LA--9179-MS

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LA-9179-MS

UC-70
Issued: June 1982

Conceptual Design Report
Exploratory Shaft-Phase I,
Nevada Nuclear Waste Storage Investigations

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Contributions made by
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TABLE OF CONTENTS

EXECUTIVE SUMMARY		1
ABSTRACT		3
I.	INTRODUCTION	3
	A. Background	3
	B. Program Status	4
	C. Purpose	6
II.	DESIGN BASIS	6
	A. Design Objectives	6
	1. Safety	6
	2. Environment	6
	3. Technology	6
	4. Licensability	6
	5. Future Disposition	6
	B. Principal Functional Design Requirements	6
	1. Access to Underground Openings	6
	2. Underground Openings	7
	3. Supporting Facilities and Services	7
	C. Design Assumptions	7
	D. Principal Design Criteria	8
	1. Access to Underground Openings	8
	2. Shaft Internals	8
	3. Underground Openings	9
III.	TEST PROGRAM	9
	A. Objectives	9
	B. Principal Functional Requirements	10
	C. Principal Operational Requirements	11
IV.	CONCEPTUAL DESIGN DESCRIPTION	11
	A. Site Work and Surface Support Facilities	12
	1. Functions	12
	2. Design Requirements	12
	3. Design Description	16
	B. ES Drilling, Casing, and Cementing	19
	1. Functions	19
	2. Design Requirements	19
	3. Design Description	20
	C. Shaft Internals, Hoisting, and Headframe	25
	1. Functions	26
	2. Design Requirements	26
	3. Design Description	26
	D. Underground Openings	28
	1. Functions	29
	2. Design Requirements	29
	3. Design Description	31

E. Ventilation 33
1. Functions 33
2. Design Requirements 34
3. Design Description 34
F. Test Equipment 35

V. OPERATIONS AND MAINTENANCE 36
A. Operations 36
1. Construction Operations 36
2. Exploratory Drilling and Testing 36
B. Maintenance 37
1. Objectives 37
2. Corrective Maintenance 37
3. Preventive Maintenance 37
4. In-Service Inspection and Surveillance 37

VI. SAFETY 37

VII. QUALITY ASSURANCE 38
A. General 38
B. Quality Assurance Program 38
C. Design Control 39
D. Construction and Operational Control 39

VIII. CONSTRUCTION COST ESTIMATE AND SCHEDULE 39
A. Introduction 39
B. Cost Estimate 40
1. Operating Expense Funds 40
2. Capital Equipment Funds 42
3. Optional Operating Expense and Capital Equipment 42
C. Construction Schedule 44
D. Procurement Plan 44

IX. PROJECT MANAGEMENT 46

APPENDIX A - CONCEPTUAL DESIGN OF A CONVENTIONALLY SUNK EXPLORATORY SHAFT 47

APPENDIX B - HOLMES & NARVER, INC. SURFACE FACILITY DESIGN STUDY AND COST ESTIMATE 65

APPENDIX C - (PART I) FENIX & SCISSON, INC. STUDY REQUEST NO. 1 SHAFT DRILLING AND CASING FOR EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY 75

APPENDIX C - (PART II) FENIX & SCISSON, INC. BUDGETARY ESTIMATE U-25 WASTE ISOLATION SHAFT NO. 1 COST ESTIMATE SUMMARY (UNIT-PRICE DRILLING CONTRACTOR) 110

APPENDIX D - FENIX & SCISSON, INC. ENGINEERING SPECIFICATIONS 1015 AND 1018 124

APPENDIX E - FENIX & SCISSON, INC. STUDY REQUEST NO. 3
INTERNAL VS EXTERNAL UTILITIES COMPARISON FOR
EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY
MINING PHASE 151

APPENDIX F - FENIX & SCISSON, INC. STUDY REQUEST NO. 2
SHAFT INTERNALS, HOISTING, AND HEADFRAME FOR
EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY 176

APPENDIX G - FENIX & SCISSON, INC. STUDY REQUEST NO. 4
EXPLORATORY OPENINGS FOR EXPLORATORY SHAFT
CONCEPTUAL DESIGN STUDY 193

APPENDIX H - FENIX & SCISSON, INC. STUDY REQUEST NO. 7
VENTILATION SYSTEM FOR EXPLORATORY SHAFT
CONCEPTUAL DESIGN STUDY 205

APPENDIX I - FENIX & SCISSON, INC.
ESTIMATED SMOKE-OUT TIME FOR PROPOSED AREA 25
EXPLORATORY SHAFT 216

APPENDIX J - FENIX & SCISSON, INC.
COST ESTIMATE FOR MINING PORTION OF PHASE I
CONCEPTUAL DESIGN 220

EXECUTIVE SUMMARY

It is proposed that an Exploratory Shaft (ES) be constructed in Yucca Mountain on or near the southwest portion of the Nevada Test Site (NTS) as part of the Nevada Nuclear Waste Storage Investigations (NNWSI). The purpose of the ES is to provide direct access to the selected horizon(s) for exploration at depth. The ES shall proceed in two phases; Phase I is to determine the suitability of the site as a possible location for a Test and Evaluation Facility (TEF) and Phase II is the evaluation of the suitability of the site for a full-scale licensed repository for high-level radioactive waste. This document primarily discusses Phase I.

For the purposes of conceptual design and to obtain a representative cost estimate, a location and depth of the shaft have been assumed. Actual location and depth will not be selected until sometime in early FY 1983. It is assumed that blind shaft drilling techniques will be used to construct the ES, although conventional methods of shaft sinking have not been ruled out. The current plan is that limited exploration will be done in the shaft during its construction. The size of the underground openings and the extent of an *in situ* experimental program have been assumed because the characteristics and conditions required to qualify a site have not been fully defined. Decisions that change any one of these assumptions could have a significant effect on the project cost estimate and schedule.

About seven miles of road construction will be required to the proposed ES site. Other site work and surface support facilities include grading and stabilizing about five acres of land; bringing utilities to the ES site; and constructing structures to house offices, laboratories, change rooms, warehouse, shops, and first aid station.

Access to the underground openings will be provided by a shaft lined with a 98-in.-i.d. steel casing. The shaft will be outfitted with a main hoist, an emergency hoist, and pipelines and conduits for utilities and services, as well as signal and communication systems. About 85 000 ft^3 of rock will be excavated to form two rooms from which exploratory boreholes can be drilled and in which *in situ* experiments can be performed. These exploratory operations will provide qualitative information on some actual conditions at depth, such as rock quality, lithology and structure, characteristics of jointing, lateral variations and properties, rock deformation, stability of openings, stabilization of damaged rock, and groundwater conditions (flow rates, pressure, and temperature).

Site work is scheduled to begin in April 1983, the shaft will be spudded by the end of September 1983, and drilling operations will begin in October 1983. Shaft construction (drilling and casing) will take about nine months (complete by July 1984). Outfitting the shaft and mining operations will be completed by February 1985. Drilling of the Phase I horizontal exploratory holes will require about four months and will be completed by June 1985.

The estimated cost of the ES is about $63 million. The intent is to use as much existing NTS drilling and mining equipment as possible; however, at this time, it is not possible to predict the availability of all items. The item of greatest concern is a Class I drill rig. The future availability of commercial drill rigs with the required capacity is uncertain, as is the future availability of the only NTS drill rig (IDECO 2500) with the capacity to meet the project requirements. The current schedule for this project requires that the rig be available by September 1983. It is estimated that 18 months will be required after manufacturer receipt of an order to deliver a new drill rig. Therefore, if a new drill rig is to be purchased, the order should be placed by March 1982. Congressional reprogramming actions that would be required for the acquisition of a drill rig have not been initiated; therefore, the study assumes that the drilling will be done by a unit-price contractor.

CONCEPTUAL DESIGN REPORT
EXPLORATORY SHAFT - PHASE I
NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS

by

D. C. Nelson, T. J. Merson, P. L. McGuire, and W. L. Sibbitt

ABSTRACT

It is proposed that an Exploratory Shaft (ES) be constructed in Yucca Mountain on or near the southwest portion of the Nevada Test Site (NTS) as part of the Nevada Nuclear Waste Storage Investigations. This document describes a conceptual design for an ES and a cost estimate based on a set of construction assumptions. Included in this document are appendixes consisting of supporting studies done at NTS by Fenix & Scisson, Inc. and Holmes & Narver, Inc. These appendixes constitute a history of the development of the design and are included as part of the record.

I. INTRODUCTION

A. Background

The Department of Energy (DOE) has forecast that a full-scale licensed repository will be ready to receive commercially generated high-level radioactive waste sometime between 1997 and 2006. The Nuclear Regulatory Commission (NRC) has passed into law procedural requirements for the characterization of potential repository sites leading up to an application for the construction of a full-scale repository. These requirements include that an Exploratory Shaft (ES) be developed and that an underground examination of a site be made before consideration of any license application. The NRC also requires that (1) at least three such sites shall be examined, (2) these sites shall be in at least two different rock types, and (3) at least one of these rock types shall not be salt. The DOE is focusing its attention on three specific locations, one of which is on or near the Nevada Test Site (NTS).

Current plans within DOE for the development of test facilities for the characterization and evaluation of potential repository sites include the At-Depth Testing (ADT) and the Test and Evaluation Facility (TEF) after sinking the ES. An ES shall be constructed at each of the three sites and then the investigation shall proceed in two phases. The purpose of Phase I shall be to determine the suitability of the site for the construction of the TEF. Phase II will be an expanded Phase I to determine if the site qualifies as a repository site. If the site fails to qualify as a potential site for the TEF, it is also assumed it will not qualify as a repository site, and all exploratory work at the site will cease. Should the site be found acceptable during Phases I and II, then work on the ADT may proceed. The primary use of the ADT will be the performance of *in situ* experiments for verification of repository design features. One of the three sites will be selected by DOE for the construction of the TEF, a facility for verifying the operational features of a repository. The TEF will contain 200 to 300 high-level radioactive waste containers stored in a retrievable fashion. Experiments that involve containers of radioactive waste will not be conducted in either the ES or the ADT.

This document addresses the conceptual design of the ES only, with emphasis on Phase I.

B. Program Status

After extensive surface exploration of the NTS, the tuff formations in and near the southwest portion of the reservation in the vicinity of Yucca Mountain have been selected for further investigation. This will include the sinking of an ES to allow direct observation of the proposed host rock at depths considered suitable for a repository. The initial purpose (Phase I) will be to determine the suitability of the site for the TEF. If acceptable, Phase II will be implemented to resolve major site viability uncertainties with respect to repository site selection decisions.

Several potential target horizons (depths) have been identified where a repository could possibly be located. For this document, it is assumed that the ES will be constructed to a depth of 3500 ft. Other tuff rock formations being considered and possible horizon depths are Topopah Spring (1200 ft), Calico Hills (1600 ft), Bullfrog (2500 ft), and Tram (3100 ft). The Topopah Spring and Calico Hills members are above the static water level; the Bullfrog and Tram members are below the water level.

This study assumes that the ES will be constructed using large-hole drilling methods. However, conventional shaft sinking (mining) is still under consideration as a construction method. This concept is discussed in Appendix A.

Although it has been assumed for cost estimating purposes that the ES will be constructed near exploratory Drill Hole USW-H1, several other possible locations have been identified for the ES (see Fig. 1). The number of suitable sites for the ES is somewhat limited because of the Yucca Mountain Topography.

Figure 1 shows the boundary of the principal block proposed for the repository. The assumed location for the ES is on the northern boundary of this block and in the extended block area. To optimize the amount of horizontal exploration that can be accomplished in the principal block, locating the ES in the washes identified as A, B, and C on the eastern side of Yucca Mountain may be desirable. These locations are on US Air Force and Bureau of Land Management properties.

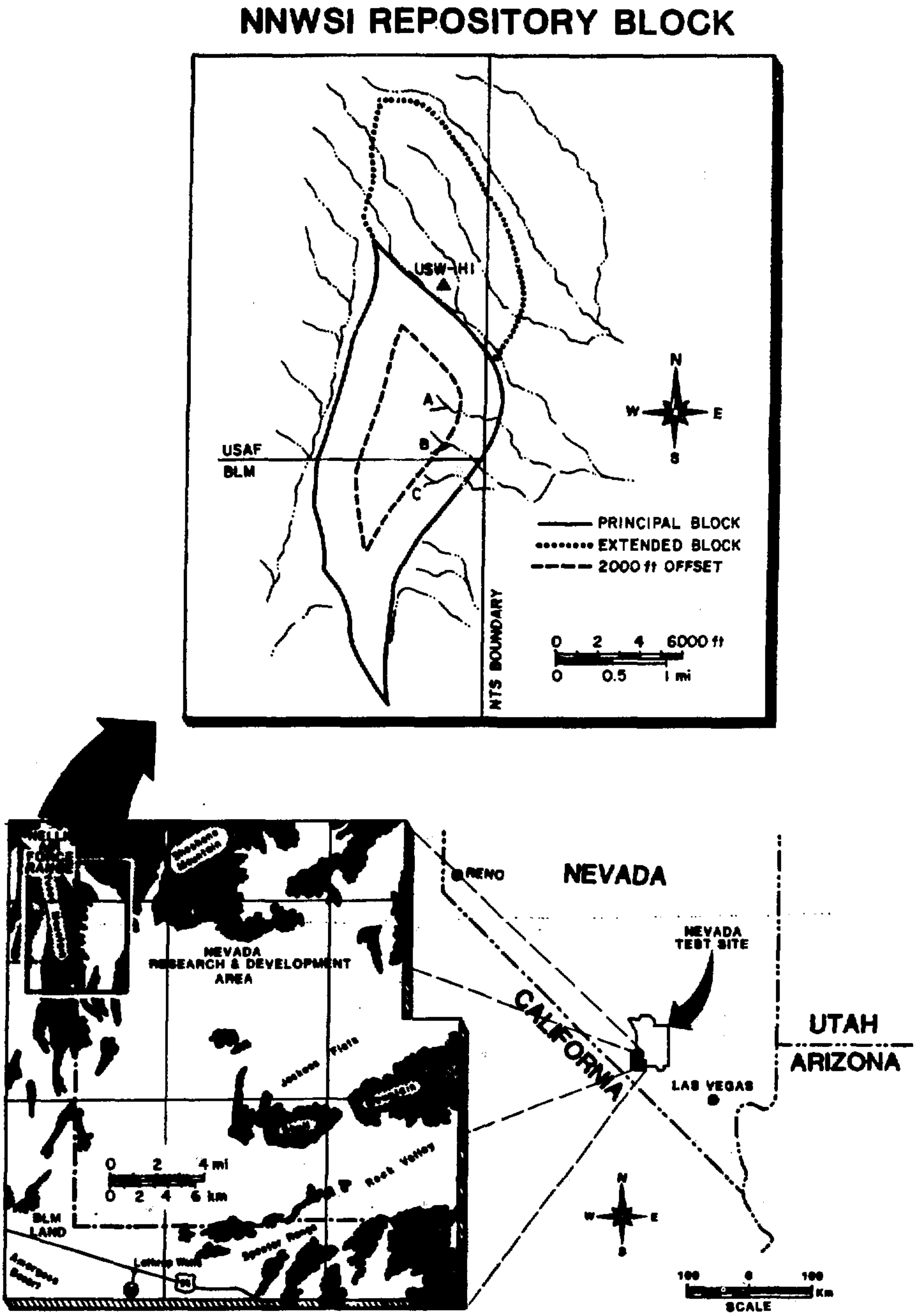


Fig. 1. Repository block location.

C. Purpose

This document provides a description of a conceptual design of the facilities, equipment, and systems associated with the ES that could satisfy all the functional requirements established within the Design Basis (Sec. II). This ES will allow direct access to the host rock for detailed investigations and for extensive explorations within and adjacent to the selected horizon.

II. DESIGN BASIS

The ES shall provide personnel access to allow *in situ* and horizontal exploration of the target tuff formations in the Yucca Mountain area on or near the southwestern quadrant of the NTS. Phase I of the exploration shall continue to the point where a decision can be made as to the suitability of the site for a TEF. The design objectives, principal functional design requirements, design assumptions, and principal design criteria are defined in this section.

A. Design Objectives

The design, construction, and planned use of the ES shall be based on achieving and maintaining the objectives described and defined below.

1. Safety. The ES shall be designed and constructed in accordance with established concepts and procedures that comply with current and planned standards of the regulatory authorities so that personnel shall not be exposed to unacceptable risks or hazards.

2. Environment. The ES shall be designed and constructed so that the environment is not adversely affected for the long term.

3. Technology. Planned design concepts and construction methods shall be based on established and proven technology. Use of unproven technology or improper application of known technology could force abandonment of the site and prevent its use as part of a full-scale repository.

4. Licensability. The ES will not be an NRC-licensed facility; however, extreme care shall be taken during design and construction to assure that nothing is done that will preclude its use as part of a licensed repository at some future date.

5. Future Disposition. The ES may be incorporated in the design of the TEF, ADT, and/or a repository. Another option will be to decommission and abandon the ES if the site is judged unsuitable for further use.

B. Principal Functional Design Requirements

The following principal functional requirements have been established for the ES to meet the objectives defined above.

1. Access to Underground Openings. A large-diameter shaft shall provide capabilities for

a. Personnel access to the underground openings during normal and emergency conditions;

b. Muck removal during excavation of underground openings;

c. Transfer of material, supplies, and equipment between the surface and the underground openings; and

d. Housing of utility lines servicing the underground openings.

2. Underground Openings. The underground openings shall provide space and working conditions for conducting necessary *in situ* exploration to determine the feasibility of using the site as a potential TEF and a repository.

3. Supporting Facilities and Services. The ES shall be an independent facility with the necessary facilities and services for personnel support. Utility requirements shall be served from existing NTS systems where possible. Redundant systems shall be provided for essential operations, because failures of the primary systems may occur.

C. Design Assumptions

Surface exploration of the Yucca Mountain area is still in progress. Sufficient data are not expected to be available to allow the selection of an ES location or horizon (depth) before early FY 1983. In addition, the technical data required to determine the suitability of the site for a repository or a TEF have not been fully defined. As a result, certain assumptions have been made concerning the scope of the ES to serve as a basis for the cost estimate and construction schedule. It is recognized that when the above issues are resolved, they may differ considerably from the assumptions and could affect both the cost and schedule. For example, if the ES is located somewhere other than at the assumed location, items such as length of access roads and utility lines can be affected, the depth to the selected horizon can be increased up to 500 ft (neglecting dip) if the ES is located atop Yucca Mountain, and site preparations can vary. Features affecting ES design, such as *in situ* rock temperatures, stresses and strengths, and hydrologic conditions, will depend upon the specific horizon selected.

The following assumptions have been used to prepare this conceptual design; however, the concept has the flexibility to adapt to other conditions as better information is available.

a. The ES will be located in the vicinity of hole USW-H1.

b. The ES will be drilled to a depth of about 3500 ft.

c. The shaft will be constructed using drilling techniques as opposed to conventional shaft-sinking methods (drill and blast).

d. A confirmatory borehole will be located in proximity to the proposed location for the ES.

e. The drilling and mining operations will not be extensively interrupted by exploratory-type experiments.

f. The *in situ* rock temperature at the target horizon is 106°F.

g. The water seepage rate into the underground openings will not exceed 100 gpm.

h. Three horizontal or near-horizontal boreholes will be drilled approximately 2000 ft each to evaluate the TEF horizon. (Nine additional boreholes will be drilled as part of Phase II.)

Additional constraints that have not been explicitly factored into the conceptual design include

- the ES shall be located 2000 ft inside the boundary of the proposed repository block (a location off the NTS) to allow optimum exploration of the repository horizon, and
- the TEF shall be located on the NTS; thus, it could be about 2000 ft from the ES.

If the extended block in Fig. 1 is not available, then the location in the vicinity of USW-H1 is not possible with the above constraint. Alternative sites at locations A and B satisfy the above constraints for the principal block and do not significantly affect the conceptual design except for surface facility layouts that are constrained by different topography.

D. Principal Design Criteria

As more is learned about the site, the assumptions discussed in the previous section shall be refined and established as part of these criteria. The principal functional design requirements defined in Sec. II.B. for the ES shall be achieved by properly designing, constructing, and operating the facility in accordance with these principal design criteria.

1. Access to Underground Openings.

a. The access shaft shall be fitted with a steel casing (or other lining) sized to house the personnel hoist and muck skip, emergency hoist, ventilation ducts, and other service and utility lines.

b. The casing shall be designed to withstand anticipated structural and hydrostatic loads, with an appropriate safety factor.

c. The shaft shall be constructed to minimize the probability of an incident that would require abandonment of the hole. Such an incident might be a hole cave-in or an out-of-plumb hole so that the casing cannot be installed.

2. Shaft Internals. The design criteria for the shaft internals shall consist of the following.

a. A main hoist (used for equipment, personnel, and muck).

b. An emergency hoist as required for personnel safety.

c. A muck skip rated at 10 000 lb.

d. Service and utility lines for ventilation air, water supply, dewatering, electrical power, instrument signals, compressed air, and communications.

3. Underground Openings.

a. The underground openings shall consist of such items as the shaft breakout, shaft station, muck pocket, drifts, exploration room(s), and horizontal borings.

b. The exploratory room(s) shall be located far enough removed so that they are elastically independent of the access shaft.

c. Ground support, if needed, in the rooms and drifts shall be provided by rockbolts and wire mesh and possibly shotcrete.

III. TEST PROGRAM

A. Objectives

The initial objective of the ES test program is to search for gross anomalies (geotechnical and hydrologic) that might immediately disqualify this location as a site for a TEF and/or a repository. If an insuperable defect is located, proceeding with the exploration and testing at depth would be useless. The subsurface geologic environment has been predicted from surface reconnaissance and boreholes: surface geologic mapping; surface geophysical surveys; and geologic, hydrogeologic, and geophysical studies in a few boreholes. These studies have not located regions of gross weaknesses, particularly those associated with major faulting. Several hundred feet of pertinent core were obtained from the vertical boreholes, but these do not provide an adequate basis for an assessment of the lateral continuity of stratigraphic intervals. Thus, the initial underground exploratory activities should provide information to verify that the underground structural features do exist that were predicted and can be traced in the subsurface. Only by direct exploration at depth (tunneling and drilling of boreholes) can the following details be determined with sufficient accuracy to verify the adequacy of the design of the underground openings.

(1) Characteristics of the jointing of the rock mass and

(2) Identification of geologic or rock structure, which is important in determining the stability of underground openings.

Most of the information from the initial explorations (Phase I) will be of a qualitative nature and even somewhat subjective. Some quantitative measurements will be made of ground movement and perhaps of groundwater pressures and flow rates. It may be necessary to measure loadings with some type of strain meter during the early development of the openings. The completion of the ES will demonstrate that a shaft can be sunk at the selected location and then will afford a direct evaluation of the shaft seal and of the effect of the construction-affected zone upon the adequacy of the shaft seal. Water samples collected from seeps immediately after formation of the openings will probably be contaminated and will not be representative of the original groundwater. Some indirect indications of the *in situ* state of the stress may be obtained if the cores exhibit the disking phenomena.

The conditions required to qualify the site for either a TEF or a repository have not been fully specified. The specific tests that will be performed during Phases I and II are in the process of being outlined in detail. The test program for qualifying the site for a TEF is expected to be considerably less extensive than for a repository. Phase II will primarily be the effort to obtain quantitative data (media properties, rock mass characteristics, hydrology, and *in situ* state of stress) that will enable characterization of the site. The cores will provide samples for the generic type of testing in the laboratory. *In situ* experiments (for hydraulic properties and stresses) will be required to make realistic assessments of some conditions within the horizon. In addition to the data accumulated during Phase I, it will be necessary to make some preliminary tests before a rational design for some of the *in situ* tests can be specified.

During Phase I, a suitable work space must be developed from which three horizontal boreholes will be drilled out to the vicinity of the TEF. These holes will be about 2000 ft long with complete core recovery. Potential water inflow zones will be tested as needed to assure mineability.

The tentative plan for Phase II exploratory drilling in the selected horizon specifies an additional nine HQ-size, 2000-ft-long holes to be drilled from the underground complex. Five or six (depending on the location of the three Phase I holes) of these holes are to be rayed on a 45° pattern; the need, location, and direction for the other four holes will be determined later in the program. Over 300 acres of the horizon will be explored. Representative samples of the host rock from within the selected horizon will then be available because over 20 000 ft of core will be obtained.

B. Principal Functional Requirements

Work spaces of suitable size, shape, and environment must be provided at the appropriate locations to allow drilling of exploratory boreholes and taking of cores that are representative samples of the selected horizon. Additional work areas must be provided for the initial logging, marking, wrapping and packaging, and temporary storage of cores, as well as for storage of drill rods and auxiliary equipment.

Adequate space should be provided for investigating the stabilization of damaged and jointed rock. Damage to the host rock may result from both the mining operations and the ventilation of the drifts, and this damage should be monitored.

C. Principal Operational Requirements

All operations must be performed in a safe manner, yet they should be performed in an expeditious manner. Thus, the detailed plans for the exploration must be flexible because they may be continually altered as the work progresses and the resulting data are analyzed.

The openings and boreholes must not compromise the suitability of the site. Thus, exploratory holes should not be drilled into the shaft pillar; although at some later time, strain meters may be placed in the shaft pillar to measure the loadings.

A specific work room should be positioned outside the sphere of influence of the other work rooms; that is, the superposition of stress concentrations should be avoided as much as is practical.

IV. CONCEPTUAL DESIGN DESCRIPTION

The principal function of the ES is to provide access to the target horizons at Yucca Mountain where investigations can be conducted to determine the suitability of the tuff formations for use as a TEF and/or a radioactive waste disposal facility. The following sections describe the conceptual design of the ES in terms of the major work breakdowns or systems that make up the facility. This format permits later expansion for use in design control and documentation.

The conceptual design is composed of the following sections.

- Site Work and Surface Support Facilities. Section IV.A. describes site improvements such as roads, grading, and parking lots for access and storage and support facilities such as structures and utilities to support the mission of the ES.

- ES Drilling, Casing, and Cementing. Section IV.B. describes the design and construction of the shaft and the installation of the casing. Conventionally sinking the ES is discussed in Appendix A. This alternative method of ES construction could be the method chosen once horizon and other factors have been defined.

- Shaft Internals, Hoisting, and Headframe. Section IV.C. describes outfitting the shaft with the necessary hardware to provide access for men, material, and services to the underground openings.

- Underground Openings. Section IV.D. describes the shaft breakout, mining of underground openings, and borehole drilling.

- Ventilation. Section IV.E. describes the system for providing personnel comfort and removing shot gases, mining dust, and other airborne particles.

- Test Equipment. Section IV.F. describes equipment required to conduct the *in situ* tests.

A. Site Work and Surface Support Facilities

For this report, the ES site was assumed to be located near Hole USW-H1, about seven miles from the E-MAD facility. The ES will require extensive improvements above ground to fulfill its mission downhole (see Drawings JS-025-055-C1, JS-025-055-M2, and JS-025-055-M3). These improvements have been divided into three areas: site work, utilities, and support facilities. Additional information on site work and surface support facilities is contained in a study by Holmes & Narver, Inc. (H&N), NTS, that is attached as Appendix B.

The location eventually selected for the ES will determine the actual amount of grading required and the distances that roads, electrical power transmission lines, and water supply pipelines must be constructed. Although it has been assumed that the water will be supplied from an existing NTS production well (J-13), it may be possible to pump water from one of the nearby exploration holes drilled in Yucca Mountain. Current constraints prohibit pumping water from a well that might affect hydrology studies.

1. Functions.

a. Site work. This will include grading and stabilizing about five acres for drilling and mining operations and providing an all-weather access road to the ES site. The site will be provided with a concrete drill pad and jack pad at the shaft location, and will also have mud and cutting pits, storage areas, a muck pile, a construction working area, and locations for both temporary and permanent structures.

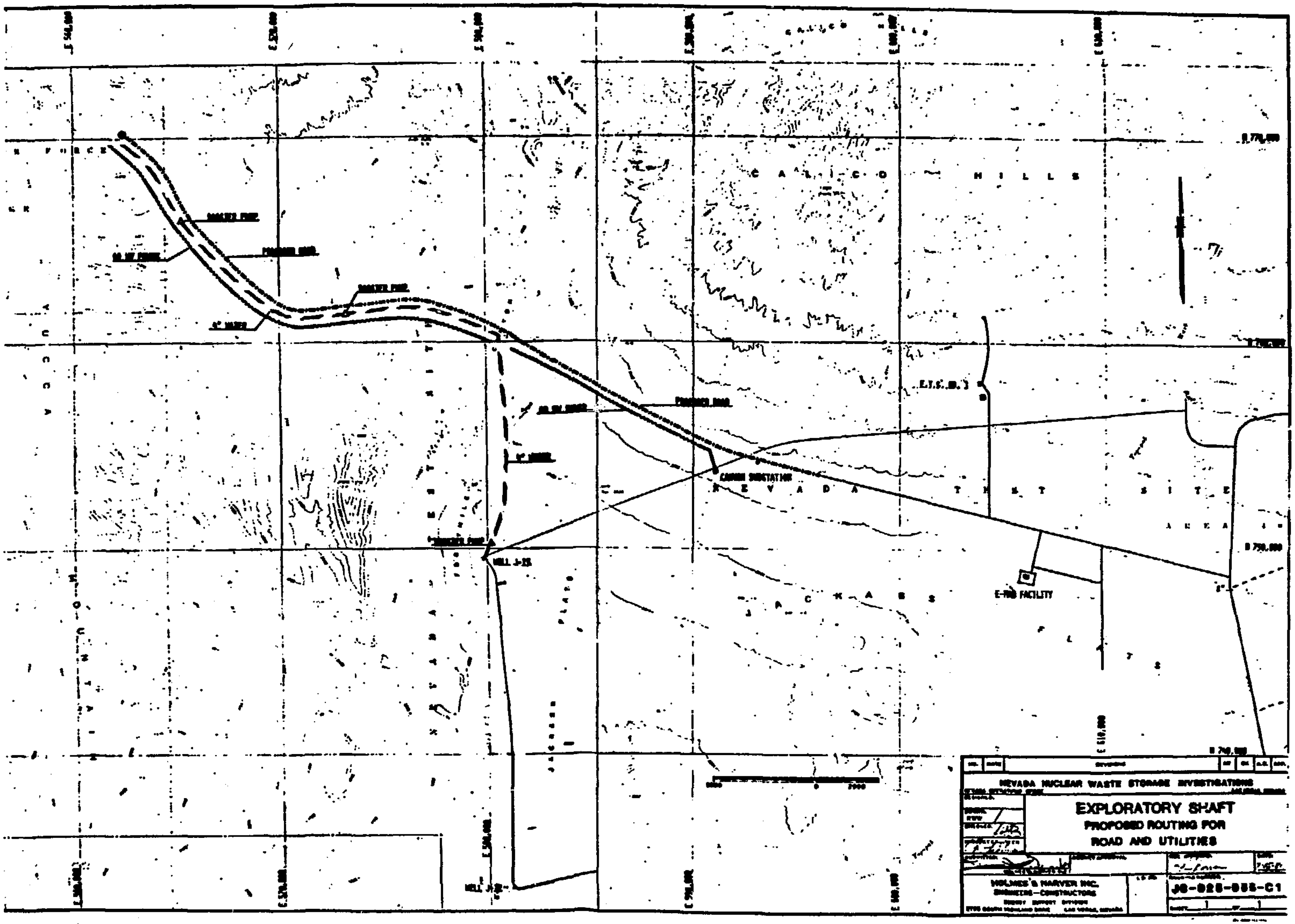
b. Utilities. These will include electrical distribution systems to provide power for both surface and downhole facilities, as well as standby generator power for downhole operation in case of power failure. Water supply systems to provide potable water, process water, and fire protection are also included.

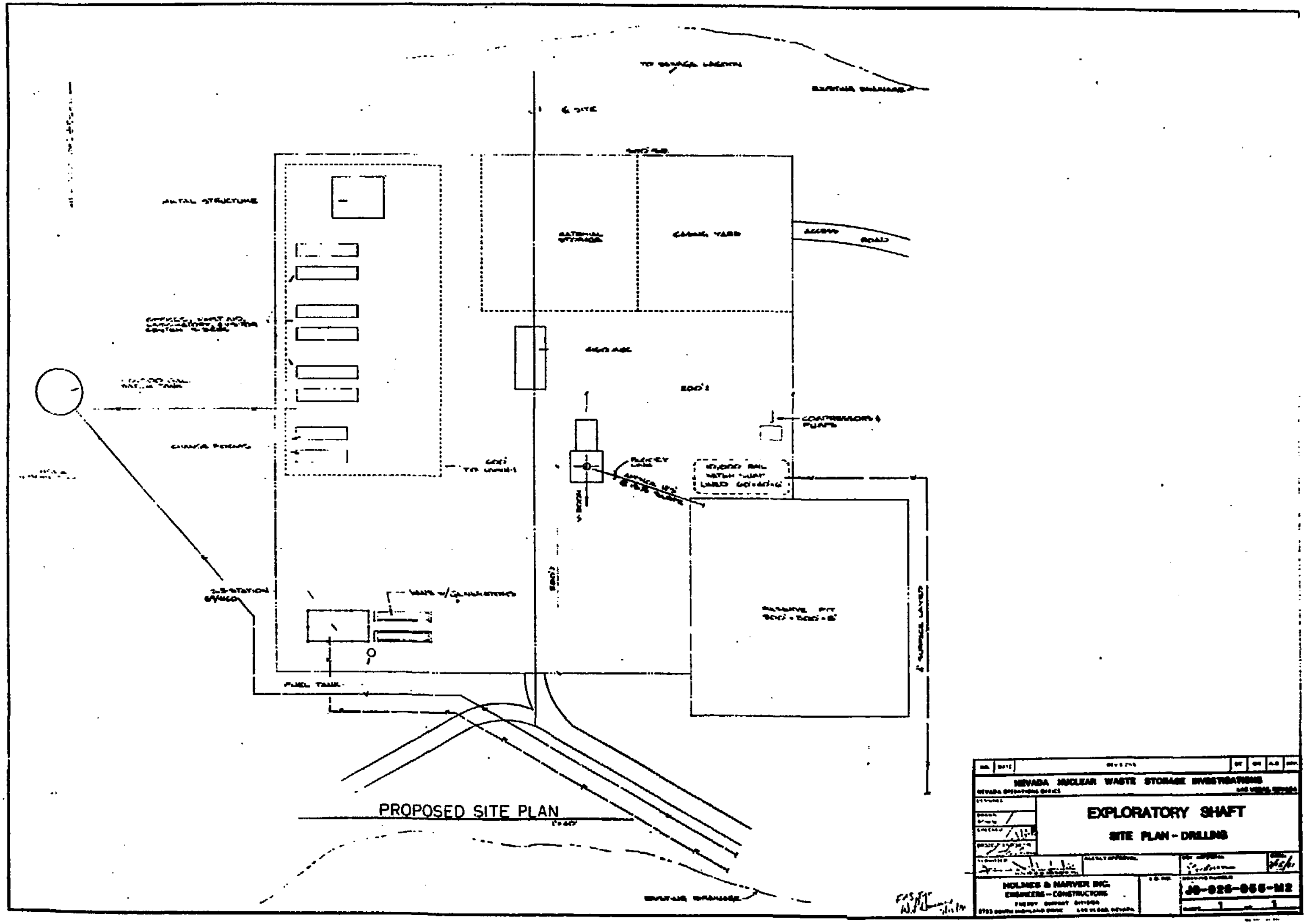
c. Support facilities. These will include temporary buildings to provide office space, laboratory space, change rooms, showers, and visitor center. A shop and warehouse building, a communications building, a sanitary sewer system, and a chilled-water plant to provide cooling downhole are also required.

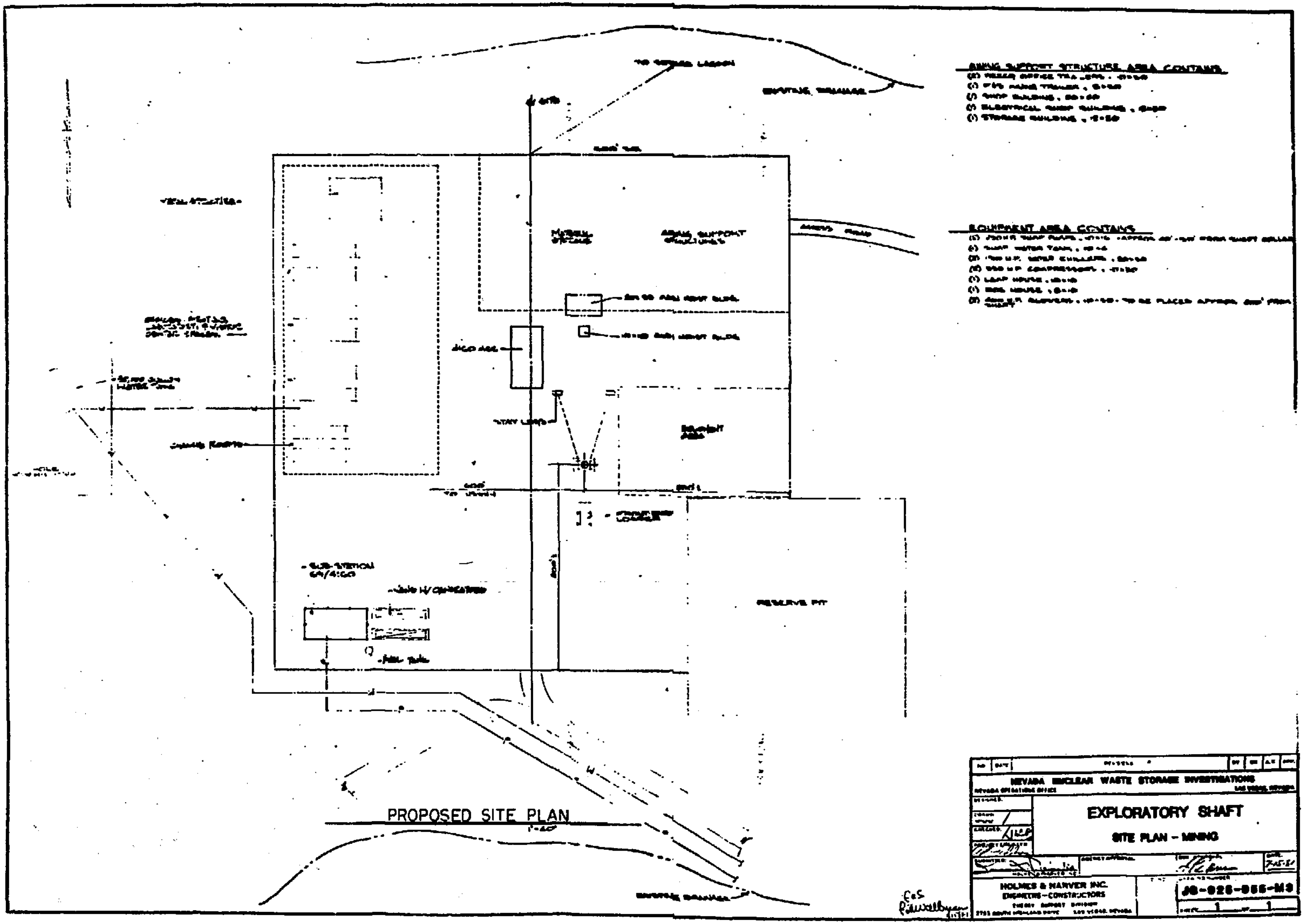
2. Design Requirements. The primary design requirement is for safety. This includes back-up systems for emergency operations, reasonable structural margins on design of components, and conservative estimates of operational design parameters.

A secondary design requirement is that all surface support operations required for a successful downhole exploration program be carried out in an expedient and cost-effective manner. To the extent possible, the design should have sufficient flexibility to accommodate unforeseen demands that are inherent in exploration activities in a region of limited prior experience.

A third design requirement is that the surface facilities be constructed and operated in such a way as to have a minimal impact on the environment. Impacts such as increased erosion, devegetation, and hazards to potentially


CALICO HILLS
NEVADA TEST SITE
JACKASS FLATS
WELL J-13
E-MAD FACILITY
NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS
EXPLORATORY SHAFT
PROPOSED ROUTING FOR
ROAD AND UTILITIES
HOLMES & NARVER INC.
ENGINEERS—CONSTRUCTORS


PROPOSED SITE PLAN
NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS
EXPLORATORY SHAFT
SITE PLAN - DRILLING
HOLMES & NARVER INC.
ENGINEERS - CONSTRUCTORS


EQUIPMENT AREA CONTAINS
RESERVE PIT
PROPOSED SITE PLAN
NEVADA NUCLEAR WASTE STORAGE INVESTIGATIONS
EXPLORATORY SHAFT
SITE PLAN - MINING
HOLMES & NARVER INC.
ENGINEERS-CONSTRUCTORS

endangered species will be mitigated to the extent consistent with good engineering practice and relevant environmental regulations.

3. Design Description.

a. Site work. Site preparation will provide for the following.

- Clearing, grading, and stabilizing an area of approximately five acres near Hole USW-H1. Grade elevation should be selected to balance the "cut" and "fill," and then the area will be stabilized with Type II aggregate hauled from a pit in Area 25.

- Constructing a 25- by 60- by 2-ft-thick reinforced-concrete drill slab and a 4-ft-thick jack pad.

- Digging a 250- by 250- by 8-ft-deep mud pit.

- Digging a 100- by 100- by 8-ft-deep cutting pit, which will later be used for the muck pile.

- The balance of the stabilized area will be used for building locations, parking, pipe and material storage, and a working area.

Road work will include building approximately seven miles of new all-weather road from the end of the paved road west of E-MAD to the ES site. The road will be 22 ft wide, with 4-ft shoulders on each side. Because of the nature of some of the existing native materials on the path of the road, it is estimated that five miles of the road will require a 6-in. subbase. The road will be surfaced with double oil and chips.

b. Utilities. Electric power will be provided at the ES site by constructing approximately 6 miles of 69-kV overhead power line from the canyon substation to a main substation at the project site. This will be a 5000-kVA substation with a 69- to 4.16-kV transformer, and 1000-kVA capacity, 4.16-kV to 120/208-V. The substation will also include cutouts, distribution panels, conduit and wires, fencing, trenching, and concrete work. A grounding system will be provided.

Electric power will be provided to three 30-hp booster water pumps by constructing about 4.5 miles of underbuilt 4.16-kV power line from the ES substation along the water supply line to Well J-13. Separate transformer stations are required for each pump.

Standby generator power will be provided by two 750-kW diesel generators in weatherproof enclosures. Support facilities include two 5000-gal fuel tanks, two manual transfer switches, necessary fuel piping, conduit and wire, oil-fused cutout, and concrete work. These emergency generators will provide power for the following equipment.

- One 500-hp emergency hoist

- One 350-hp air compressor

- One 250-hp sump pump
- One 600-hp blower
- 50-hp downhole equipment
- One 250-hp water chiller

Surface electrical distribution facilities will include a substation, distribution panels, underground conduit and wire, trenching, and concrete work to provide electric service to the following structures.

- Six trailers
- One warehouse and shop building
- Two change rooms
- One hoist house
- Ventilation and chiller equipment
- Communications enclosures

Electric service will also be provided to the following surface motors.

- One 1500-hp hoist motor
- One 500-hp emergency hoist motor
- Two 350-hp air compressors
- Two 250-hp sump pumps
- Two 400-hp blower motors
- Two 150-hp chiller motors
- Four 30-hp booster water pumps
- One 5-hp fire water pump
- One 2-hp portable water pump
- Four 100-hp winches and miscellaneous motors

Area lighting consisting of four 35-ft wood poles with four 400-W floodlights on each, along with necessary underground conduit and wire, photocell controls, and trenching, will also be included. Provisions will be made for temporary power and lighting during construction.

Water supply will be provided by tapping into the existing 6-in. water main at Well J-13 and installing a 4-in. gate valve. Approximately 6-1/2 miles of 4-in. Schedule-80 PVC pipe will be trenched and buried at least 3 ft deep, and four 30-hp booster pumps, along with required pump shelters and pressure switches, will be installed. Three of the booster pumps will require 500-gal surge tanks. The water will be pumped into a 50 000-gal steel storage tank and will be distributed to the eight portable structures, the shop and warehouse building, and the chiller plant. This will require the equivalent of about 600 linear ft of 1-1/2-in. PVC pipe in trenches, along with valves and fittings. A 2-hp, 150-gal pressure system for potable water and a 5-hp, 150-gal pressure system for fire protection in the shop and warehouse building will also be installed. Additional water will be temporarily stored in the drilling mud pit for use when large water-use rates are required for drilling.

Downhole electrical services will provide the following.

- Temporary power and lighting for mining
- A 300-kVA, 4.16-kV to 277/480-V substation with shielded three-conductor, No. 2/0, 5-kV downhole cable, cutouts, trenched surface wire and conduit, and 480-V distribution panel
- A 75-kVA, 480- to 120/208-V dry-type transformer and distribution panel with necessary wiring for about ten duplex receptacle outlets and two 60A, three-phase power outlets
- A lighting system for shaft and underground drifts and drilling rooms
- A hoist signal system similar to that installed on the Spent Fuel Test/Climax Project

The shaft electric cable will be placed inside a conduit that will be installed inside the shaft casing at the time of casing installation.

Instrumentation cables will be run from an instrumentation trailer on the surface, through conduit that will be installed inside the shaft casing, and extended to the end of the drift. The following cables will be run.

- Three 25 Pair No. 22 I.P.S. cables
- One 19 Pair No. 22 I.P.S. cables
- Two 9 Pair No. 16 I.P.S. cables
- Four RF-14 coaxial cables

c. Support facilities. Temporary buildings include six 12- by 60-ft portable structures that will provide office space, laboratory space, a first aid room, and a visitor center, and two 12- by 50-ft change rooms that will provide showers and lockers for the construction and technical staff. Each structure will be supplied with water, power, and sewer systems, and will have restrooms, heating, and air conditioning.

The shop and warehouse building will be a 2000-ft^2 prefabricated metal building erected on a 4-in.-thick concrete slab. The building will have a

12-ft eave height and will be insulated. A restroom and two offices are included, with the remainder of the building being open area. Water, power, a sewer system, heating, air conditioning, and a fire sprinkler system will be provided.

The sanitary sewer system will include a 100- by 100- by 4-ft-deep sewer lagoon, a 20- by 20- by 4-ft-deep collection basin, about 600 ft of 6-in. ACP buried sewer main, about 300 ft of 4-in. ACP buried sewer pipe, and one manhole. Depending on location with respect to surface water run-off and expected use, a septic tank and drain field could be preferred.

The chilled-water plant will include two 120-ton chiller units, two 30 000 cfm fans, foundations, supports, and miscellaneous hardware required to make an operable plant.

The communications systems will include a 12-channel surface microwave-link system and a two-way radio system to the mining cage.

B. ES Drilling, Casing, and Cementing

A cased shaft will be required to provide access to the horizon (depth) to be explored. Large-hole drilling techniques will be used and a steel casing will be installed and cemented in place.

This section describes the drilling program, casing design and emplacement, and grouting of the casing. Additional information and details are contained in Appendixes C (a study conducted by Fenix & Scisson, Inc. (F&S)) and D (F&S engineering specifications). Appendix A provides a conceptual design for a conventionally sunk shaft.

Figure 2 shows the conceptual design, including diameters, of the drilled shafts and casings. For conceptual design purposes, a depth of 3500 ft is assumed, but the target horizon for exploration has not been determined. Horizons near 1200 ft (Topopah Spring), 1600 ft (Bedded Tuff of the Calico Hills formation above the water table), 2500 ft (Bullfrog member of the Crater Flat Tuff), and 2800 ft (Tram member of the Crater Flat Tuff) are among the formations being considered. Shaft design details will be determined by the shaft depth and could vary considerably from the conceptual design presented here. For example, if the unsaturated zone is selected as the proposed horizon, the double-casing concept probably will not be required. Likewise, the exact location of the ES has not yet been defined. Because the beds in the Yucca Mountain dip at about 3-6° and the surface topography is not level, the location of the shaft will affect the depth to the target horizon.

1. Functions. The shaft will provide access to the horizon (or horizons) of interest for lateral exploration. A secondary objective will be to provide some information on rock above the target horizon. This will be accomplished after the shaft is complete and the casing is in place by horizontal exploratory drilling from inside the shaft at various elevations.

2. Design Requirements. The primary design requirements are as follows.

- Provide safe access to the target horizon.

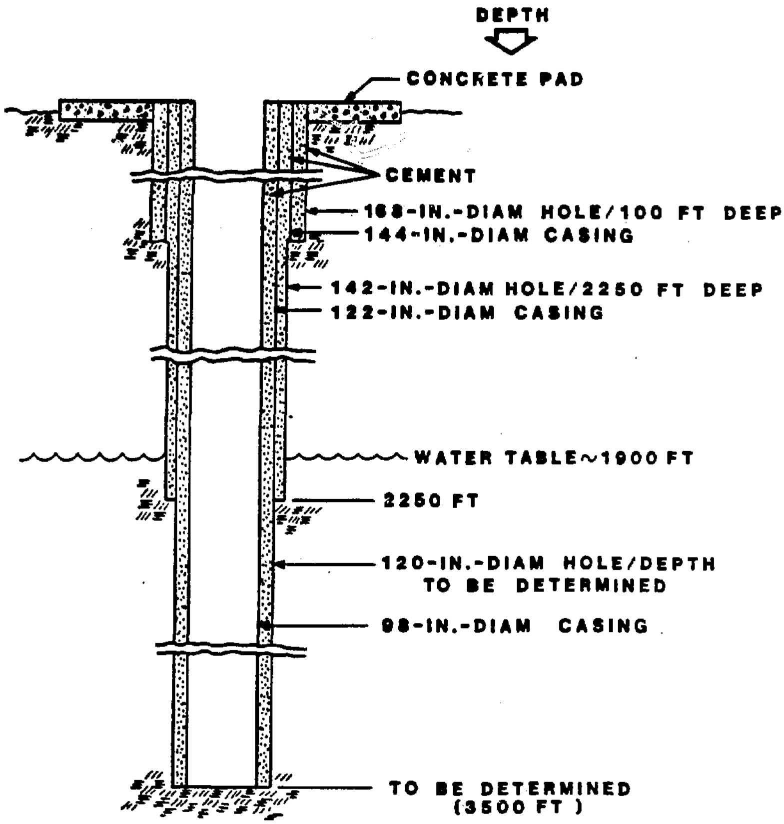


Fig. 2. Vertical cross-sectional view of shaft.

- Provide sufficient shaft cross section so that efficient exploratory operations can be conducted.
- Use construction practices that do not jeopardize the licensability of the site for a future repository.
- Consistent with the above requirements, provide a shaft with minimum cost and in a short time frame. The shaft construction must be completed by July 1984 to meet programmatic schedule requirements.

3. Design Description.

Blind shaft drilling is the method chosen for constructing the ES. Advantages compared with "conventional" shaft sinking (by mining) include the following.

- Safety - With drilling, there are no workers in the shaft until it is cased and dewatered.

- Speed - Drilling penetration rates are significantly greater than conventional mining and muck removal.

- Efficiency - Because no personnel are below ground, poor downhole environment (such as temperature and water inflow) does not affect productivity.

- Water Control - Reverse circulation drilling eliminates most water problems. Water zones can be pregrouted, and, because drilling does not require blasting, fissures are not reopened as with conventional shaft sinking.

Another big consideration in the choice of shaft drilling is the considerable experience by personnel at the NTS with large-hole drilling.

The sequence of operations for constructing the shaft is discussed below.

- Mobilize and set conductor pipe.
- Drill 142-in. hole to about 2250 ft.
- Case with 122-in.-i.d. casing to about 2250 ft.
- Cement 122-in. casing.
- Drill 120-in. hole to total depth.
- Case with 98-in. casing.
- Cement casing in place.
- Dewater and demobilize.

As a separate study, consideration was given to using a 72-in.-i.d. casing with utility lines external to the casing. Details of the comparison are found in Appendix E for mining considerations and in Appendix C for drilling. Major conclusions include the following.

- Cost benefits of the smaller casing are partially compensated by increased cementing and ventilation costs.

- Pipes outside the casing can be damaged during installation of the casing in the hole. Maintenance of pipes placed outside the casing is a potential high-cost item.

- The larger shaft i.d. affords more flexibility and the potential for increased support to underground operations (two useful cages vs one cage).

a. <u>Mobilize and set conductor pipe</u>. Site preparation is discussed in Sec. IV.A. Before actually starting shaft construction, roads and water systems will be in place.

A 200-in.-diam by 10-ft corrugated metal pipe (CMP) will be set in an excavated hole that will be backfilled with native material.

A 144-in.-i.d. conductor pipe will be placed to a depth of about 100 ft. This will be done with an auger drill rig. As outlined in Appendix C, the conceptual procedure is to drill and blast the surface rock before drilling with the auger for the conductor pipe. The exact details of the blasting will depend on conditions at the location chosen for the ES. The purpose of the blasting is to break any boulders in the surface alluvium.

The conductor pipe will be A-441 steel with 144-in. i.d. and 3/4-in. wall thickness. The pipe will be suspended about 1 ft off the bottom of the hole (to establish a plumb vertical conductor) and will be cemented in place. Cement specifications and staging requirements are to be determined. As estimated in Appendix C, this task should take 35 days.

b. Drill 142-in. hole. The shaft will be drilled near the water table and lined with a steel casing. (This will be done using a Class I drilling rig.) The casing will provide protection of the hole from cave-in while drilling below the static water level so that the site will not be compromised from a licensability perspective. The exact depth of this 142-in. hole is to be determined based on the stratigraphy at the location. For cost estimation purposes, a depth of 2250 ft is assumed in Appendix C. Mobilization of the drill rig is estimated to take nine days.

As outlined in Appendix C, the drilling will be done using standard large-hole drilling technology that has been developed at NTS. This technology uses integral dual-string drill pipe with reverse air and water circulation. Estimated drilling parameters, based on experience in other areas of NTS (but in similar rock), are as follows:

- 12-16 revolutions per min (RPM) rotational speed,
- 100 000-250 000 lb weight on the bit,
- 14-24 barrels per minute (BPM) fluid circulation, and
- Air circulation sufficient to achieve equal rates of fluid injection and discharge.

A string stabilizer with eight tooth-type rollers will be run above the weights. For cost estimation, a drilling time of 84 days and a rig charge of about $17 000 per day were assumed. Actual penetration rates could exceed 30 to 40 ft per day based on NTS experience, but a slower rate (26 ft per day) was assumed to allow contingency for equipment and drilling problems.

The schedule for the project, as estimated in Appendix C, allows three days for logging of the hole before casing. The details of the required logging are to be determined, but the cost of the drill rig must be considered in any justification for extensive geologic investigations while the drill rig is on standby.

c. Case to about 2250 ft with 122-in.-i.d. casing. After completion of drilling of the 142-in. hole, the drill rig will be moved aside so that the casing can be installed with casing jacks to the determined depth (about 2250 ft). Casing details are presented in Appendixes C and D. This run of casing will be above the water table and is not designed for a hydrostatic head. The casing material will be A-441 steel with a wall thickness of 3/4 in. and stiffener rings (also used for jacking) 1-1/2 in. by 6 in. on 96-in. centers. The total weight of this casing is about 2.5 x 10^6 lb. Details of the field fabrication and welding procedures based on standard NTS casing procedures are given in Appendix D. Running the casing on the casing jacks and field assembly are estimated to take 12 days.

d. Cement 122-in. casing. Details of the cementing requirements for the 122-in. casing are yet to be determined. A cementing program of 50/50 cement/ pozzolan mixture is being considered. This casing will be above the water table. The volume of material in the annnulus between the casing and the drilled hole is about 60 000 ft^3. Cement is estimated to cost $10 per ft^3, in place, at NTS. Actual volumes of cement material could significantly exceed the calculated volumes if the unconsolidated material along the shaft wall has sloughed into the hole. Cementing is required to prevent subsequent tool impacts from causing this casing to dislodge and fall into the 120-in. hole being drilled below the bottom of the 122-in. casing.

Operations involved with running and cementing this casing are estimated to take about 28 days.

e. Drill 120-in. hole to total depth. After the 122-in. casing has been run and cemented in place, the Class I drill rig will be moved back over the hole and rigged up. This is estimated to take three days.

A 120-in.-diam hole will be drilled from about 2250 ft to the as-yet-undetermined final depth. A final depth of 3500 ft has been assumed for cost- and schedule-estimating purposes.

This hole will be drilled using standard large-hole drilling technology that has been developed at NTS. This technology uses integral dual-string drill pipe with reverse air and water circulation. Estimated drilling parameters, based on experience in other areas of NTS (but in similar rock), are as follows:

- 14-20 RPM rotational speed,
- 100 000-250 000 lb weight on the bit,
- 10-20 BPM fluid circulation, and
- Air circulation rates maintained to achieve equal rates of fluid injection and discharge.

A string stabilizer with eight tooth-type rollers will be run above the weights.

As discussed in more detail in Appendix C, it is estimated that penetration rates will be about 28 ft per day, and a contingency of 20 days is assumed in the cost estimates for miscellaneous operations and delays. Logging is assumed to take nine days, but the exact logging schedule is to be determined and will probably be modified based on stratigraphy at the shaft location and the data required to support licensability issues.

Demobilization of the rig is assumed to take nine days.

f. Line 120-in. hole with 98-in.-i.d. casing. After drilling the 120-in. hole to depth, the drill rig will be moved off the hole and demobilized. Casing jacks (recommended 8-million-lb capacity) and a truck-mounted crane will be mobilized. The jacks must be modified to handle the 98-in. casing (after having been used to run the 122-in. casing). The crane is to support the casing sections for the field welding of the casing before lowering the section downhole with the jacks.

A casing schedule, assuming a depth of 3500 ft and a water table near 2000 ft, is included in Appendix C. This casing is designed to withstand the hydrostatic head (with a 1.5 safety factor) below the water table. Casing material will be A-441 steel and will be fabricated according to specifications similar to those in Appendix D. Various quality assurance procedures will be followed. Appendix D indicates some of the procedures currently used as standard practice at NTS.

The 98-in.-diam casing is expected to weigh 3.2 million lb when it starts to float at the static water level (4.4 million lb total weight in air).

Steel sets that are to be used as supports in the shaft internal outfitting (such as hoist and supply lines) are preinstalled by the casing manufacturer and are described in Sec. IV.C. Grout-line guides are run with the casing.

It is estimated that 45 days will be required to run the 98-in. casing, including the field welding and x-ray inspection of the welds.

g. Cement 98-in.-i.d. casing in place. Details of the cementing program for the 98-in.-i.d. casing are to be determined. Licensability requirements and the depth are not yet known and must be considered in the final specifications.

A cementing program is included in Appendix C and is based on Class A neat cement with 2 per cent $CaCl_2$. This should be satisfactory for the preliminary cost estimate. Cementing of the 98-in. casing will be from the total depth to the surface.

Other possible cementing programs could include "chemical seal rings" (a polymer elastomer used in a nuclear test in a salt dome); adding silica flour to expanding cement in any pillar regions of expected repository temperatures above 200°F, an expansive cement (containing $CaSO_4$); and using inert material as an extender above the water table or a pozzolanic cement.

Cement will be emplaced through lines in the grout-line guides (installed as part of the casing), using staging techniques as outlined in Appendix C.

h. Dewater shaft and demobilize. After the 98-in. casing has been cemented in place, a Class III drilling rig will be mobilized over the shaft and a submersible pump will be used to dewater the hole.

A steel hole cover will remain over the 98-in. casing. At this point, the drilling program is complete, and the shaft is turned over to the mining operations.

C. Shaft Internals, Hoisting, and Headframe

The proposed ES will have a 98-in.-i.d. casing installed from the surface to below the horizon (depth) of the underground workings. Shaft sets of structural steel to support the shaft guides, compressed air, water, pump discharge, ventilation, electric power, and scientific cable pipe lines, as well as signal and communication systems, will be inside this casing. This section discusses the sizing, fabrication, and emplacement of these components in the shaft. Figure 3 shows the conceptual arrangement of the shaft internals.

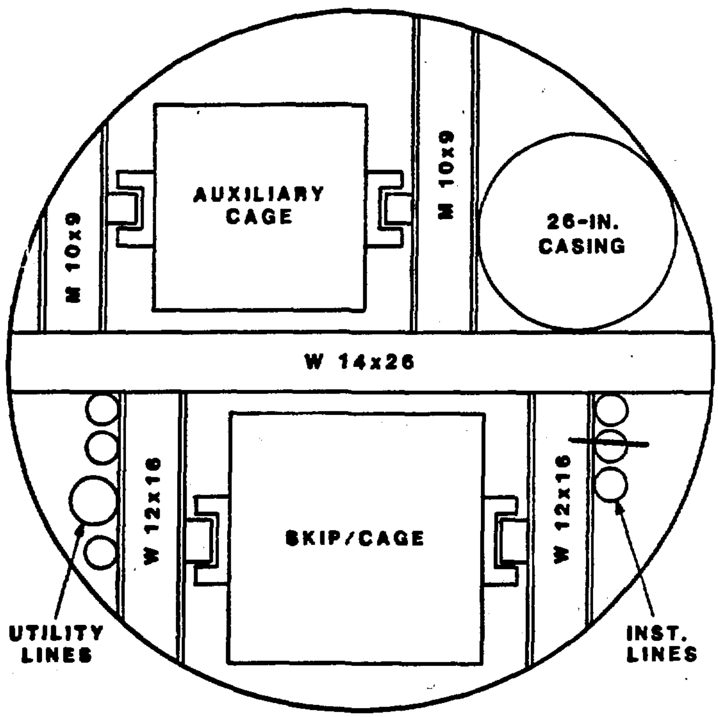


Fig. 3. Horizontal cross-sectional view of shaft.

1. Functions. The shaft internal design will provide all services downhole necessary to meet the objectives of the ES. These systems include hoisting for personnel and material, water pumping for removing anticipated water inflow, power for lighting and equipment, and ventilation air and compressed air for equipment needs.

2. Design Requirements. The primary design requirement will be for safety. This includes back-up systems for emergency operation, large structural safety margins on design of components, and conservative estimates of operational design parameters.

A secondary design requirement will be that all functions required for successful downhole exploration must be carried out in an expeditious and efficient manner.

To the extent possible, the design should allow adaptation to accommodate additional demands caused by the nature of an exploration in a region of limited prior experience.

3. Design Description.

a. Shaft casing and sets. Specifications and discussion of the shaft casing are included in Sec. IV.B. The casing material will be A-441 steel and will be designed to withstand any hydrostatic head that might be external to the casing.

The shaft sets, consisting of structural steel beams, have been designed to hold the weight of all the interior lines (including the weight of water in the water and pump discharge lines), plus any dynamic load that might occur if the hoist rope should break causing the safety dogs to engage on the guides when a fully loaded hoist is going down at full speed. Preliminary specifications on the steel set shapes are shown in Fig. 3. Details of the structural calculations are given in Appendix F.

These shaft sets will be preinstalled in the 98-in.-i.d. casing during fabrication and kept aligned as the casing is installed downhole. Sets will be placed on 20-ft stations through the entire length of the shaft. Steel tubing for the various utilities and the skip and cage guides will be welded to these sets as the miners proceed downhole.

b. Utility lines. Utility lines for ventilation, compressed air, electrical power, sump pump discharge, water, and scientific and communications cable conduits will be installed from the surface by lowering them with a drill rig or crane and welding on new joints to form continuous lines. These pipes will be designed to be self-supporting at total depth. Details of the calculation for preliminary pipe sizes are shown in Appendix F. These lines will be supported on strongbacks at ground level temporarily, and as the miners proceed down the shaft, they will weld support brackets to the shaft sets every 20 ft.

Sizes of the utility lines are still to be determined. Preliminary sizes are shown in Fig. 3. If additional capacity is necessary, space exists to increase pipe sizes or add pipes.

c. Hoisting systems. The conceptual design is based on two separate hoisting compartments as shown in Fig. 3. The main hoisting compartment is designed primarily for hoisting muck, but it is also available for hoisting personnel during shift changes. The second compartment is intended for hoisting personnel and materials during the shift and also as an emergency escape way in case of loss of main power supply or other underground emergencies requiring evacuation of the personnel.

Consideration was given to a configuration of one hoist and an emergency escape ladderway in a second compartment. This concept was not chosen for several reasons: the air in the shaft may be too hot and humid for personnel to safely climb to the surface (the air in the shaft is exhaust air), and two hoisting systems will give increased capability to move personnel and material to expedite the exploration downhole.

Guides for the skip and cages (muck bucket and elevator) will be square or rectangular structural steel tubing that run continuously from the surface to total depth.

The main skip and cage will have a cross section of about 3 ft by 3 ft, and the skip will be about 10 ft long. This will accommodate an estimated 10 000-lb load and a capacity of about 30 tons per hour. The emergency cage will be about 31 in. by 31 in. and will be a two-deck cage to hold a total of eight personnel. Both will be equipped with safety dogs to prevent the cages from falling if the hoist rope should fail.

Landings at ground level and at the mining level will be enclosed by a fence, and the entrance will be through a gate that will be kept closed except for traffic under control of the skiptender.

An electric signal system will be provided for each hoist and will consist of bell knockers, spaced approximately every 500 ft down the shaft, equipped with a wire rope signal cord so they can be rung from anywhere in the shaft. A separate cage radio system will also be supplied.

Hoists for the shaft have been selected based on estimated skip and cage weights, muck weight, and hoisting speed. These details are shown in Appendix F as calculated by a major hoist manufacturer. These are based on 10 000-lb muck load, 10 000-lb cage weight, 3500-ft hoisting distance, 1500 ft per min rope speed and unbalanced operation for the main hoist, and on 4600-lb load, 5400-lb cage weight, 3500-ft hoisting distance, and 780 ft per min (later ratioed to 1200 ft per min) for the emergency hoist. The main hoist is estimated to require 1500 hp, and the emergency hoist requires 500 hp. They will be located at a distance from the shaft to give no more than a 1-1/4° fleet angle on the hoist drum. Both hoists will be equipped with standard controls, including dead-man switches, controllers to prevent overrun and overspeed, and caliper-type brakes. They will be "First Class" hoists as defined in the California Mine Safety Orders.

Power for both hoists will consist of main line power from an ES substation. The emergency hoist will also be connected to an alternate diesel-powered generator set in case of a main power failure. This will allow anyone underground to be hoisted to the surface if main line power failure should occur. Ventilation systems will also be powered under emergency conditions from the diesel standby power.

The headframe will be 90 ft high and will be equipped with two offset head sheaves for the two compartments. A dumping track will cause the bottom dump skip to open and dump the hoisted muck into a chute and onto the ground. A muck bin is not necessary for Phases I and II of the ES because of the relatively small volume of muck to be hoisted. A front-end loader will be used for disposal to the muck pile, or, as an alternative, a truck can be parked under the chute to catch the muck. The headframe shall meet the requirements of the California Mine Safety Orders.

d. Ventilation line. Ventilation requirements are discussed in more detail in Sec. IV.E. The conceptual design has 22 000 cfm of ventilation air provided by centrifugal-type blowers down the 26-in. pipeline. The air will be chilled on the surface and dehumidified to provide cool, dry air downhole. Because the ventilation line is preinstalled, immediate ventilation is provided before personnel go downhole. Exhaust air is vented up the shaft. A 30-in.-diam space will be provided to allow lowering of the 26-in.-o.d. vent line (the maximum o.d. is 28 in. because of lifting rings required at each joint). The ventilation line will be installed from the surface in the same manner as the other utility lines. Stress calculations based on a 3/16-in.-thick wall and Grade A-36 steel are shown in Appendix F and indicate a safety factor greater than 4 before supporting the line from the steel sets.

e. Sump pump. The shaft liner will extend below the mining horizon. This will allow water to drain into the space below the landing. A downhole Kobe pump unit will provide for pumping of any water produced. Current conceptual design is based on a pump that will handle 100 gpm. The Kobe pump is powered by pressurized water; this water will be supplied by a surface-installed Triplex pump and feed tank. As the water inflow conditions become better known, the size of the Kobe pump will be re-evaluated. Sufficient room exists in the shaft to install additional water pipes or larger lines, if required. A spare Kobe pump will be maintained on hand and can be changed out from the surface in the event of pump malfunction.

f. Compressed air. Air compressors will be located on the surface to provide air for underground mining equipment. Two 1500-cfm, 100-psi, electric-driven compressors will be located near the shaft, but at a distance so that noise levels will be acceptable. They will be connected to the main power supply; one of them will also be connected to the auxiliary power supply in case of main power loss. As an alternative, a smaller (600-900 cfm) diesel-powered standby compressor could be used to provide emergency compressed air.

D. Underground Openings

The extent of the underground openings and related exploration required for Phase I is less than for Phase II. However, a suitable work space must be provided so that a diamond drill, HQ-size, can take core (complete recovery) from three horizontal boreholes out to a distance of 2000 ft, thus terminating in the vicinity of the site of the TEF. The use of 20-ft core barrels will expedite this operation. The exploratory openings must not damage the shaft pillar.

These Phase I exploratory operations will provide qualitative information on some actual conditions at depth, such as

- Rock quality,
- Lithology and structure,
- Characteristics of the jointing,
- Lateral variations of properties,
- Rock deformation,
- Stability of openings,
- Stabilization of damaged rock, and
- Groundwater conditions (flow rates, pressure, and temperature).

The information accumulated during Phase I will be quantitized, collated, and then used to plan and guide Phase II. The tentative Phase II design specifies suitable underground openings to allow obtaining core (16 000 to 24 000 ft) that will provide representative samples from over 300 acres of the country rock at the selected horizon.

The limited mining operation will remove about 85 000 ft^3 of host rock. These openings will provide an exposed free-surface area of about 16 500 ft^2 for operations such as mapping. However, over 80 per cent of this free-surface area may eventually be covered with wire mesh as part of the rock support system. Representative rock samples will be selected from the cores for generic testing in the laboratory. Samples of groundwater will be obtained for analysis (thermodynamic state, age, and origin). Regions within the underground openings will then be selected for *in situ* tests to establish the hydraulic properties and rock mass characteristics for a representative volume (ideally, some value averaged for the surrounding country rock) of the host rock.

1. Functions. The primary objective of the mining operation is to develop suitable downhole work spaces for exploration of the target horizon to obtain information that will provide some basis for a judgment as to the suitability of the site for a TEF and/or a repository. The work space for Phase I must accommodate at least one diamond drill. For Phase II, these work spaces must accommodate four diamond drills (using 20-ft core barrels) to drill four holes simultaneously without interference. Additional work areas must be provided for storage of auxiliary equipment and the necessary support activities.

The development of these underground openings will be direct proof of the minability of the host rock. The drifts and work spaces will afford a direct assessment of the quality of the host rock (in the near vicinity of the shaft) and of the stability of the openings.

2. Design Requirements. The preliminary design of the openings is tentative. If a predominant orientation (at depth) of a dominant joint system exists, then the large work chambers must be aligned to reduce the possibility

of excessive overbreak and spalling. This preliminary design specifies two work chambers located at opposite ends of a drift driven to a distance of about 10 shaft diameters in each direction from the shaft. Each work chamber will have sufficient space for two diamond drills to operate simultaneously using 20-ft core barrels.

The drift will have a cross section of about 15 ft by 15 ft, and thus provides space for temporary storage of core boxes, drill rods, and auxiliary equipment, as well as work spaces for the preliminary inspection, logging, wrapping, and packaging of the core. A shop, lunch room, and transformer alcove have been provided.

Rockbolts and wire mesh are specified for ground support. The rockbolt diameters will be matched to the bolt lengths and loads, but the bolt lengths and rockbolt pattern will be determined for each specific opening after actual mining operations start. Shotcrete may be used in selected areas if the ground conditions require it.

Ground movement will be measured with extensometers. If excessive ground movement should occur, remedial measures will be taken to protect the personnel and the facility. Strain meters may be used to measure some loadings.

If the directions and magnitudes of the underground stresses were known, the openings could (ideally) be shaped and oriented to achieve maximum stability; but if wrongly oriented, the tangential stresses might be increased to the danger point. Because rock usually fails in shear, the maximum stability in a drift will be achieved for a specific stress ratio when the shear stress around the periphery of the drift is constant. Thus, when the axes of a drift of elliptical cross section are in the same ratio as the principal stresses and if the major axis is in the same direction as the major principal stress, then maximum stability will be achieved. Hence, there is a very significant interest in measuring the stress distribution underground.

No normal stress can be transmitted across a free face; thus, when an excavation is made at depth, the stresses must be thrown back into the country rock. These stress changes produced by the excavation will extend an infinite distance; however, the magnitude of the tangential stress change decreases rapidly. The magnitude of the stresses induced about most types of excavations in elastic media depends upon the shape of the excavation, and not upon the size. Most rocks exhibit a pronounced elastic phase over a limited pressure range; thus, the assumption that the theory of elasticity applies for an idealized rock provides a basis for the preliminary design of the underground openings. The zone of influence of a specific opening can be arbitrarily defined to encompass the region where induced shear stresses have decreased to some small fraction (less than 2 or 3 per cent) of the normal field stresses. This zone of influence is then somewhat enlarged to account for the overbreak.

Thus, each opening is surrounded by enough rock so that a specified opening is essentially elastically independent of its neighbors. That is, the mutual effects of one opening on another opening are negligible.

Other than by definition, there is no real shaft pillar in this design. The extraction ratio near the bottom is about 13 per cent; therefore, from a mechanical point of view, it is unlikely that any special consideration needs to be given to a shaft pillar. If highly faulted ground were to be encountered during the drilling of the shaft, a shaft pillar would be a necessary consideration.

3. Design Description. The preliminary design of the underground openings were developed as detailed in Figs. 4 and 5 and discussed in Appendix G. How much less than this may be adequate to determine the suitability of the site for a TEF has not yet been determined. The arrangement is symmetrical with a work chamber located at opposite ends of the drift. Ground support in these openings will be provided by rockbolts and wire mesh. The wire mesh will extend down the ribs and terminate about 4 ft above the floor level.

The bottom 100 ft of the shaft will provide a sump to collect water, a bulkhead to prevent spill rock from falling into the sump, and a skip-loading station. A muck pocket will be excavated to hold at least one drift round. A rail grizzly with 11-in. openings will cover the muck pocket. A short chute with gates at the top and bottom will be connected to the bottom of the muck pocket. The loading chute will hold one skip-load.

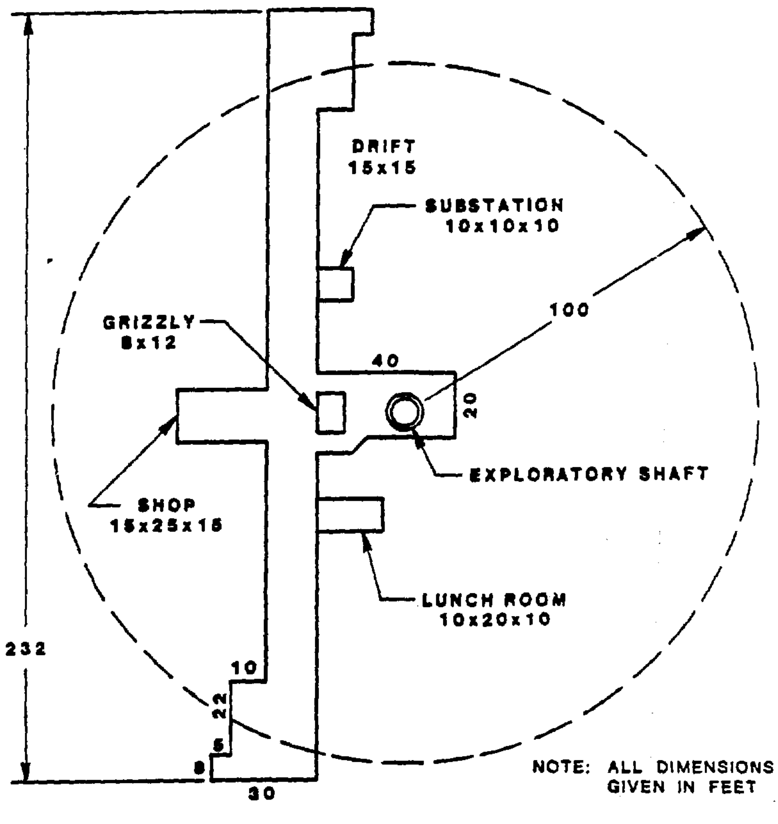


Fig. 4. Arrangement of underground openings.

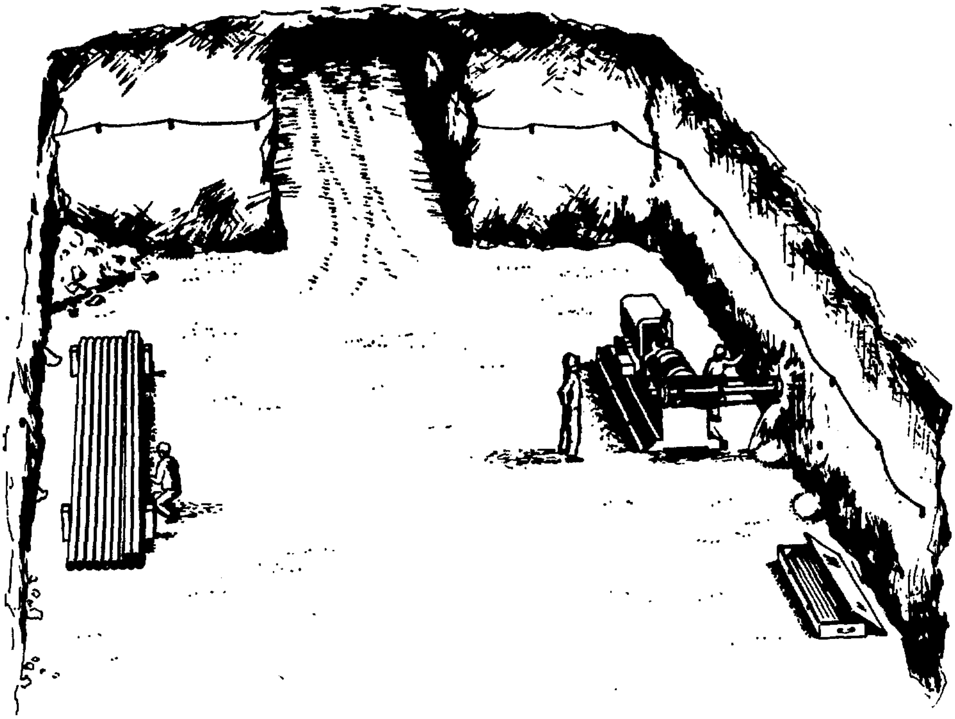


Fig. 5. Underground core drilling activities.

A two-boom, full-face drill jumbo with hydraulic drills will be used in the mining operation. Explosives will be used to break the rock; thus, some degree of overbreak will occur. An overshot loader will be used close to the shaft for mucking directly into the skip pocket. When mining has progressed away from the shaft, a Load-Haul-Dump unit with a 3.5-yd^3 bucket will be used for mucking. A rockbolt jumbo will be used to drill holes for the rockbolts.

A number of exploratory holes will be drilled from the shaft to evaluate hydrostatic conditions and to investigate geologic interfaces. The ground surrounding the casing must be tested for groundwater (amount and pressure) before the casing is cut. That is, the groundwater conditions in a fairly thick section of a strata must be verified to be suitable before breakout from the shaft. Holes will be drilled out from the shaft to about 40 ft. The hole pattern will be eight per row (45° spacing) with several staggered rows. If water at high-pressure or high-flow rates is encountered, pressure-grouting procedures must be applied to ameliorate the condition. Then the efficacy of the grouting operations must be verified by additional testing of the groundwater conditions.

The initial testing for groundwater will be done by setting up a diamond drill rig inside the cased shaft and drilling out through preinstalled grout ports. If additional holes are necessary, high-pressure nipples can be welded to the inner surface of the casing to form portholes for drilling near any specified location. A blowout preventer device (a high-pressure valve and packing-gland arrangement) will be used during drilling. A check valve will also be installed in the drilling fluid system.

If the ES is constructed by the conventional shaft-sinking method, the hydrostatic conditions in the very near vicinity of the shaft will be known. Nevertheless, it is advisable to verify that the groundwater conditions are tractable (out to a distance of about 40 ft from the shaft) before the work station is developed at the specified horizon. After the work station has been completed, the bottom section of the shaft (sump and muck pocket) will be constructed.

When and if the groundwater conditions are acceptable, the casing may be cut and the mining can proceed. As mining progresses outward from the shaft, probe holes will be drilled ahead of the face (horizontally and angled up and down) to test the strata for water. Procedures may be modified as data on the groundwater conditions are accumulated and confidence in the minability of the rock is acquired.

The underground openings will have been surveyed and known fixed points will have been provided for reference when the first diamond drill is set to obtain core and drill the first 2000-ft-long hole. The hole collar will be located and the drill aligned in accordance with the ray pattern. The exact location and direction of the hole with respect to known fixed points will be recorded: station, side of drift, elevation, inclination, and bearing. Horizontal and vertical plots of the actual drill hole vs the selected center line will be maintained to show the directional trend of the hole. When the coring operations have been completed, the terminuses of adjacent holes should be about 1500 ft apart. The actual position of the terminus of a specific hole will be problematical until it has been surveyed. An actual survey by line-of-sight methods can be made up to the depth where line-of-sight is lost (about 100 ft); from that point to completion of the hole, directional surveys can be taken as needed.

E. Ventilation

Ventilation will be required when people are working below ground. Details of the ventilation system proposed for the conceptual design of the ES are discussed in Appendix H. The depth of the horizon where the exploratory horizontal drilling will be done has not yet been determined. Temperatures of the rock will increase with depth as shown in Fig. 6.

The ventilation system conceptual design consists of large centrifugal blowers on the surface. Air from the blowers at about 80 in. of water gauge (WG) is passed through chiller units and through a 26-in. pipe located in the cased shaft to the underground workings. As the workings expand at the target horizon, the supply air will be ducted to near the working faces. Exhaust air returns through the drifts and up the shaft.

1. Functions. The primary function of the ventilation system will be to provide environmental conditioning and fresh, breathable air to workers downhole. A secondary function is to remove blasting smoke, dust, and water vapor from the underground workings.

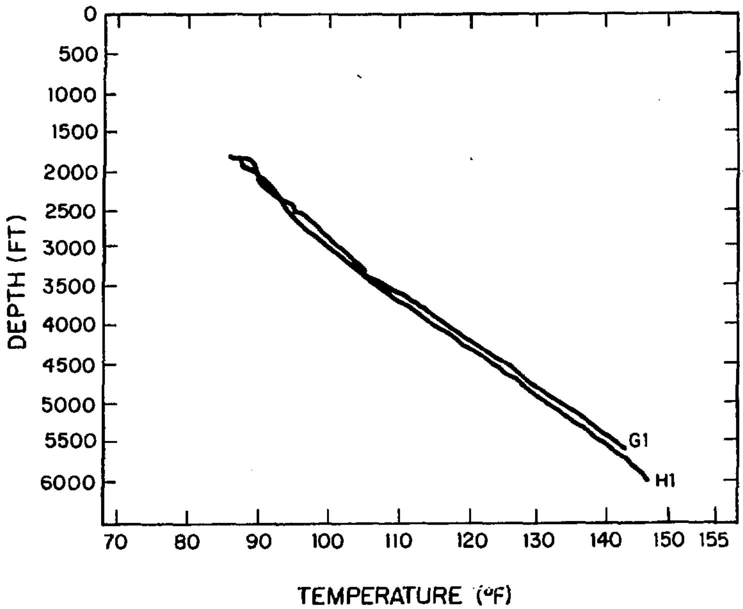


Fig. 6. Yucca Mountain temperature vs depth.

2. Design Requirements. The primary design requirements will be to provide environmental control and safety of the air in the underground workings. The rock temperature is expected to be about 106°F (based on temperature logs at 3500 ft in drill hole USW-H1). Also, at this depth, the rock is expected to be saturated with water. Cool, moving air will be required for miners to work in this environment. Safety regulations require nominal amounts of fresh breathing air to be supplied downhole, and the ventilation system is also required to remove explosive shot smoke and exhaust (if any) from equipment. Dust control is not expected to be a problem, but the ventilation system is designed to remove dust.

3. Design Description. The ventilation system design is based on blowing chilled air down the shaft through the 26-in.-i.d. vent line and exhausting warm, moist air up the main shaft. Exact definition of the equipment required will depend on the conditions expected at the working horizon. For this study, a downhole temperature of 106°F and a work regimen of 75 per cent work and 25 per cent rest each hour are assumed. Also, it is assumed that the air supply will be pressurized using a centrifugal-type blower rated at 30 000 cfm at 80 in. WG at sea level. The drive motor is 400 hp, 440 V, 60 Hz, 3 phase. The skid-mounted unit will be a plug-in type and will consist of a fan, motor, controller, coupling, flex connection, butterfly valve, and inlet and outlet straight-through-type silencers. This blower will supply about 22 000 cfm downhole (calculations are shown in Appendix H) based on operation at ambient pressure (because of elevation less than sea-level pressure) and the 26-in. supply pipe.

Air delivered downhole must be 65°F or cooler (at 100 per cent relative humidity) for the prescribed work regimen. Ambient air temperatures and the effect of autocompression will require that the air be chilled. Calculations in Appendix H show that a chiller of 113-ton refrigeration capacity is required.

During construction of the shaft internals, before breakout, the ventilation line will discharge at the bottom of the shaft and provide ventilation for the entire shaft. After breakout, supply air will be ducted along the drifts to provide ventilation to the working faces. Shot gas removal will be accomplished by direct flushing for the size of underground workings considered for the ES. Appendix I discusses the removal of blasting smoke.

A spare blower will be provided. Both blowers will be connected to the power and ventilation lines, but only one will operate at a time. Emergency chiller requirements are still to be determined.

F. Test Equipment

The *in situ* tests that are required to qualify the site have not been fully delineated; thus, a listing of most of the test equipment cannot be compiled.

Some test equipment will be used during the development of the exploratory openings and boreholes. Extensometers will be used to measure ground movement. Some type of strain meters may be used to monitor loadings. Both line-of-site and directional survey instruments will be used to establish the exact position of various openings. The instruments used to monitor the groundwater will depend upon the actual conditions that are encountered at depth.

The continuing study to develop pertinent test programs has been hampered to some extent by the absence of tentative specifications for the waste package, backfill, design of the repository, and mode of operation of the repository. However, to characterize the site, it is obvious that quantitative data (mean values and variability) must be obtained at-depth in the following areas.

- Media properties
- Lithologic and structural properties
- Hydrology
- *In situ* stresses

Some of this information must be obtained at other horizons, as well as at the main horizon. The openings, boreholes, and cores can yield only a portion of the required information. In some cases, only the *in situ* experiments can yield definitive values. Additional excavations and boreholes will be required for some experiments. Diamond drill rigs will be needed for setting packers and instrument sondes, as well as for drilling more boreholes.

V. OPERATIONS AND MAINTENANCE

A. Operations

Operation of the ES is discussed in this section during the construction period and when exploratory drilling and testing are being conducted. Details of the operational procedures and responsibilities will be defined in later documents.

1. Construction Operations. Construction operations will have three separate, but coordinated, activities.

- Surface facilities construction
- Shaft drilling and casing
- Underground mining

Construction management and Title III inspection services will be provided by DOE prime contractors at NTS.

a. Surface facilities. Surface facility construction will be in two major phases: (1) preparing for the drilling and (2) erecting the headframe, hoist house, and ventilation system for the mining operations. These activities will be defined and scheduled in the design phase of the project. Coordination and inspection, as well as visitor control, security, safety, and environmental protection, will be the responsibility of a DOE prime contractor at NTS.

b. Shaft drilling and casing. The drilling contractor will be responsible for all operations (including safety) during the drilling and casing phases of the shaft construction. Coordination with the surface facility contractor, visitor control, and security will be provided by a DOE prime contractor.

c. Mining construction. The mining contractor will be responsible for all operations during the mining phase of construction. This includes outfitting the shaft internals, breakout, and subsequent mining and exploratory operations. Coordination with the surface facility contractor will be provided by a DOE prime contractor.

Preparation of procedures for training of personnel, as well as the operation, maintenance, and visitor control procedures, will be a joint responsibility of the mining contractor and the DOE prime contractor. All applicable safety codes and regulations will be followed.

2. Exploratory Drilling and Testing. During exploratory drilling and testing to determine the suitability of the site for a repository, the mining contractor will have operational control. Overview and coordination will be the responsibility of the DOE prime contractor.

A test plan will be developed that defines the scope of the underground drilling and testing. This test plan will also define handling procedures and record requirements for cores and other data.

Surface operational support will include visitor control, safety monitoring, security, housekeeping, utilities, and maintenance. This operational support will be the responsibility of the DOE prime contractor.

If a testing program is conducted downhole after the mining construction has been completed, qualified hoist operators and other specially trained personnel will be required to support the experimentation. These personnel will be the continuing responsibility of the DOE prime contractor. Details of these requirements will be defined in later documents.

All safety regulations will be followed, including training programs for underground personnel.

B. Maintenance

1. Objectives. The maintenance program will be designed to maximize safety and personnel protection and to insure achievement of the maximum operational availability of the facility.

Critical items and equipment (those where failure would result in prolonged shutdown or constitute undue risk to personnel) will be identified during the design phase of this project. For these items, special maintenance procedures will be developed.

2. Corrective Maintenance. Defective or worn equipment will be repaired or replaced using appropriate techniques. Contractors with responsibility for various phases of operation (surface facilities, drilling, or mining) will be responsible for maintaining the appropriate equipment.

3. Preventive Maintenance. Preventive maintenance will include periodic inspection and servicing of systems and components to insure reliable operation. Schedules and procedures for preventive maintenance will generally be based on manufacturers' recommendations.

During the design phase of the project, consideration will be given to designing access to equipment for preventive maintenance. Spare part requirements, special tools, and special personnel training will be identified and provided as necessary.

4. In-Service Inspection and Surveillance. In-service inspection will be required for certain systems such as ground support structures. Procedures will be developed to insure safe and reliable operation through instrumentation, inspections, and quality assurance.

Surveillance of critical systems will include instrumentation calibration, periodic testing of standby equipment, and monitoring to detect abnormal conditions.

VI. SAFETY

A detailed safety analysis of the ES project has not been performed; however, the same safety requirements shall apply as for other large-hole drilling and underground mining activities for the NTS weapons program. When an ES shaft location and depth have been selected, a detailed safety analysis of both the construction and operation phases shall be performed.

The ES safety program will be concerned primarily with minimizing hazards inherent with drilling and mining operations and particularly those associated with the operation of heavy equipment. For example, it has been proposed to drill the shaft rather than use conventional shaft-mining techniques (drill and blast) as no personnel will be downhole until after the shaft is cased and dewatered. Also, emergency systems shall be provided for back-up protection in case of off-site power interruption, primary hoist failure, or sump pump failure.

Specific safety hazards that have been considered during conceptual design and will be addressed in greater detail during detailed design include fires, falls, cave-ins, rock falls, flooding, explosions, hoist failures, sump pump failures, ventilation system failures, electrical hazards, excessive noise, and equipment malfunctions or misuse.

VII. QUALITY ASSURANCE

A. General

A Quality Assurance Program shall be prepared, implemented, and maintained for the design, construction, and operational phases of the ES. Each participating organization in the ES project shall prepare and implement a Quality Assurance Program that meets the applicable portions of 10 CFR 50, Appendix B, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants, and ANSI/ASME NQA-1-1979, Quality Assurance Program Requirements for Nuclear Power Plants. Quality Assurance Programs are to be evaluated and approved by the DOE Nevada Operations Office (DOE/NV) before work commences.

B. Quality Assurance Program

Each participating organization in the ES program shall evaluate the criteria described in 10 CFR 50, Appendix B, and ANSI/ASME NQA-1-1979 and comply with the applicable portions. As a minimum, the program shall include the following.

- A Quality Assurance Program Plan or equivalent document. This document shall describe how the requirements of 10 CFR 50, Appendix B, and ANSI/ASME NQA-1-1979 will be met. All sections shall be addressed, and their applicability to the design, construction, and operational phases of the ES shall be described.

- A Quality Assurance Manual or equivalent document. This document shall include the quality assurance procedures, detailed procedures, work plans, and other needed plans and instructions for carrying out the requirements of the Quality Assurance Program Plan.

C. Design Control

Each participating organization that contributes to the conceptual or detailed (Titles I and II) designs of the ES shall prepare and implement a design control document.

In this document, measures shall be established to assure that regulatory requirements, design criteria, and quality standards are included in specifications and drawings. The measures shall provide for a documented verification or checking process performed by individuals other than those who perform the original work. This work shall be reviewed and authenticated by the quality assurance organization.

Procedures for changing project design, documents, specifications, and drawings shall be documented and established to effectively control changes to assure appropriate review and distribution and also for the discarding of the old and outmoded items. This work shall be reviewed and authenticated by the quality assurance organization.

D. Construction and Operational Control

Each organization participating in the construction and/or operation of the ES shall prepare and implement a Quality Assurance Program to assure compliance with design documents (drawings and specifications). Procedures shall be defined for obtaining approval for design deviations.

VIII. CONSTRUCTION COST ESTIMATE AND SCHEDULE

A. Introduction

The cost estimate and construction schedule for the ES are based on a conceptual design that assumes a location and depth for the ES and the extent of the underground facilities and experiments to be conducted. Therefore, it must be recognized that there is considerable uncertainty in the accuracy of this estimate. Because of the extensive experience at the NTS in large-hole drilling and mining operations, the accuracy of the cost estimates based on the assumed concept are highly reliable. The assumptions were established using a "reasonable worst-case" type of reasoning. For example, the most significant assumption relates to the depth of the ES. The assumed depth of 3500 ft is near the bottom of the Tram member. Only one horizon (Lithic Rich) is being considered below the Tram, and, although it has not been eliminated from consideration, it is unlikely to be selected because of the severe design conditions that would be encountered (temperature and stress, primarily).

A contingency of about 15 per cent has been included for all work except drilling operations. Drilling operations have been escalated 20 per cent per year, including contingency. Escalation has been included consistent with the project schedule at 20 per cent per year for all other work.

It is intended that the existing NTS mining and drilling equipment be used whenever possible. Because of the uncertainty of the availability of some of this equipment two to four years hence, a basic cost estimate has been established that is based on a unit-price drilling contract.

The cost of drilling a confirmatory borehole before construction of the ES is not included in the costs presented in this study.

B. Cost Estimate

Table I summarizes the construction cost estimate, and Table II gives a cost breakdown by fiscal year, with dollars escalated to the year of expenditure. Both operating expense funds and capital equipment funds are required and are shown in Table II. Cost estimates for surface construction are based on Appendix B. Drilling costs are based on Appendix C, Part II. Mining costs are based on Appendix J. In all cases, adjustments have been made to the costs to reflect different assumptions regarding schedule, escalation, and more recent design specifications. The cost estimate is for construction activities only. Costs associated with geological investigations or national laboratory programs are not included.

1. Operating Expense Funds. The ES will be constructed with operating expense funds. Table II provides a more detailed breakdown of these costs. Operating expense-funded equipment is shown in Table III.

TABLE I

EXPLORATORY SHAFT - PHASE I
CONCEPTUAL DESIGN COST ESTIMATE SUMMARY
(Dollars in Thousands)

Engineering	$ 2 760
Construction	
Site work and surface support facilities	4 615
Drilling and casing	31 295
Mining	10 055
Maintenance and operations	3 785
Subtotal Operating Expense	$52 510
Capital equipment[a]	8 005
NTS allocation	3 135
Total Project Estimate	$63 650

[a]The capital equipment estimate could be reduced by as much as $2245 if some equipment items are available at NTS or are leased (see Table IV).

TABLE II

EXPLORATORY SHAFT PHASE I COST ESTIMATE – CAPITAL AND OPERATING EXPENSE BREAKDOWN

(Dollars in Thousands)

	FY 1981		FY 1982		FY 1983		FY 1984		FY 1985		Total	
	Capital	Expense	Capital	Expense	Capital	Expense	Capital	Expense	Capital	Expense	Capital	Expense
1. Engineering												
a. Facilities engineering (H&N)	–	25	–	105	–	540	–	295	–	140	–	1 105
b. Drilling and mining engineering												
(1) Drilling (F&S)	–	25	–	70	–	245	–	575	–	–	–	915
(2) Mining (F&S)	–	–	–	–	–	50	–	315	–	375	–	740
Subtotal – Engineering	–	50	–	175	–	835	–	1 185	–	515	–	2 760
2. Construction												
a. Site work and surface facilities												
(1) Site preparation and grading	–	–	–	–	–	235	–	–	–	–	–	235
(2) Roads	–	–	–	–	–	1 250	–	–	–	–	–	1 250
(3) Electrical power system	–	–	275	–	–	980	–	–	–	–	275	980
(4) Standby power generator	–	–	–	–	500	–	–	180	–	–	500	180
(5) Surface electrical distribution	–	–	15	–	–	–	–	420	–	–	15	420
(6) Water supply	–	–	–	–	–	650	–	–	–	–	–	650
(7) Communication system	–	–	30	–	–	400	–	–	–	–	30	400
(8) Temporary buildings	–	–	–	–	290	30	–	–	–	–	290	30
(9) Shop and warehouse	–	–	–	–	–	–	–	300	–	–	–	300
(10) Sanitary sewer	–	–	–	–	–	70	–	–	–	–	–	70
(11) Chilled-water plant	–	–	–	–	350	–	–	100	–	–	350	100
Subtotal – Site work and surface facilities	–	–	320	–	1 140	3 615	–	1 000	–	–	1 460	4 615
b. Drilling and casing operations												
(1) Drill and case shaft	–	–	–	–	–	980	–	29 165	–	–	–	30 145
(2) Casing jacks	–	–	–	–	1 700	–	–	–	–	–	1 700	–
(3) Drilling tools	–	–	285	–	–	720	–	430	–	–	285	1 150
Subtotal – Drilling and casing operations	–	–	285	–	1 700	1 700	–	29 595	–	–	1 985	31 295
c. Mining operations												
(1) Outfit shaft	–	–	–	–	2 000	–	310	770	–	430	2 310	1 200
(2) Mine surface plant	–	–	–	–	300	–	–	400	–	–	300	400
(3) Underground electrical	–	–	–	–	–	–	–	–	–	430	–	430
(4) Instrumentation	–	–	–	–	–	–	–	–	–	270	–	270
(5) Mining	–	–	–	–	–	–	1 740	–	–	3 920	1 740	3 920
(6) Exploratory drilling (3 rigs)	–	–	–	–	–	–	210	–	–	1 510	210	1 510
(7) Underground construction support	–	–	–	–	–	–	–	715	–	1 610	–	2 325
Subtotal – Mining operations	–	–	–	–	2 300	–	2 260	1 885	–	8 170	4 560	10 055
Total – Construction	–	–	605	–	5 140	5 315	2 260	32 480	–	8 170	8 005	45 965
3. Maintenance and Operations												
a. Site maintenance	–	–	–	–	–	430	–	500	–	570	–	1 500
b. Project operations	–	–	–	–	–	445	–	500	–	755	–	1 700
c. Users support	–	–	–	–	–	65	–	75	–	85	–	225
d. Safety training	–	–	–	–	–	120	–	120	–	120	–	360
Subtotal – Maintenance and Operations	–	–	–	–	–	1 060	–	1 195	–	1 530	–	3 785
4. NTS Allocation @ 6%	–	5	–	10	–	430	–	2 075	–	615	–	3 135
TOTAL – Engineering, Construction, and Maintenance and Operations	–	55	605	185	5 140	7 640	2 260	36 935	–	10 830	8 005	55 645

TABLE III

EXPENSE EQUIPMENT
(Dollars in Thousands)

Item	Date Needed	Delivery Time (mo)	BA/BO	Cost
Casing and Pipe				
144-in.-i.d. casing - 100 ft	8/83	6	83/83	270
122-in.-i.d. casing - 2200 ft	10/83	6	83/84	5064
98-in.-i.d. casing - 3500 ft	3/84	6	83/84	6816
7-in. inner string for 13-3/8-in. drill pipe - 1200 ft[a]	8/83	6	83/83	107
7-in. tremmie pipe - 2000 ft[b]	6/83	6	83/83	120
- 5000 ft[b]	10/83	6	83/84	300
98-in. hemi-head	3/84	6	83/84	30
Bit Cutters				
142-in. bit - 7 sets	8/83	3	83/83	720
120-in. bit - 4 sets	10/83	3	83/84	430

[a]Includes both fabrication and installation of the 7-in. string inside the 13-3/8-in. drill pipe.

[b]Assumes that 1/3 is required in FY 1983 and 2/3 are deferred to FY 1984.

2. Capital Equipment Funds. Capital equipment items required for the construction of the ES are shown in Table IV, along with their cost. This table also shows the items that may be available at NTS or the items that might be leased. The procurement time for these items after receipt of an order by the supplier and the year required for budget authorization (B/A) and obligation (B/O) are also shown.

3. Optional Operating Expense and Capital Equipment. Operational changes occurring in the weapons program preclude the ability to determine the availability of NTS weapons program equipment for use on the construction of the ES. The cost estimate in Table II is based on the assumption of a unit-price drilling contractor being used to construct the shaft. Current assumptions are that the weapons program drill rig will not be available for use on the ES. The other option of purchasing a new rig does not appear possible as a large budget authorization is required in FY 1982 to meet the schedule, and no budget action has been initiated.

a. Optional drilling equipment. The basic operating expense estimate, $55.6 million, includes the cost of obtaining a unit-price contractor drill rig to drill the ES. Most drilling tools required by a drilling contractor to drill a large-diameter hole are available from the NTS equipment pool (swivel, mud pumps, kelly and bushing, drilling assembly, drill pipe elevators, some casing elevators, drill pipe, and other miscellaneous equipment). Some

TABLE IV

CAPITAL EQUIPMENT (DRILLED SHAFT)
(Dollars in Thousands)

Item	Date Needed	Delivery Time[a]	Capital Funds BA/BO	Capital Funds Cost
Drilling and Casing Operations				
Power breaking tongs for 13-3/8-in. drill pipe	8/83	9	82/83	210
Casing jacks for 122-in. and 98-in. casing	8/83	8	83/83	1700
Spinning tongs	8/83	6	83/83	75
Drill rig[b,c]	8/83	18	82/83	5965
Surface Support Facilities				
Electric power transformers	6/83	12	82/83	275
Two shelters and mine cage communications system	6/83	6	82/83	30
Standby electric generator	2/84	6	83/84	500
Surface electrical distribution transformers	8/83	6	83/83	15
Temporary buildings	6/83	6	83/83	290
Chilled-water plant	2/84	6	83/84	350
Shaft Internals and Hoisting				
Main hoist	2/84	14	83/84	1200
Skip/cage combination	2/84	14	83/84	80
Secondary hoist[c]	2/84	12	83/84	530
Two-deck cage	2/84	12	83/84	40
Headframe	2/84	8	83/84	150
Ventilation blowers - two	2/84	6	83/84	300
Sump pumps - two	2/84	4	84/84	310
Mining Operations				
Rockbolt jumbo[d]	5/84	4	84/84	310
Two-boom jumbo[d]	5/84	3	84/84	300
Load haul dump[d]	5/84	3	84/84	125
Overshot loader[c]	5/84	3	84/84	75
Fork lift (20-ton, 10-ton)[c,d]	5/84	3	84/84	160
5-yd^3 front-end loader[c,d]	5/84	3	84/84	310
Mobile air compressors - three[d]	5/84	2	84/84	435
Skid-mounted diamond drills - three	9/84	2	84/84	210
High lift	5/84	3	84/84	25

[a]Estimated time from placement of purchase order to delivery at NTS.

[b]Not purchased if drilled by unit-price contractor (not included in cost estimate).

[c]Possibly available at NTS.

[d]Possible lease items.

drilling tools required for this project will have to be purchased (drill pipe tongs, 1 000 ft of 7-in.-i.d. inner string piping for 13-3/8-in.-i.d. drill pipe, and 8-million-lb-capacity casing jacks).

Optional drilling equipment items include a capital equipment cost estimate of about $6 million to purchase a new 2-million-lb-capacity, Class I drill rig. This option may need to be exercised because of the current and projected drilling industry availability of drill rigs with the capacity to meet the project requirements and also the current and future availability of the only NTS drill rig (IDECO 2500) with the capacity to meet the project requirements. The current project schedule requires the rig by September 1983. It is estimated that 18 months would be required after receipt of an order for delivery of a new drill rig. Therefore, if this option is to be exercised, the order should be placed by March 1982 to be consistent with the project schedule. Preparation of specifications, DOE/HQ and Field Office procurement approvals, and contract actions would have to be completed before this time to exercise the drill rig procurement option. Procurement of the drill rig is shown in FY 1983. To achieve procurement lead-time requirements, budget authorization is required in FY 1982. Congressional reprogramming action will be required if the acquisition of this drill rig is to be initiated in FY 1982. This action has not been initiated so it does not appear likely that a new drill rig will be purchased. Therefore, this capital cost has not been included in the estimate. Instead, the estimate is based upon a unit-price contractor drilling the shaft.

b. Optional mining equipment. Some items of mining equipment (1) may be available at NTS at the time and for the duration of need at no additional cost to the project, (2) could be leased (with an option to purchase) at a leased cost for the duration of need as a FY-1984 and -1985 operating expense to the project, or (3) could be purchased with capital equipment funds as a part of the project. The cost estimate assumes purchase of this equipment; specialized equipment is not readily available for short-term lease or from other NTS projects and purchase would make it available for future NTS needs. The capital equipment costs could be reduced by as much as $2245K if all items identified as possibly available at NTS or leased (Table IV) are not purchased for this project.

C. Construction Schedule

The ES construction schedule is based on starting shaft drilling by September 1983. This has been defined as the completion of the shaft-spudding operation and mobilization of the drill rig on the hole ready to begin operation by the end of September 1983. The project schedule for major activities is shown in Fig. 7.

D. Procurement Plan

Long-lead procurement is an important factor in maintaining the schedule of Fig. 7. Table IV shows anticipated lead times around which a procurement plan must be developed. If the shaft is sunk by mining, the main hoist is needed in August 1983. Because of the 14-month lead time, this would require a B/A in FY 1982. If the shaft is drilled, securing a drill rig seems to be the most critical long-lead item.

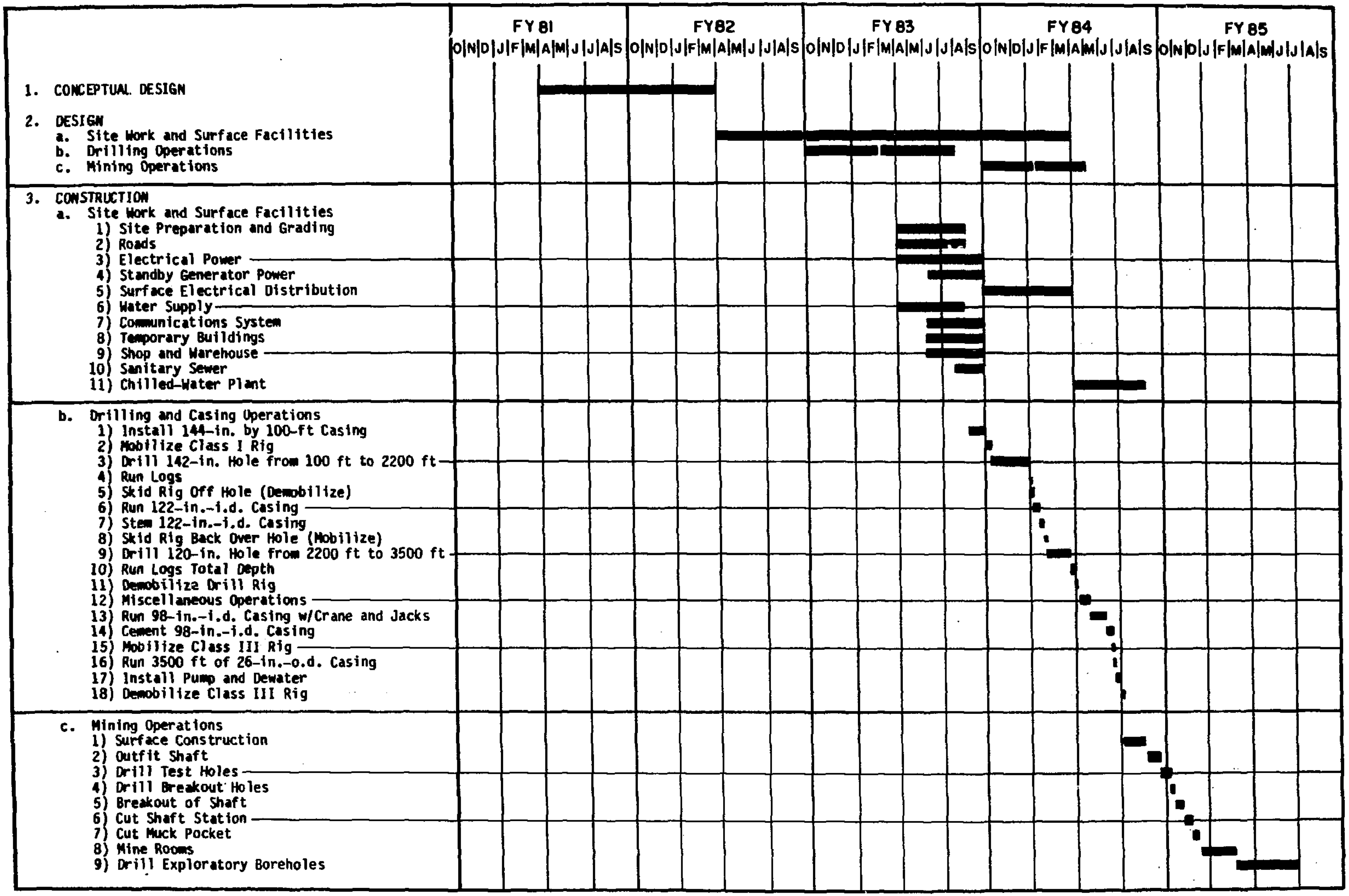


Fig. 7. Exploratory shaft design and construction schedule.

IX. PROJECT MANAGEMENT

This project will be managed by DOE/NV. Los Alamos National Laboratory will provide the technical direction for the design and construction activities. Engineering design and inspection will be performed by the NTS Operating Architect-Engineers: H&N for site work and surface support facilities and F&S for drilling and mining activities. Generally, construction will be performed by the NTS operating contractor, Reynolds Electric and Engineering Company, Inc. (REECo). Competitive contracts for major construction activities (if required) and equipment procurement or leasing will be initiated as DOE prime contracts, REECo subcontracts, or F&S subcontracts. Title III engineering services will be provided by F&S and H&N. Quality assurance auditing will be performed under the direction of the NNWSI QA program. A project management plan will be prepared by DOE/NV.

APPENDIX A
(PART I)

CONCEPTUAL DESIGN OF
A CONVENTIONALLY SUNK EXPLORATORY SHAFT

APPENDIX A

CONCEPTUAL DESIGN OF A CONVENTIONALLY SUNK EXPLORATORY SHAFT

I. INTRODUCTION

As an alternative to drilling the Exploratory Shaft (ES), conventional shaft sinking (mining) is discussed in this appendix. Several factors favor conventional shaft construction.

- With conventional shaft sinking, a larger diameter shaft (larger than the 98-in. i.d. for the drilled construction) is optimum. This larger shaft will allow more flexibility if the shaft is eventually incorporated into a repository design.

- Peer reviewers and others have expressed concern that a drilled shaft does not allow maximum study of the rock overburden to the target horizon. Conventional shaft sinking does allow more access to the rock walls of the shaft for obtaining geological data before liner placement.

- The concern over the availability of a drill rig by September 1983 is not a problem if conventional shaft-sinking methods are used.

- A recent Fenix and Scisson study (Parts II and III) indicates mining to be less expensive than drilling. These cost estimates represent state-of-the-art design based on assumed ground quality and water inflow conditions. These costs do not consider changes in construction or design that might be required for licensing considerations by the Nuclear Regulatory Commission (NRC) should the ES ultimately be incorporated in the repository. Also, the preliminary cost estimates are based on a particular shaft diameter that is considered practical to construct. A somewhat larger diameter shaft may be cost effective when future use is considered. More study is needed on the questions of shaft size, effect of quality assurance on costs, and the particular geology and how it will affect construction techniques once final depth and location of the ES have been defined.

Conversely, in addition to the factors outlined previously that favor drilling as the method of construction (see Sec. IV.B.3.), liner construction and quality assurance requirements to meet NRC licensing requirements could be difficult to factor into conventional shaft-sinking design and procedures. Safety of workers in a conventional shaft-sinking operation is a primary concern as this method is more dangerous than drilling and lining a shaft from the surface.

An additional consideration is the time schedule for a conventionally sunk shaft. Current estimates indicate that a conventionally constructed shaft will take several months longer to complete than drilling.

II. DESIGN BASIS

The design objectives and principal functional design requirements for a conventionally constructed shaft are identical to those outlined previously in the report for a drilled access shaft. Some modifications to the testing program may be possible as access to exposed shaft walls for geologic inspection and mapping will be possible during excavation and before the liner is placed.

III. CONCEPTUAL DESIGN DESCRIPTION

A preliminary conceptual design study is discussed in Part II, and a subsequent variation is discussed in Part III. This study is based on the assumption that water inflow and rock temperatures are not in excess of 5-6 gallons per minute (gpm) per vertical foot of unlined rock and 106°F. If a horizon above the water table is chosen, these concerns do not apply.

The design proposed in Part II is based on sinking the shaft to 3500 ft to be consistent with the design basis for the drilled shaft. An excavated diameter of 14 ft was selected to allow sufficient working room for personnel and equipment. The inside diameter after lining is complete will be 12 ft. Because of this increased diameter (compared to the 8-ft-i.d. for the drilled shaft), there will be more space for ventilation ducts and possibly larger skips. Tradeoff studies and new designs of the shaft internal arrangement have not been done; Part II illustrates that even with larger skip dimensions and two ventilation lines, the shaft internal design is not as constrained as with the 8-ft shaft.

The shaft would be drilled and blasted. A shaft jumbo used to drill the holes would be lowered down the shaft when required and hoisted to the surface when not in use. As conceptually illustrated in Fig. A-1, mucking would be done with a Cryderman mucking machine that would be permanently hung below the platform. A multilevel work platform would be hung in the shaft at the working level and lowered, as required, by winches on the surface. The multilevel platform would give added flexibility in installing shaft sets and utilities, as well as holding the Cryderman mucker, and would also carry the concrete forms for the shaft liner. The Part II study assumes an advance rate of 15 feet per day (fpd) to the water level and 12 fpd below that. Part III discusses the effect of slower advance rates (12 and 6 fpd, respectively).

Above the water table, the shaft would be equipped with 12-ft-i.d. by 13-ft-o.d. circular steel sets on 6-ft centers. Metallic lagging (for long life) would be attached between the sets for ground support and safety. One divider would run through the shaft to provide for hoist guide, vent line, electric line, and utility line support. Below the water table, a 1-ft-thick concrete liner would be poured for ground support and groundwater control. Again, one divider would be run through the shaft for hoist guide, vent line, electric line, and utility line support.

The shaft would be divided into two hoisting compartments: one for mining and the other for an auxiliary man cage, each connected to a separate hoist on the surface. The auxiliary hoist would be electrically connected to both the main power supply and an auxiliary diesel-operated generator in case

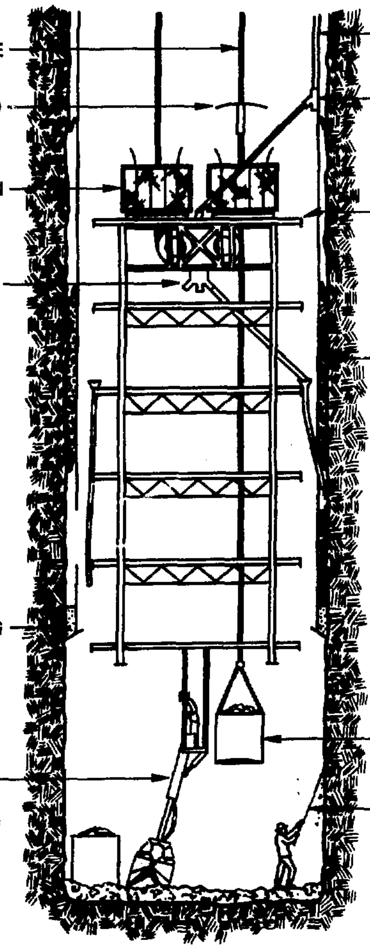


Fig. A-1. Conventional shaft sinking

of main power failure. This arrangement would have the added capability of being adaptable later to a two-drum hoist for increased hoisting capacity if the facility were to be enlarged.

Ventilation would be provided by two 26-in. vent lines installed as the shaft is mined. Because of the need to provide ventilation air continuously down shaft, two lines are required to be able to advance them one at a time without shutting off the blower(s). This will also provide the capability of furnishing more air to the underground facility, if desired later.

It is quite possible that licensing requirements will affect the design of the shaft-wall support system. The proposed methods of circular steel sets and lagging represent standard practices for ground control above the water table. However, lining the entire depth of the shaft with concrete may be required, and a change in design such as that will increase the cost and perhaps affect the schedule.

Water inflow problems are anticipated to be manageable except in a few zones. For these zones, pressure grouting outside the shaft diameter ahead of the mining is anticipated to provide satisfactory water control. Water handling systems, possibly involving staged lift pumps, water rings, or Kobe pumps, will be the subject of future design studies.

The design of the shaft lining system to include quality assurance controls also requires further study. Conventional practices for a watertight lining of a conventionally sunk shaft include welding a steel liner as one of the forms for the concrete structural member. Inspection and quality assurance of this welding need to be developed. These procedures may not be standard mining practice and could affect both the schedule and cost. An alternative approach to licensability could be to construct the shaft in a conventional and expeditious manner for ES Phases I and II requirements and later upgrade it if it should be decided to use it as part of the repository. This would have the advantage of minimum impact on both cost and schedule for ES Phases I and II and allow the upgrade to take advantage of more advanced sealing technology at some future date.

The work platform and construction procedure could be similar to that shown in Fig. A-1. The number of decks on the work platform will be determined in future design studies in conjunction with the shaft lining details. Forming and pouring of the concrete liner and any steel work can be performed from the work platforms while the Cryderman mucker is being used to excavate the shaft. The shaft drill jumbo can also be lowered and operated while lining construction proceeds from the decks of the platform. Blasting will occur between shifts when no personnel are underground, and smoke-out can be accomplished either by reversing the ventilation air flow to suck the shot gasses or by using the direct exhaust and waiting a sufficient time before workers re-enter the shaft. The question of full-face or benching excavation methods will also be the subject of further study based on water inflow expected and considerations such as overbreak.

Hoisting operations will be performed using the permanent headframe and hoists required for ES Phases I and II. The requirement that these systems be in place before the actual start of shaft construction will have an impact on surface facility design and will probably place the hoist system procurement on a critical time path for start of construction. Other capital equipment long-lead procurement requirements are anticipated to be less severe than for the hoist systems.

APPENDIX A
(PART II)

NOTE: Because the estimated times for tasks are included in the tables, the schedule figure has been omitted.

FENIX & SCISSON, INC.
P. O. BOX 498
MERCURY, NEVADA 89023

ADDRESS REPLY TO: D/S 1046

October 15, 1981

Mr. J. H. Dryden, Director
Nevada Operations, NTS Support Office
U. S. Department of Energy
Post Office Box 435
Mercury, NV 89023

ATTN: Mr. F. R. Huckabee, Chief
Test Construction Branch

LANL REQUEST FILE NUMBER WX-4-4238 (TTF-WX4-9/81-5) REQUESTING AN ESTIMATE TO MINE THE EXPLORATORY SHAFT

Enclosed please find the requested study showing a time and cost estimate for mining the shaft, and an equipment list.

F. D. Waltman

F. D. WALTMAN
MANAGER, MINING

FDW:ys

Encl.

✓cc: M. P. Kunich, DOE/NVOO (3)

FENIX & SCISSON, INC.
ADDITIONAL STUDY REQUEST
FOR MINING THE SHAFT
FOR
EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY

This study covers mining an exploratory shaft in Area 25. It is assumed that mining would start in July, 1983, (see attached bar chart).

The size of the shaft was chosen to be 12' Ø I.D. (by approximately 14' O.D. excavated) in order to allow sufficient working room for the men and equipment. Any smaller size would lead to inefficiency due to cramped working space.

The shaft would be drilled and blasted, using a shaft jumbo to drill the holes. The jumbo would be lowered down shaft for use, and hoisted to the surface when not in use. Mucking would be done with a Cryderman mucking machine which would be permanently hung below the work deck. A two or three deck work deck would be hung in the shaft at the working level and lowered as required by means of winches on the surface. This would give added flexibility in installing shaft sets and utilities as well as holding the Cryderman mucker and would also carry the concrete forms for the shaft liner. The estimate assumes an advance rate of 15 fpd (feet per day) to the water level and 12 fpd below that.

Above the water table, the shaft would be equipped with 12' Ø I.D. x 13' Ø O.D. circular steel sets on 6' centers. Metallic lagging (for long life) would be attached between the sets for ground support and safety. One divider would run through the shaft to provide for guide, vent line, electric line and utility line support. Below the water table, a concrete liner, one foot thick, would be poured for ground support and ground water control. Again, one divider would be run through the shaft for guide, vent line, electric line and utility line support. (See attached sketch)

The shaft would therefore be divided into two hoisting compartments, one for mining, and the other for an auxiliary man cage, each connected to a separate hoist on the surface. The auxiliary hoist would be electrically connected to both the main power supply and an auxiliary diesel operated generator in case of main power failure. This arrangement would have the added capability of later being adaptable to a two drum hoist for increased hoisting capacity if the facility were to be enlarged, with a second shaft being constructed, thus providing a second way out and eliminating the need for an auxiliary hoist for men only.

Ventilation would be provided by means of two 26" vent lines installed as the shaft is mined. Because of the need to provide ventilation air continuously down shaft, two lines are required in order to be able to advance them one at a time without shutting off the blower(s). This will also provide the capability of furnishing more air to the under ground facility if desired, later on.

It has been assumed, and the estimates have been based on, water inflow not exceeding 50 gpm, and rock temperature not exceeding 106°F. Insufficient information exists to accurately pinpoint either one, but some preliminary information from USGS indicates that from 1880' - 2257' depths, the water inflow could be as high as 6 gpm per foot. Since the concrete shaft liner will lag behind the shaft bottom by as much as 30 - 40 feet, the inflow could be 180 - 240 gpm, which would not only require extensive pumping equipment, but would also slow the advance rate to an indeterminate footage (depending on exact conditions encountered) and proportionately increase the cost. If inflow became unmanageable, other measures would be required such as high pressure grouting or possibly freezing of the water bearing zone to control the inflow and allow advancement. Both of these measures are expensive and time consuming and could easily escalate the cost by several times.

The rock temperature from logs taken appears to range from 86° - 93°F at a depth of 1800 - 2200 feet to 106.5°F at 3500' in hole H1. A log in hole B1, approximately one mile away shows temperatures as high as 130° - 140°. New logs are to be run shortly and should give more accurate information, since the holes have been standing for several weeks and the temperatures should now be stabilized. Our original study for Study Request Number 7, on ventilation, assumed a temperature of 106°F. If the temperature is much higher than this, a further indepth study may be required to determine if mining is feasible, and what kind of ventilation would need to be provided. An added problem would be that if the shaft is mined, and hot flowing water is encountered, the problem would be compounded due to men working under such conditions, and might be impossible.

FENIX & SCISSON, INC.

TIME AND COST ESTIMATE

TO MINE A 12' Ø X 3500' EXPLORATORY SHAFT

IN AREA 25

October 15, 1981

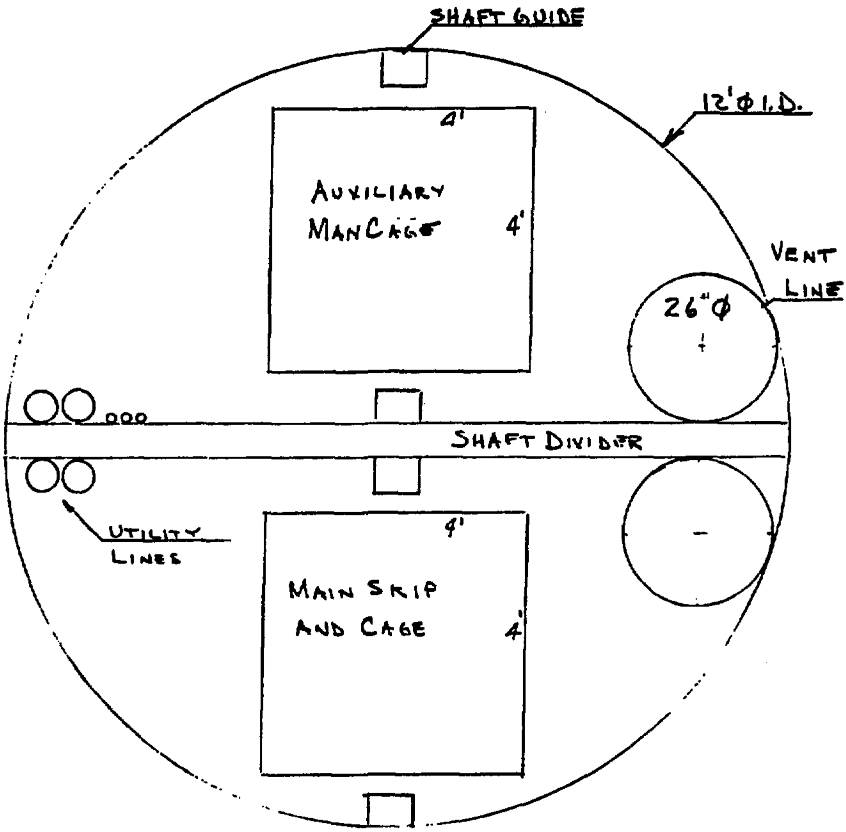
ITEM	FY83 DAYS	FY83 K$	FY84 DAYS	FY84 K$	FY85 DAYS	FY85 K$	TOTAL DAYS	TOTAL K$
Surface Construction	30	$ 304					30	$ 304
Sink the Shaft (Start July 83)	49	1,703	222	$10,629			271	12,332
Drill Test Holes			10	201			10	201
Drill Mng. Level Test Holes			6	122			6	122
Mine Shaft Station			10	403			10	403
Mine Muck Pocket			12	482			12	482
Drift Mining			42	1,672			42	1,672
Exploratory Drilling			25	713	135	$4,429	160	5,142
Underground Const. Support	*Conc.	473	*Conc.	2,253	*Conc.	1,071	*Conc.	3,797
Subtotals	79	$2,480	327	$16,475	135	$5,500	541	$24,455
15% Contingency	12	372	49	2,471	20	825	81	3,668
TOTALS	91	$2,852	376	$18,946	155	$6,325	622	$28,123

*Conc. = Concurrent

FENIX & SCISSON, INC.
CAPITAL EQUIPMENT BUDGET ESTIMATE
TO MINE A 12' Ø I.D. X 3500'
EXPLORATORY SHAFT IN AREA 25

October 15, 1981

ITEM	LEAD TIME	FY82 K$	FY83 K$	FY84 K$
Headframe with skip and cage	8 Mos.		$ 345	
Single drum unbalanced hoist	14	$1,485		
Sinking deck with winches	9	45		
Shaft jumbo	6		172	
Cryderman mucker	6		35	
Sinking skip	6		40	
Sinking pumps	6		170	
Concrete bulk plant	3		65	
Shaft liner forms	9	53		
Stage pumps in shaft (2 required)	6		350	
Kobe/Triplex pumps (2 required)	4			$304
Vent fans (2 required)	6		264	
LHD	3		172	
2 Boom drill jumbo	3		370	
4 Diamond drills	2			304
2 Compressors	2		238	
Rock bolt jumbo	4		264	
1 - 15 ton forklift	3		106	
Front end loader	3		251	
Subtotals		$1,583	$2,842	$608
15% Contingency		237	426	91
TOTALS		$1,820	$3,268	$699



PREPARED BY **FENIX & SCISSON, INC.** ENGINEERS & CONTRACTORS MERCURY, NEVADA	FOR **U.S. DEPARTMENT OF ENERGY** NEVADA OPERATIONS OFFICE LAS VEGAS, NEVADA

CONVENTIONALLY SUNK AREA 25 EXPLORATORY SHAFT CONCEPT				DRAWING NO.
DRAWN	CHECKED	DATE 10/14/81	SCALE 1/2" = 1'0"	SHEET ____ OF ____

APPENDIX A
(PART III)

NOTE: Because the estimated times for tasks are included in the tables, the schedule figures have been omitted.

FENIX & SCISSON, INC.
P. O. BOX 498
MERCURY, NEVADA 89023

ADDRESS REPLY TO: ADM-6023

November 25, 1981

Mr. J. H. Dryden, Director
Nevada Operations, NTS Support Office
U. S. Department of Energy
Post Office Box 435
Mercury, NV 89023

ATTN: Mr. F. R. Huckabee, Chief
Test Construction Branch

EXPLORATORY SHAFT - RECOMMENDATION OF MINING VERSUS DRILLING

In our estimate of October 15, symbol D/S 1046, we estimated the cost of sinking a 12' Ø I.D. x 3500' shaft based on advance rates of 15 feet per day (fpd) above the water table, and 12 fpd below the water table assuming that water inflow would not exceed 50 gpm and rock temperature would not exceed 106°F.

In order to have some numbers to compare to these to show what effect slower advance rates would have, we arbitrarily chose rates of 12 fpd above the water table and 6 fpd below it to arrive at a set of different costs. Comparing the original and second estimates shows a difference of about $8 million for the shaft and $11 million for the entire project. Part of the increase is due to slower advance rates and part to increased inflation caused by extending the time into later FY's. Other faster or slower advance rates should show a comparable difference.

A third comparison was made using a Unit Price Drilling Contractor (UPC) to drill the shaft, with REECo doing the underground portion of the project. This showed a further $9 million increase in the shaft cost and $7 million for the entire project.

More details are furnished on the attached pages.

Conversations with USGS personnel indicate that the expected water inflow should be in the range of about 6 gpm per foot of unlined shaft (similar to hole H-1 location), although certain specific locations might run many times that amount.

Because of the wide cost spread between drilling and mining the shaft, our recommendation would be to mine it, with the stipulation that it be in a location where water inflow does not exceed 5 - 6 gpm per foot and rock temperature does not exceed 106°F. We feel that the

Mr. J. H. Dryden
ADM-6023
Page 2

cost should then be in the range as shown by our estimate using 12 fpd advance above the water table, and 6 fpd below it.

J. A. CROSS, MANAGER
LAS VEGAS BRANCH

JAC:FDW:ys

Encl.

cc: M. P. Kunich, DOE/NV (3)
J. R. Wamsley, DOE/NV
D. C. Nelson, (2)

D/S 1059

FENIX & SCISSON, INC.
TIME & COST ESTIMATE
TO MINE A SHAFT
AT 15 FPD TO 1900' & 12 FPD FROM 1900' - 3500'

November 17, 1981

ITEM	FY 83 DAYS	FY 83 K$	FY 84 DAYS	FY 84 K$	FY 85 DAYS	FY 85 K$	TOTAL DAYS	TOTAL K$
Surface Construction	30	$ 350					30	$ 350
Mine the Shaft 0 - 1900'	49	1,950	88	$ 5,134			137	7,092
Mine the Shaft 1900 - 3500'			134	7,090			134	7,090
MINING SUBTOTALS:	79	$2,308	222	$12,224			301	$14,532
Drill Test Holes			10	231			10	231
Drill Breakout Holes			6	140			6	140
Mine Shaft Station			10	463			10	463
Mine Muck Pocket			12	209			12	209
ift Mining			42	1,923			42	1,923
Expl. Drilling			25	820	135	$5,093	160	5,913
U.G. Const. Support	Conc.*	544	Conc.	2,591	Conc.	1,232	Conc.	4,367
TOTALS:	79	$2,852	327	$18,601	135	$6,325	541	$27,778

All costs include 15% inflation per year and 15% contingency

*Conc. = Concurrent

D/S 1059

FENIX & SCISSON, INC.
TIME & COST ESTIMATE
TO MINE A SHAFT
AT 12 FPD TO 1900' & 6 FPD FROM 1900' - 3500'

November 17, 1981

ITEM	FY 83 DAYS	FY 83 K$	FY 84 DAYS	FY 84 K$	FY 85 DAYS	FY 85 K$	TOTALS DAYS	TOTALS K$
Surface Construction	30	$ 350					30	$ 350
Mine the Shaft 0 - 1900'	49	1,980	124	$ 6,893			173	8,873
Mine the Shaft 1900 - 3500'			241	12,037	26	$1,475	267	13,512
MINING SUBTOTALS:	79	$2,330	365	$18,930	26	$1,475	470	$22,735
Drill Test Holes					10	266	10	266
Drill Breakout Holes					6	161	6	161
Mine Shaft Station					10	534	10	534
Mine Muck Pocket					12	638	12	638
.ift Mining					42	2,214	42	2,214
Expl. Drilling					160	6,038	160	6,038
U.G. Const. Support	Conc.*	544	Conc.	2,892	Conc.	2,427	Conc.	5,863
TOTALS:	79	$2,874	365	$21,822	266	$13,753	710	$38,449

All costs include 15% inflation per year and 15% contingency.

*Conc. = Concurrent

D/S 1059

FENIX & SCISSON, INC.
TIME & COST ESTIMATE
UNIT PRICE DRILLING CONTRACTOR
WITH
REECO MINING

November 17, 1981

ITEM	FY 83 DAYS	FY 83 K$	FY 84 DAYS	FY 84 K$	FY 85 DAYS	FY 85 K$	DAYS	K$
Surface Construction			30	$ 401				
Equip the Shaft			20	768				
Drill Test Holes			10	231				
Drill Breakout Holes			6	140				
Breakout of Shaft			10	464				
Mine Shaft Station			10	464				
Mine Muck Pocket			12	554				
ift Mining					42	$ 2,214		
Expl. Drilling					160	6,038		
U.G. Const. Support			Conc.*	776	Conc.	1,843		
SUBTOTALS:			98	$ 3,798	202	$10,095	300	$13,893
UPC Drill the Shaft	35	2,276	278	28,999			313	31,275
TOTALS:	35	$2,276	376	$32,797	202	$10,095	613	$45,168

All costs include 15% inflation per year and 15% contingency.

*Conc. = Concurrent

APPENDIX B

HOLMES & NARVER, INC.
SURFACE FACILITY
DESIGN STUDY AND COST ESTIMATE

NOTES: (1) Some of the information contained in this study is not consistent with current assumptions. For example, some equipment specifications have changed since this study was completed.

(2) The data in this appendix serve as the bases for cost estimates in Table II, Sec. VIII.

DOCUMENT/DRAWING DISTRIBUTION	HOLMES & NARVER, INC. ENGINEERS • CONSTRUCTORS ON-CONTINENT TEST DIVISION	DATE: May 7, 1981 NO.: ES-137

NUMBER	REV.	FACILITY	DESCRIPTION
N/A		At-Depth Test Facility	Preliminary Cost Estimate

COMMENTS:

ACTION
- [X] REVIEW AND COMMENT
- [ ] FOR APPROVAL
- [ ] CONSTRUCTION
- [ ] INFORMATION
- [ ] YOUR REQUEST
- [ ] SEE COMMENTS

QUANTITY		QUANTITY	
3	DOE/ E&CM M. Kunich	1	H & N/ESTIMATING / G. Christensen
1	DOE/ NTSSO L. Skousen		H & N/CONSTRUCTION SERVICES
1	LLL /NTSSO R. Escobedo		H & N/QUALITY ASSURANCE
	LASL		H & N/ENGINEERING SERVICES
	SANDIA CORP.		H & N/PROJECT ENGINEERING
	EG & G		H & N/COMMUNICATIONS
	DOD/DNA		H & N/MATERIALS TESTING LAB.
		1	H & N/TECH. SERVICES FILES

COST ESTIMATE	HOLMES & NARVER, INC. ENGINEERS • CONSTRUCTORS ON-CONTINENT TEST DIVISION	DATE: May 7, 1981

TO: Project Engineer - J. Berry - w/3 FROM: Chief Estimator

PROJECT: Waste Isolation I.D. NO.: ______ REV.: ______ SITE: Area 25

SUBJECT: AT-DEPTH TEST FACILITY, PHASE I

REFERENCES:

Requesting Agency: DOE, M. Kunich/L. Skousen

Date of Request: 4/17/81

Telephone ______, verbal X, Ltr. ______, or Memo. ______ Symbol: ______

TYPE OF ESTIMATE:

___ Work Authorization ___ Comparative
XX Preliminary ___ Work Order
___ A-E ___ Other (Specify)

TYPE OF WORK:

___ Engineering & Engr. Support ___ O&M Support
___ Engineering, Engr. Support & Construction ___ Other (Specify)
___ Construction Only

CONSTRUCTION IS EXPECTED TO BE:

CPFF XX LUMP SUM (Contract/Subcontract) ______

REMARKS: An estimate for the items that are H&N's responsibility on Phase I of the At-Depth Test Facility is attached. Also attached is a "Scope of work description" reflecting our understanding of the scope of work based on the "Basis for Estimating the Cost of Phase I" Dated April 13, 1981, the Work Order Outline and the two meetings with DOE and DOE contractors. Estimate includes H&N's Title I, II and III Engineering, Materials Test Lab. (including NDT) and Survey.

Estimated costs are shown in FY-83 dollars. Each item in the estimate includes contingency.

Estimated costs of Capital Equipment are shown separately from expense costs.

Estimated costs are broken down by Fiscal Year

GEC:ac

cc: Manager, Technical Services, w/1
General Supv. Construction Services, w/1
Chief Engineering Services, w/1
Estimating Files, w/o

Recommended ______

Approved G. Christensen

Approved ______

(Use reverse side for additional remarks)

FORM 406 (REV. 8/71)

AT DEPTH TEST FACILITY
PHASE I
H&N PRELIMINARY ESTIMATE, MAY 7, 1981

WORK ORDER NO.	TITLE	FY 1981		FY 1982		FY 1983		FY 1984		FY 1985		TOTAL	
		CAP $000	EXP $000	CAP $000	EXP $000	CAP $000	EXP $000	CAP $000	EXP $000	CAP $000	EXP $000	CAP $000	EXP $000
100	Site Preparation & Grading	0	0	0	0	0	235	0	0	0	0	0	235
101	Roads	0	0	0	0	0	1250	0	0	0	0	0	1250
102	Electrical Power	0	0	0	0	115	980	0	0	0	0	115	980
103	Standby Generator Power	0	0	0	0	415	140	0	0	0	0	415	140
104	Surface Electrical Distribution	0	0	0	0	0	0	15	420	0	0	15	420
105	Water Supply	0	0	0	0	0	650	0	0	0	0	0	650
106	Communications System	0	0	0	0	430	0	0	0	0	0	430	0
107	Temporary Buildings	0	0	0	0	400	30	0	0	0	0	400	30
108	Shop & Warehouse Building	0	0	0	0	0	250	0	0	0	0	0	250
109	Sanitary Sewer System	0	0	0	0	0	70	0	0	0	0	0	70
110	Chilled Water Plant	0	0	0	0	0	0	575	100	0	0	575	100
302	Underground Electrical	0	0	0	0	0	0	0	195	0	195	0	390
303	Instrumentation	0	0	0	0	0	0	0	0	0	270	0	270
	SUBTOTAL											1950	4785
	Holmes & Narver Support												
	Conceptual Design	0	30	0	15	0	0	0	0	0	0	0	45
	Title I & II Engineering	0	0	0	70	0	320	0	80	0	30	0	500
	Title III Inspection	0	0	0	0	0	60	0	15	0	0	0	75
	Material Test Lab & NDT	0	0	0	15	0	90	0	90	0	15	0	210
	Survey	0	0	0	15	0	70	0	110	0	95	0	290
	SUBTOTAL												1120
	TOTAL											1950	5905

AT DEPTH TEST FACILITY

PHASE I

H&N PRELIMINARY ESTIMATE, MAY 7, 1981

SCOPE OF WORK DESCRIPTION

WORK ORDER XXXX-100, SITE PREPARATION & GRADING

This item includes the following scope of work:

a. Clearing, grading, and stabilizing an area of approximately 5 acres near hole USW-H-1. It is assumed that a grade elevation will be selected so that the "cut" and the "fill" will balance. The area will be stabilized with Type II aggregate hauled from a pit in Area 25.

b. A 25 ft. x 60 ft. x 2 ft. thick reinforced concrete drill slab and a 4 ft. thick jack pad.

c. A 250 ft. x 250 ft. x 8 ft. deep mud pit.

d. A 100 ft. x 100 ft. x 8 ft. deep cutting pit.

e. A 100 ft. x 100 ft. x 9 ft. high muck pile.

f. The balance of the stabilized area will be used for building locations, parking, pipe storage, and a construction working area.

WORK ORDER XXXX-101, ROADS

This item includes approximately 11½ miles of new road from the end of the paved road West of E-MAD to the ADTF site near Hole USW-H-1. The road will be 22 ft. wide with 4 ft. shoulders each side. Due to the nature of some of the existing native materials in the path of the road, it is assumed that 5 miles of the road will require a 6 in. sub-base. The road will be surfaced with double oil and chips.

WORK ORDER XXXX-102, ELECTRICAL POWER

This item includes the following scope of work:

a. A 69 KV overhead power line from canyon substation to a main substation at the project site (approximately 6 miles).

b. Approximately 4.5 miles of under-built 4.16 KV power line from the main substation at the project site to serve three 30 HP booster water pumps. Three transformer stations are required.

c. A 5000 KVA substation, including a 69 KV to 4.16 KV transformer, a 1000 KVA, 4.16 KV to 277/480 V transformer, a 500 KVA, 4.16 KV to 120/208 V transformer, necessary oil fused cutouts, distribution panels, conduit and wire, fencing, trenching, concrete work, etc.

WORK ORDER XXXX-103, STANDBY GENERATOR POWER

This item includes two 750 KW diesel generators, two 5000 gallon fuel tanks, two manual transfer switches, necessary fuel piping, conduit, wire oil fused cutouts, concrete work, and weather proof enclosures for the diesel generators.

WORK ORDER XXXX-104, SURFACE ELECTRICAL DISTRIBUTION

This item includes the following scope of work:

a. Substations, distribution panels, underground conduit and wire, trenching, concrete work, etc. to provide electric service to the following structures:
   1. Six trailers.
   2. One warehouse and shop building.
   3. Two change rooms.
   4. One hoise house.
   5. Ventilation and Chiller equipment.
   6. One communication van.

b. Conduit, wire, oil fused cutouts, trenching as required for the following surface mounted motors:

1. 900 H.P. hoist motor.
2. 450 H.P. emergency hoist motor.
3. Two 350 H.P. air compressors.
4. Two 250 H.P. sump pumps.
5. Two 400 H.P. blower motors.
6. Three 150 H.P. chiller motors.
7. Four 30 H.P. booster water pumps.
8. 5 H.P. fire pump.
9. 2 H.P. potable water pump.
10. Four 100 H.P. winch and miscellaneous motors.

c. Area lighting consisting of four 35'wood poles with four 400 Watt H.P.S. floodlights on each and necessary underground conduit, wire, photocells, trenching, etc.

d. Temporary power and lighting for construction.

WORK ORDER XXXX-105, WATER SUPPLY

This item includes the following scope of work:

a. Tapping in to the existing 6" water main at Well J-13 and installing a 4" gate valve.

b. Installing in a trench approximately 6½ miles of 4" schedule 80 P.V.C. pipe.

c. Installing four 30 H.P. booster pumps, pressure switches, pump shelters, etc., along the line. Three of the booster pump stations will require 500 gallon surge tanks.

d. Installing a 50,000 gallon steel storage tank.

e. Installing a water distribution system at the site to the 8 portable structures, the shop and warehouse building, the chiller plant, etc. It is estimated that this will require the equivalent of 600 lin. ft. of 1½" P.V.C. pipe in trenches along with valves and fittings.

f. Installing a 2 H.P., 150 gallon pressure system for potable water and a 5 H.P., 150 gallon pressure system for fire protection.

Note: The above scope assumes a permanent water line. If a temporary water line is selected, i.e., using vitaulic couplings and installing the line in a shallow V-ditch, $100,000 may be deducted from the estimated cost.

WORK ORDER XXXX-106, COMMUNICATIONS SYSTEM

This item includes a 12-channel surface microwave link communications system and a two-way radio system to the mining cage.

WORK ORDER XXXX-107, TEMPORARY BUILDINGS

This item includes six 12 ft. x 60 ft. portable structures that will provide office space, laboratory space, a first aid room, a visitor center, etc.; and two 12 ft. x 50 ft. change room skids that will provide showers and lockers for the construction and technical staff. Each structure will be supplied with water, power, and sewer systems and will have rest rooms, heating, and air conditioning.

WORK ORDER XXXX-108, SHOP & WAREHOUSE BUILDING

This item includes a 2,000 sq. ft. prefabricated metal building erected on a 4 inch thick concrete slab that will provide shop and warehouse space. The building will have a 12 ft. eave height and will be insulated. The building will have water, power, sewer, heating, air conditioning, and a fire sprinkler system. A rest room and two offices are included. The rest of the building will be open area.

WORK ORDER XXXX-109, SANITARY SEWER SYSTEM

This item includes a 100 ft. x 100 ft. x 4 ft. deep sewer lagoon, a 20 ft. x 50 ft. x 4 ft. deep collection basin, approximately 600 ft. of 6" ACP buried sewer main, approximately 300 ft. of 4" ACP buried sewer pipe, and one man-hole.

WORK ORDER XXXX-110, CHILLED WATER PLANT

This item includes three 120 ton chiller units, two 20,000 CFM fans, foundations, supports and miscellaneous hardware required to make an operable plant.

WORK ORDER XXXX-302, UNDERGROUND ELECTRICAL

This item includes the following scope of work:

a. Temporary power and lighting for mining.

b. A 300 KVA, 4.16 KV to 277/480 V substation with 3/C, #2/0 5 KV downhole cable, oil fused cutouts, surface wire and conduit, trenching, 480 Volt distribution panel. Downhole cable will be installed in conduit furnished by others.

c. A 75 KVA, 480 V to 120/208 V dry type transformer and distribution panel with necessary wiring for approximately 10 duplex receptacle outlets and two 60 AMP, 3 phase, power outlets.

d. A lighting system for shaft and underground drifts and drilling rooms similar to that installed on the Spent Fuel Test/Climax Project.

e. A hoist signal system similar to that installed on the Spent Fuel Test/ Climax Project.

WORK ORDER XXXX-303 - INSTRUMENTATION

This item includes the following runs of instrumentation cables from an instrumentation trailer on the surface, than downhole and extend to end of drift. Cables will be installed in conduit provided by others.

3 - 25 Pr. #22 I.P.S. cables
1 - 19 Pr. #22 I.P.S. cables
2 - 9 Pr. #16 I.P.S. cables
4 - RF-14 Coaxial cables

All estimated costs include contingency and escalation.

APPENDIX C
(PART I)

FENIX & SCISSON, INC.
STUDY REQUEST NO. 1
SHAFT DRILLING AND CASING FOR
EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY

NOTES: (1) Portions of the original study discussing stemming loads on the casing and specifications for a 300-ton crane have been omitted from Part I.

(2) Cementing of the 122-in. casing is assumed to be preferred. References to stemming contained in this study should be considered as an alternative concept.

FENIX & SCISSON, INC.

STUDY REQUEST NO. 1

SHAFT DRILLING AND CASING
FOR
EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY

The proposed shaft for the NTS consists of a 98" I.D. finished cased hole to 3500'. Inside of the casing will be shaft sets of structural steel to support shaft guides, compressed air, water, pump discharge, ventilation, electric power and scientific cable pipe lines, as well as signal and communication systems. Design calculations and specifications pertaining to the drilling and casing of the exploratory shaft are furnished in this study.

The drilling and casing of the shaft are outlined in a proposed drilling program which is consistent with the general procedure used in drilling 96" diameter holes on Pahute Mesa. Maximum diameter of the 98" inside diameter casing going into the 120" hole will be 114", leaving a 3" clearance on each side. This tolerance is within acceptable limits of casings run in holes on Pahute Mesa. The geologic strata of Yucca Mountain are believed to have similar drilling characteristics to those which have been drilled on Pahute Mesa. No significant hole deviation problems are expected at Yucca Mountain site. However, every effort will be made to maintain a true vertical hole. Multishot cluster gyro surveys will be run on ± 30' stations. Any unacceptable hole deviations will be corrected prior to running casing. Drilling of the 142" WIPP shaft will be closely watched to determine if the addition of a top stabilizer to the drilling assembly aids in drilling a straight hole (without offsets) at strata interfaces. Recommended drilling weights (as determined by previous drilling experience) will be maintained while drilling. Rotary speed will be within optimum limits. Careful control of these drilling parameters, along with the use of a properly designed drilling assembly, should produce a plumb hole for the exploratory shaft.

The 98" inside diameter casing for the shaft has been designed using ASTM A-441 steel. Stiffener rings on 120", or less, spacing will be used for jack rings while lowering the casing in the shaft. (See attached Casing Design). The static water level at the exploratory shaft site will have to be estiblished prior to making a final casing design. Casing design calculations were made with the usually acceptable 1.5 safety factor for expected hydrostatic heads. Tensile stresses on the casing and casing jacks while lowering in the hole are well below acceptable stresses. Casing jacks will be designed for 8 million pounds capacity. The 98" inside diameter casing will weigh approximately 3.2 million pounds when it starts to float at the static water level (4.4 million pounds gross weight in air). Quality assurance of all casing, welding, casing jacks, and surface equipment is covered in a separate part of the conceptual design study. The 122" inside diameter casing is to be run above the static water level and has not been designed to withstand a hydrostatic head. This casing is to be run to protect the hole from caving while drilling below static water level. Stemming and cementing of all downhole casing is covered in another section of this study.

Steel sets will be pre-installed by the casing manufacturer. Details of this prefabrication are covered by others in another part of this study. Alignment of the casing sections prior to welding must be precise to ensure downhole alignment of all shaft equipment.

As the 122" inside diameter casing is to be run to protect the upper hole down to the static water level, stemming the casing annulus with NTS pea gravel is recommended. Grouting with cement would not be cost effective (See attached Casing Design). The feasibility of using native stemming material without collapsing the casing is considered in separate items of this study. Feasibility of this concept is indicated by all calculations made to date. Cementing of the 98" inside diameter casing would be done in the same manner as all casing cementing jobs which are done at NTS. (See 98" I.D. Cementing Program). The usual safety factor of 2 has been calculated in this program.

A drawing of the exploratory shaft configuration is provided in this study. Fenix & Scisson, Inc., drawings of the 98" inside diameter and 122" inside diameter casing, showing details of stiffener and jack rings, length of joints, and other details are submitted at the end of this study. Two casing sizes (98" I.D. and 72" I.D.) have been considered in the conceptual design of the shaft. The cost comparison of the two concepts are made in the cost estimate section of this study. The merits and disadvantages of each concept are compared by others in a different section of this study.

BUDGET ESTIMATE

Phase I

U-25 Waste Isolation Shaft #1
Cost Estimate Summary
(1983 and 1984 Dollars)

	Estimated Cost 1981	Estimated Cost 1983 Dollars		Estimated Cost 1984 Dollars	
		Expense	Capital	Expense	Capital
FY 1983					
Drill surface hole to 100'. Set and cement 144" I.D. casing. Mobilize Class I rig. Drill 142" hole to 2200'. Also includes purchase 122" casing.	$ 6,245,198	$ 8,993,085			
Capital Equipment					
Tongs - one set for 13-3/8" drill pipe.	$ 75,000		$ 108,000		
One set of two casing elevators for 98" I.D. casing.	382,000		550,000		
Hydraulic jacks for 122" I.D. and 100" I.D. casing, 8 million pound capacity, less hydraulic power unit.	1,154,000		1,661,000		
Total	$ 1,611,000		$ 2,319,000		
FY 1984					
Log 142" hole. Run and stem 122" casing to 2200'. Drill 120" hole 2200' to 3500'. Log. Demobe Class I rig. Set and cement 98" I.D. casing with crane and casing jacks. Mobilize Class III rig to run vent line and dewater casing.	$ 8,761,062	$12,615,292		$15,139,115	
Totals by FY	$15,006,260	$ 8,993,085	$ 2,319,000	$15,139,115	

	1981	1983	1984
Fenix & Scisson, Inc., Cost	$472,506	$680,408	$816,491

Note: FY 1983 and FY 1984 cost are based on FY 1981 estimates escalated by a factor of 20 percent per year from FY 1981.

COST ESTIMATE
U-25 WASTE ISOLATION SHAFT #1

	Days	Base Total	Subtotal	Grand Total
A. Site Preparation				
1. Site leveling, access road. Rig pad, jack pad, pits, etc. Furnished on H&N work order		N/A	N/A	
B. Rig Operation				
1. Excavate hole for 10' of 200" CMP with backhoe. Install CMP and backfill	3	2,517		
2. Mobe and demobe CP rig 3 man @ $5,426/day	2	10,852		
3. Drill shot holes to 100' and blast	12	65,112		
4. Mobe and demobe auger rig 3 man @ $5,618/day	2	11,236		
5. Auger 168" hole to 100'	12	67,416		
6. Mobe and demobe crane 100 ton crane w/support $1,867/day	2	3,734		
7. Install Casing with crane	2	3,734		
Sub Total			164,601	
Total				164,
C. Material and Services				
1. a. 10' - 200" CMP		12,636		
b. 98' - 144" x 1" wall casing (if available)		76,500		
Material Handling	11%	9,805		
G&A	9%	8,022		
Sub Total			106,963	
2. Blasting Material	L.S.	13,052		
Sub Total			13,052	

	Days	Base Total	Subtotal	Grand Total
3. Cement (Redi-Mix)	6500 ft^3	29,250		
Sub Total			29,250	
4. Welders (8)				
a. Double joint 24hrs. x 8 men x $47.00		18,048		
b. Run 24hrs. x 8 men x $47.00		18,048		
Sub Total			36,096	
Total				185,361

D. Drilling Operation

	Days	Base Total	Subtotal	Grand Total
1. Mobilize Class I Rig 9 days @ $17,137/day	9	154,233		
2. Drill 142" hole from 100' to 2200' (r/p = 26'/day)	84	1,439,508		
3. Run logs	3	51,411		
4. Skid rig off hole to allow casing installation with crane and casing jacks	3	51,411		
5. Run 122" I.D. casing	12	308,466		
6. Stem 122" I.D. casing	10	171,370		
7. Skid rig back over hole	3	51,411		
8. Drill 120" hole from 2200' to 3500' (r/p = 28'/day)	52	891,124		
9. Run logs total depth	3	51,411		
10. Demobe drill rig	9	154,233		
11. Miscellaneous operations and delays	20	342,740		
12. Run 98" I.D. casing with crane and casing jacks	33	N/A		

	Days	Base Total	Subtotal	Grand Total
13. Cement 98" I.D. casing	18	N/A		
14. Mobilize Class III Rig w/o equipment 2 days @ $10,138/day	2	20,276		
15. Run 3500' of 26" O.D. casing	3	30,414		
16. Run pump and dewater casing	12	164,856		
17. Demobe Class III Rig	2	20,276		
Sub Total	278		3,800,318	
Total				3,800,318
E. Supplies, Materials and Services				
1. Casing				
A. 122" I.D. x 3/4" wall	2200'	2,343,750		
B. 98" I.D. x 1-1/2" to 3/4" wall	3500'	3,150,000		
C. Tremmie Pipe 7" x 1/4" wall	7000'	201,600		
Sub Total		5,695,350		
Casing Handling	16%	911,256		
G&A	9%	512,582		
Sub Total			7,119,188	
2. Bit Cutters				
A. 142" Bit - 7 sets @ $57,058		399,406		
B. 120" Bit - 4 sets @ $49,642		198,568		
Material Handling	11%	65,777		
G&A	9%	53,818		
Sub Total			717,569	
3. Mud Material	L.S.	150,000		
Sub Total			150,000	

	Days	Base Total	Subtotal	Grand Total
4. Fabrication and Installation of 1200' of 7" inner string in 13-3/8" Reed V-4 drill pipe, 28 joints		67,200		
G&A	9%	6,048		
Sub Total			73,248	
5. Welding				
A. 122" casing 60' joints 36 welds @ 8hr./welds x 8 welders x $47/hr.		108,288		
Sub Total			108,288	
B. 98" casing				
40'/joints to 960' = 24 joints, 60'/joints 960' to 3500' = 42 joints = 66 welds @ 12hrs./weld x 8 men x $47.00		297,792		
Sub Total			297,792	
6. 98" Hemi-head		15,000		
Material Handling	11%	1,650		
G&A	9%	1,350		
Sub Total			18,000	
7. Reconditioning 7000' of 2-3/8" hydril tubing for cementing operations	L.S.	35,000		
Sub Total			35,000	
8. Miscellaneous Trucking	L.S.	50,000		
Sub Total			50,000	
9. Miscellaneous Supplies	L.S.	100,000		
Sub Total			100,000	

	Days	Base Total	Subtotal	Grand Total
10. Crane, Forklift and Crews				
Casing Installation				
A. 122" casing 12 days @ $6,1907/day	12	34,280		
B. 98" casing w/rig crew 33 days @ $10,681/day	33	352,473		
Sub Total			426,753	
11. Cranes for Cementing Operation				
(2) hydro cranes, (1) 50-T crane	18	148,572		
Sub Total			148,572	
12. Casing Jack Operation				
A. Run 122" casing				
(1) Mobe ($10,649)	3	31,947		
(2) Run ($4,030)	12	48,360		
(3) Demobe ($10,649)	3	31,947		
(4) Supplies/repair/maintenance ($300)	12	36,000		
Sub Total			148,254	
B. Run 98" casing				
(1) Mod. of jacks to run 98" casing ($10,649)	6	63,849		
(2) Mobe ($10,649)	3	31,947		
(3) Run ($4,030)	33	132,990		
(4) Demobe ($10,649)	3	31,947		
(5) Supplies/repair/maintenance ($300)	33	9,900		
Sub Total			270,678	
13. Magnetic Particle				
Inspection of 85 joints of 13-3/8" drill pipe		2,990		
Sub Total			2,990	
Total				9,633,932

	Days	Base Total	Subtotal	Grand Total
F. Subcontract Services, F&S				
1. Logging				
A. There will be logging at 2200', 3500' monitoring of 98" casing cement job. No logging criteria has been supplied	L.S.	100,000		
Sub Total			100,000	
2. Gyro Cluster Shot Survey taken at 30' stations for 210 days = 7 months $16,000 per month	L.S.	112,000		
Sub Total			112,000	
3. Cementing/Stemming				
A. 122" casing				
(1) Labor Cost ($9,516)	10	95,160		
(2) Material Transportation	L.S.	41,112		
(3) 10' cement plug, 122" I.D. casing x 2200'	1,100 Ft^3	11,000		
B. Cement Casing 98" I.D. casing x 3500'	94,842 Ft^3	948,420		
Sub Total			1,010,048	
Total				1,222,048
GRAND TOTAL				15,006,260

U-25 WASTE ISOLATION SHAFT #1

F&S Labor Cost

A. Labor Cost

1.	Drilling Specialist 48 weeks x 3 x $1,560	$224,640
2.	Project Engineer 41 weeks x $1,888	77,408
3.	Design Engineer 26 weeks x $1,640	42,640
4.	Technical Writer 12 weeks x $948	11,376
5.	Quality Assurance Engineer 26 weeks x $1,445	37,570
6.	Estimator 12 weeks x $1,243	14,916
7.	Logging Engineer 6 weeks x $1,360	8,160
8.	Drafting 52 weeks x $1,073	55,796
	TOTAL	$472,506

CAPITAL EQUIPMENT LIST
U-25 WASTE ISOLATION SHAFT #1
Revision #2

Two-million pound API static hook load rig.	1983 Dollars (K$)	Lead Time
1. Two-million pound L. C. Moore mast, 147' x 38' x 37' floor 30' width between sub-structure boxes, crown block 9-sheave, 1.125-ton capacity, two million pounds casing capacity, one-million pounds setback capacity, 1,000-ton, 8 sheave traveling block	$ 1898	15 months
2. National 1625-DE electric drawworks, 3,000 H.P. with double drum and 6 speeds	893	18 months
3. 2 - Baylor 7838 electric brakes	245	18 months
4. 3 - GE 752 or EMD electric motors	121	18 months
5. 2 - EMD engine generator sets, 2200 BHP each	1210	18 months
6. 1 - SCR power conversion AC to DC	720	18 months
7. 1 - National C375 rotary table with two-speed transmission and one GE 752 DC motor	220	18 months
*8. Tongs- one set for 13-3/8" drill pipe	108	18 months
*9. One set of 2 casing elevators for 98" I.D. casing	550	18 months

Other Equipment

* Hydraulic jacks for 122" I.D. and 100" I.D. casing, 8-million pound capacity, less hydraulic power unit		
Upper and lower yoke system	890	8 months
8 - 500-ton, 3,000 psi Rams	518	8 months
8 - leveling jacks	253	8 months
TOTAL	$ 7,626	

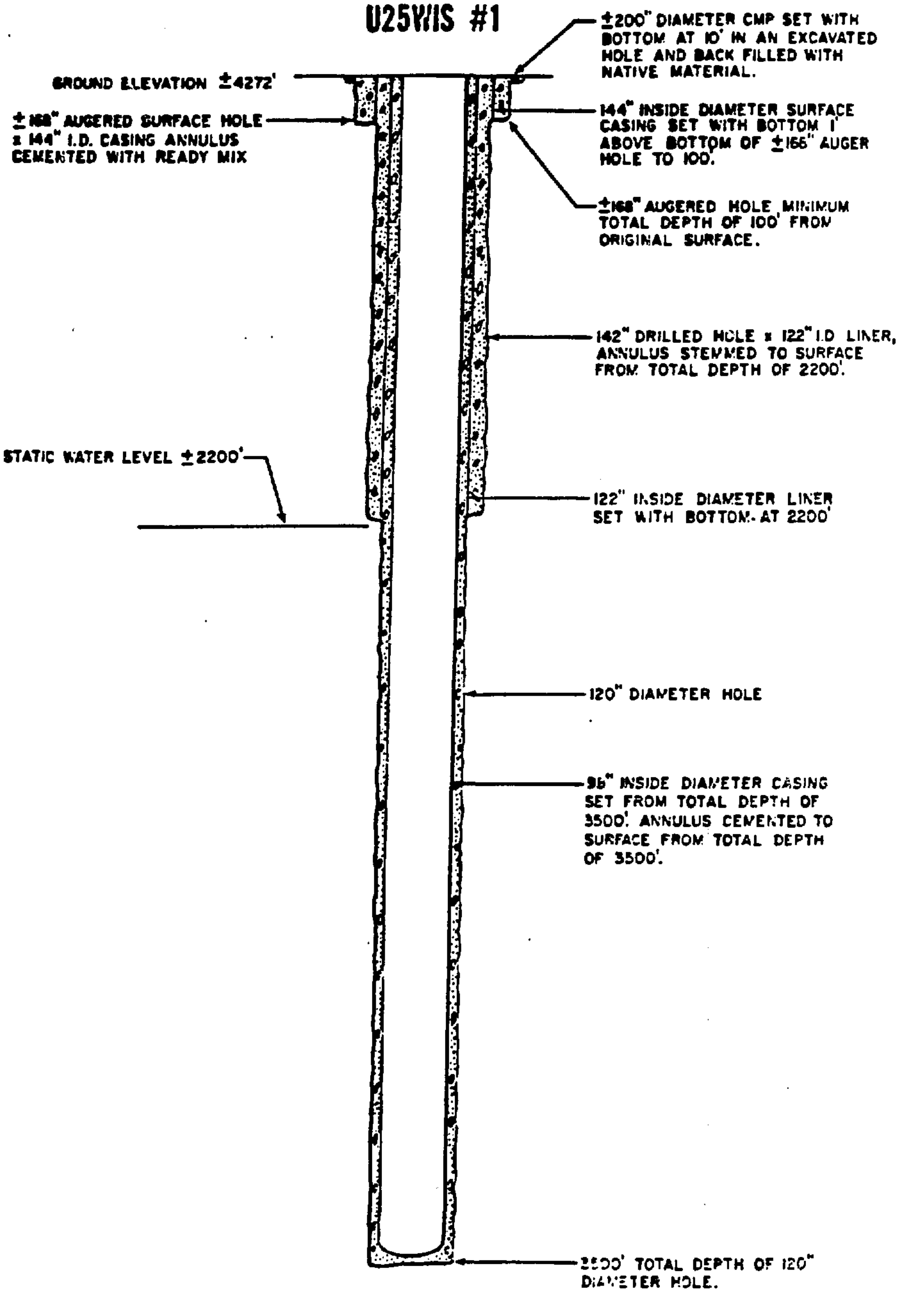
* Included in Capital Equipment Estimate for FY-83

Notes:

1. 1983 cost of equipment is based on 1981 price quotations using a 15 percent per year escalation factor and a 5 percent contingency factor.

2. Lead time for delivery of equipment is based on recent quotations and is necessarily subject to change.

PROPOSED 98" INSIDE DIAMETER CASED EXPLORATORY SHAFT U25WIS #1



D-007-006

FENIX & SCISSON, INC.
ENGINEERS-CONTRACTORS

RE: PREPARATION OF DRILL SITE
STATION U-25 WASTE ISOLATION
SHAFT #1 ORIGINAL

W.O.#: XXXX-200
Preliminary for
Conceptual Design
Study

LOCATION: To be selected

DATE: July 16, 1981

PROJECT ENGINEER: [signature] 7-30-81

PRESENT CONDITIONS:

The U-25 WI Shaft #1 is distantly removed from any expended hole.

PROGRAM:

1. Rad-Safe must be notified prior to commencing work. Rad-Safe will prepare a radiation safety program which will be followed by the drilling contractor.

2. Approval to drill the hole must be obtained from DOE/NTSSO prior to moving the rig on location.

3. Access road and drill site to be prepared by others prior to commencement of drilling operations for the surface casing.

4. Move in CP rig and drill 6-1/4" shot holes as required to 100' using a Mission downhole hammer drill. Holes shall be spaced for optimum blasting effect. Move rig off location. Load and blast shot holes including the hole(s) for a mouse hole.

5. Others shall excavate a 2' deep area for the drill pad and a 4' deep area for the 200" diameter corrugated metal pipe (CMP) conductor casing. CMP will be installed and backfilled with native material.

6. Move in an Auger rig and auger a 168" hole to 100'.

7. Install 144" I.D. x 3/4" wall x 100' surface casing and cement casing to the surface with required amount of ready-mix cement. The 144" I.D. x 3/4" wall casing shall be hung 1' off bottom and centered in the hole prior to cementing.

8. Demobilize Auger rig.

NOTES:

A. All depths are from Holmes & Narver, Inc. reference mark.

B. Install Fenix & Scisson, Inc., bench marker on the surface casing.

C. [illegible] the hole covered and fenced when left unattended.

D-007-007

FENIX & SCISSON, INC.
ENGINEERS-CONTRACTORS

RE: DRILLING PROGRAM
STATION U-25 WASTE ISOLATION SHAFT #1
ORIGINAL

W.O.#: -201

PRELIMINARY FOR CONCEPTUAL DESIGN STUDY

LOCATION: TO BE SELECTED

DATE: 7-16-81

PROJECT ENGINEER: Bill Garcia
7-30-81

PRESENT CONDITIONS:

1. The U-25 WI shaft #1 is distantly removed from any expended hole.

2. Approval to drill the hole must be obtained from DOE/NTSSO prior to moving the rig on location.

3. Road and location have been constructed and drill pad poured.

4. Surface casing: 144" I.D. x 3/4" wall casing will be set at 99' and cemented to the surface.

PROGRAM:

1. Rad-Safe must be notified to programmed job. Rad-Safe will prepare a radiation safety program to be followed by the drilling contractor.

2. Move in a Class I rig, drill a 142" hole to ± 2250', using integral dual string drill pipe with reverse air and water circulation.

   a. The stabilization shall be such that the hole may be drilled straight and accurate.

   b. Fluid levels should be calculated and recorded on each connection.

3. Recommended drilling parameters are:

   a. Run a 142" bit with medium mill-tooth cutters while drilling to ± 2250'.

   b. Rotate 12 - 16 RPM.

   c. Run 100 - 250,000 pounds weight on bit.

   d. Fluid circulation rate 14 - 24 BPM. Report accurate volumes of water: GPM in and GPM out.

   e. Air circulation rate should be maintained to achieve equal rates of fluid injection and discharge.

4. Recommended bottom hole assembly:

   a. 13 each, 90" weights on 16" mandrel.

   b. A string stabilizer with 8 tooth type rollers will be run above the weights.

   c. Bit and jet bowl jet sizes to be determined at a later date.

5. Remove all fluid from hole by blowing and bailing if required. Run fluid probe.

6. Skid Class I rig off of hole.

7. Run geophysical logs as required.

8. Move in a truck-mounted crane, pick up, weld, and run ± 2200' of 122" I.D. x 3/4" wall casing, bottom joint belled, to total depth of hole. Lower casing on casing jacks.

9. Spot a 10' cement plug, neat plus 2% $CaCl_2$, in bottom of hole through a tremmie pipe inside the casing.

10. Stem annulus of the 122" I.D. casing with ground-matching material using tremmie pipes. Remove casing jacks.

11. Skid Class I rig over hole and rig up.

12. Drill a 120" hole from bottom of 122" I.D. intermediate casing to 3500', using integral dual string drill pipe with reverse air and water circulation.

13. Recommended drilling parameters are:

    a. Run a 120" bit with medium mill-tooth cutters while drilling to 3500'.

    b. Rotate 14 - 20 RPM.

    c. Run 100 - 250,000 pound weight on bit.

    d. Fluid circulation rate 10 - 20 BPM. Report accurate volumes of water: GPM in and GPM out.

    e. Air circulation rates should be maintained to achieve equal rates of fluid injection and discharge.

14. Recommended bottom hole assembly:

a. 12 each, 90" weights on a 16" mandrel.

b. A string stabilizer with 8 tooth type rollers will be run above the weights.

c. Bit and jet bowl jet sizes to be determined at a later date.

15. Condition hole for logging by blowing hole clean.

16. Skid Class I rig off of hole. Move in casing jacks.

17. Run geophysical logs as required.

18. Move in truck-mounted crane, pick up, weld, and run 3500' of 98" I.D. casing to total depth of hole. Lower casing on casing jacks.

19. Cement 98" I.D. casing according to the cementing program. Use Birdwell NAIL (Nuclear Annular Investigation Log) tool to monitor cement stages.

20. Move in Class III rig and run submersible pump inside previously run 26" O.D. air vent line.

21. Evacuate fluid from 98" I. D. casing. Fluid level and total depth will be obtained using a fluid density tool.

22. Skid Class III rig off hole. A permanent type steel hole cover will remain over the 98" I.D. casing.

122" I.D. LINER RUNNING AND CEMENTING PROGRAM:

1. The following will be accomplished:

a. The 60' sections of 122" I.D. liner will be inspected onsite upon arrival.

b. All sections will be tallied and marked in order of going downhole according to the appropriate drawing.

c. All running equipment; elevators, becket, slings, shackles, casing jacks, jack rings, etc., will undergo appropriate nondestructive examination.

2. Running Procedure:

   a. A set of casing jacks of sufficient size and 8,000,000-pound capacity will be positioned on the ground and centered over the 144" I.D. surface casing. The jacks will be leveled.

   b. The bottom section of 122" I.D. liner will be picked up using the 122" elevators. An appropriate crane, forklift or other equipment will be provided to "tail in" each joint while hoisting through the casing jacks.

   c. The bottom section will be lowered and set down on the casing jacks using the elevators. The second joint will be picked up, lowered and aligned horizontally and vertically with the first joint.

   d. The two joints will be joined in accordance with F&S Engineering Specification #1018, "Standard Procedures for Field Fusion Welding of Casing." The nondestructive examination of 100% of the weld will be conducted after completion of the root weld and final pass. The inspection port will be plugged and welded.

   e. Each subsequent joint shall be picked up, aligned and welded as described above in Step D.

NOTES:

A. Composition of Class "A" + $CaCl_2$ cement slurry is as follows:

   94 lbs. API Class "A" cement + 5.2 gal. fresh water yields a slurry of 15.65 lbs./gal. and 1.18 ft^3. Setting time at 91°F is approximately one hour and 17 minutes. Compressive strength at 80°F after six hours is 410 psi, 1020 psi after 12 hours, and 2510 psi after 24 hours.

B. Volumes of stemming material and cement are based on 142" hole plus 20% excess. Actual volumes will be determined using a caliper log after the hole has been drilled.

C. Cementing and stemming program will be submitted at a later date.

98" I.D. LINER RUNNING AND CEMENTING PROGRAM:

1. The following will be accomplished:

   a. All the sections of 98" I.D. liner will be inspected onsite upon arrival. The 40' sections will be run to 840'.

   b. After 840' of casing has been run in the hole, the 60' sections will be run.

c. Double joint welds will undergo nondestructive examination (100% coverage).

d. All sections will be will be tallied and marked in order of going downhole according to the appropriate drawing.

e. The 3 - 3-1/2" O.D. slotted grout line guide and 1 - 3-1/2" O.D. slotted monitor guide will be installed on the exterior of the 40' and 60' sections as per the appropriate drawings.

f. All running equipment: elevators, becket, slings, shackles, casing jacks, jack rings, etc., will undergo appropriate nondestructive examination.

2. Running Procedure:

a. A set of casing jacks of sufficient size and 8,000,000-pound capacity will be positioned on the ground and centered over the 122" I.D. intermediate casing. The casing jacks will be leveled.

b. The bottom section of 98" I.D. liner which contains the hemi-head will be picked up using the 98" elevators. An appropriate crane, forklift or other equipment will be provided to "tail in" each joint while hoisting through the casing jacks.

c. The bottom section will be lowered and set down on the casing jacks. The second joint will be picked up, lowered and aligned horizontally and vertically with the first joint.

d. The two joints will be joined in accordance with F&S Engineering Specification #1018, "Standard Procedures for Field Fusion Welding of Casing." The nondestructive examination of 100% of the weld will be conducted after completion of the root weld and final pass. Grout line splices will be made and the inspection port will be plugged and welded.

e. Each subsequent joint shall be picked up, aligned and welded as described above in step d. Water will have to be added to the inside of the liner while going downhole in order to prevent floatation.

NOTES:

A. Composition of "Cal-Seal" cement slurry is as follows:

100 lbs. of "Cal-Seal" + 4.8 gal. fresh water yields a slurry of 15.1 lbs/gal. and 1.23 ft^3. Setting time between 60^oF and 180^oF is

NOTES (cont.)

from 50 - 60 minutes. Compressive strength is 2500 psi within 1 hour after setting.

B. Compositon of Class "A" + $CaCl_2$ cement slurry is as follows:

94 lbs. API Class "A" cement + 5.2 gal. fresh water yields a slurry of 15.65 lbs./gal. and 1.18 ft^3. Setting time at 91°F is approximately one hour and 17 minutes. Compressive strength at 80°F after six hours is 410 psi, 1020 psi after 12 hours, and 2510 psi after 24 hours.

C. All calculations above are based on a 8.33 lbs/gal water.

D. Volumes of cement are based on 120" hole plus 30% excess and 122" I.D. casing from 2200' to surface. Actual volumes will be determined using a caliper log after the hole has been drilled.

E. A NAIL (Nuclear Annular Investigation Log) tool will be used inside the monitor guide to monitor the rise of cement during each stage.

F. The bottom of the grout lines will be kept below the top of the cement at all times while pumping cement. The grout lines will be reciprocated during cementing, and joints removed as the cement rises. After each stage, the grout lines will be pulled ± 150' above the top of the cement and flushed with 5 barrels of water down each line.

G. The grout lines will be used to tag the top of each stage of cement after it has set. The depth of tags of each line will be compared to the tag using the NAIL tool in the monitor guide.

H. Ten barrels of water will be pumped down each grout line prior to each cementing stage. The cementing lines and valves will be tested to 2000 psi for 5 minutes prior to each stage.

I. At least 3 cement samples at beginning, in the middle and at the end of each stage will be obtained for compressive strength analysis.

J. A continuous recording densiometer will be used during each stage to record the density of the slurry. The densiometer will be calibrated with a mud balance prior to each stage and density checks using a mud balance will be obtained during cementing. The barrel counters on the pumping units will also be calibrated prior to each stage with a graduated tank.

K. After cement has reached the surface, the remaining grout tubing will be laid down, cementing equipment rigged down and demobilized, casing jacks removed, casing cut off 1' above ground level, and hole cover installed.

CEMENTING PROGRAM **(98" I.D. CASING IN 120" HOLE)**
(Length 3500ft. 3500 ft. - Surface)

STAGE NO.	CEMENTED INTERVAL FROM	TO	NET INTERVAL	F.L. IN 98"	JOINT MK	CSG. DESIGN YIELD	ΔP	S.F.	CALC. VOLUME	CEMENT TYPE & WEIGHT
1.	3500	3100	400	2200		635	-310		11,908	Class "A" Neat + 2% $CaCl_2$
2.	3100	2700	400	1800	F&S Dwg. #H3312-02	382	152	2.5	11,908	" "
3.	2700	2300	400	1300		237	109	2.2	11,908	" "
4.	2300	1900	400	700		100	-110		10,592	" "
5.	1900	1500	400	700		100	- 21		10,216	" "
6.	1500	1100	400	300		100	-102		10,216	" "
7.	1100	700	400	- 0 -		100	22	4.5	10,216	" "
8.	700	500	200	- 0 -		100	- 54		5,108	" "
9.	500	300	200	- 0 -		100	33	3	5,108	" "
10.	300	200	100	- 0 -		100	33	3	2,554	" "
11.	200	100	100	- 0 -		100	38	2.6	2,554	" "
12.	100	0	100	- 0 -		100	38	2.6	2,544	" "
								TOTAL	94,842 Ft^3	

NOTES:

1. Estimates static fluid level ± 2200'. Safety factor calculated on the assumption that water in the annulus will rise above static water level by the amount displaced by the cement pumped.
2. Cement volumes calculated on a gage hole plus 30% oversize. Actual volumes will vary, depending on caliper log of the hole. Cement volume in the annulus between 98" I.D., casing and 122" I.D., casing is based on the true volume.
3. Cement tops will be determined by fluid density log. The sonde will be pulled at least 50' above the cement top on every other reading to determine and record the contamination above the cement top.
4. Cement top will be tagged with tubing and Birdwell after each stage.
5. A revised cementing program will follow after caliper log is run.
6. During cementing operations, cement samples must be obtained every 15 minutes and weight checked using a mud balance.
7. Composition of Class "A" + $CaCl_2$ cement slurry is as follows: 94 lbs. API Class "A" cement + 5.2 gal. fresh water yields a slurry of 15.65 lbs./gal. and 1.18 ft^3. Setting time at 91°F is approximately one hour and 17 minutes. Compressive strength at 80°F after six hours is 410 psi, 1020 psi after 12 hours, and 2510 psi after 24 hours.

AREA 25 WASTE ISOLATION PROJECT

2200' of Casing | Casing I.D. 122" | Static Water Level 2200'

ELEVATION		LIN FT	ACTUAL PRESS	DESIGN PRESS	CSG YIELD PRESS	SAFETY FACTOR	CASING DESCRIPTION			WEIGHT			5-6-81	
FROM	TO						MATL	SHELL THK	STIFFENER SIZE & SPACING	PER FT (LBS)	TOTAL K	ACCUM K	NO. OF JOINTS	MARK NO.
2200	0	2200	-	-	37	-	A-441	3/4"	1-1/2" x 6" @ 96"	1141.4	2511.1	2511.1		

The above weight includes 2 - 4-1/2" grout line guides, 1 - 4-1/2" monitor line guide. Total weight 32.4 lbs./ft.

Casing is to be lowered using hydraulic jacks and cemented in place.

AREA 25 WASTE ISOLATION PROJECT

3500 Ft. 98" I.D. Casing Static Water Level 2200 Ft.

ELEVATION		LIN FT	ACTUAL PRESS	DESIGN PRESS	CSG YIELD PRESS	SAFETY FACTOR	CASING DESCRIPTION			WEIGHT			NO. OF JOINTS	MARK NO.
FROM	TO						MATL	SHELL THK	STIFFENER SIZE & SPACING	PER FT (LBS)	TOTAL K	ACCUM K		
3500	3380	120	563	845	949	1.7	A-441	1-1/2"	3" x 10" @ 48"	2322.7	283.1	283.1		
3380	3260	120	511	756	823	1.6	A-441	1-1/2"	2-1/2" x 10" @ 48"	2204.1	264.5	547.6		
3260	3140	120	459	689	723	1.6	A-441	1-1/4"	2-1/2" x 10" @ 48"	1932.1	231.9	779.5		
3140	2900	240	407	611	635	1.56	A-441	1-1/4"	2-1/4" x 10" @ 48"	1873.4	449.6	1229.1		
2900	2780	120	303	455	510	1.68	A-441	1"	2-1/4" x 10" @ 48"	1603.1	192.4	1421.5		
2780	2660	120	251	377	382	1.5	A-441	1"	2-1/4" x 10" @ 72"	1432.3	171.9	1593.4		
2660	2540	120	199	299	306	1.5	A-441	1"	2" x 10" @ 72"	1393.6	167.2	1760.6		
2540	2300	240	147	221	237	1.6	A-441	1"	2" x 10" @ 96"	1090.7	261.8	2022.4		
2300	0	2300	43	65	99.8	2.3	A-441	3/4"	2" x 6" @ 120"	932.6	2145.0	4167.4		

The above weight includes a (4.4K#) 1" wall hemihead, 2 - 4-1/2" grout line guides, 1 - 4-1/2" monitor line guide (32.4#/ft.)

The maximum hook load weight of 2,955,600 lbs. will occur when the hemihead touches the water at a depth of 2200'.

AREA 25 WASTE ISOLATION PROJECT

2200' of Casing — Casing I.D. 122" — Static Water Level 2200'

5-6-81

ELEVATION							CASING DESCRIPTION			WEIGHT				
FROM	TO	LIN FT	ACTUAL PRESS	DESIGN PRESS	CSG YIELD PRESS	SAFETY FACTOR	MATL	SHELL THK	STIFFENER SIZE & SPACING	PER FT (LBS)	TOTAL K	ACCUM K	NO. OF JOINTS	MARK NO.
2200	0	2200	-	-	37	-	A-441	3/4"	1-1/2" x 6" @ 96"	1141.4	2511.1	2511.1		

The above weight includes 2 - 4-1/2" grout line guides, 1 - 4-1/2" monitor line guide. Total weight 32.4 lbs./ft.

Casing is to be lowered using hydraulic jacks and cemented in place.

D-007-006

PROGRAM USING 72" I.D. CASING

FENIX & SCISSON, INC.
ENGINEERS-CONTRACTORS

RE: PREPARATION OF DRILL SITE
STATION U-25 WASTE ISOLATION
SHAFT #1 ORIGINAL

W.O.#: XXXX-200
Preliminary for
Conceptual Design
Study

LOCATION: To be selected

DATE: July 16, 1981

PROJECT ENGINEER: [signature]
7-30-81

PRESENT CONDITIONS:

The U-25 WI Shaft #1 is distantly removed from any expended hole.

PROGRAM:

1. Rad-Safe must be notified prior to commencing work. Rad-Safe will prepare a radiation safety program which will be followed by the drilling contractor.

2. Approval to drill the hole must be obtained from DOE/NTSSO prior to moving the rig on location.

3. Access road and drill site to be prepared by others prior to commencement of drilling operations for the surface casing.

4. Move in CP rig and drill 6-1/4" shot holes as required to 100' using a Mission downhole hammer drill. Holes shall be spaced for optimum blasting effect. Move rig off location. Load and blast shot holes including the hole(s) for a mouse hole.

5. Others shall excavate a 2' deep area for the drill pad and a 4' deep area for the 200" diameter corrugated metal pipe (CMP) conductor casing. CMP will be installed and backfilled with native material.

6. Move in an Auger rig and auger a 168" hole to 100'.

7. Install 144" I.D. x 3/4" wall x 100' surface casing and cement casing to the surface with required amount of ready-mix cement. The 144" I.D. x 3/4" wall casing shall be hung 1' off bottom and centered in the hole prior to cementing.

8. Demobilize Auger rig.

NOTES:

A. All depths are from Holmes & Narver, Inc. reference mark.

B. Install Fenix & Scisson, Inc., bench marker on the surface casing.

C. Keep the hole covered and fenced when left unattended.

D-007-007

PROGRAM USING 72" I.D. CASING

FENIX & SCISSON, INC.
ENGINEERS-CONTRACTORS

RE: DRILLING PROGRAM
STATION U-25 WASTE ISOLATION SHAFT #1
ORIGINAL

W.O.#: -201

PRELIMINARY FOR CONCEPTUAL DESIGN STUDY

LOCATION: TO BE SELECTED

DATE: 7-16-81

PROJECT ENGINEER: [signature] 7-30-81

PRESENT CONDITIONS:

1. The U-25 WI shaft #1 is distantly removed from any expended hole.
2. Approval to drill the hole must be obtained from DOE/NTSSO prior to moving the rig on location.
3. Road and location have been constructed and drill pad poured.
4. Surface casing: 144" I.D. x 3/4" wall casing will be set at 99' and cemented to the surface.

PROGRAM:

1. Rad-Safe must be notified to programmed job. Rad-Safe will prepare a radiation safety program to be followed by the drilling contractor.
2. Move in a Class I rig, drill a 142" hole to ± 2250', using integral dual string drill pipe with reverse air and water circulation.
   a. The stabilization shall be such that the hole may be drilled straight and accurate.
   b. Fluid levels should be calculated and recorded on each connection.
3. Recommended drilling parameters are:
   a. Run a 142" bit with medium mill-tooth cutters while drilling to ± 2250'.
   b. Rotate 12 - 16 RPM.
   c. Run 100 - 250,000 pounds weight on bit.
   d. Fluid circulation rate 14 - 24 BPM. Report accurate volumes of water: GPM in and GPM out.
   e. Air circulation rate should be maintained to achieve equal rates of fluid injection and discharge.

4. Recommended bottom hole assembly:

   a. 13 each, 90" weights on 16" mandrel.

   b. A string stabilizer with 8 tooth type rollers will be run above the weights.

   c. Bit and jet bowl jet sizes to be determined at a later date.

5. Remove all fluid from hole by blowing and bailing if required. Run fluid probe.

6. Skid Class I rig off of hole.

7. Run geophysical logs as required.

8. Move in a truck-mounted crane, pick up, weld, and run ± 2200' of 122" I.D. x 3/4" wall casing, bottom joint belled, to total depth of hole. Lower casing on casing jacks.

9. Spot a 10' cement plug, neat plus 2% $CaCl_2$, in bottom of hole through a tremmie pipe inside the casing.

10. Stem annulus of the 122" I.D. casing with ground-matching material using tremmie pipes. Remove casing jacks.

11. Skid Class I rig over hole and rig up.

12. Drill a 120" hole from bottom of 122" I.D. intermediate casing to 3500', using integral dual string drill pipe with reverse air and water circulation.

13. Recommended drilling parameters are:

    a. Run a 120" bit with medium mill-tooth cutters while drilling to 3500'.

    b. Rotate 14 - 20 RPM.

    c. Run 100 - 250,000 pound weight on bit.

    d. Fluid circulation rate 10 - 20 BPM. Report accurate volumes of water: GPM in and GPM out.

    e. Air circulation rates should be maintained to achieve equal rates of fluid injection and discharge.

14. Recommended bottom hole assembly:

a. 12 each, 90" weights on a 16" mandrel.

b. A string stabilizer with 8 tooth type rollers will be run above the weights.

c. Bit and jet bowl jet sizes to be determined at a later date.

15. Condition hole for logging by blowing hole clean.

16. Skid Class I rig off of hole. Move in casing jacks.

17. Run geophysical logs as required.

18. Move in truck-mounted crane, pick up, weld, and run 3500' of 98" I.D. casing to total depth of hole. Lower casing on casing jacks.

19. Cement 72" I.D. casing according to the cementing program. Use Birdwell NAIL (Nuclear Annular Investigation Log) tool to monitor cement stages.

20. Move in Class III rig and run submersible pump inside 72" I.D. casing.

21. Evacuate fluid from 72" I. D. casing. Fluid level and total depth will be obtained using a fluid density tool.

22. Skid Class III rig off hole. A permanent type steel hole cover will remain over the 72" I.D. casing.

122" I.D. LINER RUNNING AND CEMENTING PROGRAM:

1. The following will be accomplished:

   a. The 60' sections of 122" I.D. liner will be inspected onsite upon arrival.

   b. All sections will be tallied and marked in order of going downhole according to the appropriate drawing.

   c. All running equipment; elevators, becket, slings, shackles, casing jacks, jack rings, etc., will undergo appropriate nondestructive examination.

2. Running Procedure:

   a. A set of casing jacks of sufficient size and 8,000,000-pound capacity will be positioned on the ground and centered over the 144" I.D. surface casing. The jacks will be leveled.

   b. The bottom section of 122" I.D. liner will be picked up using the 122" elevators. An appropriate crane, forklift or other equipment will be provided to "tail in" each joint while hoisting through the casing jacks.

   c. The bottom section will be lowered and set down on the casing jacks using the elevators. The second joint will be picked up, lowered and aligned horizontally and vertically with the first joint.

   d. The two joints will be joined in accordance with F&S Engineering Specification #1018, "Standard Procedures for Field Fusion Welding of Casing." The nondestructive examination of 100% of the weld will be conducted after completion of the root weld and final pass. The inspection port will be plugged and welded.

   e. Each subsequent joint shall be picked up, aligned and welded as described above in Step D.

NOTES:

A. Composition of Class "A" + $CaCl_2$ cement slurry is as follows:

   94 lbs. API Class "A" cement + 5.2 gal. fresh water yields a slurry of 15.65 lbs./gal. and 1.18 ft^3. Setting time at 91°F is approximately one hour and 17 minutes. Compressive strength at 80°F after six hours is 410 psi, 1020 psi after 12 hours, and 2510 psi after 24 hours.

B. Volumes of stemming material and cement are based on 142" hole plus 20% excess. Actual volumes will be determined using a caliper log after the hole has been drilled.

C. Cementing and stemming program will be submitted at a later date.

72" I.D. LINER RUNNING AND CEMENTING PROGRAM:

1. The following will be accomplished:

   a. All the sections of 72" I.D. liner will be inspected onsite upon arrival. The 40' sections will be run to 240'.

   b. After 240' of casing has been run in the hole, the 60' sections will be run.

c. Double joint welds will undergo nondestructive examination (100% coverage).

d. All sections will be will be tallied and marked in order of going downhole according to the appropriate drawing.

e. The 3 - 3-1/2" O.D. slotted grout line guide and 1 - 3-1/2" O.D. slotted monitor guide will be installed on the exterior of the 40' and 60' sections as per the appropriate drawings.

f. All running equipment: elevators, becket, slings, shackles, casing jacks, jack rings, etc., will undergo appropriate nondestructive examination.

2. Running Procedure:

a. A set of casing jacks of sufficient size and 8,000,000-pound capacity will be positioned on the ground and centered over the 122" I.D. intermediate casing. The casing jacks will be leveled.

b. The bottom section of 72" I.D. liner which contains the hemi-head will be picked up using the 72"elevators. An appropriate crane, forklift or other equipment will be provided to "tail in" each joint while hoisting through the casing jacks.

c. The bottom section will be lowered and set down on the casing jacks. The second joint will be picked up, lowered and aligned horizontally and vertically with the first joint.

d. The two joints will be joined in accordance with F&S Engineering Specification #1018, "Standard Procedures for Field Fusion Welding of Casing." The nondestructive examination of 100% of the weld will be conducted after completion of the root weld and final pass. Grout line splices will be made and the inspection port will be plugged and welded.

e. Each subsequent joint shall be picked up, aligned and welded as described above in step d. Water will have to be added to the inside of the liner while going downhole in order to prevent floatation.

NOTES:

A. Composition of "Cal-Seal" cement slurry is as follows:

100 lbs. of "Cal-Seal" + 4.8 gal. fresh water yields a slurry of 15.1 lbs/gal. and 1.23 ft^3. Setting time between 60^{o}F and 180^{o}F is

NOTES (cont.)

from 50 - 60 minutes. Compressive strength is 2500 psi within 1 hour after setting.

B. Compositon of Class "A" + $CaCl_2$ cement slurry is as follows:

94 lbs. API Class "A" cement + 5.2 gal. fresh water yields a slurry of 15.65 lbs./gal. and 1.18 ft^3. Setting time at 91°F is approximately one hour and 17 minutes. Compressive strength at 80°F after six hours is 410 psi, 1020 psi after 12 hours, and 2510 psi after 24 hours.

C. All calculations above are based on a 8.33 lbs/gal water.

D. Volumes of cement are based on 120" hole plus 30% excess and 122" I.D. casing from 2200' to surface. Actual volumes will be determined using a caliper log after the hole has been drilled.

E. A NAIL (Nuclear Annular Investigation Log) tool will be used inside the monitor guide to monitor the rise of cement during each stage.

F. The bottom of the grout lines will be kept below the top of the cement at all times while pumping cement. The grout lines will be reciprocated during cementing, and joints removed as the cement rises. After each stage, the grout lines will be pulled ± 150' above the top of the cement and flushed with 5 barrels of water down each line.

G. The grout lines will be used to tag the top of each stage of cement after it has set. The depth of tags of each line will be compared to the tag using the NAIL tool in the monitor guide.

H. Ten barrels of water will be pumped down each grout line prior to each cementing stage. The cementing lines and valves will be tested to 2000 psi for 5 minutes prior to each stage.

I. At least 3 cement samples at beginning, in the middle and at the end of each stage will be obtained for compressive strength analysis.

J. A continuous recording densiometer will be used during each stage to record the density of the slurry. The densiometer will be calibrated with a mud balance prior to each stage and density checks using a mud balance will be obtained during cementing. The barrel counters on the pumping units will also be calibrated prior to each stage with a graduated tank.

K. After cement has reached the surface, the remaining grout tubing will be laid down, cementing equipment rigged down and demobilized, casing jacks removed, casing cut off 1' above ground level, and hole cover installed.

L. Four 10-3/4" O.D. flush joint air vent lines will be welded to the outside of the 72" I.D. casing as it is lowered in the hole.

3500 ft. casing

72" I.D. Casing

Static Water Level 2200 ft.

ELEVATION								CASING DESCRIPTION			WEIGHT				
FROM	TO	LTH FT	ACTUAL PRESS	DESIGN PRESS	CSG YIELD PRESS	SAFETY FACTOR	MATL	SHELL THK	STIFFENER SIZE & SPACING	PER FT (LBS)	TOTAL K	ACCUM K	NO. OF JOINTS	[illegible]
3500	3380	120	563	845	891	1.6	A-441	1-1/2"	2" x 8" @ 72"	1393.9	169.7	169.7		
3380	2260	120	511	756	885	1.7	A-441	1-1/2"	2-1/4" x 6" @ 72"	1365.8	163.9	333.6		
3260	3140	120	459	689	710	1.55	A-441	1-1/4"	2" x 6" @ 60"	1174.8	141.0	474.6		
3140	2900	240	407	611	613	1.5	A-441	1-1/4"	2" x 6" @ 72"	1147.5	275.4	750.0		
2900	2780	120	303	455	487	1.6	A-441	1"	2" x 6" @ 72"	948.2	113.8	863.8		
2780	2620	160	251	377	380	1.5	A-441	1"	2" x 6" @ 96"	914.3	146.3	1010.1		
2620	2460	160	182	273	279	1.5	A-441	1"	2" x 6" @ 120"	894.0	143.0	1153.1		
2460	2300	160	113	170	211	1.9	A-441	3/4"	2" x 6" @ 120"	696.4	111.4	1264.5		
2300	0	2300	43	65	95	2.2	A-441	3/4"	1" x 4" @ 120"	642.2	1592.1	2856.6		

The above weight includes a 1" wall hemi-head at 2-4K#, 2- 4-1/2" grout line guides, 1- 4-1/4" monitor line guide (32.4 lbs per ft.)

The maximum hook load weight of 1,906,700 lbs. will occur when the hemi-head touches the water at a depth of 2200 ft.

U-25 WASTE ISOLATION SHAFT #1

CEMENTING PROGRAM (72" I.D.CASING IN 120" HOLE)
(Length 3500 ft. 3500 ft. - Surface)

STAGE NO.	CEMENTED INTERVAL FROM	TO	NET INTERVAL	F.L. IN 74"	JOINT MK	CSG. DESIGN YIELD	ΔP	S.F.	CALC. VOLUME	CEMENT TYPE & WEIGHT
1.	3500	3200	300	2200		891	-319	-	18,447	Class "A" Neat
2.	3200	2900	300	1900		613	244	2.51	18,447	+ 2% $CaCl_2$
3.	2900	2600	300	1300		380	114	3.33	18,447	15.65#/gal.
4.	2600	2300	300	700		211	- 16	-	18,447	"
5.	2300	2000	300	400		95	- 16	-	19,149	"
6.	2000	1800	200	Surface		95	-140	-	10,000	"
7.	1800	1600	200	"		95	- 11	-	10,000	"
8.	1600	1475	125			95	47.5	2	6,250	"
9.	1475	1350	125	"		95	47.5	2	6,250	"
10.	1350	1225	125	"		95	47.5	2	6,250	"
11.	1225	1100	125	"		95	47.5	2	6,250	"
12.	1100	975	125	"		95	47.5	2	6,250	"
13.	975	850	125	"		95	47.5	2	6,250	"
14.	850	725	125	"		95	47.5	2	6,250	"
15.	725	600	125	"		95	47.5	2	6,250	"
16.	600	475	125	"		95	47.5	2	6,250	"
17.	475	350	125	"		95	47.5	2	6,250	"
18.	350	225	125	"		95	47.5	2	6,250	"
19.	225	100	125	"		95	47.5	2	6,250	"
20.	100	0	125	"		95	47.5	2	6,250	"
								TOTAL	194,187 Ft^3	

NOTES:

1. Estimates static fluid level ± 2200'. Safety factor calculated on the assumption that water in the annulus will rise above static water level by the amount displaced by the cement pumped.
2. Cement volumes calculated on a gage hole plus 30% oversize. Actual volumes will vary, depending on caliper log of the hole. Cement volume in the annulus between 72" I.D., casing and 122" I.D., casing is based on the true volume.
3. Cement tops will be determined by fluid density log. The sonde will be pulled at least 50' above the cement top on every other reading to determine and record the contamination above the cement top.
4. Cement top will be tagged with tubing and Birdwell after each stage.
5. A revised cementing program will follow after caliper log is run.
6. During cementing operations, cement samples must be obtained every 15 minutes and weight checked using a mud balance
7. Composition of Class "A" + $CaCl_2$ cement slurry is as follows: 94 lbs. API Class "A" cement + 5.2 gal. fresh water yields a slurry of 15.65 lbs./gal. and 1.18 ft3/ Setting time at 91oF is approximately one hour and 17 minutes. Compressive strength at 80oF after six hours is 410 psi, 1020 psi after 12 hours, and 2510 psi after 24 hours.

APPENDIX C
(PART II)

FENIX & SCISSON, INC.
BUDGETARY ESTIMATE
U-25 WASTE ISOLATION SHAFT NO. 1
COST ESTIMATE SUMMARY
(UNIT-PRICE DRILLING CONTRACTOR)

NOTES: (1) This study served as the basis for drilling cost estimates summarized in Sec. VIII.

(2) Cementing of the 122-in. casing is assumed.

FENIX & SCISSON, INC.

FS engineering construction management

TULSA LAS VEGAS

PLEASE REPLY TO: TES-2500
P. O. BOX 15028
LAS VEGAS, NEVADA 89101

November 18, 1981

Mr. J. H. Dryden, Director
U. S. Department of Energy
Nevada Operations, NTS Support Office
Post Office Box 435
Mercury, Nevada 89023

ATTN: Mr. F. R. Huckabee, Chief
Test Construction Branch

LASL STUDY REQUESTS TO SUPPORT THE CONCEPTUAL DESIGN OF THE EXPLORATORY SHAFT

As requested by M. P. Kunich, DOE/NVOO, verbal communication, we are submitting our Budgetary Estimate. A revised site support schedule is submitted also.

G. T. Bruesch

G. T. BRUESCH, MANAGER
TECHNICAL SUPPORT

GTB:cab

cc: R. A. Escobedo, DOE/NTS, w/encl. (3)
M. P. Kunich, DOE/NVOO, w/encl. (3)
D. C. Nelson, (LASL, WX-4) w/encl. (2)

BUDGETARY ESTIMATE
U-25 WASTE ISOLATION SHAFT #1
COST ESTIMATE SUMMARY
(1983 and 1984 DOLLARS)

	FY 1981 Base	ESTIMATED AMOUNT $K FY 1983	FY 1984
I. Expense Items			
Drill and Case Shaft			
A. Drill surface hole and set 100' of 144" surface casing.	$ 165	$ 238	$
B. Material and Services Surface casing	186	269	
C. Drilling Operation	5,795		10,014
D. Supplies, Materials and Services.	9,679		16,725
E. Subcontract Services, F&S.	1,308		2,260
TOTAL, EXPENSE ITEMS	$17,133	$ 507	$28,999
II. Capital Items			
Tongs - 1 set for 13-3/8" drill pipe.	75	108	-0-
Hydraulic Jacks for 122" I.D. and 100" I.D. casing, 8 million pound capacity less hydraulic power unit.	1,154	1,661	-0-
TOTAL, CAPITAL ITEMS	$ 1,229	$ 1,769	-0-

These numbers were estimated on FY 1981 base totals. The totals for FY 1983 and FY 1984 were based on a compounded 20% yearly factor applied to the base total. The 20% was an arbitrary figure consisting of 15% inflation and 5% contingency.

COST ESTIMATE
U-25 WASTE ISOLATION SHAFT #1

	Days	Base Total	Subtotal	Grand Total
A. Site Preparation				
1. Site leveling, access road. Rig pad, jack pad, pits, etc. Furnished on H&N work order		N/A	N/A	
B. Drill Surface Hole and set 100' of 144" Surface casing				
1. Excavate hole for 10' of 200" CMP with backhoe. Install CMP and backfill	3	2,517		
2. Mobe and demobe CP rig 3 man @ $5,426/day	2	10,852		
3. Drill shot holes to 100' and blast	12	65,112		
4. Mobe and demobe auger rig 3 man @ $5,618/day	2	11,236		
5. Auger 168" hole to 100'	12	67,416		
6. Mobe and demobe crane 100 ton crane w/ support $1,867/day	2	3,734		
7. Install Casing with crane	2	3,734		
Sub Total			164,601	
Total				164,601
C. Material and Services - Surface casing				
1. a. 10' - 200" CMP		12,636		
b. 98' - 144" x 1" wall casing (if available)		76,500		
Material Handling	11%	9,805		
G&A	9%	8,022		
Sub Total			106,963	
2. Blasting Material	L.S.	13,052		
Sub Total			13,052	

	Days	Base Total	Subtotal	Gran Tota
3. Cement (Redi-Mix)	6500 ft^3	29,250		
Sub Total			29,250	
4. Welders (8)				
a. Double joint 24 hrs. x 8 men x $48.50		18,624		
b. Run 24 hrs. x 8 men x $48.50		18,624		
Sub Total			37,248	
Total				186,57
D. Drilling Operation (Unit Price Contractor @ $19,000/day)				
1. Mobilize	9	500,000		
2. Drill 142" hole from 100' to 2200' (r/p = 26'/day)	84	1,596,000		
3. Run logs	3	57,000		
4. Skid rig off hole to allow casing installation with crane and casing jacks	3	100,000		
5. Run 122" I.D. casing	12	228,000		
6. Stem 122" I.D. casing	10	190,000		
7. Skid rig back over hole	3	100,000		
8. Drill 120" hole from 2200' to 3500' (r/p - 28'/day)	52	988,000		
9. Run logs total depth	3	57,000		
10. Demobe drill rig	9	200,000		
11. Miscellaneous operations and delays	20	380,000		
12. Run 98" I.D. casing with crane and casing jacks	33	N/A		

	Days	Base Total	Subtotal	Grand Total
13. Air compressors 190 days @ $1,440/Day x 3 plus (1) Booster @ $1,800/Day		1,162,800		
14. Cement 98" I.D. casing	18	N/A		
15. Mobilize REECo Class III Rig w/o equipment 2 days @ $10,138/day	2	20,276		
16. Run 3500' of 26" O.D. casing	3	30,414		
17. Run pump and dewater casing	12	164,856		
18. Demobe Class III Rig	2	20,276		
Sub Total	278		5,794,622	
Total				5,794,622
E. Supplies, Materials and Services				
1. Casing				
a. 122" I.D. x 3/4" wall	2200'	2,343,750		
b. 98" I.D. x 1-1/2" to 3/4" wall	3500'	3,150,000		
c. Tremmie Pipe 7" x 1/4" wall	7000'	201,600		
Sub Total		5,695,350		
Casing Handling	16%	911,256		
G&A	9%	512,582		
Sub Total			7,119,188	
2. Bit Cutters				
a. 142" Bit - 7 sets @ $57,058		399,406		
b. 120" Bit - 4 sets @ $49,642		198,568		
Material Handling	11%	65,777		
G&A	9%	53,818		
Sub Total			717,569	
3. Mud Material	L.S.	150,000		
Sub Total			150,000	

	Days	Base Total	Sub Total	Grand Total
4. Fabrication and Installation of 1200' of 7" inner string in 13-3/8" Reed V-4 drill pipe, 28 joints		67,200		
G&A	9%	6,048		
Sub Total			73,248	
5. Welding				
a. 122" casing 60' joints 36 welds @ 8hr./welds x 8 welders x $48.50		111,744		
Sub Total			111,744	
b. 98" casing				
40'/joints to 960' = 24 joints, 60'/joints 960' to 3500' = 42 joints = 66 welds @ 12hrs./weld x 8 men x $48.50		307,296		
Sub Total			307,296	
6. 98" Hemi-head		15,000		
Material Handling	11%	1,650		
G&A	9%	1,350		
Sub Total			18,000	
7. Reconditioning 7000' of 2-3/8" hydril tubing for cementing operations	L.S.	35,000		
Sub Total			35,000	
8. Miscellaneous Trucking	L.S.	50,000		
Sub Total			50,000	
9. Miscellaneous Supplies	L.S.	100,000		
Sub Total			100,000	

	Days	Base Total	Sub Total	Grand Total
10. Crane, Forklift and Crews				
Casing Installation				
a. 122" casing 12 days @ $6,190/day	12	74,280		
b. 98" casing w/rig crew 33 days @ $10,681/day	33	352,473		
Sub Total			426,753	
11. Cranes for Cementing Operation				
(2) hydro cranes, (1) 50-T crane	18	148,572		
Sub Total			148,572	
12. Casing Jack Operation				
a. Run 122" casing				
(1) Mobe ($10,649)	3	31,947		
(2) Run ($4,030)	12	48,360		
(3) Demobe ($10,649)	3	31,947		
(4) Supplies/repair/ maintenance ($300)	12	36,000		
Sub Total			148,254	
b. Run 98" casing				
(1) Mod. of jacks to run 98" casing ($10,649)	6	63,849		
(2) Mobe ($10,649)	3	31,947		
(3) Run ($4,030)	33	132,990		
(4) Demobe ($10,649)	3	31,947		
(5) Supplies/repair/ maintenance ($300)	33	9,900		
Sub Total			270,678	
13. Magnetic Particle				
Inspection of 85 joints of 13-3/8" drill pipe		2,990		
Sub Total			2,990	
Total				9,679,292

	Days	Base Total	Subtotal	Grand Total
F. Subcontract Services, F&S				
1. Logging				
a. There will be logging at 2200', 3500' monitoring of 98" casing cement job. No logging criteria has been supplied	L.S.	100,000		
Sub Total			100,000	
2. Gyro Cluster Shot Survey taken at 30' stations for 210 days = 7 months $16,000 per month	L.S.	112,000		
Sub Total			112,000	
3. Cementing/Stemming				
a. 122" casing				
(1) Labor Cost ($9,516)	10	95,160		
(2) Material and Transportation	L.S.	41,112		
(3) 10' cement plug, 122" I.D. casing x 2200'	1,100 Ft^3	11,000		
Sub Total			147,272	
b. Cement Casing 98" I.D. casing x 3500' @ ($10/Ft)	94,842 Ft^3	948,420		
Sub Total			948,420	
Total				1,307,692
GRAND TOTAL				17,132,720

OPTIONAL METHOD

CEMENT 122" INTERMEDIATE CASING

	ESTIMATED AMOUNT $K		
	ESTIMATED AMOUNT	SUBTOTAL	GRAND TOTAL
ADD			
D. 6. Drill Rig cost during 122" intermediate casing cementing operations (12 days @ $19,000/Day)	228		
E. 11. Crane for 122" intermediate casing cementing operations 22/days @ $8,254/Day	182		
F. 3. Cementing Operations 122" intermediate casing 85,800 ft3 @ $10.00	858		
Subtotal		1,268	
DELETE			
F. 3. A. Stemming 122" intermediate casing	(147)		
Subtotal		(147)	
TOTAL ADDITIONAL AMOUNT			1,121
ADDITIONAL AMOUNT ADJUSTED TO FY 1984			1,937

CAPITAL ITEM - DESIGN ESTIMATING AND PROCUREMENT

MAN WEEK EFFORT

CLASSIFICATION DRILLING	FY '82 Rate/Wk	FY '82 Labor Cost	FY '82 M/W	FY '83 Rate/Wk	FY '83 Labor Cost	FY '83 M/W	FY '84 Rate/Wk	FY '84 Labor Cost	FY''84 M/W	Total Labor Cost	Total M/W
Drilling Specialist (3)	1,563	(7,815)	5	1,876	(39,396)	21	2,251	(283,626)	126	(330,837)	152
Project Eng.	1,888	(18,880)	10	2,266	(45,320)	20	2,719	(119,636)	44	(183,836)	74
Design Eng.	1,646	(21,398)	13	1,975	(51,350)	26	2,370	(30,810)	13	(103,558)	52
Technical Writer	948	(0)	-0-	1,138	(2,276)	2	1,366	(15,026)	11	(17,302)	13
Quality Assur. Engineer	1,786	(14,288)	8	2,143	(55,718)	26	2,572	(66,872)	26	(136,878)	60
Estimator	1,243	(7,458)	6	1,492	(8,952)	6	1,790	(7,160)	4	(23,570)	16
Contract Coord.	1,360	(1,360)	1	1,632	(13,056)	8	1,958	(25,454)	13	(39,870)	22
Logging Eng.	1,435	(1,435)	1	1,722	(3,444)	2	2,066	(8,264)	4	(13,143)	7
Drafting	1,073	(21,460)	20	1,288	(25,760)	20	1,546	(18,552)	12	(65,772)	52
TOTALS		(94,094)	64		(245,272)	131		(575,400)	253	(914,766)	448

F&S LABOR COST - TASK BREAKDOWN

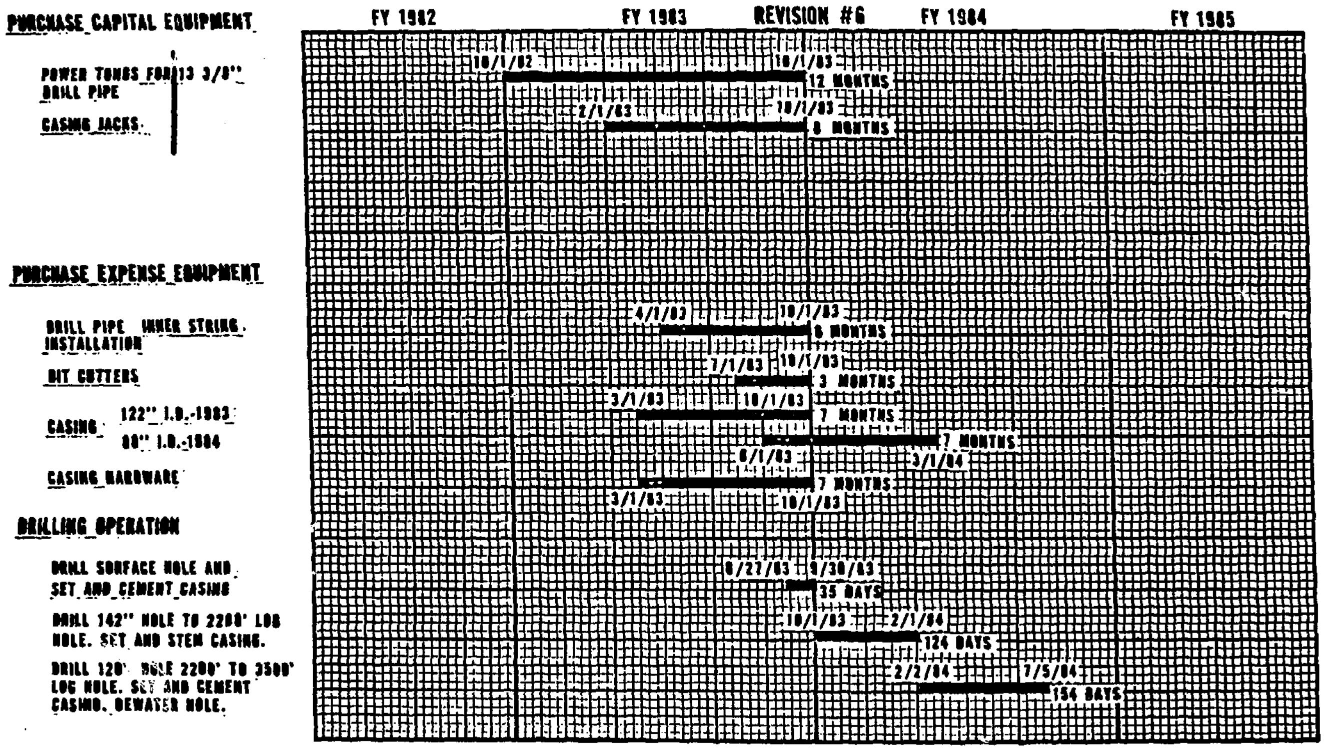
CLASSIFICATION	FY '82	FY '83	FY '84
Drilling Specialist		1. Coordinate Drilling Operations as Specified in Program Criteria. 2. Check on Equipment	1. Coordinate Drilling Operations As Specified in Program Criteria. 2. Check on Equipment 3. Drilling Supervision 4. Demobe of Equipment
Drilling Engineer	1. Project Planning and Drilling Programs 2. Equipment Specs. & Procurement A. Power Tongs B. Drill Pipe C. Casing Jacks D. Casing E. Tubing F. Drill Rig G. Miscellaneous Equipment	1. Drilling Program and Project Engineering 2. Equipment Specs. & Procurement A. Power Tongs B. Drill Pipe C. Casing Jacks D. Casing E. Tubing F. Drill Rig G. Miscellaneous Equipment 3. Drilling and Construction Supervision as Required By Program Criteria	1. Drilling Program and Project Engineering 2. Equipment Specs. & Procurement A. Power Tongs B. Drill Pipe C. Casing Jacks D. Casing E. Tubing F. Drill Rig G. Miscellaneous Equipment 3. Drilling and Construction Supervision as Required By Program Criteria
Design Engineer	1. Equipment Specs. & Procurement A. Power Tongs B. Drill Pipe C. Casing Jacks D. Casing E. Tubing F. Drill Rig G. Miscellaneous Equipment As Required	1. Equipment Specs. & Procurement A. Power Tongs B. Drill Pipe C. Casing Jacks D. Casing E. Tubing F. Drill Rig G. Miscellaneous Equipment As Required	

F&S LABOR COST
TASK BREAKDOWN
Page: 2

Classification	FY '82	FY '83	FY '84
Technical Writer		1. Daily Reports and Hole History	1. Daily Reports and Hole History
Quality Assurance Engineer	1. Equipment Specs. & Procurement A. Power Tongs B. Drill Pipe C. Casing Jacks D. Casing E. Tubing F. Drill Rig G. Miscellaneous Equipment	1. In Plant Inspection as Required to Maintain QA as Programmed	1. In Plant Inspection as Required to Maintain QA as Programmed 2. Casing Installation in Field
Estimator	1. Planning Estimates 2. Equipment Estimates	1. Planning Estimates 2. Equipment Estimates	1. Planning Estimates 2. Equipment Estimates
Contract Coord.	1. Equipment & Drilling Contract Spec.	1. Equipment & Drilling Contract Spec. 2. Drilling Contract Admin.	1. Drilling Contract Admin.
Logging Engineer	1. Logging Programs	1. Logging Programs and Specs.	1. Field Supervision of Logging Operations

U25 WASTE ISOLATION SHAFT #1
SCHEDULE PHASE 1

11/10/81



APPENDIX D

FENIX & SCISSON, INC.
ENGINEERING SPECIFICATIONS 1015 AND 1018

FENIX & SCISSON, INC. LAS VEGAS BRANCH	ENGINEERING SPECIFICATION		
	Prepared By: M. C. Jay	Date: 4-25-73	Number: 1015
Subject: STEEL CASING (STOCK) MANUFACTURING SPECIFICATION FOR VARIABLE DIAMETERS, WALL THICKNESSES AND LIFT RINGS		Revision: 3-5-5-77	Page: 1 of 17

1.0 SCOPE

The work under this specification includes furnishing all labor, materials, tools and services for the manufacture, fabrication and delivery of welded steel casing in accordance with the requirements herein subject to the terms and conditions of the purchase order.

1.1 The purchase order shall specify the following:

(a) Number of casing sections and nominal length of each, in feet.

(b) Surface casing (if applicable).

(c) Nominal internal diameter and nominal wall thickness, in inches.

(d) Type A, B, or C, as applicable (refer to Sketch No. I).

(e) If lift rings are required, the cross-sectional width and depth of each ring and the number of rings required on each casing section.

(f) If shop drawings are not required, the purchase order shall so state.

NOTE: If the casing is to be fabricated from other than A-36 structural steel, approval by the ERDA representative is required.

2.0 APPLICABLE SPECIFICATIONS

The following documents form a part of this specification to the extent specified herein. Documents not identified by revision or amendment and date shall be of the issue in effect on the date of invitation for bids.

2.1	ASTM-A-36	Structural Steel
2.2	ASTM-E-109	~~Dry~~ Powder Magnetic Particle Inspection
2.3	ASTM-E-165	Liquid Penetrant Inspection
2.4	ASME Boiler and Pressure Vessel Code	Section VIII, Pressure Vessels Section IX, Welder Qualification

	F&S Quality Control:	F&S Approval:	USERDA Approval:
	D. A. Robins 5-17-77	R. N. Ashbel 5/17/77	F. L. Hinkelan 5-24-77

2.5 AWS-A.17 — Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding

2.6 AWS-A.18 — Mild Steel Electrodes for Gas Metal Arc Welding

2.7 AWS-A-5.1 — Mild Steel Covered Arc Welding Electrodes

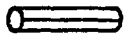
2.8 AWS-A-5.20-69 — Mild Steel Electrodes for Flux-Cored Arc Welding

3.0 GENERAL

3.1 Definitions

3.1.1 ERDA Representative. The authorized ERDA Representative as referred to herein shall be construed to mean Fenix & Scisson, Inc.

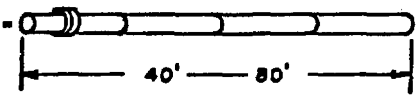
3.1.2 Cylinder. Shall mean a single rolled member of casing section.

Example = 

3.1.3 Sub-Assembly. Shall mean two or more cylinders of a casing assembly but less than a section.

Example = 

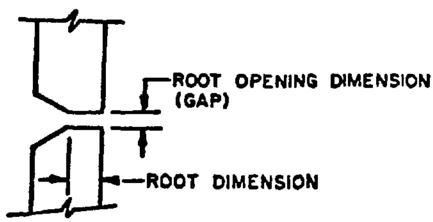
3.1.4 Casing Section. Shall mean the finalized major assembly (final length) of a casing assembly, but less than a general assembly which is field fabricated.

Example = 

or any final length designated by drawing or purchase order.

3.1.5 Nominal Dimension. Shall be defined as any dimension specified in the purchase order.

3.1.6 Root Dimension. The following illustrates weld joint root dimensions:



3.2 Precedence. In the event of conflict between this specification and a drawing referencing this specification, the drawing shall take precedence.

4.0 REQUIREMENTS

4.1 Base Materials. Steel plates and bars used in the manufacture of subject casing assemblies shall be A-36 material in accordance with the applicable specification. (Refer to para. 2.1)

4.2 Initial Production. Not less than five days prior to production, the seller shall notify the Purchaser that initial in-plant surveillance inspection is required and state date of initial production.

4.3 Radiographic Requirements. Purchase orders denoting "Surface Casing" irrespective of diameters, wall thicknesses, section lengths, with or without lift rings, require only spot-radiographic examination of longitudinal and circumferential plate welds. (Refer to para. 5.5.2)

4.3.1 All other casing not so designated shall be 100% radiographic inspected along all longitudinal and circumferential plate welds. (Refer to para. 5.5.2)

4.3.2 All lift and stiffener rings, if any, shall be 10% radiographic inspected. (Refer to Para. 5.5.1.3)

4.4 Documentation. The Seller shall maintain all records and correlate them to the specific purchase order affected in accordance with the requirements herein. Seller's records relative to this specification shall be made available for ready inspection, upon notice, by the cognizant ERDA Representative at any time and copies be made available as follows:

NOTE: Prior to production of casing under contract the Seller shall forward two copies to the Purchaser and one copy to the ERDA Representative of the documentation outlined in para. 4.4.1 through 4.4.3.

4.4.1 Welder/Welding Operator Qualification. Seller's certification of welder's/welding operator's performance qualification is required in accordance with para. 2.4, Section IX, and records thereof.

4.4.2 Welding Procedure Qualification. The welding procedures to be used in the fabrication of casing and the welding operator's performance shall be qualified in accordance with para. 2.4, Section IX, and records made thereof.

4.4.3 Filler Materials and Flux. The Seller shall demonstrate that the filler metals and flux comply with the applicable specification requirements of para. 2.5 through 2.8 and shall furnish copies of his purchase order or manufacturer's certification of compliance.

NOTE: The Seller shall forward two copies to the Purchaser *and one copy to the ERDA Representative progressively* with each shipment made of the documentation outlined in para. 4.4.4 through 4.4.7.

4.4.4 Mill Certifications. The Seller shall be required to certify compliance with the applicable specification for base material in para. 2.1; i.e., heat number, chemical composition, mechanical properties and thicknesses.

4.4.5 Plate Thicknesses. Prior to processing each plate, thickness measurements shall be recorded and shall be made available for examination by the ERDA Representative. Each plate shall be measured with a micrometer at each corner and not less than at two points equally spaced on each edge of the plate. Plates shall be ordered to the thicknesses specified and shall not be less than 0.010 inches below the nominal thickness specified.

4.4.6 Radiographic Examinations. The Seller shall furnish a radiographic examination report of welds for each finalized casing section. (Refer to Form No. 1)

4.4.7 Seller's Verification and Acceptance. The Seller's verification and acceptance report, signed by his duly authorized quality control representative, is required for each finalized casing section. This report shall account for each in-process operation being performed in accordance with the pre-established manufacturing procedures, in compliance with the requirements herein and shall designate that the casing section is acceptable to the Seller prior to shipment. (Refer to Form No. II)

4.4.8 Shop Drawings. Upon award of contract, the Seller shall submit seven sets of shop drawings to the Purchaser within fifteen days of award, unless otherwise specified.

4.5 Manufacturing

4.5.1 Plate Dimensions. Selection of plate width and length shall be commensurate with the casing dimensions specified.

4.5.1.1 Plate Squareness. The sides and ends of each plate shall be parallel and all four corners shall be 90°, subject to the following tolerence. The difference between the two longest diagonal measurements across the plate shall not exceed 1/8 inch.

4.5.1.2 Number of Weld Joints. Casing shall have no more than two longitudinal weld seams per cylinder and not more than four circumferential weld seams per forty-foot length of casing section.

4.5.1.3 Plate Preparation. Finalized plate width, length and weld joint dimensions may be obtained by shearing, machining, flame or arc cutting processes. Flame or arc cutting processes shall be performed with the aid of a mechanical guide to insure straightness.

4.5.1.4 Plate Identification. Each plate shall be numbered consecutively using one-half inch high steel stamps for purposes of in-process identification of cylinders.

4.5.1.5 Weld Joint Preparation. Unless otherwise specified, weld joint geometry and configuration for longitudinal and circumferential welds performed upon casing weld assemblies by the Seller shall be at his option in accordance with the qualified welding procedure, except, Seller's prerogative of selecting his weld joint dimensions shall insure depositions of welds having 100 percent penetration with near and far-side deposited weld reinforcement.

4.5.1.6 Casing Section Ends. Both ends of each finalized casing section shall be chamfered at 30 degrees. The root dimension shall be 1/8 inch, minus 0 inch, plus 1/16 inch. (Refer to Sketch No. II)

4.5.1.6.1 Subsequent to weld joint preparation, both ends of each finalized casing section shall be mechanically finished to remove slag and surface oxidation.

4.5.1.6.2 Mechanical finishing of finelized casing section ends shall result in a nominally uniform surface. Gradual and intermittent scalloping up to 1/8 of an inch is acceptable. (Refer to Sketch No. II)

4.5.1.7 Plate Rolling. Plates and bars shall be mechanically rolled to the required diameters. Press braking of leading or trailing ends of plates or bars to maintain the required configuration is acceptable providing permanent and sharp incremental demarcations do not result.

4.5.1.8 Bar Ring Rolling. Rings may be rolled in their entirety or be made in halves. The inside diameter of the ring shall be metal-to-metal fit with the outside diameter of the casing cylinder with a tolerance of plus 1/16 inch on the radius.

4.6 Fabrication

4.6.1 Welding Processes. The approved fusion welding processes for the weld fabrication of subject casing are as follows:

(a) Automatic, submerged-arc process (sub-arc)

(b) Automatic or semi-automatic metal inert gas process (MIG)

(c) Automatic or semi-automatic flux-cored arc welding process (flux core)

(d) Manual, metal arc flux shielded electrode process (stick)

4.6.2 Welding Process Applications. The sub-arc process shall be employed to make all longitudinal and circumferential welds in the plate cylinder assemblies. All other welds and weld repairs, may be performed with any of the approved welding processes or combinations thereof, listed above.

4.6.3 Weld Joint Root-Beads. The far-side of every longitudinal and circumferential plate weld root-bead shall be mechanically cleaned or air-arc gouged to clean metal prior to the deposition of additional weld metal.

NOTES: (1) Mechanical or arc-air gouged grooves shall be suitably tapered to prevent short-circuiting of the arc to the groove side walls to avoid bridging of subsequent weld deposit.

(2) Arc-air gouging slag at parent metal faces on either side of the arc-air groove shall be mechanically removed flush with parent metal prior to welding.

(3) Arc-air grooved surfaces need not be mechanically finished to parent metal prior to welding.

(4) Ring to casing fillet welds must have root penetration.

4.6.4 Welder Qualification. Manual and semi-automatic welders shall be qualified in accordance with para. 4.4.1 prior to performing production welds upon subject casing.

4.6.5 Automatic Welding Process Operator Qualification. Automatic welding process operators shall be qualified in accordance with para 4.4.1 prior to performing production welds upon subject casing.

4.6.6 Weld Filler Materials. Selection of filler wires, flux and electrode shall be the prerogative of the Seller except:

(a) Yield strength of the filler material shall not be less than that specified for the base-metal.

(b) Filler material selections shall conform with the respective and applicable specifications outlined in para. 2.5, 2.6, 2.7 and 2.8.

(c) Use of reground sub-arc welding flux is prohibited.

4.6.7 Cleanliness. All weld and immediate adjacent areas of the parent-metal faces shall be free of all foreign matter prior to welding. Grease, oil, tars, preservatives and all carbonaceous materials shall be removed, preferably with non-flammable solvents. Use of kerosene is prohibited.

4.6.8 Weld Quality

4.6.8.1 Stress Risers. Visually discernable stress risers upon weld or parent metal surfaces; i.e., sharp and abrupt changes in weld-bead geometry, open to surface laminae, inclusions, open porosity, arc-starts, cold-laps, lack of fusion, parent metal pull-out caused by removal of temporary appurtenances, chisel marks or gouges, are not acceptable and shall be repaired by welding prior to final inspection.

4.6.8.2 Undercuts. Weld undercuts shall be rejected except; intermittent undercuts (6 inches long in any 24 inches of weld) having a smooth and gradual transition having a depth of 1/32 inch or less are acceptable.

4.6.8.3 Radiographic Acceptance Standards. (Refer to para. 5.5.2 and 5.5.1.3.)

4.7 Tolerances. Casing assemblies shall be fabricated to the following tolerances. Tolerances not specified shall be, plus or minus 1/8 inch.

4.7.1 Weld Joint Root Opening. For longitudinal and circumferential plate welds the Seller shall have the option of a root-gap ranging from 0 to 3/16 inch maximum. Ring closure grooved joint(s) (assembled onto the cylinder) shall have sufficient root opening to permit 100% weld of the bar with the root bead fusing into the cylinder wall.

4.7.2 Staggered Welds. Longitudinal welds of cylinders in a casing section assembly shall be staggered a minimum of 24 inches.

4.7.3 Mismatch. Longitudinal weld seam abutting edges of cylinders shall not exceed 1/16 inch mismatch. Circumferential weld seam abutting edges shall not exceed 1/8 inch mismatch.

4.7.4 Lift Ring Spacing. The top lifting ring dimension of 3 feet 0 inches shown on Sketch No. I is mandatory for all type "B" and type "C" casing. For casing sections with multiple lifting rings such as type "C", the distance between each lifting ring must be equally spaced. The distance between lifting rings is equal to the total casing section length divided by the number of lifting rings required. Lift ring location may vary plus or minus one inch. Circumferential plate weld joints shall be located so that the weld is no closer than 6 inches to a lift ring.

4.7.5 Section Straightness. Finalized casing sections shall be straight, with walls parallel to the axis of the casing. The variation in straightness of the casing when measured from a reference line parallel to the axis shall not exceed 3/16 inch in 10 feet. (Refer to Sketch No. I.)

4.7.6 Section Ends. Ends of casing sections, when measured with a plumb-bob across the diameter at any point to the levelled longitudinal plane of the casing section, shall not vary more than:

(a) 3/16 inch for 66-inch I.D. and larger.

(b) 1/8 inch for inside diameters less than 66 inch. (Refer to Sketch No. I.)

4.7.7 Ring Weld. Ring closure weld joint shall have not less than a nominal 45 degrees but not greater than a nominal 60 degrees included angle. (Refer to Sketch No. I)

4.7.8 Lift Rings. The plane of the bottom edge of each lift ring shall be parallel with the plane of the top of the casing section within 1/8 inch.

4.7.9 Casing Section Length. The finalized casing section length specified in the purchase order may vary plus or minus one inch for nominal 40-foot lengths, plus or minus 1-3/4 inches for nominal 60-foot lengths, and plus or minus 2-1/2 inches for nominal 80-foot lengths.

4.7.10 Weld Reinforcement. Weld reinforcement of inside diameter welds shall not exceed 1/8 inch and shall be feather-edged. Outside diameter weld reinforcement shall not exceed 1/4 inch and shall be feather-edged.

4.7.11 Diameter and Out-of-Roundness Tolerances. Casing sections shall be manufactured to the tolerances specified in Table I.

(See next page for Table I)

TABLE I

CASING INTERNAL DIAMETER TOLERANCES (in inches)

Nominal Inside Diameter	Determined by Circumferential Measurement		Measured Diametrically	
	Min. I.D. (Pi-Tape)	Max. I.D. (Pi-Tape)	Min. I.D. (Out-of-Round)	Max. I.D. (Out-of-Round)
BOTH ENDS OF CASING SECTION				
36	36	36 1/4	35 7/8	36 1/8
48	48	48 1/4	47 7/8	48 1/8
54	54	54 1/4	53 13/16	54 3/16
66	66	66 1/4	65 3/4	66 1/4
74	74	74 1/4	73 5/8	74 3/8
88	88	88 1/4	87 5/8	88 3/8
98	98	98 1/4	97 5/8	98 3/8
120	120	120 1/4	119 5/8	120 3/8
144	144	144 1/4	143 5/8	144 3/8
THROUGHOUT THE INTERIOR OF THE CASING SECTION				
36	36	36 1/4	35 7/8	36 1/8
48	48	48 1/4	47 7/8	48 1/8
54	54	54 1/4	53 13/16	54 3/16
66	66	66 1/4	65 3/4	66 1/4
74	74	74 1/4	73 5/8	74 3/8
88	88	88 1/4	87 9/16	88 7/16
98	98	98 1/4	97 1/2	98 1/2
120	120	120 1/4	119 3/8	120 5/8
144	144	144 1/4	143 1/4	144 3/4

4.8 Identification Marking

4.8.1 Welding Operator Identification. All welds shall bear the welding operator's identification mark. Such identification shall be located adjacent to the weld but not closer than one-inch from the heat affected area. Steel stamps employed shall imprint a radius not a sharp demarcation.

4.8.2 Casing Sections. Each finalized casing section shall be marked on the inside , six inches from each end as follows:

(a) Using not less than 3/8 inch high metal stamps, denote Seller, ASTM designation of base metal and total calculated weight of finalized section in pounds.

(b) Using a paint stenciling system not less than 1-inch high, denote the I.D., wall thickness, weight per foot, length in feet and decimal, purchase order number and in the event the casing is surface casing, identify it as "Surface Casing". Such stenciling shall be placed upon clean base metal free of scale, rust or any other foreign matter. Stenciling shall be in contrast to base-metal.

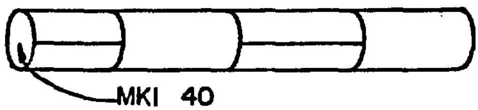
(c) Steel stamping and stenciling systems shall be localized and a transparant surface protective system over such identification shall be applied to provide maximum duration during outside storage.

4.8.2.1 MK Identification. Each finalized casing section shall bear a free-hand applied MK identification located at each end of casing section on the inside surface.

Such MK identification shall be placed at a distance from each end to avail ready visibility to the viewer without entry into the casing.

The MK identification may be applied with a paint spray gun, aerosol can or brush and shall be not less than 18 inches tall.

The MK identification shall enumerate consecutively each type of casing of each diameter and its section length, starting with MK 1 and ending with the last number of such casing on order.



5.0 INSPECTION

5.1 Seller. The Seller shall be responsible for the physical performance of all required in-process inspection and quality control functions during the manufacture of subject casing under contract.

5.1.1 The Seller shall furnish all materials and prepare and perform all required tests outlined herein.

5.2 In-Plant Inspection. The ERDA Representative shall perform the surveillance inspection functions of all required documentation and in-process operations at manufacturing, fabrication and inspection performance cycles to insure compliance with the requirements herein.

5.3 Disqualification. Welding power sources, associated tooling, proficiency of welding operations, pre-qualified procedures, certified weld schedules and workmanship, which in the opinion of the ERDA Representative, do not meet the requirements of this specification, or do not result in a uniformity of casing production shall be cause for disqualification.

NOTE: A disqualified operator, operation, machine or tool shall be immediately prohibited from performing further production operations upon casing under contract until such time as the disqualification has been suitably resolved and the qualification status re-established to the satisfaction of the ERDA representative in accordance with the requirements herein.

5.4 Retesting. When, in the opinion of the ERDA Representative, the structural integrity of the weldment is in question, he shall have the prerogative to request such additional tests as he deems necessary to meet the requirements of this specification at the expense of the seller.

5.5 Non-Destructive Inspection

5.5.1 Lifting Rings and Stiffener Rings. Ring closure weld, groove weld and fillet weld of all lifting and stiffener rings shall be 100% magnetic particle inspected per paragraph 2.2.

5.5.1.1 Magnetic Particle Inspection, Quality Gradient Acceptance Standard

Cracks - All external or subsurface cracks shall be rejected.

Porosity - Grossly aligned globule or elongated porosity indicative of potential propagation shall be rejected.

Lack of Fusion - Incomplete penetration, lack of fusion or cold laps shall be rejected.

Linear Discontinuities - Population and frequency shall be evaluated as outlined in Appendix VI, Section UA72, paragraph 8 of the ASME Code, Section VIII, and accepted or rejected accordingly.

5.5.1.2 Liquid Penetrant Inspection Quality Gradient Acceptance Standard. Surface imperfection interpretations in dispute with the magnetic particle inspection indications shall be verified with liquid penetrant process per paragraph 2.3.

Non-relevant indications or penetrant retentions having no significant depth or re-emersion of penetrant, which are readily removable by simple erasure or mechanical blending with no adverse effects to the weld, shall be considered acceptable.

Harmful indications which arise at or project to the surface of the weld; i.e., laminations, fractures, sharp or abrupt surface demarcations, cold laps or undue undercuts which are detrimental to the weld shall be rejected.

5.5.1.3 All lift ring end stiffener ring welds shall be 10% radiographically inspected. One film shall be placed so that the ring closure weld is in the center of the negative. The quality gradient acceptance standard shall be in accordance with the ASME Code, Section VIII, paragraph UW-52. (Refer to paragraph 2.4.)

5.5.2 Longitudinal and Circumferential Welds. For spot radiographic inspection the Seller's quality control inspector shall designate a portion of each longitudinal and each circumferential production weld for a distance of not less than 12 inches but not more than 24 inches. The quality gradient acceptance standard shall be in accordance with para. UW-52, ASME Code, Section VIII. All welds requiring 100% radiographic inspection shall meet the quality gradient acceptance standard of para. UW-51, ASME Code, Section VIII. (Refer to para. 2.4.)

5.5.2.1 X-ray Film. X-ray negatives representative of production welds shall be kept on file by the Seller for a period of not less than one year. At the end of this period the disposition of the negative shall be at the discretion of the Purchaser.

5.5.3 Visual Inspection. Visual inspection shall be performed upon all in-process operations and finalized welds. Visually discernable weld rejections which are readily repairable without adverse effects to the weld or parent metal shall be repaired prior to the application of non-destructive inspection processes.

5.5.4 Weld Repairs. Weld repairs necessitated by visual inspection shall be visually re-examined subsequent to repairs. The ERDA Representative shall have the prerogative to request X-ray examination when structural integrity of such repairs are in question.

6.1 Casing Supports. Seller shall provide and install suitable mechanical supports on each finalized casing section, 54-inch I.D. and larger, in order to maintain the required diameter tolerances and to prevent permanent deformation of casing during handling and shipping.

6.1.1 Mechanical supports shall be suitably tack welded to prevent loss during handling. They shall be located at a nominal 18 inches from the ends of casing section to facilitate fit-up in subsequent field joining operations.

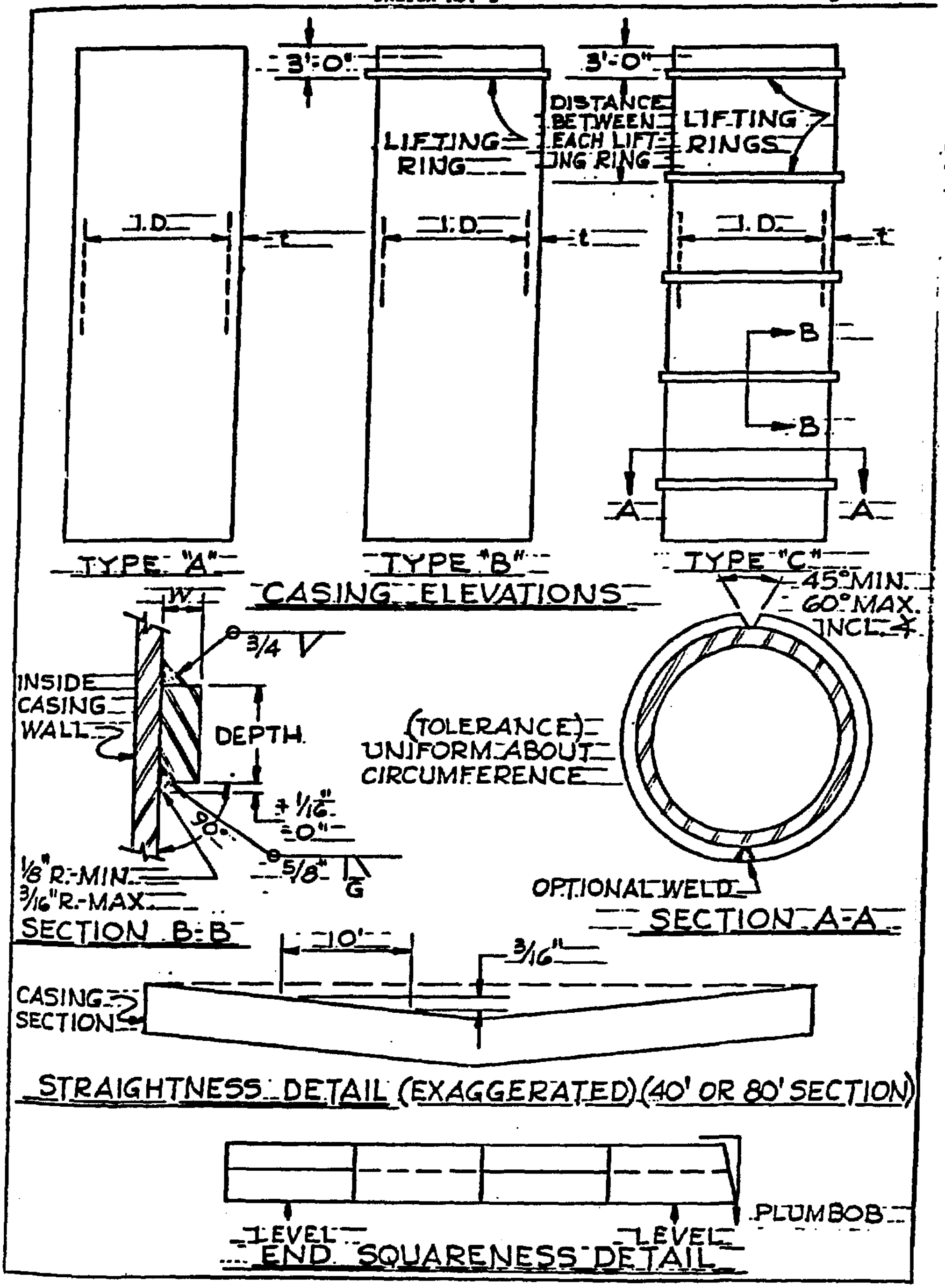
6.1.2 External segmented stiffener rings shall be provided at both ends of all finalized casing sections, 54-inch I.D. through 98-inch I.D. inclusive. Stiffener segments may be flame cut. 3/8-inch thick plate stock nominally 4 inches wide shall be used and the stiffener segments must be joined into a ring configuration by either butt joints or by lap joints at the option of the Seller.

6.1.3 Internal stiffener braces shall be provided at both ends of all finalized casing sections larger than 98-inch I.D. The number and type of braces used shall be at the option of the Seller.

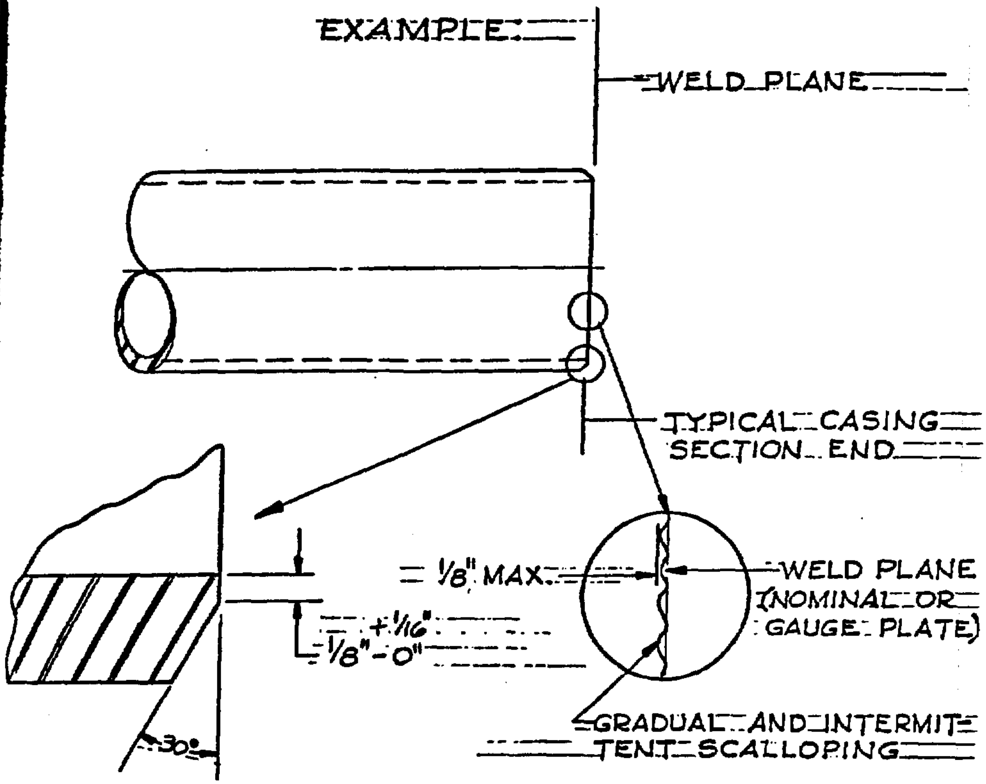
6.1.4 Loss of or damage to casing incurred during shipment shall be the liability of the Seller.

6.2 <u>Surface Protective System</u>. Each end of each finalized casing section shall be mechanically cleaned to parent-metal for a distance of not less than one inch, internally and externally, beyond the terminating ends of weld joint preparations. The cleaned areas shall be primed with a weld-through, aluminum-chromate base, fast drying primer. Masking is not required.

SKETCH NO. 1


3'-0"
3'-0"
LIFTING RING
DISTANCE BETWEEN EACH LIFTING RING
LIFTING RINGS
I.D.
t
B
A
TYPE "A"
TYPE "B"
TYPE "C"
CASING ELEVATIONS
W
3/4 V
INSIDE CASING WALL
DEPTH
+1/16"
-0"
90°
5/8
G
1/8"R.-MIN.
3/16"R.-MAX.
SECTION B-B
45° MIN.
60° MAX.
INCL ∡
(TOLERANCE) UNIFORM ABOUT CIRCUMFERENCE
OPTIONAL WELD
SECTION A-A
10'
3/16"
CASING SECTION
STRAIGHTNESS DETAIL (EXAGGERATED) (40' OR 80' SECTION)
PLUMBOB
LEVEL
LEVEL
END SQUARENESS DETAIL

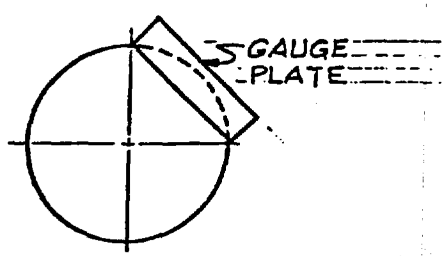
SKETCH NO. II



NOTES:

1. TOLERANCES FOR SCALLOPING 1/8" MAXIMUM.

2. INSPECTION OF TOLERANCE SHALL BE MEASURED WITH A GAUGE PLATE AS SHOWN.



FORM NO. I
(TYPICAL)

PAGE 1 OF____

RADIOGRAPHIC WELD REPORT — CERTIFIED TEST REPORT

DATE____ LABORATORY NO.____

RECEIVED____ NDT CONTROL NO.____

CUST. P.O.____ SHIPPER NO.____

MATERIAL____

SPECIFICATION____

PART NO.____

AREA X-RAYED____

RADIOGRAPH NUMBER	REPAIR NO.	ACCEPTED	REJECTED	CRACK - LONGITUDINAL	CRACK - TRANSVERSE	CRACK - CRATER	PARENT METAL	LACK OF FUSION	INCOMPLETE PENETRATION	POROSITY LINEAR	POROSITY SCATTERED	INCLUSION - METALLIC	INCLUSION - NON-METALLIC	SLAG - LINEAR	SLAG - SCATTERED	SURFACE CONTOUR	SURFACE CRATER	GAS HOLE

REMARKS

INTERPRETATION DEFECT LEGEND

0 — NO APPARENT DEFECT
1 — SLIGHT
2 — MODERATE
3 — LARGE
4 — EXCESSIVE

FILM USED

14x17 ____ 4½x17 ____
11x14 ____ 3½x17 ____
10x12 ____ 35 MM ____
8x10 ____ 70 MM ____
5x7 ____ ____

:____ DATE:____

BY____ DATE:____

DELIVERY RECEIPT

REPORT____
FILM____
DRAWINGS____
ACCEPTED PARTS____
REJECTED PARTS____
NO DISPOSITION PARTS____
DELIVERED BY____
RECEIVED BY____

LV-117 (Sets) FORM NO. II

CASING INSPECTION REPORT

Casing Mark No. ______________

Casing Description:

a. Inside Diameter ______________

b. Shell Thickness ______________

c. Lift Ring Size ______________

Spacing ______________

d. Stiffener Ring Size ______________

Spacing ______________

Reference Drawings ______________

Specifications ______________

Purchase Order No. ______________

6. Hole or Stock No. ______________

7. Fabricator ______________

____

8. Fabricator's Job No. ______________

9. Inspection Agency ______________

10. This Casing Section Mark No. ______________ has been fabricated in accordance with the reference drawings and specifications. This Casing Section has been inspected and released for shipment.

By ______________

Date ______________

INSPECTION CHECK LIST

Material:

a. ASTM Specification ______________

b. Heat Numbers

1. ______ 4. ______
2. ______ 5. ______
3. ______ 6. ______

c. Mill Certificates ______________

d. Surface Defects ______________

Thickness (Micrometer Range)

a. Shell Plates ______________

b. Lift Rings ______________

c. Stiffener Rings ______________

Edge Preparation and Cleaning

Rolling:

a. Edge Broken ______________

b. Cold Rolled ______________

c. Hot Rolled ______________

d. Mill Scale Removed ______________

Fit Up

a. Longitudinal ______________

b. Circumferential ______________

c. Rings ______________

Length ______________

Straightness ______________

Lift Ring Spacing ______________

Stiffener Ring Spacing ______________

End Squareness ______________

End Bevel ______________

12. Welding:

a. A.E.C. Approved Procedure

No. ______________ Date ______

No. ______________ Date ______

b. Qualified Welders ______________

c. Internal Reinf. ______________

d. Back Gouged ______________

e. Fillet Weld Size ______________

f. Bevel Weld Size & Tolerance ______________

g. General Appearance ______________

h. Repairs (Approx.) ______________

13. Magnetic Particle Inspection ______________

14. X-Ray Inspection:

a. Longitudinal Seam ______________

b. Circumferential Seam ______________

c. Lift Ring ______________

d. Film Quality ______________

e. Repair Films Checked ______________

15. Diameter (Inside)

a. Lower end ________ Max. ________ Min

b. Upper end ________ Max. ________ Min

c. Interior Locations ______________

16. Guide Pipes:

a. Attached ______________

b. Shipped Loose ______________

17. Interior Marking ______________

18. Interior Bracing ______________

19. End Bevel Protection ______________

FS FENIX & SCISSON, INC. LAS VEGAS BRANCH	ENGINEERING SPECIFICATION		
	Prepared By: M. C. Jay	Date: 6-12-73	Number: 1018
Subject: STANDARD PROCEDURE FOR FIELD FUSION WELDING OF CASING (SUPERCEDES: F&S FIELD WELDING SPECIFICATIONS DTD. 3-20-64)		Revision: 2-5-5-76	Page: 1 of 9

1.0 SCOPE

To specify the pre-qualified method, processes and procedures for field fusion welding of casing assemblies manufactured from mild-carbon, hot-rolled structural steel base materials such as ASTM-A-36, or equivalent.

2.0 APPLICATIONS

This Specification applies only to field welding of structural grade circumferential welds, performed in a fixed horizontal position from one side (O.D.) only; without the aid of any mechanical weld back-up devices, as applied to large diameter protective casing assemblies, namely:

2.1 Surface casing or conductor casing.

2.2 Intermediate casing.

2.3 Long string casing or deep hole casing.

2.4 Casing liners or specially designed casing.

3.0 APPLICABLE SPECIFICATIONS

The following specifications shall apply to the extent specified herein.

3.1	ASME Boiler and Pressure Vessel Code	Section VIII, Radiography Section IX Welder Qualification
3.2	AWS Structural Welding Code	Welder Qualification Terms and Definitions
3.3	AWS-A-5.1	Mild Steel Covered Arc Welding Electrodes
3.4	AWS-A-5.20-69	Mild Steel Electrodes for Flux Cored Arc Welding

4.0 GENERAL REQUIREMENTS

4.1 Welding Processes

The following fusion welding processes only are applicable to this Specification.

	F&S Quality Control	F&S Approval	USERDA Approval
	[signature]	[signature]	[signature]
	5-17-77	5/17/77	5-24-77

4.1.1 Manual, Shielded Metal Arc Welding (SMAW) (stick welding).

4.1.2 Semi-automatic, Fluxed Core Arc Welding (FCAW) (flux-core).

4.2 Welder Certifications

Welders shall be required to hold a current Welder's Certification Status in accordance with the applicable portions of specifications in paragraph 3.1 or 3.2 above, with the applicable processes, welding position and in the Material Group outlined herein as a prerequisite to field welding casing assemblies.

4.2.1 Each welder shall demonstrate his proficiency by successfully welding a standard weld test sample in accordance with the procedure as shown in Sketch No. I and the techniques outlined herein.

4.2.2 The test sample shall meet the following requirements:

(a) Not less than 1/2-inch base-plate thickness.
(b) Not less than 6-inch long test specimen.
(c) Single "Vee" groove, 60-degree included angle, 1/8-inch root and 3/16-inch root opening.
(d) Fixed horizontal position.
(e) No back-up (open root).
(f) Welded from one side only (beveled side).
(g) With resulting far side weld reinforcement.

NOTE: The test plate need not be welded to completion, however, the root-weld shall be covered with a second pass to demonstrate proficiency of no-burn-through.

4.2.2.1 Visual Inspection Requirements for Test Sample

Grind the far side of the resulting weld reinforcement flush with parent metal but not less than 0.005 inches below parent metal faces and visually inspect for the following defects open to the surface.

(a) Cracks are not acceptable.
(b) Highly scattered striations of flux, open porosity or lack of fusion not greater than 1/16 inch in size and not more than 2 per inch of weld shall be acceptable.

4.2.3 Qualified welders who have previously field welded casing within a six-month period in accordance with the requirements of this specification need not comply with paragraph 4.2.1 above.

4.3 Pre-heat Requirements

Any one or more of the following prevailing conditions in the field shall require pre-heat of weld areas to a nominal temperature range of 100 to 150 degrees F. prior to tacking or welding.

4.3.1 Ambient temperatures of plus 40 degrees F or less.

4.3.2 Presence of moisture upon surfaces of weld areas or adjacent base metal.

4.3.3 Base metal thickness of one-inch or greater.

4.4 Radiographic Inspection Requirements (Refer to Sketch No. II)

4.4.1 All welds requiring 100% radiographic inspection shall meet the requirements of Paragraph UW-51 of the ASME Boiler and Pressure Vessel Code, Section VIII.

4.4.2 Interpretation of the radiographs shall be performed by the cognizant ERDA representative who shall accept the weld or shall indicate weld areas requiring repair.

4.4.3 Weld repairs shall be radiographed and shall be interpreted as in Paragraph 4.4.2.

4.5 Cleanliness

Rust, scale, tapes, or other surface protective systems such as paint, transparent coatings or plastics (aluminum chromate base primer is acceptable) shall be removed by grinding or wire brushing to clean metal before welding. The use of solvents is prohibited.

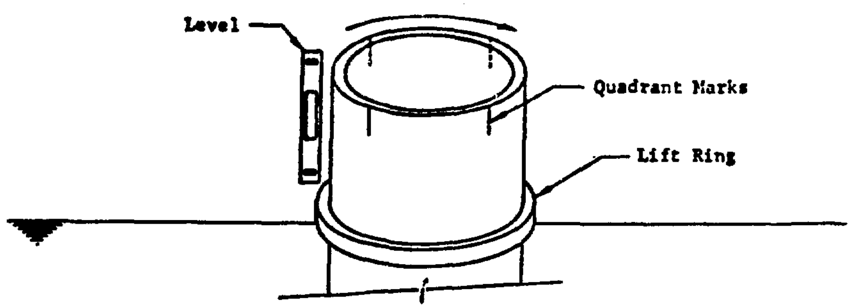
4.6 Tack Welding, Root Welding and Final Welding Techniques (See Sketch No. I)

5.0 FIELD WELDING PROCEDURES

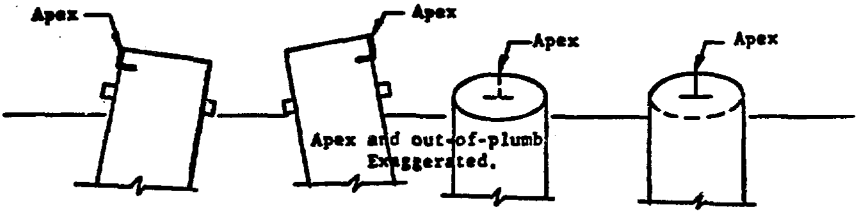
5.1 Fit-Up

5.1.1 When the first casing section is set into the hole, check the upper portion of the casing for out-of-plumb, using a level.

5.1.2 If the casing is found to be in a true vertical position, plainly mark or scribe four points, arbitrarily dividing the circumference into four equal quadrants as shown.

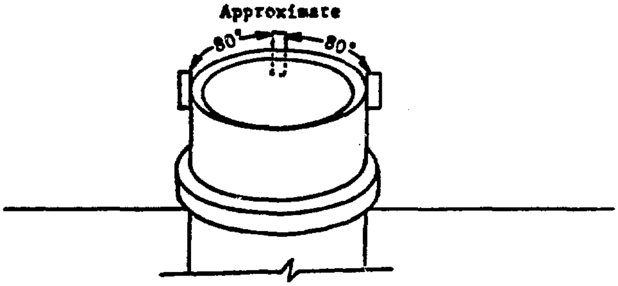


5.1.3 If the casing is found to be out-of-plumb, the apex of the horizontal weld plane shall be marked as shown.



Starting at this point (the apex) divide the circumference into four equal quadrants as outlined above in paragraph 5.1.2.

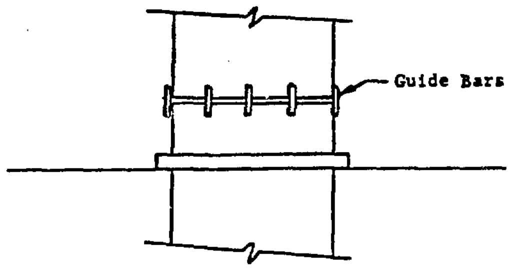
5.1.4 Tack-weld 3 guide bars (on one side only) to the top of the casing section in the hole as shown.



5.1.5 Lower second casing section into position above the casing in the hole and place it against the flat-bar guides attached above. Gradually lower the upper casing within 1/2 inch of abuttment with the lower casing and suspend it in this position.

5.1.6 If the casing does not have grout line guides installed, rotate the upper casing until the best free fit-up (match) is acquired around the entire circumference, assuring that the casing vertical weld seams are separated by no less than 12 inches.

5.1.7 Tack-weld additional guide bars (intermittently spaced) to the lower casing and only at locations which match or protrude beyond the diameter of the upper casing. Surround the entire circumference with sufficient number of guide bars to ensure enclosure of the upper casing section as shown.

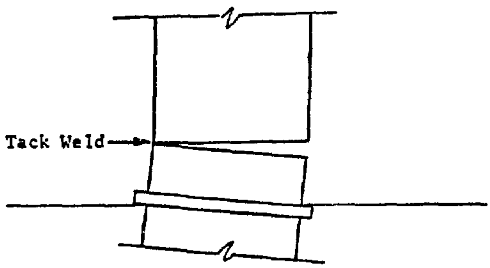


5.2 Casing Which is Plumb

GRADUALLY lower upper casing section to within a nominal abuttment of 3/16 inch about the entire circumference and substantially tack-weld in four places at points where casing walls match vertically. Hold the load of the upper casing section suspended.

5.3 Casing Out-of-Plumb

Proceed as above except tack-weld at apex only as shown.



5.3.1 GRADUALLY slack off load of upper casing section and match out-of-plumb with lower casing section. Tack-weld as outlined in paragraph 5.2 above. Continue to keep load suspended.

5.4 Tack-weld required number of wedge dog clips to mismatched areas of upper and lower casing sections as needed. Finalize matching of both sections using substantial tack-welds to completion. Keep load suspended.

5.5 Welding of Root-Welds

5.5.1 After finalizing tack-welds, remove all guide bars and dog clips. Wire brush tack welded areas and begin root-weld.

5.5.2 Assign one welder to each designated quadrant and proceed to deposit root-weld in between tack-welds. All welders shall weld in the same direction in each quadrant.

5.5.3 Use 3/32-inch diameter electrodes AWS-E 6011, D.C. Reverse polarity, such as Lincoln Fleetweld No. 180 or equal and insure that weld passes protrude beyond the far side faces of parent metal to provide suitable far side weld reinforcement.

5.5.4 Deslag and wire brush each weld pass progressively to finalization of root-weld.

5.5.5 Subsequent to completion of root-weld, all fractured tack-welds shall be removed in their entirety by mechanical grinding using a narrow grinding wheel, prior to weld rework.

5.5.6 During the course of welding, any slag, porosity, lack of fusion, or lack of weld reinforcement (far side) shall be removed by grinding prior to weld progression. Keep load suspended.

5.5.7 X-ray the root-weld. (Refer to Sketch No. II)

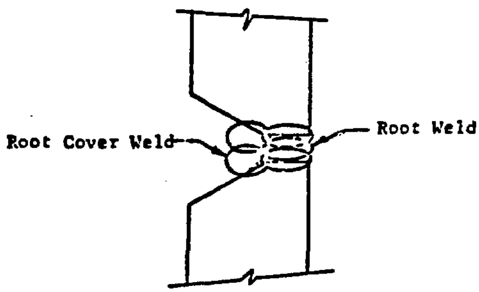
5.6 <u>Finalizing the Circumferential Weld</u>

Either the SMAW or the FCAW process may be employed for finalizing the weld but not both upon any one weld, as follows:

5.6.1 Using the Shielded Metal Arc Welding (SMAW) process and with load suspended, use 1/8-inch, 5/32-inch and 3/16-inch diameter electrodes progressively. Employ type E-70XX electrodes. Employ bead-weld technique.

NOTE: <u>Load Release</u>

(a) After <u>finalizing</u> the root cover weld in all quadrants release the load completely.



(b) From this point on to completion of entire weld, ensure that the entire weight of the upper casing section rests on the lower casing section at all times.

(c) For safety purposes, however, the upper casing shall remain hooked to the elevator until the weld is completed.

5.6.2 On completion of SMAW weld, X-ray. (Refer to Sketch No. II)

5.6.3 Using the Fluxed Core Arc Welding (FCAW) process and with load suspended, use 5/64-inch diameter fluxed core spool wire electrode progressively. Employ type E-70T-G electrode such as Lincoln NR-202 or equivelant. Employ bead-weld technique.

5.6.3.1 Caution shall be exercised not to burn-through the root-weld. Use wash-bead technique, if required.

5.6.3.2 Observe load release requirements outlined in paragraph 5.6.1 "Note" above.

5.6.3.3 On completion of FCAW weld, X-ray. (Refer to Sketch No. II)

5.7 <u>Permanent Sealing of Casing Plugs</u>

When required and subsequent to final acceptance of Radiographic Inspection of finalized weld, the inspection port plug shall be screwed into the coupling and torqued tightly. Sealant thread compound shall not be used.

The junction of the plug and coupling shall be permanently sealed by welding with a bead-weld. Subsequently, apply a weave-pass over the bead-weld and visually inspect. Cracks are not acceptable.

6.0 <u>ENGINEERING DESIGN DRAWING</u>

When in conflict with this Specification, Engineering Design Drawing requirements shall have precedence.

7.0 <u>APPURTENANCES</u>

Any additional attachment of accessory details consisting of mild-carbon steels to the subject casing, when such attachment is to be performed by fusion welding in the field or upon finalized emplaced casing in the hole, shall be performed in accordance with Engineering Design Requirements.

7.1 Appurtenances such as grout line guide pipes, brackets, or lifting plugs; or double joining of casing components in the flat or rolled position when welded from both sides or repairs made thereto by fusion welding, shall be accomplished with the welding processes and filler materials specified for finalizing welds, outlined herein.

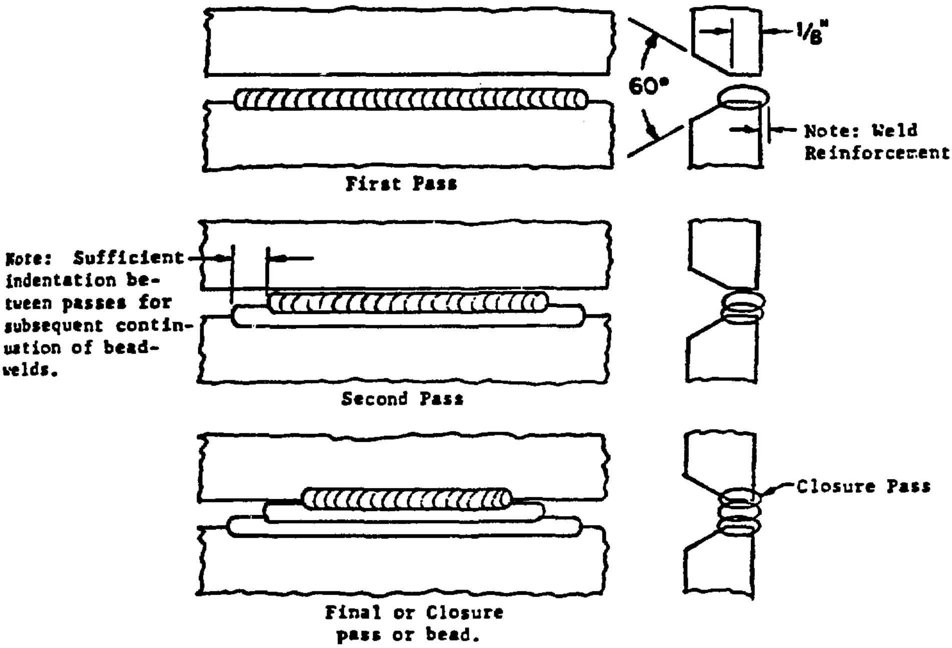
7.2 Fusion welding shall be performed in accordance with standard practices and workmanship prescribed by the American Welding Society for structural grade weldments.

7.3 Attachment to the subject casing of base-metals other than mild-carbon steels or usage of any other fusion welding processes, other than those specified herein, is beyond the scope of this specification.

SKETCH NO. I

TACK WELDING AND ROOT WELDING TECHNIQUE

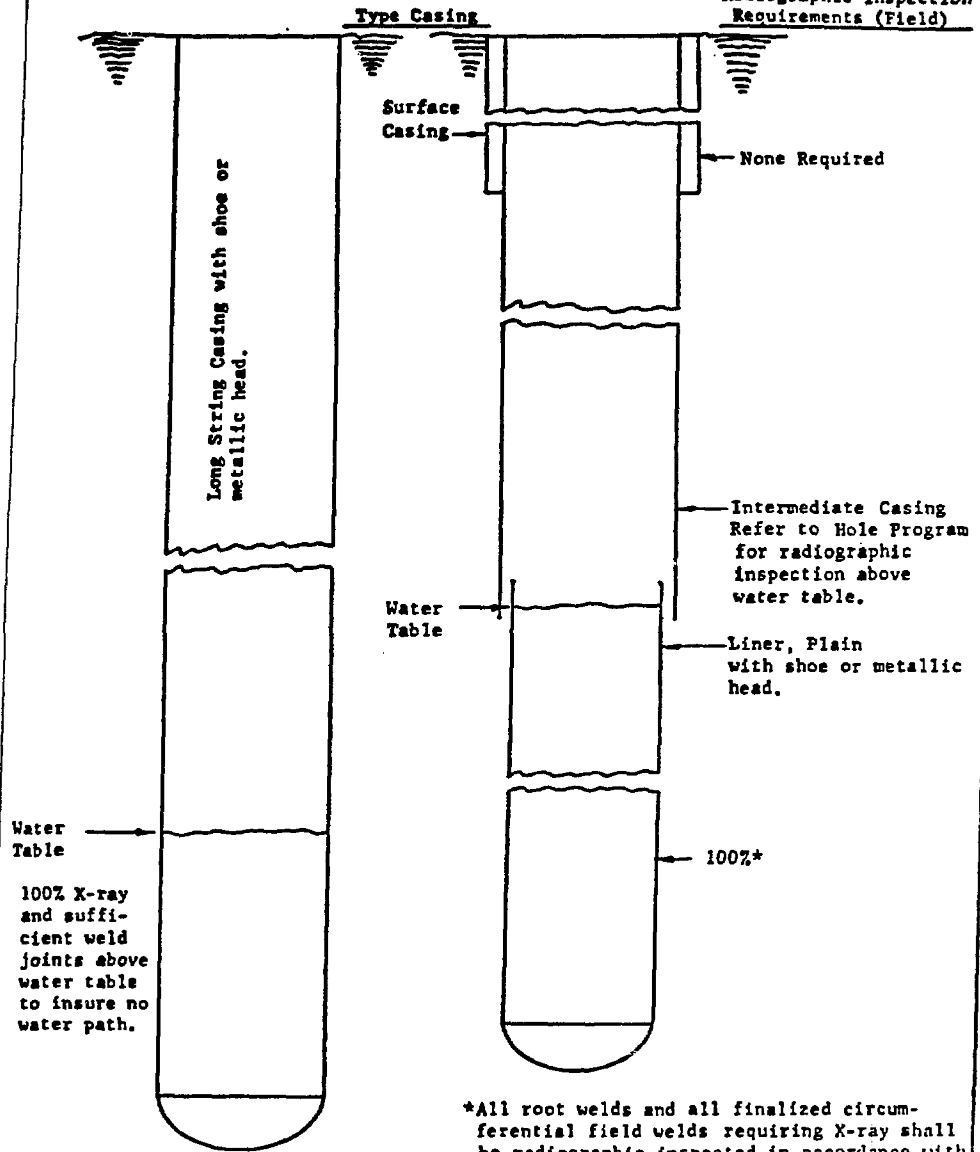
Tack-welds and root-welds shall be performed in the same manner and with the same technique as shown:



Use as many bead welds as are necessary to close off the root opening.

Assure sufficient opening for closure pass without resulting undercut or lack of fusion of far-side.

SKETCH NO. II



*All root welds and all finalized circumferential field welds requiring X-ray shall be radiographic inspected in accordance with ASME Code, Section VIII, para. UW-51. (Refer to para. 3.1)

APPENDIX E

FENIX & SCISSON, INC.
STUDY REQUEST NO. 3
INTERNAL VS EXTERNAL UTILITIES COMPARISON FOR EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY
MINING PHASE

NOTE: The 100-in.-diam casing has been changed to 98-in. diam since this study was completed.

STUDY REQUEST NO. 3

INTERNAL VS EXTERNAL UTILITIES COMPARISON
FOR
EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY

MINING PHASE

The proposed shaft for the NTS consists of a 120" diameter drilled hole, with a 100" I.D. casing installed and grouted in from bottom to surface. No lines to be used for mining purposes will be on the outside of the casing.

Inside of the casing will be all air, water, pump discharge and ventilation lines as well as all signal and power cables. Two alternative shaft designs are being considered by the A-E at this time.

1. A design giving a muck hoisting compartment and a manway.

2. A design giving a muck hoisting compartment and a secondary hoisting compartment instead of a manway.

   (See Appendix A for details)

Utility lines would be installed either by running them in from the surface with a drill rig or crane, or by installing them in sections as men proceed down shaft. Shaft sets, landings, ladders, etc., would be pre-installed as much as possible depending on weight and whether it is possible due to design, while all electrical items would be installed as men proceed down shaft. Pre-installation is desirous from a time and cost standpoint and should be investigated for use at any location being considered. Since the 100" casing will be internally flooded with water during grouting of the casing in the hole, items that could be water damaged such as electric items must be installed after the casing annulus is grouted and the casing dewatered.

The proposed shaft for Hanford consists (as we understand it) of a 110" drilled hole, with a 72" I.D. casing installed, with utility lines on the outside consisting of 4-1/2" O.D. groutline guides and 8" O.D. (maybe 10") utility lines for compressed air ventilation, water, power lines, etc. Not clearly stated is how the air and water would be made available to the inside of the casing, but presumably would be by penetrations through the casing. This is seen as one possible point of weakness during grouting of the 72" casing in the drilled hole, as well as high pressure ground water intrusion if one of the lines should become ruptured. Installation procedures for the shaft sets, etc., are not known to us, but appear to be similar to a design used formerly on the NTS which was installed using a drill rig or crane.

The mining advantages of using a 100" casing vs 72" for Hanford are:

1. No utility lines are outside the casing during shaft liner running, therefore cannot become damaged. (If lines are outside and damaged, no repair or replacement is possible. Also, a path may exist for high pressure ground water to enter an external ruptured pipeline and exit inside the cased hole).

2. All lines are available for repairs or replacement.

3. All lines are available for immediate usage at any point in the shaft.

4. More cross-sectional area is provided for shaft conveyances.

5. Two separate hoist compartments providing for more flexibility for concurrent operations, as well as providing for greater safety for men underground.

6. More cross-sectional area is available for exploratory drilling to test for ground water before the casing is cut for exit at any horizon.

7. Ventilation of over 20,000 cfm is provided at atmospheric pressure avoiding noise produced by expanding compressed air, and most importantly, the air can be cooled on the surface to combat the high temperature (106° F) expected underground. It should be borne in mind that at 100° F and 100% humidity, a person can no longer perspire and his life may be placed in jeopardy.

8. Shaft guides are of a size and/or shape to safely guide the shaft conveyances without derailing, and also provide sufficient area for safety dogs to work in case of an emergency. The sketch provided by Hanford of their proposed shaft is similar to a design formerly used on the NTS where two 4-1/2" F.J. pipes on opposite sides of the casing doubled as air and water lines and also as guides for the skip and cage. We had numerous derailments using this method, and also questioned whether the safety dogs would work properly on the guides, or if the possibility existed of tearing the pipe guides loose if the skip/cage should drop and the dogs engage. For these reasons, we designed a different system whereby these problems were eliminated.

9. Increased manpower productivity due to better ventilation. (Hanford stated they intended to rotate crews every 2 hours vs our continuous work).

The mining advantages of Hanford vs NTS are:

1. All utility lines are pre-installed, albeit on the outside of the casing.

2. Probably lower shaft guide costs due to smaller cross-sectional area and guide design.

3. Shaft sets can probably be installed from the surface in one continuous operation.

Our utility lines will consist of 6 strings of 4-1/2" O.D. tubing for water, pump discharge, power cable and scientific cables and one string of 7" O.D. casing for a compressed air line. These will be self-supporting from ground level to total depth and can thus be run in with a drill rig or crane and hung off on strongbacks. They will later be additionally supported down shaft every 20 feet. These lines are anticipated to be readily available within the time limits involved in drilling the shaft.

One string of 26" pipe with a 3/16" wall thickness would be used for a ventilation line. This has been selected because it can be run in from the surface in one continuous operation and be self-supporting at total depth. The sections would be welded together as it is lowered, and the completed line would be hung off at the surface on a strongback and later supported additionally down shaft every 20 feet. This line is available in a spiral weld pipe on a 6 to 8 week delivery time.

Shaft guides will be structural steel tubing run in from the surface as one continuous line by welding sections together as they are lowered. For the main skip/cage combination, they would be 4" x 6" x 1/4", and for the emergency cage (for Alternate No. 2) they would be 4" x 4" x 1/4". These are readily available as off the shelf items in a few weeks.

ESTIMATED CONSTRUCTION COSTS FOR THE TWO ALTERNATE DESIGNS ARE:

	Alternate No. 1 (Hoist & Manway)		Alternate No. 2 2 Hoist Compartments	
ITEM	DAYS	K$	DAYS	K$
Surface Const.	30	$ 349	30	$ 349
Equip Shaft	36	1,150	36	1,144
Subtotal	66	$1,499	66	$1,493
15% Cont.	10	225	10	224
	76	$1,724	76	$1,717

Estimated capital equipment costs remain as before at K$ 4,088

15% Cont.	613
	K$ 4,701

NOTE: All dollars are 1983-1984.

STUDY REQUEST NO. 3

APPENDIX A

There are two shaft designs being considered by the A-E at the present time. One is a design giving a muck hoisting compartment and a manway, and the other giving a muck hoisting compartment and a secondary hoisting compartment instead of a manway. These are further detailed below. Alternate number 2 is recommended.

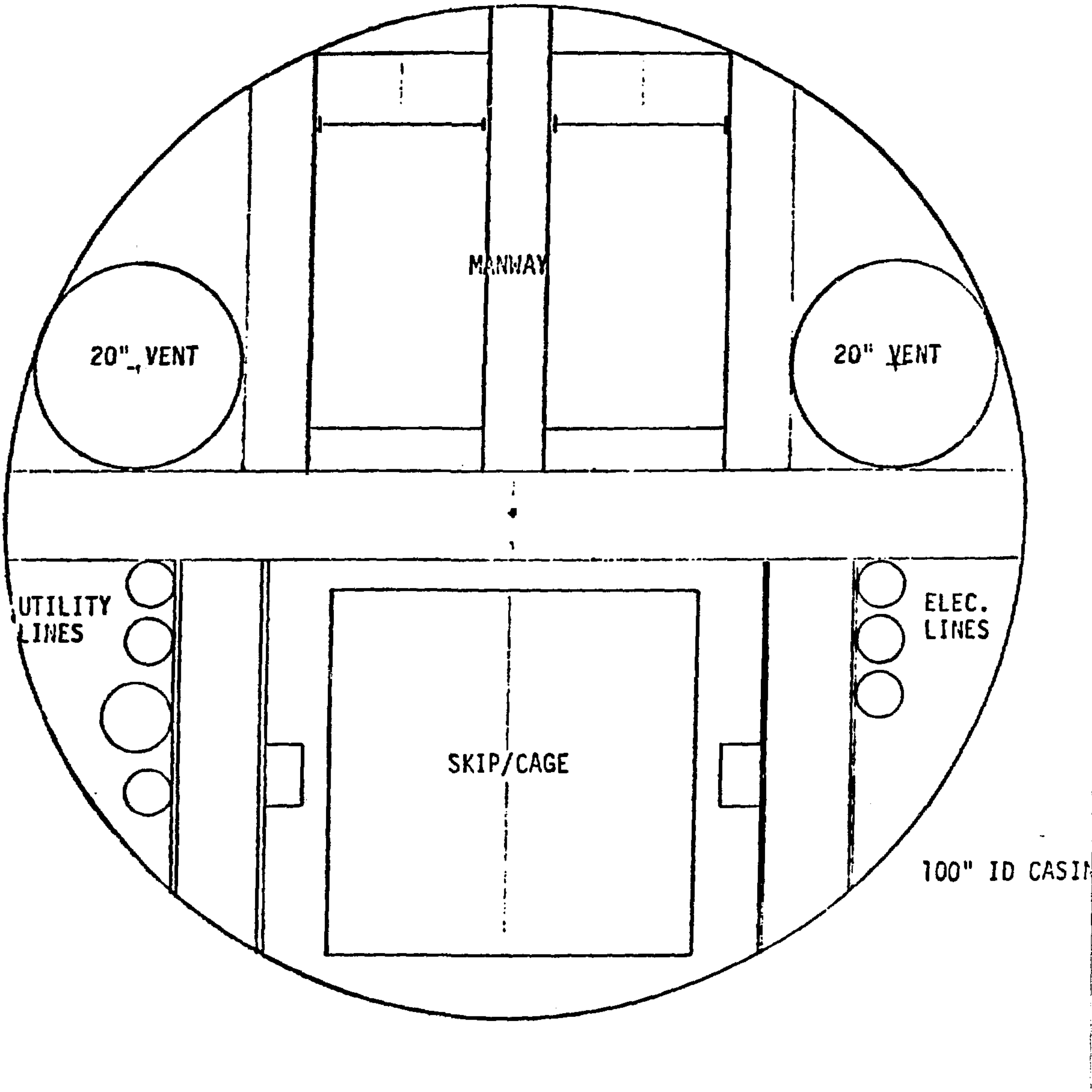
1. Dividers in the shaft form one compartment for hoisting and one for a manway consisting of ladders and landings with two 20" I.D. vent lines along with small miscellaneous air, water and pump discharge lines (See Sketch #1). Because of the dimension requirements of OSHA, and good engineering, the manway compartment requires a large part of the shaft area. This restricts the space for vent pipe so that two 20" I.D. lines are the largest that may be installed. There is an abundance of room for the other lines in the hoisting compartment due to their smaller size. Installation problems are compounded with this design due to the requirement for numerous subdividers and other support members for landings and vent pipes every 20' maximum. In addition, because the vent lines would not be self-supporting, if an attempt were made to install them from the surface in one continuous operation by lowering them while adding new line at the surface, they must be installed one 20' length at a time while proceeding down shaft. This further adds to installation problems as each piece would have to be suspended under that line already installed, coupled together and support brackets installed to the dividers in the shaft. At least one line would have to be installed in this manner to provide ventilation to the shaft bottom as the men proceed down shaft. The other line could be installed from the bottom up, a much easier operation.

   It is further intended that, in order to reduce installation time, thereby reducing costs, all possible internal items shall be either pre-installed in the casing sections, or installed at the surface as the casing is lowered into the drilled hole. These would consist of all steel sets, other required secondary steel support members, landings and ladders. The guide rails, air and water lines, pump discharge lines and four pipelines for power and scientific cables would be run in from the surface later, using oil field casing which would be self-supporting for its full length. These lines would be hung off at ground level on strongbacks and later additionally supported in the shaft as men proceed down hole for the first time. The remaining items would be installed as men proceed down hole from ground level and would consist of vent lines, signal systems and communication lines. Since the 100" casing will be internally flooded with water during grouting of the casing in the hole, items that could be water damaged, such as electric items, must be installed after the casing annulus is grouted and the casing dewatered.

2. As an alternate, dividers would separate the shaft into a muck hoisting compartment and a secondary hoisting compartment, vice manway, leaving an area large enough to install one 26" vent line. It is anticipated that this vent line would be pipe of approximately 3/16" thickness, run in the shaft after the main casing was grouted in place, using the drill rig, and welding it together. It would be hung off at the surface on a strongback and later supported additionally down hole. As in the first method, the guide rails, air, water, pump, power and scientific cable pipes would also be run from the surface and supported by strongbacks. They would later be additionally supported down shaft. (See Sketch #2). This solution calls for fewer subdividers and other support members, less weight pre-installed and probably faster installation. Since the vent line is installed before men go down the shaft, immediate ventilation is possible. The thickness of the vent line would reduce damage and simplify maintenance over that expected from regular vent pipe. At the same time, one 26" line would furnish the same amount of air as two 20" lines.

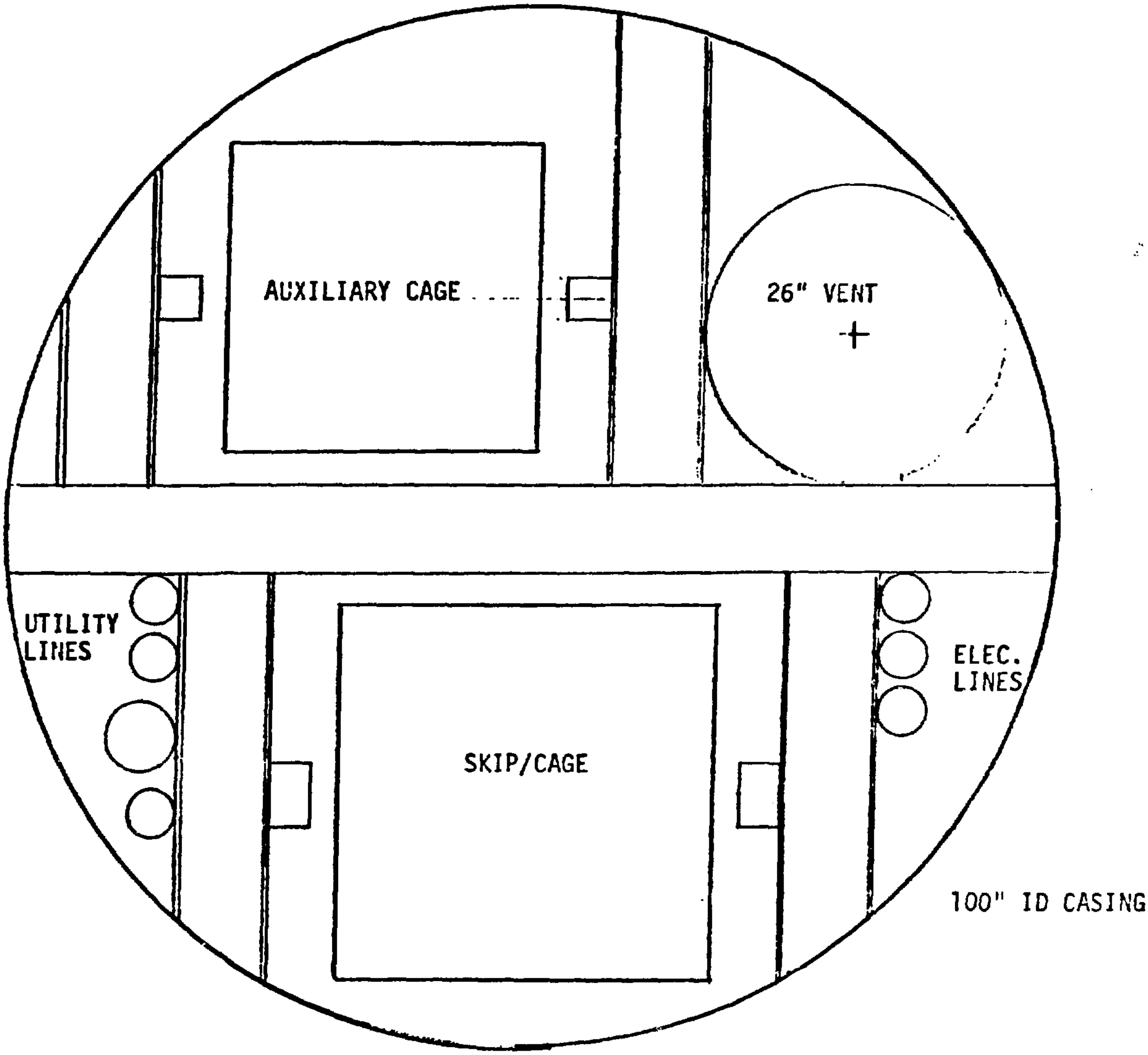
The secondary hoisting compartment would be operated by a second mine hoist connected to the main power supply as well as a secondary power supply, so that in an emergency, men could be hoisted to the surface if the main hoist were inoperative. In addition, it could be used to hoist men and materials at any time even though the main hoist was being used to hoist muck.

Because Alternate 2 gives more flexibility for access and supplies, and because men could be hoisted to the surface rather than climb the manway in case of an emergency, it is recommended as the method to be used.



Fenix & Scisson, Inc.
Mercury, Nevada
Exploratory Shaft Conceptual Design
Study Request No. 3
Appendix A Alternate No. 1

3/4"=1" 6/29/81



Fenix & Scisson, Inc.
Mercury, Nevada
Exploratory Shaft Conceptual Design
Study Request No. 3
Appendix A Alternate No. 2

3/4"=1"   6/29/81

FENIX & SCISSON, INC.

STUDY REQUEST NO. 3 ADDENDUM

INTERNAL VERSUS EXTERNAL UTILITIES COMPARISON

FOR

EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY

MINING PHASE

Since our previous study on Study Request No. 3, this office has made a further study which is the basis for the following addendum.

This is a study comparing our 120" diameter hole and a 98" I.D. casing with a 120" diameter hole and a 72" diameter casing. (Our previous study was a 120" hole and a 100" casing, which has been modified in our later work to a 98" casing).

Our study shows that the cost of the 120"/72" design is $215,000 more than the cost of the 120"/98" design, as shown later in this report.

This is due mainly to the increased cost of installing 4 - 10" pipes on the outside of the casing to be used as vent lines. Because of the problems of stabbing a vertical 40' length of pipe with regular threads into a coupling and getting the pipe started without cross-threading it, and then running and torquing it up with a set of power tongs suspended 40' in the air by a crane, it was decided to use pipe with Hydril threads to alleviate this problem. This pipe costs approximately twice as much as regular threaded pipe. In addition, these pipes must be added in 40' lengths and welded to the 72" casing as it is added in 40' lengths, rather than in a continuous string lowered into the hole (or shaft interior) with resulting higher rig costs. It was also our decision to use 10" pipe rather than 7" (Hanford size) to reduce the air velocity by approximately one-half, and therefore the resultant noise level to make working conditions easier. The approximate noise level from a 7" pipe, using a muffler, ear-plugs and ear-muffs would be about 105 dBA using the REECo method of calculation (versus 86 dBA for a 10"). At this level, no work could be done.

Because noise levels from compressed air ventilation can be a serious problem, we requested REECo Industrial Hygiene to make a study of expected noise level at the discharge point at shaft bottom using as criteria, 10,000 cfm at a discharge pressure of 25 psi from a 10" I.D. pipe line. Two such lines would be used to furnish a total of 20,000 cfm of free air. Their study shows the noise level would be 128 dBA at 3 feet. By using a muffler, ear-plugs and ear-muffs, this can be reduced to 86 dBA at 3 feet, which would allow about 6 hours work per 8 hour shift. Therefore, in order to maintain advance rates, two underground crews might be required, at a further escalation in costs.

The National Aeronautics and Space Administration (NASA) at Langley Air Force Base calculated the sound power level for us at 96 dB which corrects to 93 dBA. By using a muffler, this could be reduced to below 84 dBA, which is allowable for 8 hours continuous exposure. NASA used basically the same formula as REECo, but added two correction factors, one of which is based on emperical data derived from jet engine tests and which in our view is suspect as to applicability to our case.

The Naval Ship Research and Development Center (NSRDC), at Annapolis, Maryland is also working on this problem for us, but have not yet furnished us with any information, although they verbally expressed the opinion that they would be higher than NASA. Their analyses will be based on work they have done in the past in ventilating ships with compressed air through ducts, which is similar to what we are looking at. When their results are received, they will be forwarded. Copies of the REECo and NASA studies are included at the end of this report.

Bear in mind that while the initial work is going on inside the casing, ventilation must be provided through one of the internal lines, either a 4-1/2" or 7". Because the pipe line will be of smaller diameter, and the same volume is required, the velocity must be higher. Since the formula used to determine noise uses velocity to the 8th power as one of the factors, noise levels will be even higher for the early phases of work.

In the first case (120"/98"), all utility lines are inside of the casing. In this added study (120"/72"), some of the utility lines are inside and some outside of the casing. This added study addresses two concepts, the first called the "Standard Design", and the second called the "Full Hole Design". Because of some doubts as to reliability and safety aspects of the "Full Hole Design", we would recommend the "Standard Design" over it. However, because of costs and certain other disadvantages, our overall recommendation is for the 98" casing with two hoisting compartments. These are detailed further on in this report.

In the "Standard Design", two brackets will be pre-installed in the casing per level at 180^{o} and on a 20' vertical spacing, at the point of fabrication of the casing, as shown on the enclosed drawing. The bracket will consist of a stand to which the structural steel tubing guide will be later welded, and an extension on each side which will receive 7" O.D. and 4-1/2" O.D. pipes later. These pipes will be for compressed air for mining, pump discharge line, water line, power cable and scientific cables. On the outside of the casing will be installed four - 10" I.D. pipe lines for compressed ventilation air and such other uses as may develop. At least two - 10" lines are required for ventilation. Since the possibility exists for losing one of these lines during casing running operations, a minimum of one additional line is required for backup. It is quite possible that one may also be required for scientific cables, providing the high temperature environment will not affect them. Our design calls for a total of four lines to be installed. The "Standard Design" utilizes 4" x 6" structural steel tubing for guides. These will be run in from the surface after the 72" casing is grouted in the hole, in one continuous string, by welding on new sections as they are lowered into the shaft with a drill rig or crane, and will be self-supporting at total depth. They will be landed on a strongback at ground level temporarily, and later welded to the brackets every 20' as the miners proceed down hole. Safety dogs, in case of hoist rope breakage, will act on the tubing guides to prevent the skip/cage from falling to bottom. Four - 4-1/2" O.D. and two - 7" O.D. pipe lines will be lowered one at a time in a similar manner and landed on strongbacks. These will be fastened to the brackets with bolted clamps by the miners as they proceed down hole. Initial ventilation will be provided by compressed air through one of the internal lines. The 10" vent lines on the outside of the casing will not be used until the casing is cut and mining begins. Therefore, a very high noise level from the compressed air ventilation will be present during all of the early phases of work inside of the casing.

The "Full Hole Design" is based on a similar design developed several years ago for use in 48" casings. In this design, the safety dogs act on the wall of the casing itself. At the time we developed this system, a prototype cage was fabricated, a length of 48" casing was stood on end on the ground, being held in place by guy wires, and the prototype was drop tested, using a crane. The system was instrumented with accelerometers and strain gauges to determine stress and strain and "g" forces acting on the assembly. From the information derived from this test, it was determined to be safe and feasible to use. The proposed enlargement of this 48" system to 72" has not been tested in such a manner and leaves some question as to its reliability and safety.

In this system, two pipe lines, in this case 7" O.D., are run in the hole on the same side, simultaneously, using an equalizing sheave to compensate for difference of length in the new joints being added on. Every 40', a bracket is attached to these lines by bolting it on with clamps. The lines are only partially encircled with the bracket and clamps, since they also serve to act as guides. (See Enclosed Drawing) At the same time, it is possible to feed in power, communication and signal lines and support them from the brackets using Kellum grips and turnbuckles. The bell knocker system can also be installed at the same time. When the assembly is at total depth, it is landed on a special strongback, and after erection of the headframe, the miners proceed down hole and weld the brackets to the casing. If desired, a third pipe line can be run in the hole at a later time and fastened to the bracket. The main advantage of this system is that it is complete in itself. All signal lines, etc., are installed and ready for use. The skip/cage unit utilizes the pipe lines as a guide, while the safety dogs act on the wall of the casing itself. There are rubber rollers top and bottom of the assembly to keep it centered in the shaft. Above ground level, and at the shaft station level where there is no casing for the skip/cage to run in, wide flange beams are installed vertically at the position where the safety dogs are located, (90^{o} from the guide shoe position), in effect replacing the casing, and keep the cage aligned and provide a surface for the safety dogs to act on.

Because of limited room inside the 72" casing, it will be necessary to install the 10" vent lines on the outside as well as some of the 4-1/2" O.D. utility lines. As in the other concept, two - 10" lines are a minimum for ventilation, with a third as a backup in case of loss of one, with a total of four being installed to provide some excess capability. Again, initial ventilation must be provided inside the casing by high pressure compressed air with attendant high noise levels. Only after the casing is cut and mining begins, will the 10" outside lines be available for use.

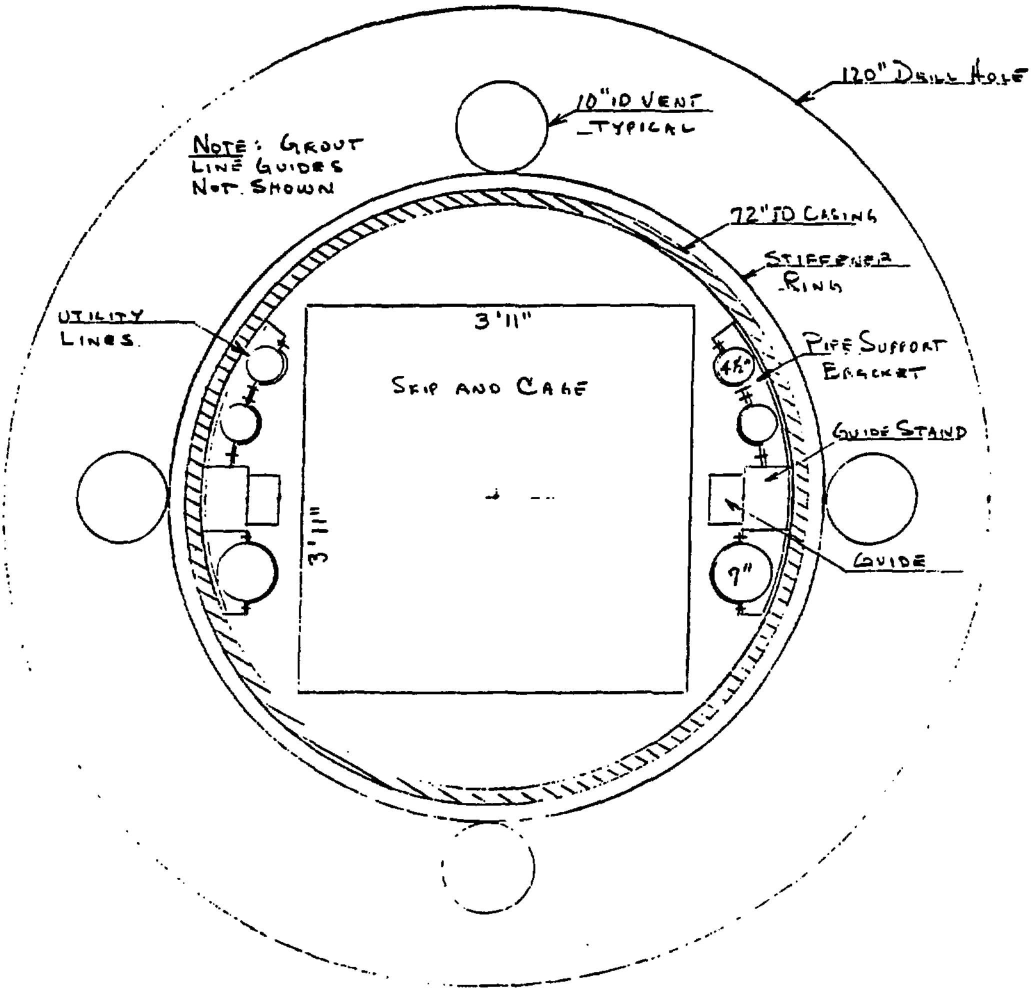
In both of these concepts, the 10" vent lines will be encased in cement grout which is in contact with the host rock at an elevated temperature. This will allow a higher heat radiation into the vent pipes than will be the case where the vent line(s) is on the inside hanging in free air. No calculations have been made on this problem, since, as will be shown, these concepts are more expensive than the system using a 98" casing, as well as having other major disadvantages.

In both concepts, to provide a second way out, a secondary hoist and mancage will be provided. This secondary hoist will be electrically connected to both the main power supply, and a diesel powered generating set in case of main power failure. The emergency cage will have a slot cut into it to its center line, so that it can be placed in the shaft over the main hoist cable. No safety dogs will be used on this cage because of this slot arrangement occupying and interfering with the space usually used for the safety dog system. The emergency cage will be hung in the headframe, but outside of the shaft area. In case of need, the cage will be swung into the shaft, utilizing a "swing away" portion in the guide system and is then ready for use. This procedure can be estimated to take a minimum of 15 to 20 minutes to accomplish. It is important to realize that this cage can only be lowered in the shaft to where the main cage is. Thus, if the main cage is stalled somewhere in the shaft, and other men are at the shaft bottom, only those men who are on the main cage may be removed from the shaft, leaving the other men at shaft bottom until such time as the main cage can be moved.

Because the reliability and safety aspects of the "Full Hole" system are unknown, our recommendation would be to use the "Standard Design" if the 72" casing were to be used. However, our overall recommendation is for the 98" casing design with two hoisting compartments as detailed in our original Study No. 3, and further detailed in Study Request No. 2.

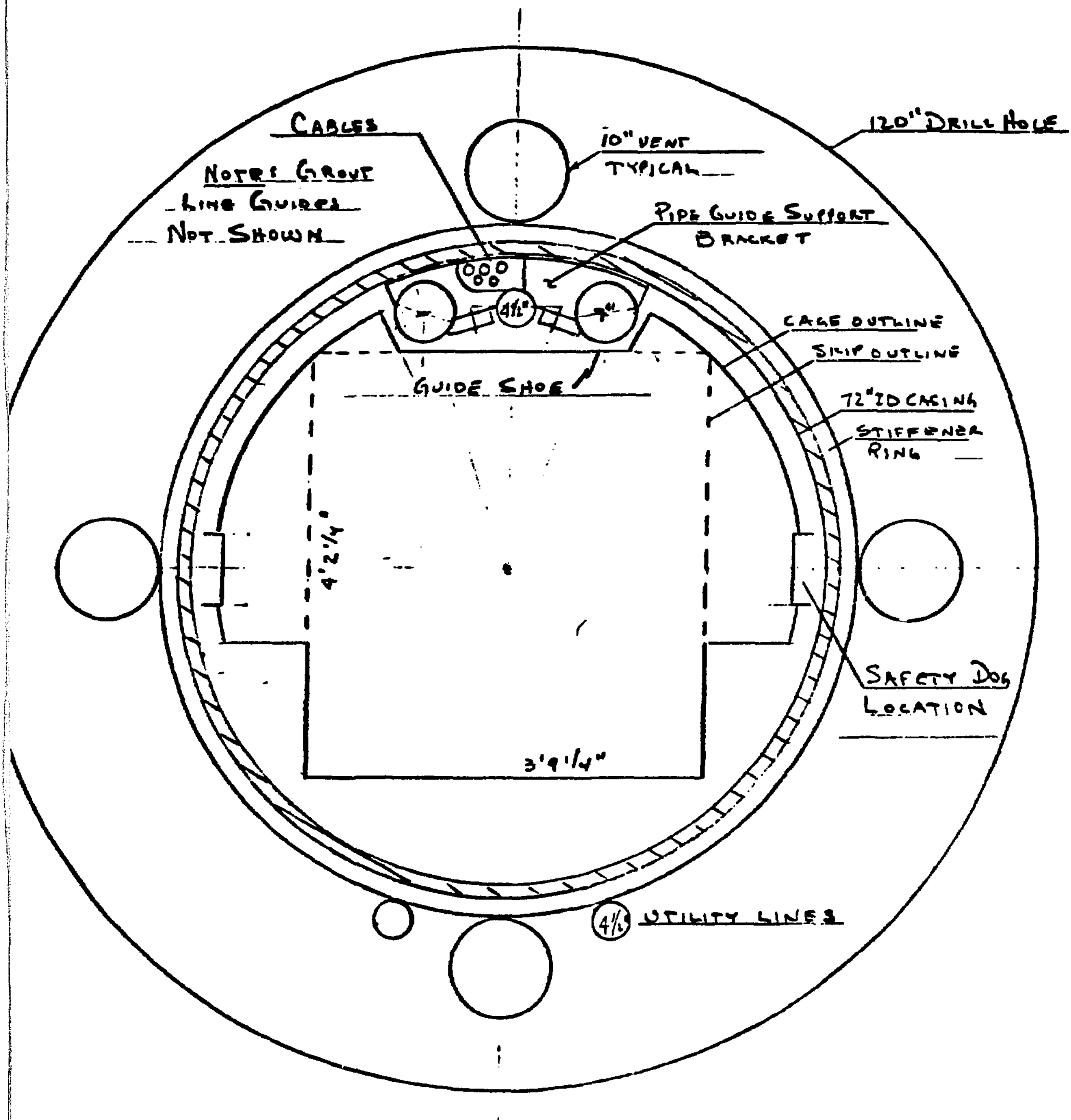
Our cost estimates show that it will be $215,000 cheaper to use the 98" casing design. The 98" casing installed and grouted cost will be $315,000 more than the 72". However, smaller mining items installation costs will subtract $530,000, for a total savings of $215,000 as shown on the attached estimate comparing the 120"/98" with the 120"/72" Standard Design. We have not estimated the cost of the 120"/72" Full Hole Design since it is less desirable than the Standard Design, but since more of the utility lines would have to be on the outside of the casing, and such installation is more costly due to being added in 40' lengths (as the 72" casing is) instead of as a continuous string, and welded to the 72" casing for support, the overall cost would be even more.

Therefore, because of the cost difference, the serious disadvantage of probably not being able to get to bottom with the secondary cage, the high noise levels from ventilating with compressed air, the high heat load into the chilled air lines due to radiation through pipe lines encased in cement grout, the possibility of losing one or more of the external pipe lines during casing running operations, less room in which to work, as well as the other disadvantages detailed in our earlier report, these systems in a 72" casing are considerably less attractive than that in the 98" casing.



FENIX & SCISSON, INC.
Mercury, Nevada
Exploratory Shaft Conceptual Design
Study Request No. 3 Addendum
72" Standard Skip/Cage Design

3/4"=1' 7/22/81



FENIX & SCISSON, INC.
Mercury, Nevada
Exploratory Shaft Conceptual Design
Study Request No. 3 Addendum
72" Full Hole Skip/Cage Design

3/4"=1'   7/22/81

COST COMPARISON OF 72" & 98" CASED HOLES
STUDY REQUEST NO. 3 ADDENDUM

	72"		98"		
	Shifts	K$	Shifts	K$	Diff.
MINING					
Pre-install (brackets / sets) in casing	---	$ 80.15	---	$ 52.38	
Run 4 x 6 guides in casing	10	115.00	10	115.00	
Run 4 x 4 guides in casing	---	---	10	94.84	
Run 4-1/2" & 7" pipes in casing	6	294.20	6	288.84	
Run 10" pipes on outside of casing	---	911.62	---	---	
Weld guides in shaft	25	111.00	25	222.00	
Fasten pipes in shaft	15	67.00	23	104.20	
Run 26" vent line in casing	---	---	3	144.58	
Weld 26" vent line to sets	---	---	5	22.00	
SUBTOTAL	56	$1,578.97	82	$1,048.84	($530.13)
DRILLING					
Cased cost inc., welding, grout, casing jacks, rig time & required spt.		9,975.64		10,290.99	315.35
		$11,554.61		$11,339.83	$214.78

NOTE: All costs are 1984

LANGLEY RESEARCH CENTER FACSIMILE TRANSMISSION 11-1

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2. Material should be typed or neatly printed in black ink (pencil and colored ink not acceptable), and the material should be submitted on 8½ x 11 inch white bond paper (Xerox copies are acceptable if readable).
3. Refer any questions to Extension 3167.
4. Mail or deliver to the Telecommunications Office – Mail Stop 196.

TO:	PHONE:	OFFICE USE ONLY
Mr. Ned Smithberg	546-9041	

AT:

- ______ NASA Headquarters
- ______ NASA Lewis Research Center
- ______ NASA Ames Research Center
- ______ NASA Wallops
- ______ Kennedy Space Flight Center
- ______ Johnson Space Flight Center
- ______ Goddard Space Flight Center
- ______ Marshall Space Flight Center
- ______ Dryden Flight Research Center
- ______ Jet Propulsion Lab

STATION NUMBER: 928-2169

MESSAGE NUMBER: 11

PAGES: TOTAL 4; LEAD and (# pages) 3

DATE: 8-3-81

OTHER (If not NASA installation) (Please give Name, Address, and Facsimile Number)

Mr. Ned Smithberg (DOE)
P.O. Box 498
Mercury, Nevada 89023

REQUESTER	PHONE	MAIL STOP
J. Yu	X2617	460

REMARKS:

Information requested on noise prediction of a 10" dia. air jet

NASA Langley Form 173 (October 1976)

TABULATION OF SOUND PRESSURE LEVEL FROM NASA INFORMATION

Octave Band Freq. (Hz)	dB From Graph	dBA Corr. From Table*	dBA
31.5	65	-39	26
40	72	-35	37
50	75	-30	45
63	78	-26	52
80	81	-22	59
100	82	-19	63
125	83	-16	67
160	84	-13	71
200	84	-11	73
250	84	- 9	75
315	84	- 7	77
400	83	- 5	78
500	82	- 3	79
630	82	- 2	80
800	82	- 0.8	81
1,000	81.5	0	81.5
1,250	81	+ 0.6	81.6
1,600	80	+ 1	81
2,000	79	+ 1.2	80.2
2,500	78	+ 1.3	79.3
3,150	77	+ 1.2	78.2
4,000	76	+ 1	77
5,000	75	+ 0.5	75.5
6,300	74.5	- 0.1	74.4
8,000	74	- 1.1	73
10,000	72	- 2.5	69.5
12,500	71	- 4.0	67
16,000	69	- 7.0	62

Calculated dBA level is 89 dBA (without muffler, etc.)

Add for sound pres. level + 4 (Worst case adjacent to discharge point)

93 dBA

*Noise and Vibration Control by Beranek, McGraw Hill

1. Total Power, $\dot{W}$

$$W = 6.67 \times 10^{-5} \rho_j \frac{V_j^8 A_j}{c_\infty^5} F\left(\frac{V_j}{c_\infty}\right) \qquad (1)$$

ρ_j = jet exit density
V_j = jet exit velocity
A_j = jet exit area
c_∞ = ambient sound speed
F = power correction factor, a function of V_j/c_∞

$D = 10''$ Diam $\Rightarrow A_j = 5.07 \times 10^{-2}\ m^2$

$Q = 10^4$ CFM $\Rightarrow V_j \approx 93$ m/sec

$T_\infty = 60°F \Rightarrow c_\infty = 341$ m/sec

$\rho_j \approx .075$ lbs/cu ft $= 1.21\ kg/m^3$

$F = 0.74$

Thus, $W = 3.7 \times 10^{-3}$ watt

PWL (re 10^{-12} watt) = 95.7 dB

2. Power Spectrum, 1/3 octave band

see Fig. 1.

Fig 1 is a typical power spectrum in 1/3 octave band to be used for computing typical SPL in a reverberant field. For an observer close to the source, in the direct field of the p-3

P.2

source, the actual spl may be 4 dB higher than the reverberant spl.

Reference:

NASA ANOPP (Aircraft noise prediction program) manual, jet noise module, 1981 (currently under revision)

FIG. 1 1/3 oct. band power spectrum for a 10" diam. 305 fps air jet.

Reynolds Electrical & Engineering Co., Inc.
P. O. Box 14400 • Las Vegas, Nevada 89114

IN REPLY REFER TO
566-01-646

AUG 5 1981

Mr. F. D. Waltman
Fenix & Scisson, Inc.
Post Office Box 498
Mercury, NV 89023

PREDICTED NOISE LEVEL FROM COMPRESSED
AIR VENTILATION AT SHAFT BOTTOM

As per your conversation with A. R. Frazier, the calculations to predict the noise level generated at the end of the proposed compressed air ventilation system have been corrected dimensionally. The overall result is about a 12 decibel downward shift in expected noise levels. Assumptions that apply are noted in the enclosure. Please note also that the normally expected 6 dB decrease in the noise level with each doubling of the distance away from the source probably would not hold. It would probably be significantly less due to reverberation. As before, the calculations do not include noise generated by the compressor.

Should you have any questions, please call A. R. Frazier at 986-0030.

for Arden E. Bicker, Manager
Environmental Sciences Department

AEB:ARF:cak

Enclosure
As stated

REECo
AN EG&G COMPANY

CALCULATION OF PREDICTED NOISE LEVEL

Assumptions:

1. The velocity profile, V^8 holds
2. Flow is not choked
3. Discontinuities do not exist
4. Directivity factor Q, is 4
5. Personnel are only three feet away from duct end at start of work
6. Six dB per octave slope
7. Muffler performance as shown
8. Work area is very reverberant
9. Six dB drop-off per doubling of distance from source will not hold

Constraints:

1. 10,000 cfm of air delivered
2. Delivery pressure is 25 psi
3. Elevation is 3500 ft. above MSL
4. Duct diameter is 10 inches

Acoustical Power at Source: $w = \left[\frac{\rho S V^8}{C^5}\right]\left[\frac{hp}{550 \text{ ft}\cdot\text{lb/sec}}\right]\left[\frac{746w}{hp}\right]$

Where:

ρ is air density; lbs/cu ft divided by 32.2 ft/sec^2

S is area of opening, sq ft (.55 sq ft)

V is flow velocity, ft/sec (303 ft/sec)

C is speed of sound in the gas, ft/sec (1104 ft/sec)

hp is horsepower

Specific Volume

$$\left[\frac{14.7}{25 + 12.9}\right] \left[\frac{460 + 80}{460 + 70}\right] \times 13.35 = 5.3 \text{ cu ft/lb}$$

$$\rho = \frac{0.190 \text{ lb/cu ft}}{32.2 \text{ ft/sec}^2} = 0.0059 \text{ lb } \frac{\text{sec}^2}{\text{ft}^4}$$

Speed of Sound: $C = C_o + 0.6\ t$

$C_o = 1087.9$ ft/sec

$t = C^0$

$C = 1087.9 + 0.6 \times 26.7 = 1104$ ft/sec

$$\text{Power, } w = \frac{\rho S V^8}{C^5} = \frac{(0.0059)(.55)(303)^8(746)}{(1104)^5(550)} = 190.67$$

$$\text{Power Level, } Lw = 10 \log \left[\frac{190.67}{10^{-12}}\right] = 142.8 \text{ dB}$$

Assume work space is 10' x 10' x 10' (1000 cu ft)

Room constant R=30

Distance from source is 3 ft

Q = Directivity factor

$$\text{Sound pressure level, } Lp = Lw + 10 \log \left[\frac{Q}{4\pi r^2}\right] + \left[\frac{4}{R}\right] + 10.5$$

$$Lp = Lw + 10 \log \left[\frac{4}{4\pi(3)^2}\right]\left[\frac{4}{30}\right] + 10.5$$

$$Lp = 142.8 \text{ dB} + 2.8 \approx 146$$

$$f_{max} = 0.2 \frac{v}{d}$$

Where f_{max} is frequency of highest level

v is velocity (303 ft/sec)

d is diameter of opening (ft)

$$f = 0.2 \frac{303}{.833} = 75 \text{ Hz}$$

Assume 6 dB/octave slope

Octave band frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Lp (dB)	146	140	134	128	122	116	110	104
dBA correction	-26	-16	-9	-3	0	+1	+1	-1
	120	124	125	125	122	117	111	103

Calculated dBA level is ≈ 130 dBA at 3 ft

Assume typical muffler

Octave band frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Lp (dB)	146	140	134	128	122	116	110	104
With muffler	-15	-15	-17	-20	-22	-28	-34	-40
	131	125	117	108	100	88	76	64
dBA correction	-26	-16	-9	-3	0	+1	+1	-1
	105	109	108	105	100	89	77	63

Calculated dBA level is = 114 dBA at 3 ft

Expected potential exposure of person wearing ear plugs and ear muffs is 88 dBA at 3 ft

Maximum allowable working time at 88 dBA is 6 hours/8 hours

No attempt has been made to predict noise peculiar to the compressor

APPENDIX F

FENIX & SCISSON, INC.
STUDY REQUEST NO. 2
SHAFT INTERNALS, HOISTING, AND HEADFRAME FOR EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY

DRAFT FOR REVIEW

FENIX & SCISSON, INC.

STUDY REQUEST NO. 2

SHAFT INTERNALS, HOISTING AND HEAD FRAME
FOR
EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY

The proposed shaft for the NTS consists of a 120" diameter drilled shaft with a 98" I.D. casing installed and grouted from bottom to surface. Inside of the casing will be shaft sets of structural steel to support shaft guides, compressed air, water, pump discharge, ventilation, electric power and scientific cable pipe lines, as well as signal and communication systems. Design calculations and specifications are provided as separate items at the end of this study.

Our recommended design consists of two hoisting compartments (See Attached Drawing) with one being a main hoisting compartment primarily designed for muck hoisting, and men during shift change, and the second for hoisting men and materials during shift, and also as an emergency escape way in case of loss of main power supply or other emergency underground requiring evacuation of the men.

The shaft sets, consisting of structural steel beams, have been designed to hold the weight of all the interior lines, including the weight of water in the water and pump discharge lines, plus a dynamic load that would occur should the hoist rope break causing the safety dogs to engage on the guides going at full load and full speed down, without bending. These sets will be pre-installed in the 98" casing at the point of fabrication, and kept aligned as the casing is installed in the drilled hole.

Guides for the skip and cages (muck bucket and elevator) will be square or rectangular structural steel tubing run continuously from surface to total depth. Several pipe lines for compressed air, construction water, pump discharge, power and scientific cables will be installed from the surface to total depth and will consist of oil field pipe lines. One 26" O.D. x 3/16" wall pipe, with one - 1" x 4" lifting ring per joint will be run from surface to total depth for a ventilation line. All of these lines will be installed from the surface by lowering them with a drill rig or crane and welding on new joints to form a continuous line, and will be self-supporting at total depth. They will be landed on strongbacks at ground level temporarily. As the miners proceed down hole, they will weld support brackets to the shaft sets every 20' for additional support and safety.

An electric signal system will be provided for each hoist and will consist of bell knockers spaced approximately every 500' down the shaft and will be equipped with a wire rope signal cord so they can be rung from anywhere in the shaft. A separate cage radio system will also be supplied.

Hoists for the shaft have been selected based on estimated skip and cage weights, muck weight and hoisting speed. These have been computer designed by a major hoist manufacturer based on information supplied by us. The main hoist has been tentatively estimated at 1500 HP with a rope speed of 1500 feet per minute (fpm), and the emergency hoist has been estimated at 500 HP with a rope speed of 1200 fpm. They will be located at a distance from the shaft to give no more than a 1-1/4^o fleet angle on the hoist drum. Both hoists will be equipped with standard controls including dead man switches, Lilly Controllers to prevent overrun and overspeed, and caliper type brakes. They will be "First Class" hoists as defined in the California Mine Safety Orders. Power for both hoists will consist of main line power from a substation. The emergency hoist will also be connected to an alternate, diesel powered generator set in case of main power failure. This will allow anyone underground to be hoisted to the surface, as well as keeping the ventilation blowers running. Manufacturers' information for hoists and related equipment are provided at the end of this study.

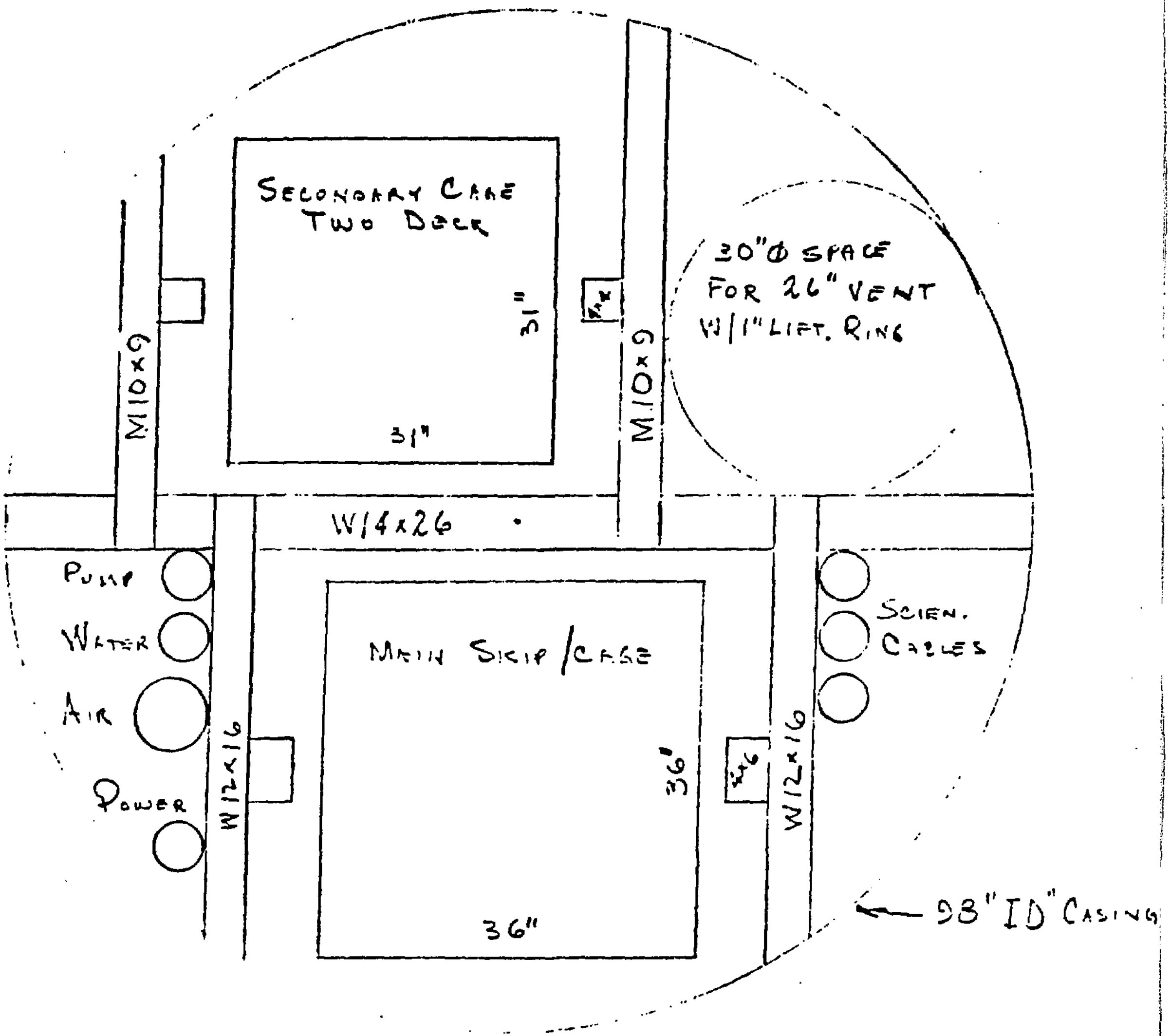
The headframe will be 90' high and equipped with two offset head sheaves for the two compartments. A dumping track will cause the bottom dump skip to open and dump the hoisted muck into a chute and onto the ground. A muck bin is not considered necessary for this phase due to the relatively small volume of muck to be hoisted. Instead, it will be picked up with a front end loader for disposal. As an alternate, a truck can be parked under the chute to catch the muck. The headframe shall meet the requirements of the California Mine Safety Orders.

The main skip and cage will have a cross-section of about 3' x 3' and the skip will be about 10' long. This will hold an estimated 10,000 pound load. The emergency cage will be about 31" x 31" and will be a two deck cage to hold a total of 8 men. Both will be equipped with safety dogs to hold the cages from falling in case of hoist rope breakage. Landings at ground level and the mining level will be enclosed by a fence and entrance will be through a gate that will be kept closed except for traffic under the control of the skiptender.

Ventilation will be provided by means of centrifugal type blowers down the 26" pipeline in the amount of ± 22,000 cfm. The air will be chilled on the surface to provide cool air down hole. Since the vent line is pre-installed before men go down hole, immediate ventilation is provided. A space of 30" diameter has been provided in the shaft to allow lowering of the 26" O.D. vent line, which will have a maximum O.D. of 28" due to lifting rings required on each joint. During lowering, the vent line will have the bottom end tapered somewhat to allow it to slide off any shaft set it may hit. This tapered portion will be cut off later. The blowers will be connected to both the main and auxiliary power supplies so that ventilation will be provided down shaft at all times.

Air compressors to provide air for mining equipment underground will be furnished. Two 1500 cfm, 100 psi, electric driven compressors will be located on the surface near the shaft, but at a distance so that noise levels will not cause inconvenience. They will be connected to the main power supply, with one of them also connected to the auxiliary power supply in case of main power loss. As an alternate, a smaller (600 - 900 cfm) diesel powered standby compressor could be utilized to provide emergency compressed air.

A down hole Kobe pump unit will provide for pumping of any water produced up to 100 gpm. This will be operated by a surface installed Triplex pump and feed tank for the power fluid. This unit will be located near the shaft collar in a non-interference zone.



Fenix & Scisson, Inc.
Mercury, Nevada
Exploratory Shaft Conceptual Design
Study Request No. 2
Preliminary Shaft Design

3/4"=1' 7/7/81

CAPITAL EQUIPMENT BUDGET ESTIMATES

Study Request No. 2

ITEM	Est. Cost FY 1983 K$	Lead Time	FY 1984 K$	Lead Time	If Rented FY 1983 K$/Mo.	If Rented FY 1984 K$/Mo.
90' Headframe w/dump scrolls	150	8 mos.				
1500 HP Main Hoist	1,120	14 mos.				
Skip/Cage Combs.	77	14 mos.				
500 HP Secondary Hoist	528	12 mos.				
2 Deck Cage	38	12 mos.				
2 -20000 cfm Centrifugal blowers	264	6 mos.				
2 - Pump Units (Triplex/Kobe)			304	4 mos.		
2 - 1500 cfm Compressors			274	2 mos.		10.2
1 - 15 Ton Fork Lift			122	3 mos.		5.5
1 - 5CY Front-End Loader			289	3 mos.		12.2

Calculate Shaft Sets

Assume hoist rope breaks allowing safety dogs to set. Conveyance traveling down shaft at 1500 fpm with total load including skip and cage of 20,000 pounds, (worst case). Conveyance to stop in a distance of 8 inches. One half of the load will be transmitted to the nearest shaft set, with the remainder distributed over the remaining sets through the shaft guides and pipelines.

Formulas Used

$$V^2 = Vo^2 + 2as$$ (velocity, accel., distance)

$$F = \frac{Wa}{g} = Ma$$ (force, weight, accel.) (gravity)

$$Sx = \frac{M}{F_b}$$ (Elastic Section Modulus, mass) (Max. allow. bending stress)

$$R_1 = \frac{Pb^2}{l^3}(3a + b)$$ (reaction, load, distances to load) (length of beam)

$$R_2 = \frac{Pa^2}{l^3}(a + 3b)$$ (reaction 2, etc.)

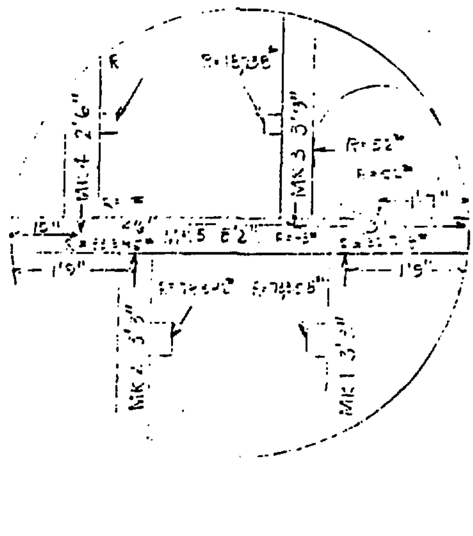
$$M_2 \text{ (max)} = \frac{Pa^2b}{l^2}$$ (Max moment in beam)

F_b = Allowable bending stress = 24 Ksi

All beams are fixed at both ends.

For main hoist V = 1500 fpm = 25 fps; W = 20,000#; s = 8"

For secondary hoist V = 1200 fpm = 20 fps; w = 10,000#; s = 8"



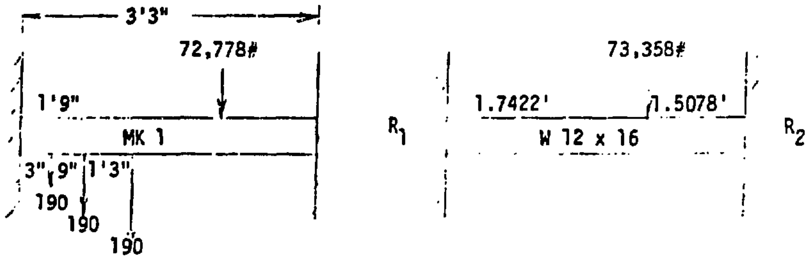
MAIN HOISTING COMPARTMENT SHAFT SETS

$V^2 = 2as,\ 25^2 = 2a\frac{8}{12}\ ;\ a = 468.75$ fps/sec.

$F = \frac{20{,}000 \times 468.75}{32.2} = 291{,}149$ lbs. on 2 guides
$145{,}575$ lbs. on 1 guide

Beam is fixed at both ends w/eccentric loading.
Convert several loads to one equivalent load.

Calc MK 1 Take 1/2 of dynamic load per set. $\frac{145{,}575}{2} = 72{,}778\#$



Total load on set $190 + 190 + 190 + 72{,}778 = 73{,}358\#$

$\Sigma mom_{R_1} = 190 \times .25 + 190 \times .75 + 190 \times 1.25 + 72{,}778 \times 1.75 = 127{,}806'\#$

$a = \frac{127{,}806}{73{,}358} = 1.7422'\ ;\ b = 1.5078'$

$M_2 = \frac{Pa^2b}{l^2} = \frac{73{,}358 \times 1.7422^2 \times 1.5078}{3.25^2} = 31{,}784'\#$

$31{,}784 \times \frac{12}{1000} = 381.41$ Kip In.

$Sx = \frac{M}{F_b} = \frac{381.41}{24} = 15.892\ in^3$

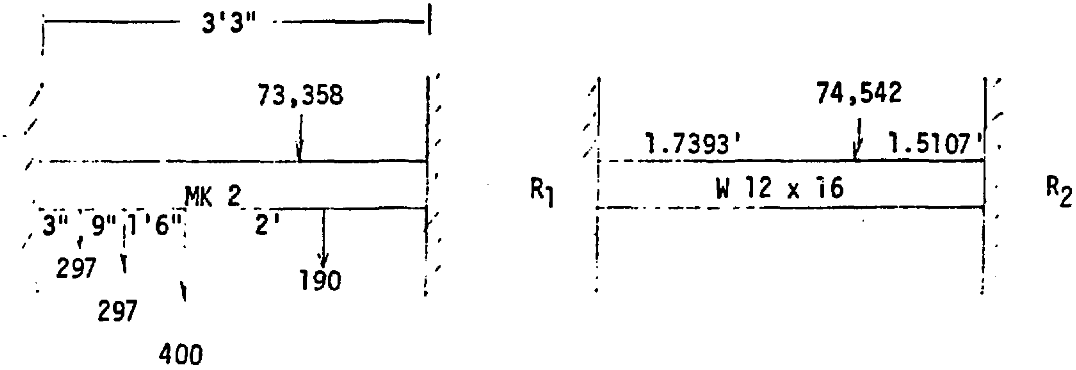
From Allowable Stress Design Selection Table use W 12 x 16 Beam.

$R_1 = \frac{Pb^2}{l^3}(3a + b) = \frac{73{,}358 \times 1.5078^2(3 \times 1.7422 + 1.5078)}{3.25^3} = 32{,}717.78\#$

$R_2 = \frac{Pa^2}{l^3}(a + 3b) = \frac{73{,}358 \times 1.7422^2(1.7422 + 3 \times 1.5078)}{3.25^3} = 40{,}640.22\#$

Check $73{,}358\ \#$

Calc. MK 2



Total load on set 297 + 297 + 400 + 190 + 73,358 = 74,542#

$\Sigma_{mom_{R_2}}$ = 297 x .25 + 297 x .75 + 400 x 1.5 + 190 x 2 + 73,558 x 1.75 = 129,654'#

$a = \frac{129,654}{74,542} = 1.7393'; \quad b = 1.5107'$

$M_2 = \frac{Pa^2b}{l^2} = \frac{74,542 \times 1.7393^2 \times 1.5107}{3.25^2} = 32,252'\#$

$32,252 \times \frac{12}{1000} = 387.02$ Kip In.

$Sx = \frac{M}{F_b} = \frac{387.02}{24} = 16.13 \text{ in}^3$

From Allowable Stress Design Selection Table use W 12 x 16 beam.

$R_1 = \frac{Pb^2}{l^3}(3a + b) = \frac{74,542 \times 1.5107^2}{3.25^3}(3 \times 1.7393 + 1.5107) = 33,345.11\#$

$R_2 = \frac{Pa^2}{l^3}(a + 3b) = \frac{74,542 \times 1.7393^2}{3.25^3}(1.7393 + 3 \times 1.5107) = \underline{41,196.89\#}$

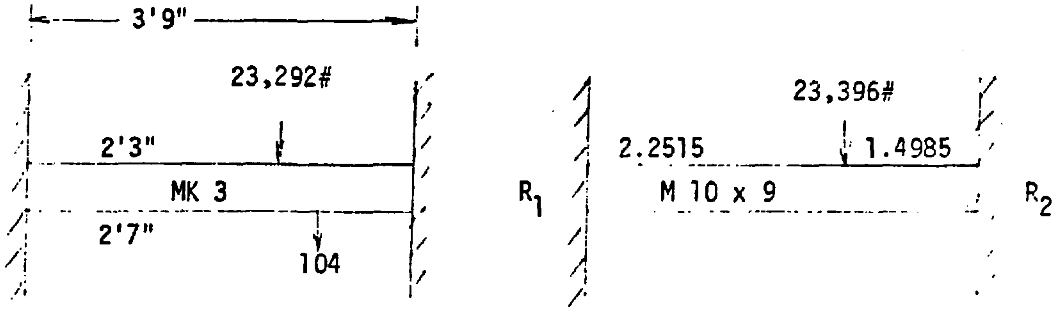
Check 74,542 #

SECONDARY HOISTING COMPARTMENT SHAFT SETS

$V^2 = 2as;\ 20^2 = 2a\frac{8}{12};\ a = 300$ fps/sec

$F = \frac{10{,}000 \times 300}{32.2} = 93{,}168\#$ on two guides
$= 46{,}584\#$ on one guide

Calc. MK 3 Take 1/2 of dynamic load $\frac{46{,}584}{2} = 23{,}292\#$



Total load on set $23{,}292 + 104 = 23{,}396\#$

$\Sigma mom_{R_1} = 23{,}396 \times 2.25 + 104 \times 2.5833 = 52{,}676'\#$

$a = \frac{52{,}676}{23{,}396} = 2.2515';\ b = 1.4985'$

$M_2 = \frac{Pa^2b}{l^2} = \frac{23{,}396 \times 2.2515^2 \times 1.4985}{3.75^2} = 12{,}638\#$

$\frac{12{,}638 \times 12}{1000} = 151.66$ Kip In.

$Sx = \frac{M}{F_b} = \frac{151.66}{24} = 6.3190\ in^3$

From Allowable Stress Design Table use M 10 x 9 beam.

$R_1 = \frac{Pb^2}{l^3}(3a + b) = \frac{23{,}396 \times 1.4985^2}{3.75^3}(3 \times 2.2515 + 1.4985) = 8221.92\#$

$R_2 = \frac{Pa^2}{l^3}(a + 3b) = \frac{23{,}396 \times 2.2515^2}{3.75^3}(2.2515 + 3 \times 1.4985) = 15{,}174.09\#$

Check $= 23{,}396\ \#$

Calculate R_1 & R_2 without dynamic load since both skips will not engage dogs at same time. Use these numbers in calculations of MK 5.

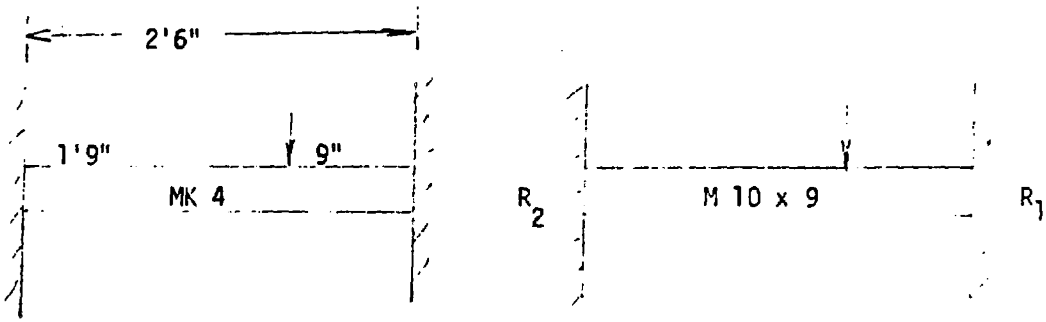
$$R_{1_{alt}} = \frac{2.5833}{3.75} \times 104 = 71.64 + 1/2 \text{ weight of beam}$$

$$= 71.64 + \frac{3.75 \times 9}{2} = 88.52\#$$

$$R_{2_{alt}} = \frac{1.1667}{3.75} \times 104 = 32.36 + 1/2 \text{ weight of beam}$$

$$= 32.36 + \frac{3.75 \times 9}{2} = 49.24\#$$

Calc. MK 4



Total load on set 18,364#. Will have less load than MK 3, so use same size beam, M 10 x 9

$$R_1 = \frac{Pb^2}{l^3}(3a + b) = \frac{18,364 \times 1.75^2}{2.5^3}(3 \times .75 + 1.75) = 14,397.38\#$$

$$R_2 = \frac{Pa^2}{l^3}(a + 3b) = \frac{18,364 \times .75^2}{2.5^3}(0.75 + 3 \times 1.75) = 3,966.62\#$$

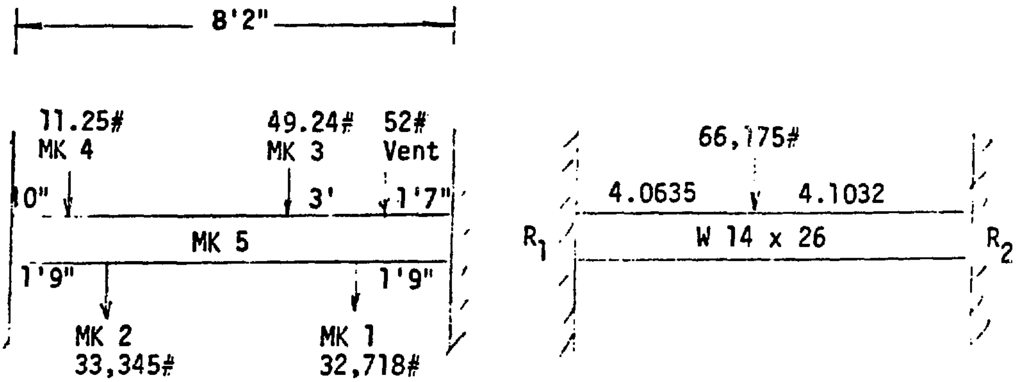
Check 18,364 #

$$R_{1_{alt}} = 1/2 \text{ of beam weight} = \frac{2.5 \times 9}{2} = 11.25\#$$

$$R_{2_{alt}} = R_{1_{alt}} = 11.25\#$$

SHAFT CENTER BEAM

Calc. MK 5



Total load on beam = 11.25 + 33,345 + 49.24 + 32,718 + 52 = 66,175.49

$$\Sigma_{mom_{R_1}} = 11.25 \times \frac{10}{12} + 33,345 \times 1.75 + 49.24 \times \frac{62}{12} + 32,718 \times \frac{77}{12} + 52 \times \frac{80}{12}$$

$$= 268,903'\#$$

$$a = \frac{268,903}{66,175} = 4.0635'; \quad b = 4.1032'$$

$$M_1 = \frac{Pab^2}{l^2} = \frac{66,174 \times 4.0635 \times 4.1032^2}{8.1667^2} = 66,880'\#$$

$$66,880 \times \frac{12}{1000} = 814.56 \text{ Kip In.}$$

$$Sx = \frac{M}{F_b} = \frac{814.56}{24} = 33.94 \text{ in}^3$$

From Allowable Stress Design Selection Table use W 14 x 26 Beam.

INTERNAL VERTICAL UTILITY AND GUIDE LINES

Calculate 4" x 4" x 1/4" structural tubular guide for self-support at 3500'.

From supplier, cross sectional area = 4.65 in^2
weight = 12.21#/ft., A 500 grade B = 46,000 psi yield

12.21 x 3500 = 42,735#
4.65 x 46,000 = 213,900#
$\frac{213,900}{42,735}$ = 5.005 factor safety

Calculate 4" x 6" x 1/4" structural tubular guide

Cross sectional area = 6.25 in^2, weight = 15.62#/ft.

15.62 x 3500 = 54,670#
6.25 x 46,000 = 287,500#
$\frac{287,500}{54,670}$ = 5.259 factor safety

Calculate 26" x 3/16" vent line

From manf., cross sectional area 21.10 in^2;
weight 51.7#/ft., A 36 grade = 36,000 psi yield

51.7 x 3500 = 180,950#
21.10 x 36,000 = 759,600#
$\frac{759,600}{180,950}$ = 4.198 factor safety

Calculate K55, 4-1/2", 9.5#/ft, .20" thick tubing. See note below.

Calculate K55, 7", 20.0#/ft., .272" thick casing. See note below.

9.5 x 3500 = 33,250#
20.0 x 3500 = 70,000#

Manufacturers catalog shows the joint strength (weakest point) to be:

4-1/2" = 112,000# ÷ 33,250# = 3.37 F.S.

7" = 254,000# ÷ 70,000# = 3.63 F.S.

Rexnord

June 29, 1981

Fennix & Scisson
Post Office Box 498
Mercury, Nevada 89023

Process Machinery Division
P.O. Box 383
Milwaukee, WI 53201
TELEX 2-6601
My No 414 643-3486

ATTENTION: MR. NORD SMITHBERG

SUBJECT: MINE HOIST ESTIMATE

Dear Mr. Smithberg:

In response to your telephone call of 6/26/81, enclosed is a copy of a computer run that I made for the larger single drum hoist. Also enclosed are two prints covering a similar sized hoist so that you have dimensional data.

SKIP CAGE LOAD	-	10,000 Lbs.
SKIP CAGE WEIGHT	-	10,000 Lbs.
HOISTING DISTANCE	-	3,500 Ft.
ROPE SPEED	-	1500-2000 FPM
UNBALANCED OPERATION		

Also, you had asked for data on a small single drum hoist for light loads and escape duty. Enclosed are 2 prints on a similar duty unit that we built for CF&I Steel The estimated cost of a unit like this would be about $200,000.

Delivery on single drum hoists would be about 9-10 months at the present time.

If we can be of any further assistance to you, please feel free to contact us.

Very truly yours,

Gary Beerkircher

Gary Beerkircher, P.E.
Sales Manager
Process Equipment and Systems
Mills and Hoists

/aa

cc: Jim Mascuch
Bill Brown

Enclosures

1

SLOPE HOIST ANALYSIS

```
CODING---
DRUM NUMBER-
  1=SINGLE DRUM
  2=DOUBLE DRUM
MOTOR NUMBER-
  1=DC MOTOR
  2=AC MOTOR
ROPE NUMBER-
  1=ROUND STRAND
  2=FLATTENED STRAND
  3=LOCKED COIL
  4=ENTER NEW ROPE
BALANCE NUMBER-
  1=BALANCED HOIST
  2=UNBALANCED HOIST

ENTER SLOPE ANGLE(DEG),LENGTH OF THE SLOPE(FT),
DRUM NO.,MOTOR NO.,ROPE NO.,SAFETY FACTOR

 ? 90.0,3500.0,1,1,2,4.0
ENTER DRUM DIA/ROPE DIA RATIO,BALANCE NUMBER

 ? 80.0,2
ENTER ACCELERATION,RETARD,CREEP TIME,IDLE TIME

 ? 2.0,3.0,6.0,10.0

ENTER NO. OF WTS.,MATERIAL WT.VALUES(LBS),CAR WT. VALUES(LBS)
AND THE CORRESPONDING VELOCITIES(FPS)

 ? 2,10000.0,10000.0,30.0,10000.0,10000.0,25.0

 LOAD WT.   CAR WT.   VELOCITY

   10000     10000          30
   10000     10000          25

ROPE   FACE    DRUM    RMS    PEAK
DIA    WIDTH   DIA     HP     HP
1.125  198     90.000  1478   1948
1.125  148     90.000  1238   1626
STOP.
*RDY*
```

Handwritten annotations: "COMPUTER RUNS SHOW H.P. FOR TWO DIFFERENT SPEEDS"; face width values 198 and 148 struck through, with "60"" written below and an arrow; "HOIST COST — MECH. – $450,000. / ELECT. – 380,000. / $830,000."

PROGRAM HOISTS 7/15/81 Telefax No.

From Rexnord 702/986-9041

SLOPE HOIST ANALYSIS Fennix & Scisson

CODING--- Nord Smithberg

DRUM NUMBER- 702-986-6987

1=SINGLE DRUM

2=DOUBLE DRUM

MOTOR NUMBER- Emergency Hoist

1=DC MOTOR

2=AC MOTOR Area 25

ROPE NUMBER-

1=ROUND STRAND

2=FLATTENED STRAND

3=LOCKED COIL

4=ENTER NEW ROPE

BALANCE NUMBER-

1=BALANCED HOIST

2=UNBALANCED HOIST

7/9/81

ENTER SLOPE ANGLE(DEG),LENGTH OF THE SLOPE(FT),
DRUM NO.,MOTOR NO.,ROPE NO.,SAFETY FACTOR

? 90,3500,1,1,2,4

ENTER DRUM DIA/ROPE DIA RATIO,BALANCE NUMBER

? 60,2

ON OR ABOUT LINE NUMBER 00380, ILLEGAL DATA-REENTER REMAINDER.

? 60,2

ON OR ABOUT LINE NUMBER 00380, MORE DATA THAN LIST-REENTER DATA

? 60,2

ENTER ACCELERATION,RETARD,CREEP TIME,IDLE TIME

? 1,1,6,30

ENTER NO. OF WTS.,MATERIAL WT.VALUES(LBS),CAR WT. VALUES(LBS)
AND THE CORRESPONDING VELOCITIES(FPS)

? 1,4600,5400,12

LOAD WT.	CAR WT.	VELOCITY
4600	5400	12

60" S.D. } $320,000
300 H.P. } Est.

ROPE DIA	FACE WIDTH	DRUM DIA	RMS HP	PEAK HP
.875	25"	52.500	304	397

STOP. 52 5 Layers

RDY

@ 1260 FPM

BYE

CT = 00.05 SU-A = 3.3

KCH = 3 60" S.D @ 500 H.P.

R326202 LOG OFF. 15.10.22.

$ 400,000 Est.

UNINET NODE 23 CHNL 40E37 FROM ROXNUAD (BILL BROWN)

SERVICE : 65

```
UCS  07/09/81. 15.13.37. R116
USER NUMBER:R326202
[illegible]
PROJECT-ID REQUIRED:BILL
*RDY-FOR*
OLD,HOISTS
*RDY-FOR*
RUN
```

EMERGENCY HOIST
AREA 25

```
07/09/81. 15.14.26.
PROGRAM  HOISTS

1

SLOPE HOIST ANALYSIS
```

@ 1200 FPM

```
CODING---
DRUM NUMBER-
 1=SINGLE DRUM
 2=DOUBLE DRUM
MOTOR NUMBER-
 1=DC MOTOR
 2=AC MOTOR
ROPE NUMBER-
 1=ROUND STRAND
 2=FLATTENED STRAND
 3=LOCKED COIL
 4=ENTER NEW ROPE
BALANCE NUMBER-
 1=BALANCED HOIST
 2=UNBALANCED HOIST
```

20 x 328 = 500 H.P.
13
60" x 50" 4 500 H.P.
$ 500,000 FGT.
559 K

```
ENTER SLOPE ANGLE(DEG),LENGTH OF THE SLOPE(FT),
DRUM NO.,MOTOR NO.,ROPE NO.,SAFETY FACTOR

? 90,3000,1,1,2,4
ENTER DRUM DIA/ROPE DIA RATIO,BALANCE NUMBER

? 60,2
ENTER ACCELERATION,RETARD,CREEP TIME,IDLE TIME

? 1,1,6,30

ENTER NO. OF WTS.,MATERIAL WT.VALUES(LBS),CAR WT. VALUES(LBS)
AND THE CORRESPONDING VELOCITIES(FPS)

? 1,4600,5400,13

LOAD WT.   CAR WT.   VELOCITY

4600       5400      13

ROPE   FACE    DRUM    RMS   PEAK
DIA    WIDTH   DIA     HP    HP
.875   251     52.500  328   421
STOP.
*RDY*
RUN
```

APPENDIX G

FENIX & SCISSON, INC.
STUDY REQUEST NO. 4
EXPLORATORY OPENINGS FOR
EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY

FENIX & SCISSON, INC.

STUDY REQUEST NO. 4

EXPLORATORY OPENINGS
FOR
EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY

Before the casing is cut, the ground surrounding the casing, especially at mining level, should be tested for ground water to determine amount and pressure. This will be done by setting up a diamond drill rig on the inside of the casing and drilling out through pre-installed grout ports to a depth of about 30' to 40'. Drilling will be done through a high pressure valve and packing gland arrangement so that if high pressure water is encountered, the drill rods can be withdrawn from the hole under controlled conditions, and the valve shut off to prevent flow into the shaft. A check valve will also be installed in the drill rod string to prevent back flow through it. The pattern of holes should be eight per row on a 45^{o} spacing, with several rows to adequately test a fairly thick section of strata. Alternate rows should have the holes staggered to provide more coverage. If little or no water is encountered, the casing may then be cut and mining proceed. If high volume or high pressure water is encountered, then pressure grouting should be done to reduce the flow/pressure to an acceptable level. The grouting procedure can only be finally determined after seeing what conditions actually exist, but in general would consist of a testing program using dye water to establish channels of communication and times required for communication between holes, flow rates and pumping pressures. From this would be determined type and amount of grout and equipment to be used and sequence of grouting. If additional holes were required, it is possible to weld high pressure nipples to the casing wall and core through the steel casing and on into the rock. Such holes very probably would be needed to test the formation after grouting to assure that water inflow would be at an acceptable level.

As mining progresses, probe holes should be drilled ahead of the face horizontally and angled up and down to test the strata for water. This procedure should be followed until such time as full confidence is acquired that no unexpected inflows of high volume and/or high pressure water will occur.

Written procedures and safety rules shall be established and followed, with all personnel being fully indoctrinated before any work begins. Full records of all operations and procedures will be kept, with a copy maintained on site at all times for use by the personnel involved in the testing and pressure grouting operations.

Twelve HQ x 2000' horizontal holes are to be drilled from the underground complex to test the area surrounding the shaft. Eight of these holes are to be rayed on a 45° pattern, and the other four are as yet unspecified. Holes are not to be drilled in the shaft pillar, but are to be located 5 to 10 shaft diameters away. Drifts have been specified to be 15' high, with widths as required.

A preliminary design has been developed as detailed on the enclosed drawing. Basically it consists of two rooms located at opposite ends of a drift driven to a distance of approximately 10 shaft diameters in each direction. Sufficient room has been allowed to set up two diamond drills in each room and drill two holes simultaneously without interference, using 20' core barrels. The drift has a cross-section of 15' x 15' giving sufficient room for storage of drill rods, auxiliary equipment and core wrapping and temporary core storage. It may be possible to reduce the drift width as more criteria becomes available, such as later possible use of this drift. A transformer alcove, a shop and a lunch room have been provided.

Mining will be accomplished using a two boom, full face drill jumbo with hydraulic drills. Rock will be broken using dynamite. Mucking while close to the shaft will be done with an Eimco 630 overshot loader directly into the skip pocket. As mining progresses outward, a Load-Haul-Dump (LHD) unit, similar to a front end loader, with a 3-1/2 c. y. bucket will be used to muck with. A rock bolt jumbo will be used to drill holes for the rock bolts.

Ground support will be provided by rock bolts and wire mesh. Bolt length will be approximately 1/2 the largest cross-section dimension of the opening. Shotcrete is not intended to be used, but may be used in selected areas if ground conditions call for it. Rock bolt anchors will be expansion shells since this is a hard rock. The rock bolt pattern will be finally determined after actual mining operations start, but is tentatively set to be on a 4' x 4' spacing in the drifts and possibly a 3' x 4' pattern in the larger rooms. Wire mesh will extend down the ribs to a point about 4' above floor level. Rock bolt diameter will match bolt length and loads expected or field determined.

It is recommended that ground movement instrumentation be installed consisting of extensometers to measure movement and possibly some type of strain meters to measure loading. These would be read periodically to detect excess ground movement and allow remedial measures to be taken to protect the facility and personnel before a major problem develops.

Diamond drills are anticipated to be either Longyear 44 with air motors or Longyear 38 EHS which are electric hydraulic operated. The latter are preferred due to lower noise levels and the built in infinite control of RPM, thrust and torque.

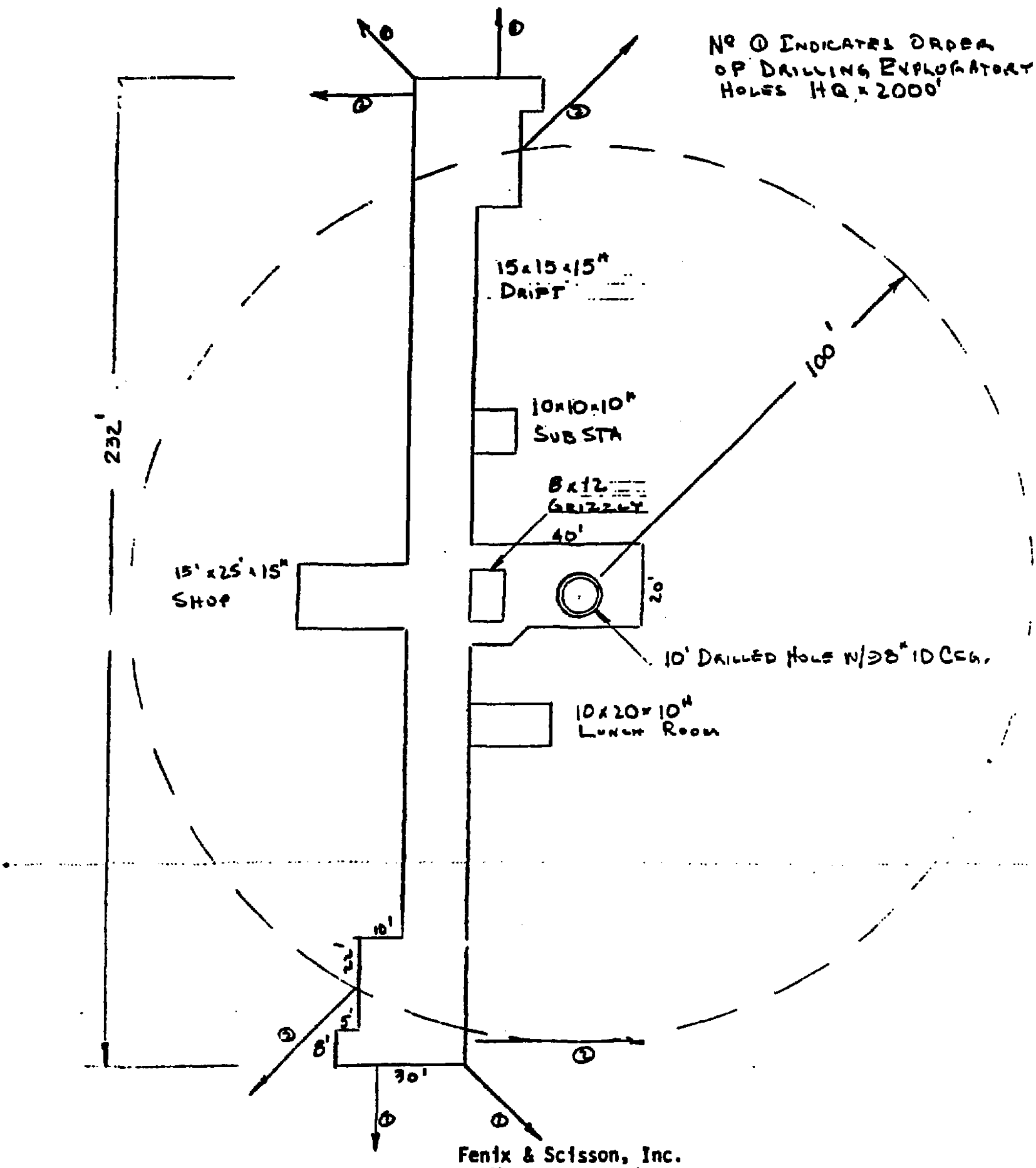
Past experience on the NTS has given us some information on straightness of horizontal diamond drill holes. These, however, have been NQ in size, and drilled in non-welded tuff. Straightness can be controlled in a vertical direction by changing speed of rotation, thrust, and reamer size. No control can be exercised in a horizontal direction. Since clockwise rotation of the drill normally causes the hole to go to the right, we usually start the hole approximately 1/2° to the left of the desired line. Attached is a compilation of some of the holes drilled on the NTS showing depth and deflection. Magnetic surveys should be taken every 20' to 30' and a plot maintained of the hole, being tied to true north by a transit down hole survey to where line-of-sight is lost.

Wrapping of the diamond drill core will be done using aluminum foil and beeswax to keep selected core samples in-situ for later tests. Special reporting forms will be used for diamond drilling showing depths, feet, recovery, simple geology, etc. A core report form is attached at the end of this report.

Based on criteria received, the project engineer will issue written programs and detailed drawings outlining the work to be done for approval by the Laboratory and DOE. After approval, these will be issued to the Contractor. Work Orders will be issued to authorize the work to proceed and to show the amount of money authorized for that work. Inspection will be provided on a continuous basis during all working hours, and 8 hour and 24 hour progress reports made. Copies of these are attached at the end of this report. These reports will also call to the attention of the project engineer, any deviation from plans. If the deviation is important, or needs more urgent action, the inspectors will phone the engineer for his instructions and guidance. Additional reports will be provided as required by the Laboratory or DOE.

The bottom 100' of the 98" shaft will be used to provide a skip loading station, a bulkhead to prevent spill rock from falling to the bottom into the sump, and a sump to collect water. The pumpline will extend through the bulkhead to the bottom, and the Kobe pump, which is installed in the pumpline, will pump water to the surface as required. The Kobe pump system consists of a Triplex pump on the surface which pumps fluid to the bottom-hole pump. This pump is composed of an engine and pump as a single assembly. The power fluid activates the engine which in turn drives the pump. Both the power fluid and produced fluid return to the surface. Therefore, no down hole electric power is required for the pump. The pump can also be changed from the surface by reversing the direction of the flow down the discharge line, which floats the pump out of the casing. A new pump is then dropped in the casing and floats to bottom. The system selected will pump 100 gpm from total depth.

A muck pocket will be excavated of a size to hold at least one drift round to provide surge capacity. It will be covered with a rail grizzly with openings of about 11" to prevent large boulders from entering the pocket and causing a hangup in the chute. Out of the bottom of the pocket will extend a short chute with an air operated gate at both the top and bottom. The chute will be sized to hold one skip-load to speed loading of the skip and prevent overfill and spill down the shaft.



Fenix & Scisson, Inc.
Mercury, Nevada
Exploratory Shaft Conceptual Design
Study Request No. 4
Exploratory Openings

1"=30' 7/10/81

CAPITAL EQUIPMENT BUDGET ESTIMATE

STUDY REQUEST NO. 4

ITEM	FY1984 Estimated Cost K$	FY1984 Estimated Cost Lead Time	FY1984 If Rental K$/Mo.
1 - LHD Unit	$ 198	3 mos.	$ 16.7
1 - 2 Boom Jumbo	426	3 mos.	21.3*
1 - Rock Bolt Jumbo	304	4 mos.	15.2*
4 - Skid Mounted Diamond Drills	228	2 mos.	
1 - Eimco 630 Loader	76	3 mos.	
TOTAL	$ 1,232		

*Rental availability of these items is uncertain as exact equipment required may not be available at the time they are required.

LONG UNDERGROUND HORIZONTAL EXPLORATORY DRILL HOLES AND TARGET RESULTS FENIX & SCISSON, INC. NEVADA TEST SITE 1967 - 1977

HOLE NO.	HOLE DEPTH IN FEET	DEVIATION FROM 10'x10' TARGET HORIZONTAL	VERTICAL	DATE COMPLETED
U12e.11 - 1	830	.2' LT	6.10' LOW	11-67
U12t.01 - 1	2001	1.3' LT	5.85' HIGH	12-68
U12t.02 - 1	1142	28.25' RT	-0-	1-69
U12t.02 - 2	2443	63.2' RT **	4.04' LOW	3-69
U12t.02 - 3	2700	212.0' RT *	0.4' HIGH	6-69
U12e.12 - 1	906	21.81' RT	40.72' LOW	7-69
U12e.12 - 2	858	7.36' RT	5.69' LOW	8-69
U12n.07 - 1	1452	24.46' RT	20.44' LOW	11-70
U12n.05 - 2	2389	21.3' RT	16.83' LOW	1-71
U12n.05 - 3	1114	.90' RT	12.5' LOW	2-71
U12e.06 - 1	1488	17.6' RT	1.19' HIGH	4-71
U12e.15 - 1	1404	1.33' LT	-0-	3-72
U12e.15 - 2	2500	3.86' RT	-0-	7-72
U12e.14 - 2	335	-0-	8.36' LOW	ABAND. 8-1-72
U12e.14 - 2A	1024	11.79' LT	1.9' HIGH	8-72
U12t.03 - 1	3690	186.49' RT ***	227.25' LOW	11-72
U12n.02 - 1	2649	2.96' RT	6.5' HIGH	11-72
U12e.14 - 3	1376	8.2' RT	-0-	12-72
U12t.03 - 2	1544	1.9' RT	5.0' HIGH	12-72
U12n.07 - 3	2653	3.36' RT	-0-	2-73
U12e.04 - 1	1848	227.42' RT	1.39' LOW	4-73
U12t.04 - 1	1900	53.20' RT	4.41' HIGH	6-73
U12t.05 - 1	2402	55.99' RT	4.54' LOW	8-73
U12e.14 - 10	2004	63.36' RT	5.20' LOW	8-73
U12t.06 - 1	2002	6.60' LT	8.28' LOW	10-73
U12e.14 - 11	1588	20.48' RT	0.20' LOW	11-73
U12n.07 - 10	774	4.87' LT	2.43' LOW	12-73
U12n.07 - 11	715	3.71' LT	110.81' HIGH	12-73
U12t.03 - 3	1600	38.31' RT	2.57' LOW	7-74
U12n.10 - 1	1402	11.25' RT	2.84' LOW	1-75
U12n.10 - 4	363	0.9' LT	3.5' LOW	6-75
U12n.10 - 6A	270	0.96' LT	2.59' LOW	6-75
U12n.10 - 7	313	0.53' LT	3.64' HIGH	7-75
U12n.11 - 1	2000	6.4' RT	0.4' HIGH	10-76
U12e.20 - 1	515	31.4' RT	4.18' LOW	2-77
U12e.20 - 2	408	0.8' LT	2.94' LOW	2-77

* NO ATTEMPT WAS MADE TO CORRECT FOR EXCESSIVE HORIZONTAL DEVIATION TO RIGHT.

** 5 WHIPSTOCKS TO LEFT WITH NO BENEFITS.

*** HOLE PERMITTED TO DEVIATE TO RIGHT AND DOWN.

[illegible] & SCISSON INC.
[illegible]tion No. Q-LA-5-81
[illegible] 6, 1981

WELL EQUIPMENT

ITEM	QUANTITY	PART NO.	DESCRIPTION	PRICE
1.	1	85-54-11	4" Type "A" pump, Fixed, OPF 4 x 2$\frac{3}{8}$-2$\frac{3}{8}$ x 2	$25,640.
2.	1	2-29099	Seating Shoe 4", Type 1	890.
3.	1	2-26603	Starting Filter	368.
4.	1	2-10286	Sand Tube	68.
5.	1	2-31017	Circulating Valve 2$\frac{3}{8}$"	1,270.
			SUB TOTAL:	$28,236.

SURFACE EQUIPMENT

6.	1	3-80002	Triplex Solo Unit, water for 200 HP Elec. Motor drive	46,825.
7.	1	3-42237	Coupling, Falk	1,080.
8.	1	3-80031	Coupling Guard	226.
9.	1	0-79701	200 HP Elec. Motor, 1800 RPM TEFC NEMA B	6,680.
10.	1	0-99156	Vessel, Solo, 4' x 10' Crd, 3 Cones	12,161.
11.	1	0-99171	Control Panel, Size 5 4/200H.P. 460 V Elec. Motor W/Starter Disconnect	3,972.
			TOTAL:	$99,180.

All prices are F.O.B. Huntington Park California delivery is approximate [illegible] after Receipt of Order.

USER ______ **FENIX & SCISSON INC.** FILE ______

DAILY MINE INSPECTOR REPORT

'ECTOR: ______ SHIFT 1 2 3 DATE ______

FROM ______ FACE ______ + ______

JOB ______ TIME LOCATION

TO ______ LAST SET ______ + ______ NO. ______

REMARKS & RECOMMENDATIONS	PERSONNEL	
	SUPT	
	WALKER	
	SHIFTER	
	OPER	
	MECH	
	MINER	
	ELECT	
	BULL GANG	
	B. G. FORE	
	LABOR	
DELAYS (TIME & REASON)		
	TOTAL	

SPECIAL ITEMS (ACCIDENTS, UNSAFE PRACTICES, BAD GROUND CONDITIONS, ETC.)

...-ORTED TO COMPANY TIME DATE

REPLY:

FENIX & SCISSON, INC.

MINING FIELD REPORT

Report By____________________

Date____________________

Time____________________

Shift 1 2 3

PROJECT

19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 2 1

10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10

SKETCH OF BREAST

STA. AT BREAST________________

PREVIOUS BREAST STA.________________

FOOTAGE ADVANCE________________

VOLUME EXCAVATED________________

SET NUMBER	STA.	SIZE

ROCKBOLTS					
Number	Dia. of Bolt	Dia. of Hole	Anchor	Pattern	Length

MANPOWER		
Direct	Support	Total

SQ. FT. MESH________________

NO. MATS INST.________________

Men	No.
Shifter	
Operator	
Mechanic	
Miners	
Electricians	
Bull Gang	
Bull Gang Fore.	

CURRENT PROGRAM DATE____________ CURRENT DWG. No.____________

DEVIATION FROM SPECIFICATIONS

CURRENT STATUS OF WORK

UNDERGROUND CORE DRILLING REPORT

U ______________________________ Date: ______________________

Ho No: ____________________ Core Size: ______________ Shift: ______________________

Area: __________ Tunnel: __________ Project Drift: ______________ Station: ________ Inspector: ______________________

Rig No: ______________________________

CORE RUN NO.	ELAPSED TIME TURNING START FINISH TOTAL	DEPTH START	DEPTH FINISH	FOOTAGE CORE DRILLED	FOOTAGE CORE RECOVERED	% REC.	DRILLING RATE-MIN. TO DRILL 1 FOOT	RPM	PSI	NO. OF PIECES IN CORE	LONGEST PIECE	WRAPPED FROM WRAPPED TO
	S F T											
	S F T											
	S F T											
	S F T											
	S F T											
	S F T											
	S F T											
	S F T											

Footage Drilled this Shift: ______________________ Core Recovered: Footage __________ % __________

Footage Drilled to Date: ______________________ Core Recovered: Footage __________ % __________

Remarks: (List all pertinent and unusual events)*

____

____

____

____

* List any unusual changes in penetration rate, changes in drill water color, voids encountered or other changes even though they may not appear important at the time. Also, comment on reasons for changes in RPM, penetration rate or pressure in the remarks section.

FENIX & SCISSON, INC.
Daily Mining Summary

DATE________

PROJECT NUMBER	PROJECT NAME	USER	DESIGN DIMENSIONS (X-Section / T.D.)	COMPLETE TO DATE	PERCENT COMPLETE	24 HOUR ADVANCE	ESTIMATED ADVANCE RATE	SHIFTS WORKED	TOTAL NUMBER of MEN	SUMMARY OF DI

ABBREVIATIONS: Sh. = Shift; Sft. = Shaft; dft. = drift; Tnl. = Tunnel; AlC. = Alcove; Adv. = Advance; Mng. = Mining; M.D. = Main drift; W.P. - Working point; T.D. = Total depth or length; W.D. = Work drift; S.D. Side drift; Dlg. - Drilling

APPENDIX H

FENIX & SCISSON, INC.
STUDY REQUEST NO. 7
VENTILATION SYSTEM FOR
EXPLORATORY SHAFT CONCEPTUAL DESIGN STUDY

STUDY REQUEST NO. 7

VENTILATION SYSTEM
FOR
EXPLORATORY SHAFT CONCEPTIONAL DESIGN STUDY

Ventilation requirements will cover two early time periods.

1. During work in, and breaking out, from the shaft.

2. After breaking out of the shaft.

For the first case, ventilation is simple and will consist of ± 22,000 cfm of chilled air delivered down the vent line and back up the shaft. For the second case, additional vent line will be added on underground to reach the working face as required and may require valves and dampers to split and meter the air into more than one heading.

Temperature logs from exploratory hole USW-H1 indicate that at a depth of 3500', the temperature will be 106° F. Air temperature needs to be below 63° F at 100% relative humidity (RH) for continuous work, or 65° and 100% RH for a work regimen of 75% work and 25% rest. It is expected that our work regimen would be more the 75 - 25% than continuous. An evaluation of the heat stress made by REECo Environmental Science is included at the end of this report. Our calculations show that to have a downhole temperature of 60° F, 113 tons of refrigeration will be required. These calculations are also included.

Two chiller units of 120 tons each will then be required, with one in use and one standby. Exact specifications for these units are not available at this time. If underground temperatures are higher than 106°, more refrigeration capacity will be required. For budgeting purposes, it has been assumed that a temperature as high as 130° may exist, which would require two 120 ton units in use and one as a spare.

In order to supply ventilation air, a centrifugal type blower, Buffalo Forge or equal, will be required. This will be a type R 96", top horizontal right hand discharge, 30,000 cfm, 80" WG at sea level, motor 400 HP, 440V, 60 Hz, 3 phase, controller GE primary resistor size 6, starter 1C 7056. Unit to consist of fan, motor, controller, coupling, flex connection, butterfly valve, inlet and outlet straight through type silencers. Unit to be a skid mounted plug-in type. In order to provide for breakdown, a spare blower will be required. Both blowers will be connected to power and vent line, but only one will be operating at a time.

The downhole vent line will consist of 26" O.D. x 3/16" wall spiral welded pipe, with one 1" x 4" lifting ring per joint. This pipe may be made in any length. Our exact length will depend on what lengths can be hauled over the highway, and height of the drill rig mast. Double jointing on the ground can be done if needed. This pipe will be run in the shaft from the surface using a drill rig or crane, welding the joints together as they go downhole. This pipe will be self-supporting at 3500' depth and will be landed temporarily on a strong-back at the surface. As the miners proceed down hole, they will weld the pipe with brackets to the shaft sets every 20' for additional support. This pipe will furnish + 22,000 cfm of air underground. Additional 26" regular vent line will be used underground to distribute the air to needed locations. Booster blowers underground should not be required in this phase.

Reynolds Electrical & Engineering Co., Inc.
P. O. Box 14400 • Las Vegas, Nevada 89114

IN REPLY REFER TO
566-01-428

APR 27 1981

J. W. Bartlett
Fenix & Scisson, Inc.
Post Office Box 498
Mercury, NV 89023

PREDICTED HEAT STRESS, YUCCA MOUNTAIN MINING

Enclosed is a discussion and calculations of the predicted heat stress during mining at the bottom of a 3500 foot shaft in Yucca Mountain.

Contact P. R. Bolton if you have any questions.

Arden E. Bicker, Manager
Environmental Sciences Department

AEB:PRB:cak

Enclosures
As stated

REECo

PREDICTED HEAT STRESS FOR MINING AT BOTTOM OF SHAFT IN YUCCA MOUNTAIN

Data

Shaft depth - 3500 feet
Ground temperature - 110°F
Ventilation rate - 22,000 cfm
Air velocity in 15' x 15' drift - 100 fpm

Reference

Threshold Limit Values for Heat Stress, pp. 58-61 (copy enclosed)

Permissible Heat Exposure (Table 1, reference)

Work - Rest Regimen - 75% work, 25% rest each hour
Work Load - Heavy
Threshold Limit Value (TLV) 25.9°C WBGT
WBGT = 0.7 WB + 0.3 GT (no solar load; equation 2, p. 58 of reference)
WB = Natural Wet-Bulb Temperature
GT = Globe-Thermometer Temperature

Discussion

The Natural Wet-Bulb Temperature (WB_N) measures the cooling (or heating) effects of the ambient air. The measured value is dependent upon the humidity, ambient air velocity, air temperature, and radiant heat. The WB_N is a higher value than the Psychometric Wet-Bulb Temperature (WB_P), which is used for the determination of relative humidity, because the air velocity over the wet bulb for WB_P measurements is much higher (500-900 fpm) than the air velocity over the wet bulb for WB_N meausrements (100 fpm in this case). Putting it another way, the WB_N depression is less than the WB_P depression.

The Globe Thermometer Temperature (GT) measures the radiant heat load from surrounding surfaces (e.g. the ground).

Assumptions

1. WB_N depression = 1/3 WB_P depression for a given Dry Bulb Temperature (DB) and a given Relative Humidity (RH)

2. GT = ground temperature at working level = 110°F

Calculations

1. RH of ventilation air = 100% (WB_N = DB)

DB	WB_N	WBGT	
100°F	100°F	103°F	39.4°C
95	95	99.5	37.5
90	90	96	35.5
85	85	92.5	33.6
80	80	89	31.7
75	75	85.5	29.7
70	70	82	27.8
65	65	78.5	25.8
60	60	75	23.9

2. RH of ventilation air = 40%

DB	WB_P	WB_P depression	WB_N depression	WB_N	WBGT	
100°F	79°F	21°F	7°F	93°F	98°F	37°C
90	71	19	6	84	92	33
80	64	16	5	75	85	29
70	56	14	5	65	78	25.5
60	48	12	4	56	72	20

3. RH of ventilation air = 10%

DB	WB_P	WB_P depression	WB_N depression	WB_N	WBGT	
100°F	63°F	37°F	12°F	88°F	95°F	35°C
90	58	32	11	79	88	31
80	53	27	9	71	83	28.3
75	50	25	8	67	80	26.7
70	47	23	8	62	76	24.5
60	41	19	6	54	71	21.6

Summary and Conclusions

The ventilation air temperature and relative humidity should not exceed the following values so that the TLV for heat stress does not exceed a WBGT of 25.9°C:

RH	DB
100%	65°F
40	70
10	72-73

For each 10°F drop in GT (essentially the ground temperature), the temperature of the ventilation air can raise 4°F to maintain the same WBGT.

PRB:cak
REECo Industrial Hygiene

DESIGN OF 26" O.D. VENT LINE

Calculate 26" x 3/16 wall vent line

From manufacturer, cross-sectional = 21.10 in^2,

weight 51.7#/ft., A-36 grade steel = 36,000 psi yield

51.7 x 3500 = 180,950#

21.10 x 36,000 = 759,600#

$\frac{759{,}600}{180{,}950}$ = 4.2 factor of safety

FORM LV-114

FENIX & SCISSON, INC.
Engineers - Contractors

TO: Files JOB: D/S 1022

FROM: K. L. Schulenburg RE: AREA 25 EXPLORATORY SHAFT - VENTILATION

DATE: July 13, 1981

From the Accompanying Graph

3500 ft. of 26" Ø vent line with a Buffalo Forge 96" type R

Fan will produce 22,600 CFM at 71" WG (Sea Level)

Cooling Required

Autocompression down the shaft

1° F per 185' decrease in elevation

$$\frac{3500}{185}$$

18.9° rise in temperature

Condition at top of shaft at intake

$T = 110^{\circ}$ Hot summer day

Relative humidity ~ 10%

$$T_D = 110^{\circ} \text{ F}$$

$$T_W = 68.5^{\circ} \text{ F}$$

$$\emptyset = \frac{P_v}{P_s}$$

$$\emptyset = .10$$

$$.10 = \frac{P_v}{2.597}$$

$P_v = .260$ in HG

$$W = .622 \frac{P_v}{P_B - P_v}$$

$$= .622 \frac{.260}{25.84 - .260}$$

$W = .0063$ lb. H_2O/lb. dry air

$$V = \frac{R\ T_D}{P_a}$$

$$V = \frac{53.3 \times (460 + 110)}{(25.84 - .26)\ .491 \times 144}$$

$V = 16.798$ ft^3/lb. dry air

$$W = \frac{1}{v}(W+1)$$

$W = .0599$ lb./ft^3

$H = .24\ t_D + W(1060 + .45\ t_D)$

$= .24(110) + .0063(1060 + .45(110))$

$H = 33.39$ BTU/lb. dry air

Conditions at bottom of shaft without cooling

$T_D = 110 + 19$

$= 129^\circ$ F (adiabatic compression)

$W = .0063$ lb. H_2O/lb. dry air (no water added)

$H = .24(129) + .0063\ (1060 + .45(129))$

$H = 38.00$ BTU/lb. dry air

Cool air at bottom of shaft

$T_D = 60^\circ$ F

$W = .0063$ again no water added or lost

$H = .24(60) + .0063(1060 + .45(60))$

$= 21.25$ BTU/lb. dry air

Cooling required

$\Delta H = 38.00 - 21.25$

16.75 BTU/lb. dry air

Mass flow

$$G = \frac{22{,}600 \times 60}{16.798}$$

= 80,724 lb. dry air/hr.

$Q = 16.75 \times 80{,}724$

1,352,000 BTU/hr.

$$\text{Refrigeration} = \frac{1{,}352{,}000}{12{,}000}$$

= 112.7 tons

Relative humidity bottom of cooled shaft
49% from psychrometric chart

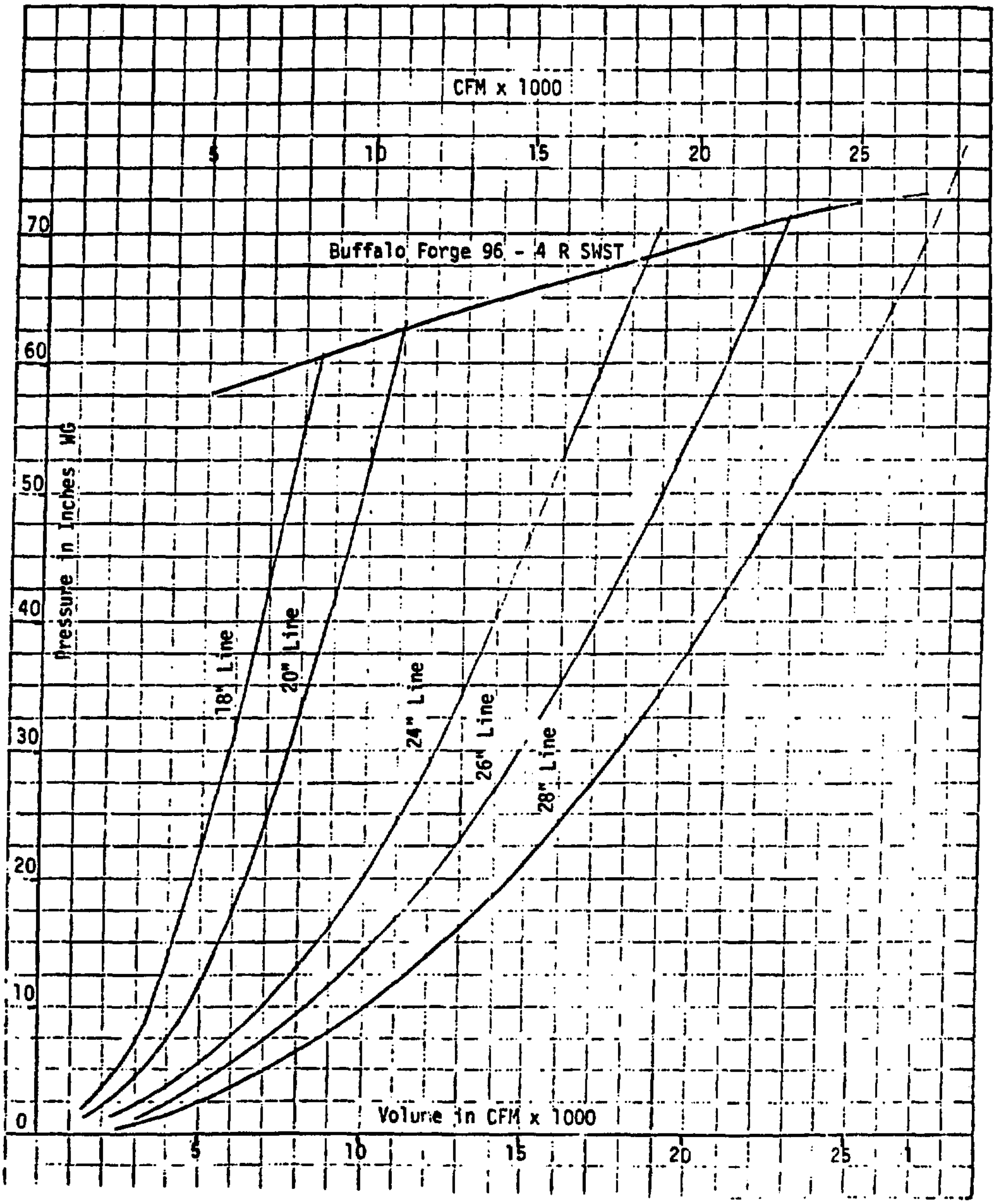
FORM LV-247 #6238-1353

FENIX & SCISSON, INC.
LAS VEGAS, NEVADA 89101

COMPUTED BY: DESIGN SHEET SHEET ___ OF ___

CHECKED BY: PROJECT NO.

CALCULATIONS FOR: Pressure-Volume Curves for 3500' of Vent line DATE 7-13-81



APPENDIX I

FENIX & SCISSON, INC.
ESTIMATED SMOKE-OUT TIME FOR PROPOSED AREA 25 EXPLORATORY SHAFT

FCLW LV-114

FENIX & SCISSON, INC.
Engineers - Contractors

TO: M. P. Kunich

FROM: F. D. Waltman

JOB: D/S 1035

RE: ESTIMATED SMOKE-OUT TIME FOR PROPOSED AREA 25 EXPLORATORY SHAFT

DATE: August 27, 1981

In compliance with a request from Tom Merson, of LANL, we are submitting a letter from Mr. N. M. Lencioni of REECo Industrial Hygiene estimating the time required to remove powder smoke after blasting in the proposed underground configuration with the ventilation system blowing air down hole.

Under usual circumstances, it is normal to reverse the air flow at shot time and exhaust the foul air inside of the vent pipe in order to prevent spreading the powder smoke throughout the facility. However, in our case, there are only two headings, which are very short in length, and do not present a problem.

It is possible to use a reversing system and exhaust the foul air, but this would require a complicated system of piping and valves on the surface which would require an automated electric drive system on the various valves to open and close them in the proper order to reverse the flow with the blower running, as well as bypass the chiller units to prevent dirtying the coils. Because of the relatively small amount of mining to be done, it probably would not be advantageous to use a reversing system.

Another alternative under consideration would be to utilize an auxiliary axivane fan underground, connected to a separate vent line into the heading, and used only at shot time, to exhaust from the heading being blasted to the shaft bottom, where the regular air flow would exhaust the smoke to the surface. This should speed up smoke removal from the heading.

In the final analysis, if smoke can be removed in thirty minutes or less, no problem should exist, since it is normal procedure to wait that long after blasting before returning to the heading in case of a misfire.

FDW:ys

Encl.

cc: R. A. Escobedo
√L. P. Skousen
√Dean Nelson/Tom Merson

Reynolds Electrical & Engineering Co., Inc.
P. O. Box 14400 • Las Vegas, Nevada 89114

IN REPLY REFER TO:
566-01-659
AUG 13 1981

RECEIVED
F-S ADMIN
AUG 14 1 49 PM '81

Mr. F. D. Waltman
Fenix & Scisson, Inc.
Post Office Box 498
Mercury, NV 89023

ESTIMATED SMOKE-OUT TIME FOR PROPOSED AREA 25 SHAFT

In answer to your telephone conversation with N. M. Lencioni on August 7, 1981, the requested smoke-out times for the proposed Area 25 shaft are shown below.

Assumptions:

Ventilation available: 20,000 cfm
Drift size: 100' long x 15' high x 15' wide (225 ft^2)
Shaft size: 3500' deep x 96" diameter (50 ft^2)
Shot round: 6' x full face, approximately 75 lbs. of Tovex

Transport times:

The leading edge of the gas cloud will traverse 100' of the 15' x 15' drift in 1 minute and 3500' of the 8' shaft in 8 minutes. Total transport time is approximately 9 minutes from face to surface.

Duration of gases:

Gas concentrations throughout the drift from the blast cloud can be expected to be within acceptable levels in about 10 minutes. Based on prior measurements in large drifts, however, gas released from the muckpile can be expected in significant quantity at the muckpile for approximately 20 minutes.

A conservative estimate, based on the decay rate for gases from the muckpile versus the dilution factor for 20,000 cfm in a 225 ft^2 heading, would be a 15 minute smoke-out time for the heading.

REECo
AN EG&G COMPANY

Conclusion:

The total time between firing a round in the heading until the blast gases in the shaft are at an acceptable level for personnel reentry, is approximately 24 minutes.

If you have any questions regarding the above, please contact N. M. Lencioni at 986-0030.

Arden E. Bicker, Manager
Environmental Sciences Department

AEB:NML:cak

APPENDIX J

FENIX & SCISSON, INC.
COST ESTIMATE FOR MINING PORTION OF PHASE I CONCEPTUAL DESIGN

NOTE: These numbers are the bases for Table II in Sec. VIII with adjustment for schedule modifications and escalation factors.

FENIX & SCISSON, INC.
P. O. BOX 498
MERCURY, NEVADA 89023

ADDRESS REPLY TO: D/S 1002

May 11, 1981

Mr. J. H. Dryden, Director
Nevada Operations, NTS Support Office
U. S. Department of Energy
Post Office Box 435
Mercury, Nevada 89023

ATTN: Mr. F. R. Huckabee, Chief
Test Construction Branch

AT DEPTH TEST FACILITY, AREA 25, REVISED

As requested, please find our revised Time and Cost Budget Estimates reflecting inflated costs versus current costs, and Mining Time Schedules for a proposed Waste Isolation Facility in Area 25, Nevada Test Site.

Sincerely yours,

F. D. Waltman

F. D. WALTMAN
MANAGER, MINING

FDW:ys

Encl.

cc: M. Kunich, DOE/NVOO (3)

5-11-81
D/S 1002

FENIX & SCISSON, INC.
MINING & DRILLING
TIME & COST BUDGET ESTIMATE
AREA 25 "AT DEPTH"
TEST FACILITY PHASE 1
WITH
SHAFT ITEMS PRE-INSTALLED IN CASING
2000' - 3500' DEPTH

ITEM	DAYS	K$
Surface Construction	30	$ 377
Equip Shaft	35	1,427
Drill Test Holes	10	216
Drill Break-Out Holes	6	131
Break Out of Shaft	10	435
Mine Shaft Station	10	435
Mine Muck Pocket	12	520
Drift Mining	42	1,804
Exploratory Drilling	160	4,920
Underground Construction Support	*Conc.	2,624
Subtotal	315	$12,889
+15% Cont.	47	1,993
TOTAL	362	$14,822
A-E Mining Costs		$ 628
+15% Cont.		94
TOTAL		$ 722

*Conc. = Concurrent

5-11-81
D/S 1002

FENIX & SCISSON, INC.
MINING & DRILLING
TIME & COST BUDGET ESTIMATE
AREA 25 "AT DEPTH"
TEST FACILITY PHASE 1
WITH
SHAFT ITEMS PRE-INSTALLED IN CASING
FROM 0 - 3500' DEPTH

	FY84		FY85		TOTAL	
ITEM	DAYS	K$	DAYS	K$	DAYS	K$
Surface Construction	30	$ 349			30	$ 349
Install Guides, Etc.	20	668			20	668
Drill Test Holes	10	201			10	201
Drill Break-Out Holes	6	122			6	122
Break Out of Shaft	10	403			10	403
Mine Shaft Station	10	403			10	403
Mine Muck Pocket	12	482			12	482
Drift Mining	42	1,672			42	1,672
Exploratory Drilling	9	257	151	$4,954	160	5,211
Underground Construction Support	*Conc.	1,208	*Conc.	1,409	*Conc.	2,617
Subtotal	149	$5,765	151	$6,363	300	$12,128
+15% Cont.	22	865	23	954	45	1,819
TOTAL	171	$6,630	174	$7,317	345	$13,947
A-E Mining Costs		$ 274		$ 324		$ 598
15% Cont.		41		49		90
TOTAL		$ 315		$ 373		$ 688

Conc. = Concurrent

5-11-81
D/S 1002

CAPITAL EQUIPMENT BUDGET ESTIMATE
FOR AT DEPTH TEST FACILITY
PHASE 1, AREA 25

EQUIPMENT	COST $K	LEAD TIME
1. Headframe Complete With Skip and Cage	$ 227	8 Months
2. Single Drum, Unbalanced Hoist	1,122	14 Months
3. Emergency Single Drum, Unbalanced Hoist	330	12 Months
4. 1 LHD Unit	198	3 Months
5. 1 - 2 Boom Drill, Jumbo	426	3 Months
6. 4 Skid Mounted Diamond Drills	304	2 Months
7. 2 Mobile Air Compressors	274	2 Months
8. 2 Ventilation Fans	264	6 Months
9. 1 Sump Pump	152	4 Months
10. 1 Rock Bolt, Jumbo	304	4 Months
11. 1 - 15 Ton Fork Lift	122	3 Months
12. 1 Eimco 630	76	3 Months
13. 1 Front End Loader	289	3 Months
Subtotal	$4,088	
+15% Contingency	613	
TOTAL	$4,701	

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