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PUBLIC DRAFT

NATIONAL PLAN FOR SITING HIGH-LEVEL RADIOACTIVE WASTE REPOSITORIES AND ENVIRONMENTAL ASSESSMENT

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U.S. Department of Energy
Assistant Secretary for Nuclear Energy
Office of Deputy Assistant Secretary
for Nuclear Waste Management and
Fuel Cycle Programs

and

Assistant Secretary for Environmental Protection,
Safety, and Emergency Preparedness

NOTICE TO READER

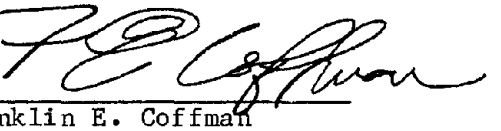
This National Plan for Siting High-Level Radioactive Waste Repositories describes the process the Department of Energy (DOE) is using to find sites suitable for disposal of commercially generated high-level radioactive waste. This plan is one element of the National Waste Terminal Storage (NWTS) Program being conducted by DOE to develop the necessary technology and to qualify sites to establish mined geologic repositories for these wastes.

This siting plan describes existing and planned activities for screening successively smaller portions of land within the United States to identify suitable candidate sites, and for subsequently selecting one or more of these sites for permanent waste disposal. In response to newly adopted procedural rules of 10 CFR 60 (Federal Register, February 25, 1981), the DOE siting activities have been modified from those described in DOE's April, 1980 Statement of Position in the Nuclear Regulatory Commission's Waste Confidence Rulemaking.

An Environmental Assessment (EA) has been prepared as input to the decision to adopt or modify this Plan. Environmental effects of the anticipated range of field studies to characterize various land areas and reasonable alternative siting strategies are assessed. The EA provides the basis for a finding of whether or not implementation of this Plan will result in significant environmental impacts. This finding will be made by DOE after public review of the Plan. DOE has prepared this EA in compliance with Council on Environmental Quality regulations, and has published it in the same volume as the Plan. Site specific environmental impacts of constructing exploratory shafts, test facilities, and repositories will be assessed in later documents.

DOE will consider comments received on the Plan and the Environmental Assessment prior to its decision with respect to adoption or modification of the Plan for the NWTS Program. It is expected that the Plan will continue to evolve as details of the siting process are further developed. Consequently, DOE anticipates that this Plan will be revised as necessary to reflect the results of the ongoing program.

Written comments on the Plan and Environmental Assessment are due on or before April 30, 1982. Comments should be addressed to Mr. Critz H. George, Office of Waste Isolation, NE-330, U.S. Department of Energy, Washington, D.C. 20545.



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ABSTRACT

The National Plan for Siting High-Level Radioactive Waste Repositories describes the process the Department of Energy (DOE) is using to find sites suitable for disposal of high-level radioactive waste. Potential environmental impacts of implementing the Plan are included in an attached Environmental Assessment.

The Plan is one element of the National Waste Terminal Storage (NWTS) Program being conducted by DOE to develop the necessary technology and to qualify sites to establish mined geologic repositories for these wastes.

The Plan describes existing and planned activities for screening successively smaller portions of land within the United States to identify suitable candidate sites, and for subsequently selecting one or more of these sites, for permanent disposal of radioactive wastes.

Environmental effects of the proposed action, including the anticipated range of field studies to characterize various land areas and reasonable alternative siting strategies, are assessed. The Environmental Assessment provides the basis for a finding of whether or not implementation of this plan will result in significant environmental impacts.

ACKNOWLEDGEMENTS

The Department of Energy acknowledges the assistance of W. H. McIntosh, M. L. Brown, and B. H. Smith of the Project Management Division, Battelle Memorial Institute, in the preparation of this document. Major contributors were:

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EXECUTIVE SUMMARY

Through its National Waste Terminal Storage (NWTS) Program, the Department of Energy (DOE) will provide facilities to permanently dispose of high-level nuclear waste (HLW) in a manner that will ensure public health and safety and that will be environmentally acceptable. The program has placed principal emphasis on developing deep, underground repositories, with efforts targeted toward having the first facility operational between 1998 and 2006.

To reach this objective, an extensive program has been developed to find sites that would be suitable for a repository. This National Plan for Siting High-Level Radioactive Waste Repositories describes the ongoing and planned program activities that comprise the process DOE uses to find sites. This siting process involves a stepwise screening of large portions of the United States, identification and detailed study of potential sites, and selection of one or more of these sites for permanent HLW disposal, all with state and public involvement.

DOE recognizes that "perfect" or "flawless" sites for repositories do not exist in nature. Further, innumerable sites may exist which could be shown to be suitable. Through a comprehensive siting process, DOE seeks a reasonable number of sites which, on balance, exhibit characteristics favorable for waste isolation. Decisions DOE will make in the search for sites will be primarily investment decisions which allow resources to be concentrated on places judged the more likely, after full site characterization, to be demonstrable as safe and acceptable under regulatory review. Full study of all but the more favorable sites is unnecessary and would be prohibitively expensive. Only those sites shown to be suitable will be considered for selection as repository sites.

The siting process will involve intensive field work including the construction of exploratory shafts at several potential sites beginning in 1983. At one of these sites, a Test and Evaluation (T&E) Facility will be constructed to evaluate waste handling and emplacement techniques, to provide for training of persons who would operate a repository, and to allow for resolution of generic repository engineering issues. The T&E Facility is related

to, but is not part of, the repository site selection process. The location of such a facility at a potential repository site does not represent a commitment to that location as a repository site.

By implementation of this process, DOE plans to recommend a site for the initial repository late in 1987 from several alternatives. The selection would be confirmed only after extensive public review. Studies may be continued to identify sites even after the first is recommended, so a system of geographically dispersed repositories eventually can be provided.

An Environmental Assessment of the potential environmental impacts of implementing the siting plan and alternative siting strategies is attached. Potential site-specific impacts of exploratory shafts, a T&E Facility, and repository activities will be assessed in subsequent environmental documents supporting decisions to proceed with those activities..

Site Suitability

Criteria have been established against which the suitability of particular sites can be assessed. The broadly stated criteria encompass all factors potentially important to containing and isolating the waste (e.g., site geometry, geohydrology, geochemistry, tectonic environment, human intrusion, topography) as well as the environmental and social acceptability of candidate sites. The criteria are directed toward the key objectives in site selection: assuring public health and safety while protecting the environment. The NWTS site performance criteria are consistent with the Nuclear Regulatory Commission's (NRC) technical criteria in proposed rulemaking for 10 CFR 60, published in the Federal Register July 8, 1981.(1) Following a public comment period, 10 CFR 60 sections pertaining to technical criteria will be finalized and will, thereafter, provide the regulatory criteria for judging site suitability.

Siting Principles

The siting process described in this Plan is guided by the need for:

- Public involvement, which is provided through (1) close consultation with officials of state, local, and tribal governments,

(2) public information programs, and (3) programs to encourage direct public participation.

- Assurance that information used to support siting decisions is sound.
- Compliance with Nuclear Regulatory Commission (NRC) licensing procedures[2] and Environmental Protection Agency (EPA) standards through interaction with those agencies.
- Compliance with the National Environmental Policy Act (NEPA) of 1969,[3] as amended, through appropriate environmental reviews for the various steps in the siting process.

Siting Process

DOE has planned a three-phase siting process. The phases are site screening, detailed site studies, and site selection.

"Site screening" describes a decision process. The site screening phase consists of a set of decisions made sequentially to identify sites favorable for waste disposal from vast land areas. Several approaches to site screening are being used. All approaches use a stepwise method that may proceed through National, Region, Area, and Location Surveys. These surveys narrow the land areas considered from region, to area, to location, and to site (these terms being defined in relatively decreasing sizes of land area).

National, region, area, or location surveys may be either a starting point or one of several steps in the screening phase. Decisions to continue or discontinue study of each alternative land area can be made after any of the survey steps.

Each of these surveys itself and site selection consists of a common set of steps, as follows:

Step 1. Important factors and information needed to make screening or selection decisions are identified

Step 2. Required information is gathered in accord with applicable federal and state consultation procedures

Step 3. Possible alternative land areas are identified

Step 4. Alternatives are evaluated

Step 5. Candidate alternatives are compared and preferred choices are recommended

Step 6. Decisions are reviewed in consultation with involved states.

A great many variables must be measured and evaluated before a site can be identified and shown to be suitable through detailed study. For economic reasons site screening usually begins by considering a limited number of variables over broad land areas to identify places which exhibit characteristics favorable for waste isolation. Further study of all but the more favorable places is deferred indefinitely or until such time as intractable uncertainties arise at places undergoing further study. Additional variables are considered and the screening process becomes more rigorous as smaller areas, such as a few potential sites, are identified.

Multiple approaches to site screening result from the choice of variables to use for initial screening. For example, early consideration of prior land-use has resulted in screening the DOE lands at the Nevada Test Site and at the Hanford Site in Washington State for potential repository sites.

The detailed site study phase consists of scientifically collecting and evaluating information about the physical, chemical, geologic, and human environment necessary to judge site suitability. Detailed surface and subsurface studies will be performed at a small number of sites. The studies will include the construction of an exploratory shaft and testing of rock at repository depth as required by the procedural rules (10 CFR 60) of the NRC.(2)

"Site selection" is the decision to choose a site for a repository. The site selection phase will include those events, after detailed site studies, that precede the final selection decision. In this phase alternative sites will be compared, and one or more will be recommended for a repository. Public review of the recommended site will occur before DOE makes the final selection and prepares a license application.

Methods to resolve potential conflicts with state or tribal governments are still evolving. However, the process will involve preparation of a draft environmental impact statement and site recommendation report, followed by agency and public review. On the basis of that process, a final environmental impact statement and site selection report will be issued. Sites not initially selected may remain candidates for future selection as repository sites.

After public review of the reports which recommend a site be selected, a license application will be prepared and filed with NRC. If the DOE selected site is accepted by NRC, the selection decision is confirmed. The siting process, however, will continue to identify additional sites which later may be selected for repositories subsequent to the first.

Protection of some land against possible uses not compatible with detailed site study or possible repository siting may be needed. Land protection measures taken after DOE deems a site as suitable for a repository are to reserve the site for possible repository selection. Possible land protection measures include fee-simple purchase, leases of land or rights, and withdrawals. Such action will be taken where it is needed to preserve the investment of public monies in exploration work. The DOE action which protected the land could be reversed if the suitability of the site is not confirmed by NRC.

Program Implementation

To implement the program, DOE has established an organization of field offices and contractors, established coordination with other federal agencies, and defined work tasks, budgets, and schedules. The schedules include constructing exploratory shafts at three sites, beginning in 1983, and continuing detailed site studies and technology development efforts to support a repository site recommendation, planned for late 1987. One potential repository site may be selected in 1985 for construction of the T&E Facility, though other independent sites might also be considered.

Environmental Assessment

The attached Environmental Assessment was prepared to evaluate the potential environmental impacts resulting from implementing the strategy and screening phase field activities described in the Plan and its alternatives. The ongoing and planned field activities may affect the environments of geographically dispersed drilling or survey sites. Potential impacts of Plan implementation up to the decision to select a site for detailed site studies have been assessed and are expected to be minimal. Implementation impacts of constructing exploratory shafts, the T&E Facility, and repositories at

specific sites will be considered in subsequent environmental reviews. DOE plans to avoid impacts by careful siting and mitigate the impacts that do occur to the extent feasible.

ACRONYMS

ADM - Action Description Memorandum

BLM - Bureau of Land Management

BWIP - Basalt Waste Isolation Project

CEQ - Council on Environmental Quality

CFR - Code of Federal Regulations

CWM - Commercial Waste Management

DOE - U.S. Department of Energy

DOI - U.S. Department of Interior

DOT - U.S. Department of Transportation

EA - Environmental Assessment

EE - Environmental Evaluation

EIS - Environmental Impact Statement

EPA - U.S. Environmental Protection Agency

ESTP - Earth Science Technical Plan

FEIS - Final Environmental Impact Statement

FPAS - Federal Property and Administrative Services Act

GSA - General Services Administration

HLW - High-Level Radioactive Waste

IRG - Interagency Review Group

NEPA - National Environmental Policy Act

NMSS - Nuclear Material Safety and Safeguards

NNWSI - Nevada Nuclear Waste Storage Investigations

NPO - NWTS Program Office (DOE)

NRC - U.S. Nuclear Regulatory Commission

NSP - National Siting Plan (short title for National Plan for Siting High-Level Radioactive Waste Repositories)

NTS - Nevada Test Site

NWTS - National Waste Terminal Storage (program)

OMB - Office of Management and Budget

ONI - Office of National Waste Terminal Storage Program Integration

ONWI - Office of Nuclear Waste Isolation

ONWM - Office of Nuclear Waste Management and Fuel Cycle Programs

SCR - Site Characterization Report

SPC - State Planning Council

T&E - Test and Evaluation (Facility)

TRU - Transuranic Waste

USDA - U.S. Department of Agriculture

USGS - U.S. Geological Survey

WBS - Work Breakdown Structure

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NATIONAL PLAN FOR SITING HIGH-LEVEL RADIOACTIVE WASTE REPOSITORIES

1.0 INTRODUCTION

This draft National Plan for Siting High-Level Radioactive Waste Repositories (referred to as the National Siting Plan or Plan) is one of the guiding documents for the Department of Energy's (DOE) National Waste Terminal Storage (NWTS) program. The document describes plans for identifying candidate repository sites that will isolate radioactive waste in a manner that assures the public health and safety and is environmentally acceptable. The plans include searching federal and nonfederal lands for sites that will meet federal requirements for safe, long-term, and environmentally acceptable isolation of high-level radioactive waste.

Chapter 1 describes the purpose and scope of the Plan and provides background information on the NWTS program. Chapter 2 describes the evolving criteria for use in assessing site suitability, and Chapter 3 describes principles DOE will use in executing the process for identifying candidate sites and selecting one or more for licensing. On the basis of these perspectives, Chapter 4 describes the planned siting process itself, and Chapter 5 describes the program organization to implement this process.

The Plan provides a context within which many decisions will be made for years to come. The Plan is a framework, not a roadmap, because the actual path to choosing repository sites will unfold with the discoveries of the exploration or site screening process, as affected by consultations among the participants in the process.

1.1 PURPOSE AND SCOPE OF THE PLAN

The purpose of the National Siting Plan is to describe DOE's existing and planned activities for (1) screening successively smaller portions of land within the United States to identify suitable candidate sites and (2) selecting one or more of those sites for permanent disposal of high-level

radioactive waste in mined repositories. By doing so, the Plan will provide a vehicle for state, regulatory, and public review and comment on the DOE approach.

The Plan addresses:

- Establishment of requirements and criteria placed on the isolation system and the site
- Identification of the principles guiding the process used to find and select repository sites
- Delineation of the major elements of the siting process -- screening land areas, performing detailed site studies and selecting sites for repository development
- Development and application of scientific techniques for both locating and evaluating sites
- Development and application of the institutional processes needed for siting
- Compliance with National Environmental Policy Act (NEPA) requirements
- Involvement of state and local government and the public
- Coordination with other federal and state agencies
- Relationships with the Nuclear Regulatory Commission, and Environmental Protection Agency
- Organization and management of the program activities
- The anticipated schedule for repository siting
- The status of the siting program.

The Plan will continue to evolve as details of the siting process develop. The process will require continual, effective public participation.

An Environmental Assessment (EA) has been prepared and is attached. The EA considers environmental effects of implementing the Plan overall. However, impacts of implementing site-specific plans for exploratory shaft, repository, and T&E Facility construction and operation will be assessed in future environmental documents. The EA also discusses the potential impacts of reasonable alternatives to the proposed siting strategy.

1.2 BACKGROUND

The National Waste Terminal Storage (NWTS) program was established in 1976 by DOE's predecessor agency, the Energy Research and Development Administration. DOE is developing this technical program to meet applicable regulatory requirements and to ensure that nuclear waste management problems will not be deferred to future generations.

NWTS activities include providing the technology and facilities for the terminal isolation of high-level nuclear waste (HLW) and transuranic nuclear waste (TRU) generated by commercial power reactors, unreprocessed spent fuel (if disposal is deemed appropriate), and HLW from the DOE programs.

The program emphasizes disposal in mined repositories deep underground in stable geologic formations. Rock types being studied include bedded salt and salt domes, basalt, welded tuff, and "crystalline"* rocks. Studies of disposal in the subseabed or in very deep holes are being continued as long-range options to the geologic program. Space disposal is being studied for possible application to disposal of specific isotopes.

The NWTS program is undertaking the identification of potential repository sites and development of technologies and methods necessary to design, license, construct, operate, and decommission repositories. Engineering design and construction will be initiated once a specific site or sites have been selected.

This work is being accomplished by four projects: (1) the Office of Nuclear Waste Isolation (ONWI), (2) the Basalt Waste Isolation Project (BWIP), (3) the Nevada Nuclear Waste Storage Investigations (NNWSI), and (4) the Subseabed Disposal Program. The work of these projects is being coordinated by DOE's Office of Waste Isolation with the assistance of the Office of National Waste Terminal Storage Program Integration (ONI) at Battelle Memorial Institute.

The BWIP, ONWI, and NNWSI projects are concerned with geologic disposal. The subseabed program is evaluating the feasibility of disposing of HLW within sediments of the deep ocean floor. This Plan discusses the siting

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*"Crystalline" is a general term for igneous and metamorphic rocks (e.g., granite), not including sedimentary rocks.

activities of ONWI, BWIP, and NNWSI, the projects implementing the geologic disposal option.

Within the NWTS program, ONWI is responsible for developing the technology common to the design, construction, operation, and decommissioning of geologic repositories, and for exploration of non-DOE lands. BWIP is investigating basalt formations underlying DOE's Hanford Site. NNWSI is investigating several different rock types (principally tuff, a volcanic ash) underlying DOE's Nevada Test Site (NTS). ONWI is evaluating other geologic formations within the United States including domed and bedded salt and granite. The U.S. Geological Survey (USGS) is assisting by providing technical expertise in all of these program elements and by screening geohydrologic provinces on a prototypical basis.

Many documents have influenced planning of the NWTS program and siting process. Among them, the Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste (FEIS)[4] provided a detailed evaluation of alternative methods for waste disposal and concluded that the technology for emplacement of radioactive wastes in geologic formations can be developed and applied with minimal environmental consequences. This evaluation resulted in the DOE decision that research and development should focus on development of geologic repositories (46 Federal Register 26677).[5] DOE's Statement of Position[6] and Cross-Statement,[7] prepared as DOE's contribution to a rulemaking of the Nuclear Regulatory Commission (Waste Confidence Rulemaking), explained how the NWTS program derived from the recommended policy and technical guidance provided in the report of an Interagency Review Group on Nuclear Waste Management (IRG Report)[8], the Earth Science Technical Plan (ESTP)[9], and the draft EIS on Management of Commercially Generated Radioactive Wastes[10].

The ESTP[9], a product of cooperative effort by DOE and the USGS, identified research and development needs and specific earth-science issues. Definition, integration, and scheduling of specific program activities are detailed in the NWTS Program Plan which is currently in draft.

Since DOE issued its Statement of Position in the NRC's Waste Confidence Rulemaking, the procedural rule (10 CFR 60) governing disposal of high-level radioactive wastes in geologic repositories has been adopted (46 Federal Register 13971, February 25, 1981).[2] Although the rule provides for

exemption under certain circumstances, it generally requires an exploratory shaft be constructed and in situ testing be performed as part of site characterization. This requirement was considered as an option in the siting process described in DOE's Statement of Position[6]. This requirement results in the following modifications to the program described in the DOE Position Statement.

- Because in situ testing is required, DOE will not judge site suitability until data from this testing are obtained
- As was anticipated in the DOE Statement of Position, if exploratory shafts became necessary, the earliest date that a repository may be available is projected as 1998
- The location studies have been reduced in scope and the EA attached to this plan replaces the Environmental Assessment contemplated for location studies
- DOE will reserve the option of choosing its first site from among three alternatives, not the four to five alternatives previously planned.

An additional change attributable to changed policy is the plan for construction of a Test and Evaluation facility in a potential repository environment, as explained in Section 1.5.

These developments are reflected in this Plan and add conservatism to an already conservative process. More in situ testing than planned in the DOE Statement of Position will be done before the suitability of a site is judged.

1.3 WASTE ISOLATION PERFORMANCE OBJECTIVES

The overall goals of the NWTS program are expressed in terms of general performance objectives. These objectives are structured to allow flexibility to meet regulatory requirements. The objectives do not negate the need for NRC and EPA regulations, but provide interim guidance until final regulations are issued. Further, DOE imposes its own requirements where NRC and EPA do not have jurisdiction.

The performance objectives for the waste-isolation system established in the Waste Confidence Rulemaking Statement[6] apply to any method of waste disposal (i.e., they are not restricted to geologic disposal). The objectives are:

(1) Waste containment within the immediate vicinity of initial placement should be virtually complete during the period when radiation and thermal output are dominated by fission-product decay. Any loss of containment should be a gradual process which results in very small fractional waste-inventory release rates extending over very long release times, i.e., catastrophic losses of containment should not occur. "Containment" means confining the radioactive wastes within prescribed boundaries (e.g., within a waste package).

(2) Disposal systems should provide reasonable assurance that waste will be isolated from the accessible environment for a period of at least 10,000 years, with no prediction of significant decreases in isolation beyond that time. "Reasonable assurance" means that the preponderance of technical evidence, as interpreted by objective experts in the field, supports the conclusions drawn. Wastes will be considered to be "isolated" if long-term radiological consequences to the public due to the effects of any reasonably foreseeable events or processes are predicted to be within the range of variations experienced in background radiation.

(3) Risks during the operational phase of waste-disposal systems should not be greater than those allowed for other nuclear fuel-cycle facilities. Appropriate regulatory requirements established for other fuel-cycle facilities of a like nature should be met. "Operational Phase" risks refer to radiological risks either to members of the public or to facility personnel. "Appropriate regulatory requirements" refer to safety standards which are derived for similar quantities of radioactive materials and/or systems subject to similar potential modes of failure and which can, with little or no modification, be applied to a high-level waste disposal facility.

(4) The environmental impacts associated with waste-disposal systems should be mitigated to the extent reasonably achievable. "To the extent reasonably achievable" means that which is shown to be reasonable considering the costs and benefits associated with potential mitigative measures and reasonable alternative courses of action in accordance with requirements set forth by the National Environmental Policy Act (NEPA) of 1969 and the Council on Environmental Quality (CEQ).

(5) The waste-disposal system design and the analytical methods used to develop and demonstrate system effectiveness should be sufficiently conservative to compensate for residual design, operational, and long-term predictive uncertainties of potential importance to system effectiveness, and should provide reasonable assurance that regulatory standards will be met. "Conservatism" means taking a course of action in design, analysis, or operation which would tend to overestimate adverse consequences, underestimate mitigating factors, or otherwise provide large margins of safety against undesirable outcomes. Conservative measures might include:

- A careful stepwise approach to design and operation
- Multiple containment and isolation barriers with sufficient independence and residual effectiveness to assure compliance with appropriate radiation standards over the range of credible failures
- Design and operating margins which compensate for the effects of system uncertainties.

(6) Waste-disposal systems selected for implementation should be based upon a level of technology that can be implemented within a reasonable period of time, should not depend upon scientific breakthroughs, should be able to be assessed with current capabilities, and should not require active maintenance or surveillance for unreasonable times into the future.

(7) Waste-disposal concepts selected for implementation should be independent of the size of the nuclear industry and of the resolution of specific fuel-cycle or reactor-design issues and should be compatible with national policies.

1.4 GEOLOGIC ISOLATION SYSTEM

Geologic isolation is the primary method of waste disposal being pursued by the NWTS program to meet the above objectives. Conceptually, the geologic repository as a waste-isolation system consists of three parts that together provide multiple barriers to the release of the waste into the accessible environment. These parts, or subsystems, are the waste package, the repository, and the site (Figure 1-1).

The waste package includes the waste form itself and a system of engineered barriers consisting of a filler material (in the case of spent fuel), a high-integrity canister, and one or more layers of protective materials selected to minimize interactions among the waste, host rock, and ground water. During the repository operational phase, the waste package provides safe containment of the waste material during handling and emplacement operations and helps ensure that the waste can be safely retrieved, if necessary, from the repository. During the time that fission product decay is dominant and radiation and thermal output are high (i.e., the thermal period), the waste package and repository will contain the waste. The site provides long-term waste isolation and an added barrier against failure of the waste package or repository.

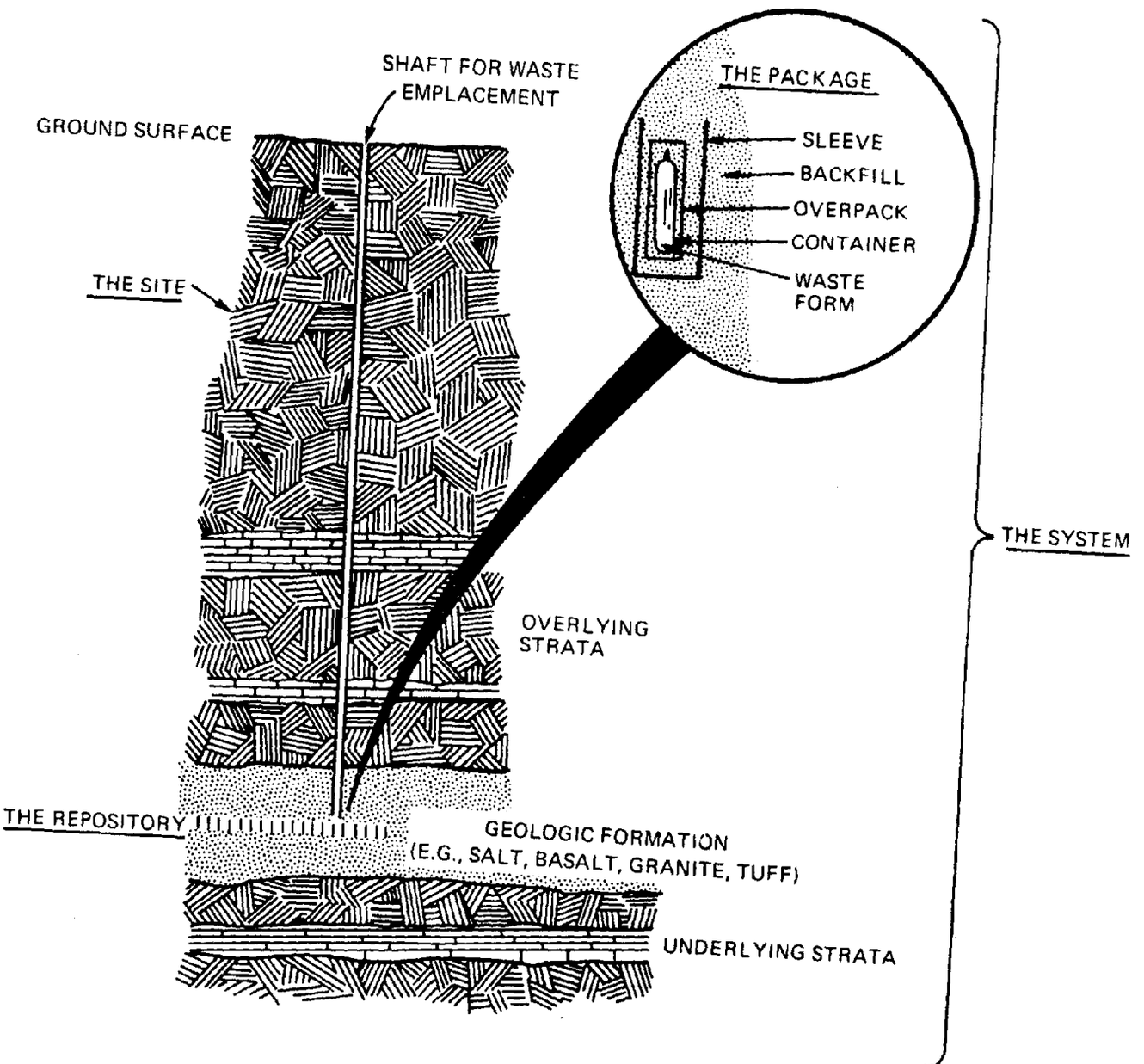

FIGURE 1-1. SCHEMATIC CROSS SECTION OF A CONCEPTUAL GEOLOGIC WASTE ISOLATION SYSTEM

The repository (Figure 1-2) is, in some ways, similar to a conventional mine. Surface structures are built to create access through shafts to the underground rock. Corridors and the rooms are excavated, but for waste emplacement. Unlike a mine, man-made barriers are emplaced to contain and isolate wastes. Site activities are performed to preserve the containment and isolation capabilities of the rock and overburden of the sites.

The repository site will contain a host rock, suitable for construction of the repository, and natural barriers (the host and surrounding rock formations) to contain and isolate the wastes. These barriers will "act" to (1) maintain the waste in its emplaced location; (2) limit radionuclide mobility through the geohydrologic environment; and (3) assist in preventing human intrusion.

1.5 TECHNOLOGY DEVELOPMENT

DOE is developing technology for waste isolation in parallel with the site exploration process. The work is designed to provide information which generally is applicable to any site and which can be performed independently from the site exploration process.

A major element in the technology development program described here is the construction of a Test and Evaluation (T&E) Facility.

The T&E Facility is planned to:

- Test waste handling, emplacement, and retrieval techniques
- Provide a data base to evaluate occupational exposures underground
- Provide a data base on equipment reliability
- Train personnel in safe waste handling operations underground and
- Allow for resolution of repository engineering issues not specific to one rock type.

As such, the T&E Facility will be a developmental facility, the results of which will be used to improve waste handling designs and procedures for repositories.

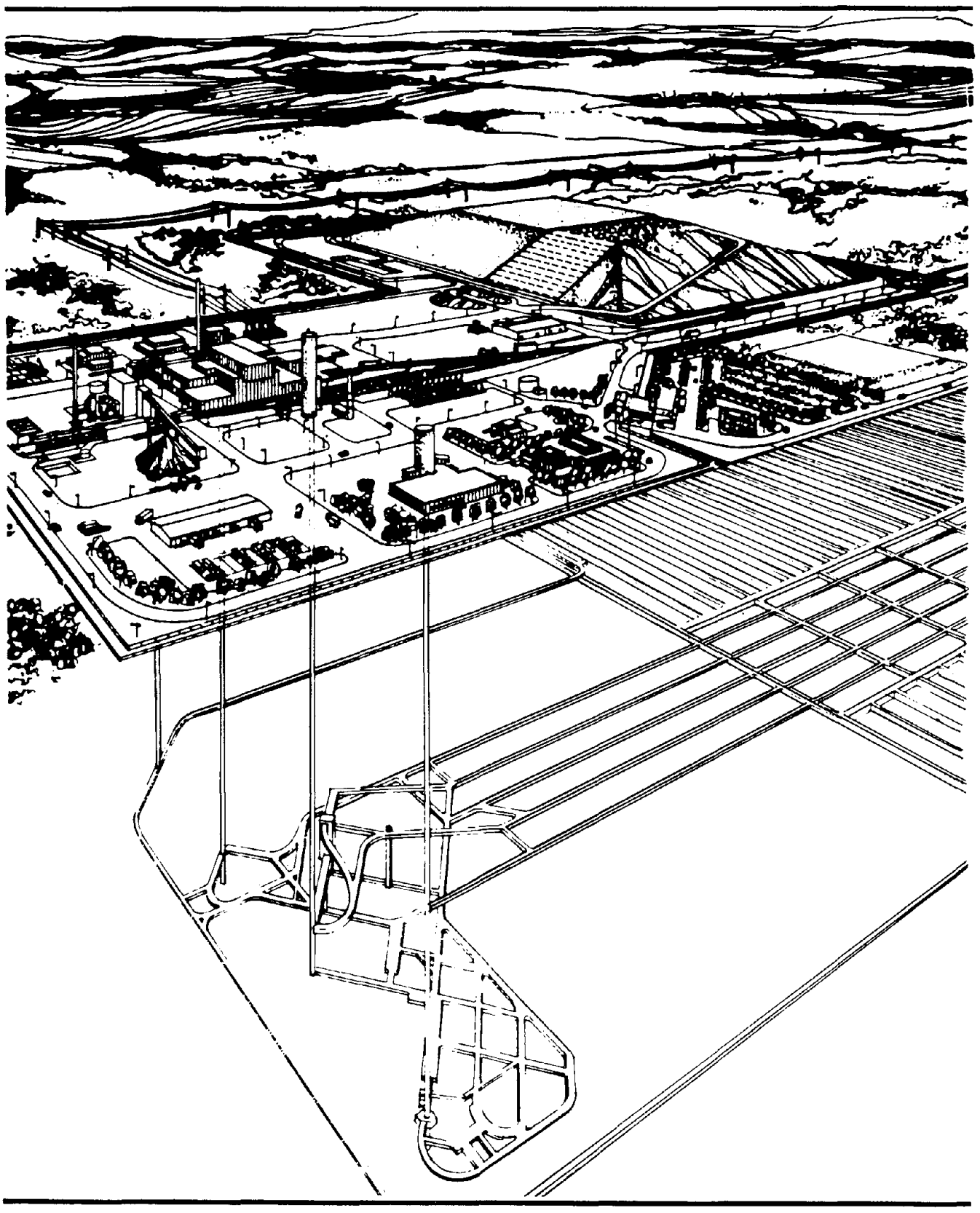

FIGURE 1-2. CONCEPTUAL LAYOUT OF A GEOLOGIC REPOSITORY

Design of the facility will allow for handling and emplacement of a few hundred canisters of a variety of wastes, including solidified high-level waste, in multibarrier packages. Emplacement would be designed for continuous monitoring and retrieval of waste packages. Information developed at this facility generally will be adaptable for use in repository designs in different rock types.

DOE does not plan to license this facility, but will maintain the site in a licensable condition. The information, developed from actual (rather than simulated) underground tests, should provide stronger technical bases for evaluating designs and design trade-offs. Having such bases can serve to shorten the regulatory reviews for a repository and improve eventual designs.

DOE has chosen to construct the $100 to $200 million T&E Facility at one of the first three potential repository sites that are identified using the siting process described herein. While repository siting is independent of and could proceed without a T&E Facility, its presence at a potential repository site prior to a site selection decision makes it necessary to consider how its presence may affect the repository siting process.

First, technology development lead times extend over several years, making it necessary for the engineering testing to be started before the suitability of any site for a repository is established. The site for a T&E Facility could be recommended prior to a DOE determination of the suitability of up to three sites undergoing detailed study, and prior to NRC acceptance of the DOE site. This will enable several years of operating experience to be factored into repository design.

Second, DOE will continue evaluation of alternate repository sites in parallel (or nearly so) with development of the T&E Facility. In situ testing to satisfy 10 CFR 60 will be separate from, but occur at the same time as, T&E Facility engineering tests. The repository site selection decision will not be made until requisite in situ studies at three sites have been concluded. Thus, the suitability of each alternative site will be determined whether or not a T&E Facility is present. Further, the environmental comparisons of alternatives will be made pursuant to NEPA requirements.

Third, the decision to site a T&E Facility at one of three potential repository sites or at an independent site will be independent from the decision to site a repository. Developing information which is transferable to many potential sites, not providing site-specific information, is a primary objective of the T&E Facility. The costs expended for the T&E Facility will not be considered in the decision for repository selection unless the T&E Facility site is judged geologically and environmentally comparable to the other alternatives. Only in such a case would the investment in machines and excavation, that could be applied later to a repository, be factored into the decision for repository selection. Furthermore, it is possible that technology development associated with the T&E Facility may render the site unsuitable for a repository.

Finally, the states and the public will have the opportunity to participate in the decision as to where DOE constructs the T&E Facility. DOE will issue a T&E Facility site recommendation report, which will be accompanied by a draft environmental impact statement (EIS) for review and comment by the involved state(s) and the public. This recommendation report will be in addition to other siting documents (discussed in Chapter 4) which describe how sites were initially selected for detailed study. As part of the input to the T&E Facility site selection decision, an EIS will consider the implications of subsequent repository siting at the candidate T&E Facility site. DOE will address state and public concerns prior to making the T&E Facility site selection decision and issuing the final EIS. The T&E Facility site selection, design, construction, and operations schedule are presented in Chapter 5.

2.0 SITE SUITABILITY

A first step in developing a plan for siting radioactive waste repositories is to establish criteria for sites being sought. Sites should provide safe, permanent isolation of waste in a manner that is environmentally and institutionally acceptable.(11) Criteria have been established for determining suitability of sites.(12) The term "criterion" is used to mean a standard rule or test by which something can be judged. These criteria are used to judge how the characteristics of any site either enhance or diminish its capability to meet the waste isolation performance objectives discussed in Chapter 1. Suitable sites will be selected for repository development on the basis of these criteria, as well as on other waste-management system considerations.

2.1 USE OF CRITERIA AND CONSIDERATIONS

The Nuclear Regulatory Commission (NRC) will define the requirements against which site suitability ultimately will be judged.(1) The Environmental Protection Agency (EPA) will provide the standards upon which NRC requirements will be based. Because the regulatory agency criteria are in the process of being developed and will not comprehensively address all waste management concerns DOE is responsible for addressing, DOE has formulated criteria to guide the NWTS program siting and technology development efforts. Both functional requirements and performance criteria have been formulated. Functional requirements establish the capabilities that the mined geologic disposal system must provide to achieve the performance objectives discussed in Chapter 1.0. Performance criteria designate how the disposal system and its components must perform to ensure that the functional requirements are met. The site performance criteria are written in general terms to provide for analysis of the total consequence of the many interacting characteristics of the natural and human environment which may affect a repository site (see Appendix A).

The suitability of a location cannot be determined on the basis of only one or two characteristics, such as tectonics or geochemistry; nor can it

be expected that perfect locations will be found, where every characteristic is ideal. Geologic systems are found as they are, not engineered, so each candidate location will have advantages and disadvantages which will be compared in narrowing the range of alternatives or, ultimately, in selecting sites. Whereas one geographic area might be considered less favorable on the basis of an evaluation of tectonic factors alone, other characteristics such as land use or geohydrology may be so favorable as to counterbalance the low degree of compliance with the criteria for tectonic environment.

In searching for suitable sites criteria are used to narrow the range of candidates as follows:

- Land areas, be they large regions or smaller areas, that may satisfy siting criteria become candidates. The significant and distinguishing characteristics of these candidates are compared to identify those well suited for continued study.
- Land areas that appear less favorable than the recommended candidates on the basis of early comparison of reconnaissance level data are deferred from additional detailed study. Deferred candidates remain available for later consideration should the recommended candidates prove unsuitable after acquiring additional information.
- Land areas also may be deferred or eliminated because of significant technical uncertainties which do not necessarily establish a safety inadequacy, but may foretell either inordinately expensive testing requirements or intractable questions.

The range of candidates thus is narrowed as some portions survive a screening. The screening decision involves suppositions in regard to some undetermined characteristics, and these suppositions remain to be proved in subsequent phases of study. Before a site can be determined to be suitable, information on the full range of characteristics will be needed to allow evaluation of the site against the siting criteria.

2.2 SITE FUNCTIONAL REQUIREMENTS

Functional requirements covering the waste-isolation system, site, waste package, and repository have been established.[11] The functional requirements that apply to sites are:

- Operations. A site shall provide a setting compatible with the type and magnitude of operations expected at the waste repository. The feasibility of constructing a repository must be considered in selecting a site. In particular, the site must provide (1) an adequate volume of host rock for the underground portion of the repository, (2) a host rock in which the underground areas can be excavated safely, (3) features suitable for the construction of the surface facilities, (4) a hydrologic environment compatible with the construction and sealing of shafts, and (5) a location at which environmental and socioeconomic impacts from repository construction and operation would not render the site unacceptable.
- Containment and Isolation. The site shall provide natural barriers that will effectively contain and isolate radionuclides. Thus, the site must provide capabilities to (1) contain the waste, (2) isolate the waste from man, and (3) assist in keeping man away from the waste.

Protection of the public health and safety is the key objective in the selection of candidate sites. The site must, therefore, provide natural barriers for waste containment and isolation. These barriers should keep radionuclides from reaching man in unacceptable quantities by (1) maintaining the waste in its emplaced location for a given period of time (providing waste containment), (2) limiting radionuclide mobility through the geohydrologic environment to the biosphere (providing isolation), and (3) making human intrusion difficult, principally by locating the repository deep in a host rock (assisting in keeping man away from the waste). The site must contain a host rock suitable for constructing the repository and containing the waste, and surrounding rock formations that can provide adequate isolation. Desirable hydrologic features include low ground-water flow rates, long flow paths to

the biosphere, and long-term stability. The important natural attributes of the host rock include low hydraulic conductivity, chemical characteristics that would impede radionuclide migration by sorption, and high thermal conductivity.

2.3 SITE PERFORMANCE CRITERIA

Site performance criteria encompass all factors considered important to ensure long-term public health and safety and environmental acceptability. These criteria, provided in Appendix A, are applied during the narrowing search for sites and when determining site suitability.

The site performance criteria address site characteristics that influence system performance during three periods:

- Operational period--The time when the repository is open, and waste is being emplaced or retrieved. This period includes construction of the repository.
- Thermal period--The time after closure of the repository when radioactivity levels and heat production are dominated by fission-product decay.
- Post-thermal period--The time following predominant decay of fission products, during which the radiological hazard is dominated by the decay of actinides and their daughters.

During the operational period, site characteristics important to safety are those that affect excavation and maintenance of underground openings, construction and operation of surface facilities, and surface conditions. Site characteristics that determine system response to thermal, chemical, and mechanical stresses imposed by the waste are important to system performance during the thermal period. During the post-thermal period, the site's ability to retard and limit radionuclide mobility and release to the biosphere is of principal concern. Natural phenomena (such as climatic changes and earthquakes), and human-induced phenomena (such as mining and pumping water from wells), which have potential to affect a site must be considered.

Table 2-1 provides an expanded list of the factors and considerations that need to be addressed throughout the siting process. Concerns raised over

TABLE 2-1. TYPICAL SITE SUITABILITY CONSIDERATIONS

Criterion[a]	Sub-Criterion	Factors	Considerations
1.0 Site geometry	1.1 Minimum depth	Surface erosion	What is the maximum credible depth of erosion? Is this a potential hazard?
		Depth to host rock	What is the shallowest host rock?
		Uplift rates	Can uplift expose the repository?
		Location of aquiclude	What is relation of aquiclude depth to repository depth?
		Aquifer flow rates	What is direction and rate of ground-water flow?
		Location of aquifers	What is relation of aquifer depth to repository depth?
	1.2 Thickness and lateral extent of host rock	Available space in acres	What is area available at repository depth? Is area adequate?
		Shape of host rock formation	What is the shape of the host rock formation at repository depth?
		Nature of contact with surrounding rocks?	What is the configuration of the contacts between host and surrounding rocks? Is it acceptable?
		Temperature differences	What is ΔT between the host and surrounding rock?
		Presence of boreholes Number into overburden Number into host rock	How many boreholes presently exist? What is their location and depth? Do these pose a problem?
		Time to remove "X" feet by dissolution	Given ground-water flow rate, what is dissolution rate?

(a) For a full statement of each criterion and sub-criterion see Appendix A, Site Performance Criteria.

TABLE 2-1. (Continued)

Criterion	Sub-Criterion	Factors	Considerations
2.0 Geohydrology	2.1 Geohydrological regime	Travel time of water from host rock at repository depth	What is the calculated travel time of water from the host rock to the biosphere? Is the rate of concern?
		Travel time of radionuclides from host rock to biosphere	What is the calculated travel time of radionuclides from the host rock to the biosphere? Is the rate of concern?
		Minimum path length	What is the minimal ground-water path from the repository horizon to biosphere?
		Path orientation	What is the orientation of this path? Is the path of concern?
		Head differential	What is the head differential? What is the significance?
	2.2 Hydrological regime/ shaft construction	Shaft sealing	Does shaft construction (dewatering techniques) impact performance predictions? Can reliable shaft sealing be accomplished?
	2.3 Subsurface rock dissolution	Dissolution rate	What is the calculated dissolution rate, if any? Would this expose the repository?
3.0 Geochemistry	3.1 Geochemical interactions	Redox potentials, pH, solution equilibria	What is the chemistry that may affect waste packages or that may interact with the waste form?
		Retardation coefficients	What are the sorptive properties of the material in potential flow paths? Are these sufficient to slow predicted radionuclide travel times?
4.0 Geological characteristics	4.1 Subsurface setting	Hydrological modeling Model complexity	Is subsurface setting sufficiently known to allow modeling? Is complexity such as to cast doubt on the credibility of the model?

TABLE 2-1. (Continued)

Criterion	Sub-Criterion	Factors	Considerations
	4.2 Host rock characteristics	Chemical and physical characteristics	Are chemical/physical characteristics compatible with waste containment, isolation, and retrieval?
		Impurities	
		Water content	
		Texture	
		Fracture zones	
		Gas content	
		Permeability/porosity	
	4.2.1 Induced stresses and host rock response	Host rock/formation contacts Heat, radiation, stability Closure rates Yield strengths	What is the predicted response of the repository opening and the isolation system to natural and man-made loads imposed during operational and isolational phases?
	4.3 Engineering feasibility	Development, operation, closure	What is the feasibility of repository development, operation, and closure in a safe manner, given the geologic characteristics present?
5.0 Tectonic Environment	5.1 Tectonic elements	Faulting, volcanism, geothermal gradients	Are there tectonic elements present that might affect repository performance?
	5.2 Major regional faults	Distance	What is the distance to the nearest major regional fault or fault system?
		Orientation	What is the orientation of the fault(s)?
		Age of fault activity	What is the age of the most recent fault activity?
		Rate of motion	What was the rate of motion?
		Basement connection	Does the fault extend to the basement?
		Seismicity of fault	What is the present seismicity related to the fault?
		Existence of Quaternary overburden	Is Quaternary material present to demonstrate lack of Quaternary movement?

TABLE 2-1. (Continued)

Criterion	Sub-Criterion	Factors	Considerations
	5.2.1 Near faults	Distance	What is the distance to the nearest fault of any size?
		Orientation	What is the orientation of the fault(s)?
		Age of fault activity	What is the age of the most recent fault movement?
	5.3 Quaternary igneous activity		Is there any evidence of Quaternary igneous activity that might have an adverse impact on repository performance?
	5.4 Uplift or subsidence rates	Rate of movement	What is the rate of movement of the host formation?
		Associated anomalies	Is there any evidence of associated anomalies?
		Regional uplift/ subsidence	What is the rate of regional uplift or subsidence, if any?
	5.5 Ground motion	Tectonic environment Tectonic history	What is maximum credible ground motion related to earthquakes?
6.0 Human intrusion	6.1 Resources	Hydrocarbons Minerals Thermal energy Potable water Exploitable features Other subsurface uses	Are there resources present or likely to be present that would invite future human intrustion?
	6.2 Exploration history	Boreholes and wells Mining	Can the history of exploration for natural resources be defined and documented? Are there factors related to this history that have an adverse impact on repository performance? Can we demonstrate that the opposite is true?
	6.3 Ownership control	Current ownership State laws/regulations	Are there conditions which would prevent or make difficult the federal government ultimately obtaining ownership to the repository site and controlling the necessary access?
7.0 Surface characteristics	7.1 Surficial hydrologic system	Fluvial cycle	What are the climatic differences between the present and glacial periods?
		Flood plain disposition (major river)	Could changes in flood plains cause detrimental effects?

TABLE 2-1. (Continued)

Criterion	Sub-Criterion	Factors	Considerations
		Proximity to dams (upstream within watershed)	Could a future reservoir upstream cause detrimental effects?
		Proximity to surface water	Could future expected changes in the unconfined ground-water regime cause detrimental effects?
		Annual cycle	Are there detrimental effects due to annual climate/ground-water fluctuations?
		Probable maximum flood	What is the probable maximum flood? What area would be inundated? Would there be detrimental effects?
		Probable maximum precipitation	What is the maximum credible precipitation? Would such precipitation cause detrimental effects? Impact on engineering feasibility?
	7.2 Surface topographic features	Accessibility Slope stability Grades	Is topography of the potential site detrimental to repository access, construction, or operation?
	7.3 Meteorological conditions	Flash flood Avalanches High winds Tornadoes Hurricanes	Are meteorological conditions such that they would be detrimental to access, construction, or operation?
	7.4 Nearby Hazards	Proximity to transportation routes Industrial/military installations Gas or petroleum pipelines/storage areas	What is the proximity of the site to hazards? Could offsite explosions, collisions, or other accidents affect repository safety?
8.0 Demography	8.1 Human proximity	Distance and direction Population density with distance	Where are the urban centers and what are the population densities proximate to the site?

TABLE 2-1. (Continued)

Criterion	Sub-Criterion	Factors	Considerations
	8.2 Transportation risk	Roads/highways RR class Distance to source point	What are the regional transportation risks associated with the site under consideration?
9.0 Environmental protection	9.1 Environmental impact	Flora and fauna Ecosystem characteristics Spoil disposal Endangered species Natural resources Noise, odor Air, water quality Wetlands Construction effluents	What are the environmental impacts of the alternatives under consideration?
	9.2 Land use conflicts	Parks, recreation Industry and agriculture Wilderness Archaeological and historic features Forests Endangered species Wild and scenic rivers Wildlife preserves National parks Historical sites Military reservations	What are the land use conflicts to be evaluated and resolved for the various alternatives under consideration?

TABLE 2-1. (Continued)

Criterion	Sub-Criterion	Factors	Considerations
	9.3 Normal and extreme environmental conditions	Secondary impacts associated with high winds, tornadoes, rainfall, flooding	What are the impacts of normal and extreme environmental conditions on the areas adjacent to the repository construction or operations areas?
10.0 Social, political, and economic impacts	10.1 Social impact	Residential displacement Social infrastructures Industrial conflict Demographic composition Income levels Education Housing needs Economic expansion Fiscal capacity Land utilization Perceptions of risk	What are the social, political, and economic concerns to be evaluated for the various alternatives under consideration?
	10.2 Access and utility requirements	Labor pool Services and utility Highways, railways Airports	What upgrading of access routes, utilities, and services will be required and what are the impacts of the upgrading? Where will construction and operating personnel come from? What provisions need to be made for the work force?

the years[13] about each of these factors received extensive review and evaluation prior to formulation of the criteria in Appendix A. Additional discussion of the criteria can be found in Reference 12.

The criteria in Table 2-1 can be divided into two categories:

- Those contributing to public health and safety, (criteria 1 through 8) and
- Those contributing to environmental and socioeconomic acceptability (criteria 9 and 10).

These categories are discussed below.

2.3.1 Public Health and Safety Factors

Public health and safety factors are features or conditions that promote or inhibit movement of radionuclides. These features or conditions, on or within the Earth's crust, include characteristics of the host rock, the surrounding geologic formation, the fluids within them, and changes in these features or conditions which are naturally or human-induced.

The factors listed in Table 2-1 are categorized by criteria which cover features or conditions that may in some way affect repository performance. There is some overlap among the categories. For example, hydrologic conditions are closely related to such geologic characteristics as rock types, rock distribution, and the geometric configuration of fractures. Also, the study of geologic factors is used to determine tectonic processes and the presence of potentially useful minerals. Thus, the separation of site characteristics into components is discretionary, but it facilitates understanding and discussion of the phenomena that potentially affect site performance.

2.3.2 Environmental Acceptability Factors

Factors to be considered in the siting process, other than those affecting public health and safety, include the human, plant, animal, and aesthetic and land use features or conditions. Environmental, socioeconomic, and land-use factors such as those listed in Table 2-1 will be considered in the site selection process to ensure that adverse effects are prevented, if possible, or kept within acceptable limits.

2.4 NRC SITE SUITABILITY CRITERIA

As indicated in Section 2.1, the NRC will promulgate the regulations and criteria for waste disposal in geologic repositories with which DOE must comply. On February 25, 1981, NRC published in the Federal Register[2] final regulations for licensing geologic repositories for the disposal of high-level radioactive waste (10 CFR 60). This rule contained only the procedural requirements concerning general provisions, license, and participation by state governments.

The NRC also published in the Federal Register on July 8, 1981, a proposed rule on the technical criteria intended for inclusion in 10 CFR Part 60, "Technical Criteria for Regulating Geologic Disposal of High-Level Radioactive Waste".[1] The proposed rule specifies technical criteria for disposal of high-level radioactive wastes in geologic repositories. The Federal Register notice solicits comments for consideration in preparation of a final rule. Thus, the criteria are in a formative stage.

Table 2-2 provides a summary comparison of the NWTS criteria content with the content of NRC and other proposed criteria.[14,15,16] The original documents, identified in the table, can be referenced for more detail. It can be seen from Table 2-2 that the NWTS criteria include content similar to the NRC proposed criteria but in a different format. The draft NRC criteria suggest that the presence of adverse conditions may compromise site suitability. Such conditions will require careful analysis and perhaps additional measures to compensate for them (10 CFR 60.123).

In the DOE search for sites, this issue is addressed by avoiding obviously unacceptable conditions, while other conditions or features are evaluated for their degree of compliance with the appropriate criteria. A certain condition, for example, may not be favorable, but the site need not be avoided if it is shown to have multiple, offsetting favorable features. Comprehensive investigations and performance analyses that consider all such conditions are performed before any final judgment on site suitability can be made.

TABLE 2-2. COMPARISON OF DOE AND OTHER SITING CRITERIA

DEPARTMENT OF ENERGY NATIONAL WASTE TERMINAL STORAGE PROGRAM NWTS-33(2) NWTS Criteria for the Geologic Disposal of Radioactive Wastes: Site Performance Criteria (February 1980)	DEPARTMENT OF ENERGY DOE/EIS-0046/F Final Environmental Impact Statement Management of Commercially Generated Radioactive Wastes, Vol. 1 (October 1980)	NATIONAL RESEARCH COUNCIL NATIONAL ACADEMY OF SCIENCE Geological Criteria for Repositories for High-Level Radioactive Wastes (August 1978)	NUCLEAR REGULATORY COMMISSION 10 CFR Part 60, Subpart B Draft (May, 1980)	INTERNATIONAL ATOMIC ENERGY AGENCY Technical Reports Series No. 177 Site Selection Factors for Repositories of Solid High-Level and Alpha-Bearing Wastes in Geological Formations (October 1977)	OFFICE OF WASTE ISOLATION Y/OWI/TM-47 Geological Criteria for Radioactive Waste Repositories (November 1977)
I. Site Geometry • Minimum Depth • Thickness • Lateral Extent	Section 5.1.1., Item 1. Geologic Environment Geometry	Section 3.1.1. Depth Section 3.1.2. Size and Shape of Rock Section 3.1.3. Geometry of Rock	60.122 (c)(2) - Minimum Depth 60.122 (a)(9) - Thickness 60.122 (a)(9) - Lateral Extent	Selection Factor 4.3.1 Depth Selection Factor 4.3.2. Thickness & Extent Selection Factor 4.8.1. Buffer Zone	Criterion 1: Depth Criterion 2: Vertical Extent Criterion 3: Lateral Extent
II. Geohydrology • Hydrological Regime/ Path Length/Travel Time • Water Bodies/Climatic Cycles • Aquifer Flow/Construction • Dissolution of Rock	Section 5.1.1., Item 3. Subsurface Hydrologic Characteristics	Section 3.3.1 Fluid Transport Section 3.3.3. Past Hydrological Conditions Section 3.4.3. Waste/Rock Interaction	60.122 (a)(1), (a)(2), (a)(3), (a)(4), (a)(9), (b)(3), (c)(1) and (c)(2) - Hydrological Regime/Path Length/Travel Time 60.122 (c)(2) - Water Bodies/Climatic Cycles 60.132 (c)(2) - Aquifer Flow/Construction 60.122 (a)(9), (c)(1) - Dissolution of Rock	Selection Factor 4.5.1 Permeability, Porosity, Dispersiveness Selection Factor 4.5.5. Sorption Capacity Selection Factor 4.5.6. Mineral Sources of Water Selection Factor 4.6.2. Ground Waters	Criterion 7: Hydrological Properties Criterion 8: Waste/Water Interaction Water Content of Host Rock
III. Geochemistry • Chemical Interactions • Radionuclide Retardation	Section 5.1.1., Item 3. Subsurface Geochemical Characteristics	Section 3.4.1. Heat/Radiation Effects Section 3.4.2. Waste/Rock Interaction Section 3.4.4. Waste Water/Rock Geochemistry	60.122 (c)(1), (a)(4), (a)(9), (b)(4) Chemical Interactions 60.111 (c)(4), and 60.122 (c)(1) - Radionuclide Retardation	Selection Factor 4.5.4. Thermal Effects Selection Factor 4.5.5. Sorption Capacity Selection Factor 4.5.6. Mineral Sources of Water Selection Factor 4.5.7. Radiation Effects	Criterion 9: Radiation/Rock Interaction Criterion 10: Waste/Rock Interaction
IV. Geologic Characteristics • Stratigraphy • Host Rock Characteristics • Virgin Rock Strength	Section 5.1.1., Item 2. Geologic Characteristics	Section 3.1.3. Geometry and Properties of Host Rock Section 3.2.4. Mechanical/Geophysical Properties, State-of-Stress	60.122 (a)(1-4), (b)(2), (c)(2) - Stratigraphy/Host Rock Characteristics 60.122 (a)(9) - Virgin Rock Strength 60.111 (c)(4) - Geologic Stability	Selection Factor 4.3.3. Consistency, Homogeneity, Purity Selection Factor 4.3.4. Surrounding Beds Selection Factor 4.4.1. Dip Selection Factor 4.4.2. Faults & Joints Selection Factor 4.5.3. Rock Mechanics Selection Factor 4.5.4. Thermal Effects	Criterion 11: Mechanical Properties of Rock Criterion 12: State of Stress Criterion 14: Geological Setting
V. Tectonic Environment • Tectonic Elements • Quaternary Faults • Quaternary Igneous Activity • Uplift or Subsidence Rates • Seismicity	Section 5.1.1., Item 5. Tectonic Stability, Faulting, Deformation, Volcanic Activity	Section 3.2.1. Stability & Tectonic Boundaries Section 3.2.2. Faults Section 3.2.3. Volcanic Activity	60.122 (c)(1), (a)(3), (a)(4) - Tectonic Environment 60.122 (b)(2) - Tectonic Elements 60.122 (b)(2), (a)(2), (b)(3) - Quaternary Faults 60.122 (b)(2) - Quaternary Igneous Activity 60.122 (b)(2) - Uplift or Subsidence Rates 60.122 (b)(2) - Seismicity	Selection Factor 4.2. Tectonics & Seismicity Selection Factor 4.4.2. Faults & Joints Selection Factor 4.4.3. Diapirism	Criterion 4: Uplift/Subsidence Criterion 5: Faults Criterion 6: Igneous Activity Criterion 13: Seismicity

TABLE 2-2. (CONTINUED)

DEPARTMENT OF ENERGY NATIONAL WASTE TERMINAL STORAGE PROGRAM	DEPARTMENT OF ENERGY	NATIONAL RESEARCH COUNCIL NATIONAL ACADEMY OF SCIENCE	NUCLEAR REGULATORY COMMISSION	INTERNATIONAL ATOMIC ENERGY AGENCY	OFFICE OF WASTE ISOLATION
VI. Human Intrusion • Resources • Exploration History • Ownership and Control	Section 5.1.1., Item 6. Resource Potential of Site	Section 4.1. Exploration History Section 4.2. Resource Analysis	60.122 (b)(1), (a)(2-4), (a)(8) -Resources 60.122 (b)(1), (a)(8) - Exploration History 60.121 - Ownership/Control	Selection Factor 4.8.2. Preexisting Boreholes and Excavations Selection Factor 4.9.1. Resource Potential (Economic) Selection Factor 4.9.4. Jurisdiction of Land Selection Factor 4.9.5. Existing Rights	Criterion 15: Mineral Resources Criterion 16: Water Resources
VII. Surface Characteristics • Hydrological System • Topographic Features • Meteorological Phenomena • Industrial/Transportation/ • Military Installations	Section 5.1.1., Item 4. Surficial Hydrologic System, Climatic Cycles	Section 4.3. Flooding (Dams)	60.122 (b)(3), (b)(1) - Hydrological System 60.122 (b)(1) - Water Bodies 60.122 (b)(1), (b)(3) - Topographic Features 60.132 (b)(3-5, 7) - Industrial Transportation/ Utility Hazards	Selection Factor 4.1. Topography Selection Factor 4.6.1. Surface Waters	Criterion 14: Geographic and Topographic
VIII. Demography • Urban Areas • Transportation	No criteria specified	No criteria specified	60.122 (c)(2) - Urban Areas Not specifically addressed - Transportation	Selection Factor 4.9.3. Population Density	No criteria specified
IX. Environmental Protection • Wilderness • Rivers • Wildlife • National Parks • Archaeology • National Heritage • Ambient Conditions	No criteria specified	No criteria specified	No criteria specified	Selection Factor 4.6.1. Surface Waters Selection Factor 4.8.6. Ecological Effects Selection Factor 4.9.2. Land Value & Use	Criterion 16: Water Resources Criterion 17: Land Use
X. Socioeconomic Impacts • Management of Impacts • Transportation Impacts	No criteria specified	No criteria specified	No criteria specified	Selection Factor 4.8.5. Waste Transportation Selection Factor 4.9.6. Accessibility & Services	No criteria specified

3.0 PRINCIPLES GUIDING THE SITING PROCESS

Certain principles must be considered in developing a siting process. These principles are the need (1) to obtain public involvement, (2) to assure that DOE siting decisions are based on sound information, (3) to comply with Nuclear Regulatory Commission (NRC) procedures, and (4) to consider, in accordance with requirements of the National Environmental Policy Act (NEPA), the potential impacts of proposed action which may have a significant effect on the environment.

3.1 PUBLIC INVOLVEMENT

Permanently isolating radioactive waste from the environment is an issue of great public interest. This interest has been expressed by citizens' groups as well as by representatives of state and local governments and the nuclear industry. The management of wastes to be isolated spans the jurisdictions of a number of established institutions and extends into areas of social concern for which institutional responsibilities and authorities are still being defined.

The Department of Energy has committed itself to conduct the radioactive waste program in close consultation with the states.[6,7] Under the procedures now being developed, an involved state will have a continuing role in reviewing federal decision-making on the siting, design, and construction of a high-level waste repository.

Past experience in siting nuclear facilities suggests that early and meaningful public involvement in the siting process can improve significantly the acceptability of siting decisions. Such involvement is, accordingly, structured integrally within the DOE siting process. The sections below discuss the state groups; consultation with state, local, and tribal governments; public information programs; direct public participation; and peer review which may influence the siting process.

3.1.1 Involvement of State Groups

Various state groups have given or are providing input and oversight for the NWTS program, including the State Planning Council on Radioactive Waste Management (SPC), the State Working Group on High-Level Nuclear Waste Management (SWG), the National Governors' Association (NGA), and National Council of State Legislatures (NCSL).

The State Planning Council (SPC) was appointed for an 18-month term in February, 1980, to advise the President and Secretary of Energy on methods to strengthen working relationships among federal, state, tribal, and local governmental officials on high and low-level radioactive waste management issues.(17) Its membership included eight governors, three state legislators, a mayor, a county commissioner, the chairman of an Indian nation, the secretaries of three federal departments, and the head of one federal agency. The SPC's major role was to define specific mechanisms that states could use to interact with the federal government. The State Planning Council has completed its deliberations and submitted its recommendations to the President on August 1, 1981.(18)

The State Working Group (SWG) was also organized in early 1980 and is composed of representatives from various states in which DOE is conducting studies as part of the site-selection process. The SWG, funded by the National Governors' Association (NGA), shares information, discusses subjects of concern, and reviews reports of other groups such as the NGA.

Both the National Governors' Association and the National Conference of State Legislatures (NCSL) have taken active roles in federal-state interaction. In August, 1978, the nation's governors recommended to the President and the Congress that radioactive wastes be considered a national responsibility that cannot be solved by a federal source alone. NGA also recommended the solution be based on the principles of cooperative federalism. NGA issued two subsequent position papers on this subject: Nuclear Energy Policy Position Adopted by National Governors' Association (August, 1979), and Toward Establishing a Responsive and Acceptable National Nuclear Waste Management Policy (April, 1979).(19)

Representatives of both the NGA and the NCSL participated in a 1979 workshop in Eastsound, Washington. The workshop, sponsored by DOE, was held to explore and define the concept of cooperative federalism or, alternatively, consultation and concurrence and provided an opportunity for various public officials and others to explore the issues informally. Participants included former governors, state legislators, state officials, DOE representatives, representatives of both environmental groups and the nuclear industry, and academic analysts with backgrounds in nuclear waste or related issues.

3.1.2 Consultation with State, Local, and Tribal Governments*

DOE is committed to providing state, local, and tribal governments opportunities to participate in the siting process, through consultation on matters relating to the selection of repository sites.

While specific programs will vary, procedures to guide geologic and hydrologic studies will be established between DOE and a state or group of states. DOE will provide each state opportunities to involve its agencies and educational institutions in planning the field investigations and site characterization. Grants may be made available to the states to fund their independent review of the work being conducted. Chapter 4 describes consultation activities generally applicable to the various phases of the siting process.

While specific elements of the process are still evolving, essential elements of the consultation process, common to all phases of siting, are unlikely to change dramatically. The process includes exchange of information between the state and DOE, state advice to DOE on exploration plans, factoring state concerns into DOE's program, and the opportunity for negotiation with DOE on key issues.

Direct state participation through appropriate agencies or technical groups is desired. Contracts (or grants if appropriate) may be given to state research groups to assess state, local, or tribal community socioeconomic impacts. Information produced from these activities will be factored into DOE decision making.

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*For brevity, state, local, and tribal governments are sometimes referred to as "states".

Environmental, social, and economic considerations contribute importantly to the selection of potential repository sites, and data on these factors are taken during the exploratory phase. Along with extensive research on the socioeconomic effects on nearby communities, a community planning document, entitled Framework for Community Planning Associated with Nuclear Repository Siting, has been prepared by DOE to aid state, local, and tribal communities in identifying potential impacts and planning for their mitigation.(20) Mechanisms by which these affected parties can obtain financial and technical resources are included. Further discussion of the socioeconomic factors in repository siting may be found in the accompanying Environmental Assessment in this document.

Details of the consultation process may be established through formal or informal agreements developed between DOE and an individual state. DOE has established or is negotiating such agreements with several states in which studies are under way.

The following elements are considered in formulating agreements between DOE and a state:

- DOE and its representatives will brief the governor of the state or designated representative or tribal leader when land within the state has been identified as having potential. Additional briefings and meetings will take place on a basis agreeable to both parties.
- The state will have an opportunity to review and comment on all field activities proposed within the state. DOE will consider state and tribal concerns before completing any plans.
- Managers of DOE field offices will build on existing communication channels with states to discuss siting activities within their zones of jurisdiction.
- Field exploration plans, characterization data, recommendation reports, and environmental documents developed for the NWTS program will be provided to representatives of involved states for comment prior to being made final.
- A focus for state communication with the federal government will be established through the state's representative, if communication channels need to be augmented.

- The state's representative will generally develop methods for coordinating with local organizations on NWTS activities and will generally receive and disburse any funds provided to the state for participating in cooperative studies.
- DOE provides to the state technical results of characterization work and DOE recommendations for subsequent field activities in the state, if any.
- DOE will not initiate any new study phase in a state, beyond those already under way, until the state has had reasonable opportunity to review and comment on the previous phase's results and recommendations, or has had an opportunity to review and comment on the plan for exploration activities.
- Announcements to the news media on DOE's exploration activity in a state will be coordinated with the state's representative.

Mechanisms for working with state and local governments are being established and used during the current phases of the program. Generally, when substantive issues are raised by a state, DOE's policy is to modify its activities as necessary and reasonable to address the concerns. Conflicts between states and the federal government can be avoided by continued joint resolution of concerns during each phase of the program. The use of cooperative mechanisms already established in the program, and much of the continuing work of the Congress, the National Governors' Association, the National Association of State Legislatures, state groups, and various federal departments, is directed toward providing conflict resolution mechanisms when they are needed. Consultation aspects at each step in the siting process are discussed in Section 4.2.

3.1.3 Public Information

To support informed public participation, DOE is directing its program to:

- Routinely update the status of knowledge on nuclear waste management and provide this information to the public at large in understandable terms

- Increase discussions between federal program managers and institutions and organizations desiring such discussion
- Support private sector efforts to generate a greater degree of understanding of nuclear-waste management issues.

Through its nuclear-waste management program, DOE has organized national and state-level public conferences to discuss the progress of waste-management activities and the local impacts of project activities. DOE has provided community leaders with conference grants to attend topical conferences and field test sites. DOE has also prepared brochures, fact sheets, and media materials describing the program and reporting on progress. Other mechanisms to enhance public participation will continue to be explored.

To help make the issues of radioactive-waste management more understandable to interested audiences, the NWTS program uses motion pictures, audiovisual presentations, and exhibits. These presentations are shown at public and technical meetings, legislative functions, professional society meetings, state and local briefings, and other appropriate events. Educational exhibits are displayed at various meetings and technical symposia, and a comprehensive popular-level exhibit has been designed for exhibition at major science museums.

The NWTS Office of Nuclear Waste Isolation maintains a library and reference center at 505 King Avenue, Columbus, Ohio 43201 (telephone 614-424-7697), which is available to the public upon request and has an on-line interactive computer terminal to access scientific and technical data bases at Oak Ridge National Laboratory. In addition, numerous periodic activity reports, technical reports, quarterly progress summaries, and other information materials are available on request. Program documents and informative material are also provided to public libraries in the vicinity of study areas.

One of the important communication tools is briefing material for meetings with state and local officials. In states where the NWTS program is active, State Briefing Books summarizing study activities may be used. The DOE Public Affairs Office prepares news releases on significant activities and provides news media with reference resources. Annual technical information meetings on the NWTS program, hosted by ONWI and BWIP, are sponsored by DOE. These meetings provide a forum to discuss current and future technical activities, and to address the related political and social issues.

3.1.4 Direct Public Participation

DOE recognizes that the public does not speak as a single, uniformly dedicated body. Diverse concerns and perspectives exist among individuals and interest groups. To accommodate this diversity DOE provides opportunities for the public to participate in various ways.

DOE regularly provides for public review of program documents by state agencies and individual scientists. A request for comments on the Draft Environmental Impact Statement: Management of Commercially Generated Radioactive Waste[10] yielded 219 letters containing approximately 2,000 separate comments. In addition, two-day public hearings were held in five cities. Other waste management documents that have been formally circulated for public comment include:

- Earth Science Technical Plan[9]
- Site Performance Criteria[12]
- Summary reports of characterization studies carried out in the program to identify sites[21-25].

In each case, the final editions of the documents will contain modifications to respond to issues raised by reviewers.

Other techniques DOE uses to obtain public comment on the waste-management program include public meetings held in various locations throughout the country, news-media interviews, and radio and television panel discussions. All these techniques are needed to spread information and address the questions of a concerned public.

3.2 ASSURING QUALITY OF INFORMATION

An additional principle of particular importance to the siting process is the need to assure that siting decisions are based on sound information and data. This is done by applying peer review and a formal quality assurance program to siting and technology development activities. The peer review process is an essential element in assuring that the decision makers base their decisions on relevant and sufficient information.

Decisions by DOE officials are based upon recommendations made by the program organization. However, intensive scientific peer review serves to assure the technical soundness of DOE's programs and its recommendations. Program and peer review committees, some long-standing, others assembled for ad-hoc reviews of specific portions of the program, have been established and meet as needed to perform their functions. Representative review groups include:

- Program Review Committee
- Technical Advisory Committee
- Earth Science Review Group
- State Geologists Technical Review Group
- Geologic Exploration Review Group (ONWI)
- BWIP Geology Overview Committee
- BWIP Hydrology Overview Committee
- BWIP Rock Mechanics Overview Committee
- BWIP Waste Package Overview Committee
- BWIP Intergovernmental Basalt Working Group
- NNWSI Geological Investigations Peer Review Group
- NNWSI Media Studies Experimental Planning Peer Review Group
- NNWSI Climax Spent Fuel Test Peer Review Group.

These groups, comprised of individuals from a variety of disciplines, provide an expanded perspective on the NWTS program's scope, technical adequacy, and achievement. Along with the program reviews performed by state, local, and tribal governments, the peer review groups help assure a balanced view of the siting process and expand the perspective from which siting decisions are made.

3.3 NRC LICENSING PROCEDURES

As discussed in Chapter 2, a candidate site will need to meet the technical criteria of NRC before DOE can be licensed to review and possess nuclear material at that site. In addition, the siting process itself will need to comply with NRC's procedural requirements that define the repository licensing process. These requirements were published in the Federal Register on February 25, 1981.(2) Accordingly, DOE's siting plans have been drawn to conform with the intent of these procedures.

The rule divides the regulatory process into four phases: (1) site characterization, (2) construction authorization, (3) repository licensing, and (4) repository decommissioning. The first part has most relevance to the siting process. NRC's first review of DOE's siting activities is expected to follow the filing of a Site Characterization Report (SCR) with the Commission at the time a site is identified for detailed site studies and the repository operations area is outlined (explained in Chapter 4). The SCR will describe (1) the potential site, (2) application of siting criteria and the screening process that DOE used to identify the site, (3) the characterization and quality assurance procedures to be used to study the site, (4) a discussion of the status of other siting activities, and (5) any related issues DOE wishes the Commission to review.

Discussions will be held with NRC about detailed site studies described in the Site Characterization Report before and during exploratory shaft construction. The NRC staff will prepare an analysis of the SCR. This analysis will be provided to the concerned states and published for public comment. Subsequent to receipt of comments a final analysis of the SCR and an opinion letter will be sent to DOE. The opinion letter will present the NRC's review of the SCR, and in turn, will be addressed by DOE.

The 10 CFR 60 procedural rule requires DOE to characterize fully a minimum of three sites representing at least two geologic media (one must be other than salt) before one is selected. Because issues that bear on judging site suitability have not yet been resolved, DOE plans to resolve as many issues as possible with the NRC staff during the site-characterization program. DOE is preparing licensing topical reports to provide bases for focused discussions with NRC on key issues during the site-characterization process. Information acquired during these discussions will be considered in DOE plans for detailed study and licensing of repository sites.

3.4 ENVIRONMENTAL REVIEW

Because DOE is employing a multi-phased siting process, it is essential to identify early in the planning process the decision steps needing environmental review. To this end, DOE has prepared a NEPA Implementation Plan for Siting High-Level Radioactive Waste Repositories which is described in Section 4.5. The Plan provides for appropriate environmental reviews at decision points where siting activities, by virtue of resource commitment or elapsed time for completion, may foreclose reasonable site alternatives. These reviews will be performed in accordance with established DOE guidelines.(26,27)

The NEPA Implementation Plan provides for the preparation of an EIS as input to the site selection and construction of a repository for disposal of nuclear waste. In addition, DOE plans to prepare an EIS for the construction and operation of the T&E Facility described in Section 1.5. The Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste(4) provides the programmatic impact analysis DOE will use as a basis for the above environmental reviews.

DOE also recognizes that during the siting process, modifications to plans may become necessary due to fluctuation in the budget, allocation of resources, and levels of knowledge obtained in the data gathering process. The modifications may affect the number of alternatives considered, the level of detail of study of a particular alternative, and when specific alternatives are compared. DOE expects some modifications to become necessary, and will factor them into future environmental analyses as appropriate.

4.0 THE SITING PROCESS

This chapter describes the three-phased siting process, being implemented by DOE, which has been designed consistent with the considerations of Chapter 2.0 and 3.0. The information base, decision processes, and supporting documents planned for each phase are described.

The first phase of the siting process, termed site screening and described in Section 4.2, covers the activities planned to find sites favorable for waste isolation. A number of approaches have been, or could be, used to initiate screening studies. Each approach eventually uses common steps to arrive at and evaluate specific sites. The differences pertain to how one selects geographic starting points for conducting the more time-consuming and costly investigations necessary to pinpoint and intensively evaluate specific sites. Whereas one approach identifies large, multi-state regions of the country, overlying geologic formations of potential interest, another approach investigates land already owned by the federal government, committed to nuclear activities, and having geologic properties that may compare favorably against the site requirements previously discussed.

DOE is concurrently using the above approaches to identify starting points for screening studies rather than relying on a single approach, consistent with its objective to be conservative in its approach. Specifically, four approaches have been examined and, to varying degrees, implemented.

(1) A host-rock approach begins by identifying regions containing potentially suitable host-rock types. Early in the NWTS program, rock salt was so identified, and regions in the conterminous United States containing salt domes and bedded salt formations were delineated as starting points for site screening. Recently, the Department has screened the U.S. for regions containing "crystalline" (intrusive igneous and high-grade metamorphic) rocks such as granite.

(2) An approach that defines current land use as a basis for identifying areas where site exploration will be conducted is also inherited from historical siting activities. In particular, DOE has initiated siting studies at federally owned land tracts in

Nevada and Washington (known as the Nevada Test Site and Hanford Site), which have been committed to nuclear activities, and which may contain suitable host rocks at appropriate depths for a repository.

(3) Another approach, province screening, is based on scrutiny of successively smaller subdivisions of broad provinces where geohydrologic conditions include multiple natural barriers to radionuclide migration. This approach is being implemented by the USGS on an experimental basis in one of eleven geohydrologic provinces of the U.S., the Basin and Range. A Province Working Group, composed of earth scientists from the states in the Province and USGS, is initiating the prototypical studies.

(4) An approach to screen the United States on the basis of simultaneous consideration of all site suitability criteria and using available coarse scale data is also being considered. This approach, if implemented, would be an additional way to identify regions or smaller areas which potentially contain repository sites.

The host-rock and land-use approaches may identify candidate sites from which the first site for a repository will be selected. The province screening and other approaches may identify alternative sites for later repositories.

Whether the starting point of the process is according to rock type, land use, geohydrology, or some combination of these factors, locations of comparable size eventually will be identified. These similarly sized locations will then require the same types of study to determine if they contain sites that could be developed for repositories. Study specifics may vary with rock type and site characteristics. Locations containing promising sites are compared to select sites for the next siting phase.

Once promising sites are identified, detailed site studies, comprising the second siting phase, begin. This phase involves considerable time, money, and effort to assess whether that site can pass regulatory scrutiny and meet other societal concerns. The safety and environment of the site must be thoroughly assessed first from surface activities including boreholes, then at depth from the base of an exploratory shaft.

The 10 CFR 60 procedural rule generally requires constructing an exploratory shaft and conducting underground tests at the proposed repository depth. Data obtained from the detailed site studies phase will be used to evaluate the suitability of the site for waste isolation.

The third phase of the siting process is site selection, discussed in Section 4.4. As currently envisioned, site selection is the process by which one or more suitable sites are selected for licensing. National, state, and local participation in public meetings and hearings will review the process by which a site is recommended and the suitability of the recommended site. Additional review will begin when DOE applies to the NRC for a license to receive and process nuclear material at a DOE selected repository site. An NRC construction authorization would allow repository construction to begin. The following sections discuss each of three siting phases further.

4.1 GENERAL APPROACH TO SCREENING

The site screening process is designed to assure that all pertinent questions are considered and adequately answered before proceeding with repository development. Each step builds a base of understanding for steps which follow. However, only after detailed site studies have been completed can a site's characteristics be shown to meet performance criteria and regulatory requirements. DOE recognizes that "perfect" or "flawless" sites for repositories do not exist in nature and that innumerable sites could be shown to be suitable. Study of all sites is unnecessary and would be prohibitively expensive, so DOE plans to concentrate its studies on only the more favorable sites. Screening decisions to focus subsequent exploration on certain areas will be primarily investment decisions which allow resources to be expended on places judged most likely, after full site characterization, to be demonstrable as safe and acceptable under regulatory review. The screening process is not designed to identify all acceptable sites in the nation; rather, it is intended specifically to identify three or more alternative sites, from which one or more sites may be selected for development.

Considerable information will be needed to make screening judgments. Generally speaking, information needs will be determined by identifying which

factors (discussed in Chapter 2) are considered significant at each step in the screening process. The amount of information needed increases as the screening process proceeds, but not all factors need be considered all the time and at all places during the screening phase. Accordingly, information needs will change with time and from place to place. Investigative methods and data used in analyses will likewise depend on the particular factors important at the geographic scale of concern and the physical and institutional conditions in a given area. The eventual determination of site suitability will depend on extensive field measurements and data obtained at specific candidate sites. A series of documents is planned to expose for critical review these aspects of the screening process.

The remainder of this section introduces the concept of a stepwise screening process (Section 4.1.1) and discusses the general process of moving from one screening step to another (Section 4.1.2). Section 4.2 discusses the information needs, investigative methods, supporting documents, and public and governmental interactions appropriate for each screening step.

4.1.1 Stepwise Screening

The stepwise approach to screening planned by DOE calls for winnowing the lands under consideration, thereby focusing attention and exploration resources on progressively smaller land units appearing to have potential for eventual repository development.

Before going further, it is useful to outline a nomenclature for referring to varying sizes of geographic units. Regions are defined as conterminous land units which may extend across several states which appear to contain host rocks, geohydrologic environments, ecological conditions, or institutional settings amenable to repository development. These are generally identified from surveys of available information. Regions, in turn, are typically evaluated and screened using literature studies to identify any smaller sized areas thought to have conditions suitable for waste isolation. Likewise, areas are screened for locations, typically tens of square miles. Locations are then studied and compared to identify a specific site for detailed site studies.

In some surveys, the geographic scale may make it impossible to meaningfully identify alternatives for the next screening step without first subdividing the geographic unit and identifying an intermediate set of alternatives. In contrast, a geographic screening step may be deleted, if smaller, potentially suitable land units become obvious. The sizes of alternative regions, areas, and locations are not exact nor particularly as important as understanding that a region is larger than areas within it. In turn, areas are larger than locations. While a location may be large enough to contain several sites, generally, a single potential site will be identified.

The survey of areas and locations and characterization of sites will require progressively more thorough field surveys and testing, increasingly detailed laboratory investigations of rock and water properties, and progressively refined analyses.

The site screening phase planned by DOE consists of four possible steps. Each has been titled for reference as follows:

- National Survey (Nation to Region Screening)
- Regional Survey (Region to Area Screening)
- Area Survey (Area to Location Screening)
- Location Survey (Location to Site Screening).

These steps are illustrated in Figure 4-1 and are explained further in Section 4.2.

This approach has been in use by DOE and its predecessor agencies for a number of years, primarily to screen the nation for repository sites in salt host rocks.[28,29] These previous activities have resulted in identification of salt deposits shown in Chapter 5.0. In addition, DOE is screening DOE land at the Hanford Site in Washington State and the Nevada Test Site. The initial steps in the screening process are not applicable to studies of DOE lands at the Hanford or Nevada sites because of the small areal extent of the geographic starting point.

4.1.2 General Process for Each Screening Step

This section describes the general process for progressing from one screening step to the next. The process forms the framework for identifying, gathering, and using information to make siting recommendations.

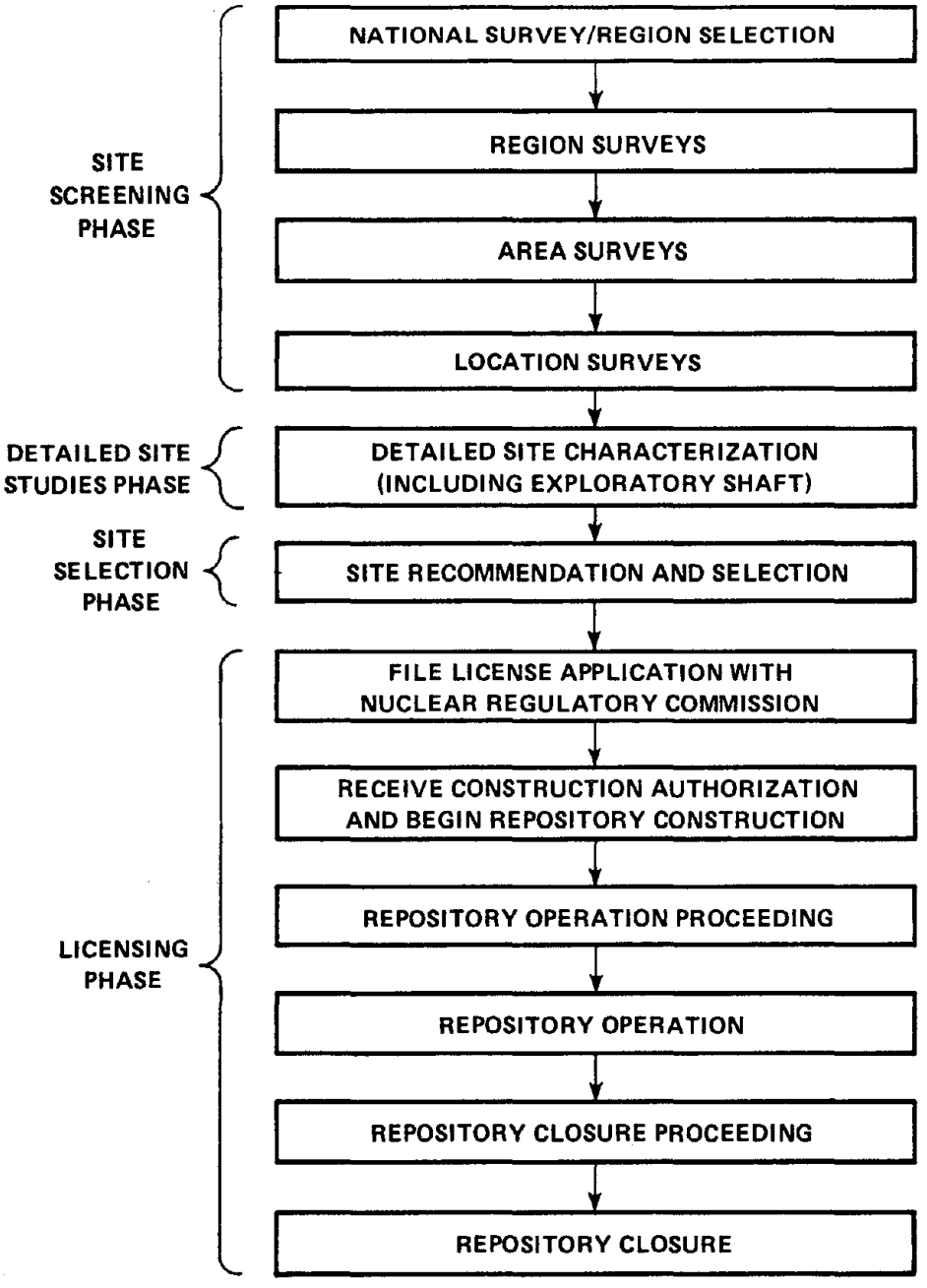


FIGURE 4-1. REPOSITORY SITING PROCESS AND SUBSEQUENT LICENSING STEPS

The process may identify regions, areas, or locations, some more favorable than others. If many appear favorable, some are nonetheless deferred from further study. Further study of all but the more favorable land units is unnecessary and would be prohibitively expensive. Further studies, then, are focused on only as many favorable alternatives as reasonably necessary to (a) make it very likely that several alternative sites are identified and ultimately shown to be acceptable and (b) to consider a reasonable number of alternatives through each screening step.

Regions, areas, or locations may also be eliminated if there is a high likelihood that major siting criteria will not be met. In this situation, resources need not be expended to demonstrate unsuitability. Screening decisions, then, are made to focus efforts on the more favorable land units.

The general decision-making approach for each of the region, area, and location survey steps consists itself of several steps as follows:

Step 1. Factors and information thought to be important to the next screening decision are identified

Step 2. Required information is gathered in accord with applicable consultation procedures

Step 3. Possible alternatives are identified, for the level of survey in progress (i.e., regions, areas, or locations)

Step 4. Each alternative is evaluated against previously identified criteria

Step 5. Candidate alternatives are compared, and one (or more) is recommended

Step 6. Screening decisions are reviewed in consultation with involved states.

Step 1. Identify Factors and Information Thought to be Important to the Next Screening Decision

A decision must be made at the end of each screening survey to determine which of the land subunits studied deserves more intensive study. Factors identified at this time are those technical and institutional considerations that may significantly influence the decision. The actual effect of

each factor on the decision will be evaluated in Step 4 after needed information is gathered. The geographic extent of a factor (characteristic) is important to assessing when in the screening process it can be meaningfully evaluated. For example, tectonic stability may be generally uniform across a large geographic region and may not facilitate discrimination among locations within such a region. Historic monuments, on the other hand, are generally very localized, and thus cannot be effectively used to differentiate among large areas or regions. The "measure", tectonic stability, is generally useful in defining regions and areas, while consideration of historic monuments is better applied in locating or comparing sites.

The level of information needed to make a decision depends upon the nature of the decision and the factors that potentially influence that decision. For example, information needed to select areas from regions may not be sufficient to allow site-specific safety or environmental assessments of repository effects. Information needed to make the area-selection decision will usually be less than that required to support a site safety assessment. Requirements for additional information to support screening decisions will be assessed by answering the question, "Will the incremental 'improvement' of a screening decision be commensurate with the resources expended to obtain the additional information?" During screening, consideration will continue to be given to favorable geographical units if no evidence is found to suggest an unmitigable flaw.

Once a site is identified however, suitability may not be presumed, but must be demonstrated with a high level of confidence by safety assessments and environmental analyses. Additional areal- and regional-level data may need to be gathered. The requirements for information to support a determination of suitability will be assessed by answering the question, "Can we show with confidence that significant uncertainties affecting site containment and isolation capabilities and safety have been uncovered, understood, and avoided or minimized by design?"

The level of information needed is affected, in part, by the period over which site integrity is desired. Predictions of changes in the natural condition of a site that might affect its suitability must rely on the geologic record as presently interpreted by scientists.

Step 2. Gather the Required Information in Accord with Applicable Consultation Procedures

During this step, information on each candidate alternative is obtained by methods described in Section 4.2. As the geographic area under investigation is reduced, the information gathered becomes more intensive and more detailed. Information gathered during region, area, and location steps of the site screening phase is used to find potentially suitable sites, but may not be sufficient to judge the suitability of a particular site. During the detailed site studies phase new region, area, and location data are collected and existing data evaluated as part of the assessment of site suitability. Information is obtained from public files, published and unpublished records, the open literature, and by purchasing data from private sources, such as petroleum and mineral exploration companies. Field information is obtained by DOE contractors, state agencies, and state institutions by direct observation, remote sensing, direct measurement, sampling, and mapping.

Information gathering, particularly field investigations on non-DOE land, will involve interactions with states and local representatives. Data gathering will proceed in accordance with understandings developed with state, local, and tribal officials. These officials will be consulted prior to initiation of field-data gathering and exploration efforts.

Step 3. Identify Possible Alternatives for the Level of Survey in Progress

For each region, area, or location screening step, alternatives are identified from which recommended candidate areas, locations, or sites (as appropriate) will be selected. Based on consultation with experts, land units appearing to have a good chance of meeting site performance criteria, upon subsequent study and evaluation, are identified in a preliminary manner. Identification of alternatives will be made on the bases of a lack of obvious safety or environmental impediments and on the potential for getting enough information to make a screening decision. Therefore, each alternative identified may contain suitable sites.

Step 4. Evaluate Each Alternative Against Previously Identified Criteria

This step involves determining, for each factor, how each alternative compares to the site performance criteria. Each alternative will be compared (e.g., "favorable", less favorable", "more favorable", or "uncertain") by summarizing its expected performance with respect to each of the factors considered at the given level of screening. Overall performance is evaluated to rate the suitability of each candidate alternative. Differences and similarities between the alternatives are highlighted. Only factors for which the information suggests key differences between alternatives are useful in the next step. These differentiating factors provide the bases for recommending one alternative(s) over another.

Step 5. Compare and Recommend Candidate Alternatives

At the end of each region, area, or location screening step, DOE must decide which, if any, of the favorably rated alternatives should be selected for further study and evaluation. In so doing, DOE also may: (1) defer consideration of some favorable alternatives until such time as a recommended alternative(s) may eventually prove to be unsuitable, (2) eliminate nonrecommended alternatives from further consideration, or (3) defer the decision until such time as needed information is available.

The decision of which alternatives to select will be made by comparing their key differences and weighing the relative importance of those key differences. Numerous computer codes and manual techniques are available to assist in making these comparisons.

The decision, and the analytical basis for comparing alternatives, will be documented including an explicit description of assumptions, definitions, logic, information base, and uncertainties in the comparison process. The reasoning for selecting, deferring, or eliminating each alternative will be explained. Significant, soundly based dissenting opinions, if any, within the recommending and decision-making bodies will be discussed in decision documents.

Sensitivity analyses of the importance of differentiating factors may also be performed. Such analyses explain the effect, for example, of allowing

either institutional or safety factors to dominate the analytical basis for ranking the alternatives. Such analyses make explicit the dialogue on the trade-offs between safety objectives, e.g., long-term versus operational safety.

Because different relative weightings of screening factors may result in different decisions, the sensitivity analyses will be documented carefully to make the reasoning for assigning a given importance to each factor explicit. In this manner, the dialogue among parties concerned with repository siting can be focused on the factors or issues that most influence the decisions.

Step 6. Review the Screening Decisions in Accord with Applicable Consultation with Involved States

DOE will strive to spread an understanding of the process used to find sites, and of determining the suitability of sites, by encouraging early review of the application of the siting process to specific regions, areas, and locations. Designated individuals or groups from the technical community, government officials, and the public from specific regions, areas, and locations will review the plans for work, others will review the technical procedures and tests. Advisory committees have been formed to ensure representation of a broad field of experience and knowledge. Government officials and the public will be provided oportunities to obtain an awareness of the whole isolation problem and what constitutes site suitability for geologic disposal. Broadly based participation will ensure that public concerns are considered in the decision process.

Appropriate technical, governmental, and public review will be solicited and factored into DOE decisions. For screening activities on DOE lands, the appropriate DOE Operations Offices will be primarily responsible for organizing and coordinating the review by states consistent with NWTS program plans. The NWTS Program Office will be primarily responsible for organizing the review process for activities on non-DOE lands.

4.2 SCREENING STEPS

The following sections describe the information base, supporting documentation, and consultation procedures appropriate at each screening step. Environmental reviews and documentation are described in Section 4.5. Figure 4-2 and Tables 4-1 through 4-6 summarize this information for all three siting phases.

- Table 4-1 presents the minimum document chain the program will have produced by the time a site is selected.
- Table 4-2 provides the purpose and scope of reports that potentially document the process of finding sites.
- Table 4-3 explains the types of siting decisions to be made.
- Table 4-4 indicates the investigative methods that may be used in each screening step.
- Table 4-5 summarizes the level of data and study methods which may be used for region, area, and location surveys, and detailed site studies. The detail in this table is only for example. Site-specific characterization work may differ from what is shown.
- Table 4-6 indicates which field activities may be useful in addressing the various factors potentially affecting site performance and environmental acceptability.

Due to their length, these tables are placed at the end of this chapter.

While the tables and figures depicting the siting process show the steps involved in the national, region, area, and location surveys, the process provides a framework that can accommodate variations. The studies of DOE lands in Nevada and Washington, examples of screening performed in fewer steps, were started at the area-level. In this case the size of the DOE lands to be screened dictated a study detail comparable to that developed in area-level studies on non-DOE lands. The Province Screening, an example of added steps, subdivided the nation into geohydrologic provinces. One province, the Basin and Range, will be surveyed for regions containing potentially suitable sites. The size of area studied and level of detail are, at least, partially dictated by the size or geographic expression of discrete features which may impact repository safety, and which, therefore, need to be displayed on maps.

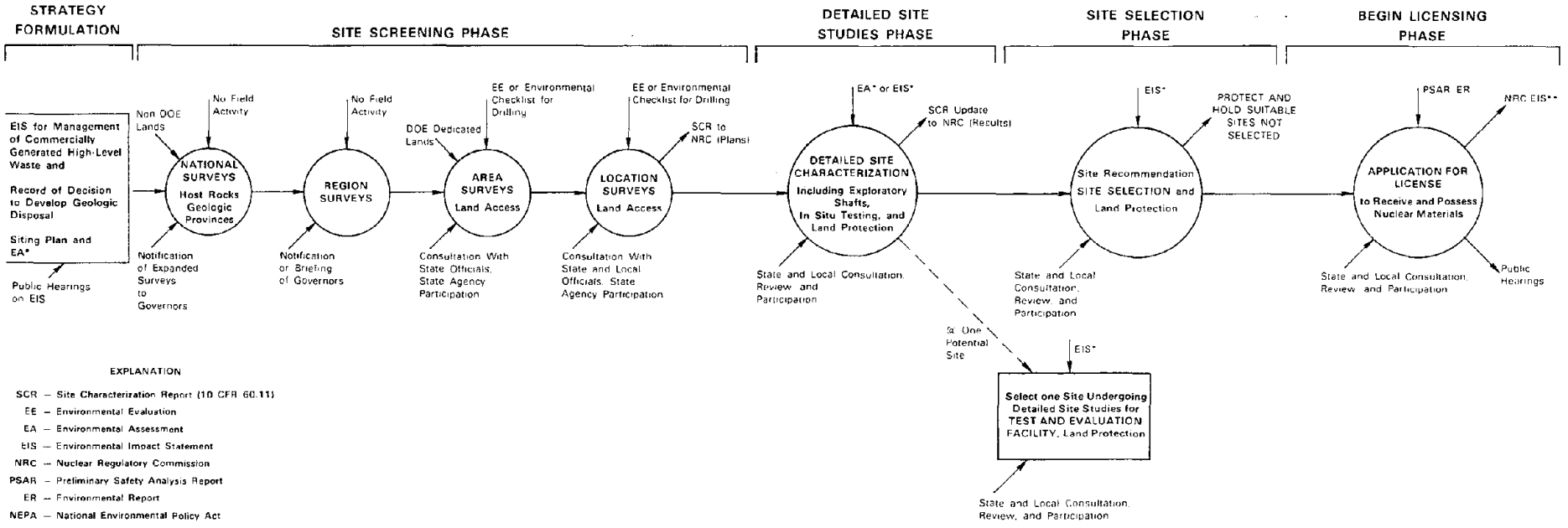


FIGURE 4-2. REPOSITORY SITING PROCESS

*DOE's NEPA documents will be tiered in order to eliminate repetitive discussion, to focus on issues ripe for decisionmaking and to benefit from earlier analysis plus the most-recently available data.

**DOE is hopeful that the NRC could adopt the DOE EIS in whole or in part to support NRC decisionmaking.

4.2.1 National Surveys

4.2.1.1 Information Base

New siting initiatives generally will begin with national screening surveys which examine the entire United States. National surveys using the host rock approach described in Section 4.0 already have been performed for salt and "crystalline" type rocks. A survey of argillaceous rocks is nearing completion and DOE is evaluating whether or not region surveys of argillaceous rocks should be conducted. Table 4-1 shows the information associated with major criteria that typically is needed at the national survey level to identify regions of thousands of square miles for further study. Information available from federal and state agencies and published sources is gathered for National Surveys.

The objectives of these national surveys are to screen the United States for particular rock types, geohydrologic systems, or other features to identify those portions that appear to be suitable for further investigation. These screenings use the NWTS-33(2) site performance criteria, or draft NRC criteria in the case of the Province screening, and are based on an evaluation of available existing geologic and environmental information.

4.2.1.2 Documentation

The documentation of this process as defined in Table 4-2 includes a national survey report which presents the information base, and a recommendation report which summarizes the evaluation and recommends one or more regions for further study.

4.2.1.3 State Consultation

All 50 states have been informed that the Department is performing screening surveys to gather existing information about the geology and environment in each state. National surveys will generally be completed without additional state contact. The survey reports that contain regional or geohydrologic systems selected for further study are made available to the

involved states. DOE will brief officials of these states on the survey results if region surveys are to be conducted.

4.2.2 Region Surveys

4.2.2.1 Information Base

The information base required to support regional screening, similar to that collected during the national survey, is specific to regions identified by the national survey. The level of information obtained must provide a general characterization of the region to eliminate or defer large areas that are not likely to contain siting alternatives. Areas which remain are likely to contain sites that will, upon further study, meet the site performance criteria.

Generally, this level of data is available in major public libraries and unpublished information available from state and federal agencies operating within the regions being studied. Information will be gathered by techniques summarized in Table 4-4. These include review of published scientific reports; geologic maps; drilling records generated in oil, gas, and mineral exploration programs; records of earthquake occurrences and intensities; records of oil, gas, and mineral production; and records from regional water-well drilling or pumping operations. Existing airborne geophysical survey results may be used to support the literature-based geologic and resource studies.

Geologic characteristics generally considered in regional surveys will include the structure, stratigraphy, depth, thickness, and continuity of rock formations; regional flow characteristics of the ground-water systems; gross physical characteristics and chemistry of major formations (lithology, mineralogy, petrology); occurrence of natural resources and their current or future production potential; existence of folds or faults; general surface characteristics; and seismic history of the region.

Environmental and socioeconomic characteristics of the region considered at this stage will usually include dedicated land use areas, population centers, economic conditions, and transportation systems.

4.2.2.2 Documentation

Table 4-2 describes the documents which apply to studies of non-DOE lands typically produced at this screening level. A variety of regional characterization studies will cover different characteristics of each region. Reports on these studies, which may vary in scope and in style, will provide input to regional summary and recommendation reports. These reports will summarize regional evaluations and identify recommended areas for further evaluation.

4.2.2.3 State Consultation

DOE will notify states in which new regional surveys are planned in advance of new study initiatives. Federal officials will consult with the governor, the legislature, and any special committees established by the states as appropriate during the exploration process.

DOE will consult with other state officials and technical agencies and seek their views and advice on exploration plans so that, as surveys progress from regions to areas, necessary agreements can be developed. DOE regional representatives seek to establish continuous interaction between DOE and the state governments in the region for which they are responsible.

DOE operations offices also interact with state governments as appropriate for specific DOE program responsibilities. Direct DOE communication on repository siting activities should assure continuity of established DOE-state cooperative efforts. These communication procedures will continue through the area and location surveys and detailed site studies.

Because field activities are generally not conducted for region surveys, public meetings are not thought to be necessary in this step.

4.2.3 Area Surveys

Area surveys of non-DOE lands will be conducted to characterize areas recommended in regional survey reports and designated for study by DOE. The level of data to be gathered must be sufficient to identify potential land units, called locations, for further study.

The Nevada Nuclear Waste Storage Investigations, in Nevada and the Basalt Waste Isolation Project, near Richland, Washington, began by screening DOE lands previously committed to nuclear uses. The size of these lands corresponded roughly to an area that may have resulted from screening a region. Although these two projects did not procede through national and region survey steps, data on regional features or conditions which may influence the suitability of sites is being gathered.

Environmental, socioeconomic, and geologic factors will be evaluated in greater detail than in the region surveys. Area surveys will be used to identify potentially suitable locations.

4.2.3.1 Information Base

Some field studies will be performed to augment information available from existing sources. Table 4-5 summarizes the data which may be needed to address each of the site performance criteria.

Investigative methods, as noted in Table 4-4 and 4-6, may include drilling to investigate the subsurface conditions and to determine whether a potentially suitable host rock occurs at the depths of interest; hydrologic well testing to estimate the hydrologic parameters of aquifers and aquitards; evaluation of aerial photography and Landsat data to help identify faults that might affect repository performance; and field mapping of selected areas to estimate the presence of exploitable resources and to increase understanding of geologic conditions. Surface and aerial geophysical surveys may be used to supplement the geologic field work. These surveys may consist of aeromagnetic, electrical, gravity, and seismic measurements.

The presence of mineral and energy resources will be determined by field mapping, rock-core and geophysical-log interpretation, geophysical surveys, as well as study of past mineral and energy resource production records. If there are indications of such resources, drilling and geochemical analyses may be performed to estimate their significance relative to locations which may be recommended.

4.2.3.2 Documentation

Table 4-2 describes the documentation which may be produced from area surveys. Each project (NNWSI, BWIP, ONWI) will identify its own project-specific documentation needs within the framework of this Plan. As with regional surveys, various area characterization reports or report sections prepared by contractors or state agencies under contract to DOE may support an area summary and location recommendation report for each area. These reports will be prepared to summarize the basis for recommendation of one or more alternative locations. For DOE lands, results of area and location level studies may be documented in a single integrated report.

4.2.3.3 State Consultation

Interaction among the Department and state and local officals will become more frequent during area studies on non-DOE lands. Interest will be focused on specific parts of a state, making it likely that local residents and officials will want to be more directly involved. In states where study of DOE lands is ongoing, state officials will be informed of study progress from time to time. Existing communication channels between the DOE field office and state will be used and enhanced, if necessary, to facilitate interaction.

State officials and technical experts will be given an opportunity to review and participate in the planning, gathering, and the interpretation of field data during area studies on non-DOE lands. Their comments will be considered in preparation of the final report and decisions affecting the next survey step. Selected peer review groups, advisory groups, public interest groups, and interested individuals will be asked to review the recommendation document prior to selection of locations. The responsible project office will recommend to DOE Headquarters those locations deemed most promising for further study. DOE Headquarters will then review and approve the final selection, considering the comments received.

4.2.4 Location Surveys

4.2.4.1 Information Base

The purpose of location surveys is to develop the basis to further narrow the scope of investigation to one or more sites if multiple locations are identified in the area step. Location studies will also be used to select a place for an exploratory shaft. Geologic data gathering at this stage may include additional drilling to obtain detailed geologic and hydrologic information and extensive testing of geologic and geochemical samples. Environmental and socioeconomic studies during this phase may include sampling programs and impact evaluation sufficient to identify the more favorable site(s) from among several locations, to provide input to the recommended location for a shaft including site information to be used for an assessment of impacts on the environment surrounding the proposed shaft location.

4.2.4.2 Documentation

Plans for location studies will be prepared and circulated for state review for non-DOE lands, where they facilitate dialogue with the involved state. The Plan will describe the screening process to this step and include plans for surveys of locations. The focus of location surveys is on key technical issues and uncertainties at multiple potential sites. Addressing key issues should enable DOE to recommend one (or more) for detailed site studies.

Table 4-2 describes the documentation planned for the location surveys on non-DOE lands. These documents will be similar to those described for region and area surveys.

4.2.4.3 State Consultation

At this stage DOE will establish or increase direct contact with local officials and the general public while maintaining communication channels with state government officials. Local information will be provided through many types of communications. A DOE representative may be assigned to specific locations to provide information to local communities. DOE may

provide funding for independent state studies, and access to data collected by DOE or its contractors.

The plan for characterization of locations will be prepared with the assistance of state agencies or review by state officials. Their concerns will be considered and the resulting plans will provide the basis for continued work.

4.3 DETAILED SITE STUDIES

In this phase information specific to potential sites is scientifically collected and evaluated. DOE will use the information gathered to assess a site's suitability for a repository. The geologic, environmental, and socioeconomic data obtained are similar to that obtained during the screening phase but in greater detail.

Now that the potential site is known, new regional and areal data may be collected. Existing data may be reevaluated to evaluate the significance of regional features to a particular site. Surface characterization and borehole drilling to repository depth will be performed to supplement data obtained in previous screening steps. If initial study results are favorable, an exploratory shaft may be constructed.

When appropriate, DOE will take steps to protect the land at sites being characterized from uses incompatible with a repository. These measures protect DOE's investment of public monies in the work but will not become permanent at this step.

A part of detailed site studies will be the construction of exploratory shafts. Exploratory shafts will allow direct observation of proposed host rocks at depths considered suitable for repositories.

In 1983, DOE expects to begin constructing an exploratory shaft at each of three sites. By 1985, shaft construction will reach repository depth (2,000 to 4,000 feet) and studies will begin at depth. One of the first three sites with an exploratory shaft will be chosen for construction of the T&E Facility described in Section 1.5.

Screening of other regions and areas will continue to identify additional potential sites. Exploratory shafts will be constructed after 1987 at those additional alternatives showing the greatest potential.

4.3.1 Information Base

A Site Characterization Report, prepared after location surveys in the NRC format, will summarize how DOE selected the place for an exploratory shaft, what is known about the site from the exploratory work of the screening phase, what issues remain to be resolved, and the plans for resolving those issues.

Geologic study methods to characterize sites will include borehole drilling, geologic field mapping, laboratory testing of cores, geophysical borehole logging, geophysical surveys, and conceptual modeling and an exploratory shaft. Field mapping of lithologic units will be performed in part of the exploratory shaft and over the proposed repository site. Chemical and isotopic-dating analyses of selected field and core samples may also be performed. Surface geophysical surveys may include high-resolution seismic-reflection and refraction and electrical-resistivity methods and other useful geophysical techniques.

The structural geology of the area will be determined by a combination of geologic field mapping, core logging, and geophysical surveys. Features to be mapped include the location, attitude, and displacement of faults and fold axes; frequency and attitude of joints, fractures, and foliations; and the distribution and attitudes of lithologic units. Geophysical surveys will be used to help determine the subsurface distribution of lithologic units, ground-water composition, and hydraulic conductivity.

Ground-water hydrology will be characterized by a combination of hydraulic testing of boreholes, modeling of the ground-water flow systems, and in situ tests. Isotopic age dating of ground water will be employed as needed. Discharge areas down-gradient from the proposed site will be determined to the extent possible, and core samples will be tested to estimate porosity.

Physical and chemical properties of the proposed host rock, adjacent media, and rock units along ground-water flow paths, will be determined by laboratory testing on core samples. Properties including thermal conductivity, thermal diffusivity, thermal expansion, Young's modulus, Poisson's ratio, yield strength, bulk modulus, thermo-mechanical and chemical properties, sorption coefficients, and mineralogic and chemical composition will be estimated.

Surface hydrology of the proposed site will be characterized in detail. The analyses will include determining the occurrence, distribution, and characteristics of streams, lakes, impoundments, swamps, and wetlands. Stream flows will be determined from gauging stations, and chemical analyses will be performed on water samples. Seasonal variations and historical extremes for relevant parameters will be determined.

The possible presence of exploitable mineral, water, and energy resources will be assessed by field mapping, drill-core and geophysical-log interpretation, and geophysical surveys, as well as by study of past resource exploration and production records. If there are indications of such resources, drilling and analyses may be performed to estimate the location and value of such resources.

Shaft studies are planned to be be conducted in two phases. The first phase will be shaft construction to repository depth. The second phase will include in situ testing at the planned repository depth to establish a knowledge base sufficient to judge site suitability. Conceptual test plans are yet to be made final, but horizontal drilling work and in situ stress "measurements" at the bottom of the shaft are being planned.

An environmental sampling and socioeconomic program will be conducted in this phase. Information will be gathered for each season of the year. DOE will use the information gathered on the local environment to prepare the environmental impact statement for site selection and to prepare the environmental report for NRC. The characterization will include studies of atmospheric conditions, background radiation, noise, demographic characteristics, socioeconomic and cultural resources, land and water use patterns, and ecological resources. Socioeconomic impact assessments will be made and may serve as a basis for development planning in communities potentially affected by the repository.

4.3.2 Documentation

Construction of exploratory shafts will be preceded by filing the Site Characterization Reports, with the NRC. SCRs will describe the detailed investigative studies proposed to characterize the site. At the same time DOE sends copies to NRC, DOE will forward copies to the state in which the site is located for review. The involved state may expect a request for comments from NRC as well. After staff review, the Director of the Office of Nuclear Material Safety and Safeguards (NMSS), NRC will issue an advisory opinion to DOE as to the adequacy of the SCR, considering state and public comments.

During NRC review of the SCR, DOE plans to continue its site characterization activities and provide NRC with reports of its progress at six-month intervals.

The Site Characterization Report will be updated at the completion of the detailed site study phase. It will be transformed from a plan to a report of study results. Assuming the site is confirmed as suitable, land withdrawal or acquisition activities may be finalized to protect the site for possible selection later and additional information for engineering design optimization may be gathered.

4.3.3 State Consultation

Consultation activities during the detailed site study phase, generally, will be a continuation of those initiated in the screening phase. Impacts of exploratory shaft construction are explored and impact mitigation measures may be planned with local and state representatives. For planning impact mitigation, DOE has published a report that may be useful to communities that do not have past experience or existing mechanisms to deal with social and economic impacts from nuclear-related facilities or federal construction projects.(20)

4.3.4 Site Protection

Land protection measures, consisting of options, purchase, land withdrawal, or other similar actions, may be taken during screening or detailed study phases

to protect DOE's exploration investment. If DOE judges a site to be suitable it may take additional protection measures. Land acquisition action taken during this phase is for protection of the site; it does not constitute a decision by DOE that this land will be dedicated for repository development. This decision will not be made until a site's suitability is accepted by NRC.

DOE and the state will discuss how land protection should proceed. Several options appear to exist, depending on whether the land being considered is federally or privately owned. Protection of a site does not require that DOE have full ownership rights to the property. It does need sufficient ownership interest to maintain the integrity of the site and to have full access.

The surface and subterranean rights of sites ultimately selected for a repository must be acquired in fee simple or permanently withdrawn for this specific use before construction of facilities can begin. If full ownership of the site is not obtained during this phase, DOE will complete acquisition of the land before it receives a construction authorization from NRC.

DOE expects it will acquire surface and subsurface rights for land on which the repository is built. It is expected the area purchased or withdrawn (both surface and subsurface rights) for facilities could range from 400 up to about 3,200 acres, similar to areas needed for today's nuclear power plants. To provide aditional protection against intrusion into the repository by drilling or other human activities, subterranean rights of a much larger area may need to be acquired. The actual area affected will be site-specific, but is expected to be in the 10,000 to 20,000 acre range.

4.3.5 Considerations for Protecting Federal Land

Land at the Hanford and Nevada test sites and other locations which may be identified on existing federal land may be protected by transfer or withdrawal procedures discussed below.

At present land protection at the Hanford site can be accomplished by administrative operational controls by the manager of the reservation.

At the NTS site, an agreement between the Air Force, BLM, and DOE will be needed to protect the site identified as a potential geologic repository operations area. If either of these sites is selected, additional protection measures may be needed.

4.3.5.1 Transfer

Transfers of all but four classes of land from one federal agency to another are subject to the Federal Property and Administrative Services Act (FPAS) and regulations thereunder (40 U.S.C. Sections 471 et seq. and 41 CFR Part 101-47). Federal lands not subject to this act are:

- Public domain, which consists of land subject to sale or disposal under general land laws and not reserved for any special governmental or public purpose (40 U.S.C. Sec. 472(d) and 41 CFR Sec. 101-47. 103-12)
- Lands reserved or dedicated for national forest or national park purposes (40 U.S.C. Sec. 472(d) and 41 CFR Sec. 101-47.103-12)
- Minerals in land or portions of land already withdrawn or reserved for public domain which are suitable for disposition under public mining and mineral leasing laws (40 U.S.C. Sec. 472(d) and 41 CFR Sec. 101-47.103-12)
- Lands already withdrawn or reserved from the public domain unless they are no longer suitable to retain for public domain because they have substantially changed in character since their withdrawal (40 U.S.C. Sec. 472(d) and 41 CFR Sec. 101-47.103-12).

If the proposed site is subject to the FPAS Act, the General Services Administration (GSA) will have procedural authority over the transfer.

Transfer procedures are set forth in 41 CFR Sec. 101-47.203.7. To obtain a transfer, DOE will make an application to GSA. The Office of Management and Budget (OMB) will have to concur in the decision that the transfer is in the best interest of the government when the value of the land exceeds one million dollars or if the case is unusual. The transfer of land for a repository likely would be an unusual case needing OMB concurrence.

No hearings are required with a transfer.

4.3.5.2 Withdrawal

The Federal Land Policy and Management Act of 1976, (FLPMA; 43 U.S.C. Secs. 1701 et seq.), controls withdrawal actions for federal lands not

considered property governed by the FPAS Act. The following withdrawal procedures are used to obtain an interest in this category of land.

The Secretary of Interior may withdraw a land area of less than 5,000 acres for the following time periods without congressional notification or approval:

- As long as he deems desirable for a resource use
- Not over 20 years for any other use, including but not limited to use for administrative sites, location of facilities, and other proprietary purposes
- Not over 5 years to preserve such a tract for a specific use then under consideration by the Congress [43 U.S.C. 1714(d].

The Secretary of Interior can withdraw land areas exceeding 5,000 acres under his jurisdiction for a period of not more than 20 years. If the Secretary does not have jurisdiction over lands subject to withdrawal, consent of the head of the department or agency concerned must be obtained. Withdrawals of this nature require congressional notification and are subject to a vote of nonconcurrence by the Congress [43 U.S.C. 1714(c)(i)].

Within 30 days of the filing of an application for withdrawal, the Secretary of Interior will publish a notice of the application in the Federal Register. Upon the filing of the application, the land will be segregated from the operation of the public land laws to the extent specified in the Federal Register, i.e., the land cannot be used for other purposes. Segregation will terminate upon (1) the rejection of the application, (2) withdrawal of lands, or (3) the expiration of two years from the date in the Federal Register notice. All withdrawals will be subject to the BLM regulations for land withdrawal (43 CFR 2300) which provide for public hearings.

When the Secretary of Interior notifies the Congress of an effective date for withdrawal, he is required to give specified Congressional committees information pertaining to the site and the impact of withdrawal. For a list of this information see 43 U.S.C. Sec. 1714.

If federal land that has been withdrawn is chosen for the repository, legislation may be needed to commit the land for waste disposal permanently.

4.3.6 General Considerations for Protecting Nonfederal Land

During the site screening or detailed study phases, it may not be necessary to obtain full ownership rights to nonfederal land. All that may be necessary is a lease or an easement, which will allow site characterization activities to continue and prevent other activities by the landowner that may jeopardize the integrity of the site.

Full ownership rights will be needed after site selection. Ownership of nonfederal land is obtained by purchase or condemnation of the real property by DOE. As directed by DOE Order 4200, the procedures for lease, purchase, or condemnation of land will be those indicated in the DOE Real Estate Manual.

4.4 SITE RECOMMENDATION AND SELECTION

DOE will construct exploratory shafts and conduct tests at repository depth at several sites. From among these sites which are judged acceptable, DOE will select one and file a license application with NRC. Those sites not initially selected, plus sites that undergo detailed site studies in later years, will become candidates for repositories subsequent to the first.

This section describes DOE's present plans for selecting sites. The details are still evolving and subject to further definition in light of congressional legislation recommendations made by the state advisory groups, and agreements adopted by DOE and the states as part of the consultation process. Subject to such revision, the following steps serve as a basis for interim planning.

DOE will make an initial choice of the site it will recommend for construction authorization. Because several sites should be acceptable, this choice will necessarily involve DOE's judgment of the site suitability considerations discussed in Chapter 2, including considerations of the planned system of regional repositories.

DOE will then issue a Repository Site Recommendation Report (Table 4-2), which will present a comparative analysis of the alternative sites' geologic, environmental, and socioeconomic characteristics; a description of

the site selection process; and recommendation of a site for a license application. A Draft Environmental Impact Statement assessing impacts of repositories at the chosen and alternative sites also will be prepared. DOE will provide the public, involved state(s), and other federal agencies the report for review. DOE will seek comment on the site's technical, environmental, and institutional acceptability. Based on state and federal agency comments, DOE will revise the site recommendation report as appropriate. The final revision, documenting DOE's selection of the site for a construction authorization application, will be issued as a Site Selection Report along with the Final Environmental Impact Statement.

DOE will make every effort to address concerns. When it has addressed state and federal agencies' concerns to the best of its judgment, DOE will decide whether or not to go forward.

Disagreement over the site selection decision is possible. DOE, state groups, and Congress are now considering the mechanisms for conflict resolution. The NRC review is one mechanism for resolving technical issues bearing on a site's acceptability from the standpoint of public health and safety. In addition, Congress is considering legislation that would provide mechanisms for resolving disagreement concerning the selection of sites.

4.5 National Environmental Policy Act (NEPA) Implementation Plan

The National Environmental Policy Act of 1969 (NEPA), as implemented by the regulations (40 CFR Parts 1500-1508) of the Council on Environmental Quality (CEQ) and the DOE guidelines,[26,27] requires that potential environmental consequences and appropriate alternative courses of action be considered in DOE planning and decision making.

Under NEPA an Environmental Assessment (EA) is a concise public document to provide evidence and analysis of the potential environmental effects of an activity. An EA serves as a basis for a DOE finding to prepare an Environmental Impact Statement (EIS) or to issue a finding of no significant impact (FONSI). If the EA results in DOE deciding that the proposed action will have no significant impact, a FONSI is made available to the affected public. If the proposed action is of national concern, a FONSI is published in the Federal Register.

Under NEPA an EIS is an analysis required by Section 102(2(c) of NEPA for major federal actions significantly affecting the quality of the human environment. An EIS evaluates the impact to the environment of a proposed action and its alternatives. At the time of its decision, but no earlier than 30 days after a final EIS is issued, DOE publishes a public record of decision in the Federal Register.

In managing the National Waste Terminal Storage (NWTS) Program, DOE may undertake actions having potential environmental consequences, the effects and significance of which vary. Actions range from decisions on the overall strategy for waste disposal (involving a major resource commitment which ultimately may have a spectrum of potential environmental effects specific to that strategy) to the selection of specific sites for waste disposal facilities. Other actions include the conduct of research, which may have little environmental effect, but which may have important technological, cost, and time implications on long-term waste disposal.

DOE has developed a NEPA Implementation Plan which is integrated with the overall DOE planning and decision-making framework for the deep geologic disposal strategy. Figure 4-2 shows the integration of the NEPA plan and the overall decision-making process. The NEPA Implementation Plan herein is a modification of the NEPA Implementation Plan found in the Statement of Position of the United States Department of Energy (DOE/ NE-0007) filed In the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste (Waste Confidence Rulemaking).(6) Modifications to this plan were required because of the anticipated changes in NRC's requirement for exploratory shaft construction and in situ testing at three alternative sites prior to DOE submitting a license application. Modifications to the NEPA Implementation Plan found in the DOE Statement of Position are noted in this text.

The program's NEPA Implementation Plan is based on the "tiered" approach, which is designed to eliminate repetitive discussions of the same issues and to focus on the actual issues ripe for decision at each level of environmental review. This approach allows coverage of general matters in broad EISs with subsequent narrower EISs or EAs incorporating by reference the general discussions and concentrating solely on the issues specific to the subsequent decision.

4.5.1 NEPA Documents Anticipated for the NWTS Program

The NEPA Implemenation Plan identifies the major decision points in the program to assure that appropriate environmental review is completed prior to each such decision and prior to the conduct of activities that may cause an adverse environmental impact or limit the choice of reasonable alternatives. It also identifies the level of environmental documentation which DOE presently believes is necessary to comply with NEPA.

The first major decision process in the NWTS program was the selection of a program strategy for disposal of nuclear waste (Table 4-1). The environmental effects of selecting a program strategy, including the selection of a preferred technical concept for waste disposal, are addressed in the Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste, DOE/EIS/ 0045F (October 1980).[4] Ten concepts, including mined geologic disposal, are analyzed in the EIS. The substantive issues raised through the public comment process were reviewed and addressed in the Final EIS. The Record of Decision selecting the mined geologic disposal program alternative was published on May 14, 1981 (46 Federal Register 26677).

The second major decision process is that involving the selection of sites for the disposal of nuclear waste (Table 4-1). The major points in the site selection process, described in Sections 4.1 to 4.4 are:

1. Adoption of a National Plan for Siting High-Level Radioactive Waste Repositories and performance of screening surveys.
2. Detailed site studies (including exploratory shaft).
3. Acquiring an interest in land, including action to protect potential sites from other uses.
4. Selection of a candidate site for the first, or a subsequent, repository.

The selection of a site for the T&E Facility is not part of, but is related to, the repository siting process. Because such a facility may cause impacts at a site under study for a repository, it is included in the NEPA Implementation Plan.

While the appropriate NEPA document is being prepared for the various decision points, program activities that have been analyzed in previous NEPA documents may continue. In addition, new site characterization activities may begin, if it is clear on the basis of DOE's review, that they do not (1) have an adverse environmental impact or (2) limit the choice of reasonable alternatives. These activities could include additional environmental studies, routine geophysical studies, and borehole drilling.

Figure 4-2 presents each of these decision points in the siting process and the NEPA document which DOE believes to be appropriate. The proposed purpose, timing, and scope of each of these documents is described below and listed in Table 4-2.

National Plan for Siting High-Level Radioactive Waste Repositories

DOE proposes to adopt this National Plan for Siting High-Level Radioactive Waste Repositories and Environmental Assessment. The title proposed for the siting plan in Reference 6 was "National Site Characterization and Selection Plan." An EA has been prepared as input to the decision on whether to adopt or modify this plan.

The proposed plan includes the methodology, criteria, and steps for screening regions, areas, and locations for potential sites to be studied in detail. The environmental impacts of the strategy in the proposed plan and their reasonable alternatives are assessed. In addition to the selection of areas for further study, the anticipated range of environmental impacts of field activities called for in the screening phase of the plan are analyzed.

Experience from ongoing field activities indicates that the implementation of the Plan will not have significant environmental impacts. Therefore, it is believed at this time, that an EA, is the appropriate level of NEPA documentation for the National Siting Plan. DOE will consider the results of the environmental review prior to deciding whether to adopt or modify the proposed Plan.

Location Survey

Under the NEPA Implementation Plan described in Reference 6, a major decision point was location studies. The phase is now referred to as location survey. As a consequence of the NRC regulations generally requiring exploratory shafts, the scope of activities is reduced from that presented in the DOE Statement of Position.(6) Much of the work contemplated in the location phase will be done now in the Detailed Site Studies phase. Field activities will be evaluated to determine whether they were outside the range of anticipated activities discussed in the EA accompanying this plan. Alternative location(s) and environmental factors associated with the location(s) will be discussed in characterization or recommendation reports. For location surveys planned on BLM land, BLM may undertake an environmental review before it issues appropriate permits for DOE study activities that may have significant environmental impacts.

DOE has determined that neither an EA nor an EIS is required for the location survey, because the limited activities in this step are not expected to have significant environmental effects or to foreclose alternatives.

Detailed Site Studies Phase (Including Exploratory Shaft)

Following completion of location surveys in a particular area, an EA or EIS will be prepared as input to a decision to: (1) narrow the investigations of numerous locations to one or more potential sites, (2) conduct detailed site studies including exploratory shafts, and (3) protect the integrity of the site through a land protection action.

Although the activities to be carried out during the detailed site study phase are site-specific and have not yet been finalized, activities at all sites currently are envisioned to include (1) constructing an exploratory shaft for at-depth testing, (2) gathering environmental data, (3) drilling boreholes, and (4) digging trenches and test pits. The activities will be described in the Site Characterization Report required by 10 CFR 60. The proposed EA or EIS, prepared as input to selection of sites for detailed

study, will review the process leading to selection of sites for detailed studies and quantify the potential impacts of the activities specified in the SCR at each site. In addition, the EA or EIS will address qualitatively the potential impacts of transporting and emplacing nuclear wastes at each site, should the site be chosen for the T&E Facility or a repository.

DOE is evaluating the potential for detailed site studies to have significant environmental impacts and the appropriate level of environmental review will be determined on the basis of this evaluation.

Test and Evaluation Facility (T&E Facility)

The T&E Facility discussed in Section 1.5 is not an element of the siting process in that the selection of a repository site could be made without a T&E Facility and the facility is not needed for site characterization. The facility will be used for design development and operator training purposes. Construction of this facility, planned for a site at which a shaft is constructed, may cause some environmental impacts in addition to those resulting from construction of an exploratory shaft. It is currently proposed that an EIS is the appropriate environmental document for construction, operation, and decommissioning of a T&E Facility.

Site Selection

At the conclusion of the detailed site studies phase at three sites, the data necessary to make a determination of site suitability will be available. DOE plans to prepare an EIS on the site-specific environmental impacts of the proposed repository. This EIS will include evaluating the environmental impacts of constructing a repository, transporting and emplacing wastes, and of eventual closure and decommissioning of the repository at the proposed site and its alternatives. DOE may propose more than one repository site in the EIS. If additional repository sites are subsequently proposed, DOE will prepare a separate EIS.

License Application

As required by 10 CFR Part 60.3, DOE will apply to NRC for a license to receive and possess nuclear material at the chosen repository site. This application is made well before the proposed start of construction. The EIS prepared for site selection will be integrated into the environmental report (ER) which will accompany the application.

Land Protection

During the detailed site study phase, DOE may take temporary steps to protect the land from conflicting land use in order to protect the integrity of the site and the investment of public monies in exploration work. The EA or EIS prepared for that phase of the siting process normally will be used as input to that decision. If a decision to protect land is made separately from the siting decision discussed above, separate environmental documentation would be prepared.

As a part of the site selection process, DOE may take steps to acquire permanent ownership of the site selected. The site selection EIS will be used as input to this decision.

4.5.2 Cooperation with Federal and State Agencies

Other federal or state agencies also may have to prepare an environmental document to fulfill a permitting or statutory requirement to allow a project or the program to move forward. In these cases, DOE will attempt to avoid duplicate effort by cooperating with that agency in preparing environmental documentation, either as a lead or cooperating agency, as these terms are defined in the CEQ Regulations (40 CFR Parts 1500-1508) for implementing NEPA.

TABLE 4-1. PLANNED SITING DOCUMENT CHAIN[a]

Document	Content or Proposed Content
Commercial Waste FEIS[4]	Provides assessment of potential impact of geologic disposal of HLW
National Siting Plan/EA	Describes siting strategy and its potential impact
Characterization/Integration Report[b]	Presents data and decision rationale used to screen larger land areas for potential sites
Site Characterization Report (SCR)/ EA or EIS[c]	Describes activities of site studies and their potential impacts
Test Evaluation Facility Recommendation Report/EIS	Describes T&E Facility site selection and potential impacts of the facility
Updated Site Characterization Report(SCR)/EA or EIS for land protection	Describes data on which site suitability judgment may be based, and assesses potential impact of land protection measures
Repository Site Recommendation Report/EIS	Provides data and rationale for site selection decision and potential impacts of the repository

[a]This table lists the minimum variety of reports that will support the selection of a repository site. Each will appear (appeared) in draft for public comment before being finalized.

[b]May be a collection of region, area, location reports or an integrated report containing equivalent information. Because this collection of reports describes results of various screening studies, they are sometimes referred to as "screening documents".

[c]Initial SCR will discuss design and test plans for an exploratory shaft. Other documents such as Site Characterization Plans (SCPs) may be prepared where they facilitate state review of the DOE process.

TABLE 4-2. POTENTIAL REPORTS THAT MAY DOCUMENT THE SITING PROCESS[a]

Planning Documents

National Siting Plan[b]

Purpose: Document the DOE existing and planned activities for screening land within the U.S. and evaluating DOE lands to identify suitable candidate sites and for selecting one or more of those sites for HLW disposal. Provide a vehicle for state, regulatory, and societal review of the DOE siting strategy.

Scope: Describes policy, requirements, and criteria under which siting is performed, the siting process, program organization and management elements responsible for siting, and the schedule and status of siting efforts.

Region, Area Survey Plans*

Purpose: To document plans for screening a region or area.

Scope: Describes survey objectives, constraints, study methods, and issues and criteria to be addressed.

Site Characterization Report

Purpose: Identify the data necessary to fully characterize locations or sites, plans for acquiring the data including exploratory shafts, and the measures to ensure that site investigations will not unacceptably affect site integrity. The first draft need not contain shaft test plans and design, if document supports DOE's decision for only surface-based characterization activities. The document for NRC contains exploratory shaft test plans.

Scope: Sequential drafts of increasing detail are contemplated. Describe the location or site to be characterized and describe how the screening methodology used to identify that site. Present the plans for conducting geological, environmental, and engineering studies to characterize the site. Discuss special issues related to the site and the plans to resolve those issues. Prepared in Nuclear Regulatory Commission format as modified by DOE.

[a]Each project will produce the documents identified as a "project" report in Table 4-1. Projects may produce some or all of the additional documents identified here to facilitate stepwise decision-making or state involvement. Reports followed by an asterisk (*) will not be produced for projects investigating DOE lands. Projects may produce one report which may combine the elements of two or more documents, if this is done with DOE approval and if the multipurposes of the report are explicit. Document types are defined on the last page of this table.

[b]Report titles are generic; actual titles will be chosen by the projects or program as appropriate.

Table 4-2. (Continued)

Characterization Documents

National Survey Reports*

Purpose: These reports are reconnaissance-level literature surveys on which to base selection of regions that potentially contain suitable natural systems for radioactive waste disposal.

Scope: Identifies favorable or adverse features that are expressed over broad geographic regions that either could be investigated further or should be avoided. One or more site suitability criterion (NWTS-33(2)) is applied in conducting these surveys.

Region Characterization Reports*

Purpose: Provide the geohydrologic, environmental, and socioeconomic characteristics on which to base identification of areas that potentially encompass isolation systems. These reports will be based on contractor and state agency studies of varying scope.

Scope: Describe reconnaissance level surveys of the literature and open government agency files to identify geologic and environmental features favorable or unfavorable to isolation systems that are expressed over tens to hundreds of square miles. Provides maps and data summaries used to identify promising areas and potential conflicts.

Area Characterization or Integration Reports

Purpose: Provide the geologic and environmental characteristics on which to base identification of locations (tens of square miles) or sites for isolation systems. Reports will be based on contractor and state or federal agency studies.

Scope: Present data obtained from the literature, field surveys, mapping, borehole drilling, and contacts with government agencies. They (1) identify key geologic factors expressed within or over hundreds of sq miles (2) identify natural and petroleum resource areas, (3) provide maps and data summaries of areal geologic structure or features that may affect repository performance, (4) characterize the surface environment overlying promising geohydrologic systems, and (5) identify protected areas, major habitats, and conditions that may affect or be affected by repository development in that area.

Updated Site Characterization Reports

Purpose: Provide geohydrologic and environmental data obtained in accordance with the initial SCR sufficient to determine site suitability and to prepare licensing documents, perform design trade-off studies, and perform performance assessments.

Scope: Present descriptions related to site design requirements and parameters, performance assessments, and any additional geological, environmental, and socioeconomic data needed to support them. Present data from in situ testing performed in an exploratory shaft.

Table 4-2. (Continued)

Recommendation Documents
Region Summary and Area Recommendation Reports*
Purpose: Recommend areas for further investigation.
Scope: Summarize the geological and environmental characterization data and describe the decision process used in making area recommendations.
Area Summary and Recommendation Reports
Purpose: Recommend locations (tens of sq miles) or sites for further investigation.
Scope: Summarize the geologic and environmental characterization data relevant to recommending locations or sites for further study and describe the decision process used in making the recommendations. Where several distinct locations are identified, a subsequent site recommendation report may be necessary.
T&E Facility Recommendation Report
Purpose: Recommend a particular site to be selected for the Test and Evaluation Facility.
Scope: Present a comparative analysis of technical and environmental characteristics of candidate sites; a description of the application of the selection and decision processes; and the recommended decision for the T&E Facility.
Repository Site Recommendation Report
Purpose: The draft report will recommend a particular site to be selected for a license application. The final report will document the decision to select a site for disposal of high-level radioactive waste.
Scope: Present a summary of characterization and decision processes that led to the selection of a particular site, present the review process, and include major comments received and DOE responses on the draft report comments.

Table 4-2. (Continued)

NEPA Documents	
Environmental Assessment for Implementing the National Siting Plan	Assess environmental impacts of implementing the National Plan for Siting of High-Level Radioactive Waste Repositories, alternative strategies, and field activities which precede exploratory shafts. Identify the types of impacts associated with carrying out geographic screenings, site searches, detailed site studies and selection. Describe how the proposed methodology impacts cost, timing, amount of available data, potential for public participation, and the availability of resources. Also consider alternatives to the strategy recommended.
NEPA Documents (EAs or EISs) for Detailed Site Studies	Evaluate the impacts of performing field activities including exploratory shafts and work planned in the SCR. Evaluate the impacts of land protection measures necessary to protect the integrity of the site. Review site selection process. Describe and quantify the potential impacts of the activities planned in the SCR. Examine sites using the NWTS Performance Criteria (Appendix A) or the NRC and EPA criteria as soon as they have been developed and adopted. Qualitatively discuss the nature of potential issues and possible impacts should a site be eventually selected for a T&E Facility or repository site.
Environmental Impact Statement for Test and Evaluation Facility (TEF)	Identify and evaluate the potential impacts resulting from selection of a specific site for a TEF, including construction and operating impacts and site restoration plans. Qualitatively consider the potential for siting a repository at the location and the impacts associated with it. Define the possible alternatives and evaluate the potential impacts on the site of construction, operation, and decommissioning of the TEF, and the possibility of constructing a repository.
Environmental Impact Statement for Site Recommendation and Selection	Assess environmental impacts of selecting a specific site for construction, operation, and closure of a mined geologic repository for isolating nuclear wastes. Identify and evaluate potential environmental (including socioeconomic) impacts of developing the site and alternatives for the purpose of isolating nuclear wastes in a mined geologic repository. Impact mitigation plans are evaluated at a site-specific level in this document.
Environmental Document for Protecting Land	Evalute the impacts of limiting future land uses of a site, if this has not been completed with other siting decisions. Define and evaluate the potential impacts of limiting land uses to protect site suitability and DOE's investment of public monies in exploration to find the site. Evaluate the impacts of DOE planning to reserve the site as a candidate site for radioactive waste repositories and qualitatively evaluate the impacts of constructing, operating, and closing a repository at the site.

Table 4-2. (Continued)

Definitions
Planning document: Program or Project report or report section that clearly defines specific siting objectives, policies and criteria, identifies the activities (content and timing) needed to accomplish the objectives, the organizational components responsible for implementation, and the driving forces for conflict resolution. The report summarizes the decision(s) which the plan will implement.
Characterization document: Project report that presents physical, chemical, ecologic, and/or socioeconomic characteristics of regions, areas or sites, both surface and subsurface. Characterization includes predicted responses of the things characterized to the loadings and stresses imposed by the project. For the geographic screening phase, characteristics that may have a significant influence on screening choices receive emphasis. For site suitability, characteristics that contribute to a demonstration of safety, repository design and construction feasibility, and environmental and social compatibility receive emphasis.
Recommendation document: Program or project report or report section that describes the alternatives considered and recommends places for further study, sites for exploratory shafts or TEF, or sites for license application and development. Documents that recommend actions potentially affecting the environment or foreclosing alternatives are accompanied by an environmental document. The process used to arrive at the recommendation is described; essential data supporting the recommendation are summarized; future activities dependent on the recommendation are described.
NEPA document: In this context a NEPA document defines the proposed action and explains the need for that action, and to varying degrees analyzes alternatives to the proposed action including alternative actions and alternative methodologies for implementing the proposed action, and identifies and evaluates the potential impacts which may directly or in directly result from implementing the proposed action or alternatives. Enviromental impacts include both beneficial and adverse impacts to the physical/chemical environment, the human environment, and to ecosystems. In accordance with 40 CFR Part 1508.10 environmental documents include Environmental Assessments (EAs), Environmental Impact Statements (EISs), Finding of No Significant Impact (FONSIs) and Notice of Intent. In accordance with DOE Order 5440.1A (October 20, 1980) "NEPA documents" include "environmental documents" and "any other documentation prepared pursuant to a NEPA requirement."

TABLE 4-3. DECISIONS BY SITING PHASE

SITE SCREENING PHASE

Establish the Siting Process

DOE proposes the siting strategy and evaluates the potential impacts of implementing that siting strategy in an environmental assessment. DOE's adoption of the final plan for siting a high-level radioactive waste repository constitutes the decision. State government and public comments are sought on the draft plan (this document) prior to its adoption.

Initiate Survey Approaches

DOE initiates survey approaches likely to identify promising sites. The initiation of surveys to determine the character and extent of land areas potentially containing sites constitutes the decision. Consultation with states to be involved precedes surveys.

Choose Alternative Regions, Areas, Locations, or Candidate Sites for Additional Study

DOE chooses the regions, areas, locations, or potential sites that will receive additional study. DOE approvals of recommendation reports or study plans constitute the decisions. State and local governments and representatives, non-DOE federal agencies and departments, and NWTS program and project offices may be involved in these decisions. Public opinion of socioeconomic, environmental, and health and safety issues is considered. Local governments may become significantly involved in review of reports recommending sites on non-DOE lands.

DETAILED SITE STUDIES PHASE

Approve Site Characterization Reports

DOE develops the plans it will use to characterize sites. The plans will be called Site Characterization Reports (SCRs) to maintain a consistency with 10 CFR 60 terminology. The planned activities will address site suitability issues and provide the data needed for repository design and performance assessment without compromising site integrity. An updated SCR will describe site data and analyses which provide confidence in site suitability. DOE will involve the NRC early in the site characterization planning process and give NRC staff an opportunity to review the Site Characterization Report called for by 10 CFR 60 prior to authorizing the construction of an exploratory shaft. Also involved in site characterization planning are federal, state, and local government officials, and scientists.

TABLE 4-3. (Continued)

Determine Site Suitability
DOE chooses sites to be reserved for possible selection on the basis of characterization data. The event constituting this decision will be DOE approval of an update of the Site Characterization Report that concludes the site to be suitable and which recommends it be reserved for possible selection. DOE may then complete options, ownership, or initiate withdrawal action sufficient to control the access and activities on and beneath the surface of a site if it has not already done so. The site suitability decision is subject to NRC's regulatory review.
SITE SELECTION PHASE
Select a Repository Site
DOE selects sites for repository development. The event that constitutes the decision is DOE approval of a Repository Site Recommendation Report and companion EIS after consideration of public comments. Site selection precedes filing of an application for construction authorization to the Nuclear Regulatory Commission.
Select a Test and Evaluation Facility Site
DOE selects a site, from among those undergoing detailed studies, that will be used for study of generic engineering design and repository operating procedures. The event constituting the decision is approval of a T&E Facility recommendation report and companion EIS after public comments have been addressed.

TABLE 4-4. INVESTIGATIVE METHODS BY SCREENING STEP - TYPICAL

Geologic Investigations

	Method/Phase[a]														
	Geophysical											Geological			
	Airborne						Land Based								
	Photography					T.I.R.[c] False					Down	Geologic		Lab Testing	
Factors	Space	Air	Aeromagnetics	Gravity	S.L.A.R.[b]	Color	Magnetic	Gravity	Seismic	Electric	Hole Logging	Mapping Lithology	Subsurf. Expl. Stratigraphy	RK Samples for Eng. Parameters	Subsurf. Test
Geologic	NR	RAL	RA	R		RAL	AL	AL	AL	RA	AL	RAL	AL	AL	AL
Hydrologic	NRA	RAL				RA			L	AL	AL	RAL	AL	AL	AL
Tectonic	NR	AL	RA	RA	RAL	RAL		AL	AL	L		RAL	AL	L	AL
Resource		AL	RA			AL	AL		AL	AL	AL	RAL	AL	AL	

(a) Phases: N - National
R - Regional
A - Area
L - Location/Site.

(b) S.L.A.R. is "Side-Looking Airborne Radar".

(c) T.I.R. is "Thermal Infrared".

TABLE 4-4. (Continued)

Environmental Investigations

Factors	Methods							
	Laboratory Analysis	Photography	Maps	Permit Review	Literature	Unpublished Data	Field Studies	Models
Aesthetic	–	AL[a]	NRAL	AL	NRAL	NRAL	L	–
Aquatic	L	AL	NRAL	AL	NRAL	NRAL	AL	AL
Terrestrial	L	AL	NRAL	AL	NRAL	NRAL	AL	AL
Socioeconomic	–	–	NRAL	AL	NRAL	NRAL	L	AL
Land Use	–	AL	NRAL	AL	NRAL	NRAL	AL	AL

(a) Phases: N National
R Regional
A Area
L Location/Site.

TABLE 4-5. EXAMPLE NWTS SITING ACTIVITIES THAT ADDRESS SITE PERFORMANCE CRITERIA

CRITERIA \ CHARACTERIZATION PHASE		NATIONAL SURVEY	REGIONAL SURVEY	AREA SURVEY	LOCATION SURVEY[a]	DETAILED SITE STUDIES
1. SITE GEOMETRY	a. Minimum Depth b. Thickness and Lateral Extent of Host Rock	Data Needed: Generalized Subsurface Stratigraphic data sufficient in depth to delineate regions where host rock most likely would meet minimum depth, thickness and lateral extent criteria. Methods: General review and interpretation of compilations of existing satellite imagery, deep well logs, aeromagnetic and geophysical surveys and field mapping.	Data Needed: More spacially specific subsurface stratigraphic data of sufficient scope and depth to define areas which most clearly show evidence of the depth, thickness and lateral extent of host rock favorable for further study. Methods: More detailed review of regions specific compilations of existing, satellite photography, aerial geophysical surveys, land based geophysical surveys and field mapping.	Data Needed: Area specific subsurface data on stratigraphy and structure to delineate locations having the most favorable host rock depth, thickness and lateral extent. Methods: Field exploration including aerial photography airborne and land based geophysical surveys, shallow boreholes, deep drill holes, well logging, field mapping.	Data Needed: Data indicating subsurface geometry, structure, and lithology sufficient to compare one location with another and identify sites. Methods: Borehole drilling, geophysical surveys.	Data Needed: Specific stratigraphic data to provide evidence that the potential sites have the desirable host rock geometries for safe development and performance of a repository. Sites specific subsurface stratigraphic data to confirm the apparent host rock depth, thickness and lateral extent including buffer zones and restricted areas. Methods: Field exploration studies including: aerial photography, geophysical surveys, deep well drilling, laboratory analysis of cores, and exploration shaft.
2. GEOHYDROLOGY	a. Geohydrological Regime	Data Needed: Identification and general characterization of hydrologic basins to define regions favorable for further screening. Methods: Evaluation of existing data on water bearing formations and water quality from well testing, laboratory analysis, well geophysical logs.	Data Needed: Region specific characterization of water bearing formations sufficient to define areas suitable for further screening. Methods: Evaluation of existing formation hydrologic data from borehole, borehole logs, seismic profiles, core analyses and water chemistry.	Data Needed: Area specific ground water and aquifer characteristics and properties to define those locations having characteristics most favorable to repository development and performance for further screening. Methods: Field exploration including: borehole, deep well, pump tests, core analysis, well logging, seismic profiles, laboratory analyses.	Data Needed: Location specific aquifer isopach maps, geohydrologic cross-sections, recharge and discharge areas, permeability and porosity of target and surrounding rocks, estimation of ground-water travel time and estimated potential for short circuiting of flow paths to compare relative suitability of locations. Methods: Aquifer pumping tests, geophysical and lithologic logging, literature review, laboratory testing of case samples, and simple models.	Data Needed: Determinations of water residence times, recharge + discharge rates, pressure head differentials, hydraulic path lengths, and orientations, ground water travel times, hydraulic factors and model development. Site specific confirmatory information validating ground-water models establish design parameters for repository development and performance. Methods: Borehole, and deep well coring and analysis pump tests, laboratory analysis, well logging, water sampling, exploratory shaft.
	b. Hydrological Regime/ Shaft Construction	Data Needed: General characterization of regional ground-water occurrence and aquifer systems (hydrology — hydraulics — water chemistry) for assessing potential effects on shaft and repository construction. Methods: Evaluation of existing compilations of regional hydrologic data from well sampling and testing, laboratory analyses and well logging.	Data Needed: Region specific characterization of ground-water hydrologic basins (aquifer and water-bearing formations) including water quality and provenance for assessing potential effects on shaft and repository construction. Methods: Review and evaluation of existing hydrologic data from well testing and sampling, well logging, laboratory analyses and pump tests.	Data Needed: Area specific ground-water aquifer hydraulic properties, solution history and corrosive propensities to define any potential effects on shaft and repository construction and/or operation. Methods: Field studies including boreholes, deep wells, pump tests, well logging, laboratory analyses and core analyses.	Data Needed: Location specific estimates of aquifer composition and yield. Methods: Borehole drilling, pumping tests, core analysis.	Data Needed: Determinations hydraulic properties, corrosivity and dissolution capacities. Information and modeling to establish design and engineering parameters for repository construction. Methods: Pump tests, chemical analyses, in situ testing, exposure and solution tests, core drilling and well logging exploratory shaft.
	c. Subsurface rock Dissolution	Data Needed: Characterization of rock dissolution at the national screening level would not be a distinguishing characteristic and therefore is not considered here. Methods: Not applicable.	Data Needed: Region specific characterization of subsurface stratigraphy and evidence of past dissolution features and defining areas for further screening. Methods: Evaluation of existing borehole, and deep drill hole cores, seismic surveys, airborne geophysical surveys and directional drilling.	Data Needed: Area specific investigation to define areas of dissolution. Methods: Boreholes, deep drill core analysis, laboratory analysis, drill stem testing.	Data Needed: Location specific chemical and physical properties of water including age estimates. Methods: In situ and laboratory analysis of water.	Data Needed: Determination of existing or potential rock dissolution, information on host rock and surrounding strata relative to modeling validation and engineering and design of repository to meet performance objectives. Methods: Extensive boreholes, deep drill core analyses, laboratory analyses, drill stem testing, in situ shaft studies.
3. GEOCHEMISTRY	a. Geochemical Interactions	Data Needed: Identification and general characterization of water quality and geochemistry for assessing general suitability of host media. Methods: Evaluation of existing information	Data Needed: Region specific characterization of ground-water chemistry and host rock geochemistry. Methods: Evaluation of existing data.	Data Needed: Area specific ground-water properties to define potential effects on typical waste packages and radionuclides Methods: Supplement existing data as needed with field data.	Data Needed: Chemical and physical properties of ground waters and geologic materials, radioactive decay constants, isotopic analysis, retardation factors sufficient to estimate general sorption and reactivity of materials in host and surrounding media. Methods: In situ and laboratory chemical and physical analysis of water, mineral analysis of core samples, radiometric age-dating techniques, chemical equilibria modeling, literature review.	Data Needed: Determination of ground-water chemistry including radionuclide retardation factors and corrosivity for validating performance models, and design parameter assumptions. Methods: Field and laboratory studies.
4. GEOLOGIC CHARACTERISTICS	a. Subsurface Setting	Data Needed: General characterization of regional stratigraphic (basement to surface) to evaluate stratigraphic settings conducive to repository integrity and construction and waste isolation. Methods: Evaluation of existing compilations of subsurface stratigraphic, boreholes, deep well logs, core analysis, geophysical surveys and correlation studies (national) remote sensing, field mapping + seismic profiles.	Data Needed: Region specific stratigraphic characterization defining those areas most favorable for further screening. Methods: Evaluation of existing compilations of subsurface stratigraphic, boreholes, correlation studies, remote sensing, field mapping + seismic profiles.	Data Needed: Area specific detail on rock units surrounding the host rock, including lithologic character engineering + chemical properties. Methods: Field exploration program of borehole + deep well drilling, logging, core analysis, laboratory analysis, and geophysical surveys.	Data Needed: Location specific information on structure and complexity of the subsurface setting including lithology, stratigraphy, isopach and contour maps, and cross sections sufficient to compare locations and identify sites. Methods: Geophysical and lithologic logging of boreholes, geophysical survey techniques, paleontological, petrographic, and mineralogical analysis, geologic mapping, and remote sensing.	Data Needed: Characterization of rock units surrounding host rock as a medium to inhibit waste movement, enhance isolation and minimize geochemical interactions, develop models, block diagrams and cross sections. Methods: Well and deep hole drilling coring + logging, laboratory analysis, seismic profiling, exploratory shaft.
	b. Host Rock Characteristics c. Engineering Feasibility	Data Needed: General information on rock characteristics considered suitable for a repository in the broadest sense and defining regions where various host media of sufficient extent occurs. Methods: Evaluation of existing compilations of regional geology and stratigraphy; core drilling, well logging, and geophysical surveys.	Data Needed: Region specific information on rock physical and chemical properties to delineate areas where rock character is potentially suited for repository development. Methods: Evaluations of existing compilations of geology and stratigraphy, deep drilling and core analysis, laboratory analyses, geochemical and thermo-mechanical analyses and testing.	Data Needed: Area specific characterization of host rock chemical, mechanical, geothermal and general engineering properties. Methods: Deep drilling, core analysis geophysical logging, drill stem testing hydrofacture, laboratory analysis.	Data Needed: Thermal and mechanical properties including rock strength, stress conditions, and rock response to heat, vibration, and stress. Methods: Literature review, laboratory testing of rock core, geophysical logging and surveys.	Data Needed: Characterization of chemical, mechanical, geothermal and engineering properties of host rock to develop conceptual models or repository design and engineering including block diagrams cross sections and engineering section. Methods: Deep drilling, core analysis, geophysical well logging, drill stem testing, hydrofracture tests, laboratory analysis (engineering properties) and exploratory shaft for in situ testing.

[a] Potential sites may be contained in locations. Studies of locations are designed to address only key uncertainties and differences with other locations to provide information that will help make a choice as to which site shows most promise of being suitable. These studies will be performed at a level of detail needed to make intelligent choices among locations. Not all data specified are needed at each location. Site studies including exploratory shafts and baseline studies will be performed at only the most promising sites.

TABLE 4-5. (Continued)

CRITERIA \ CHARACTERIZATION PHASE		NATIONAL SURVEY	REGIONAL SURVEY	AREA SURVEY	LOCATION SURVEY[a]	DETAILED SITE STUDIES
5. TECTONIC ENVIRONMENT	a. Tectonic Elements	Data Needed: Identification and location of major tectonic features (e.g. mountains, plate boundaries) to define regions for further screening. Methods: Evaluation of existing satellite and aerial imagery, deep well logs.	Data Needed: Identification and definition of regional tectonic features for use in further screening. Methods: Evaluation of existing airborne and land based magnetic and gravity surveys, seismic profiles, borehole and deep well logging and field mapping.	Data Needed: Development of a conceptual model of area tectonic evolution. Methods: Field exploration utilizing shallow boreholes, borehole logging, microseismic networks, seismic surveys, and geologic mapping.	Data Needed: Proximity of location to regional tectonic features and response of location to tectonic activity to identify potential sites. Methods: Literature survey, field exploration, geologic mapping, seismic monitoring.	Data Needed: Data defining the tectonic elements if any that may affect repository performance and confirmatory information of tectonic elements to provide input to design and engineering necessary to develop a repository that can meet performance objectives. Methods: Field surveys including: shallow boreholes, borehole logging, microseismic network, deep well drilling, well logging, geophysical surveys, geologic mapping, microseismic monitoring.
	b. Quaternary Faults (Regional and Local)	Data Needed: Sufficient generalized information on fault location, movement and age on a regional scale to delineate regions considered to be relatively unaffected by active or potentially active regional faulting for further screenings. Methods: Evaluation of existing satellite and aerial photography airborne and land based geophysical surveys and field mapping.	Data Needed: Region specific data on major fault zones and fault movement locations and ages to further define areas expected to be most unaffected by them such that repository performance would not be compromised. Methods: Evaluation of existing airborne and land based magnetic and gravity surveys, seismic and thermal I-R surveys and field mapping.	Data Needed: Field data to identify fault lengths, tectonic framework, and the existence of unmapped Quarternary faults at suspected locations and define locations least affected by regional faults for further location surveys. Methods: Aerial photography TIR + SLAR/ field mapping trenching, boreholes, deep drilling, geophysical surveys, and microseismic networks.	Data Needed: Identification of quaternary faulting in or near location: size, age, extent, and activity of such faulting. Proximity of potential sites to quaternary faults. Methods: Literature review, aerial and infrared photography, side-looking airborne radar, field exploration, mapping, trenching, geophysical surveys, seismic monitoring.	Data Needed: Site specific confirmation of existence of faults to determine design and engineering necessary to meet repository performance objectives. Methods: Onsite microseismic surveys, airborne TIR, gravity and magnetic surveys, boreholes, deep wells, geophysical logging, field mapping, trenching, and age dating.
	c. Quaternary Igneous Activity	Data Needed: Location of major regions evidenced to have had Quaternary igneous activity and define those regions unaffected or seemingly so for further screening toward repository sites. Methods: Evaluation of existing aeromagnetic and gravity surveys, satellite and aerial photography, SLAR, Thermal IR., field mapping, drill and borehole core analysis.	Data Needed: Region specific evidence of Quaternary volcanic activity to delineate areas for further screening. Methods: Evaluation of existing airborne and land based magnetic and gravity surveys, aerial photography, SLAR, thermal I-R, field mapping deep drill hole core and laboratory analysis.	Data Needed: Area specific evidence if any of Quaternary volcanic activity (extrusive and intrusive) to define locations most likely unaffected by volcanism. Methods: Airborne and land based magnetic and gravity surveys, aerial photography, SLAR, thermal I-R, field mapping deep drill hole core and laboratory analysis.	Data Needed: Proximity of location to region or area volcanic activity or features and response of location to distant activity. Methods: Literature review, airborne and land-based gravity and magnetic surveys, borehole core logging and analysis.	Data Needed: Site specific confirmation of Quaternary volcanism to determine level of design and engineering necessary to meet repository performance objectives. Methods: Field exploration including land based gravity and magnetic surveys, seismic surveys, borehole and deep well drilling, borehole and deep well logging and microseismic network monitoring and field mapping.
	d. Uplift or Subsidence Rates	Data Needed: Identification of major zones that have evidenced uplift and/or subsidence to define regions having the least potential for being affected for further screening. Methods: Evaluation of existing remote sensing (airborne magnetic and gravity surveys) boreholes, borehole logging, seismic surveys, and geologic field mapping.	Data Needed: Identification of areas within screened regions which evidence the least potential for being affected by uplift and subsidence (i.e., most stable) for further screening. Methods: Evaluation of existing airborne and land based magnetic and gravity surveys, seismic profiles, borehole and deep well logging and field mapping.	Data Needed: Area specific information to identify any past or potential for uplift or subsidence. Methods: Field exploration, microseismic networks, seismic surveys, geologic mapping, and geodetic networks.	Data Needed: Location specific differential uplift or subsidence rates sufficient to compare locations and identify potential sites. Methods: Evaluation of leveling data, literature review.	Data Needed: Site specific confirmation of any subsidence or uplift and their potential to aid in determinations of repository design and engineering features to safely meet repository performance requirements. Methods: Field mapping and topographic surveying, tilt meter and microseismic network monitoring, fine mesh magnetic surveys.
	e. Ground Motion	Data Needed: Generalized information on seismic stability and earthquake occurrence magnitude and frequency to delineate region most stable for further screening. Methods: Analysis and evaluation of instrumentally recorded observed, and historic earthquake activity.	Data Needed: More region specific seismic sensitivity analyses and determinations of earthquake frequency, magnitude and intensity to define the most stable areas for further screening. Methods: Analysis and interpretation of available seismic monitoring and earthquake records.	Data Needed: Estimates of maximum credible earthquake and associated ground acceleration expected for the area. Methods: Evaluation and analysis of earthquake records that may be supplemented with installed microseismic networks.	Data Needed: Estimated ground acceleration expected from earthquakes and induced seismic events (e.g., reservoirs, oil-field pumping) in or outside the location. Methods: Seismic monitoring and literature review.	Data Needed: Site specific seismic data to confirm the estimated maximum credible earthquake such that repository design and engineering can be refined for maximum performance and long-term integrity. Methods: Seismic data from onsite microseismic network, rock core analysis and possibly in situ host rock engineering stability analyses.
6. HUMAN INTRUSION	a. Resources b. Exploration History c. Ownership and Control	Data Needed: General information on regionalized mineral and energy resources to determine if past or future recovery could potentially compromise repository performance. Methods: Evaluation of existing exploration records, exploratory drilling surveys, borings, shafts, adits, well logs and geophysical surveys.	Data Needed: Identification and location of major mineral, energy or other commercial resource operations including potential resource deposits and past and active exploration activities. Methods: Evaluation and review of existing exploration drilling, shaft boring, resource evaluations, well and deep drilling cores, well logging and land base geophysical surveys.	Data Needed: Identification and location of mineral and energy resource rights land ownership and subsurface rights including claims and exploration permits and abandoned or lost exploratory borings. Methods: Review and evaluation of claim data, plant surveys and Federal, state and local land records, mineral claims.	Data Needed: Proximity of location to regional and area resources. Location specific resources and exploration history, land ownership records. Methods: Literature review, permit files, interviews with exploration companies, field inventory, review land ownership records, interviews.	Data Needed: Detailed location of mineral and energy reserves, resources, active and inactive mining operations and locations of exploration borings adits or shafts, ownership of land and subsurface rights of potential repository site and determination of ease of DOE obtaining ownership. Methods: Same as area but add, lost-well field surveys.

TABLE 4-5. (Continued)

CRITERIA / CHARACTERIZATION PHASE		NATIONAL SURVEY	REGIONAL SURVEY	AREA SURVEY	LOCATION SURVEY[a]	DETAILED SITE STUDIES
7. SURFACE CHARACTERISTICS	a. Surface Hydrologic System b. Meteorological Conditions	Data Needed: General regional characterization of surficial water bodies, climatic conditions and extremes, probable maximum precipitation (PMP), probable maximum flood (PMF) and severe natural phenomena. Methods: Evaluation of existing space and aerial photography, Thermal Infra-Red (T.I.R.), field mapping, water stage and flow records, and meteorological records.	Data Needed: Region specific information on surface water bodies, historical fluctuations and extremes, PMP, PMF and severe natural phenomena. Methods: Evaluations of existing compilations of records from stream, lake and reservoir gaging stations, meteorological records, field studies, aerial photography	Data Needed: Area specific data on surface water bodies and climate to define locations most favorable as potential repository sites in terms of flooding and severe storms. Methods: Field surveys including mapping, stream and lake/reservoir gaging.	Data Needed: Severe natural phenomena (e.g., severe storms, flooding), frequency, size, intensity of severe storms, hourly precipitation during maximum floods. Methods: Review of historical meteorological data.	Data Needed: Detailed information on water bodies or climatic and meteorological conditions that can potentially affect repository performance. Methods: Field surveys, mapping (floodplains and runoff patterns), meteorological monitoring, stream and reservoir/lake gaging and flow monitoring.
	c. Surface Topographic Features d. Nearby Hazards	Data Needed: Regionalized characterization of topographic expression relative to construction and operation of a repository and safety (avoid mountainous regions). Methods: Evaluation of existing satellite and aerial photography.	Data Needed: Region specific characterization of topography and slope related hazards (avalanche + landslides). Methods: Evaluation of existing satellite and aerial photography.	Data Needed: Area specific characterization of topography for avoiding potential hazards to repository construction and/or waste shipment access. Methods: Evaluation of existing satellite and aerial photography field mapping.	Data Needed: Identification of air restrictions, potentially hazardous facilities (manufacturing or storage of hazardous materials; e.g., chemicals, explosives, nuclear facilities). Methods: Literature survey, map review, evaluation of aerial photography, field reconnaissance.	Data Needed: Detailed site specific characterization of topography, slope, design and engineering conceptual models of repository and surface facility siting. Methods: Fine grid aerial photography and ground surveys.
8. DEMOGRAPHY	a. Human Proximity	Data Needed: At the national screening level identification of population centers is of low priority if not inappropriate in repository siting. Methods: N/A	Data Needed: Identification and location of major urban population centers and growth projections in the region. Methods: Aerial photography and census counting (historical growth patterns).	Data Needed: Locate urban population centers in the area such that they can be avoided in siting a repository. Methods: Aerial photography and field mapping, census counting (historical growth patterns).	Data Needed: Identify and locate areas of population and growth, population density; population composition and characteristics based on 1980 census. Field surveys to identify and locate populations in location and along major transportation routes. Methods: Obtain information from 1980 census, aerial photographs, and onsite investigation where data are lacking.	Data Needed: Identification and location of population centers and growth projections, detailed demographic data. Methods: Aerial photography and field mapping, census counting (historical growth patterns).
	b. Transportation Risk	Data Needed: At the national screening level assessment of transportation routes and access corridors for repository siting is of low priority if not irrelevant. Methods: N/A	Data Needed: Identification and location of regional transportation networks, rail and highway and waterways. Methods: Review and evaluation of aerial photography and field mapping.	Data Needed: Location of transportation routes to potential repository sites that would minimize risks to populations and accidents with shipped wastes. Methods: Aerial photography and field mapping.	Data Needed: Locate existing transportation and access routes within 50 miles to determine routes that would minimize risks to population. Methods: Obtain data through evaluation of aerial photographs and updating of transportation routing models.	Data Needed: Location of site specific transportation routes such that they can be utilized for waste transport or new facilities constructed or added to existing systems. Methods: Field mapping and surveying.

TABLE 4-5. (Continued)

CRITERIA / CHARACTERIZATION PHASE		NATIONAL SURVEY	REGIONAL SURVEY	AREA STUDY	LOCATION SURVEY[a]	DETAILED SITE STUDIES
9. ENVIRONMENTAL PROTECTION	a. Environmental Impact Air Quality, Radiation, and Noise	Data Needed: Environmental impact is not a consideration during the national survey.	Data Needed: Summary of mixing and dispersion conditions and background particulate levels. Cosmic, terrestrial and fallout levels of background radiation. Source: Air Quality Maintenance District (AQMD) records, National Weather Service and military weather records. Environmental Protection Agency and the National Council on Radiation Protection and Measurements.	Data Needed: Area specific dispersion conditions including discussions of topographic influences and atmospheric stability estimates based on the Pasquill-Turner approach. Levels of atmospheric particulates. Major pollution sources and compliance with federal, state, and local air quality standards. Description of radioactive ion concentration and pathways in water, air, and background radiation described to the detail available in the literature. Source: AQMD, National Weather Service and Environmental Protection Agency Records. Appropriate state health agencies and universities. Analysis of pathways from the environment to man.	Data Needed: Annual, seasonal, and monthly mixing layer data and verifications within locations of strength of episode days; effects of land forms on dispersion; extreme and severe weather conditions; ambient air quality. Methods: Review state health agency data; university studies; nuclear power plant data; nuclear defense activity; cosmic terrestrial and fallout background radiation; data on air and water quality.	Data Needed: Annual, seasonal, and monthly mixing layer information. Variations within the location of the strength of episode days of poor dispersion. The effects of land forms on dispersion. General levels of particulates and gaseous pollutions. Identification of hot spots and previous, ongoing, and proposed nuclear activity. Identification of possible pathways and the possibility of bioconcentration. Source: Monitoring of atmospheric pollutants in conjunction with meteorological monitoring. Continued use of AQMD records. State health agency data, university studies, test plots, and on-site investigations.
	a. (Continued) Natural Resources	Data Needed: None, natural resources is not a consideration during the national survey.	Data Needed: Existing and potential surface and subsurface mineral resources (including water). Source: U.S. Department of the Interior (USDI) and appropriate state agencies.	Data Needed: Potential extent of subsurface mineral resources; past, ongoing, and projected mineral extraction activities. Surface and subsurface water resources and use. Source: Federal, state, and local agencies; published and unpublished studies, field verification of data and field research.	Data Needed: Type, location, and extent of mineral resources; status of mineral production; mineral leases and exploration. Kinds and extent of present and planned water use; distribution of water sources and use patterns. Methods: Obtain data from state and local resource agencies, well records, public health agencies, mineral lease records, and mineral companies.	Data Needed: Type, location, and extent of mineral resources are described. Status of mineral production. Kinds and extent of water use. Distribution of water sources and patterns of use. Relationship of surface and ground water. Trends in water use. Source: State, federal, and local water resource agencies, geologic investigations, well records and public health agencies. Federal, state, and local agencies managing mineral resource extraction.
	a. (Continued) Terrestrial	Data Needed: None, terrestrial ecology is not a consideration during the national survey.	Data Needed: Regional vegetation types, threatened biota, and primary agricultural uses. Source: Federal and state governmental agencies, published and unpublished literature.	Data Needed: Description of major, valuable, unique and stressed ecosystems. Critical habitats and known ranges of important species. Dominant species, habitat reclamation potential, tolerance to disturbance, threatened and endangered species. Important agricultural resources, prime agricultural land, and unique farmland. Source: Published and unpublished data, aerial photographs, federal and state governmental agencies, available published and unpublished literature.	Data Needed: Ecological evaluation of the location sufficient to identify and locate designated and proposed threatened or endangered species and/or critical habitat, valuable or unique ecosystems. Methods: Intensive literature search and preliminary field surveys will be conducted.	Data Needed: A detailed ecological evaluation of the location which will provide sufficient information to predict future trends with or without the project. Source: Intensive field studies utilizing a wide variety of field sampling techniques which will provide both qualitative and quantitative data.
	a. (Continued) Aquatic	Data Needed: None, aquatic ecology is not a consideration during the national survey.	Data Needed: A listing of water resource regions, drainage basin characteristics, water quality and stream gauging station locations. Source: Federal and state agencies published and unpublished data, aerial photographs, and U.S. Geologic Survey maps.	Data Needed: Hydrologic and biologic characteristics and significance of waterbodies and wetlands, water chemistry, pollutants, species of plant and animals present. Source: Published and unpublished data, federal and state agencies, universities, local experts. Field verification of data where necessary and analysis of aerial photographs.	Data Needed: Locate and identify presence of threatened or endangered species and/or critical habitat. Hydrologic characteristics and significance of water bodies and wetlands. Methods: Intensive literature review and preliminary field surveys.	Data Needed: An evaluation of the aquatic environment in sufficient detail to predict future trends with or without the project. Source: Intensive field sampling utilizing a wide variety of field sampling techniques which will provide both qualitative and quantitative data.

TABLE 4-5. (Continued)

CRITERIA / CHARACTERIZATION PHASE		NATIONAL SURVEY	REGIONAL SURVEY	AREA SURVEY	LOCATION SURVEY[a]	DETAILED SITE STUDIES
9. (Continued)	b. Air, Water, and Land Use Conflicts	Data Needed: Identification of major exclusionary air, water, and land uses such as national parks, wild and scenic rivers. Source: Recent Geologic Survey or other government maps.	Data Needed: Existing and proposed air, water, and land uses within or adjacent to the region. Source: Maps, regional land use plans, state and local planning commissions.	Data Needed: Existing and proposed air, water, and land uses. Existing restricted land uses such as parks, natural areas, and historic sites. Source: County maps and county planning commissions, aerial photographs, and state historical societies. Field verification of data may be necessary.	Data Needed: Identify beef, milk, poultry, and produce areas; existing and proposed land uses; zoning and subdivisions regulations/plans; environmental regulations; unique or valuable agricultural areas; identify existing parks and usage; existing restricted land and air uses, including parks, natural areas, historic sites, recreational areas; existing and potential archeological sites; wild and scenic rivers; visual aesthetics; identification of potential interactive uses. Methods: Obtain data from state, regional, and local agencies with field surveys as required; investigate onsite potential archeological/historical areas/sites. Review federal, state, and local regulations; identify and analyze legal and institutional constraints.	Data Needed: Milk, beef, and produce production areas are delineated for future radiological studies. Existing and proposed land use patterns, plans, zoning, subdivisions, and environmental protection laws are described. Source: Analysis of published and unpublished literature with field studies, and analysis of aerial photographs to verify and fill in data.
	c. Normal and Extreme Environmental Conditions	Data Needed: None, these conditions are not a consideration during the national survey	Data Needed: Normal and extreme weather patterns and paleoclimatology summarized for the region. Source: National Weather Service and Federal Aviation Administration weather records.	Data Needed: Normal, monthly, and seasonal weather patterns; historic extreme events such as flooding, tornadoes, and rainfall. Prediction of 100 year frequency events such as stream discharge, wind speed, flood plains, and 24 hour rainfall. Source: National Weather Service, Federal Aviation Administration, and U.S. Geologic Survey published and unpublished data.	Data Needed: Identify and evaluate general and historic climate including normal monthly and seasonal weather patterns, historic extreme events (e.g., flooding, tornadoes, hurricanes, etc.), prediction of 100-year frequency of events including flood planes, 24-hour rainfall, stream discharge. Methods: Review of published and unpublished available data.	Data Needed: In addition to published and unpublished data, monitoring of location specific meteorologic conditions will be conducted. This and previously collected data will be used in the evaluation of specific sites. Source: Meteorological stations erected at sites. These data will be supplemented by data collected by other meteorological sampling techniques (e.g., radiosonde).
10. SOCIAL, POLITICAL, AND ECONOMIC IMPACTS	a. Social and Economic Impacts	Data Needed: None, socioeconomics is not a consideration during the national survey.	Data Needed: Regional economic base and per capita income, as well as the four major categories of economic activities are described. Source: U.S. Department of Commerce.	Data Needed: Nine categories of economic activity and their relative importance. Trends in employment, unemployment, and mean income by county. Source: U.S. Department of Commerce, State and local data. Field verification of information if necessary.	Data Needed: Evaluate existing and projected fiscal capacity of host jurisdiction and nearby communities; revenue sources, expenditures, interrelationships of taxing jurisdictions; employment data, commercial and industrial activity, public services and facilities including police and fire protection, sewer and water services, social service programs, housing, education, utilities. Methods: Obtain data from state, regional, and local officials and businesses; conduct onsite interviews as necessary.	Data Needed: Information on social structure, citizen well-being and involvement. Existing and future fiscal capacity, local regional and state taxing jurisdictions and interrelationships, employment data. Commercial and industrial activity, employment programs, housing, education, utility systems capacity, etc. Source: Census Bureau, federal, state, and local agency statistics, interviews with agency officials, sociological field studies, attitude surveys, etc.
	b. Access and Utility Capability	Data Needed: None, transportation is not a consideration during the national survey.	Data Needed: Description and maps of U.S. and state highway systems, railroad systems, and navigable waterways. Source: U.S. Department of Transportation, state highway departments, U.S. Army Corps of Engineers and maps.	Data Needed: Description of the area's transportation network, Class I and II railroads, navigable waterways (depth and season of use) and ports. Source: Local transportation interests, state, federal, and local agencies.	Data Needed: Description of roads, railroads, navigable waterways and utility corridors. Methods: Obtain data on capacity, condition and level of use from state and local transportation officials; use of aerial photographs and on-site verification.	Data Needed: Description of roads, railroads, navigable waterways. Their condition and level of use. Utility corridors are also described. Source: Contact with local and regional transportation and utility interests. Federal, state, and local agencies involved with transportation. Maps, aerial photographs, as well as site investigation.

TABLE 4-6. INVESTIGATIVE METHODS BY CRITERION AND FACTOR--TYPICAL

Criteria	Subcriteria	Factor \ Investigative Method	Gravity Geophysics	Shallow Borings	Deep Drillholes	Borehole Geophysics	Drill-Stem Testing	Hydro-Fracture Testing	Seismic Reflection & Refraction	Geologic Mapping	Microseismic Networks	Remote Sensing Surveys	Laboratory Analyses	Hydrogeologic Surveys	Lost-Well Surveys	Down-Hole Radar	Electrical Resistivity	Directional Drilling	Literature
I. Site Geometry	Minimum Depth	Eolian erosion								X		X							X
		Overburden; aquifer flow rate		X		X	X						X	X					
		Fluvial erosion		X						X		X							
		Glacial erosion		X					X	X		X							X
		Mass wasting								X									
		Aquiclude depth		X	X	X			X				X			X			
		Rock type		X	X	X				X									X
		Topography								X		X							
		Uplift rate		X	X	X			X	X		X							X
	Thickness	Fractures	X	X	X	X	X	X				X		X			X		
		Induced stress			X			X					X						
		Thermal expansion			X	X							X						
		Thermal transport behavior			X	X							X						
		Homogeneity and isotropy		X	X	X	X						X						
		Mechanical properties		X	X	X	X	X	X				X						
		Rheological properties			X			X					X						
	Lateral Extent	Fractures		X	X	X	X	X		X		X		X		X	X		
		Buffer zone	X							X					X	X			
		Induced stress			X			X					X						
		Thermal expansion			X	X							X						
		Thermal transport behavior			X	X							X						
		Available space in acres	X		X	X			X							X		X	
		Homogeneity and isotropy		X	X	X	X			X			X						
		Mechanical properties		X	X	X	X	X	X	X			X						
II. Geohydrology	Geohydrological Regime/ Path-Length/Travel/Time	Ground-water residence time			X	X	X		X				X	X					
		Recharge rates		X	X	X	X							X					
		Head differentials		X	X	X	X							X	X				
		Path lengths			X	X	X		X	X			X	X	X				
		Path orientation			X	X			X					X					
		Water levels		X	X	X								X					
		Water travel-times		X	X	X	X			X				X					
	Hydrological Regional Shaft Construction	Aquiclude thickness		X	X	X							X						X
		Aquifer isolation		X	X	X							X						
		Aquifer flow rates		X	X	X	X							X					
		Head differential			X									X					
	Subsurface Rock Dissolution	Surface solution features	X	X		X	X		X	X	X	X		X	X	X			X
		Fluid content			X	X							X			X			
		Saline "plumes"		X	X	X	X						X	X					X
		Rate of dissolution			X	X	X						X	X					
		Sheath present			X	X			X				X	X		X		X	
		Sheath continuity			X	X			X				X	X		X		X	
		Sheath impermeability			X	X	X						X	X				X	
		Deep aquifer salinity			X	X	X						X	X					
		Deep aquifer movement rates			X	X		X					X	X					
		Subsurface dissolution features			X	X	X						X	X		X		X	X

TABLE 4-6. (Continued)

Criteria	Subcriteria	Investigative Method / Factor	Gravity Geophysics	Shallow Borings	Deep Drillholes	Borehole Geophysics	Drill-Stem Testing	Hydro-Fracture Testing	Seismic Reflection & Refraction	Geologic Mapping	Microseismic Networks	Remote Sensing Surveys	Laboratory Analyses	Hydrogeologic Surveys	Lost-Well Surveys	Down-Hole Radar	Electrical Resistivity	Directional Drilling	Literature
III. Geochemistry	Geochemical Interactions																		
		Redox potentials, pH, temperature, pressure			X		X						X						X
	Sorption																		
		Retardation coefficients			X								X						X
IV. Geologic Characteristics	Subsurface Setting																		
		Hydrologic modeling	X	X	X	X	X		X	X		X		X		X		X	
		Model complexity	X	X	X	X	X		X			X		X		X		X	
	Host Rock Characteristics																		
		Chemical/physical			X	X							X						
		Impurities			X	X							X			X			
		Brine content			X		X						X						X
		Gas content			X	X	X						X						X
		Permeability			X	X	X						X						
		Caprock porosity			X	X	X						X	X					
		Salt-caprock contact			X	X							X						
		Anomalous zones			X	X							X						
	Rock Strength																		
		Rheological properties			X								X						
		Fractures			X	X	X	X											
		Rock fabric			X	X				X									
		Host rock/formation contacts			X														
		Heat, radiation, stability											X						
		Closure rates																	
		Yield strengths																	
V. Tectonic Environment	Engineering Feasibility																		
		Development, operation, closure		X	X	X	X		X	X			X	X			X	X	
	Ground Motion																		
		Historical seismicity									X								X
		Maximum credible earthquake									X								X
	Quaternary Faults																		
		Crustal loading			X	X					X								
		Diapirise		X	X	X			X	X		X							
		Distance of faults		X	X	X			X			X					X		X
		Quaternary deposits		X	X	X			X	X	X	X	X						X
		Seismicity									X								X
		Tectonic history		X	X	X			X	X	X	X							X
	Quaternary Igneous Activity																		
		Geothermal gradient			X	X													
		Distribution of activity			X	X			X	X	X	X							X
		Character of activity									X								X
		Tectonic history		X	X	X			X	X	X	X							X
		Volcanic activity			X					X		X							X

TABLE 4-6. (Continued)

Criteria	Subcriteria	Factor \ Investigative Method	Gravity Geophysics	Shallow Borings	Deep Drillholes	Borehole Geophysics	Drill-Stem Testing	Hydro-Fracture Testing	Seismic Reflection & Refraction	Geologic Mapping	Microseismic Networks	Remote Sensing Surveys	Laboratory Analyses	Hydrogeologic Surveys	Lost-Well Surveys	Down-Hole Radar	Electrical Resistivity	Directional Drilling	Literature
V. Tectonic Environment, cont.	Uplift or Subsidence	Evaluation of rates				X	X			X		X							
		Diapirise			X	X	X			X	X		X						
		Regional seismicity										X							X
		Anomalous zones			X	X	X			X							X	X	
	Tectonic Elements																		
		Active faults			X	X	X			X	X	X	X					X	X
		Active volcanoes				X	X				X	X	X						X
VI. Human Intrusion	Resources	Resource proximity				X	X			X	X		X			X			X
		Resource demand																	X
		Resource distribution								X	X		X			X			X
		Resource grade				X	X			X				X					
	Exploration History	Near site														X			X
		Proximity to site														X			X
	Ownership and Control																		
		Site ownership																	X
		Surface/subsurface rights ownership																	X

TABLE 4-6. (Continued)

Criteria	Subcriteria	Factor (Investigative Method)	Laboratory Analysis	Photography/Remote Sensing	Maps	Permit Review	Literature	Unpublished Data	Field Studies/Reconaissance	Models
VII. Surface Characteristics	Hydrological System	Annual rainfall cycle					X			X
		Probable maximum flood			X		X		X	X
		Probable maximum rainfall					X			X
		Lake		X	X				X	
		Embayment		X	X					
		Bayou		X	X					
		River		X	X					
		Fluvial cycle					X			X
		Stream proximity		X	X	X	X			
		Proximity to dams			X		X			
	Topographic Features	Depression		X	X				X	
		Steep grades		X	X				X	
		Switchbacks		X	X				X	
		Rugged terrain		X	X				X	
	Meteorological Phenomena	Severe storms					X			X
		Tornados					X			X
		Dispersion					X		X	X
	Industrial Transportation/ Military Installations	Gas, oil pipelines			X	X		X	X	X
		Road and rail shipments			X	X	X	X	X	X
		Factories			X			X	X	X
		Refineries			X			X	X	X
		Testing ranges			X			X	X	X
VIII. Demography	Urban Areas	Population distribution		X	X		X	X	X	X
		Total population			X		X	X	X	X
		Population density			X		X	X	X	X
	Transportation	Roads/highways		X	X	X	X	X	X	
		Railroad shipment risk				X	X	X		X
		Cumulative distance to source point			X		X	X		X
IX. Environmental Protection	Environmental Impact	Flora & Fauna	X	X	X	X	X	X	X	X
		Spoil disposal		X	X	X	X	X	X	X
		Endangered species		X	X	X	X	X	X	
		Natural resources		X	X	X	X	X	X	X
		Noise				X	X	X	X	X
		Displacement					X	X	X	X
		Construction effluents	X		X	X	X	X	X	X
		Air quality	X	X	X	X	X	X	X	X
		Water quality	X	X	X	X	X	X	X	X
	Air, Water and Land Use Conflicts	Parks		X	X	X				
		Agriculture		X	X		X	X	X	
		Wilderness		X	X	X		X		
		Archaeological/historical sites		X	X	X	X	X	X	
		Forests		X	X	X	X	X	X	X
		Endangered species			X	X	X	X	X	
		Wild & scenic rivers		X	X	X	X	X		
		Wildlife preserves		X	X	X	X	X		
		Urban land uses & plans		X	X	X	X	X	X	X
		Military reservations		X	X	X		X		
X. Socioeconomics	Social Impacts	Labor supply and demand					X	X	X	
		Worker influx					X			X
		Population growth					X	X	X	X
		Community services					X	X	X	
		Local economy					X	X	X	X
		Taxation					X	X	X	
		Conflict with land use patterns or plans			X	X	X	X		
		Interactive uses			X	X	X	X		
	Site Access, Utilities	Highways		X	X	X			X	
		Railroads		X	X	X			X	
		Water supply			X	X			X	
		Electrical supply			X	X			X	
		Sewerage			X	X			X	

5.0 PROGRAM IMPLEMENTATION

The Secretary of Energy has overall responsibility for integrating the nation's nuclear waste management program. In its lead role the Department of Energy (DOE) is (1) coordinating federal nonregulatory aspects of nuclear waste management; (2) maintaining effective working relationships with the Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission (NRC); and (3) developing policy and working ties between the federal government and the states on all aspects of nuclear waste management.

To accomplish these tasks, DOE has established an extensive contractor organizational structure, taken steps to ensure cooperation and coordination with other cognizant government agencies, and established comprehensive work tasks and schedules. This chapter summarizes the management structure, arrangements for interagency cooperation, the work schedules for performing siting activities within the NWTS program, and the budget for these activities. The current siting program status is also summarized.

5.1 DOE MANAGEMENT STRUCTURE

Within the Department of Energy, nuclear waste management program activities are directed by the Assistant Secretary for Nuclear Energy who reports to the Under Secretary and the Secretary. The Deputy Assistant Secretary for Nuclear Waste Management and Fuel Cycle Programs (ONWM) is responsible for managing all aspects of the Department's programs both for storage and for disposal of nuclear wastes. The Deputy Assistant Secretary is also responsible for integration and coordination with other federal agency activities related to nuclear waste management.

Within ONWM, the Director of the Office of Waste Isolation is responsible for overall direction of the NWTS program. This office implements the objectives of the NWTS program by directing and controlling activities, including budgetary allocations of various DOE field offices and contractors.

DOE Headquarters is responsible for implementing the program and providing technical direction and coordination of the NWTS program elements through DOE field offices and contractors. As indicated in Section 1.2, three

NWTS projects are involved in the geologic repository program: the Office of Nuclear Waste Isolation (ONWI), the Basalt Waste Isolation Project (BWIP), and the Nevada Nuclear Waste Storage Investigations (NNWSI). In the fourth NWTS project, Subseabed Disposal, the feasibility of emplacing packaged HLW beneath the seabed is being evaluated. The interrelationship of these projects is shown in Figure 5-1, along with their respective supporting organizations. In addition to project responsibilities, the DOE NWTS Program Office (NPO) oversees the ONWI responsibility for generic technology development and coordination of site investigations on non-DOE lands.

The coordination of the waste management program elements (i.e., waste products, transportation and storage, and isolation) is achieved by a system of interface control boards.

5.2 INTERAGENCY COOPERATION

Interaction among agencies that have expertise and responsibility for elements of a waste management program is given high priority. In its role as lead agency for the management and disposal of radioactive wastes, DOE is preparing, with the cooperation of other cognizant federal agencies, a detailed National Plan for Nuclear Waste Management to implement the federal policy guidelines and the IRG recommendations.(8) The program content includes many activities recommended by the IRG to ensure that other agencies will support the DOE activities where required.

DOE has established an Interagency Working Committee on Radioactive Waste Management, chaired by the Department's Deputy Assistant Secretary for Nuclear Waste Management and Fuel Cycle Programs. This committee is composed of officials from Department of the Interior, Department of Transportation, Environmental Protection Agency, and the Nuclear Regulatory Commission. The committee's goal is to ensure that the federal waste management policy is properly implemented and that interfacing functions are coordinated. Specific functions which have been coordinated are described in the following sections.

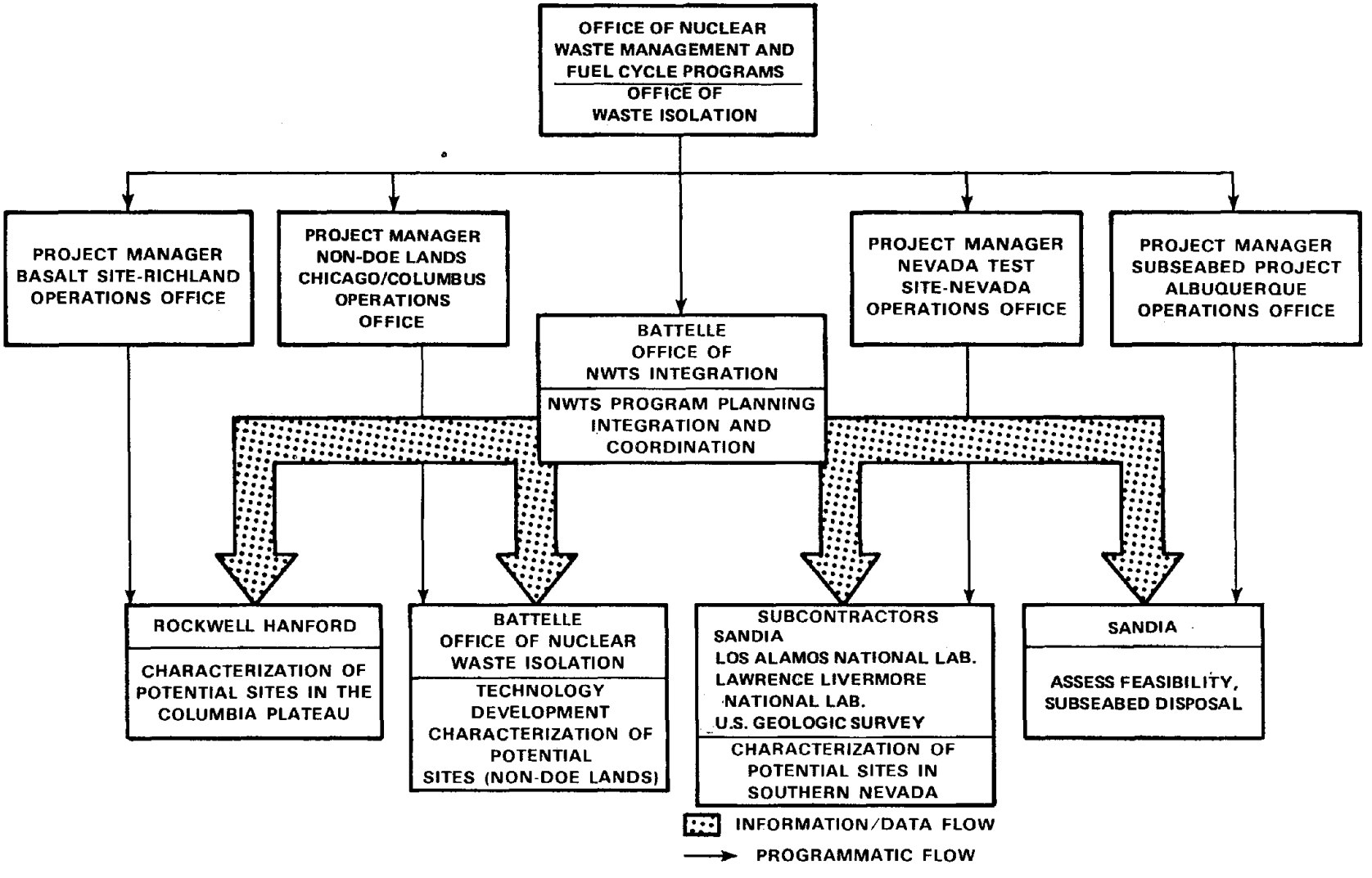


FIGURE 5-1. NWTS PROGRAM MANAGEMENT STRUCTURE

5.2.1 U.S. Geological Survey

Coordination with the U.S. Geological Survey (USGS) in the Department of the Interior occurs through periodic planning meetings, reports of technical progress, and information exchanges on the waste management programs of DOE and the U.S. Geological Survey. Senior scientists from the USGS have been located at DOE Headquarter's Office of Waste Isolation and at the NWTS Program Office in Columbus, Ohio. A formal Memorandum of Understanding is currently being developed between the Department of the Interior (DOI) and DOE covering this cooperation with the USGS, the Bureau of Land Management (BLM) and the Bureau of Indian Affairs (BIA). This Memorandum of Understanding will cover procedures related to DOI assistance in the NWTS program.

Under an existing memorandum of understanding with DOE, the USGS is being utilized to support a variety of technical activities outlined below.(30)

5.2.1.1 Earth Science Technical Plan

The USGS has participated with the Department in development of an Earth Science Technical Plan[9] to define the technical efforts required for successful mined geologic waste disposal. This plan describes technical efforts required in such areas as site screening and characterization, rock mechanics, repository sealing, waste/media interactions, and repository performance assessment. It will be used to assist in NWTS Program planning.

5.2.1.2 Evaluation of Potentially Suitable Hydrogeologic Environments

A significant portion of the USGS effort is devoted to the location of geohydrologic environments potentially suitable for disposal in which natural multiple barriers to radionuclide migration may be present. This research involves both generic considerations of the types of rocks providing such environments and the systematic search for such environments.

The USGS is initiating a project to screen for promising geohydrologic environments by convening a Province Working Group in one province

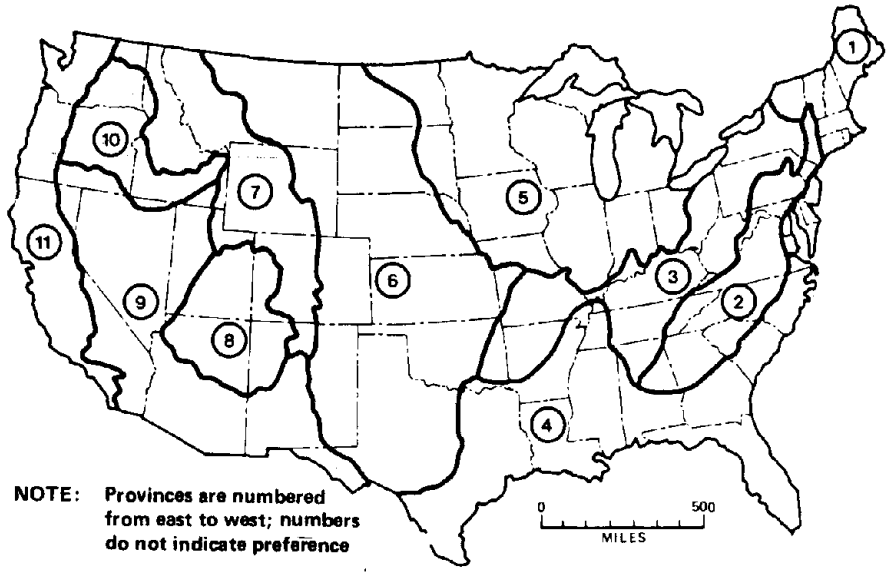
within the conterminous United States. This is a trial program in which the possibility of a federal-state partnership arrangement in implementing the screening process will be explored. The Province Working Group will consist of federal earth scientists and state participants who will jointly collect the necessary earth science technical data and make judgments on the suitability of regions and areas for future study. For the purposes of this screening, the conterminous United States has been divided into 11 Provinces (Figure 5-2). If the approach proves useful in the first province in which it is applied, additional provinces may be studied in this manner. The evaluation of geohydrologic environments will be carried to the stage of recommendation of areas for further study. Environmental and socioeconomic concerns would be addressed by DOE and appropriate state groups. Location and site study activities would proceed according to this plan. This approach is not expected to identify possible sites for the initial site, but may provide alternatives for later selection.

5.2.1.3 Other Characterization Activities

The USGS is involved in other geologic/hydrologic characterization activities that are funded through Interagency Agreements[30] as part of its support of the NWTS program. These activities include conducting studies of rock cores from drill holes; geophysical surveys, and remote sensing studies within the Paradox basin; regional geohydrologic studies of the South Central Mississippi and northern Louisiana salt dome basins; hydrologic and geologic characterization studies of the Nevada Test Site; and geologic studies of the region in which the Hanford Site is located.

5.2.1.4 Technology Development

USGS expertise is being used in certain technology studies defined in the Earth Science Technical Plan.[9] For example, the USGS participates in evaluating fundamental rock properties, rock structures, lithostatic pressures, and stability. It conducts experimental studies to determine the likely interactions among salt, brine, canisters, and waste over a range of



EXPLANATION:

Suggested Province

1. New England-Adirondack Mountains
2. Appalachian Highlands-Piedmont
3. Appalachian and Interior Plateaus
4. Coastal Plain
5. Glaciated Central Platform
6. Western Central Platform
7. Rocky Mountain System
8. Colorado Plateaus
9. Basin and Range
10. Columbia Plateaus
11. Pacific Mountain System

FIGURE 5-2. GEOHYDROLOGIC PROVINCES AS DEFINED BY ESTP SUBGROUP 1

Source: U.S. Geological Survey. Plan for Identification and Geological Characterization of Sites for Mined Radioactive Waste Repositories. Prepared by Subgroup 1 of the Earth Science Technical Plan Working Group. Open-File Report 80-686.

temperatures and pressures that may occur in disposal of high-level radioactive waste. In addition, the USGS is cooperating with DOE in a brine migration experiment being conducted at Avery Island in Louisana. Individual USGS scientists also participate in peer review committees.

5.2.2 Bureau of Land Management

The Bureau of Land Management (BLM) of the Department of the Interior has the responsibility for overseeing and controlling the use of certain federal lands. BLM is contacted and permission secured where exploration activities are conducted on such land. Whenever necessary, a formal cooperative agreement will be prepared jointly by BLM and DOE to document the activities to be performed, the manner in which the activities are to be conducted, and conditions for land restoration.

Interactions between DOE and BLM already have taken place concerning site characterization activities in the Paradox Basin in Utah.

5.2.3 U.S. Army Corps of Engineers

The Corps of Engineers of the Department of Defense has extensive experience in real property acquisition. Therefore, limited working relationships with the Corps of Engineers have been established[31] to assist the NWTS program. Future expansion of Corps of Engineers involvement to support siting of a repository or research and development activities could readily be achieved. Its services are being used to obtain access for field activities in Louisiana. Its current duties in Louisiana include:

- Determining land ownership and holders of surface and subsurface rights from whom permission must be secured in order to enter property for the purpose of field exploration and, in the future, for acquisition of a repository site
- Contacting landowners and negotiating rights-of-entry, leases, or other legal instruments as required for land access
- Making payments to landowners for leases that have been obtained.

In research and development, the Corps of Engineers Waterways Experiment Station in Vicksburg, Mississippi, is investigating the composition,

constitution, properties, and interactions of materials being considered for plugging boreholes and sealing shafts.(31)

5.2.4 U.S. Department of Agriculture

The U.S. Department of Agriculture (USDA) is responsible for access to National Forest lands. To implement the Department's program, USDA and DOE have reached agreement allowing investigations to continue in the De Soto National Forest of Mississippi while protecting the environment. A Memorandum of Understanding(32) was prepared for this purpose.

The USDA Science and Education Administration, through the Land Grant Universities, can provide socioeconomic impact determination and mitigation programs. These programs provide site-specific methodologies to assess socioeconomic impacts and to analyze whether potential mitigative actions will be responsive to local needs. The USDA is also establishing a Technical Advisory Panel for peer review and evaluation of these studies. An interagency agreement, negotiated to bring this USDA expertise to the program, is in its second year of implementation.

5.3 WORK TASKS, SCHEDULES, AND BUDGET

Implementation of the Siting Plan will permit DOE to recommend one or more sites for selection in late 1987. General acceptance of the recommended site by the scientific and political community would allow DOE to file a license application in late 1988. DOE will spend on the order of $120 million to $200 million dollars for each site it finds and characterizes with an exploratory shaft. Site work tasks and schedules associated with finding and characterizing sites are presented in this section.

5.3.1 Work Tasks

The siting program is divided into tasks and subtasks in the NWTS Work Breakdown Structure (WBS) as shown in Table 5-1. The work breakdown structure was developed for the definition, scheduling, and funding of the

NWTS program. A discussion of the entire NWTS Work Breakdown Structure is in the NWTS Program Plan which is updated bi-annually.

Activities performed in the site task are described here for the subtasks listed under "Site" in Table 5-1. Detailed descriptions of how the activities under the site task are performed will appear in the documents outlined in Chapter 4.0 subsequent to this plan.

The task incorporates activities of the U.S. Geological Survey described in Section 5.2.1 and the separately funded geohydrologic systems screening discussed in Section 4.2.1.

The seven subtasks are described below. Their relationships with other tasks in the program are shown in Figure 5-3.

The Site Baseline Subtask (1.3.1) provides a baseline for the activities of the site task. This baseline consists of the task plans, criteria, specifications, recommended techniques for evaluating compliance with the site criteria and earth science data acquisition guidelines.

The Earth Science Subtask (1.3.2) develops methodology, data, and techniques necessary to characterize the site and to permit analysis of its expected performance. It has a close interface with the Geologic Characterization and Performance Evaluation Subtasks.

The Geologic and Hydrologic Characterization Subtask (1.3.3 and 1.3.4) consists of surveys evaluating progressively smaller portions of the country in increasing levels of detail and detailed study of potential sites. The evaluations use siting criteria and factors from the Site Baseline Subtask. Data from these studies are used in the Earth Science and Performance Evaluation Subtasks.

The Environmental Characterization Subtask (1.3.5) runs parallel to the Geologic and Hydrologic Characterization Subtask, and consists of the environmental surveys of land areas identified by the various screening methods and detailed environmental characterization of candidate sites.

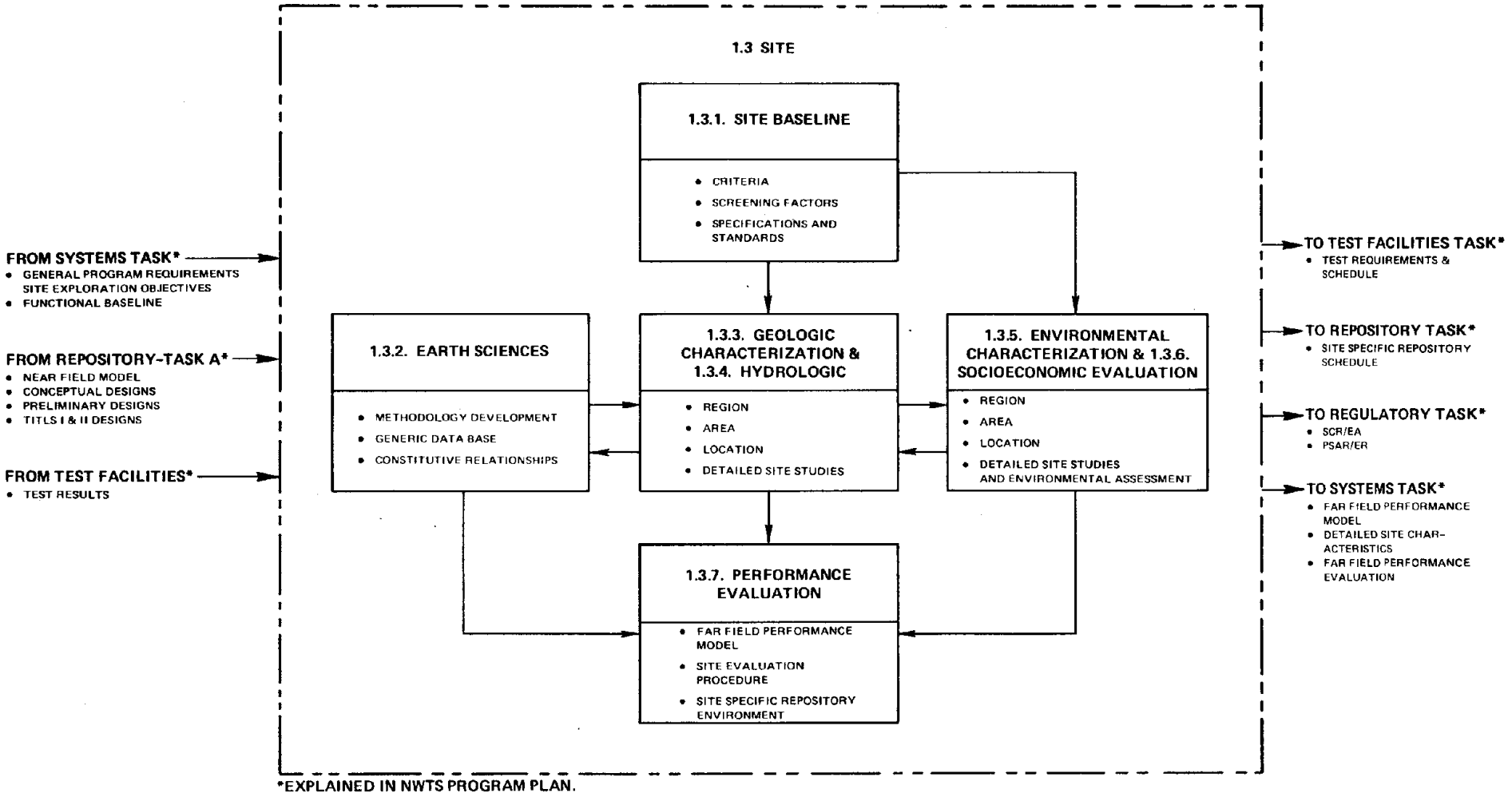


FIGURE 5-3. SITE SUBTASKS AND MAJOR INTERFACES

Information developed in this subtask supports winnowing decisions and is utilized in the Performance Evaluation Subtask.

The Socioeconomic Evaluation Subtask (1.3.6) identifies socioeconomic concerns in the siting process and implements plans for state and public interaction and for mitigation of socioeconomic impacts. This subtask interfaces with development of socioeconomic modeling and institutional subtasks under WBS 1.1.

The Performance Evaluation Subtask (1.3.7) develops models for the assessment of the isolation capability of potential repository locations. This subtask receives information from and provides analyses to the Earth Sciences Subtask and the Geologic and Environmental Characterization Subtasks.

TABLE 5-1. NWTS SITE PROGRAM WORK BREAKDOWN STRUCTURE

1.1 SYSTEMS
1.2 WASTE PACKAGES
1.3 SITE
1.3.1 Site Baseline
1.3.2 Earth Sciences
1.3.3 Geologic Characterization
1.3.4 Hydrologic Characterization
1.3.5 Environmental Characterization
1.3.6 Socioeconomic Evaluation
1.3.7 Performance Evaluation
1.4 REPOSITORY
1.5 REGULATORY AND INSTITUTIONAL
1.6 TEST FACILITIES AND EXCAVATIONS
1.7 LAND ACQUISITION
1.8 PROGRAM MANAGEMENT

5.3.2 Planned Schedule

Planning for siting activities involves detailed scheduling of siting activities. Table 5-2 indicates the length of time the various siting steps will take and the estimated duration of the screening process. Figure 5-4 indicates that the process to find and qualify several sites will take from 5 to 8 years; these durations being influenced by technical requirements and institutional constraints.

TABLE 5-2. DURATIONS FOR SITE CHARACTERIZATION STEPS

Steps	Range (Months)
National Surveys	6 - 12
Regional Surveys	6 - 12
Area Surveys	16 - 24
Location Surveys	6 - 12
Detailed Site Studies with Exploratory Shaft	30 - 36
Site Recommendation and Selection	24 - 30
TOTAL	88 - 126

The first repository for the disposal of high-level nuclear waste is expected to be in operation between 1998 and 2006. The target milestone leading to an operational facility by the above dates are:

- 1983 - Begin exploratory shafts at three potential repository sites.
- 1985 - Reach proposed repository depth and begin in situ examinations.
- 1985 - Choose one of the three sites with exploratory shafts for the T&E Facility.
- 1985 - Begin design of the T&E Facility.
- 1985 to 1987 - Continue underground testing at three sites with shafts ... continue characterizing additional potential sites, constructing exploratory shafts as required ... continue technology development.
- 1987 - Start construction of T&E Facility.

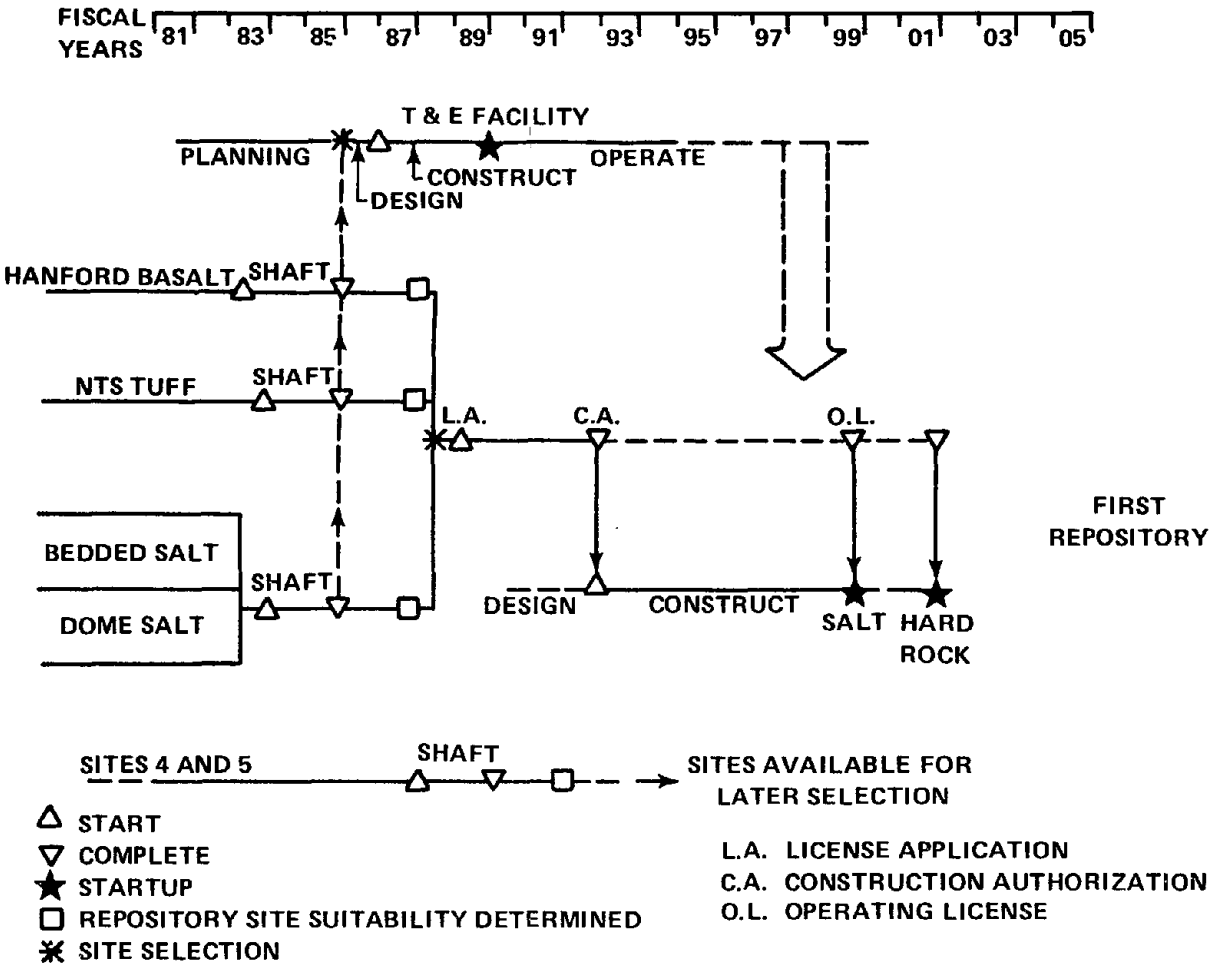


FIGURE 5-4. REPOSITORY SITING SCHEDULE

Note: Three candidate sites, at least one having other than salt as the repository host rock, are currently required by the procedural rule, 10 CFR 60, of the U.S. Nuclear Regulatory Commission.

- 1988 - File a license application with the Nuclear Regulatory Commission to obtain authorization to construct a repository at a site selected from among several alternatives.
- 1989 - Emplace a few hundred canisters of wastes in multibarrier packages in the T&E Facility.

Using conservative estimates that the licensing review process will take four years and construction five to eight years depending on the media chosen, the first repository could be operational between 1998 and 2006.

5.3.3 BUDGET

The estimated budget to implement the siting process is shown in Table 5-3. This budget is sufficient to investigate numerous geographic regions. It will allow exploratory shaft construction to reach proposed repository depths at three sites by 1985 and at two additional sites by 1990. This budget projection is subject to Congressional action and assumes that exploratory shafts are needed at each candidate site to comply with the requirements of 10 CFR 60.

TABLE 5-3. SITE BUDGET
(Budget Outlay, Millions of Dollars)

	Fiscal Year						
	1981	1982	1983	1984	1985	1986	1987
Operating Costs	60.6	81.4	94.5	75.2	76.9	62.3	50.7
Capital Costs	3.3	4.7	3.8	5.4	6.9	4.7	4.4
TOTAL	63.9	86.1	98.3	80.6	83.8	67.0	55.1

5.4 EXPLORATION STATUS

The status of activities in the NWTS site exploration program and siting process was:

- Final DOE site performance criteria that incorporate public comments were issued in April, 1981.(12)
- The Earth Science Technical Plan was issued jointly by DOE and the USGS.(9) The research and development needs identified in the document are being implemented.

- Development of models for predicting the performance of geologic site waste isolation systems is continuing. Trial applications of preliminary models have been made.

The progress is summarized on Table 5-4. Three siting approaches listed in the table have been initiated. Regions and areas containing salt, crystalline, basalt, and tuff rocks have been identified. Regional studies of "crystalline rocks" have begun in the Appalachians. In the Lake Superior region, studies have begun in Minnesota and proposed plans for characterization are being negotiated in Michigan and Wisconsin.

A national screening survey for other potential isolation systems has not gone beyond planning stages. A draft national survey report of studies to identify regions containing potentially suitable argillaceous rocks has been completed, but no siting activity in argillaceous rocks is planned.

Regional studies have been completed for the New York and Ohio portions of the Salina region (Figure 5-5).

Area characterization studies of the salt domes in the Gulf Coast region are completed (Figure 5-5). Following location level studies, one or more salt domes will be recommended to compete as a candidate for an exploratory shaft with one or more potential sites from the Paradox and Permian salt regions. One of these salt sites will then be characterized by an exploratory shaft and in situ testing.

Area-level studies are nearing completion in the Paradox region of Utah and in the Palo Duro and Dalhart areas of the Permian basin in Texas (Figure 5-5).

Drilling and other field activities as part of location-level studies are in progress at potential locations on the Department's Nevada Test Site and Hanford Site in volcanic tuff and basalt environments, respectively (Figure 5-5).

DOE issued a report in January, 1980, that describes the geologic exploration progress.[33] Progress has also been reported at annual information meetings.[34,35] A summary of geologic and environmental characteristics found in the geographic areas being studied is also contained in Reference 4.

TABLE 5-4. STATUS OF NWTS EXPLORATION EFFORTS – SEPTEMBER 1981

National Survey Approach	Rock Types	Regions Identified	Areas Identified	Locations Identified
Geologic Media	Bedded Salt	Salina Region[a]	Northeastern Ohio[b]	–
			New York – Area 1[b]	–
			New York – Area 2[b]	–
		Paradox Region	Gibson Dome[c]	–
			Elk Ridge[c]	–
			Salt Valley[c]	–
			Lisbon Valley[c]	–
		Permian Region	Palo Duro Area[c]	–
			Dalhart Area[c]	–
	Domed Salt	Gulf Coast Region	Texas Salt Domes	Oakwood Dome
			Mississippi Salt Domes	Richton, Cypress Creek Domes
			Louisiana Salt Domes	Vacherie Dome
	Crystalline Rock	Lake Superior Region[e]	–	–
		Appalachian Region[d]	–	–
	Argillaceous Rock[f]	–	–	–
Land Use (DOE Land)	Basalt	Not Applicable	Hanford Site	Cold Creek Syncline
	Various (including tuff)	Not Applicable	Nevada Test Site[i]	–
Geohydrologic Systems	Various	Province 9 (Basin and Range)[h]	–	–
National Systems Screening[g]	Various	–	–	–

(a) Regional survey partially complete.
(b) Area surveys have not been initiated in Ohio or New York.
(c) Area surveys are nearing completion.
(d) Regional surveys are in progress.
(e) Regional surveys are pending state negotiations in Michigan and Wisconsin and have begun in Minnesota.
(f) Argillaceous rock survey is nearing completion, no siting activity planned.
(g) National survey has been contemplated.
(h) Province screening to identify regions is in progress.
(i) Specifically, Nevada Research and Development Area and contiguous areas to the south and west.

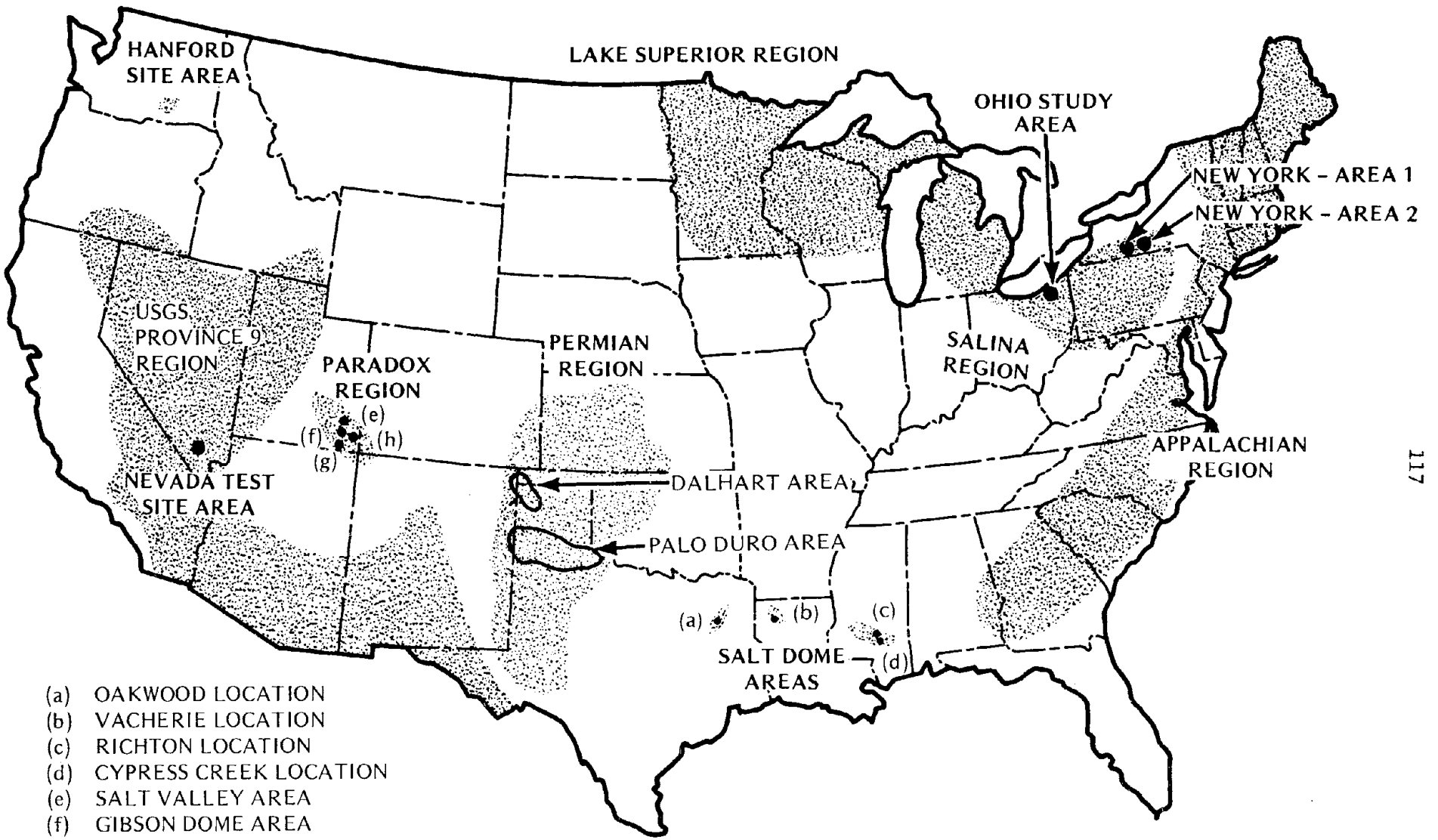


FIGURE 5-5. REGIONS, AREAS, AND LOCATIONS OF POTENTIAL INTEREST FOR TERMINAL ISOLATION OF RADIOACTIVE WASTE

6.0 REFERENCES

(1) U.S. Nuclear Regulatory Commission, 1981. "Technical Criteria for Regulating Geologic Disposal of High-Level Radioactive Waste," Federal Register, Vol. 45, No. 94, Office of Federal Register, Washington, DC, July.

(2) U.S. Nuclear Regulatory Commission, 1981. "Disposal of High-Level Radioactive Wastes in Geologic Repositories: Licensing Procedures", Final Rule Federal Register, Vol. 46, No. 37, February.

(3) National Enviromental Policy Act of 1969, as amended (42 USC 4341).

(4) U.S. Department of Energy, 1980. Final Environmental Impact Statement: Management of Commecially Generated Radioactive Waste, DOE/EIS-0046-F, Washington, DC, October.

(5) U.S. Department of Energy, 1981. "Program of Research and Development for Management and Disposal of Commercially Generated Wastes; Record of Decision (to adopt a strategy to develop mined geologic repositories ...)", Federal Register, Vol. 46, No. 93, May.

(6) U.S. Department of Energy, 1980. In the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste (Waste Confidence Rulemaking), PR-50,51 (44 FR 61372), Statement of Position of the United States Department of Energy, DOE/NE-0007, Washington, DC, April.

(7) U.S. Department of Energy, 1980. In the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste (Waste Confidence Rulemaking), PR-50,51 (44 FR 61372), Cross-Statement of the United States Department of Energy, DOE/NE-0007, Suppl., Washington, DC.

(8) Interagency Review Group on Nuclear Waste Management, 1979. Report to the President by the Interagency Review Group on Nuclear Waste Management, TID-29442, Washington, DC, March.

(9) U.S. Department of Energy and U.S. Geological Survey, 1980. Earth Science Technical Plan for Mined Geologic Disposal of Radioactive Waste, DOE/TIC-11033, Office of Nuclear Waste Management, draft, April.

(10) U.S. Department of Energy, 1979. Draft Environmental Impact Statement: Management of Commercially Generated Radioactive Waste, DOE/EIS-0046-D, Washington, DC, April. See Reference 4.

(11) Office of Nuclear Waste Isolation, 1980. NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Program Objectives, Functional Requirements, and System Performance Criteria, DOE/NWTS-33(1), Battelle Memorial Institute, Columbus, OH, May.

(12) Office of Nuclear Waste Isolation, 1981. NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria NWTS-33(2), Battelle Memorial Institute, Columbus, OH, February.

(13) Goad, Donna, 1979. A Compilation of Site Selection Criteria, Considerations and Concerns Appearing in the Literature on the Deep Geologic Disposal of Radioactive Wastes, Environmental Evaluation Group, Environmental Improvement Division, Health and Environment Dept., State of New Mexico, June.

(14) Committee on Radioactive Waste Management, 1978. Geological Criteria for Repositories for High-Level Radioactive Wastes, National Academy of Sciences, Washington, DC, August.

(15) International Atomic Energy Agency, 1977. Site Selection Factors for Repositories of Solid High-Level and Alpha-Bearing Wastes in Geological Formations, Technical Reports Series, No. 177, Vienna, Austria October.

(16) Brunton, G. D. and W. C. McClain, 1977. Geological Criteria for Radioactive Waste Repositories, Y/OWI/TM-47, Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, Oak Ridge, TN, November.

(17) Carter, J. E., President, U.S., 1980. "Comprehensive Radioactive Waste Management Program: Presidential Message to Congress, 12 February 1980," Weekly Compilation of Presidential Documents, Vol. 16, No. 7, Washington, DC.

(18) State Planning Council on Radioactive Waste Management, 1981. Recommendations on National Radioactive Waste Management Policies (Report to the President), August.

(19) National Governors' Association, 1979. Nuclear Energy Policy Position Adopted by National Governors' Association, August, and Toward Establishing a Responsive and Acceptable National Nuclear Waste Management Policy, April.

(20) Office of Nuclear Waste Isolation, 1981. Framework for Community Planning Associated with Nuclear Waste Repository Siting, ONWI-254, Battelle Memorial Institute, Columbus, OH, draft, October.

(21) Office of Nuclear Waste Isolation, 1979. Summary Characterization and Recommendation of Study Areas for the Gulf Interior Region, ONWI-18, Project Management Division, Battelle Memorial Institute, Columbus, OH, May.

(22) Office of Nuclear Waste Isolation, 1979. Draft Regional Summary and Recommended Study Areas for the Texas Panhandle Portion of the Permian Basin, ONWI-28, Battelle Memorial Institute, Columbus, OH, May.

(23) Office of Nuclear Waste Isolation, 1979. Regional Summary and Recommended Study Areas for Ohio and New York Portions of the Salina Basin, ONWI-29, Battelle Memorial Institute, Columbus, OH, September.

(24) Office of Nuclear Waste Isolation, 1981. Evaluation of Area Studies of the U.S. Gulf Coast Salt Dome Basins, ONWI-109, Battelle Memorial Institute, Columbus, OH, draft, March.

(25) Office of Nuclear Waste Isolation, 1980. Summary Characterization and Recommendation of Study Areas for the Paradox Basin Study Region, ONWI-36, Battelle Memorial Institute, Columbus, OH, draft, November.

(26) U.S. Department of Energy, 1980. "Compliance With the National Environmental Policy Act; Final Guidelines," Federal Register, Vol 45, No. 62, March.

(27) U.S. Department of Energy, 1981. Environmental Compliance Guide, Vols. 1 and 2, DOE/EV-0132, February.

(28) Pierce, W. G., and E. I. Rich, 1962. "Summary of Rock Salt Deposits in the United States as Possible Storage Sites for Radioactive Waste Materials", USGS Bulletin 1148.

(29) Johnson, K. S., and S. Gonzales, 1978. Salt Deposits in the United States and Regional Geologic Characteristics Important for Storage of Radioactive Waste, Y/OWI/SUB-7414-1, Office of Waste Isolation, Union Carbide Corporation, Nuclear Division, Oak Ridge, TN.

(30) Interagency Agreement (DOE/USGS), No. DE-A197-79ET46611, May 1, 1979; Mod. 2: October 1, 1979.

(31) Memorandum of Agreement (U.S. Army Corps of Engineers), ED-A197-79ET46612, September 24, 1979; Mod. 1: December 20, 1979.

(32) Formal Memorandum of Understanding, United States Department of Agriculture, Forest Service, DeSoto National Forest, MS, February 12, 1979.

(33) U.S. Department of Energy, 1980. National Program for Management of Commercial High-Level Nuclear Waste: Report on Geologic Exploration Activities, DOE/RL-C-14, UC-70, Battelle Memorial Institute, Columbus, OH, January.

(34) Office of Nuclear Waste Isolation, 1979. Proceedings of the National Waste Terminal Storage Program Information Meeting, Columbus, Ohio, October 30-November 1, 1979, ONWI-62, Battelle Memorial Institute, Columbus, OH, October.

(35) Office of Nuclear Waste Isolation, 1980. Proceedings of the 1980 National Waste Terminal Storage Program Information Meeting, Columbus, Ohio, December 9-11, 1980, ONWI-212, Battelle Memorial Institute, Columbus, OH, December.

APPENDIX A

NWTS PROGRAM CRITERIA FOR MINED GEOLOGIC DISPOSAL OF NUCLEAR WASTE

SITE PERFORMANCE CRITERIA[12]

These criteria have been evolved by DOE over two and one-half years. Comments were solicited from eight hundred persons. Comments received were addressed in the final report (Reference 12) which is available from the Office of Nuclear Waste Isolation, 505 King Avenue, Columbus, OH 43201.

NWTS SITE PERFORMANCE CRITERIA

These criteria delineate characteristics a site must have to ensure that the disposal system will perform as required. These criteria encompass site geometry, geohydrology, geochemistry, geologic characteristics, tectonic environment, human intrusion, surface characteristics, environment, and potential socioeconomic impacts.

In the criteria, a site characteristic that "unacceptably affects system performance" is one that might decrease the isolation capability of the disposal system to the point that releases of radionuclides might occur which are in excess of acceptable limits. The criteria appear in italics. Factors for consideration and evaluation follow each criterion.

3.1 Site Geometry

The site shall be located in a geologic environment that physically separates the radioactive wastes from the biosphere and that has geometry adequate for repository placement.

1. *The minimum depth of the repository waste emplacement area shall be such that credible human activities and natural processes acting at the surface will not unacceptably affect system performance.*

   In order to establish this depth, erosion and denudation rates, and other phenomena must be evaluated.

2. *The thickness and lateral extent of the geologic system surrounding the waste emplacement area shall be sufficient to accommodate the repository and a buffer zone and to ensure that impacts induced by construction of the repository and by waste emplacement will not unacceptably affect system performance.*

   Consideration of these impacts will include evaluation of induced stresses, heat, and radiation generated by the waste.

3.2 Geohydrology

The geohydrologic regime in which the site is located shall have characteristics compatible with waste containment, isolation, and retrieval.

1. *The site shall be located so that the present and probable future geohydrological regime will minimize contact between ground water and wastes and will prevent radionuclide migration or transport from the repository to the accessible environment in unacceptable amounts.*

   The evaluation of the geohydrological regime will include characterization of ground-water residence times, travel times, recharge rates, potentiometric surfaces, and path lengths and orientations. These factors must be assessed to show that path lengths are long enough and transport times are slow enough under present and probable future conditions to constitute effective barriers to radionuclide transport.

2. *The site shall be located so that the hydrological regime can be sufficiently characterized to permit modeling to show that present and probable future conditions have no unacceptable impact on repository performance.*

   Evaluation of the geohydrologic regime shall include consideration of surface conditions or features such as impoundments or glaciers, and changes in subsurface conditions induced, for example, by aquifer pumping or injection, or thermally-induced ground-water flow.

3. *The site shall be located so that the geohydrological regime allows construction of repository shafts and maintenance of shaft liners and seals.*

Existing aquifer systems, particularly in strata between the repository level and the land surface, must be isolated from the repository workings. Evaluations must include anticipated aquifer flow rates, reliability and effectiveness of sealing, and geohydrological perturbations of the aquifers induced by shaft construction and shaft liner emplacement.

4. *The site shall be located so that subsurface rock dissolution that may be occurring, or is likely to occur, can be shown to have no unacceptable impact on system performance.*

Existing solution features must be analyzed to identify the rate of dissolution. The effects of further dissolution or of new dissolution features on system performance must be evaluated.

3.3 Geochemistry

The site shall have geochemical characteristics compatible with waste containment, isolation, and retrieval.

1. *The site shall be located so that the chemical interactions between radionuclides, rock, ground water, or engineered components will not unacceptably affect system performance.*

The evaluation of the geochemical regime shall include characterization of factors that contribute to slowing or preventing radionuclide transport, such as solubilities, sorption, dissolution precipitation, redox environment, and pH. The evaluation of the geochemical regime shall consider any factors that may adversely affect the radionuclide containment capabilities provided by the waste package, repository, or geologic system.

3.4 Geologic Characteristics

The site shall have geologic characteristics compatible with waste containment, isolation, and retrieval.

1. *The site shall be located so that the subsurface setting can be sufficiently characterized to permit identification and evaluation of conditions that are potentially adverse or favorable to waste containment, isolation, and retrieval.*

   Characterization of the subsurface setting will include all pertinent physical, structural, mineralogical, and geochemical features of the rock units. The geologic conditions shall be shown to not unacceptably affect system performance.

2. *The site shall provide a geologic system which can be shown to accommodate anticipated geomechanical, chemical, thermal, and radiological stresses caused by waste/rock interactions.*

   Phenomena such as thermally induced fractures, hydration and dehydration of mineral components, brine migration, or other physical, chemical, or radiological phenomena must be evaluated to show that they would not unacceptably affect system performance.

3. *The site shall be located so that development, operation, and closure of underground areas can be accomplished without undue hazard to repository personnel.*

   Sites with subsurface conditions that preclude or make excessively difficult design and construction of the repository using practical procedures shall be avoided.

3.5 Tectonic Environment

The site shall be located such that credible tectonic phenomena will not degrade system performance below acceptable limits.

1. *The site shall be located so that its tectonic environment can be evaluated with a high degree of confidence to identify tectonic elements and their impact on system performance.*

   Potentially hazardous geologic elements, including faults of any age, volcanoes and anomalous geothermal gradients, must be sufficiently investigated to allow determination of their potential effects on system performance and to show that these effects will not unacceptably affect system performance.

2. *The site shall be located so that Quaternary faults can be identified and shown to have no unacceptable impact on system performance.*

   The evaluation of Quaternary faults will emphasize the determination of the potential for rupture in or adjacent to the site but will include evaluation of the likelihood and consequence of earthquake generation and plausible impacts on the regional hydrology.

3. *The site shall be located so that the centers of Quaternary igneous activity can be identified and shown to have no unacceptable impact on system performance.*

   The evaluation of the likelihood and impact of igneous activity on the disposal system will include thorough evaluations of the region's igneous history, with particular attention given to temporal and spatial distribution of activity,

character of activity, and analysis of the possibility of migration or expansion of areas of active volcanism.

4. *The site shall be located so that long-term, continuing uplift or subsidence rates can be shown to have no unacceptable impact on system performance.*

   Evaluation of the rates of uplift or subsidence is required so that effects of such movement can be shown to cause no unacceptable reduction in repository performance.

5. *The site shall be located so that ground motion associated with the maximum credible earthquake will not have unacceptable impact on system performance.*

   The evaluation of seismic effects of the disposal system requires state-of-the-art definition of (1) regional historical seismicity (both instrumental and preinstrumental), (2) maximum-credible earthquake, and (3) related seismic-design parameters such as the level of vibratory ground motion, that can be accommodated at the site by practical design measures. The seismic evaluation must be performed considering the ground motion that can be accomodated by design.

3.6 Human Intrusion

The site shall be located to reduce the likelihood that past or future human activities would cause unacceptable impacts on system performance.

The level of evaluation necessary to assess the likelihood of human intrusion will increase with the value of and the proximity of the site to exploitable features or resources such as water, thermal energy, petroleum, or minerals.

1. *The site shall be located so that the exploration history or relevant past use of the site or adjacent areas can be determined and can be shown to have no unacceptable impact on system performance.*

2. *The site shall be located on land for which the federal government can obtain ownership, control access, and obtain all surface and subsurface rights necessary to ensure that surface and subsurface activities at the site will not cause unacceptable impact on system performance.*

3.7 Surface Characteristics

The site and its surrounding area shall be such that surface characteristics or conditions can be accommodated by engineering measures and can be shown to have no unacceptable impacts on repository operation and system performance.

1. *The site shall be located so that the surficial hydrological system, both during anticipated climatic cycles and during extreme natural phenomena, will not cause unacceptable impacts on repository operations or system performance.*

   Features to be considered include nearby surface water bodies, impoundments, embayments, streams, floodplains, runoff, and drainage. Consideration of such features must include evaluation of their impact on surface and subsurface facilities and onsite access corridors during both the operational phase of the repository and the long-term isolation phase of the disposal system.

2. *The site shall be located in an area where surface topographic features do not unacceptably affect repository operation.*

   Sites in which road and rail access routes encounter steep grades, sharp switchbacks, slope instability, or other potential sources of hazard to incoming waste shipments should be avoided.

3. *The site shall be located where meteorological phenomena can be accommodated by engineering measures and can be shown to have no unacceptable effect on repository operation.*

4. *The site shall be located where present and projected effects from nearby industrial, transportation, and military installations and operations can be accommodated by engineering measures and can be shown to have no unacceptable impacts on repository operations.*

3.8 Demography

The site shall be located to minimize the potential risk to and potential conflict with the population.

1. *The site shall be located in an area of low population density and at a distance away from population concentrations and urban areas.*

2. *The site shall be located such that risk to the population from transportation of radioactive wastes and from repository operation can be reduced below acceptable levels to the extent reasonably achievable.*

"To the extent reasonably achievable" implies an evaluation must be made that takes

". . . into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety and other societal and socio-economic consideration. . ." [10CFR20.34(a)].

3.9 Environmental Protection

The site shall be located with due consideration to potential environmental impacts: air, water, and land use; and ambient environmental conditions.

1. *The site shall be located with due consideration to potential environmental impacts.*

   The evaluation of such impacts will include assessment of air, water, land, aesthetic, ecological, noise, resource, and historical factors appropriate to repository construction, operation, and isolation.

2. *The site shall be located to reduce the likelihood or consequence of air, water, and land use conflicts.*

   The consideration of air, water, and land use must include both surface use, subsurface use, and resource denial as currently regulated by local, state, and federal legislation. Current legislation and executive orders to be addressed include:

   - National Environmental Policy Act of 1969
   - The Wilderness Act of 1964
   - The Wild-and-Scenic Rivers Act of 1968
   - Wildlife Preservation Act of 1966
   - Endangered Species Act of 1973
   - National Wildlife Refuge Act of 1966
   - National Park Service Lands
   - National Historic Preservation Act of 1974
   - National Heritage Program
   - Noise Control Act of 1972

- Resource Conservation and Recovery Act of 1976
- Clean Air Act, Amended 1977
- Clean Water Act, Amended 1977
- The Land Policy and Management Act of 1976
- Floodplain Management, Executive Order 11988
- Protection of Wetlands, Executive Order 11990, 1977
- Prime or Unique Farmlands U.S.D.A 101(b)4.

Consideration of sites covered by these and other applicable acts, orders, or legislation will include evaluation of mitigating measures that could be undertaken to allow repository construction and operation. Such mitigating measures might include removal or exploitation of resources or articles of value covered by the acts, or shifting location of repository surface systems to avoid such articles. Evaluation of subsurface resources will include assessment of the impact of the denial of mineral, geothermal energy, water, or petroleum resources and the archeological value of the site. Consideration will be given to whether or not these resources or articles of value can be exploited or removed to allow siting.

3. *The site shall be located with due consideration to normal and extreme environmental conditions.*

The evaluation of such items as high winds, tornadoes, rainfall, and flooding will be included to ensure that environmental impacts that would result from construction runoff, erosion of spoil-piles and other repository-related activities are eliminated, or mitigated to the extent practicable.

3.10 Socioeconomic Impacts

The site shall be selected giving due consideration to social and economic impacts on communities and regions affected by the repository.

1. *The site shall be located so that adverse social and/or economic impacts resulting from repository construction and*

operation can be accommodated by mitigation or compensation strategies.

Social and economic impacts include both positive and negative effects on individuals, communities, and institutions, such as: the influx of new workers into a town, the effect of population growth on housing markets and community services, the fiscal burden on the local government, the impacts on governmental processes, and changes in land use patterns. Some impacts may remain for which compensation or mitigation may be necessary.

2. *The site shall be located so that adequate access and utility capability required for the repository either exists or can be provided without unacceptable impact on affected communities.*

The movement of construction equipment and supplies, and of waste to the repository during operation, can create burdens on highway and rail systems. Both systems need to be adequate to carry these loads, or may need to be upgraded if current capability is not adequate.

DOE/EA-151

Environmental Assessment

of

Implementing The National Plan For Siting High-Level Radioactive Waste Repositories

February 1982

U.S. Department of Energy
Assistant Secretary for Environmental
Protection, Safety, and Emergency
Preparedness

SUMMARY

This environmental assessment (EA) has been prepared by the U.S. Department of Energy to assess the impacts of implementing the draft National Plan for Siting High-Level Radioactive Waste Repositories (proposed Siting Plan) and of carrying out the field activities called for in the screening phase of the Plan. This EA has been prepared in accordance with DOE's guidelines (45 FR 20694, March 28, 1980) for compliance with the National Environmental Policy Act (NEPA) of 1969,[1] as implemented by regulations promulgated by the Council on Environmental Quality (CEQ, 40 CFR Parts 1500-1508, November, 1978).[2]. The proposed Siting Plan consists of three phases: the site screening phase, the detailed site studies phase, and the site selection phase. Potential impacts of the National Siting Plan could result from specific field activities and/or specific site selection strategies. Activities included in the screening phase are evaluated in this EA. (Activities to be conducted in subsequent phases will be addressed in future NEPA documents as described in Section 4.5 of the Siting Plan.)

The activity with the greatest potential for significant environmental impact during the site screening phase is borehole drilling. Primary impacts related to borehole drilling include temporary disturbance of from 1 to 13 acres of habitat for each of many drilling sites across the United States and temporary disruption of current land use at these sites. Drilling sites and areas disturbed by field activities will be restored to the extent practicable or to the extent allowed by law. Borehole drilling has been evaluated on an individual[3-15] as well as generic[16,17] basis, and has typically been shown to have little environmental impact. In fact, DOE has proposed categorizing this activity as a class which generally will cause no significant environmental impacts and will therefore not require an EA or an EIS.[18] Currently environmental checklists are prepared prior to beginning exploratory drilling in the National Waste Terminal Storage (NWTS) program to assess the potential for causing significant environmental impacts. Since screening phase field activities including borehole drilling are expected to be small and widely dispersed across the United States, no cumulative impacts are anticipated.

Five alternative strategies to the proposed Siting Plan were evaluated:

- No action (selecting sites without a plan)
- Choosing the first site now on the basis of existing information
- Conducting siting activities in preselected regions (regionalization)
- Judging site suitability earlier in the siting process
- Providing more alternative sites for the first site selection decision.

The impacts of implementing any of these alternatives are considered to be minimal. Alternative strategies differ in the number of places which would be studied to determine their suitability as potential repository sites, costs of the siting program, and in the time required to select a potential site which would ensure public health and safety and be environmentally acceptable. None of the alternatives are judged significantly better than the proposed action on the basis of environmental impacts.

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1.0 INTRODUCTION

This Environmental Assessment (EA) evaluates the potential impacts of implementing the the draft National Plan for Siting High-Level Radioactive Waste Repositories (proposed Siting Plan) and of carrying out the field activities called for in the screening phase of the Plan. This EA has been prepared in accordance with DOE's guidelines (45 FR 20694, March 28, 1980) for compliance with the National Environmental Policy Act (NEPA) of 1969,[1] as implemented by the regulations promulgated by the Council on Environmental Quality (CEQ, 40 CFR Parts 1500-1508, November, 1978).[2] On the basis of this EA, a Finding of No Significant Impact or a Notice of Intent to prepare an environmental impact statement will be published in the Federal Register.

1.1 Previous Siting Plan

Sites for disposal of commercially generated radioactive wastes have long been sought. The Department of Energy and its predecessor agencies have been involved in the management of radioactive waste since 1944 when radioactive waste was first generated as a byproduct of national defense programs. In 1958, the U.S. Geological Survey undertook a study for the Atomic Energy Commission to identify those salt deposits in the United States that might contain possible disposal sites.[19] Siting efforts have increased since that time and are now being undertaken by DOE.[20]

A systematic process to find suitable repository sites was described in both the EIS on the Management of Commercially Generated Radioactive Waste[21], and DOE's Statement of Position in the Waste Confidence Rulemaking.[20] Recent NRC regulations[22] which require an exploratory shaft and at-depth testing at each alternative have necessitated a change in the siting strategy described in these two documents. The siting strategy described in the EIS and the Waste Confidence Rulemaking is discussed in this EA as Alternative 4.

1.2 Proposed Siting Plan

The proposed Siting Plan consists of three major siting phases: (1) site screening (2) detailed site studies, and (3) site selection (see Siting Plan Figures 2-1, and 2-2, and Table 4-3). The screening phase consists of four steps; national, regional, area, and location surveys.

The first two steps, national and regional surveys, are carried out on non-DOE lands and consist of a review of existing data obtained through broad literature searches. Area surveys are conducted on DOE and non-DOE lands under study and may include geologic and environmental field studies such as shallow and deep drilling, geophysical surveys, environmental reconnaissance level investigations, and limited field confirmation activities. Location surveys, also conducted on DOE and non-DOE lands, may include all of the geologic and environmental field activities described in Section 3.7 of this EA. The resultant data are used to identify potentially suitable sites for detailed site studies.

Plans for detailed site studies have not yet been finalized, but are currently envisioned to include (1) constructing an exploratory shaft for at-depth geologic, geophysic, and geochemical field work, (2) completing environmental baseline studies, (3) drilling boreholes, and (4) trenching.

In the final phase, site selection, DOE integrates environmental and geotechnical factors with socioeconomic, legal, political, and institutional factors to select, reject, reserve for future consideration, or defer sites.

At the conclusion of the site selection phase, a license application will be filed with the Nuclear Regulatory Commissions (NRC) for the selected site. Final site suitability will be determined through the NRC licensing procedure during this phase.

1.3 Site Performance Criteria

The criteria used to determine site suitability are still being developed. The NRC and the Environmental Protection Agency (EPA) ultimately will prescribe the criteria used to judge site suitability. NRC has proposed criteria addressing siting, design, and performance of a geologic repository,

and the design and performance of the package which contains the waste within the geologic repository.[23] EPA has the authority and responsibility for setting generally applicable standards for radiation in the environment. It is the responsibility of the NRC to implement those standards in its licensing actions and assure that public health and safety are protected.

Because no EPA standard for disposal of high-level radioactive waste yet exists, and NRC's criteria are still undergoing technical and public review, DOE has developed a set of siting criteria which are comprehensive and broad enough to support early siting decisions. DOE's Site Performance Criteria[24] (see Appendix A of the Siting Plan) were developed in consideration of other existing criteria (International Atomic Energy Agency, Office of Waste Isolation and the National Research Council/National Academy of Science)[25-27]. The DOE criteria were also subjected to public review and comment before being finalized in February, 1981. NRC and EPA criteria will preempt DOE's site performance criteria when they are finalized. In the interim, however, DOE's criteria are comprehensive and broadly address issues of public health and safety, environmental protection, engineering feasibility, and institutional and socioeconomic impact.

1.4 Organization of This EA

In evaluating the potential impacts of implementing the proposed Plan and conducting site screening phase activities, the purpose and need for the Plan are reviewed (Chapter 2, see also attached Siting Plan), the proposed action and alternatives are described (Chapter 3); the affected environment is presented (Chapter 4); environmental consequences of the proposed action and alternatives are estimated (Chapter 5); and conclusions are summarized (Chapter 6).

2.0 PURPOSE AND NEED

After an analysis of alternative methods for the disposal of commercially generated radioactive wastes,[21] DOE decided to proceed with a programmatic strategy for the siting of mined geologic nuclear repositories.[28] DOE had already been searching for sites suitable for deep disposal in geologic formations under a decision to adopt geologic disposal as an interim planning strategy. Now that the strategy for a technological disposal option has been formally selected, the process of finalizing a plan for finding sites under this option can move forward.

The purpose of the proposed National Siting Plan is to describe a framework for decision making which, when implemented, will result in the identification and selection of sites suitable for development into geologic repositories for the isolation of radioactive wastes in a manner that assures the public health and safety and is environmentally acceptable. The proposed action is needed to:

- Provide a stepwise, systematic approach to repository site selection
- Provide a framework for integrating developing technology into the siting process
- Provide a vehicle for state, regulatory, and societal review and comment on the DOE approach.

In addition, implementation of the Siting Plan will provide candidate sites at which a test and evaluation facility (TEF) will be located. Three potential repository sites will be candidates for a TEF.

3.0 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

This chapter describes the proposed action, alternatives to the proposed action, and field activities common to each of the siting strategies. The proposed action is the implementation of the National Plan for Siting High-Level Radioactive Waste Repositories and the performance of field activities described in the Plan (see Section 4.5 of the Siting Plan). The Siting Plan describes the process DOE will follow to find and select repository sites for the disposal of commercially generated wastes.

Alternatives to the proposed Siting Plan include:

Alternative 1. No action (selecting sites without a plan)

Alternative 2. Choosing the first site now on the basis of existing information

Alternative 3. Conducting siting activities in preselected regions (regionalization)

Alternative 4. Judging site suitability earlier in the siting process

Alternative 5. Providing more alternatives for the first site selection decision.

Performance of field activities is the only source of potential direct impacts on the natural and human environment. Impact differences among the proposed action and alternatives arise from differences in the number of places which would be studied, the time required to select a potential repository site, and the cost of field and other activites attributable to each alternative siting approach.

3.1 The Proposed Action

The proposed action is implementation of a three-phased siting process consisting of site screening, detailed site studies, and site selection. This EA is being published with, and is attached to, the proposed Siting Plan. The siting phases are shown schematically on Siting Plan Figure 4-1. Each of these phases consists of steps (see Siting Plan Figure 4-2). The activities to be conducted in each step are summarized in Table 3-1. This EA addresses field activities to be conducted in the site screening phase.

TABLE 3-1. SUMMARY OF DOE SITING ACTIVITIES

Siting Steps	Policy and Requirements	Characterization Activities	Participants to Decision Process	NEPA and Technical Documentation	State Consultation	Land Acquisition	Mitigation
National Screening Surveys	State consultation stepwise approach	"Desk Top" studies, literature review, geologic, land use, and systems approaches	DOE, USGS, States	Characterization and recommendation report	States notified of study –	None	None
Regional Surveys	State consultation, multiple media alternatives	Studies of available literature, existing geologic and environmental reports, maps, aerial photographs and a few deep boreholes	DOE, USGS, States	Characterization reports, and recommendation reports	Governors, legislators, and their advisory committees. Public information meetings and press conferences	None	Restoration of drilling sites
Area Surveys	State and local consultation	Geologic mapping, a few deep boreholes reconnaissance surveys to develop new data for evaluation	DOE, USGS, States, local governments, other federal agencies	Deep drilling EE's Characterization Summary and recommendation reports Draft SCR	Significant increase in the level of consultation activity on non-DOE lands. Numerous federal agencies and departments enter the process. Local community leaders	Temporary access for drilling activity	Access fees and permits. Grants to support high involvement of key participants, especially state agencies and universities. Restoration of drilling sites
Location Surveys	State and local consultation Site Characterization Report 10 CFR 60	Geologic and environmental field studies sufficient to select a site for detailed study.	Those above plus local communities	Site Characterization Report. Characterization reports, recommendation reports. EA or EIS for detailed site studies (exploratory shaft).	Same as above, plus affected citizens. Begin state and local involvement for DOE lands.	Temporary access for geologic and environmental field studies.	Access fees and permits. Grants to key participants. Restoration of drilling sites.
Detailed Site Studies	State and local consultation 3 or more sites in diverse geological media or geohydrologic systems	In depth geologic and environmental field studies, including sinking an exploratory shaft to thoroughly characterize potential sites.	Same as above	Site Characterization Report (updated)	Same as above	Option or purchase of private land, transfer or withdrawal of federal land.	Determining alternatives for technical and financial assistance to communities
Site Recommendation and Selection	State and local consultation	Onsite monitoring of key geological and environmental parameters	Same as above plus the Nuclear Regulatory Commission	Site recommendation reports, DEIS, Site Selection Report and FEIS	Same as above	Purchase of private land, transfer or permanent withdrawal of federal land.	Development of plans with affected persons and communities to upgrade community utilities and services and to participate in potential project
Licensing	Meet 10 CFR 60 requirements	Use and update detailed site studies as needed	DOE, NRC	License application preliminary Safety Analysis Report Environmental Report	Same as above	Completed	

Referring to Siting Plan Figure 5-4, detailed site studies would be initiated in 1983 at three sites. These three sites will be the primary candidates from which a site will be selected for construction of the Test and Evaluation Facility in 1985. Activities to be conducted in the detailed site studies phase are site-specific and cannot yet be finalized, but are expected to include construction of an exploratory shaft, environmental studies, and at-depth geologic and hydrologic testing. Screening phase studies would continue in the Lake Superior region, Appalachian region, and Province 9 region (shown on Siting Plan Figure 5-5) until 1987, when a site from one of these regions and another site from either the Permian, Paradox, or Gulf Coast areas would be selected for detailed site studies.

Under the proposed plan, DOE may select the first site and apply to NRC for a license to receive and possess nuclear materials as early as fiscal year 1988. If a site is selected before 1991, it will be selected from among the three sites which have undergone detailed site studies. If the first site or subsequent site(s) is selected after 1991, more sites will have undergone detailed site studies, and selection may be from up to five sites for which detailed site studies will be complete. The total cost of siting under the proposed plan is estimated to be $1.8 billion for fiscal years 1981 to 1987.

3.2 Alternative 1: No Action - Siting Without a Plan

The no action alternative is defined as selecting repository sites without a structured plan. It is conceivable, given interim and developing criteria, that repository sites could be selected and NRC licenses sought on the basis of meeting those criteria in the absence of a structured methodology for characterizing and screening potential sites. This alternative could be implemented in various ways. In any case, the data base for each place currently being screened would be examined to identify issues most in need of further study before a suitability determination could be made. No specific siting phases would be designated; characterization of individual sites would proceed at their own pace. Opportunities for public input to the siting process would be provided on a schedule specific to each individual site.

3.3 Alternative 2: Choose the First Site Now

Under this alternative, the site judged to have the highest potential for meeting current and developing site performance criteria on the basis of existing data would be selected very soon. This site would be the subject of intense characterization efforts to make a site suitability determination as soon as possible. Studies of alternatives not chosen would be discontinued. Funds allocated under the proposed Plan to bring alternative sites to comparable levels of confidence for suitability determinations could be spent on other program activities, such as technology development, or could be diverted to other federal programs.

3.4 Alternative 3: Siting Within Predetermined Regions (Regionalization)

This alternative calls for dividing the country into regions (perhaps "service regions") and initiating screening activities within each region (regionalization). This alternative would require each region to accept responsibility for disposing of the nuclear waste generated in that region. After dividing the nation into regions, sites would be selected using a methodology and set of activities similar to those described in the proposed Plan. Large land units would be studied to find small areas which potentially meet siting criteria. Potential sites would eventually be identified from the small areas for detailed study to determine the suitability of each site. Sites determined to be suitable in each region would be subjected to the NRC licensing process.

3.5 Alternative 4: Judging Site Suitability Earlier in the Siting Process

Prior to the promulgation of NRC's procedural rule,[22] the Department of Energy had described an earlier plan for finding suitable repository sites.[20] Figure 3-1 illustrates the earlier DOE siting plan. The earlier plan required that the same activities be conducted as the proposed plan, but

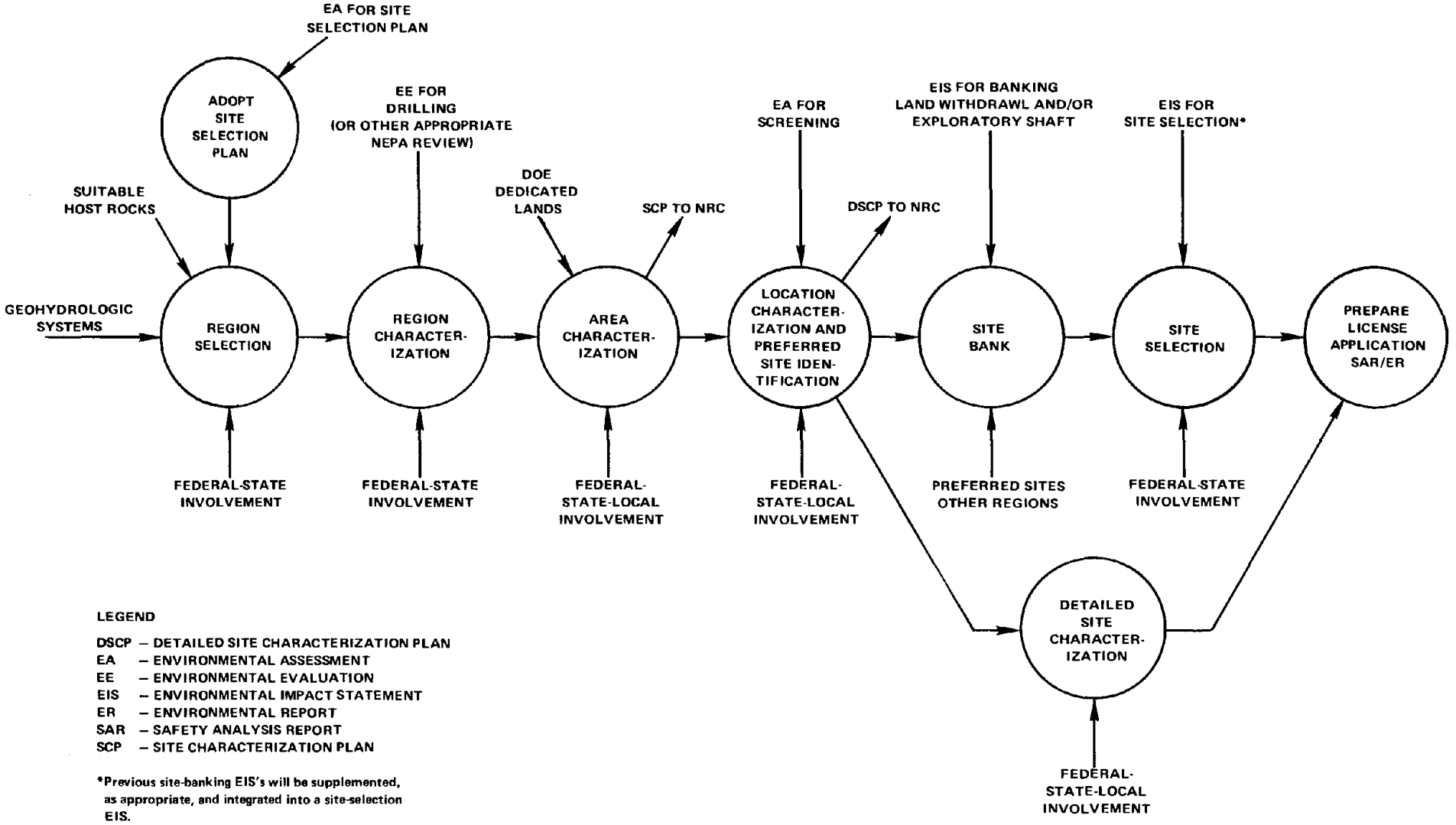

FIGURE 3-1. Site Characterization and Selection Process; Alternative 4.

is different in an important respect: a suitability determination at each potential site would be made earlier (at the conclusion of the location step), perhaps without the use of in situ data.

Under Alternative 4, activities conducted in the national, regional, and area steps of the screening phase are the same as those described in the proposed Plan. The activities which would be carried out during the location step under Alternative 4 include completing biological, physical, and socio-economic baseline surveys, and drilling several boreholes to obtain data to judge subsurface conditions. Some trenching and seismic tests would also be necessary. Those locations which could not be completely characterized and determined to be either suitable or unsuitable for repository sites from such surface activities would have exploratory shafts constructed to obtain subsurface (in situ) data. These activities would provide the data from which to judge sites as suitable for development as repositories.

Under Alternative 4, the intensity of location studies would increase. From five to ten locations would be studied in the next two years and an as yet undetermined number of locations would be studied in the following years. (Under the proposed Plan, only three sites will be characterized to this level of detail during the detailed site study phase in the next five years and two additional sites will be studied in detail in later years.)

3.6 Alternative 5: Providing More Alternative Sites for the First Selection Decision

Alternative 5 requires that an alternative site(s) in granite (or other media) be available prior to selection of the first site. This alternative would provide the decision makers with at least one additional rock type thought to be suitable before selecting the first repository site for NRC review. The proposed action, though not precluding granite site availability for the first repository selection, preserves the option of selecting a site before alternatives to Nevada tuff, Hanford basalt, and salt are available.

To bring study of granites up to a basis equal with that of studies in basalt, tuff, and salt, either substantial additions to near-term

budgets, or a delay in the first site selection until after 1992 would be necessary. If the program received additional funds in the near term to bring study of granites up to a basis equal with that of other media, it is unlikely that total program costs would differ substantially since granites are proposed to be characterized under the proposed Plan (but at a slower pace).

3.7 Field Activities Common to the Proposed Action and Alternatives

Field activities are essential to any siting strategy. Informed siting decisions can only be made with adequate field data. Potential impacts to the natural and human environment may result from field activities. This section describes the types of field activities that would probably be common to all of the alternatives and that may be a source of environmental impact during the search (screening) for potential repository sites. Many of these field activities have previously been evaluated and have been found to result in no significant environmental impact.(3-15)

Some of the activities to be conducted during the detailed site study phase are in early stages of planning and can only be described in detail when specific sites are identified. These activities include conducting detailed environmental baseline surveys, constructing exploratory shafts, and conducting tests at potential repository depth. Additionally, some activities will not be carried out at every site, but will be conducted to resolve site specific issues. Activities in early planning stages and those which are site specific will be conducted during detailed site studies and site selection phases of the proposed Plan. These activities will be described in future documents called site characterization reports (Table 4-2 of the Plan) which will provide NRC with DOE's plans for investigating individual sites. Environmental impacts of these future site-specific activities will be described in detail in future EAs and EISs.

Screening phase activities necessary at each potential site are described below. These activities can be categorized as either geotechnical or environmental.

3.7.1 Geotechnical Activities

Descriptions of the geotechnical activities that may be conducted during the search for repository sites or to evaluate the suitability of an individual site are provided below. While some site-specific differences can be expected in equipment selection and layout, materials use, and procedures, these descriptions contain sufficiently specific information to serve as a basis for environmental impact evaluations.

3.7.1.1 Deep Drilling. For purpose of this assessment, deep drilling is defined as extending to below 1,000 feet in depth. Activities associated with drilling can be divided into seven phases: exploration, site access, site preparation, drilling to total depth, logging and testing, decommissioning, and site reclamation. Table 3-2 lists the activities carried out during each phase, and the component of the environment which may be affected. Existing roads are used for drilling site access when available. When new access is required, it generally extends less than one mile from existing roads. The area disturbed for access and drilling will generally be limited to less than 13 acres. Typically, a number of deep and shallow boreholes can be drilled in this disturbed area.

3.7.1.2 Shallow Drilling. The facilities and equipment for shallow drilling are similar to those required for deep drilling. However, since the depth of the planned borehole is typically less than 1,000 feet, the magnitude of the operation is significantly less.

Existing roads are used for access to the site whenever possible. When new access is required, it generally extends less than one mile from existing roads. Site preparation typically consists of clearing and leveling approximately one acre per borehole to accommodate the drilling facility. The extent of disturbance at the drilling site depends on physical surface characteristics such as slope and drainage patterns.

3.7.1.3 Geohydrologic Testing. Once a test well has been drilled a variety of geohydrologic tests may be conducted to determine the physical and chemical characteristics of subsurface formations in the vicinity of the test

TABLE 3-2. POTENTIAL ENVIRONMENTAL IMPACTS ASSOCIATED WITH DRILLING ACTIVITIES

Drill Project Phase	Activity	Environmental Component Affected	Potential Impact
Exploration	• Seismic Survey	• Terrestrial Habitat • Wildlife	• Disruption of soil in small area (explosives) • Noise disruption of animal habitat
Access to Site	• Construct Access Road	• Terrestrial Habitat • Wildlife • Aquatic Habitat • Ground-water Aquifers • Surface Water	• Disruption of habitat through road grading • Noise disruption of wildlife behavior • Erosion and alteration of surface runoff and ground-water recharge
Site Preparation	• Clear and Grade Drilling Site and Staging Area • Acquire Water Source	• Terrestrial Habitat • Aquatic Habitat • Wildlife • Ground-water Aquifers • Land • Human Environs • Surface Water	• Disruption of 1-13 acres for drilling and staging area • Diverted land use • Alteration of surface and ground-water recharge patterns • Noise and air pollution from particulates and gaseous emissions • Disruption of wildlife behavior • Disturbance of people • Sedimentation of aquatic habitats
Drilling to Total Depth	• Construct Mud Pits • Drill to Total Depth • Dispose of Waste Fluids and Cuttings	• Ground-water Quality • Surface Water Quality • Terrestrial Habitat • Air and Noise • Aquatic Habitat • Aestetic Quality • Land • Human Environs	• Migration of disposed waste fluids to surface and ground water • Overflow of mud pits into habitats • Disturbance of people • Atmospheric input of particulates into habitats • Disruption of aquifer transmissive properties from drilling or improper plugging and casing • Air pollution from particulates and gaseous emissions • Desiccation of aquatic habitats due to water consumption • Contamination of habitats from accidental chemical spills • Diverted land use • Erosion of soil • Commitment of farm land • Presence of equipment
Logging and Testing	• Recording of Borehole Geophysical Data	• Ground-water Aquifer • Land Use	• Disturbance of people • Diverted land use
Decommission	• Removal of Equipment	• Wildlife • Human Environs	• Noise • Disruption of animal behavior • Disturbance of people
Site Reclamation	• Regrade Site • Reclaim Drilling Sumps	• Wildlife	• Noise and air pollution disruption of wildlife behavior

site. In general, the geohydrologic testing involves measuring static ground-water levels, conducting pumping and injection tests, collecting water samples for chemical analyses, and conducting ground-water tracer tests.

Access requirements for gheohydrologic testing are essentially the same as those required for drilling. Installation of test pumps can be accompanied by the drilling rig used for well construction, or by a truck of similar size equipped with a winch or hoist. Additional clearing of land is not required to provide access for geohydrologic testing.

3.7.1.3.1 Pumping Tests. Pumping tests provide data used to estimate the hydrologic properties of the tested aquifers. Data from these tests consist of measurements of ground-water level changes in observation wells that result from pumping water from another well. The data can be used in conjunction with other geological and geophysical information to calculate the transmissivity, permeability, and storage coefficient of the aquifer; to detect and quantify hydraulic connections between different aquifers; and to determine the presence and nature of hydrologic boundaries.

3.7.1.3.2 Injection Tests. The simplest forms of injection tests are the "slug test" and the "constant-head" injection test. In the slug test, a single injection of water is made into, and the water level in the casing is monitored. In a constant-head injection test, water is allowed to enter the casing from a surface reservoir and the rate of flow required to maintain a constant water level in the casing is monitored. These technqiues are generally used with small-diameter wells drilled into low-permeability formations and do not require observation wells or pumping equipment.

3.7.1.3.3 Water Sampling. Water samples are collected for analysis of the chemical quality of the ground water. Spatial and temporal variations in water quality help determine local hydrogeologic conditions, such as locations of recharge and discharge areas, or the possible presence of "saline plumes". This information is required to determine suitability for a specific purpose, such as potable water supply or drilling fluid, or to determine the apropriate means of disposing of water pumped from the test well. Several

techniques are available for collecting water samples from a well. Most of these water sampling procedures can be carried out by one person.

3.7.1.3.4 Tracer Tests. Tracer tests complement pumping and injection tests. Tracer tests, a standard industry practice for geohydrologic testing, involve introducing a known quantity and concentration of a tracer material into a well bore (typically methylene blue, sodium fluorescein chloride salts, certain radioisotopes, or strong electrolytes) and monitoring changes in tracer concentration in that and other nearby wells. The tests may be conducted under natural flow conditions or under pumping or injection conditions. These tests provide additional information on the permeability and porosity of the aquifer, as well as natural ground-water flow rates and directions.

3.7.1.3.5 Well Logging. Well logging is conducted in each borehole. The basic elements of well-logging equipment include truck-mounted electronic recording devices, motor-driven or hand-operated winches, a tripod hoisting and electrical cable, and various types of well-logging probes.

Data from well logs have several general uses: (1) correlating geologic formations from one borehole to another; (2) determining the lithology and thickness of the geologic formations; (3) evaluating subsurface water quality; and (4) determining relative physical properties of the geologic formations including the amount, location, and type of porosity; moisture content; temperature; density; elastic properties; bulk and pore compressibilities; and location of rock fractures.

3.7.1.4 Geophysical Surveys.

3.7.1.4.1 Seismic Surveys. Seismic surveys involve generating an elastic pulse (or wave) by striking a metal plate with a sledgehammer, employing an automatic vibrator, dropping a heavy weight, using explosives, or using compressed air. Seismometers or geophones are used to detect the resulting motion of the ground at nearby points.

Seismic studies may encompass an area of several square miles. The seismic crew normally consists of three or more persons with several vehicles,

including a small drill rig or truck-mounted auger. Some clearing of vegetation may be required to provide access for vehicles and to position the geophones.

3.7.1.4.2 Resistivity Surveys. The electrical resistivity survey usually consists of generating alternating electrical current, applying it to the ground through two electrodes, and measuring the potential drop between a second pair of electrodes.

The electrodes, usually from 1 to 1.5 feet in length and 0.5 inch in diameter, are driven into the ground with a sledgehammer. Wires connect the electrodes with the power source and resistivity meter, usually contained in the same box. Data derived from the resistivity survey are used to: (1) evaluate the relative lithology of the subsurface geologic formations, and (2) determine the position and form of the various formations.

3.7.1.4.3 Gravity and Magnetic Surveys. A gravity survey detects underground geologic structures by the variations in the earth's gravitational field. Gravimeters are designed to measure directly small differences in gravitation field strength. Typically, gravity measurements are taken at discrete locations within the area of investigation. The locations are usually defined by a grid system (typically 200 ft x 200 ft) established for the area. Considerable surveying and some geological reconnaissance may be required in the area of investigation prior to initiating the gravity survey. If the area of investigation covers several square miles, a helicopter-mounted gravimeter may be used.

Magnetic surveys detect geologic structures by the variations in the earth's magnetic field. Field crews may conduct magnetic surveys from ground level, or may equip airplanes such that surveys can be taken from the air. Field techniques used for magnetic surveys are identical to those for gravity surveys and the methods of presentation and interpretation of the data are similar.

3.7.1.5 Geologic Mapping. Geologic reconnaissance and mapping programs supplement and integrate information about areas under investigation.

Geologic mapping usually is accomplished by two or three geologists using aerial reconnaissance and detailed field mapping techniques. Subsurface investigations may require limited trenching with a backhoe and/or bulldozer. Trenches are used to investigate shallow soil/rock profiles for: (1) identifying, classifying, and sampling the soil and (2) determining if displacement of soil or rock has occurred. The latter information is used in conjunction with other studies to investigate faulting.

The dimensions of a trench are dependent on the depth of the soil/rock profiles to be evaluated. Dimensions of a typical trench range from 2 to 200 feet in length and width and 3 to 10 feet in depth.

3.7.2 Environmental Activities

In contrast to the geotechnical activities, many of the environmental field activities described in this section have not yet been conducted in DOE's siting efforts. These field activities, or in some cases, mitigation measures required for geotechnical activities, are required by a variety of federal (and sometimes state and local) authorities. Relevant federal environmental requirements are listed in Table 3-3.

3.7.2.1 Socioeconomic Studies. The socioeconomic data needed to characterize and to select sites for further detailed study include demographic characteristics, labor force characteristics, and information on community facilities and land use.

Most of this information can be obtained through literature reviews, studies of local and regional plans and records, and through meetings and interviews with people and groups familiar with the community.

3.7.2.2 Ecosystem Studies. Studies of major terrestrial and aquatic communities and habitats and of agricultural resources will be undertaken. Region and area study phases require only literature reviews of ecological data. The location phase studies will include:

- Identifying the representative important species, including rare and endangered species

TABLE 3-3. FEDERAL ENVIRONMENTAL REGULATIONS

Federal Regulations/Statutes

1. Air Quality

   a. Clean Air Act, as amended, 42 U.S.C. §§ 7401-7642 (Supp. 1979)
   b. Prevention of Significant Deterioration, 40 C.F.R. §§ 51.24, 52.25 (1980)

2. Cultural Resources

   a. National Historic Preservation Act of 1966, as amended, 16 U.S.C. §§ 470-470t (Supp. 1979)
   b. Protection and Enhancement of Cultural Environment, Exec. Order No. 11593, 36 Fed. Reg. 8921 (May 15, 1971)
   c. Protection of Historic and Cultural Properties, 36 C.F.R. §§ 800.1 – 800.15 (1980)
   d. Antiquity Act of 1906, 16 U.S.C. §§ 432-433 (1970 & Supp. 1979)
   e. Historic Sites, Buildings and Antiquities Act, as amended, (Historic Sites Act). 16 U.S.C. §§ 461-469i (1970 & Supp. 1979)
   f. Archaeological and Historic Preservation Act of 1974, 16 U.S.C. §§ 469-469c (Supp. 1979)
   g. Archaeological Resources Protection Act of 1979, 16 U.S.C. §§ 470aa-470ll (Supp. 1979)

3. Ecology/Wildlife Protection

   a. Endangered Species Act, as amended, 16 U.S.C. §§ 1531-1543 (1970 & Supp. 1979)
   b. National Wildlife Refuge Systems Administration Act of 1966, 16 U.S.C. §§ 668-668ee (1970 & Supp. 1979)
   c. Migratory Bird Treaty Act, as amended, 16 U.S.C. §§ 703-711 (Supp. 1979)
   d. Bald and Golden Eagle Protection Act, 16 U.S.C. §§ 668-668d (1970)
   e. U.S. Fish & Wildlife Coordination Act, as amended, 16 U.S.C. §§ 661-666c (1970)
   f. Animal Damage Control on Federal Lands, Exec. Order No. 11870, 40 Fed. Reg. 30611 (July 18, 1975) as amended by Exec. Order No. 11917, 41 Fed. Reg. 22239 (June 2, 1976)
   g. Wild Free-Roaming Horses and Burros Act, as amended, 16 U.S.C. §§ 1331-1340 (1970 & Supp. 1979)
   h. Wild Free-Roaming Horses and Burros Protection Act, Management and Control, 43 C.F.R. §§ 4700.1-1-4760.2 (1978)
   i. Range Management – Management of Wild Free-Roaming Horses and Burros, 36 C.F.R. §§ 22.20-222.36 (1980)

4. Hydrology and Water Quality

   a. Rivers and Harbors Act of 1899 (Refuse Act) 33 U.S.C. §§ 401-413 (1970)
   b. Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977, 33 U.S.C. §§ 1251-1376 (Supp. 1979)
   c. EPA Administered Permit Programs: The National Pollutant Discharge Elimination System; The Hazardous Waste Permit Program; and The Underground Injection Control Program, 40 C.F.R. §§ 122.1-122.66 (1980)
   d. EPA General Provisions for Effluent Guidelines and Standards, 40 C.F.R. §§ 401.1-401.15 (1980)
   e. EPA Water Quality Criteria, 1976; Quality Criteria for H_2O, EPA No. 055-001-0149-4 (July 1976)
   f. EPA Toxic Pollutant Effluent Standards, 40 C.F.R. RR 129.1-129.105 (1980)
   g. Safe Drinking Water Act, 42 U.S.C. §§ 300f-300j-10 (1970 & Supp. 1979) (Underground Injection)
   h. EPA Underground Injection Control Program: Criteria and Standards, 40 C.F.R. §§ 146.1-146.52 (1980)

5. Land Use

   a. Federal Land Policy and Management Act of 1976, 43 U.S.C. §§ 1701-1782 (Supp. 1979)
   b. Special Land Use Permits, 43 C.F.R. §§ 2920.0-2-2923.4-2 (1978)

c. Leasing and Permitting, 25 C.F.R. §§ 131.1-131.20 (1980)
d. Wilderness Act of 1964, 16 U.S.C. §§ 1131-1136 (1970)
e. Prime and Unique Farmland, 7 C.F.R. §§ 657.1-657.5 (1980)
f. Wild and Scenic Rivers Act, as amended, 10 U.S.C. §§ 1271-1287 (1970 and Supp. 1979)
g. Coastal Zone Management Act of 1972, 16 U.S.C. §§ 1451-1464 (Supp. 1979)
h. National Forest Management Act of 1976, 16 U.S.C. §§ 1600-1676 (Supp. 1979)
i. U.S. Forest Service: Land Use 36 C.F.R. §§ 251.1-251.64 (1980)
j. U.S. Forest Services: Minerals, 36 C.F.R. §§ 252.1-252.15 (1980)
k. Protection of Wetlands, Exec. Order No. 11990, 42 Fed. Reg. 26961 (May 25, 1977)
l. DOE-Compliance With Floodplains/Wetland Environmental Review Requirements, 10 C.F.R. §§ 1022.1-1022.21 (1980)
m. Objects Affecting Navigable Airspace, 14 C.F.R. §§ 77.1-77.75 (1980)
n. Floodplain Management, Exec. Order No. 11988, 42 Fed. Reg. 26951, (May 25, 1977) as amended by Exec. Order No. 12148, 3 C.F.R. 418 (1979 compilation)
o. Use of Off-Road Vehicles on the Public Lands, Exec. Order No. 11644, 37 Fed. Reg. 2877 (Feb. 9, 1972) as amended by Exec. Order No. 11989, 42 Fed. Reg. 26959 (May 25, 1977)
p. Use of Motor Vehicles Off Forest Development Roads, 36 C.F.R. §§ 295.1-295.6 (1980)
q. Off-Road Vehicles (BLM) 43 C.F.R. §§ 6290.0-1-6295.3 (1978)

6. Noise

a. Noise Control Act of 1972, 42 U.S.C. §§ 4901-4918 (1970)
b. Noise Emission Standards for Construction Equipment, 40 C.F.R. §§ 204.1-204.59 (1980)

7. Waste Disposal

a. Resource Conservation and Recovery Act of 1976, 42 U.S.C. §§ 6901-6987 (Supp. 1979)
b. Solid Waste Disposal Act, as amended by Resource Conservation and Recovery Act, 42 U.S.C. §§ 6901-6987 (Supp. 1979)

8. Aesthetics

a. Visibility Protection for Federal Class I Areas, 40 C.F.R. § 51.302 (1980)

- Identifying species that migrate through the area but are not generally considered permanent residents. The importance of the area as a spawning and/or nursery ground is also addressed.
- Identifying, where possible, food chains and interspecific relationships of important species.

3.7.2.3 Climatology and Air Quality Studies. Local data on hydrocarbons, sulfur oxides, nitrogen oxides, carbon monoxide levels, particulates, and average wind speed and direction will be necessary to establish local baseline conditions. If these data are not available from the Air Quality Maintenance District (AQMD), periodic measurements will be made in order to establish background levels. Although onsite meteorological and air quality data are to be gathered during detailed site studies, meteorological towers may be erected at some locations prior to the detailed study phase. A minimum of one year of onsite meteorological air quality data will eventually be required to characterize the meteorology and air quality at potential sites. These data, along with long-term weather records, are needed to meet regulatory and licensing requirements. These data are also used in designing repository pollution control equipment and predicting air pollution dispersion.

One or more meteorological towers (typically 60m in height) will be needed to record the variability of meteorological conditions at candidate sites. It may also be necessary to establish several small climatological data stations to measure temperature, precipitation, and other parameters.

3.7.2.4 Cultural Resources Studies. Unique cultural resources are those resources that have significant scientific, education, historical, prehistoric, archaeological, architectural and/or recreational value and are judged worthy of preservation and/or study. These resources may have research value, cultural and historical significance, may be used in teaching aids for field studies, or may be of recreational value.

Cultural resource investigations begin with an analysis of available published and unpublished literature on known historical, scientific, and archaeological sites in the area. Local experts will also be consulted to locate potential cultural resources. Identified sites will be field verified.

Later (detailed site) phases will include the following activities:

- A field survey of probable areas of unidentified cultural resources. This is typically a walk-over survey but may include some non-intrusive instrument readings (e.g., magnetometer).
- Field verification of the location and extent of previously identified sites.
- Sampling of some sites to determine their archaeological value.

All action taken to identify archeological and historic resources is directed by a qualified archaeologist and coordinated with the state historic preservation officer.

3.7.2.5 Hydrology and Water Quality Studies. Data on hydrology and surface-water quality and quantity may be required to help screen from locations to sites. These data are generally available in the open literature. If these data are available, field studies will be necessary.

3.7.2.6 Background Noise and Radiation Studies. The extent and variation of background noise and radiation within a location will be determined. General information on background noise levels can be obtained by monitoring at selected locations on and around the site using portable or hand-held sound level meters. The intervals over which sound levels are monitored are dependent upon both the nature of the site and the nature of the activity which is to be carried out. Frequency and sound pressure level are the variables generally recorded for background noise studies.

General information on background radiation levels in the air will be obtained by placing air samplers and thermoluminescent dosimeters or pressurized ionization chambers at locations that are being monitored for meteorological and air-quality information. Information on radioactive levels in water will be obtained by analyzing ground water and surface waters that occur in or flow through the location and its environs. No radioactive materials are used or are on site during the siting process.

4.0 AFFECTED ENVIRONMENT

The shaded portions of Siting Plan Figure 5-5 indicate places in which DOE is currently conducting screening activities. Surveys at the Hanford Site, Nevada Test Site, Paradox Basin, Permian Basin, and Gulf Coast Salt Domes are in, or will soon be in, the location step of the screening phase. Regional studies have been performed in the Salina Basin. The environmental characteristics of these six major regions are summarized in Table 4-1. Detailed description of the environments of most of these regions have been documented in characterization and recommendation reports.[29-33] In addition, DOE is beginning regional surveys in the USGS Province 9, the Lake Superior region, and the Appalachian region shown in Siting Plan Figure 5-5. These regions display a wide range of environments, from the arid environments of Hanford and Nevada to the humid Gulf Coast.

Potentially sensitive issues in an arid or semiarid habitat, such as those found in the Paradox, Permian, Hanford, and Nevada regions include: (1) the fragile nature of the soil and its susceptibility to erosion by wind or water, (2) the potential lack of revegetative capacity of the area due to infrequent rainfall, (3) the visual impact of equipment in areas where there are few trees or hills, and (4) water consumption in areas with little water.

Potentially sensitive issues in a wet, poorly drained environment such as is found in portions of the Gulf Coast, Lake Superior, the northern and southern Appalachian regions include: (1) the potential for wind or water erosion of disturbed, uncovered ground or spoil piles; (2) the effects of fugitive dust on a large variety and number of organisms, including threatened or endangered species or their habitat; (3) nearness of the water table to the surface, making construction more difficult; and (4) the saturated nature of the soil in lowland areas, necessitating the use of fill materials (for road construction, etc.) that can result in changing water courses or drying up of water bodies.

Potentially sensitive issues in wet, well drained environments, such as may be found in portions of the Salina, Lake Superior, and northern and southern Appalachian regions, include: (1) the potential for wind or water erosion of disturbed, uncovered ground or spoil piles (2) contamination of nearby streams from construction runoff, and (3) the effects of fugitive

TABLE 4-1. SUMMARY OF ENVIRONMENTAL CHARACTERISTICS OF GEOLOGIC REGIONS CURRENTLY IN THE SCREENING PHASE

Characteristic	Hanford Reservation	Nevada Test Site	Paradox Basin	Permian Basin	Salina Basin	Gulf Coast Region
Geologic Medium	Flow basalt	Welded tuff	Bedded salt	Bedded salt	Bedded salt	Domal salt
Location	SE central Washington	Southern Nevada	Southeastern Utah	Texas panhandle	Michigan, Ohio New York	Texas, Louisiana, Mississippi
Physiographic Designation	Columbia Plateau	Basin and Range	Colorado Plateaus	Great Plains	Central Lowlands	Gulf Coastal Plain
Land Surface Form	Gently sloping plains and tablelands	Plains with low mountains	Rugged tablelands	Smooth plains	Smooth to gently rolling plains	Irregular plains
Surface Soils	Sand and cobble	Sand and cobble	Rocky/clay	Silts/clay	Loams	Sands/clays
Precipitation	5-8 in.	4-10 in.	8-16 in.	16-30 in.	30-40 in.	45-60 in.
Runoff	< 1 in.	< 1 in.	1 in.	1 in.	10-20 in.	10-20 in.
Flooding	None	None	Cloudburst, lowland flooding infrequent	Spring and summer minor flash floods	Spring and summer minor flash floods frequent	Heavy lowland flooding frequent
Surface Water Availability	Poor	Poor	Poor	Intermittent streams and ponds	Good	Very good
Vegetation	Shrub steppe	Desert-shrub/ shrub-steppe	Blackbrush Juniper-pinyon	Grasslands	Oak, hickory, beech, maple	Southern mixed forest
Game Animals	Few	Few	Furbearers Big and small game	Several kinds	Deer, small game, fishing	Furbearers, deer, small game, fishing
Threatened and Endangered Species	Few transient	Few state listed	Some listed	Few listed	Few listed	Several listed
Air Pollution Potential	Moderately low	Moderate	Moderate	Low	High	Moderate
Winds (mi/hr)	6-9 Frequent dry gusts	8 Monthly dry gusts	9-16 Infrequent gusts	10-20 Dry gusts in summer	10 Gusts with rain	7 Gusts with rain
Land Use	Controlled access	Controlled access	Mostly federal, limited use	50-60 percent irrigated crop lands	Numerous potential conflicts	Mostly scattered forest/croplands
Transportation	Adequate	Adequate	Limited	Good	Very good	Good
Population Density/ sq mi	0	0	5	10 Scattered small urban areas	100 Major urban areas	50 Several small urban areas
Cultural Resources	Localized	Localized	Several designated tribal areas	Some designated areas	Several designated areas	Some designated areas

dust on a large variety and number of organisms, including threatened or endangered species or their habitat.

When field work is being planned in any of these types of environments, sensitive areas are avoided through application of the site performance criteria (Appendix A of the Plan). Additionally, environmental checklists are used to assure that specific environments and their biota will not be adversely affected by activities such as borehole drilling. If the environmental checklist should indicate a potential environmental problem at a site where field activities are scheduled, the activities will be moved to a different site, or a NEPA review will be conducted to determine if the impacts are significant and if mitigation measures are appropriate.

5.0 ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION AND ALTERNATIVES

This section presents an assessment of the environmental impacts which may result from implementing the proposed action or alternatives to it. The field activities which may result in potential environmental impact were described in Chapter 3. Although the same field activities must be conducted under each alternative, differences in environmental impact may be realized because the number, location, and intensity of the field activities required under each alternative is different. The potential environmental impacts that may result from conducting field activities are discussed in this chapter and are summarized in Table 5-1 (see Page 40 of this EA).

Future activities that would result from implementation of the proposed action would include environmental baseline surveys, constructing an exploratory shaft, testing at-depth, taking land protection measures, and site selection. Impacts of these activities will be evaluated at each individual site in subsequent site-specific environmental documents. (The NEPA implementation plan for these activities is discussed in Section 4.5 of the Plan.) A brief discussion of probable activities and potential impacts is provided below.

Potentially significant socioeconomic impacts may result from the influx of workers to a site undergoing detailed site studies. Environmental impacts may be expected during detailed site studies in the areas of air quality and noise (from vehicles), water quality and quantity (from equipment operation and transportation and runoff from spoils piles), solid waste (spoils disposal), energy (equipment fuel and transportation needs), and land use (restriction on uses).

Undertaking land protection measures and site selection activities may have many environmental impacts; one impact of which is on land use. An interest in the land may be acquired via lease, purchase, or land withdrawal for purposes of protecting the integrity of the potential site. Site selection will involve acquiring full ownership of a site. Land use conflicts will be minimized through use of the screening criteria, but the potential exists for temporary or permanent loss of a resource (i.e., grazing or farm land) and

a change in land use. Suitable sites not selected for the first repository site may be retained for consideration for future repository sites. Maintaining these sites may also result in a temporary or permanent loss of a resource, changes in land use, and other possible socioeconomic impacts to nearby residents.

Construction and operation of a test and evaluation facility is considered an engineering development step and not a siting step. Impacts of construction and operation of the facility are expected to include the types of impacts listed in the previous two paragraphs, plus additional impacts due to transportation, emplacement, and retrieval of several hundred canisters of radioactive wastes.

Generic impacts of constructing and operating a repository were examined in the Final Environmental Impact Statement: Management of Commercially Generated Waste.(21)

5.1 Impacts of Field Activities Common to the Proposed Action and Alternatives

This section describes the potential impacts that may result from the types of field activities common to all the alternative siting strategies analyzed in this EA. Many of these field activities have previously been evaluated and have been found to result in no significant environmental impact.(3-15)

5.1.1 Air Quality

Emissions from internal combustion engines used in the variety of screening activities will not be significant. All vehicle and stationary engines will comply with applicable federal and state emission control laws.

Most exploratory activities are anticipated to occur in rural areas. Except for occasionally exceeding particulate and hydrocarbon standards, these areas have clean air. Even in nonattainment areas, the emissions from exploratory activities would represent only a small increase over background levels and normally would not be large enough to trigger new source review. Because of the small overall size of the deep drilling operation and resultant emissions (SO_X, NO_X, CO, and particulate emissions of less than 50 tons per year), certification under the Clean Air Act of 1977 will not be required.

Fugitive dust will be controlled by the use of sprinklers or water trucks. Any open burning at the drill site will conform to local regulations.

5.1.2 Hydrology and Surface Water Quality

For deep drilling operations, a water source is required to supply water for drilling fluids, fugitive dust suppression, potable water, and revegetation. Water demands are low, typically less than 5 gpm with instantaneous peaks of up to 10 gpm for brief periods. These water requirements are primarily limited to the duration of the drilling activity; however, additional water is sometimes needed for revegetation subsequent to termination of the testing operations.

Even if water requirements are small, they may in some cases influence the quantity and quality of water available for other uses. To meet water demands, water rights can be acquired or water can be purchased elsewhere and transported (by pipeline or tanker) to the site.

In arid areas, the use of water necessary for wildlife and aquatic species survival should be avoided. Activities that can affect surface-water quality include site clearing, grading, filling, and pit excavation. These operations may alter site drainage patterns and increase erosion rates. To reduce the degree of such impacts, contractors are required to use approved construction practices, including proper soil compaction, reseeding, and proper slope design during site preparation activities. Care will be taken to ensure that access roads follow the contour of the land whenever practicable and that steep roadway cuts or rechanneling or diverting of streams are avoided or kept to a minimum. Road culverts can be used to maintain flows at creeks and major drainage crossings.

Cleared areas susceptible to erosion can be properly graded, stabilized and reseeded as rapidly as possible. Terraces and water barriers such as hay bales can be placed at strategic locations when required. Buffer strips of vegetation can be left along waterways whenever feasible. Even with implementation of these measures, some temporary increases in sediment load and turbidity in site surface waters are unavoidable during construction. However, these increases are not likely to be significant. Proper care during construction and operation can assure that siltation will be temporary and turbidity levels within acceptable limits.

Liquids used during and resulting from the exploration activities can be characterized as sanitary wastes, diesel fuel, lubricating oils, and drilling fluids. Drilling fluids contain weighting agents and viscosifiers, dispersants, fluid loss reducers, defoamers, flocculants, and bacteriocides. These liquids will be carefully controlled and disposed of properly. Management and disposal of these liquids will be in compliance with applicable regulations and good construction practices.

Exploration sites are selected and designed to minimize the possibility of damage from flooding. Storage pits will be sized to allow for the receipt of a 24-hour, ten-year frequency rainfall without overtopping.

Any changes in local water drainage, water quality, and/or water quantity caused by exploratory activities will be short-term and largely remedied by regrading and revegetating. The activity should not result in significant or long-term adverse impacts to local hydrology or the quality of the water.(3-15)

5.1.3 Ground-Water Quality

In areas of highly porous soil, pit seepage or accidental spills of liquids are more likely to affect shallow ground-water aquifers than surface waters. Infiltration is prevented by lining pits or storing liquid wastes in covered containers. Any accidental spills are anticipated to be of small volume and to have insignificant effects on the ground water.(3-15)

Deeper ground-water impacts could occur during the course of borehole drilling if several different water-bearing or hydrocarbon-bearing strata are penetrated. Significant adverse impacts could result if hydraulic connections between different strata occur. Freshwater aquifers could be contaminated by infiltration of hydrocarbons or saline water through the borehole. The potential for these adverse effects to occur is greatly reduced by proper drilling techniques. Drilling, casing, and plugging techniques are designed and performed to minimize the potential for contamination of water-bearing strata from petroleum and natural gas reservoirs or salt deposits. Borehole plugging and capping techniques are designed to minimize contamination of the subsurface resources by inadvertent surface drainage into the borehole and

transmission of water between different water bearing units. In addition, applicable federal and state standards and regulations are designed to prevent contamination of potable subsurface water supplies and other resources.

5.1.4 Land Use

Borehole drilling activities require the commitment of from 1 to 13 acres of land for several months or longer. This land is cleared of all vegetation, the topsoil may be removed and stockpiled, and a level drilling site is constructed.

At the end of the drilling operation and associated geophysical activities, the area will be restored to its former use to the extent allowed by law, unless the landowner's agreement specifies otherwise. All decommissioning activities will be in compliance with applicable regulations and permit requirements.

The clearing of site and access road areas and digging of the required pits necessitate a limited amount of grading, excavation (possibly blasting), and in some cases, filling. Construction activities themselves are not large-scale; the drilling rig or platform is delivered to the site in preassembled modules requiring final assembly on site.

Construction of a meteorological tower for gathering meteorological and air quality data is not required during the screening phase. However, due to timing considerations, one or more such towers may be constructed prior to the start of the detailed site study phase. This is the only environmental characterization activity which requires the dedication of any quantity of land. Erecting a meteorological tower would involve the clearing and leveling of approximately one acre of land. An electrical power source and periodic access for maintenance and repair are also required. The area taken up by the tower, including guys and appurtenant facilities, is fenced, thus removing the land from alternative land uses from one to several years.

The potential impacts of these and other characterization efforts on land use include farm land diversion and soil erosion.

Good construction practices can prevent or mitigate these impacts.[34-35] Therefore, the impacts of characterization activities on land use are expected to be minimal.

5.1.5 Terrestrial and Aquatic Ecology

Drilling rigs and other geologic and geophysical activities may have an adverse effect on the local terrestrial and aquatic ecosystems. These impacts are limited to the site of the activity, access roads, and their immediate vicinity.

These adverse effects can be minimized by using existing roadways whenever possible; limiting any filling, grading, and clearing to the extent required for the characterization activity; and by prohibiting unnecessary driving over the terrain.

Wildlife in the area may be affected or have their behavior modified by vegetation removal, increased vehicle traffic, noise, lights, water use, and the continual presence of people in the area. Animals that are displaced by habitat destruction are normally lost because similar nearby habitats are usually filled and suitable territories are unavailable. Increased traffic in the area will also take its toll of wildlife. Animal population numbers should return to normal levels after the activity has ceased and the area is restored.

Restoration of any disturbed area by grading, ensuring proper drainage, and reseeding will accelerate the return of the area to its former condition. In some areas however, the changes resulting from the geologic exploratory and other screening activities can be long lasting. For example, as the result of clearing and restoration, and at the landowner's request, former rangeland and forestland may be converted to cropland. Heavy equipment operation can result in long-lasting changes in the surface characteristics of certain desert soils.

Impacts on aquatic ecosystems or specific aquatic biota may be caused by changing watercourses or by accidentally discharging sediment or harmful chemicals into existing surface waters. Impacts are typically greater in wet environments such as the Gulf Coast Region because of the greater potential for erosion and the increased variety and extent of surface waters.

Implementation of the erosion control measures discussed previously will greatly reduce the erosion potential. The site and access road selection will be made to minimize possible impacts to aquatic resources.

5.1.5.1 Rare, Endangered, and Protected Species. Early characterization of the region and area will indicate the possible presence of rare, threatened, or endangered species or their habitat. Federal and state wildlife authorities will be contacted prior to any activity that could affect these species.

If a protected species lives in a proposed drill site or in the vicinity of other planned activities, the recommendations of the U.S. Fish and Wildlife Service(36) will be followed. Modifications of the activities, timing, or location are all possible mitigative measures.

5.1.6 Socioeconomics

Almost every aspect of the siting process will utilize the data, advice, and expertise of regional and state agencies and organizations to characterize the location.

County and community government agencies may be unable or unwilling to meet the additional demand on their time that these data gathering efforts might involve. Local regulations or practices may limit access to files or official records. Grants to states for disbursement to government agencies and institutions are already anticipated (see Section 3.1.2 of the Siting Plan). Proper timing of these grants could mitigate many of the difficulties.

Officials of local and regional special interest groups are also anticipated to be a good source of information. However, providing data, answering questions, reviewing documents, and attending meetings may all take time away from their other obligations. Hiring local people to assist in the screening efforts could reduce these impacts and help to integrate the characterization force into the local community.

Additional business will be generated by geologic and environmental screening activities. The socioeconomic impacts of screening activities should be short-lived and to a large extent can be mitigated. With proper planning, overall impacts should be small and acceptable.

5.1.7 Aesthetics

The degree of undesirable aesthetic effects from drilling activity is dependent on the number of people who may view the activity, the duration of the activity, and the nature of the activity itself. Because exploration activities are usually located in sparsely populated areas, the potential for affront to large numbers of people is small. Similarly, the limited duration of exploration activities should not make aesthetic concerns a major issue.

There may be cases in which maintenance of an uninterrupted view is an overriding concern. Thus, where there is judged to be a scenic resource, recreational area, or historically significant landmark that would visually interact with the drilling operation in an adverse manner, efforts are made to minimize the aesthetic effects by carefully planning the location of equipment and activities.

The flexibility of siting and preplanning should avoid most aesthetic impacts. Any unavoidable impacts should be of short duration, and small.

5.1.8 Cultural Resources

Prior to the initiation of any ground disturbing activities, a qualified archaeologist will determine the need for an onsite cultural resources survey. Because of the flexibility of the siting process and of the geological and environmental exploratory activities, damage to significant historical or archaeological sites identified during planning will be avoided or mitigated.

If such sites or artifacts are encountered during screening activities, the following steps will be taken:(37,38)

- All activities involving ground disturbance of the cultural site will cease
- The find will be reported to the state historic preservation officer or equivalent authority to determine its significance
- No additional work will be performed at that cultural site without the clearance of the U.S. National Park Service or the state historic preservation officer.

The impacts of cultural resources surveys are primarily related to sampling of identified sites. This involves minor disturbances of ground cover and wildlife. Identification and open publiciaton of the location of archaeological sites has the beneficial impact of expanding knowledge in this field, but also could result in destruction of the site by artifact hunters.

Most adverse impacts on cultural resources from siting activities can be avoided or mitigated. The unavoidable adverse impacts are expected to be small. Some impacts (e.g., discovery and preservation) may be beneficial.

5.1.9 Noise and Radiation

The major source of noise during the characterization phases will be deep drilling. Sound above ambient level is associated with most aspects of the site preparation and drilling operations. Field measurements near large operating drill rigs in the NWTS program indicate that noise levels at 1 meter from the source average 100 to 200 dB(A). Field measurements, however, indicate a rapid attenuation with distance resulting in noise levels of 70 dB(A) at 100 to 150 meters. Exceptions to this level do occur, particularly in arid, sparsely vegetated locations.

Should unacceptable noise levels be observed, a number of mitigative measures are available to reduce the levels to meet state and EPA gudielines. Muffling systems can be upgraded to reduce noise, baffles can be added to absorb much of the noise produced, or an insulated building can be constructed around the primary noise-producing equipment.

Field sampling techniques for assessing ambient noise levels and background radiation are not expected to have adverse environmental impacts. Sampling for background radiation levels involves no use of radioactive materials.

5.2 Impacts of the Proposed Action

Implementation of the proposed site screening phase of the Plan will result in the impacts of field activities (as described in Section 5.1) being experienced at up to 10 locations before October, 1983. Activities to take

place in the detailed site study phase will impact three potential sites in fiscal years 1984 and 1985. The impacts of these activities will be evaluated on a site-specific basis when knowledge of the planned activities and sites are more specific. Siting costs through site selection under the proposed Plan are estimated at 1.8 billion dollars for fiscal years 1981 to 1987.

5.3 Impacts of Alternative 1: No Action - Siting Without A Plan

Considering the need for and complexity of coordinating technology development, site selection studies, institutional frameworks, the cost of the program, and the degree of public sensitivity and controversy surrounding the siting process and decisions, DOE does not consider this alternative to be reasonable.

5.4 Impacts of Alternative 2: Choose the First Site Now

Although the first site chosen would be the subject of intense characterization efforts, that site would not be ready for submission to NRC licensing procedures any earlier than the first site to be chosen using the proposed Plan. Choosing a site for exploratory shaft construction is on the critical path under the proposed Plan.

This scenario, however, conflicts with current NRC regulations,[22] which require that at least three sites in two media be characterized before DOE applies for a construction authorization. If NRC regulations were changed, this alternative would assume the risk that if subsequent investigations showed the site to be unacceptable, the search for other suitable sites would have to be restarted. Interim changes could reduce the number of available suitable sites in a region. For example, potential repository locations might become unavailable because of change in land uses. Assuming a change in NRC requirements, and that the selected site would be shown to be suitable, this alternative would result in the same type of impacts as those discussed for the proposed Plan; however, the impacts would occur in only one area instead of many (see Table 5-1). If investigation of other sites were stopped or delayed under this alternative, it would result in lower costs for the

siting portion of the NWTS program in the near term. Costs of siting through 1987 would be approximately 1/3 of projected siting costs under the proposed plan, or about $600 million. DOE would, however, lose the ability to compare potential environmental impacts at various sites to the same degree in making site selection decisions.

5.5 Impacts of Alternative 3: Siting Within Predetermined Regions

This alternative would require the same activities as described for the proposed Plan. The impacts from these activities would again be of the same type for this alternative as was described for the proposed Plan. Under this alternative, however, more sites may have to be investigated, resulting in an increase in the costs and in the number of sites where impacts would be expected (see Table 5-1). A potential benefit of the regionalization alternative is a perceived increase in equity resulting from each region accepting the benefits and risks associated with nuclear power generation and waste disposal.

Because of the nature of this alternative, it is appropriate to discuss potential repository operation phase impacts. Under this alternative, a potential decrease in transportation impacts could be expected if several repositories were begun nearly simultaneously(39), as transportation distances and associated impacts on the public would be expected to decrease. Operation of regional repositories over time would not change transportation impacts from those expected for the proposed action. In any case, the expected radiological impacts to the public from transporation would be very low and the expected radiological impacts would be exceeded in magnitude by the non-radiological impacts (i.e., the normal accidents and injuries that would occur whether or not a radioactive material is being hauled). In effect, regionalization would reduce the already very low impacts to even lower levels.

5.6 Impacts of Alternative 4: Judging Site Suitability Earlier in the Siting Process

This alternative requires that activities similar to those in the proposed Plan be conducted, but is different in an important respect: the

Table 5-1. Comparison of the Potential Impacts of Alternatives Relative to Impacts of the Proposed Action

Type of Impact	Alternative 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Air Quality	NA	-	+	+	0
Hydrology and Surface Water Quality	NA	-	+	+	0
Ground-water Quality	NA	-	+	+	0
Land-Use	NA	-	+	+	0
Socioeconomic	NA	-	+	+	0
Terrestrial & Aquatic Ecology	NA	-	+	+	0
Aesthetics	NA	-	+	+	0
Cultural Resources	NA	-	+	+	0
Noise and Radiation	NA	-	+	+	0
Transportation*	NA	0	Δ	0	Δ

Key + Additional impacts of this type are anticipated due to activities being carried out at more sites.

- Fewer impacts of this type are anticipated due to activities being carried out at fewer sites.

0 no difference in impacts of this type are anticipated

Δ Fewer impacts are anticipated because transportation distances may decrease.

* Applicable only after site selection phase.

suitability determination at each potential site would be made earlier, perhaps without data which can be obtained by constructing at-depth exploratory shafts.

These changes would not result in substantial differences in the time necessary to select a repository for licensing proceedings, but would affect the number of locations which would be characterized in detail. From 5 to 10 locations would be studied in the next two years, and an as yet undetermined number of locations would be studied in the following years. All of these locations would experience the impacts of the activities described in Chapter 3. Additionally, more boreholes, trenching, and seismic tests would be required and a complete environmental baseline survey would be done at each location. On the other hand, an exploratory shaft would not be constructed at each site; only at those sites which could not be determined to be suitable from surface studies.

It is difficult to determine whether costs would increase or decrease under this alternative, because the number of sites at which an exploratory shaft would be necessary is unknown. NRC regulations now require construction of exploratory shafts and at-depth testing at all potential repository sites before suitability can be determined.(22)

5.7 Impacts of Alternative 5: Providing More Alternative Sites for the First Selection Decision

The advantages of this alternative include the potential of finding a site closer to the source of waste and therefore reducing the transporation impact, and of making available additional alternative sites and rock types from which the site selection could be made. Alternative 5 however, could result in a delay of the siting decision. Such a delay could result in increased impacts of interim radioactive waste storage. For example, it places some burdens on utilities to rerack storge pools, build additional facilities, or ship wastes to storage facilities other than utility fuel pools. These wastes would then be shipped twice under this option.

While this alternative does not increase environmental impacts or overall siting costs relative to the proposed action, (because the exploration of other media is planned under the proposed action) the environmental impacts and incurred costs may occur sooner. If selection of the first site was delayed, the impacts of increasing storage requirements and time would increase.

6.0 CONCLUSIONS

Five alternatives to the proposed action have been evaluated. None were found to offer a more reasonable approach for finding repository sites or a significant reduction in environmental impact.

- No Action - Proceeding without a plan, Alternative No. 1, is not cosidered appropriate in that siting a repository is a complex process requiring a systematic approach in order to find an acceptable site. Proceeding without a plan would also make it difficult for DOE to comply with NRC licensing requirements. The lack of a plan may result in a lack of alternatives being available for comparison, and may not provide the reasonable assurance of safety NRC requires to issue a construction authorization and license to operate.
- Choosing the first site now, Alternative No. 2, would perhaps yield fewer impacts on the environment and cost less, because fewer sites would undergo detailed site characterization. However, this immediate benefit may be negated by potential program delays, if the site is not found to be acceptable and time is lost in identifying a second viable alternative.
- Dividing the country into service regions before starting the characterization process, Alternative No. 3, would result in additional environmental impact, because more sites would need to be identified prior to site selection than in the proposed action. Transportation of waste during repository operation, however, may be lessened under this alternative, assuming simultaneous operation of regional repositories. The near-term additional cost and impacts of characterizing additional sites and simultaneously constructing regional repositories do not appear warranted at the present time.
- Alternative No. 4, judging site suitability earlier in the siting process, will likely result in environmental impacts being experienced at more sites than would be expected under the proposed action, and would not adequately respond to the requirements for in situ testing in 10 CFR 60.

- Delaying the decision of the first site selection until a site in granite or other rock type is available, Alternative 5, will not result in impacts being experienced at fewer or more sites than is anticipated under the proposed Plan. However, impacts resulting from increased storage requirements at reactor sites and away from reactor facilities is potentially increased. On the other hand, the location of an eventual site closer to a source of waste would reduce the potential transportation impact.

The proposed Plan places a high priority on technical considerations, and encourages public or state involvement in information collection, analysis, and reporting. While other approaches are available, none result in a significant reduction of environmental impacts.

7.0 REFERENCES

1. U.S. Department of Energy, 1980. "Compliance with the National Environmental Policy Act: Final Guidelines", Federal Register, Vol. 45: 20694-20701, March 28.

2. Council on Environmental Quality, 1978. "National Environmental Policy Act, Implementation and Procedural Provisions, Final Regulations", Code of Federal Regulations, Title 40, Part 1500, Federal Register, Vol. 43: 55987-56007, November 29.

3. U.S. Department of Energy, 1979. Environmental Assessment, Borehole Drilling, Cypress Creek Salt Dome, Perry County, Mississippi, DOE/EA 0080, March.

4. U.S. Department of Energy, 1979. Site-Specific Environmental Evaluation for Borehole Drilling, Regional Hydrology Program, Southeast Mississippi, Boring Site MH-5, DOE-RL-C-3, June.

5. U.S. Department of Energy, 1979. Site-Specific Environmental Evaluation for Borehole Drilling, Regional Hydrology Program, Southeast Mississippi, Boring Site MH-4, DOE-RL-C-4, June.

6. U.S. Department of Energy, 1979. Site-Specific Environmental Evaluation for Borehole Drilling, Regional Hydrology Program, Southeast Mississippi, Boring Site MH-6, DOE-RL-C-5, June.

7. U.S. Department of Energy, 1979. Site-Specific Environmental Evaluation for Borehole Drilling, Regional Hydrology Program, Southeast Mississippi, Boring Site MH-7, DOE-RL-C-6, June.

8. U.S. Department of Energy, 1979. Site-Specific Environmental Evaluation for Borehole Drilling, Oakwood Salt Dome, Freestone and Leon Counties, Texas, Boring Sites TOG-1, TOH-2, TOH-3, TOH-4, TOH-5, DOE-RL-C-7, June.

9. U.S. Department of Energy, 1979. Site-Specific Environmental Evaluation for Borehole Drilling, Richton Salt Dome, Perry County, Southeast Mississippi, Boring Site MRIG-9, MROG-10, MRIH-11, DOE-RL-C-8, June.

10. U.S. Department of Energy, 1979. Site-Specific Environmental Evaluation for Borehole Drilling, Regional Hydrology Program, Marion County, Mississippi, Boring Site MH-8, DOE-RL-C-9, July.

11. U.S. Department of Energy, 1979. Site-Specific Environmental Evaluation for Borehole Drilling, Gibson Dome, San Juan County, Utah, Boring Site GD-1, and GD-2, DOE-RL-C-10, August.

12. U.S. Department of Energy, 1979. Site-Specific Environmental Evaluation for Borehole Drilling, Elk Ridge, San Juan County, Utah, Boring Sites ER-1, and ER-2, DOE-RL-C-11, August.

13. U.S. Department of Energy, 1979. Site-Specific Environmental Evaluation for Borehole Drilling, Regional Hydrology Program, Webster and Bienville Parishes, Louisiana, Boring Sites LH-2 and LH-8, DOE-RL-C-12, July.

14. U.S. Department of Energy, 1980. Site-Specific Environmental Evaluation for Borehole Drilling, Regional Hydrology Program, Northwest Louisiana, Boring Sites LVH-6, LH-7, LRH-13, LH-17, DOE-RL-C-13, January.

15. U.S. Department of the Interior, Bureau of Land Management, 1981. Environmental Assessment; Proposed DOE Exploration Program in the Elk Ridge Area, San Juan County, Utah, April.

16. McPherson, R. B., D. A. Waite, D. B. Shipler, and M. A. Glora, 1980. Estimated Environmental Effects of Deep Drilling, ONWI-13, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, December.

17. McPherson, R. B., D. A. Waite, D. B. Shiper, and M. A. Glora, 1980. Estimated Environmental Effects of Geologic and Geophysical Exploratory Activities, ONWI-105, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, December.

18. Federal Register Vol. 46, No. 39, February 27, 1981, p. 14377.

19. Pierce, W. G., and E. I. Rich, 1962. "Summary of Rock Salt Deposits in the United States as Possible Storage Sites for Radioactive Waste Materials", USGS Bulletin 1148.

20. U.S. Nuclear Regulatory Commission, 1980. In the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste (Waste Confidence Rulemaking, PR-50, (44 FR 61372), Statement of Position of the United States Department of Energy, DOE/NE-007, Washington, D.C., April.

21. U.S. Department of Energy, 1980. Final Environmental Impact Statement: Management of Commercially Generated Waste, DOE/EIS-0046-F, Washington, D.C., October.

22. U.S. Nuclear Regulatory Commission, 1981. "Disposal of High-Level Radioactive Wastes in Geologic Repositories--Licensing Procedures", Code of Federal Regulations, Title 10 Parts 2, 19, 20, 21, 30, 40, 51, 60, and 70. Federal Register Vol. 46, p. 13971-13987.

23. U.S. Nuclear Regulatory Commission, 1980. "Technical Criteria for Regulating Geologic Disposal of High-Level Radioactive Waste", (Proposed 10 CFR Part 60), Federal Register, Vol. 45: 31393-31408, May.

24. Office of Nuclear Waste Isolation, 1981. NWTS Program Criteria for Mined Geologic Disposal of Nuclear Waste: Site Performance Criteria, NWTS-33(2), Battelle Memorial Institute, Columbus, OH, February.

25. International Atomic Energy Agency, 1977. Site Selection Factors for Repositories of Solid High-Level and Alpha-Bearing Wastes in Geologic Formations, Technical Report No. 177, Vienna, Austria, October.

26. Brunton, G. E., and W. C. McClain, 1977. Geologic Criteria for Radioactive Waste Repositories, Union Carbide Corporation-Nuclear Division, Office of Waste Isolation, Y/OWI/TM-47, Oak Ridge, TN, November.

27. National Research Council/National Academy of Sciences, 1978. Geologic Criteria for Repositories for High-Level Radioactive Waste, Washington, D.C., August.

28. U.S. Department of Energy, 1981. "Program of Research and Development for Management of Commercially Generated Radioactive Waste; Record of Decision", Federal Register Vol. 86:26677-26679, May.

29. Battelle Project Management Division, 1979. Summary Characterization and Recommendation of Study Areas for the Gulf Interior Region, ONWI-18, Battelle Memorial Institute, Columbus, OH, May.

30. NUS Corporation, 1978. Regional Report: Environmental Characterization of Bedded Salt Formations and Overlying Areas of the Permian Basin, Y/OWI/SUB-78/42505/1, Office of Waste Isolation, Union Carbide-Nuclear Division, Oak Ridge, TN, February.

31. NUS Corporation and Office of Nuclear Waste Isolation, 1979. Environmental Characterization of Bedded Salt Formations and Overlying Areas of the Salina Basin, ONWI-16, Battelle Memorial Institute, Columbus, OH, September.

32. Bechtel National, Inc., 1980. Regional Environmental Characterization Report for the Paradox Bedded Salt Region and Surrounding Territory, ONWI-68, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, November.

33. Bechtel National, Inc., 1980. Regional Environmental Characterization Report for the Gulf Interior Region and Surrounding Territory, ONWI-67, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH, November.

34. U.S. Nuclear Regulatory Commission. Environmental Standard Review Plans for Light Water Reactor Construction Permit Review, Washington, D.C., 1978.

35. U.S. Environmental Protection Agency, 1973. Process, Procedures, and Methods to Control Pollution Resulting from Construction Activity, EPA 430/9-73-007, October.

36. U.S. Fish and Wildlife Service, 1980. "Endangered and Threatened Wildlife and Plants, Annual Publication", Code of Federal Regulations, Title 50, Part 17 Federal Register, Vol. 45:33768-33781, May.

37. Historic Preservation Act, 1966, 16 U.S.C. 470 et. seq.

38. Advisory Council on Historic Preservation, Procedures for the Protection of Historic and Cultural Properties, 36 CFR 800.

39. Kirby, I.D., W. J. Elgin, W. Mitchell, III, S. E. Turner, and R. P. Hancock, 1979. Evaluation of the Regional Repository Concept for Nuclear Waste Disposal, Southern Science Applications, Inc., Dunedin, FL, October.

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