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PLANS FOR CHARACTERIZATION OF SALT SITES

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INTRODUCTION

The Office of Nuclear Waste Isolation (ONWI) is responsible for the identification and characterization of salt sites for a deep, mined, geologic repository for the storage of high-level nuclear waste. At the present time, specific sites have not been formally recommended for site characterization. When the selection is made and the President approves the sites, characterization activities will proceed. Therefore, the characterization plans presented in this paper are basic in nature and are the minimum program that meets project needs. The basic characterization plan may be expanded later to address site-specific considerations and additional questions that arise during the evaluation of data obtained during the characterization activities.

Present investigations for the salt program are focused on salt domes in the Gulf Interior Basin in Mississippi and Louisiana, bedded salt deposits in the Palo Duro Basin in the Texas Panhandle, and in the Gibson Dome area of the Paradox Basin in Utah (Fig. 1).

PURPOSE OF CHARACTERIZATION ACTIVITIES

The proposed salt site characterization program is designed to address the engineering design requirements, the performance assessment requirements, and the licensing requirements for each of the principal project elements. The project elements (Fig. 2) include the repository in the salt horizon, shafts which will connect the repository facilities with the ground surface, and the associated surface facilities. The principal engineering design and performance assessment questions which must be addressed include:

- Repository: Characteristics and behavior of the salt at the repository level. This includes both short-term and long-term behavior.
- Shafts: The characteristics of soil and rock types which must be penetrated and the groundwater conditions.

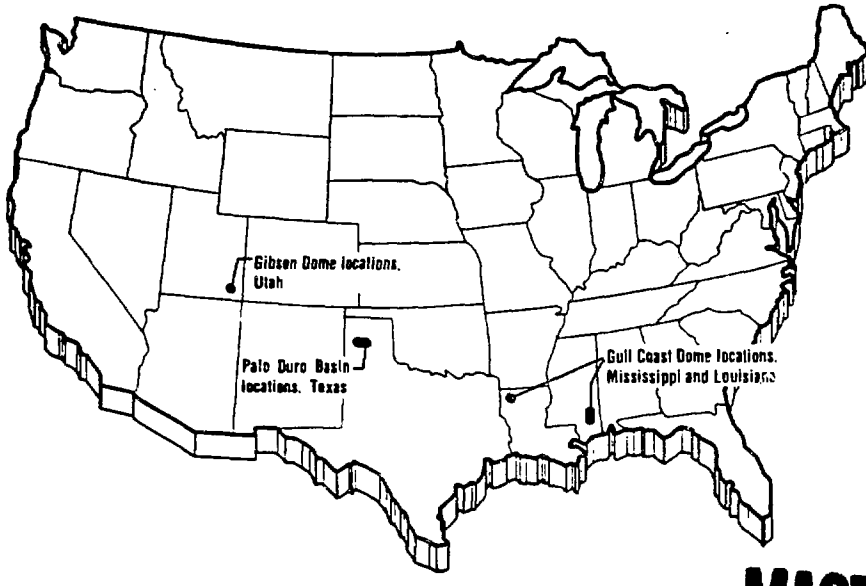

Fig. 1 Locations under consideration for characterization

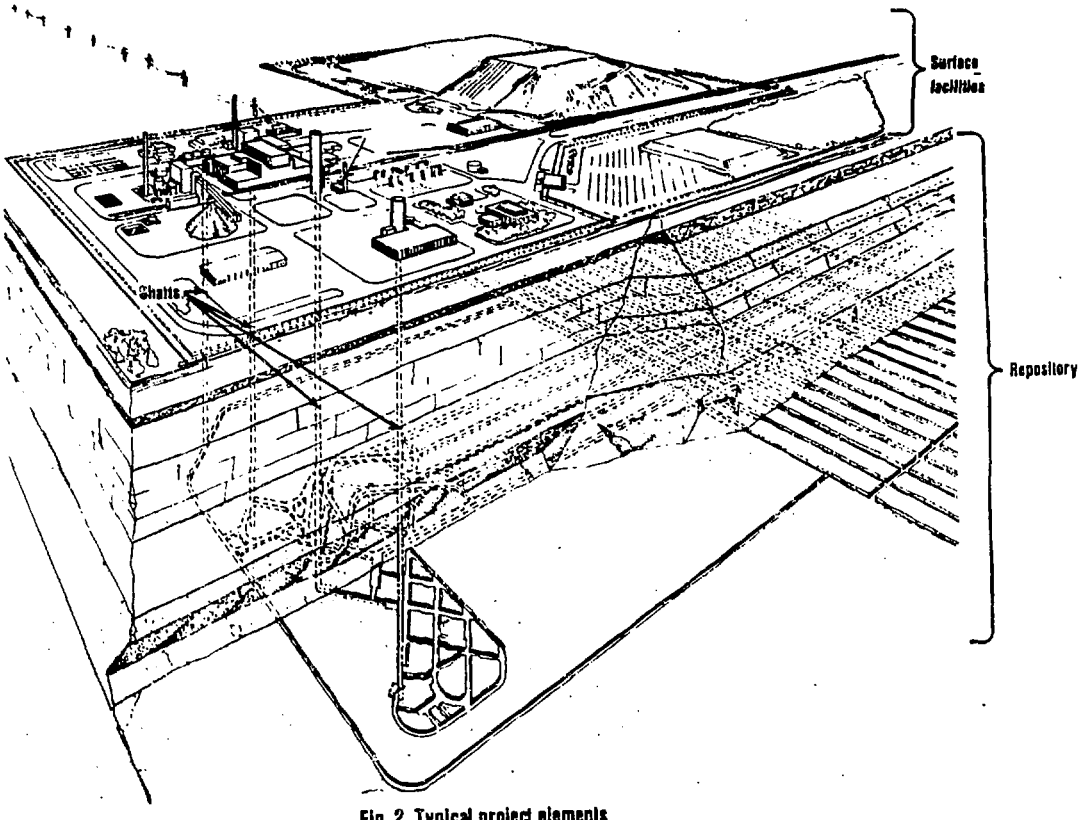

Fig. 2 Typical project elements

- Surface facilities: The characteristics of the near-surface soils and rocks for foundation design and for use in construction.

The principal licensing requirements of the U.S. Nuclear Regulatory Commission are set forth in Draft Regulatory Guide 4.17 (June 1982), Standard Format and Content of Site Characterization Reports for High-Level-Waste Geologic Repositories, and in Draft Regulatory Guide (June 1979), Standard Format and Content of License Applications for Disposal of High-Level Radioactive Waste in Geologic Repositories.

Additional characterization activities are likely to be added after a specific site is identified and during the course of investigations as data become available. The additional investigations will likely include both site and regional aspects.

The outer dimensions of the underground repository are approximately 2 miles x 2 miles. These facilities include waste storage rooms, main and branch passageways, and ventilation passageways. Various layouts are being considered. In one, the storage rooms consist of a series of small, parallel corridors separated by wide salt pillar areas. Storage rooms will be approximately 500 feet long, 20 feet high, and 14 feet wide, and the pillars will be approximately 50 to 70 feet wide. The extraction ratio is approximately 20 percent. The waste will be stored in waste packages that are placed in large-diameter holes drilled into the floor of the mine. The waste packages are approximately 15 feet long and approximately 3 feet in diameter and will be spaced approximately 60 feet apart. Within one year of completion of emplacement within a storage room, the room will be backfilled with carefully compacted salt. Later, decommissioning will result in the backfilling of all rooms, corridors, and shafts.

Five shafts are currently being considered for the facility. These shafts will range in diameter from approximately 20 feet to 30 feet. The purpose of each shaft is as follows:

Shaft 1 - transport of waste containers
Shaft 2 - transport of men, material, excavated salt, supply air, and utility lines
Shaft 3 - supply air, utility lines, and emergency egress
Shaft 4 - exhaust air and utility lines
Shaft 5 - exhaust air

The surface facilities at a repository site include: five shaft head-frame structures, a waste packaging facility, supply and exhaust underground ventilation buildings, administration and underground operation buildings, a power plant, water ponds, transportation and utility facilities, and a salt storage pile. In addition, a railroad spur will be constructed to provide access to the site for the shipment of wastes.

In developing a characterization program for any engineering project, it is important to recognize what is known about each of the project elements from similar projects and what is unique about the project under consideration. The most essential element of this project is a repository, or mine, in salt. We know that mines in salt have been safely constructed and operated throughout the world for a number of years. The operating mines have rooms, or corridors, which are much larger than those required for a repository, and the extraction ratio in these mines is generally in the range of 40 to 80 percent. The repository, in effect, is an undersized salt mine. The knowledge gained from existing mines gives one a feeling of confidence that this smaller repository can be safely designed and constructed. The unique aspect of the project is the emplacement of the heat-generating waste canisters in the floor of the mine and the subsequent backfilling of the mine.

To develop the repository, shafts must be constructed. Shafts of similar size and depth have been successfully constructed for other projects. Also, the types of soil and rock strata, and the groundwater conditions which are present at each of the salt sites under consideration have been successfully penetrated by shafts at other sites. Therefore, there is nothing which is unique to this project regarding shaft size, depth, or construction.

The various types of structures required for the surface facilities are analogous to structures that have been designed, constructed, and operated as individual elements at other types of plant facilities. There are no known foundation conditions at any of the salt sites under consideration for which structures of a similar nature have not been successfully designed.

BASIC CHARACTERIZATION PROGRAM

The proposed basic characterization program can be applied to any of the salt sites under consideration. The activities related to each of the project elements, that is, the repository, the shafts, and the surface facilities, are summarized in Tables 1, 2, and 3. These activities are presented in terms of what is needed to address design, performance assessment, and licensing considerations; why they are needed; and how the information will be obtained. The relationship between selected key activities to overall project needs is summarized in Fig. 3.

The geologic framework at a site is of primary importance in establishing an exploration program

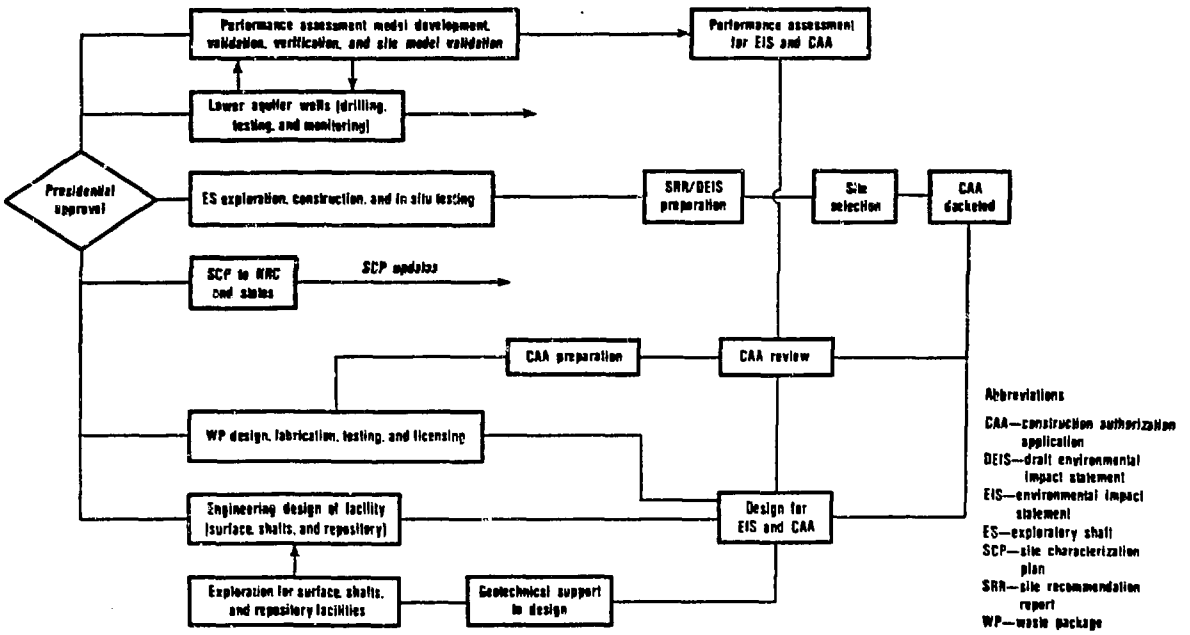

Fig. 3 Relationship of Activities for Characterization of Salt Sites

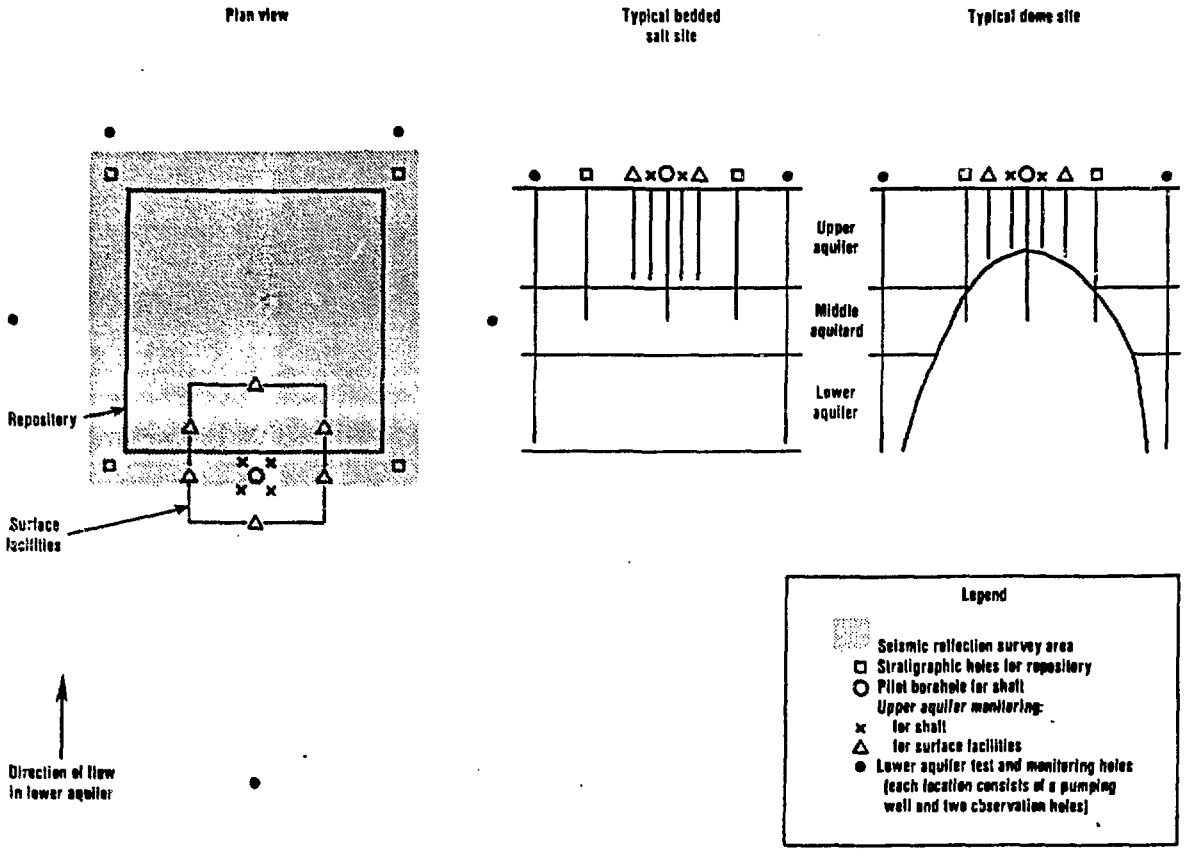

Fig. 4 Basic site characterization program

designed to provide the information required for each of the project elements. The generalized subsurface geology at bedded salt sites and at the dome is shown in Fig. 4. It consists of an upper aquifer unit, a middle aquitard unit, and a lower aquifer unit. At the bedded salt sites, the repository is located within the middle aquitard unit. In the case of the dome, the aquitard unit is adjacent to the dome at the repository depth.

Of foremost importance in characterizing a site is the establishment of the depth, geometry, thickness, lateral extent, lithologic variability, and in situ stress conditions of the repository horizon. A closely spaced, 3-D seismic reflection survey will be run over the entire repository area to establish the depth and geometry of the repository horizon. Four stratigraphic holes located at the corners of the repository will be drilled, cored, and geophysically logged to provide data to establish the details of the site stratigraphy from the surface to the repository depth. These holes will provide monitoring points in the repository horizon, but outside of the actual repository.

Laboratory analyses on samples from the stratigraphic holes will include: determination of the chemistry of soil, rock, and water encountered to provide information regarding the selection of construction materials for the shaft and waste package; and engineering testing to establish the design parameters for the repository and to assess the behavior of the rock at the repository horizon when subjected to the heat of the waste canisters. An exploratory shaft will be constructed to provide access to the repository horizon. In situ testing will be performed in the repository horizon to evaluate the stability of the underground openings and backfilling techniques, and the behavior of the salt when subjected to heater tests. Geologic mapping will be performed to document the horizontal and vertical variations within the repository horizon and to identify marker beds which can be used to control the placement of underground openings. Seismometers will be placed in the underground openings to monitor earthquake events which may occur during the period of the underground testing program.

An evaluation of crustal stability will be made to determine the probability of occurrence of tectonic processes which could affect the repository horizon at the selected site. Regional structure and historical seismicity will be evaluated along with data from the site and the microseismic network. This information will also be used to establish the design basis earthquake to be used in the design of the repository, shafts, and surface facilities.

The hydrogeologic properties of the lower aquifer unit will be used as input into the ground-water model designed to assess the effect of the accident scenario of the penetration of the repository and of a waste package resulting in a release of radioactive material in the lower aquifer unit. Five, lower aquifer hydrologic pump tests will be performed at locations carefully selected in relationship to the repository. At each location a pumping well and two observation wells will be installed. Information collected will include in situ temperatures, the piezometric levels, and the transmissivity of the aquifer unit. This information will be utilized to determine direction of flow and rate of flow. Water samples will also be collected for chemical analysis to establish baseline conditions. Each pumping well will then be converted into a long-term monitoring well.

At the shaft site, four to six upper aquifer hydrogeologic holes will be drilled prior to shaft construction. These holes will be utilized to monitor ground-water levels and to obtain samples for chemical analysis to establish baseline conditions. Water levels will be monitored for approximately one year prior to construction of the exploratory shaft, during construction, and during the operation of the shaft. An exploratory pilot borehole at the shaft site will be drilled, cored, and geophysically logged to establish the details of the stratigraphy and the engineering geology of the stratigraphic units. Rock samples will be tested to establish chemical characteristics and engineering properties of the stratigraphic units.

Investigations for the surface facilities will include establishment of design parameters for natural phenomena such as extreme winds, probable maximum floods, temperature extremes, and the design basis earthquake. Both regional and site-specific information will be utilized to establish these design factors. This will include the analysis of historical data, the installation of meteorological instruments at the site, and the installation of a microseismic earthquake network in the site area.

Detailed topographic maps will be prepared for both the site area and the access routes. A sampling and laboratory testing program will be performed to evaluate the suitability for on-site and near-site materials for use in construction. Foundation investigations will be performed both in the site area and along the access route to establish the foundation design criteria for the various structures. An additional six upper aquifer groundwater monitoring holes will be drilled around the perimeter of the surface facilities. The purpose of these holes will be to monitor ground water levels and ground water chemistry prior to construction of surface facilities to provide baseline data and during the construction and operation of such facilities.

SUMMARY

This basic salt site characterization program has been designed to provide the data required to support the design, performance assessment, and licensing of each of the principal project elements: the repository, the shafts, and the surface facilities. The work has been sequenced to meet the design and licensing schedule. It is anticipated that additional characterization activities will be performed to address site-specific considerations and to provide additional information to address questions which arise during the evaluation of characterization data.

TABLE 1. SUMMARY OF SITE CHARACTERIZATION ACTIVITIES RELATED TO THE REPOSITORY

- WHAT -	- WHY -	- HOW -
Characteristics of Repository Horizon		
Depth	minimum requirement to protect accessible environment; maximum based on strength properties and cost	review of existing subsurface information; seismic exploration; drilling and coring
Thickness	adequate for underground facilities; protection of accessible environment	drilling and coring
Geometry	layout of underground facilities	review of existing subsurface information; seismic exploration; drilling and coring
Lateral Extent	layout of underground facilities; protection of accessible environment	review of existing subsurface information; seismic exploration
Variability in Rock Type	layout of underground facilities (selection of preferred horizon); design of openings; interaction with waste package, ie, temperature and chemistry of rock and water; suitability as backfill material	drilling and coring; laboratory analyses; in situ mapping; in situ testing
Rock Defects, such as: joints, bedded planes, natural gas, brine pockets, fluid inclusions	design of underground openings; adequate preparation for range of conditions that may be encountered during construction; performance assessment of the possible impact of identified effects on operational and post closure performance	review of existing information; seismic exploration; drilling and coring from surface and within in situ test facility; laboratory analyses; in situ mapping; in situ testing
In Situ Temperature	behavior of the rock; ventilation requirements	geophysical borehole logging; in situ measurements

TABLE 1. (Continued)

- WHAT -	- WHY -	- HOW -
Behavior of Repository Horizon		
Crustal Stability	to assess the operational and post-closure stability	assessment of regional and site structure, and seismicity; microseismic network; measurement of in situ stresses
Dissolution	performance assessment of repository horizon	review of existing information; establishment of hydrogeologic setting
Interaction with Waste Package: dissipation of heat; effect of heat on minerals; effect of heat engineering properties of rock mass; effect of heat on brine migration	performance assessment of repository horizon	laboratory analyses; in situ testing
In Situ Stresses	design of openings; design of waste package; design of waste emplacement configuration	review of geologic history; hydrofracturing; in situ measurements
Release of Radioactivity in Repository Horizon	performance assessment analysis of postulated accident scenario	analysis of stratigraphic sequence based on existing information, seismic survey data, site-specific exploratory drilling, and laboratory testing; analysis of hydrogeologic setting through drilling, field testing, monitoring, and laboratory analyses; transmissivity of salt and middle aquitard unit based on field and laboratory data; evaluation of retardation of salt and middle aquitard unit based on laboratory data
Breach of Repository Horizon: faulting; drilling	performance assessment analysis of postulated accident scenario	assessment of regional and site structure, and seismicity; assessment of probability of deep drilling exploration for mineral deposits; recharge and discharge points for the aquifer units; ground water flow and dispersion analyses based on field data and model studies

TABLE 2. SUMMARY OF SITE CHARACTERIZATION ACTIVITIES RELATED TO THE EXPLORATORY SHAFT

- WHAT -	- WHY -	- HOW -
Characteristics of Soil and Rock		
Stratigraphic Sequence	design of lining and placement of seals	drilling and coring
Rock Properties	design of lining and seals	laboratory analyses to establish both engineering and chemical properties
Dynamic Response	establishment of design criteria to withstand a design basis earthquake	establishment of site-specific design basis earthquake; laboratory determination of dynamic response of soil and rock units
Rock Defects, such as: joints, bedded planes, natural gas, brine pockets	performance assessment analysis to assure adequate design	assessment of existing information; drilling, coring, and geophysically logging a pilot borehole; if construction techniques permit, in situ mapping of shaft
In Situ Stresses	design of lining	analysis of cores; laboratory analyses (swelling); in situ measurements
Ground Water		
Hydrogeologic Setting	identification of aquifer units and water levels to establish ground-water protection techniques, ground-water control methods, and seal horizons	review of existing data; drilling and coring of holes; measurement of water levels prior to construction and during construction
Hydrogeologic Parameters	to establish estimated rates of inflow during construction	hydrogeologic testing
	determination of type of permeability (intergranular or fracture) to assist in establishing control and seal techniques	examination of cores
	to establish compatibility of construction materials with ground water	laboratory determination of water chemistry
	to assess ground-water disposal requirements	estimate of quantity based on field test data; laboratory determination of water chemistry

TABLE 3. SUMMARY OF SITE CHARACTERIZATION ACTIVITIES RELATED TO THE SURFACE FACILITIES

- WHAT -	- WHY -	- HOW -
Design Basis Events:		
extreme wind; probable maximum flood; extreme temperatures; earthquakes	design input for surface facilities	historical records
Monitoring:		
meteorological	performance assessment	on-site instrumentation
seismicity	performance assessment - crustal stability	existing strong motion stations plus project microseismic network
ground water	water quality and levels during construction and operation	upper and lower aquifer monitoring
Topography:		
site; access routes	site layouts; route layout; visual impact assessments	topographic map prepared from aerial photography plus ground surveys
Foundation Conditions:		
site; access	foundation design of surface facilities; foundation design of rail bed, road bed, river crossings, and slopes	drilling, sampling, and laboratory testing
Material Properties:		
	evaluation of natural materials for use in construction: pervious material, including granular backfill; impervious material; aggregate sources; and backfill material	trenching, drilling and sampling; laboratory testing