledge and expertise. The EAG concurred with the selection of this option.

## 6.0 IMPLEMENTATION OF PREFERRED OPTION

Implementation of the plugging and redrilling option for recovery of screen #3 and completion of Well R-25 will be as follows:

1. Set up URL-1000 Workover Rig at R-25.
2. Set TAM 1 11/16 inch diameter inflatable packer below screen #3.
3. Tremie fine sand and bentonite into casing below screen #3.
4. Tremie approximately half of the required volume of Halliburton Micromatrix Cement to fill portion of casing below screen #3 and bottom 5 feet of the screen and filter material in the annular space.
5. Allow plug to begin to cure.
6. Verify location of top of plug and analyze acceptability of results.
7. Adjust accordingly and tremie remaining required volume of cement to fill portion of casing below screen #3 and bottom 5 feet of the screen and filter material in the annular space.
8. Verify location of top of plug and analyze acceptability of results. (see section 8.0 for contingency plans)
9. Drill through concrete plug with 3.83-inch outer diameter diamond core bit.
10. Ream out concrete plug with 4.5-inch outer diameter tapered reamer.
11. Run video camera down hole to inspect sections of open and plugged screen.
12. Flush out sand and bentonite and remove packer.
13. Develop all well screens.
14. Run video camera to inspect all screens. (see section 8 for contingency plans)
15. Run borehole geophysics density log through entire well.
16. Install surface pad and metal housing to cover riser pipe.
17. Remove drilling equipment from R-25 location.
18. Set up Smeal rig for installation of WESTBAY.
19. Install and test WESTBAY system.
20. Remove Smeal rig from R-25 location.

## 7.0 SCHEDULE FOR IMPLEMENTATION

Figure 7-1 is a Gantt chart showing the schedule of screen recovery and completion of well R-25. The URL-1000 Workover rig can not be acquired by the Laboratory until the early part of August. This schedule provides the best estimate of the time required to complete R-25 as a multiple completion well with nine ports assuming. The schedule does not include time for dealing with circumstances that are beyond control as their occurrence cannot be predicted.

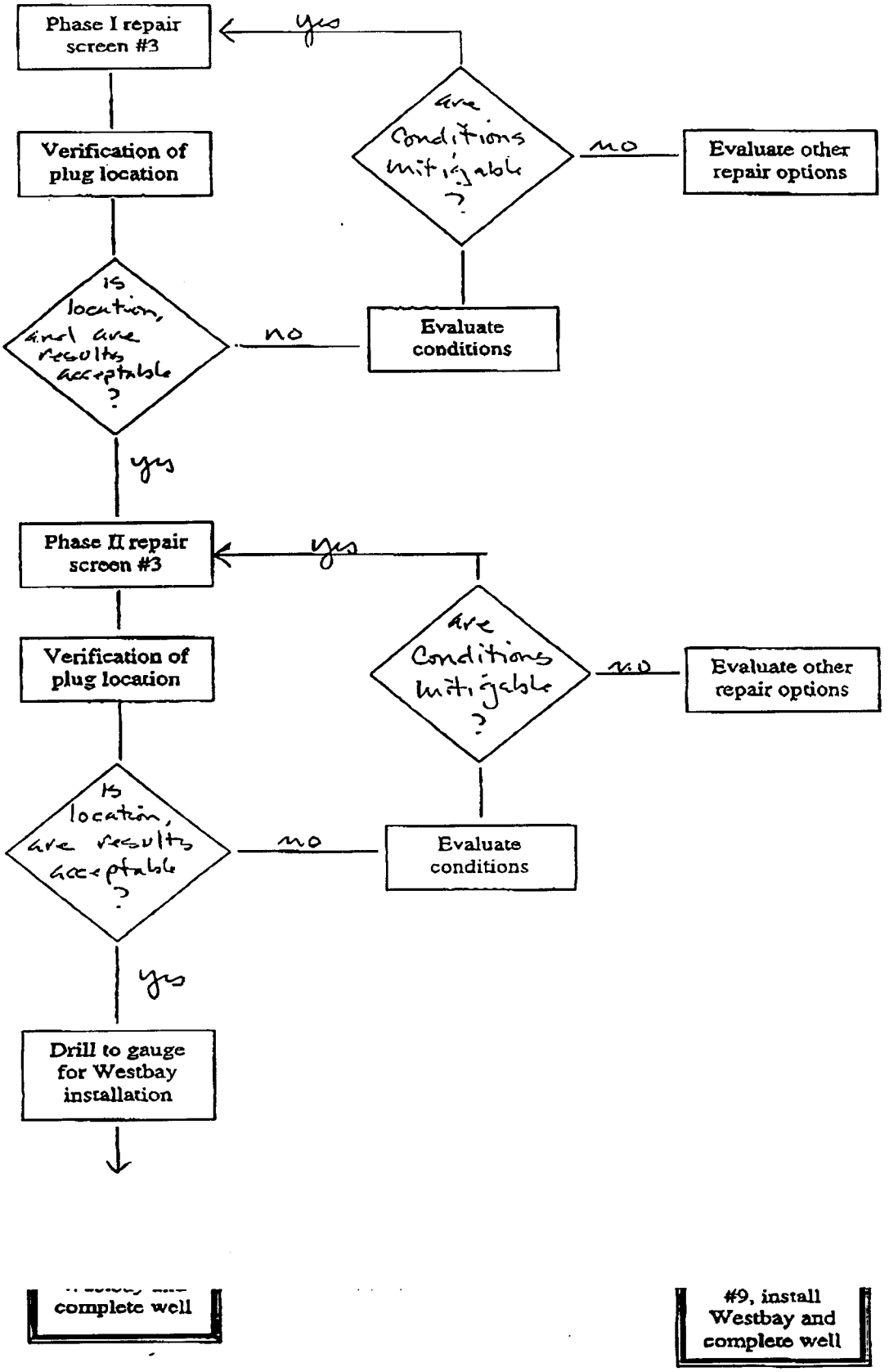



Figure 9-1. Decision tree for completion of R-25

## 8.0 CONTINGENCY PLANS

The primary purpose of Well R-25 was to provide geologic and hydrologic characterization in a portion of the laboratory where this type of characterization was needed in order to better understand the hydrogeologic conceptual model for the Pajarito Plateau. A secondary purpose was to provide downgradient monitoring for operations at TA-16.

Well R-25 was planned as a multiple completion well because of its location in an area where hydrologic characterization information is greatly needed to understand recharge near the western boundary of the Laboratory. Ideally, once screen #3 has been repaired, the well will be completed with nine sampling ports.

Two anticipated problems that might be encountered during the repair of screen #3 and completion of the well are 1) the repair of screen #3 does not proceed as expected, and 2) after development of the other screens, screen #9 shows damage. Discussion of contingency plans for each potential problem follow.

### 8.1 Screen #3 Repair Procedure Contingencies

Possible problems that may be encountered during the repair of screen #3 include

- Cement doesn't stay where it is supposed to or set up as expected, or
- Cement doesn't penetrate into the filter pack as expected.

These would result in a plug that is not located where it should be or has not solidified.

The drilling team intends to minimize the possibility of an inappropriately placed plug by installing the plug in at least two phases and checking the placement of the plug between phases. The volume of cement needed to fill the casing and annular space will be calculated. Approximately half the volume will be tremied into place and allowed enough time to begin setting up. The location of this first phase plug will be checked. If it is not at the appropriate location then it will be known whether cement is being lost into the formation or not penetrating the screen and annulus.

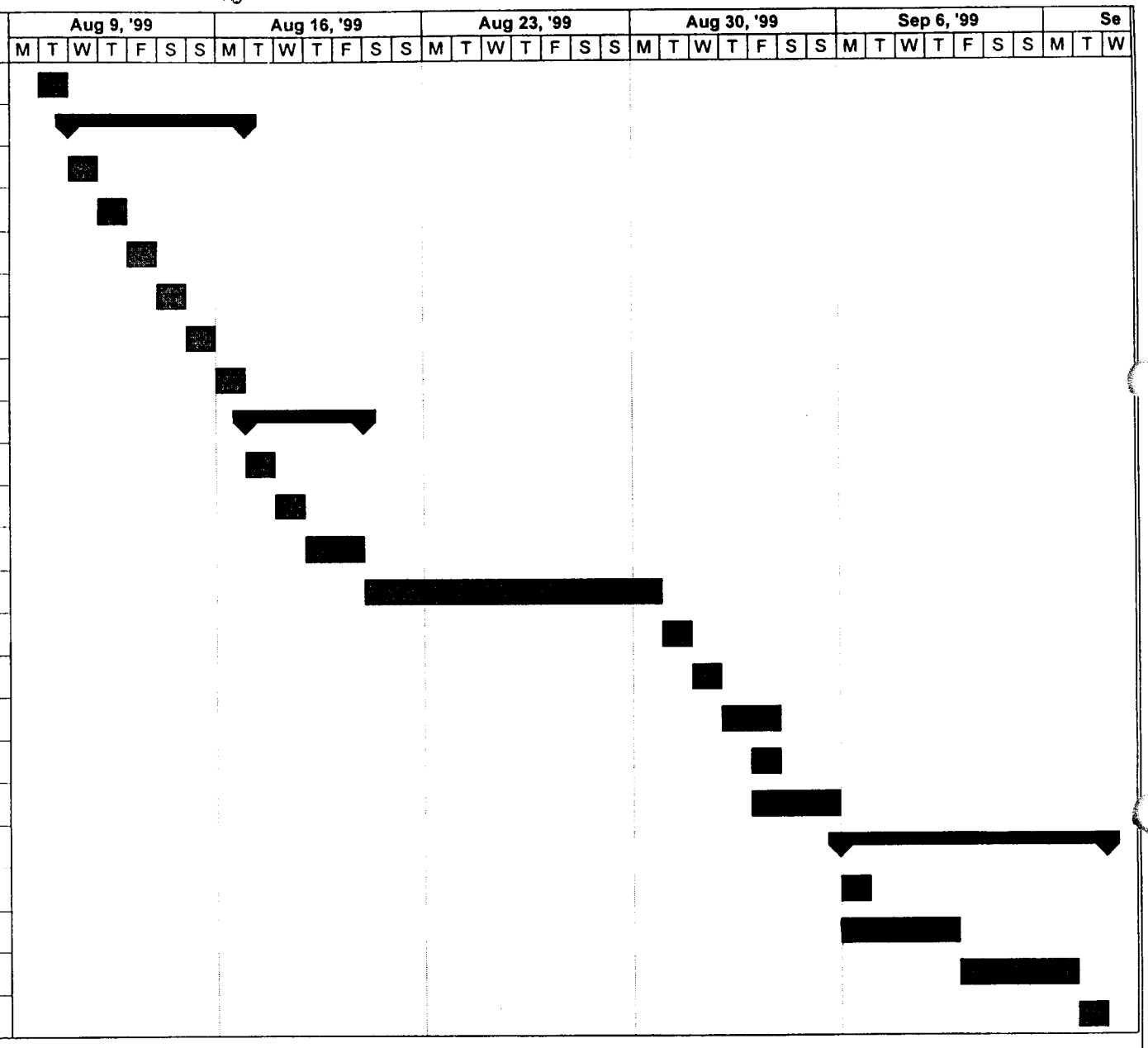
The consistency of the cement will be modified as necessary to accommodate encountered problems. If it becomes apparent that this method for recovery of screen #3 is not working, then the existing situation will be evaluate and decisions on whether to continue the attempt to salvage the screen or to plug the entire screen will be based on that.

### 8.2 Screen #9 Damage Contingencies

As of last observation with the downhole camera, screen numbers 1, 2, 4, 5, 6, 7, and 8 were in normal condition. Only screen #9 was not able to be observed due to the turbidity of the water.

If screen #9 is damaged, the damage will be evaluated and a decision will be made whether to try to salvage the screen or to plug it. The screen is in a zone that is well within the regional aquifer.

| ID | Task Name |
|---|---|
| 1 | Set up URL Workover Rig |
| 2 | **Install cement plug** |
| 3 | Install cement plug (phase 1) |
| 4 | Cement set up time |
| 5 | Verify plug location and consistency (cam |
| 6 | Install cement plug (phase 2) |
| 7 | Cement set up time |
| 8 | Verify plug location and consistency (cam |
| 9 | **Drill plug to gauge** |
| 10 | Drill plug |
| 11 | Ream plug |
| 12 | Inspect plug (camera) |
| 13 | Develop all well screens |
| 14 | Inspect all well screen (camera) |
| 15 | Run geophysics density log for entire hole |
| 16 | Install surface pad and riser pipe housing |
| 17 | Remove drilling equipment |
| 18 | Pad set up time |
| 19 | **Install and Test WESTBAY system** |
| 20 | Set up Smeal rig |
| 21 | Install WESTBAY system |
| 22 | Test WESTBAY system |
| 23 | Remove Smeal rig |




Project: R-25 rec
Date: 7/16/99

Task
Progress
Milestone
Summary
Rolled Up Task
Rolled Up Milestone
Rolled Up Progress

If observation shows damage that is not easily fixable with the equipment already available, then the screen will be plugged and the well will be completed without it.

Since it is not ultimately clear what caused the damage in screen #3, it is impossible to plan actions differently from known guidance or process knowledge. If any of the other screens become damaged during the repair of screen #3, or if screen #9 appears to be damaged once visible, and the cause of the damage can be evaluated, then decisions will be made to either salvage the screen or plug it. The decisions will be based on the importance of the data to be collected from that screened interval, whether that data could be obtained through installation of other planned wells at TA-16, on the evaluated cause of the damage, and on the evaluated cost to salvage the screen.

## 9.0 DECISION TREE OF IMPLEMENTATIONS AND CONTINGENCIES

Figure 9-1 shows the decision tree of implementations and contingencies.

# ATTACHMENT 2

## Introduction

Los Alamos National Laboratory (LANL) is conducting a groundwater characterization program with the overall objective of refining the understanding of the hydrogeologic system in order to adequately monitor groundwater. The scope of the characterization program is described in the Hydrogeologic Workplan, encompassing drilling and completing wells, data collection, information management, and modeling. R-25 is one of the 32 planned regional aquifer 32 wells. It is located in TA-16, the southwestern portion of the Laboratory.

R-25 was a high priority well in the characterization program because it is located in a areas with very limited hydrogeologic data, so it was expected that it would add a great deal to the understanding of the hydrogeologic system. During the drilling of the well, the water-bearing zones that were encountered were found to contain high explosive (HE) residue resulting from historical operational discharges from TA-16. This finding increased the importance of R-25 in the characterization program. It also resulted in a decision to deepen the planned depth of the well by 400 feet, a 25% increase in the total depth of the well.

The schedule in the Field Implementation Plan for drilling and installing R-25 extended from July 1998 to November 1998. R-25 was started in July 1998, but as of July 15, 1999 the well has not been completed. This report examines the activities and events that occurred thus far in the construction of R-25 and develops the "lessons learned" from this experience. This report also describes the actions that the LANL Groundwater Integration Team (GIT) will take to eliminate or minimize schedule delays from potential similar events in future wells.

Activities at R-25 were shut down when it was discovered that the lower 10 feet of screen 3 (the third screen from the top of the well) had collapsed. The circumference of the collapsed screen section was too small to allow passage of the WESTBAY multiple completion well equipment through this part of the well. A Recovery Plan (Attachment 1 of this package) has been developed for mitigating the collapse of screen 3. This Lessons Learned Report examines the events and problems encountered up to the shut down of R-25 activities.

## R-25 Chronology

Figure 1 shows the chronology of drilling R-25. The drilling of the borehole commenced on July 28, 1998 and the total depth of 1942 feet was reached on February 26, 1999. Well construction, which includes placing the stainless steel well casing in the borehole and backfilling with annual materials, took place between March 1 and May 26, 1999. This activity was complicated because R-25 was designed as a multiple completion well, containing 9 screened intervals. Each screened interval required filter pack that is hydraulically isolated from adjacent screened sections by bentonite grout. Well development, the flushing out of annular filter pack materials in all 9 screened intervals, was underway from May 26 to June 4 when all activities on R-25 were shut down. Figure 2 shows the relative amount of time spent in each of these well construction phases.

### Borehole Drilling

Figure 3 shows the rate of casing advance in R-25. This graph was constructed using the depth of the casing at the end of every Friday during the drilling phase. It is apparent from this graph that there were periods when the advance of the casing was very small. In fact, periods when the casing was stuck or the circulation system was not functioning properly accounted for about 74% of the drilling phase and casing advance accounted for approximately 26% of the time during the drilling phase (Figure 4).

Problems associated with drilling were:

- The lengthy drilling phase can be primarily attributed to the geologic conditions that make the borehole unstable. This instability leads to borehole squeezing and collapse which locks up the casing. It also leads to flowing sands that cause problems in the air circulation system.
- When the borehole had been advanced to the planned depth of the well, about 1500 feet, the air pressure was not sufficient to circulate the cuttings out of the borehole.
- Placing the bentonite seal below the upper water-bearing zone was difficult because the units underlying the water-bearing zone were not competent to bear the weight of the casing.

### Well Construction

Emplacing the well casing in the borehole took four shifts (March 3-6). Placing the bottom bentonite seal and the filter pack materials for screen 9 also took four shifts. After this first screened interval, backfilling of annular material went much faster, taking about one shift per interval.

Three major problems were encountered during the well construction phase: 1) dropped tremie lines, 2) the well sounder not working, and 3) using the 1-inch tremie line. The tremie lines were dropped two times. The first time was on March 6. The cable that held the tremie line broke and the tremie landed about 9 feet below the top of the casing. About 7 hours were required to retrieve the tremie line. Additionally, the tremie that was

dropped was bent and was unusable after that incident. The second incident occurred on April 7. In this incident the cable suspending the tremie lines broke, allowing both the 2-inch diameter and 1-inch diameter tremie lines to fall. After falling, the bottom of the tremie lines were at approximately 1500 feet below ground surface, between screens 7 and 8. Retrieving the 1-inch tremie (all but the lowermost 52 feet) required seven shifts of fishing time in addition to the six shifts required to determine the location and orientation of the tremie lines. Three shifts were required to pull out the 2-inch tremie line and backfill behind it. Therefore, the second dropped tremie incident required about 16 shifts of direct effort on recovering the tremie lines to correct. However, the total schedule delay resulting from this incident was 45 shifts.

The tool used to determine the depth of the well or the depth of materials in the well, called a sounder, did not function properly. A number of different sounder configurations were tried out during the well construction phase. Some configurations were too heavy and they penetrated the fine sand and went into the underlying grout, so they could not be used to determine the top of the very fine sand layers. In other cases the electronics were unreliable, making sounds before any material was reached. In some cases the cable holding the sounder would get held up on the casing and would not extend all the way to the backfill materials. The unreliable sounding tools resulted in too much grout seal between screens 5 and 4 and excess sand at screen 4. One shift was devoted to blowing the sand out of the annular space before the tremie lines dropped on April 7.

The 1-inch diameter tremie line was necessary to emplace annular backfill material in the lower portion of the well, where the drill casing has a diameter of 9 inches. Within the 9-inch diameter drill casing was a 5-inch diameter well casing, which leaves only enough room for a 1-inch diameter tremie line. Problems were anticipated with using a 1-inch tremie, so the original setup included two 1-inch tremie lines. However, the second 1-inch tremie line was bent and rendered inoperable in the March 6 tremie line incident. The problems encountered were plugging of the 1-inch tremie and bridging of backfill materials.

**Well Development**

The R-25 well development process consists of setting inflatable packers above and below a screened interval and surging water in that interval to flush out the backfill materials around the screen. The purpose is to ensure the water coming in to that screen is representative of the formation water and does not include materials introduced by the drilling process. Well development was conducted for 8 days (16 shifts) before the collapse of screen 3 was observed and the well development was shut down. Three major problems were encountered during well development. The first problem was an obstruction in the well. A downhole video camera survey was conducted while the drilling rig was set up for well development. A metal pin was observed lying horizontally in the well, held up by a casing collar. The pin apparently fell off of the inflatable packer. The packer was fabricated at the Field Support Facility and the pin that fell off was not properly attached to the apparatus. The pin was retrieved on June 3.

The second problem is the unknown condition of screen 9. This screened interval is blocked, so no assessment of the condition of the screen can be made. Initially it was thought that the screen was filled with sediment that had settled down from the screens above. About nine shifts were devoted to cleaning out screen 9 with a sand pump and by air lifting. A drive sampler was used to try and get a sample of the sediment, but the sampler met refusal and the small amount of material retrieved consisted of fine sand and bentonite. At this time, there appears to be some other blockage of the screen, possibly a collapse of the screen.

The third problem is the collapse of the lowermost 1-2 feet of screen 3 (Screen 3 is 10 feet long). Numerous drilling experts have viewed the video showing the collapsed section and all have agreed the collapse is due to compressional forces. This suggests that the well casing experienced a compressional event during the installation process which caused column collapse of the vertical rods in the screen. This compressional event has not been conclusively identified, but may have been associated with retraction of the drill casing during well construction. Additionally, it was noted from the video that screen 3 is constructed of a lighter gauge making it more susceptible to compression.

**Down Time**

About 30% of the total time spent on R-25 was "down time", considered here to be time that the drill rig/crew could not work on the well. Figure 5 shows the relative distribution within down time categories. The majority of down time is necessary and unavoidable, including holidays, burning ground closures, sampling, geophysical logging, lightning, and tour groups. Improvements can be made in the amount of time spent retrieving items that have been lost downhole (22% of the down time and 6% of the total R-25 duration) and in repairing equipment (11% of down time, 3% of total R-25 duration).

## Lessons Learned/Corrective Action

Table 1 summarizes the problems encountered, lessons learned, and corrective actions. These are described in more detail in the following section.

**Table 1: R-25 Lessons Learned and Corrective Action**

| Issue | Lesson Learned | Corrective Action |
|---|---|---|
| Geologic conditions | Unstable borehole slows drilling down by locking up casing and blocking circulation | • Use water, bentonite, foam, and reaming to keep the casing loose<br>• Use the stratigraphic model to predict when unstable geologic units are likely to be encountered.<br>• Incorporate additional time in the schedule and budget to drill through these zones.<br>• Include contingency in the budget to deepen wells if conditions warrant. |
| | Air pressure insufficient at depths below 1500 feet to lift cuttings | At depths below 1500 feet use a booster |
| Intermediate zone seal | Finding a competent perching zone may require some searching | • When selecting a suitable perching unit, look for materials competent to support the weight of the casing.<br>• schedule and budget for each well should include some contingency for sealing intermediate water-bearing zones.<br>• Use tracers to ensure the integrity of the seal. |
| Time spent "fishing" items out of the borehole | Prevent the dropping of items downhole | • Safety inspections of the rigging equipment<br>• Tailgate safety meetings should regularly emphasize awareness of holding tools over the open borehole.<br>• Operate within the specifications of the drilling equipment so that excess |

| Table 1: R-25 Lessons Learned and Corrective Action | | |
|---|---|---|
| **Issue** | **Lesson Learned** | **Corrective Action** |
| | | torque is not applied.<br>• Drill crew will attend the "Hoisting and rigging" class offered by the Lab.<br>• Use factory-made slings and avoid equipment assembled on-site that has not been tested or rated. |
| Incorrect placement of backfill materials | Use a procedure that specifies how to take a reliable measurement of backfill material depth | Develop and follow a procedures for well construction, including specifications for sounding depth of materials |
| Blockage of screen 9 | Pending | Pending |
| Collapsed screen 3 | Field crew should have well design specifications monitor interaction between well casing and drill casing | • Assign a crew member the responsibility to monitor the stainless steel well casing Pull up the tremie line prior to retracting the drill casing to minimize the space problem. |
| | Use heavy gauge well screen | Inspect casing prior to emplacement |
| Crew experience | Keep experienced crew working on wells | Have extensive on-the-job training of new crew members by experienced crew members |
| Safety incidents | Focus on safety to maintain status of no lost time due to injuries | Document daily tailgate safety meetings in memo to file |
| Drilling schedule | 24-hour drilling schedule results in missed data, ineffective oversight, and increased safety issues. | Use multiple rigs with 12-hour shifts to meet Hydrogeologic Workplan schedule |

**Issue: Geologic Conditions**

The heterogeneity of the formations below the Pajarito Plateau makes drilling very difficult. The drilling method must be capable of holding the borehole open while allowing for characterization of the rock and the water during drilling. Two methods have been identified that meet these criteria, mud rotary and casing advance.

In mud rotary drilling the drilling mud keeps the borehole open. Geophysical surveys could then be used to characterize the geology and hydrology. This method also has the benefit of being less expensive. The issues with this method are:

- unstable zones in the borehole are also likely to be zones where mud would move out into the formation and circulation would be lost, and the borehole could not be advanced;
- if contaminants were present in the groundwater, they would mix with the mud and cause cross-contamination and a lot of hazardous waste;
- Intermediate water zones could not be identified and sampled during drilling.

Drilling with the casing advance method uses the casing to hold open the hole while drilling. Characterization of the geology and hydrology can be done while drilling, which has proved beneficial in R-9 and R-25, where contaminants are present in intermediate zones. Another benefit of this method is that it provides a stable borehole in which to construct a well, which is particularly important in the unstable geologic conditions. Based on experience at R-9, R-12, and R-25, the issues associated with this method of drilling are:

- Unstable geologic units tend to "rock lock" the drilling system,
- Unstable geologic units tend to clog up the circulation system,
- It is expensive.

At this point in the characterization program, the issues with mud rotary drilling seem to outweigh the potential benefits. Considering the potential for lost circulation, it may be that casing advance is the only drilling method that can be effective in these geologic conditions. The GIT will continue to evaluate other drilling methods along with reiteration of the Data Quality Objectives. In the meantime, R-25 has provided some valuable lessons on how to manage the geologic conditions.

**Lessons Learned:**

- When the drill system begins to tighten up, immediately add some mixture of water, bentonite, and torquease.
- When drilling at depths greater than 1500 feet, use a booster to increase air pressure in the circulation system.
- Use back reaming to keep the borehole open.
- Use the stratigraphic model to predict when unstable geologic units are likely to be encountered.
- Incorporate additional time in the schedule and budget to drill through these zones.
- Include contingency in the budget to deepen wells if conditions warrant.

**Corrective Actions**

All of the above actions have been incorporated in the operations at R-15 and future wells.

**Issue: Sealing Intermediate Zones**
Intermediate water-bearing zones must be hydraulically isolated prior to advancing the borehole to ensure that cross contamination does not occur. The method for sealing off intermediate zones was developed while drilling R-9 when pressurized intermediate water-bearing zones were encountered. The procedure involves advancing the casing to an unsaturated perching unit beneath the water-bearing zone and injecting grout in the borehole. The borehole is then advanced with a smaller diameter casing, thereby leaving the grout seal intact. This procedure had to be repeated two times at R-25 because finding a competent underlying perching unit that could support the weight of the casing required some trial and error.

**Lessons Learned:**
- When selecting a suitable perching unit, look for materials competent to support the weight of the casing.
- Recognize that finding a competent perching layer will be easy in some wells (i.e. R-12) and more difficult in others (i.e. R-25). Therefore, the schedule and budget for each well should include some contingency for sealing intermediate water-bearing zones.
- Use tracers to ensure the integrity of the seal.

**Corrective Actions**
All of the above actions will be incorporated in the operations at R-15 and future wells.

**Issue: Time spent fishing**
Throughout the duration of activities at R-25, approximately 6% of the time was spent fishing for items lost down hole. Table 2 shows the items lost in R-25 based on the R-25 log books. Some items are twisted off or broken off while they are down hole, and there is little that can be done to prevent these occurrences. However, the major amount of "fishing" time was spent on retrieving the dropped tremie lines.

**Table 2: Items Fished out of R-25**

| Date | Item Lost Downhole | Time Spent Fishing |
|---|---|---|
| 7/30/98 | Socket wrench | 2 hours |
| 8/31/98 | Drill casing | 1 hour |
| 9/1/98 | Core bit twisted off downhole | 9 hours |
| 10/15/98 | Casing advance bit lost downhole | 12 hours |
| 12/2/98 | Core tube stuck downhole when pin seared off | 1 hour |
| 2/1/99 | Sounder weight | 0 (no fishing, left down hole) |
| 3/6/99 | Tremie line | 7 hours |
| 4/7/99 | Tremie lines | 144 hours |

| Table 2: Items Fished out of R-25 | | |
|---|---|---|
| **Date** | **Item Lost Downhole** | **Time Spent Fishing** |
| 5/3/99 | Metal pin (from packer?) | 12 hours |

**Lessons Learned:**

- The daily safety inspections must focus on the competence of rigging equipment (cables, slings, shackles) over the borehole.
- Tailgate safety meetings should regularly emphasize awareness of holding tools over the open borehole.
- Operate within the specifications of the drilling equipment so that excess torque is not applied.
- Request more frequent inspections of the rigging by the ESH-3 safety group.
- Drill crew will attend the "Hoisting and Rigging" class offered by the Lab.
- Use factory-made slings and avoid equipment assembled on-site that has not been tested or rated.

**Corrective Actions**

All of the above actions will be incorporated in the operations at R-15 and future wells.

**Issue: Incorrect Placement of Backfill Materials**

In R-25 the bentonite seal between screens 5 and 4 was too long and the filter pack sand for screen 4 extended too far above the screen. There are a number of factors that probably contributed to this. One factor is that the sounder(s) used to gage the depth of the backfill materials were unreliable. The R-25 log books document the various sounder configurations used and problems encountered. Another factor could be that there is not a written procedure for sounding the well that would produce reliable results (e.g. sound the well until the same measurement is read 3 times). A third factor is the log books did not indicate a consistent procedure for determining how much material a particular interval is expected to require. A fourth factor is that the materials added could have bridged, so that they would appear to be higher in the well than they actually are.

**Lessons Learned:**

- During well construction, clearly delineate a chain-of-command and responsibilities.
- Use a reliable sounding mechanism. Possibly use two sounding mechanisms as a back up and check.
- Employ a procedure that ensures the materials are consistently sounded and the measurement is reproducible.
- Employ a procedure for calculating the amount of materials expected to be required for a particular interval, tracking the amount of materials actually added, and a notification system when volume of materials required is off by a specified percentage from the calculated volume.

**Corrective Actions**

All of the above actions will be incorporated in the operations at future wells.

**Issue: Blockage of screen 9**
Screen 9 in R-25 is blocked. Various methods have been unsuccessfully employed to clear the screen including a sand pump, sampling, and air lifting. Until the collapse of screen 3 is remediated, there is no way to assess the screen integrity and the installation of the WESTBAY equipment in the screen 9 interval.

**Lessons Learned:**
Lessons learned are pending until the cause of blockage can be determined.

**Corrective Actions**
Pending until the cause of blockage can be determined.

**Issue: Collapsed screen 3**
The lowermost 1 - 2 feet of screen 3 in R-25 is collapsed. The WESTBAY equipment will not fit through the resultant opening. There are two contributing causes to this situation. The first is that the screen was not of specified gauge, and thus was weaker than it should have been. The second cause is that the well casing apparently experienced a compressional event. Numerous drilling experts that have viewed the videotape of screen 3 have all opined that the collapse is the result of compression. The well casing is supposed to be suspended in tension during the well construction. However, some compressional event must have occurred to cause the collapse. While it is likely the cause of the compression event will never be conclusively identified, it may have been caused by the interaction of the drill casing and the well casing while the drill casing was retracted.

**Lessons Learned:**
- The specifications for the well should be provided to the onsite field crew so that the casing can be inspected before it is placed in the well.
- Assign a crew member the responsibility to monitor the stainless steel well casing in the jack cellar and alert the driller if the casing is moving. If the casing begins to move, stop the upward movement of the drill casing and keep gently trying until the drill casing moves up without moving the well casing.
- Pull up the tremie line prior to retracting the drill casing to minimize the space problem.

**Corrective Actions**
All of the above actions will be incorporated in the operations at R-15 and future wells.

**Issue: Crew experience**
R-25 has been a valuable learning experience for the drilling and field crew. The crew had to contend with a new drill rig that none of them had used before in difficult geologic

conditions, which were unknown at the start. As the groundwater characterization program expands to drilling more than one well at a time, additional crew members will be needed. It is important that the experience gained at R-9, R-12, and R-25 be shared with new people.

**Lessons Learned:**

- Maintain the experienced drill crew. This is particularly important with respect to the driller who has developed a "feel" for the conditions and how to manage them.
- Screen potential crew members for experience drilling, installing, and completing wells.
- Ensure that new crew members work with experienced crew members for a specified amount of time before being left on their own.
- Have the all drilling and field support services provided by a single contractor so that experience, knowledge, and on-the-job training can be freely shared among all participants.

**Corrective Actions**

All of the above actions will be incorporated in the operations at R-15 and future wells.

**Issue: Maintain Safety Record**

The safety record at R-25 includes no lost time for injuries. The log book indicates three incidents occurred that resulted in minor scrapes or bruises, but not in stopping any activities. This is a safety record that should be maintained throughout the program.

**Lessons Learned:**

- Continue the tailgate safety meetings at the beginning of every shift. Document the content of the meetings in a memo to file.

**Corrective Actions**

All of the above actions will be incorporated in the operations at R-15 and future wells.

**Issue: Drilling Schedule**

R-25 was drilled with 12-hour shifts up until the last month. During the last month, drilling activities went on 24 hours a day in two 12-hours shifts. Based on this experience, 24-hour scheduling is not preferred. Concerns about the 24-hour schedule include: the lack of effective oversight by LANL during the night shift; missing some characterization data (e.g. water levels) during the night shift; having a single 12-hour shift provides the opportunity for problem solving in the evenings which is not afforded by the 24-hour schedule; and potential increase in safety issues with fatigue.

**Lessons Learned:**

- Meet the Hydrogeologic Workplan schedule using multiple rigs on 12-hour shifts.

**Corrective Actions**

All of the above actions will be incorporated in the operations at R-15 and future wells.

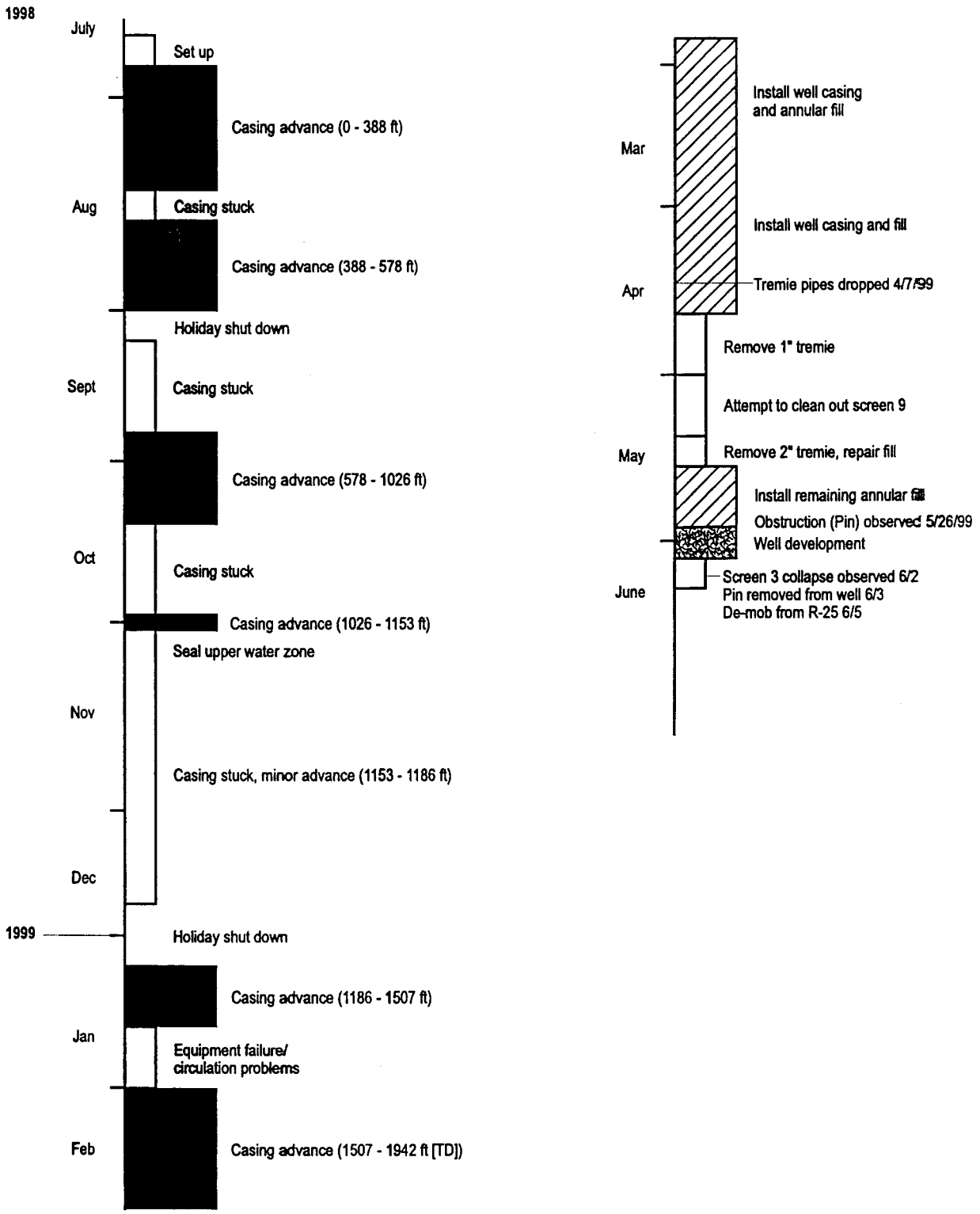



**Figure 1. Chronology of Drilling and Well Completion Activities at R-25**

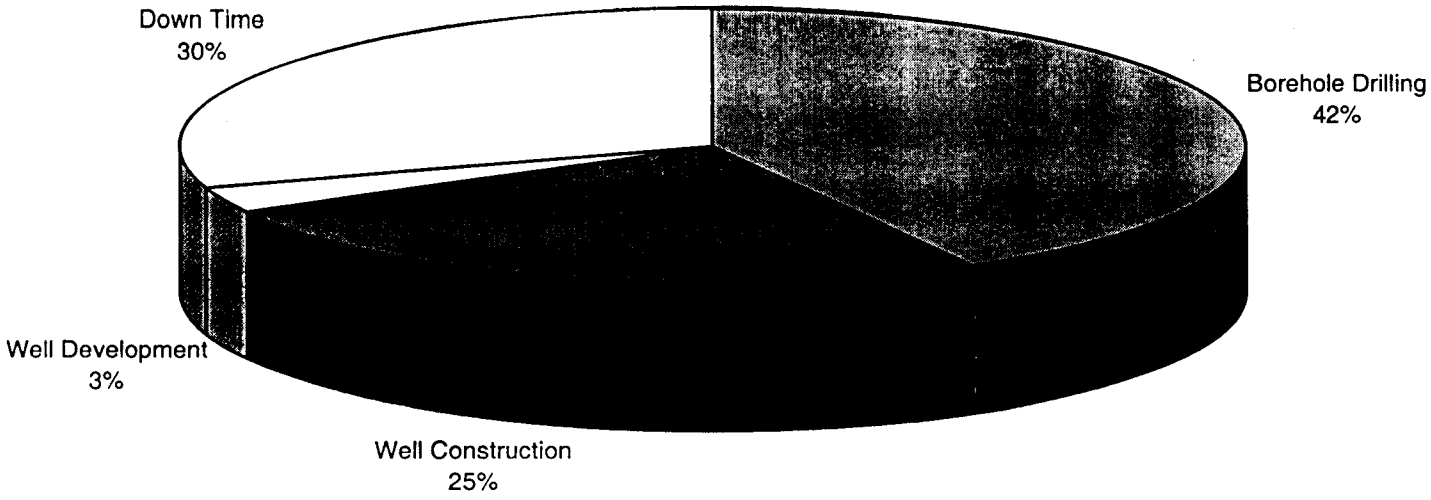



**Figure 2. R-25 Construction**

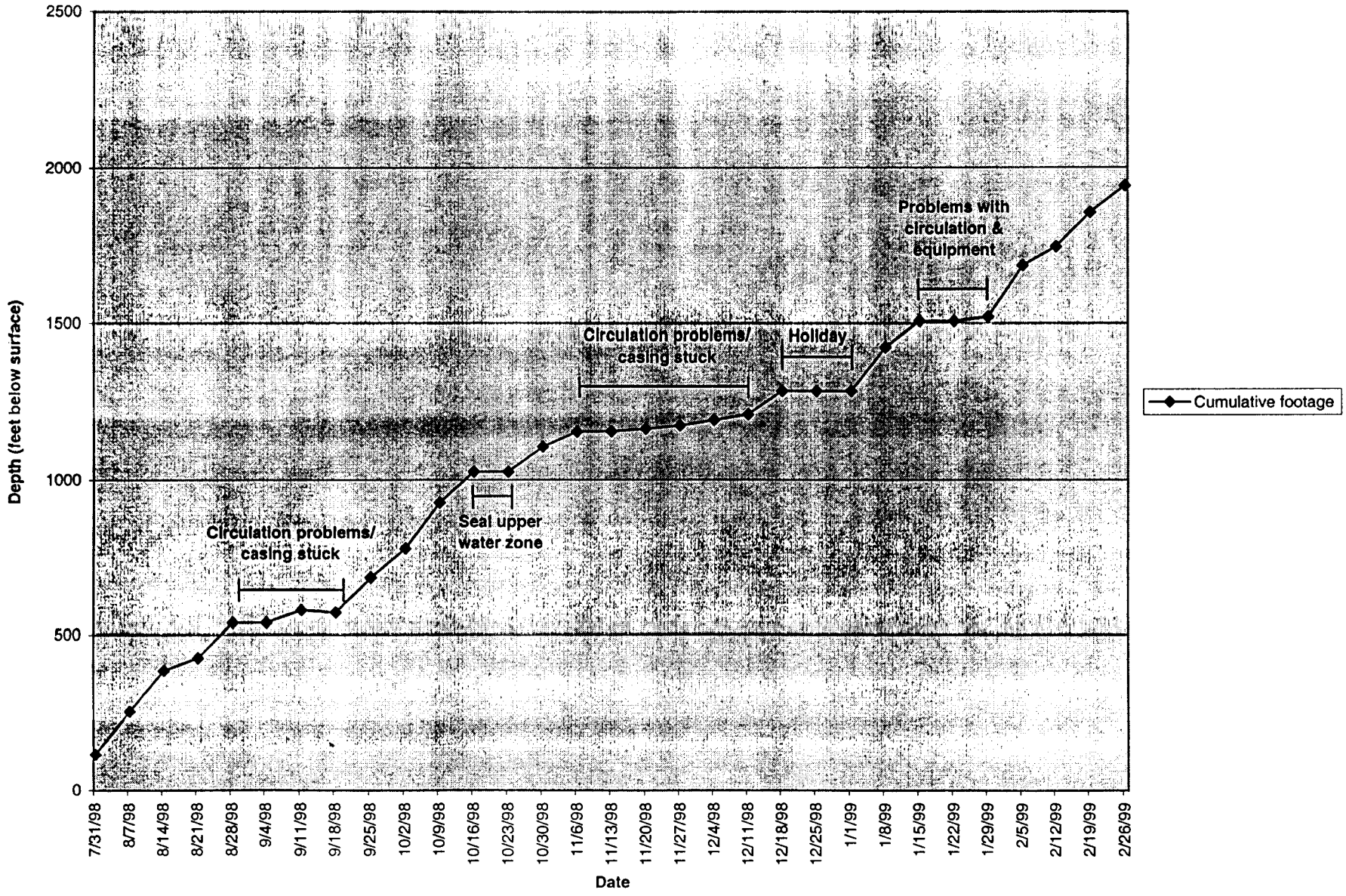



Figure 3. R-25 Depth Advance

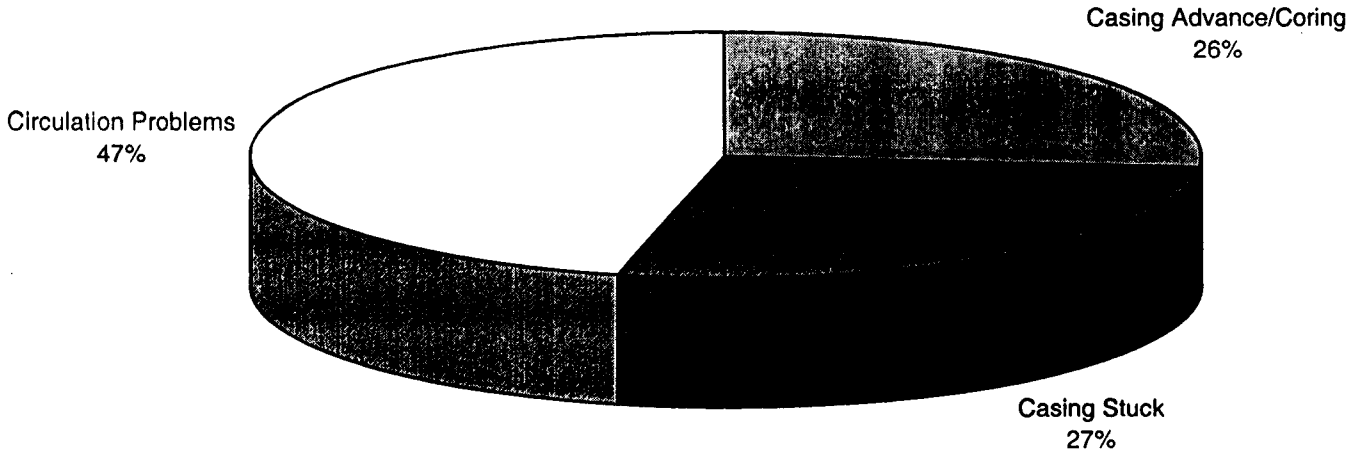



**Figure 4. R-25 Borehole Drilling**

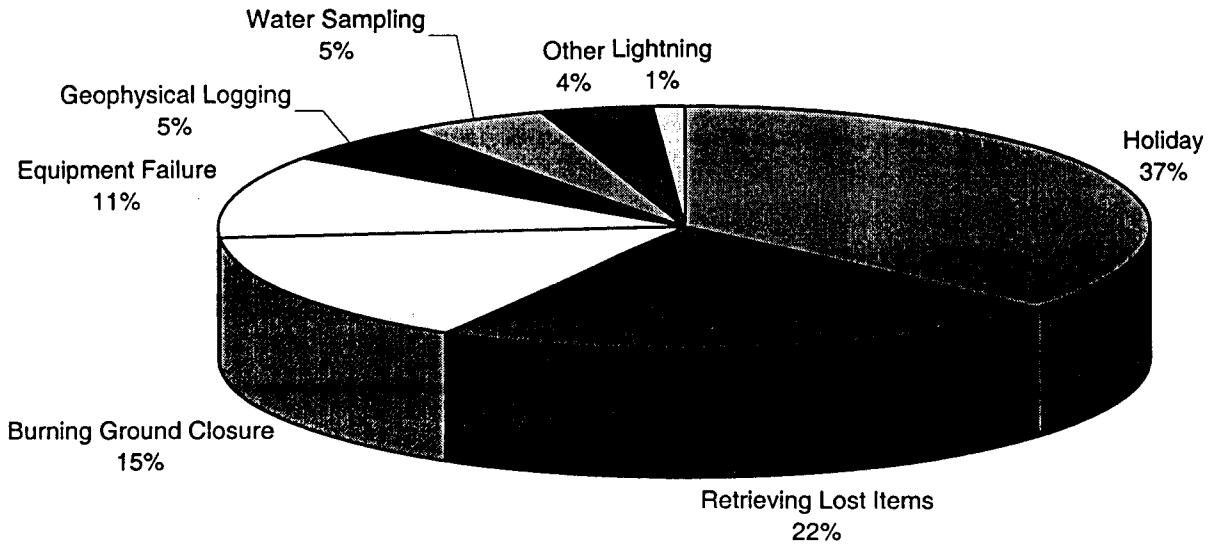



**Figure 5. R-25 Down Time**