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Site Characterization Handbook

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1.0 OVERVIEW

1.1 Introduction

The Low-Level Radioactive Waste Policy Amendments Act of 1985 (the Act) requires the Department of Energy (DOE) to provide technical assistance to "...those compact regions, host States and nonmember States determined by the Secretary to require assistance" in fulfilling their responsibility under the Act.¹ In accordance with the requirements of the Act, the "Site Characterization Handbook" was developed to assist host States in developing and implementing comprehensive site characterization programs to support the licensing of low-level radioactive waste (LLW) disposal facilities.

Site characterization is part of a continuum of activities to select a preferred site for licensing. It is preceded by efforts to select one or more candidate sites for detailed investigation. Those efforts are generally expected to rely on existing data, paper studies, and limited onsite reconnaissance work, as discussed in DOE/LLW-64T, Site Selection Handbook-Workshop on Site Selection for Low-Level Radioactive Waste Disposal Facilities.² Detailed investigations will then be conducted at each candidate site during site characterization to verify site conditions, to support or confirm the selection of a preferred site for licensing, and to provide information required for licensing of a disposal facility at that site. The precise point on the continuum where site characterization officially begins may vary from one State's approach to another's, as discussed in Section 3.3. However, a common assumption under all approaches is that it cannot begin in earnest until site access has been granted and a reasonable degree of community willingness to let characterization commence has been achieved.

Site characterization activities comprise one of the most important steps in preparing a disposal facility license application and are critical elements in the schedule to meet the following milestones set forth in the Act:

January 1, 1990

- Complete license application filed, or
- State certifies to the NRC that it will provide for LLW storage, disposal, or management, and describes actions to be taken.

January 1, 1992

- Complete license application filed.

This Handbook discusses both management and technical elements that should be considered in developing a comprehensive site characterization program. Management elements typical of any project of a comparable magnitude and complexity are combined with a discussion of strategies specific to site characterization. Information specific to the technical elements involved in site characterization is based on guidance published by the Nuclear Regulatory

Commission (NRC) with respect to licensing requirements for LLW disposal facilities.

The Handbook is intended to supplement the Site Characterization Field Manual for Near Surface Geologic Disposal of Low-Level Radioactive Waste³, prepared for the National Low-Level Waste Management Program by the University of Arizona, to reflect the large body of regulatory guidance issued by the U.S. Nuclear Regulatory Commission since the publication of that manual.

1.2 Objective

The objective of this Handbook is to provide a reference for both NRC Agreement States and non-Agreement States for use in developing a comprehensive site characterization program that meets the specific objectives of the State and/or site developer/licensee. Each site characterization program will vary depending on the objectives, licensing requirements, schedules/budgets, physical characteristics of the site, proposed facility design, and the specific concerns raised by government agencies and the public. Therefore, the Handbook is not a prescriptive guide to site characterization.

1.3 Handbook Organization

The following four sections of the Handbook discuss objectives of a site characterization program, management planning and technical strategies, a summary of data required to support the license application and activities for collecting the necessary data, and elements of a quality assurance/quality control program.

Appendix A describes the technical data types and parameters necessary during site characterization that were identified as a result of an analysis of the NRC LLW disposal regulatory requirements and guidance. This appendix consists of eighteen matrices based on the major disciplines or data types involved in a site characterization program. Each matrix contains quotations from NRC guidance documents relevant to each specific data type. Each data type is further divided into a number of specific elements or technical parameters that are fully described on the matrix attachments. The technical parameters that are explicitly or implicitly referenced in the NRC guidance documents are identified. These matrices can be used to help identify the data and analyses required to comply with requirements for the Safety Analysis Report (SAR) and Environmental Report (ER), which together comprise the facility license application.

Appendix B consists of eighteen tables that are also broken down into the technical parameters for each data type. For each technical parameter, the tables identify technical activities and study methods that can be used to collect and/or analyze the required data, typical formats or types of data, sources for acquiring data, and selected references that provide detailed information related to the required technical activities and study methods.

Appendix C describes typical field activities that can be carried out during a three-phased site characterization program designed to increase the level of detail and confidence in a site. Appendix D lists the addresses for the Federal data sources included in Appendix B.

2.0 OBJECTIVES OF SITE CHARACTERIZATION

A site characterization program is one of the primary components in the development of a license application for a LLW disposal facility. Site characterization is defined by the NRC as:

"...the program of investigations and tests, both in the field and laboratory, undertaken to define the site characteristics affecting the isolation of the low-level radioactive wastes, the long-term stability of the disposal site, and the interactions between the disposal site and its surroundings."⁴

The NRC states that the overall objective of site characterization is:

"...to investigate the characteristics of the preferred disposal site to the extent needed to 1) support a license application and environmental report, and 2) permit an independent evaluation of the proposed near-surface disposal facility by the staff."⁴

The NRC further states that:

"Specific objectives of site characterization are to develop the technical information needed for:

1. Demonstration that the performance objectives and the minimum technical requirements on site suitability will be met;
2. Evaluation of the ability of the site characteristics to contribute to isolation of the low-level radioactive wastes;
3. Design of the near-surface disposal facility;
4. Identification of interactions between the site characteristics and the low-level radioactive waste and waste containers;
5. Establishment of data collection points and a baseline of data for some portions of the site monitoring program; and
6. Identification of potential environmental impacts resulting from construction, operation, and closure of the near-surface disposal facility."⁴

States that have achieved Agreement State status with the NRC may have developed technical objectives that are specific to their State regulatory requirements. It is assumed, however, for the purposes of this document, that since Agreement State regulations are based on Title 10 Code of Federal Regulations Part 61 (10 CFR 61), "Licensing Requirements for Land Disposal of Radioactive Waste,"⁵ the technical objectives of the Agreement States are comparable to those contained in that regulation.

3.0 SITE CHARACTERIZATION PROGRAM PLANNING

As stated in Section 2, one overall objective of site characterization is to provide the information necessary to develop the Safety Analysis Report and Environmental Report, which together comprise the facility license application. Considering that these reports will be reviewed within the context of 10 CFR 61 or State regulations equivalent to this Federal regulation, 10 CFR 61 has been used in this handbook to establish the specific technical requirements for site characterization. These requirements are addressed in Appendix A.

With the regulatory requirements as a guide, the technical elements of a site characterization plan may be defined. Once defined, the various elements can be managed according to typical project management concepts and consistent with factors that may be unique to a particular State's licensing program. Regardless of variations between programs, all site characterization plans should consider certain strategies to ensure achieving the technical and management objectives of the programs. The following sections address these topics under the following headings: Technical Planning, Project Management, and Characterization Strategies. Taken together these topics comprise the primary bases for planning and managing a site characterization program.

3.1 Technical Planning

Eighteen technical data types are identified in Appendix A as relevant to determining whether a site meets the requirements of 10 CFR 61. By analyzing each of these eighteen data types for the technical parameters that are necessary to ensure site performance, it is possible to determine which technical activities/study methods (Appendix B) may be performed to characterize the site. These technical activities, specified in terms of compliance with regulatory requirements and with associated confidence levels, define the technical plan objectives of the characterization program. The technical requirements (Appendix A) and the types of technical activities/study methods that can be used to collect and analyze the required data (Appendix B) are summarized in Section 4.

3.2 Project Management

After the objectives of the project have been defined, the activities necessary to meet these objectives must be divided into their component parts (tasks) and organized into a logical and systematic framework. This is the task of project management, which integrates technical requirements, schedule constraints, and budgetary considerations. The following discussion provides a generalized guide to the steps in creating a site characterization plan and managing the site characterization process.

There are four basic steps required for creating a site characterization plan: 1) developing a work scope, 2) establishing a schedule, 3) developing a budget, and 4) developing project controls.

3.2.1 Work Scope Development

The first step in site characterization planning is the development of the work scope. The work scope is a management document that defines the full range of tasks for characterization and organizes them into a framework for planning, monitoring, and controlling the work. The four elements of a work scope are: 1) identifying project constraints, 2) identifying tasks and milestones, 3) organizing the tasks, and 4) developing task descriptions. Portions of the work scope, such as the task descriptions, can be incorporated into the Site Characterization Plan (SCP), which is a separate document recommended by the NRC as a working program guide for their review and comment.

3.2.1.1 Identifying Project Constraints. Based on technical, schedule, and financial requirements, characterization programs may have constraints that should be evaluated during the development of the work scope. An example of a technical constraint could be site subsurface conditions that preclude or limit the use of certain exploratory techniques. Overall schedule objectives (e.g., final date for a complete license application) can produce constraints on the length and scope of the characterization program. In addition, the costs of characterization studies can constrain the number of sites that can receive a complete field investigation.

3.2.1.2 Identifying Tasks and Milestones. The development of the work scope begins with the identification of:

- o all tasks required to collect, analyze, and present data in support of interim reports and the license application
- o all logistical tasks required to support the field studies (permits, access, etc.)
- o all important optional program activities (communication with outside groups)
- o all milestones for deliverable products and decision points.

Identification of technical tasks will be derived primarily from NRC or State regulatory requirements. The task list on Figure 1, based on NRC requirements, shows technical and logistical tasks that are typical of a site characterization program. Further breakdown of these tasks into subtasks of subsequent levels of detail will depend upon specific objectives of the site characterization program and conditions at the sites. This list was developed for use in the project management examples which follow.

* Tasks that can be performed in one or more phases, depending on local or site-specific conditions.

Figure 1. Example of a general site characterization program schedule based on a phased approach.

3.2.1.3 Organizing the Tasks. There are numerous ways to effectively organize tasks based on the complexity of the project, the technical objectives, and the technical requirements. For example, depending on the specific requirements, a project can be organized by development phase, by departmental responsibility, or by cost account. Techniques such as work breakdown structure (WBS) permit such flexibility in organizing project tasks and are commonly employed for large investigations. The WBS provides a visual breakdown of the tasks identified in the workscope and provides a system for organizing tasks into subsequent levels of detail. Figure 2 shows a partial WBS based on the task list used in Figure 1. The advantage of the WBS is that it permits the project tasks to be defined in terms of the project priorities and at the appropriate level of detail.

Because characterization focuses on confirming a suitable site using progressively detailed investigations, one of the most direct methods of organizing site characterization tasks is by development phases. Figure 1 shows one example of how phases can be useful for dividing the characterization program into levels of detail such as Reconnaissance, Exploration, and Confirmation phases. In this example, phases are defined by certain decision points or milestones (interim reports) that reflect an increasing level of knowledge and confidence in the site. The sequence of typical activities within each of these phases is described further in Appendix C. The utility of each phase is discussed below.

- o Phase 1, Reconnaissance, is designed to quickly and economically assess the site for fatal flaw characteristics that would disqualify a site, to develop the basic parameters for the geologic model, to begin the hydrologic and meteorologic characterization and monitoring program, and, if necessary, to permit the identification of a smaller area for the later investigation phases. Phase 1 also develops an extensive data base on the site and region from published and unpublished sources. The combined results of Phase 1 become the basis for planning the details for Phase 2 activities.
- o Phase 2, Exploration, will only proceed if the site has no obvious fatal flaws. Phase 2 comprises a more comprehensive subsurface investigation designed to expand the understanding of the geologic and hydrologic activities, focus on investigating anomalous conditions revealed in Phase 1, add to the density of subsurface investigation in a selected area of the site (identifying and partially investigating a facility location), and conducting field and laboratory testing.
- o Phase 3, Confirmation, completes the field investigation program by increasing the density of subsurface information (especially at a facility location), performing the analytical and numerical modeling, and completing the testing required to determine site parameters important to analyzing site performance objectives. Phase 3 also establishes the requirements for long-term monitoring for the hydrologic program. Phase 3 usually concludes with the preparation of technical reports for input to design and licensing documents.

Figure 2. Example of work breakdown structure (WBS) for site characterization.

3.2.1.4 Developing Task Descriptions. Each of the tasks defined in the workscope should be fully described. Typically, this information will be incorporated into a site characterization plan (SCP) which will be a working program guide. The content of the SCP and the format of the descriptions may vary, but the task descriptions should generally include the following:

- o technical discussions of the task scope and objectives (including end products, such as data reports, decisions, etc.)
- o applicable data bases, tests, and regulatory criteria
- o accuracy and precision requirements
- o use of computer models
- o data management and presentation requirements
- o equipment requirements.

3.2.2 Establish Schedule

The second step in the planning process is the development of the program schedule. Scheduling places the detailed tasks into their proper timeframe. The objective of proper scheduling is to develop a realistic, acceptable fit between the time requirements for completion of technical tasks and the constraints imposed by the project milestones.

The development of the program schedule is done by developing logic diagrams, determining dependency relationships, estimating task durations, determining critical path relations, and tailoring the schedule to time constraints.

3.2.2.1 Preparing Logic Diagrams. Logic diagrams define the overall processes that will be followed by the characterization program and outline the flow of information that will be used in the decision points or milestones. Logic diagrams are not mandatory, but they are a useful technique for clearly laying out the project objectives and processes. Figure 3 shows a logic diagram for the example characterization program used in this handbook.

3.2.2.2 Determining Dependency Relationships. After the overall logic of the program has been defined, each of the tasks must be analyzed in terms of its relationship with the other tasks. Clear relationships and dependencies must be identified between tasks, such as:

- o what must precede each task
- o what must follow each task
- o what can occur parallel with each task.

Figure 3. Site characterization logic diagram.

Figures 4 and 5 are examples of graphical depictions of the dependency relationships between selected tasks in support of the development of a ground-water model. Figure 4 shows the task start and end dates, the overall task duration, and the tasks that are critical to meeting the schedule. Figure 5 shows the interdependency of these tasks, which is prerequisite to determining critical path relations. As shown in Figure 5, field activities such as geologic mapping, surface geophysics, and monitoring well installation cannot begin until all prerequisite pre-field activities have been carried out; however, activities such as field research are independent of the pre-field surveys, and can be ongoing during both pre-field and field activities, as demonstrated in Figure 4.

3.2.2.3 Estimating Durations. The duration of each task should be established independently of other tasks so that a realistic estimate can be made. The task duration should include consideration of the planning, data collection, and technical analysis/reporting requirements. Durations may also depend upon resource usage assumptions (i.e., two people for one week). Assumptions should always be documented.

3.2.2.4 Determining Critical Path Relations. After the logical dependencies of the tasks and the estimated durations have been determined, the tasks can be arranged into a preliminary schedule and compared with the program milestones and overall time constraints. Ranges of estimated start and stop dates (earliest and latest) are determined for each task, and the maximum and minimum durations are calculated. The critical path of the program is the path through the dependency diagram along which the cumulative project duration is the longest. The tasks that control the schedule are the critical tasks because a delay in any of them not only affects completion of all tasks that follow, but also affects completion of the project as a whole. Critical path calculations are commonly developed mathematically using project management computer programs.

In a few instances, such as the requirements for ground-water and meteorological monitoring, the data gathering for the baseline studies requires a one-year minimum. This long lead time may nearly equal the time required for the entire site characterization investigation. Therefore, the tasks prerequisite to actual monitoring, such as well drilling, logging, and installation of equipment, may represent a special critical path relationship to the program, and the start of these activities should have a very high priority in the schedule.

Scheduling of characterization studies at multiple sites can place additional constraints on the critical path, especially if there are: 1) limited resources with which to complete the multiple investigations, or 2) very close schedules between the completion dates for the sites.

Notes: 1. C identifies the activity as critical to meeting the schedule.
2. See Figure 1 for complete site characterization schedule

Figure 4. Example of a Gantt chart showing typical tasks relevant to ground-water model development.

PRE-FIELD SURVEYS

Prepare Recon Plan
 Prepare QA/QC Plan
 Access Evaluation
 Literature Review
 Cultural Resources
 Survey
 Permit Applications

FIELD SURVEYS/RESEARCH

Geologic Mapping
 Surface Geophysics/
 Geochemistry
 Meteorology Studies

MONITORING WELL INSTALLATION

Drilling
 Geologic Logging
 Downhole Geophysics
 Installation
 Sampling/Testing
 Monitoring

ANALYSIS

Ground-water Evaluation
 Input to Ground-water
 Model

EXPLANATION

- ▼ — Direction of dependence
- — Source or destination of dependency
- — Dependency connection

Figure 5. Example of a dependency diagram showing activities relevant to ground-water model development.

Figure 6 shows an example of the critical path for the typical tasks supporting the development of the ground-water model. This is an example of one of the several types of computer-generated diagrams that can be used to show critical path relationships. It is important to note that the critical path tasks may change as the program progresses.

3.2.2.5 Tailoring the Schedule to Overall Time Constraints. Commonly, preliminary schedules do not satisfy the overall time constraints of the program. This requires reanalyzing the time requirements and dependency relationships of all tasks and evaluating alternate schemes for saving time. The most commonly used techniques for shortening the schedule are the following:

- o adding more resources to certain critical path activities; for example, more drill rigs and staff may be added to the drilling task to complete it sooner
- o conducting more tasks simultaneously
- o reducing or delaying the amount of information required at a selected milestone.

3.2.3 Budgeting

The third step in site characterization planning is the development of the budget. Estimates of costs for the proposed program are closely related to the details of the work scope, schedule, number of sites under consideration, amount of available resources, and the site characteristics. The elements that must be considered in developing and reviewing a budget include allocating adequate resources, optimizing the cost effectiveness of the field program, and checking the costs for realism.

3.2.3.1 Allocating Resources. The list of resources required for site characterization will depend on the exact nature of the program; however, the typical requirements for the examples in this handbook may include the following:

- o Personnel - this category will include the professional staff for conducting the surveys and analysis of the data, in addition to the support staff required for logistical and legal activities, public relations, obtaining right-of-way, laboratory analyses, and general labor activities.
- o Equipment subcontractors - this category will include specialized services for drilling, geophysical surveys, trenching, road building, and special laboratory analysis.

Figure 6. Example of a critical path diagram showing activities relevant to ground-water model development.

- o Capital Purchases - long-term monitoring systems will probably be the largest capital equipment expenditure for the site characterization program. These will include systems for collecting meteorological, ground-water, surface-water, and geochemical/hydrochemical data.
- o Expenses - direct expenses for program expenditures and purchases may be large (e.g., travel expenses, per diem, etc.), depending on the proximity of the work force to the site and the amount of support for the work force during site characterization studies.

3.2.3.2 Optimizing the Cost Effectiveness of the Field Program. Certain field investigations, such as drilling programs, will be used by a number of different disciplines as important sources of site specific data. As a result, field investigations must be carefully planned to 1) collect the data required for all appropriate disciplines and 2) maximize the use of all planned field investigations (borings, etc.), as potential sources of data for any appropriate discipline. The objective is to optimize the investigation costs by maximizing the yield of data from all the planned field investigative techniques (drilling, geophysics, trenching, etc.).

3.2.3.3 Checking Costs for Realism. Budgets for characterization studies are often complex and may have been developed by different groups using various costing assumptions. As a result, budgets that are submitted for review should be closely checked for the realism of the cost estimates. The most effective technique for determining realism is to obtain independent opinions from reliable sources. Potential sources may include State agencies familiar with costs and time requirements for performing the activities, private consultants or organizations, professional associations that publish salary data bases and price ranges for professional services, and comparisons of competitive proposals.

3.2.4 Development of Project Controls

The fourth step in site characterization planning is the development of project controls. After the baseline costs and schedule are established, a system must be organized to track and report the appropriate information about cost and progress on a periodic and timely basis. The updated cost and schedule information is used to evaluate the progress of the project and to determine any necessary adjustments to the level of effort.

3.2.4.1 Organizing Program Control. Control of the characterization program relies on the periodic and timely receipt of accurate information by the managers relevant to the technical progress and associated costs of the investigation. Since the most accurate cost/progress information is available from the personnel and contractors carrying out the work, a system must be organized that quickly gathers actual and accrued costs, preferably directly from the field. To maintain control, the frequency of reporting from the field to the program manager can vary from every day during times of intense

activity to about every week during relatively slow periods. The field reports are usually summarized by the program manager on a weekly or monthly basis into a more concise document for distribution to the client or other interested groups.

3.2.4.2 Tracking Progress. Tracking of cost and schedule is a regular and frequent function of project control. Tracking the progress of the program cost and schedule requires that:

- o there are master baseline budgets and schedules for comparison, and
- o the tasks contain the type of work that can be measured in terms of the amount of progress (for example, drilling can be broken down into how many feet per day are expected).

In instances where the task may contain the type of work that cannot be readily measured (e.g., researching baseline data), qualitative estimates of completion are often used. As stated in 3.2.5.1, the frequency of task tracking will vary depending on the nature of the task (i.e., a task on the critical path might require more attention) and the level of effort being expended (i.e., more expensive tasks can overrun the budget within short periods).

3.2.4.3 Evaluating/Adjusting the Schedule. As the field investigation progresses, the cost and schedule should be evaluated against the original program plan and adjustments should be made either to maintain the budget or to preserve the schedule. The tracking information can be compared to the baseline data and evaluated in terms of:

- o the actual costs for a task compared to the scheduled costs for the same performance period
- o the actual progress for a task compared to the scheduled progress for the same performance period
- o the schedule and cost comparisons are evaluated to determine if the progress has been in proportion to the cost and the technical plan
- o the managers must then make estimates of the level of effort to complete each task.

The level of effort for any task can then be adjusted to either step up the schedule or meet the budget.

3.3 Characterization Strategies

In implementing a site characterization program, there are a number of strategies that should be considered to ensure the achievement of the technical and management goals of the program. The following section

describes some of those strategies. The potential contribution of each should be analyzed early in the program and should be implemented at the appropriate time.

3.3.1 Early Verification of Parameters Important to Licensing

Any evaluation made during the site selection process that may have a critical influence on licensing should be confirmed with a high degree of confidence as early as possible in the characterization program. This may entail collecting certain site-specific (in particular, subsurface) data early in the project. Under certain State approaches, such early data collection activities may be an essential part of selecting the sites to be subjected to a full site investigation, particularly if existing data for critical parameters are either lacking or highly uncertain. Other State approaches may use the early verification strategy to narrow the number of sites for which the remaining characterization studies will be completed and to "bank" the other sites. This latter approach may be necessary where limited financial resources require focussing on the most promising sites.

3.3.2 Focusing on Fatal Flaws

Because site characterization is time consuming and expensive, the technical investigation should focus as early as possible on revealing any "fatal flaws" (i.e., conditions that would prohibit licensing of a disposal facility at that site). This will minimize the amount of time lost and money wasted if it is necessary to start over with another site. Initial fatal flaw studies could be part of the selection of one or more candidate sites for characterization under some State approaches, whereas in other State approaches the early phases of characterization would immediately investigate any potential problems revealed during the selection process, preliminary research, or ground reconnaissance tasks. The studies to be performed will vary depending on the characteristics of the site. Moreover, it will be important throughout the site characterization program to be alert for potential fatal flaws, to quickly investigate any that are identified, and to anticipate how to respond if any of these are determined to be significant problems.

3.3.3 Characterizing Multiple Sites

To maximize the chances of finding at least one licensable site within an established time period, many States are planning to characterize several sites. In some cases, this means full characterization of more than one site to support the final selection of a preferred site for licensing and to provide a reserve of alternative or backup sites. In other cases, only limited investigations of sites other than the initially preferred site will be carried out under the assumption that this preferred site will most likely prove to be licensable. However, even in this latter case, each of the alternative sites should have 1) a baseline monitoring program underway to avoid restarting the long lead time activities, and 2) some minimum level of

site-specific information on which to characterize them and confirm their priority status.

3.3.4 Dividing the Program into Phases

It may be useful to divide the site characterization program into phases or to otherwise identify milestones for major decision points regarding the technical suitability of the site. Several important purposes for developing phases and/or milestones are to: 1) force an integration of the technical data at various stages of the characterization program, 2) develop preliminary conclusions on the outcome and trends of the technical program, 3) assess the level of confidence in site suitability consistent with the completeness of the program, and 4) search for fatal flaws. The number of divisions or milestones within the program can be tailored to the individual site investigation. This type of strategy is discussed further in Section 3.2.1.3.

3.3.5 Anticipating Potential Delays

Potential delays should be evaluated for all significant tasks, and contingency plans should be developed to ensure that tasks progress on schedule. Examples of tasks or data that may be subject to delays include: 1) field input parameters to site computer models, 2) site permits and access, and 3) baseline monitoring of ground water and meteorology.

3.3.6 Preparing Specifications for Data Requirements

Prior to starting the investigation, each of the tasks should be evaluated to determine how much data needs to be collected. Each of the technical activities should be analyzed relevant to:

- o the amount of data required from each field technique
- o the accuracy and precision requirements
- o the required confidence level.

This planning will establish the specifications of the field data requirements and will minimize the possibility of gathering too little or too much data.

3.3.7 Institutional interfaces

An effective site characterization program should include coordination with the NRC or Agreement State regulatory agency by means of regularly scheduled briefings, informal communications, and requests for informal guidance. Depending on the nature of a specific State's LLW siting legislation and site-specific conditions, it may also be necessary and/or prudent to involve various Federal, State, and local resource management agencies in the site characterization planning process. In addition,

effective involvement of the public in the overall site development process will play a critical role in the success of the effort.

4.0 TECHNICAL DATA REQUIREMENTS AND ACTIVITIES FOR SITE CHARACTERIZATION

4.1 Introduction

The Nuclear Regulatory Commission or designated State licensing authority has the responsibility for the licensing and regulation of commercial LLW facilities, and for ensuring that these facilities comply with the National Environmental Policy Act (NEPA) of 1969, in accordance with Title 10 Code of Federal Regulations Part 51.⁶ In order to provide assistance to the States in planning and carrying out their site characterization programs and in meeting the regulatory requirements, the NRC has issued several guidance documents that contain interpretations of the regulations, recommendations as to specific types of site characterization activities that may be needed at proposed sites, and guidance as to the information that should be included in the SAR and ER, which comprise the license application. It is desirable for both project management and technical staff involved in site characterization to be cognizant of the technical guidance provided by the NRC and to maintain communication with NRC policy and technical staff.

Appendix A matrices cite specific NRC regulatory guidance statements relevant to eighteen technical disciplines or data types that are involved in characterizing a LLW site, including:

- o geology
- o ground-water hydrology
- o surface-water hydrology
- o geochemistry/hydrochemistry
- o water resources
- o geotechnical investigation
- o geography
- o demography
- o land use
- o meteorology
- o air quality
- o radiological assessment
- o ecology
- o socioeconomics
- o cultural resources
- o transportation
- o aesthetics.

Each data type is further divided into specific technical parameters that must be addressed in licensing documentation. The determination of the technical parameters was based on an interpretation of NRC guidance contained in the following documents:

- o NUREG-0902, "Site Suitability, Selection, and Characterization"⁴
- o NRC Draft "Technical Position Paper, Environmental Monitoring of Low-Level Waste Disposal Facilities"⁷

- o NUREG-1199, "Standard Format and Content - Safety Analysis Report"⁸
- o NUREG-1200, "Standard Review Plan - Safety Analysis Report"⁹
- o NUREG-1300, "Environmental Standard Review Plan - Environmental Report"¹⁰.

It should be noted that revisions to NUREG-1199 and NUREG-1200, published early in 1988, were not available at the time Appendix A was written. However, the changes in these new documents address only near-surface trench disposal, specifically those alternative concepts that incorporate structures constructed of cementitious materials with earthen covers; consequently, they do not affect the scope of information included in Appendix A.

Technical parameters are described in an attachment to each Appendix A matrix; these descriptions include the data required by the NRC for each parameter. The matrices list the parameters that are explicitly or implicitly treated in each NRC guidance statement. This Appendix should be used for guidance and reference in preparing a site characterization plan to ensure that the plan addresses all required parameters. A review of Appendix A will also aid in understanding the uses to which the site characterization data are to be put and, thus, the quality and extent of data required.

Appendix B tables list the technical activities and study methods that can be used to collect data specific to each technical parameter. The tables also identify the sources of data, the forms in which data are obtained and/or displayed, and references for additional information on technical activities pertinent to data collection and analysis. These tables describe standard site characterization activities that apply to regions with widely varying geological, hydrogeological, and environmental characteristics. It will be necessary to tailor these activities to each specific geographic region when preparing an actual site characterization plan. The information in Appendix B provides guidance that can be used in preparing and assessing the adequacy of site characterization plans and in performing periodic evaluations of the adequacy of interim characterization results.

Section 4.2 provides a general overview of the regulatory requirements and technical activities that must be carried out during site characterization. Its purpose is to condense the information provided in the appendices for each of the eighteen data types in order to provide an overall understanding of the major components of a site characterization program. Appendices A and B are intended to provide specific guidance for technical planners and project managers during the initial planning stages of the site characterization program and as work proceeds and program plans require updating or revision.

Section 4.2 also discusses guidance from the NRC as to the extent of the area to be characterized and the map scales to be used for specific data types. However, neither Section 4.2 nor Appendices A and B provide guidance on the level of effort needed to adequately characterize a site. The actual level of effort will be determined by the complexity of characteristics at a

particular site, the number of sites being characterized, and the management strategies being used.

4.2 Summary of Requirements and Activities by Data Type

4.2.1 Geology

4.2.1.1 Technical Requirements. The NRC regulatory requirements and guidance with respect to geology are directed toward providing assurance that the site geology can be adequately characterized, that the natural processes affecting the site occur at consistent and definable rates, and that the site will be geomorphically and tectonically stable for a period of 500 years. The seven parameters specific to geology identified in Appendix A are geomorphology, stratigraphy, lithology, structure, tectonics, seismology, and geologic hazards.

4.2.1.2 Data Needs and Collection Methods. The technical activities and study methods that address these seven parameters include review and tabulation of existing geologic data; surface and trench geologic mapping and sampling; borehole logging and sampling; surface and borehole geophysics; geomorphic analysis; seismic hazard analysis of tectonic structures and provinces to within 200 miles of the site; analysis of samples collected during the surface and subsurface studies; and detailed mapping, sampling, testing, and analysis in areas having potential geologic complexities. Surface mapping of the site geology should be on a scale consistent with the site topographic maps discussed in Section 4.2.3.2, and terminology used should be consistent with the accepted usage of the State geological survey or the U.S. Geological Survey.⁴ The nature and depth (degree of detail) of specific geologic investigations will depend upon the types of geologic, geomorphic, and tectonic environments at and near the site.

4.2.1.3 Data Evaluation and Reporting. Raw geologic data required in the SAR or ER include: a site topographic map; geophysical and geologic borehole logs; test pit or trench logs; petrographic data; soil and rock descriptions; age determinations; results of laboratory analyses; earthquake maps and lists of historical earthquakes within 200 miles of the site with a magnitude of 3 or more or a modified Mercalli intensity (MMI) of IV or more;⁸ large-scale maps showing all earthquakes within 50 and 5 miles of the site;⁹ maps of geologic structures and tectonic provinces within 200 miles of the site;⁸ and where applicable, geodetic monitoring data.

Data interpretation and analysis will be required for: the preparation of surface geologic maps, isopach maps, and geologic cross sections, which provide the basis for a conceptual geological model of the site; the analysis of landforms for evidence of destructive geomorphic processes, subsidence, or collapse, and the determination of the nature and rates of these processes;

the determination of the relationship between regional and site physiography and structural geology; the development of stratigraphic sections and the determination of the geologic history of the site area; the evaluation of structural features for evidence of potential deformation that may affect the site, and the determination of the nature and rates of this deformation; the identification of geologic and structural features that will affect or be affected by the disposal site; the determination of unrelieved stresses in bedrock and their potential for creep and rebound effects; the determination of the geologic and structural history of tectonic structures in the site and region; the determination of the tectonic provinces within 200 miles of the site; the evaluation of the relationship between seismicity and geologic and tectonic features, and the determination of the earthquake-generating potential of active structures; the determination of the design earthquake, horizontal ground acceleration, seismic wave transmission characteristics, and settlement and liquefaction potential at the site; the determination of the potential for volcanic activity; the identification of potential geologic hazards; the prediction of the rate and extent of changes in geologic processes during a 500-year period; the description of the paleontologic resources that could be affected by the site; and the description of site soil conditions.

4.2.2 Ground-Water Hydrology

4.2.2.1 Technical Requirements. The NRC regulatory requirements and guidance with respect to ground-water hydrology are directed toward providing assurance that the site is hydrologically simple, that the site can provide sufficient depth to the water table so that ground-water intrusion into the waste will not occur or, if disposal is below the water table, that molecular diffusion is the predominant means of radionuclide movement and the rate of movement will result in performance objectives being met. The guidance is also concerned with providing assurance that in no case will waste disposal occur within the zone marked by fluctuations of the water table, that the hydrogeologic unit used for disposal will not discharge ground water to the surface within the disposal unit, and that the ground-water regime will not be adversely affected by the site. The fourteen parameters specific to ground-water hydrology identified in Appendix A are moisture potential, moisture content, hydraulic conductivity, porosity (total and effective), geometry, boundary conditions, and hydrogeologic modeling for unsaturated flow, and hydraulic head, hydraulic conductivity, porosity (total and effective), specific storage, geometry, boundary conditions, and hydrogeologic modeling for saturated flow.

4.2.2.2 Data Needs and Collection Methods. The technical activities and study methods that address these fourteen parameters include: review and tabulation of existing ground-water data; field hydrologic testing; borehole geophysical logging; minimum one-year monitoring of soil-moisture content, water-table fluctuations, hydraulic head, and ground-water quality; laboratory testing; inventorying ground-water users; and investigating the subsurface to identify and sample all significant hydrogeologic units.

The radius of ground-water studies during site characterization should depend on the types of aquifers underlying the site. The NRC recommends that shallow, unconfined (water table) aquifers may require a study area radius on the order of several kilometers to encompass the ground-water flow system and off-site ground-water users, whereas confined (artesian) aquifers may require a study area radius on the order of several tens of kilometers.⁴ In either case, the NRC staff anticipates that the off-site data can be obtained by review of available reconnaissance-level information. All significant hydrogeologic units underlying the site should be identified to a depth on the order of 30 meters below the level of waste disposal.⁴ Ground-water monitoring wells should be located so that they continue to provide usable data during site operation, closure, and long-term care. In addition to wells downgradient of the site, upgradient wells should be installed to detect changes in background levels during later phases of facility operation.⁷ The NRC recommends that the head and moisture content be measured for a minimum period of one year and compared to historic records of precipitation, moisture content, and water levels in the same or similar aquifers.⁴ The frequency of measurement of head and moisture content during monitoring should reflect the mode of recharge of the hydrogeologic unit, with more frequent (weekly) measurements in unconfined units responding to precipitation events and less frequent (monthly) measurements in confined units not directly responding to precipitation events.⁴ The data collection points for moisture content and head measurements (above and below the water table) should be appropriately located in three dimensions within the separate hydrogeologic units to establish the boundary conditions for modeling.⁴ The nature of specific ground-water investigations will depend upon the physical and hydrological characteristics of the site and surrounding area.

4.2.2.3 Data Evaluation and Reporting. Raw ground-water hydrology data required in the SAR or ER include: detailed descriptions of all monitoring wells; descriptions of all aquifer tests and tabulated test data; descriptions of laboratory analysis techniques and tabulated results; descriptions of data and methods used for determining the principal hydraulic characteristics for each hydrogeologic unit and for determining radionuclide transport characteristics of each unit; descriptions of input parameters for hydrologic models and the transport analysis; historic and seasonal records of precipitation, moisture content, and water levels; and ground-water user inventory data.

Data interpretation and analysis will be required for: the determination of the site water budget; the identification of hydrogeologic units and the description of their areal extent and properties; the determination of interrelationships between ground-water and surface-water systems; the identification of recharge and discharge areas; the description of all potentially affected aquifer systems and unsaturated zones, and the spatial and stratigraphic distribution of their hydrologic parameters; the description of the occurrence and movement of water in the unsaturated and saturated zones; the development of numerical and conceptual models of the ground-water system in the saturated and unsaturated zones; the description of the conceptual model of the ground-water flow system in relationship to the

planned engineering design; the description of all possible ground-water pathways to the accessible environment; the description of the ground-water flow system and parameters used in the contaminant transport analyses; the calculation of the ground-water travel time downgradient from the site; and the qualitative and quantitative descriptions of the impact of the site on the ground-water system.

Ground-water user data can be obtained from the water resources studies in Section 4.2.5, and the geologic studies in Section 4.2.1 can provide input data to the identification and description of hydrogeologic units. Information on annual precipitation and evapotranspiration rates required for the ground-water flow model can be obtained from the meteorology studies in Section 4.2.11.

4.2.3 Surface-Water Hydrology

4.2.3.1 Technical Requirements. The NRC regulatory requirements and guidance with respect to surface-water hydrology are directed toward providing assurance that the site will be generally well drained and free of areas of flooding or frequent ponding, that upstream drainage areas will be minimized to decrease the amount of runoff that could erode or inundate the site, and that surface-water systems will not be adversely affected by the site. The fifteen parameters specific to surface-water hydrology identified in Appendix A are hydrologic system, water users, flood studies, drought studies, precipitation, infiltration, runoff, discharge, channel characteristics, stage, flow velocity, erosion, sedimentation, hydrologic and hydraulic modeling, and site surface-water impact.

4.2.3.2 Data Needs and Collection Methods. The technical activities and study methods that address these fifteen parameters include: review and tabulation of existing surface-water data, including water users, historic flood and drought data, and rainfall and snowfall record summaries; identification and description of the natural and man-made components of the surface-water system; field measurement of runoff, infiltration rates, and channel characteristics of drainage systems crossing the site; installation of Parshall flumes and sediment samplers, where appropriate, to determine the rate of erosion; inventorying surface-water users; and monitoring surface-water flow and temperature for a minimum of one year.

The NRC recommends that surface-water site characterization studies should include not only the site but also the upstream drainage area contributing flow across the site and the downstream drainage area to a distance of approximately 10 kilometers.⁴ The NRC suggests that topographic maps of the upstream drainage areas should be at a scale on the order of 1:2,400, whereas 1:24,000- or 1:62,500-scale maps will be acceptable for downstream areas.⁴ The inventory of existing surface-water users and municipal supplies should extend approximately 10 kilometers downstream.⁴ The nature of specific surface-water investigations will depend upon the physical and hydrological characteristics of the site and surrounding area.

4.2.3.3 Data Evaluation and Reporting. Raw surface-water hydrology data required in the SAR or ER include: water resource maps; hydrographs; stream records; data on historical flood events; topographic maps showing natural drainages, surface gradients, and man-made features; descriptions of surface-water bodies and existing and proposed water control structures and diversions in the site and surrounding areas; aerial photography showing drainage areas and areas of flooding; flood-frequency distributions and floodplain descriptions for affected streams; flow duration data; maximum, average-maximum, average, average-minimum, and minimum monthly temperatures and flow of affected water bodies; historical precipitation and drought data; surface-water-user inventory data; results of laboratory analyses; input parameters for models and the transport analysis; and detailed computations that provide the bases for the design of protective features.

Data interpretation and analysis will be required for: the determination of the interrelationship of natural and man-made components of the surface-water system; the description of the surface-water flow system and its relationship to the planned engineered design, and parameters used in the contaminant transport analyses; the evaluation of the flooding potential of the site and surrounding area, including the delineation of the 100-year floodplain, flood-flow frequencies, and the Probable Maximum Flood (PMF); the evaluation of the ability of the site to withstand floods; the estimation of erosion and sedimentation characteristics of the site; the determination of the Probable Maximum Precipitation (PMP) and precipitation characteristics that will contribute to the flooding and erosion studies; the determination of the infiltration rate at the site; the estimation of runoff, stage, flow velocity, and discharge at the site; the determination of channel characteristics; the demonstration that upstream drainage areas have been or will be minimized to decrease runoff; the computation of water-surface profiles and flood velocities for revised flow regimes created by geomorphic changes; the description of surface-water pathways; the numerical and analytical hydrologic and hydraulic modeling of surface-water flow and transport; the evaluation of radionuclide migration; the determination of the effects of dam failures, including analytical hydraulic failure models; quantitative and qualitative descriptions of ground-water-surface-water interactions; the preparation of hydrologic evaluations and design details of the site flood control system; and the qualitative and quantitative descriptions of the impact of the site on the surface-water system.

The extent of the 100-year floodplain should be defined based on Executive Order 11988, "Floodplain Management".¹¹ Guidance for determining flood-flow frequencies can be obtained in the U.S. Water Resources Council Bulletin 17-B, "Guidelines for Determining Flood Flow Frequency,"¹² and guidance for determining the PMF and PMP can be obtained in NRC Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants".¹³

Ground-water studies in Section 4.2.2 can provide data on ground-water baseflow contributions to stream flow. Activities described for the geotechnical investigation in Section 4.2.7 can provide input data on soil erodibility. Surface-water-user data can be obtained from the water resources

studies in Section 4.2.5, geomorphic data can be obtained from the geologic studies in Section 4.2.1, and temperature data can be obtained from the geochemistry/hydrochemistry studies in Section 4.2.4.

4.2.4 Geochemistry/Hydrochemistry

4.2.4.1 Technical Requirements. The NRC regulatory requirements and guidance with respect to geochemistry/hydrochemistry are directed toward providing assurance that background chemistry data is collected to permit monitoring of key indicators of water quality and any leachate migration, and to identify parameters that may affect transport of the waste leachates. The twelve parameters specific to geochemistry/hydrochemistry identified in Appendix A are water quality, ion-exchange capacity, organic content, Eh-pH, distribution coefficient, temperature, radiometric dating, isotope content, soil mineralogy and mineral solubility, hydrodynamic dispersion coefficient, geochemical model, and transport analysis.

4.2.4.2 Data Needs and Collection Methods. The technical activities and study methods that address these twelve parameters include: review and tabulation of existing geochemistry/hydrochemistry data; collection of background ground-water, surface-water, and soil samples in the field; chemical analysis, age dating, and experimental testing of field samples; monitoring of surface- and ground-water chemistry at least quarterly for a minimum 1-year period; performance of laboratory simulations of field conditions; performance of field tracer tests; performance of field measurements of temperature and Eh-pH; and performance of modeling and transport analysis.

Ground-water monitoring wells should be located so that they continue to provide usable data during site operation, closure, and long-term care. The NRC recommends that, in addition to wells downgradient of the site, upgradient wells should be installed to detect changes in background levels subsequent to initial site characterization. Surface-water sampling locations should be selected upgradient, adjacent, and downgradient of the site in all subwatersheds to which the site may contribute. Nearby impoundments and surface-water drinking sources should be included in the sampling program. The NRC suggests that effort should be made to sample ephemeral water courses during runoff periods, and samples should be taken following extreme hydrologic events. Sediment sample locations should be approximately the same as the surface-water samples. Preoperational soil samples should be taken from surficial soils as well as at depths that reflect the site stratigraphy. Soil samples should be collected at various points and depths in the cross section of the sediment profile; samples from a discrete cross section may be aggregated for radiological and chemical analysis. The nature of specific geochemistry/hydrochemistry investigations will depend upon the geologic and hydrogeologic characteristics of the site, particularly the location of the water table and surface-water system relative to the waste emplacement zone, and the composition of the waste.

4.2.4.3 Data Evaluation and Reporting. Raw geochemistry/hydrochemistry data required in the SAR or ER include a complete set of site-specific surface-water, ground-water, soil, and rock chemistry data, and the mean, range, and temporal and spatial variations in parameters as applicable; and descriptions and tabulations of regional water quality data.

Data interpretation and analysis will be required for: the determination of the coefficient of dispersion, including distribution coefficients, for radionuclides in the ground-water-soil system; the evaluation of the anticipated changes in water chemistry for ground- and surface-water systems that may be affected by the site; the calculation of radionuclide concentrations; the performance of a contaminant transport analysis; the development of conceptual and numerical geochemical models; the description of preexisting contaminated environments, and sources of contamination that may affect local water quality or site monitoring, construction, or operation; the determination of geochemical interactions between soils and water in the vadose and saturated zones; the description and analysis of surface-water pathways to demonstrate that potential radiological and nonradiological effluent concentrations will be within acceptable limits; and the determination of surface-water bodies and users that would be affected by changes in water quality caused by the site.

Activities described for geology, ground- and surface-water hydrology, and radiological assessment in Sections 4.2.1, 4.2.2, 4.2.3, and 4.2.13, respectively, can provide input data to the geochemistry/hydrochemistry studies, particularly the contaminant transport analysis.

4.2.5 Water Resources

4.2.5.1 Technical Requirements. NRC regulatory requirements and guidance with respect to water resources are directed toward avoidance of any inadvertent intrusion into the site, avoidance of water resource development activities at and near the site that would compromise, either directly or indirectly, the safety of the site, and assurance that the proposed site will have no adverse effect on the exploitation of water resources. The seven parameters specific to ground-water resources identified in Appendix A are past and present ground-water usage, past and present surface-water usage, ground-water discharge points, projected surface-water usage, projected ground-water usage, water rights and legal summaries, and site water resource impact.

4.2.5.2 Data Needs and Collection Methods. The technical activities and study methods that address these seven parameters include: review and tabulation of existing water resource data; performance of a ground-water-user inventory within approximately 2 kilometers of the site and a surface-water-user inventory in the vicinity of the site and within approximately 10 kilometers downstream of the site, including location, type, and amount of use;⁴ compilation of a summary of statutory and other legal

restrictions related to water use; and compilation of geographic, demographic, and economic information to determine future water usage. The nature of specific water resources investigations will depend upon the hydrologic, geologic, demographic, and geographic conditions at and near the site.

4.2.5.3 Data Evaluation and Reporting. Raw water resource data required in the SAR or ER include past and present surface- and ground-water-user inventory data and a summary of water rights and legal restrictions.

Data interpretation and analysis will be required for: the determination of projected surface- and ground-water usage; the preparation of a quantitative and qualitative descriptions of the direct and indirect effects of water use on site suitability; and the determination of the impact of the site on water usage.

Geographic and demographic studies described in Sections 4.2.8 and 4.2.9, respectively, can provide input data for the determination of projected water usage. The ground-water and surface-water hydrology studies described in Sections 4.2.2 and 4.2.3, respectively, can provide data on surface-water features and the ground-water flow regime for input to the analysis of the effects of water resource exploitation.

4.2.6 Geologic/Timber/Agricultural Resources

4.2.6.1 Technical Requirements. The NRC regulatory requirements and guidance with respect to geologic, timber, and agricultural resources are directed toward avoidance of any inadvertent intrusion into the site, avoidance resource development activities at and near the site that would compromise, either directly or indirectly, the safety of the site, and assurance that the proposed site will have no adverse effect on the exploitation of known resources. The nine parameters specific to natural resources identified in Appendix A are past and present resource data, mineral rights/lease data, borehole/well data, potential resource location, resource quality and quantity, resource value, direct effects of exploitation, indirect effects of exploitation, and natural resources impact.

4.2.6.2 Data Needs and Collection Methods. The technical activities and study methods that address these nine parameters include review and tabulation of existing geologic, timber, and agricultural resource data, collection of lease and well data, evaluation of samples collected and analyzed during the surface and subsurface geologic field studies for indications of geologic resource potential, and detailed mapping, sampling, testing, and analysis in areas identified as having geologic resource potential. The types of geologic resources to be investigated and the nature of specific investigations will depend upon the types of geologic environments at and near the site that could serve as potential resource hosts. The NRC has not specified a radius for the geologic resource evaluation; the area evaluated will depend upon the types of

resources existing or expected to exist at and near the site and their potential for impacting site suitability.

4.2.6.3 Data Evaluation and Reporting. Raw geologic, timber, and agricultural resource data required in the SAR or ER include: past and present resource locations, types, and commodities; quantitative data and extraction methods for active or previously active mines; quantity, quality, production data, and harvesting methods for timber and agricultural resources; the location, ownership, and types of exploration activity carried out on mining claims and mineral leases; and the location, current activity, depth, diameter, completion practices, and geophysical logs of exploration boreholes and geothermal, brine, and hydrocarbon wells.

Data interpretation and analysis will be required for: the determination of the location of potential resources; the determination of resource quality, quantity, and value; the estimation of projected resource use; the classification of mineral resources using the U.S. Geological Survey and U.S. Bureau of Mines classification system;¹⁴ the assessment of current and potential exploration and extraction methods at and near the site to determine the potential direct and indirect effects of exploration and exploitation on site suitability; and the evaluation of the effects of the proposed site on the exploitation of known resources.

Land use studies described in Section 4.2.10 will provide data on timber and agricultural resources at and near the site.

4.2.7 Geotechnical Investigation

4.2.7.1 Technical Requirements. The NRC regulatory requirements and guidance with respect to the geotechnical investigation are directed toward providing data for major design-related analyses, such as slope stability, cover integrity, erosion, compaction characteristics for backfill materials, foundation analyses, gradations for proposed filler materials, and possible interactions between the soil and waste containers. The five parameters specific to the geotechnical investigation identified in Appendix A are soil classification, engineering properties, engineering units, ground-water conditions, and engineering analysis.

4.2.7.2 Data Needs and Collection Methods. The specific technical activities and study methods that address these five parameters include field testing, collection of samples from borings, test pits, and trenches, and laboratory testing of samples to classify soils and to determine the engineering properties of the soil materials.

Regulatory Guide 1.132, "Site investigations for Foundations of Nuclear Power Plants",¹⁵ should be used as a general guide in developing the geotechnical field investigation program. Testing of soil and rock parameters should be in accordance with the general guidance of Regulatory Guide 1.138,

"Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants".¹⁶ The nature of specific geotechnical investigations will depend upon the stratigraphy, slope characteristics, and soil conditions at the site, and the proposed site design and operations.

4.2.7.3 Data Evaluation and Reporting. Raw geotechnical data required in the SAR or ER include: borehole, test pit, and trench logs; field and laboratory test data; and plans showing grades, slopes, and locations of test pits and boreholes.

Data interpretation will be required to perform the engineering analysis that develops geotechnical recommendations for slope stability, settlement/subsidence, liquefaction potential, freeze/thaw potential, active and passive earth pressures, bearing capacity, long- and short-term control of surface runoff, and fill-placement procedures. Development of plans showing cross sections and proposed borrow area limits will also require data analysis and synthesis.

Activities described for ground-water and surface-water hydrology in Sections 4.2.2 and 4.2.3, respectively, can provide information on the ground- and surface-water conditions at the site. Activities described for geology in Section 4.2.1 can provide information on potential future geologic events.

4.2.8. Geography

4.2.8.1 Technical Requirements. The term "geography" is used herein to refer collectively to the several items necessary to describe the location and physical and jurisdictional setting of the proposed site. NRC regulatory requirements and guidance specify that both highly site-specific, as well as local and regional descriptions be provided. The six parameters specific to geography identified in Appendix A are geographic location, political subdivision, nearby features, site area, topography, and site ownership.

4.2.8.2 Data Needs and Collection Methods. The technical activities and study methods that address these six parameters include identification and mapping of site ownership/control boundaries, political units such as county and city boundaries, prominent local features such as rivers and lakes and their drainage basins, site topography, and major highways and other prominent man-made features. Geographic data necessary to satisfy NRC requirements and guidance can primarily be obtained from existing map sources, but there is also the need to conduct field surveys to establish properly referenced geodetic control points. The latter are fundamental to the correct spatial referencing of much of the remaining geographic data.

4.2.8.3 Data Evaluation and Reporting. The format for reporting these data consists of at least two map series, one to describe site features to a radius of 10 km from the site at a relatively large scale, and another to

display the broader geographic context (i.e., to a radius of approximately 50 km from the site) at a smaller scale.¹⁰ Both map series can be prepared to serve as "base maps" for display of other spatially-oriented data types (e.g., demography, land use). These relatively straightforward geographic data do not require a significant degree of evaluation, although it is likely that the degree of detail (e.g., the types of highways and roads to be shown) may need to be carefully considered.

4.2.9 Demography

4.2.9.1 Technical Requirements. Demographic data required to fulfill NRC licensing requirements and regulatory guidance consist of the geographic distributions and sizes of both existing and projected human populations within designated distances from the site. The purpose of this information is to provide data for analyzing the potential health and safety impacts of facility development and operation on existing and future populations and the potential for future intrusion into the disposed waste. The five parameters specific to demography identified in Appendix A are population centers, population density, residence inventory, transient population, and projected population.

4.2.9.2 Data Needs and Collection Methods. The technical activities and study methods that address these five parameters include collection of current and historic decennial or other appropriate census records, estimates or formal projections of population, records or estimates of transient population use, and associated geographic information such as census tract boundaries, population center boundaries, and the locations of individual housing units in the vicinity of the site. These data may be collected from the U.S. Census Bureau, State demographer's office, regional and local planning agencies, and through direct field counts and estimates. The residence inventory should be conducted within approximately 2 km of the site and population centers should be identified within radial distances of 2 km, 10 km, and 50 km from the site.⁴ Population densities within 10 km of the site should be calculated.

4.2.9.3 Data Evaluation and Reporting. Reporting of demographic information makes extensive use of tabular and graphic portrayals of data; population density is commonly portrayed in mapped form. Evaluation of most census data is a relatively standard process of compiling and desegregating population figures according to appropriate spatial units (e.g., Minor Civil Division) and calculating population densities on the basis of persons per unit area. Population projections should generally be evaluated by examining the underlying assumptions and the projection methodology used; this analysis may indicate a need for modification of the assumptions or methodology to meet the specific informational requirements for low-level waste disposal licensing.

4.2.10 Land Use

4.2.10.1 Technical Requirements. The NRC guidance pertaining to the topic of land use is primarily oriented to identifying and evaluating land uses, facilities, or activities that could adversely affect the ability of the site to meet performance objectives or significantly mask the environmental monitoring program. This applies to a wide variety of existing and potential land uses. However, the regulatory guidance is also concerned with potential impacts of the LLW facility on existing and potential surrounding land uses, so the land use characterization must be comprehensive. The ten parameters specific to land use identified in Appendix A are residential land use, industrial land use, agricultural land use, recreational land use, special-use areas, zoning restrictions, local land-use plans, land ownership patterns, USDA land use classification, and utility land uses.

4.2.10.2 Data Needs and Collection Methods. The technical activities and study methods that address these ten parameters include collection of data on the locations and designations of lands classified according to: standard land use classifications such as residential, industrial, agricultural and recreational; special uses such as military bases; zoning restrictions; local or regional land use plans; USDA land capability, particularly prime or unique farmlands; and utility uses or rights-of-way. Along with the data on land use and zoning designations, information on the restrictions or permissible uses that accompany each designation should be obtained.

The land use survey should include land use patterns within a radius of approximately 10 km from the site.⁴ Collection of such data typically encompasses existing sources, such as planning and zoning authorities, aerial photo interpretation and direct field observations, and compilation of historic records and discussions with knowledgeable agency personnel and the public.

4.2.10.3 Data Evaluation and Reporting. Compilation of land use data from existing sources and original data collection utilizes both tabular summaries and maps. It is often appropriate to standardize multiple, separate land use data sets using a recognized land use classification system, such as the hierarchical method employed by the USGS. Although reporting of historic and current land use is generally not difficult, projecting future trends, particularly in areas experiencing unstable economies or major shifts in population, may require considerably more professional judgement and is subject to qualifying assumptions.

4.2.11 Meteorology

4.2.11.1 Technical Requirements. The focus of the NRC regulatory requirements and guidance with respect to meteorology is to establish baseline information on meteorologic conditions to determine the site's water budget,

to define design loads and operating bases, to evaluate the airborne release pathway, and to assess the frequency, probability, and potential consequences of severe meteorological events. The ten parameters specific to meteorology identified in Appendix A are wind speed and direction, atmospheric pressure, precipitation, pan evaporation, humidity/dew-point/wet-bulb, air and soil temperatures, frost penetration, snow cover, solar radiation, and severe weather.

4.2.11.2 Data Needs and Collection Methods. The technical activities and study methods that address these ten parameters include both the compilation of existing historical records and the establishment of an on-site monitoring program. In most cases, historical records will serve to characterize regional meteorological conditions over time and to provide perspective for on-site measurements, but will not substitute for on-site monitoring. The NRC anticipates that a minimum record of one year of site-specific meteorological data will be collected during site characterization.⁴ The monitoring activities include continuous and periodic measurements using instrumentation mounted on meteorological towers and in selected surface and subsurface locations. Meteorological data collection is especially amenable to digital data acquisition system, which can facilitate data management and analysis functions.

4.2.11.3 Data Evaluation and Reporting. The meteorological data base for site characterization is formulated by preparing tabular summaries of data collected on-site, backed up by historical records obtained from existing sources. These summaries provide hourly, daily, monthly, or seasonal averages, depending on the specific parameter. These summaries are reported individually in the SAR and ER to meet NRC regulatory guidance, and are also provided as input to other data types (e.g., hydrology, air quality) as required.

4.2.12 Air Quality

4.2.12.1 Technical Requirements. The focus of NRC regulatory requirements and guidance with respect to air quality is to define a baseline (pre-existing background conditions) for assessing the potential environmental impacts of releases of nonradiologic pollutants from disposal facility operations. The five parameters specific to air quality identified in Appendix A are pollutant type, pollutant concentrations, regional classification, air quality control region, and air quality ceilings.

4.2.12.2 Data Needs and Collection Methods. The technical activities and study methods that address these five parameters include the compilation of existing data, as well as collection of new data on-site. Existing data sources will generally be sufficient for characterization of existing emissions sources and the geographic designations of air quality status in the site region. The measurement of air quality parameters should provide at

least a one-year record of site-specific information.⁴ On-site monitoring using continuous and 24-hour integrated sampling techniques is necessary for characterization of pollutant types and concentrations in the local vicinity.

4.2.12.3 Data Evaluation and Reporting. The nonradiologic air quality data base for site characterization is compiled as tabular summaries of existing data and newly collected data summarized by hourly, daily, quarterly, or annual averages, as appropriate. The regional and local air quality designations (e.g., attainment status) are displayed on regional and local base maps. These data are used to evaluate the potential for contaminants to be dispersed to the disposal site from nearby industrial or agriculture sources, as well as to assess the potential impacts of proposed onsite facilities (e.g., incineration) or activities affecting local and regional air quality (e.g., truck traffic raising fugitive dust).

4.2.13 Radiological Assessment

4.2.13.1 Technical Requirements. NRC regulatory requirements and guidance with respect to radiological assessment focus on establishing pre-existing background concentrations of radioactive constituents at the site to form a baseline from which to identify any releases during disposal operations or following site closure. The ten parameters specific to radiological assessment identified in Appendix A address the media to be monitored, and include direct gamma radiation, airborne radionuclides, soil, surface water, ground water, sediments, flora, fauna, and food.

4.2.13.2 Data Needs and Collection Methods. It has been assumed that sites selected for characterization will not be in close proximity to facilities or areas in which detailed radiological monitoring programs have already been performed (e.g., nuclear reactor sites), as that would violate the NRC's site selection guidance to avoid areas where nearby facilities or activities may tend to mask the LLW site's environmental monitoring program. Therefore, it is generally unlikely that detailed radiological baseline data exist. Thus, the compilation of radiological data will generally require a monitoring program consisting of aerial and ground-based surveys, and periodic and continuous sampling. Radiological measurements should provide at least a one-year record of site-specific information; additional pre-operational monitoring through construction may be necessary to establish a complete baseline for the operational environmental monitoring program. Radiological monitoring is performed both as a stand-alone task, using equipment such as airborne scintillation detection devices and ground-based dosimeters, as well as in conjunction with monitoring programs for other data parameters, such as surface- and ground-water quality.

4.2.13.3 Data Evaluation and Reporting. Data obtained in the radiological monitoring program are compiled and reported in tabular formats supported by maps of sampling grid locations. Interpretation of certain

sampling data yields isometric contour maps showing radionuclide presence, location, and activity levels.

4.2.14 Ecology

4.2.14.1 Technical Requirements. NRC regulatory requirements and guidance with respect to ecology are directed toward defining the baseline terrestrial and aquatic characteristics of the site to support environmental impact assessments and mitigation planning. Important concerns include abundance and characteristics of species, importance of the species, seasonal and migratory patterns, offsite conditions, and existing natural and human-induced effects. The ten parameters specific to ecology identified in Appendix A are terrestrial fauna species, terrestrial flora species, aquatic species, livestock, food chain, migratory species, game animals, habitat, threatened and endangered species, and disease vectors and pests.

4.2.14.2 Data Needs and Collection Methods. The technical activities and study methods necessary to address these ten parameters include the compilation of existing data from agency sources, followed by onsite investigations at several levels of intensity. The ecological survey should encompass a radius on the order of 5 km from the disposal site for major vegetation types and commercially or recreationally important vertebrate species.⁴ Other important vertebrate species should be identified within a radius of 25 km. Sampling should be conducted for a minimum period of one year on a quarterly basis to determine seasonal variations of species.⁴ Site reconnaissance surveys (including aerial photography) are used to confirm information obtained from existing sources, to determine species and habitat conditions, and to select sites and techniques for more intensive investigation as necessary. These investigations include such methods as mark and recapture studies to determine species population densities and site usage, detailed surveys following grid transects for quantitative estimates of population and habitat conditions, and sampling and analysis of vegetation in monitored plots for characterization of conditions such as the presence of contaminants. Many of the characterization methods for the ecological data parameters are inter-related and should be planned and executed in an integrated manner.

4.2.14.3 Data Evaluation and Reporting. The ecological data collected for site characterization consist of species lists, maps, tabular summaries, and narratives, backed up by field notes and analytical data. Evaluation of these data is necessary to characterize the terrestrial and aquatic systems of the site itself and in surrounding areas, which might be affected by site construction and operation. The baseline ecological conditions can be assessed in terms of the overall health of the ecosystem, the importance of the habitat to the resident and migratory species, the ability of the ecosystem to accommodate site development, and the potential effects of ecological conditions on site operations. The latter should specifically address the pattern of vegetational succession that would occur if the site

were left undisturbed and unmanaged. This is useful information for characterizing surface hydrological conditions and erosion potential, as well as for planning and evaluating facility operational and performance characteristics. It should be recognized that site characterization may need to address the role and effects of long-term ecological conditions and processes as an integral part of the geohydrologic environment that surrounds and affects the LLW facility. The ecological baseline also provides an important starting point for mitigation planning related to specific site development features or operations.

4.2.15 Socioeconomics

4.2.15.1 Technical Requirements. The NRC regulatory guidance regarding the wide variety of topics encompassed under the term socioeconomics is directed toward developing the data necessary to conduct a comprehensive analysis of the potential effects of the proposed facility on local and regional economics, public services, and quality of life indicators. The focus of the analysis is on the ability of local communities to accommodate a significant construction project and long-term operation of a radioactive waste management facility. The six parameters specific to socioeconomics identified in Appendix A are labor force, housing, health and public safety systems, education systems, tax base, and sociocultural characteristics.

4.2.15.2 Data Needs and Collection Methods. A variety of data, some of which are related to the geography, demography, land use, transportation and aesthetics studies, are required for socioeconomic characterization. These include the size, composition and availability of the local labor force; the types, amounts, age, condition and availability of existing and projected housing; the capacity and capabilities of health and public safety systems to meet the needs of the labor force; the capacity and availability of educational institutions; the taxing jurisdictions, tax structures and revenues that may be affected; and various indicators of sociocultural characteristics, such as cultural values and family stability. These data are generally obtained through a combination of accessing existing public agency data sources and conducting direct surveys and interviews of local residents, community leaders, and professionals. The region for which socioeconomic data are collected should include the county in which the site is located and those portions of surrounding counties and urbanized areas (generally up to 40 km) from which the work force would be drawn or whose community services would be affected by in-migration of workers.

4.2.15.3 Data Evaluation and Reporting. Depending on the complexity of the socioeconomic characteristics of the local area and region surrounding the site, as well as the nature of significant socioeconomic concerns that have been raised, evaluations of the data obtained may vary from qualitative and quantitative analyses supported by tabular data summaries to complex socioeconomic impact assessment modeling. If modeling is used, the site characterization report would describe the quality of input data and

assumptions used, data processing methods, and the sensitivity of the model results to any qualifications regarding the data or assumptions used.

4.2.16 Cultural Resources

4.2.16.1 Technical Requirements. NRC regulatory guidance with respect to cultural resources is directed toward identifying the potential for encountering sites, buildings, structures, or objects of historical, archeological, architectural, scenic, cultural, or landmark significance during disposal facility construction, operation, or closure to support environmental impact assessments. The three parameters specific to cultural resources identified in Appendix A are historic places, archaeologic sites, and other cultural resources.

4.2.16.2 Data Needs and Collection Methods. The cultural resources survey should be performed to a radius of approximately 10 km from the site.⁴ The location of historic structures and archaeological sites should be identified through consultation with Federal and State historic preservation agencies, literature review, field reconnaissance, and limited surface testing if necessary. It is especially important in this discipline area to maintain a close working relationship with appropriate agency personnel (e.g., the State Historic Preservation Officer) in all data collection activities in order to ensure compliance with the standards and procedures that have been established for cultural resource preservation.

4.2.16.3 Data Evaluation and Reporting. The principal emphasis of the regulatory guidance on this topic is the determination of the significance of any identified cultural resources and the potential for any such resources to be found or affected during facility development. Explicit criteria have been established, for example, for evaluating the potential of a cultural site to be included on the National Register of Historic Places. Reporting on the findings of the cultural resources investigations in the documents resulting from site characterization may require special consideration for confidentiality to protect any identified sites from unauthorized intrusion. As with data collection and evaluation, reporting should also be closely coordinated with the responsible agencies.

4.2.17 Transportation

4.2.17.1 Technical Requirements. The emphasis of the NRC regulatory guidance with respect to transportation is to identify transportation modes, routes, and systems that will be used to ship wastes to the disposal facility to assess carrying capacity and condition, modifications affecting traffic flow, and potential radiation exposures to the general population along waste transport routes. The six parameters specific to transportation identified in

Appendix A are major highways, local highways and roads, navigable waterways, railroads, rights-of-way, and public transportation.

4.2.17.2 Data Needs and Collection Methods. Data collection for the transportation characterization can be coordinated with the collection of land use and demographic information. This will provide the locations and routes of local and regional transportation facilities and systems, as well as population counts along the projected waste transport routes. Data on the carrying capacities, conditions, restrictions, and planned modifications to local and regional transportation systems are generally obtained from the appropriate agencies (e.g., State and Federal departments of transportation), carriers/operators (e.g., railroad companies), and local planning agencies. Accident data pertaining to specific roads and highways may be maintained by local law enforcement agencies.

4.2.17.3 Data Evaluation and Reporting. Much transportation data can be summarized in narrative, tabular, and map formats that require little interpretation or analysis. Modifications to existing transportation systems to be imposed by a LLW disposal facility, either physically or in terms of traffic volumes or routing restrictions, may require traffic engineering or other types of transportation planning analyses. Analysis of accident scenarios and statistics along with populations resident along transport routes provides the data necessary to support subsequent dose calculations for potential accidents resulting in release of radioactive materials.

4.2.18 Aesthetics

4.2.18.1 Technical Requirements. NRC regulatory requirements and guidance with respect to aesthetics are directed toward assessing the impacts of disposal facility construction and operation on the visual quality of the area and on terrestrial biota that are sensitive to noise to support environmental impact assessments and mitigation planning. The two parameters specific to aesthetics identified in Appendix A are visual resources and noise.

4.2.18.2 Data Needs and Collection Methods. Collection of data pertaining to visual resources typically focuses on two general data categories: 1) physical conditions contributing to the quality of visual resources, such as topography, vegetation and land uses that are characterized using factors such as landform diversity, man-made alterations, and the scale of scenic vistas; and 2) visual sensitivity, or the ability of a visual resource to accommodate modification, that is characterized by measuring the number and frequency of viewers (e.g., highway travelers), the relative scenic importance of an area, and other indicators. For sites located within or adjacent to public lands, these characterizations may have been performed by the land management agency (e.g., U.S. Forest Service). If not, visual resource characterization methodologies developed by such agencies may be

applicable. The other principal component of the aesthetics characterization, ambient noise, is measured using standard noise monitoring equipment placed to develop a profile of ambient noise levels on the site and its environs.

4.2.18.3 Data Evaluation and Reporting. Reporting on the aesthetics characterizations involves both narrative descriptions and maps depicting "viewshed" boundaries and other visual resource parameters. Photo documentation of viewsheds is also essential. The ambient noise characterizations also generally utilize maps of the site area depicting sources, receptors, and noise levels. A significant degree of subjectivity and judgment is inherent in evaluation of data collected to characterize the aesthetics of a project area. This is one reason to utilize methods such as the U.S. Forest Service Visual Resource Management System, which tend to provide standardization and objectivity to the analysis process. It may be useful to establish technical linkages among the land use, socioeconomics, and aesthetics evaluation for both technical efficiency as well as to incorporate the concerns and values of local residents.

5.0 QUALITY ASSURANCE AND QUALITY CONTROL CONSIDERATIONS

5.1 Introduction and Definition of Quality Terminology

As applied to the development of LLW disposal facilities, Quality Assurance (QA) may be considered to be all of those planned, systematic activities necessary to provide adequate assurance that the facility will perform satisfactorily throughout its operational lifetime. QA is generally considered to include Quality Control (QC), which refers to those specific methodologies used to provide control or measurement of performance within given limits or specified criteria. The goal of a QA/QC program during the LLW site characterization process should be to assure the technical suitability and defensibility of the site, to assure that the data obtained during site characterization is adequate to support the facility design process, and to establish the management controls and feedback systems that will assure consistently acceptable facility performance through its operational lifetime and closure.

5.2 Regulatory Background

QA/QC program requirements for LLW facilities originate in 10 CFR 61.12(j), which requires that the applicant describe the QA/QC program in effect throughout the lifetime of the facility. Lifetime facility phases include:

- o Determination of natural disposal site characteristics
- o Design and construction of the facility
- o Facility operation
- o Facility closure.

The QA program requirements that are discussed in Section 5.3 relate to all phases of the facility's lifetime; however, those aspects pertinent to site characterization are emphasized.

5.3 Basic QA Program Requirements

The NRC has recently published NUREG-1293, "Quality Assurance Guidelines for Low-Level Radioactive Waste Disposal Facility,"¹⁷ which provides guidance to license applicants in meeting the QA/QC program requirements of 10 CFR 61.12 (j). At the time of preparation of this handbook, the document is in draft form, subject to public comment. The quality program criteria presented in NUREG-1293 are similar to those contained within 10 CFR 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants."¹⁸ The NRC has accepted these criteria as basic to any QA program, and has tailored the concepts to fit the requirements of LLW disposal facility development. The individual criteria discussed below comprise the elements of

the QA program that will be required by the State agency, private developer, or subcontractor with primary responsibilities for site characterization activity.

5.3.1 Organization

The applicant will be responsible for the development and maintenance of a QA program. The organization of the QA program must be clearly defined in terms of the authority and responsibilities of those individuals and organizations performing QA functions. The primary functions under the QA program are (a) maintenance of the QA program and systematic assurance of continued program effectiveness, and (b) verification of correct technical performance by review, inspection, auditing, or other means. The applicant may subcontract portions of the implementation and development, but must remain responsible for overall effectiveness and must be capable of independently assessing the adequacy of a contractor's performance. Sufficient organizational independence and authority must be provided to ensure that the individuals and organizations performing QA functions for site characterization can effectively identify quality problems; initiate, provide, or require solutions to such problems; and control further activities until any quality problems are resolved.

5.3.2 QA Program

The QA program should be established at the earliest practicable time, ideally, before any technical data are gathered. It should be flexible in structure to permit expansion and modification as site characterization progresses. NRC will require that all site characterization or preliminary design data be obtained under program controls or be verified and qualified by established QA procedures prior to use. It is prudent for the applicant to establish the QA program elements concerned with the review and qualification of published data and the gathering and qualification of new data as early as possible in the site characterization process. This is particularly important because the design, and consequently the ultimate safety, of the facility will be based on site characterization data. The early establishment of a QA program will not only preclude unnecessary and potentially costly reverification of data, but will also provide defensible documentation of the process. Section 5.4 discusses items that must be considered in the qualification of published and gathered data.

All elements of the QA program should be documented by written policies, procedures, and/or instructions. The program should provide for conducting all activities affecting quality in controlled conditions, and should address special controls, processes, equipment, and personnel skill levels, where required, to attain the desired level of quality. The program must provide means of verification by inspections, tests, or other methods, and should provide for the training and qualification of all personnel performing activities affecting quality. The applicant should regularly examine the overall effectiveness of the QA program. Management of other participating (or subcontracted) organizations should similarly perform a periodic review of

the portions of the QA program for which they share responsibility for effectiveness.

It will be particularly important in the design of a QA program to provide a means for evaluating site characterization activities and controlling the extent and level of application of QA program elements. The NRC has made it clear in NUREG-1293 that the relationship of all activities to the performance objectives of 10 CFR 61.12 (j) must be identified. All QA program controls should be applied at a level commensurate with the type, complexity, and criticality of the activity; when a direct relationship to performance has been identified, the full range of available controls must be considered, or other means provided to properly control the activity.

5.3.3 Design Controls

The QA program should provide the means for ensuring that the regulatory requirements of 10 CFR 61 that govern the development of the design and safe operation of the disposal facility are properly transferred to the specifications, drawings, procedures, and instructions that define the construction of the facility. Because the data resulting from the site characterization process have a major role in the development of the disposal facility design, they must be subjected to controlled QA review and approval processes. All changes to design-supporting recommendations resulting from site characterization must be submitted to the same controlled review processes utilized for the original document. If contractors are used for portions of the site characterization activity, the applicant must ensure that appropriate review processes and interface controls exist to control development of the recommendations from site characterization.

5.3.4 Procurement Document Control

During site characterization, procurement of items such as computer software, data base information, field equipment, and laboratory equipment may be required. Various types of contractor services are also likely to be needed. The QA program should provide review procedures to ensure that all applicable QA, regulatory, and design requirements are included in procurement documents. Revisions to procurement documents must undergo the same review and approval cycle as imposed for the original, and appropriate elements of the QA program should be passed on to contractors or their subtler suppliers. Procurement documents should specifically define acceptance requirements, describe nonconformance reporting and handling requirements, define contractor documentation and records retention responsibilities, and allow for applicant access for purposes of inspection or audit.

5.3.5 Instruction, Procedures, and Drawings

All activities affecting quality, including the QA program elements discussed here, must be implemented and controlled by means of procedures, instructions, drawings, specifications, or other controllable documents. When

appropriate for the affected activity, documents must include adequate qualitative or quantitative acceptance or completion criteria in order to facilitate performance verification. In site characterization, this applies to technical procedures for field and laboratory investigations, verification of computer software, review of reports, reduction of field data, and other activities.

5.3.6 Document Control

The QA program should control the review, issuance, and revision of the documents discussed in 5.3.5. Procedures for document control must ensure that documents are distributed to appropriate personnel and locations, and that only current revisions of documents are used.

5.3.7 Control of Purchased Material, Equipment and Services

Materials, services, and supplies will need to be purchased during site characterization, as described in Section 5.3.4. The QA program must provide for the evaluation and selection of suppliers and consultants, and must address the inspection or evaluation of purchased material, equipment, and services. The means selected must provide a checkpoint prior to the acceptance and use of the materials or equipment, or in the case of services, provide a means of evaluating the quality of the service provided on at least a periodic basis. The evaluation techniques may include source inspection, surveillance inspection, receiving inspection, acceptance testing, software verification and validation, technical review, auditing, or other methods. Procedures should address each potential method of evaluation, and should discuss the documentation of the acceptance or rejection of the evaluated item or service.

5.3.8 Identification and Control of Materials, Parts, and Components

The QA program should address identification and control requirements for purchased equipment, parts, and fabricated assemblies or subassemblies. In site characterization, these items may include field and laboratory test equipment used in site studies, computers or software. Item identification should be unique, maintained by physical marking or by traceable records. Identification requirements may also be interpreted to apply to physical samples such as core samples or samples for hydrologic or geochemical testing performed during site characterization.

5.3.9 Control of Processes

All processes that affect the quality of items or services must be controlled through the use of procedures, drawings, instructions, or other appropriate means as discussed in 5.3.5 above. During site characterization it will be particularly important to invoke appropriate controls over those processes that have a direct relationship to the collection, accuracy,

adequacy, and compilation of site data. Such activities may include sampling, laboratory analysis, and modeling.

Certain processes may be considered "special" and, in addition to the controls just mentioned, will require qualification of personnel, equipment, and procedures prior to actual project use as a means of controlling the quality of the item or service subsequently produced. NUREG-1293 does not specifically define the types of processes requiring qualification, but such considerations are traditionally confined to processes such as welding, heat treating, and nondestructive testing, for which it is necessary to demonstrate that a particular combination of personal skill, procedures, and equipment will produce acceptable results in actual practice.

Because such special processes are generally related to facility construction, it is unlikely that they will be used in the site characterization phase. However, if these or other such processes are identified in the future, procedures must be developed that control the qualification of personnel, equipment, and procedures in accordance with established codes, standards, or other requirements. Special process qualification activities must be completed prior to the actual use of the process.

5.3.10 Inspection

The QA program should provide procedures for inspection of activities affecting the quality of the results of site characterization. Procedures should define the qualification requirements for inspectors, and specifically require their independence from the activity being inspected. Direct inspection methods are assumed to be most applicable during site characterization; such methods include receiving inspection, in-process inspection, and surveillance inspection. Receiving inspection is performed as a means of controlling purchased items or materials, and ensures that only items in compliance with their procurement requirements are accepted for use or further processing. In-process inspection is performed at scheduled hold or check points for site characterization activities documented in plans, procedures, or other documents; in such cases, inspection will be required before the activity can proceed. Surveillance inspections are overchecks of selected items, processes, or procedures that are performed to ensure continued performance in compliance with specified requirements.

5.3.11 Test Control

All testing and analytical procedures used during site characterization should assure that the test prerequisites have been met, testing is performed under suitably controlled conditions, supporting instrumentation is both adequate and accurate, acceptance or completion criteria are provided, inspection hold points are established where appropriate, and adequate means of documenting and evaluating the test results are provided.

5.3.12 Control of Measuring and Test Equipment

The QA program should provide a system of calibration and maintenance for measuring and test equipment that will ensure the accuracy of the results of all site characterization. This system should apply to all activities involving sampling, data collection, field verification, or laboratory analysis. Responsibilities for the maintenance of the system should be clearly defined. The system should require traceability of calibrations to nationally recognized measurement standards, provide for positive identification of measuring and test equipment to calibration and maintenance records, and provide a means of controlled issue and recall of equipment to ensure that only properly serviced and calibrated equipment is utilized.

5.3.13 Handling, Storage, and Shipping

The QA program should provide measures for controlling the handling, storage, and shipment of materials and equipment. The requirement extends in particular to the handling of samples, which must be protected from degradation, deterioration, physical damage, and loss of identification. The maintenance of sample identification and preservation of in-situ characteristics, to the fullest extent possible, may be critical to the success of an investigation. Sampling procedures must properly address such considerations, and personnel must be trained to the procedure requirements.

5.3.14 Inspection, Test, and Operating Status

The QA program should provide the means of indicating the inspection status of procured materials and equipment to preclude the use of uninspected or rejected materials or items. Inspection status of tests or in-process inspections must also be determinable in order to preclude missing test steps, double inspections, or the potential invalidation of test results. Test equipment operating status must be clearly visible to preclude invalidation of results due to unauthorized movement or adjustment of test equipment.

5.3.15 Nonconforming Materials, Parts, or Components

The QA program should contain procedures for documenting and resolving nonconformances observed during receiving or in-process inspections that may be conducted during site characterization. Means must be provided for identification of nonconforming materials or items and segregation from accepted items wherever possible. Procedures must provide a systematic means for obtaining proper problem disposition; correcting the discrepancy by reanalysis, retesting, repair, rework, or returning to the supplier; and taking appropriate corrective action to reduce or preclude the possibility of similar discrepancies. Procedures must define the authority required to resolve nonconformances and provide for the complete documentation of the resolution processes.

5.3.16 Corrective Action

The QA program, in particular the inspection, nonconformance control and auditing portions, should provide the means for identifying and ensuring the prompt correction of conditions adverse to quality. The correction of a nonconforming condition is not considered complete without considering the basic or root causes of the nonconformance and taking appropriate corrective action to address those causes. The corrective actions taken as a result of nonconformances are effectiveness indicators that must be reported in a timely manner to levels of management that have overall program responsibilities.

5.3.17 Quality Assurance Records

The QA program should provide for the maintenance of records that furnish documentary evidence of quality during site characterization. Records should be retained from receiving inspections, sampling, tests, in-process inspections, surveillances, audits, work performance monitoring, training, reviews, material analyses, and radiation exposure pathway evaluations. Personnel qualification records, special process procedure qualification, and special process equipment qualifications should be retained whenever special processes are used. The applicant must assign responsibilities for records retention and establish procedures for records identification, access control, protection, retrieval, and storage.

5.3.18 Audits, Surveillance and Managerial Controls

The QA program should provide for a system of planned and periodic surveillances and audits during site characterization. Surveillance, as discussed in Section 5.3.10, may be considered to be a type of inspection; it requires overchecks of selected items, processes, or procedures to ensure continued performance in compliance with established requirements. Auditing is a planned and documented investigation performed in accordance with written procedures or checklists for the purposes of verification, by examination of objective evidence, that applicable elements of the QA program have been developed, documented, and effectively implemented. Surveillance is directed towards a specific ongoing activity; auditing is used to examine the full scope of QA program applicability, and relies in a large part on objective evidence and formal investigative techniques. Auditors must be properly trained, qualified, and independent from the activity being audited; audit results must be reviewed by management responsible for the area audited and corrective action taken where required, as described in Section 5.3.16.

5.4 Qualification of Data

Controls over the data collected during site characterization and used for the design of a disposal facility will be critical to successful licensing. All data used in the license application, whether it is pre-existing, published or newly gathered, must be qualified under a QA program meeting the requirements discussed in Section 5.3.

5.4.1 Review and Qualification of Published Data

Existing data collected during site characterization may be utilized, provided that they are examined and qualified. The examination and qualification of data must be documented and supported by formal review processes to support licensing. Qualification may be accomplished by technical review, peer review, qualification testing, software validation and verification, literature search/review, or other means, singly or in combination. Qualification techniques should be selected based on their appropriateness for the type of data that are being reviewed or examined. Each technique should be controlled by procedures and should provide the criteria for the examination, qualifications of the examiner or reviewer, and documentation of the review or decision process.

5.4.2 Gathering and Qualification of New Data

The process of gathering new data will involve many elements of the applicant's QA program; effective procedures in the following areas will be particularly crucial in the data-gathering process:

- o Training and qualification of technical, testing, and inspection personnel
- o Controlled test procedure development and test control
- o Calibration and maintenance of measuring and test equipment
- o Literature search and review
- o Computer software validation, verification, and control
- o Technical and peer review.

New data that may have been gathered when QA program controls were not in effect may be acceptable for use if qualified through one or more of the techniques discussed in 5.4.1.

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7. U.S. Nuclear Regulatory Commission, Technical Position Paper, Environmental Monitoring of Low-Level Waste Disposal Facilities, Working Draft, Division of Waste Management, 1986.
8. U.S. Nuclear Regulatory Commission, Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility; Safety Analysis Report, NUREG-1199, Office of Nuclear Material Safety and Safeguards, 1987.
9. U.S. Nuclear Regulatory Commission, Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility; Safety Analysis Report, NUREG-1200, Office of Nuclear Material Safety and Safeguards, 1987.
10. U.S. Nuclear Regulatory Commission, Environmental Standard Review of Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility; Environmental Report, NUREG-1300, Office of Nuclear Material Safety and Safeguards, 1987.
11. Executive Order 11988, "Floodplain Management", Federal Register, 42, 101, Wednesday, May 25, 1977.
12. U.S. Water Resources Council, Guidelines for Determining Flood Flow Frequency, Bulletin 17-B, Washington, D.C., 1981.

13. U.S. Nuclear Regulatory Commission, Design Basis Floods for Nuclear Power Plants, Regulatory Guide 1.59, 1977.
14. U.S. Geological Survey and U. S. Bureau of Mines, Principles of a Resource/Reserve Classification for Minerals, U.S.G.S. Circular 831, 1980.
15. U.S. Nuclear Regulatory Commission, Site Investigations for Foundations of Nuclear Power Plants, Regulatory Guide 1.132, 1979.
16. U.S. Nuclear Regulatory Commission, Laboratory Investigations of Soils for Engineering Analysis and Design of Nuclear Power Plants, Regulatory Guide 1.138, 1978.
17. U.S. Nuclear Regulatory Commission, Quality Assurance Guidelines for a Low-Level Radioactive Waste Disposal Facility, NUREG-1293, Low-Level Waste Licensing Branch (draft), 1987.
18. U.S. Nuclear Regulatory Commission, Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants, Title 10 Code of Federal Regulations Part 50 (10 CFR 50), Appendix B, 1987.

APPENDIX A

TECHNICAL PARAMETERS/
DATA REQUIREMENTS MATRICES

INSTRUCTION ON THE USE OF THE REGULATORY MATRICES IN APPENDIX A

Eighteen matrices have been developed for specific technical disciplines or data types that are involved in characterizing a LLW disposal site for licensing by the NRC. These data types include geology, ground-water hydrology, surface-water hydrology, geochemistry/hydrochemistry, water resources, geologic/timber/agricultural resources, geotechnical investigation, geography, demography, land use, meteorology, air quality, radiological assessment, ecology, socioeconomics, cultural resources, transportation and aesthetics.

Each matrix cites those sections of the NRC regulations and guidance documents that are pertinent to the data types. The NRC documents include:

- o 10 CFR 61, NRC Licensing Requirements for Land Disposal Radioactive Waste¹
- o 10 CFR 51, NRC Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions²
- o NUREG-0902, NRC Branch Technical Position on Site Suitability, Selection, and Characterization³
- o NRC Draft Technical Position on Environmental Monitoring of LLW Disposal Facilities⁴
- o NUREG-1199, Standard Format and Content - Safety Analysis Report⁵
- o NUREG-1200, Standard Review Plan - Safety Analysis Report⁶
- o NUREG-1300, Environmental Standard Review Plan - Environmental Report.⁷

Revisions to NUREG-1199 and NUREG-1200, published early in 1988, were not available at the time Appendix A was written. However, the changes in these new documents address only near-surface trench disposal, specifically those alternative concepts that incorporate structures constructed of cementitious materials with earthen covers; consequently they do not affect the scope of information included in this appendix.

The contents of Regulatory Guide 4.18, "Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste,"⁸ were considered by the NRC in the preparation of NUREG-1300. However, the overall data and information requirements of NUREG-1300 are not necessarily consistent with the guidance provided in Regulatory Guide 4.18.⁷ Until the NRC prepares a revised version of Regulatory Guide 4.18, the NRC has stated that review procedures outlined in NUREG-1300 will be followed.⁷ For this reason, Regulatory Guide 4.18 has not been included in the Appendix A matrices; however, this document should be reviewed when the revised version is published by the NRC.

For each of the above NRC documents (exclusive of the Part 51 and 61 regulations), the guidance for licensing documentation pertaining to the relevant data type is summarized in the matrix using either direct quotations or paraphrased statements. Direct quotations are enclosed by quotation marks and paraphrased passages are enclosed by brackets.

All technical parameters determined to be necessary to complete the site characterization licensing documentation for each data type are listed across the top of the matrix. These technical parameters are described in attachments accompanying each matrix. An "X" on the matrix indicates that the parameter is specifically required to address the NRC guidance statement on the left side of the matrix. A "+" on the matrix indicates that the parameter was interpreted to be implicitly required by the NRC guidance statement.

The purpose of these matrices is to provide guidance to technical planners and program managers as to the types of data that are necessary to comply with NRC licensing requirements and technical guidance. They can be used during the initial planning stages of the site characterization program and as work proceeds and program plans require updating or revision. The data types and parameters identified in this handbook are based on interpretations of NRC regulations and guidance. Individual States may find that other data types or parameters may better address their specific needs in complying with their State's licensing requirements.

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION							
DATA TYPE: GEOLOGY							
REGULATORY REQUIREMENT	PARAMETERS						
	Geomorphology	Stratigraphy	Lithology	Structure	Tectonics	Seismology	Geologic Hazards
10 CFR 61 - NRC Licensing Requirements 61.12(a)&(d) 61.13(d) 61.50(a)(2), (a)(9)&(a)(10) 61.53(a)							
10 CFR 51 - NRC Environmental Protection Regulations (Does not specifically address geology)							
REGULATORY GUIDANCE							
NUREG-0902 (Site Suitability, Selection, and Characterization) "The site characterization investigations of significant hydrogeologic units overlap with geologic and tectonic studies...Together they should identify the lithology, thickness, lateral extent, continuity, landl inclination...fault zones or joint systems landl the presence of flow barriers, such as fault zones or dikes (should also be investigated)." (p. 18)		X	X	X		X	
"Stratigraphic data will typically be generated by several types of site characterization investigations (including)...surface mapping of geologic and hydrologic features of the site...exploratory boreholes with detailed descriptions and laboratory testing of core samples...surficial geophysical surveys...borehole geophysical logging...landl test pit or slit trench excavation...." (p. 20 and 21)		X	+				
"Lithologic investigations will range from lithologic descriptions based on visual observations...to laboratory tests...." (p. 21)							X

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

REGULATORY GUIDANCE	PARAMETERS						
	Geomorphology	Stratigraphy	Lithology	Structure	Tectonics	Seismology	Geologic Hazards
NUREG-0902 (Continued)							
"Structural geologic investigations of the site should concentrate on joints and other fractures present in the hydrogeologic unit(s) used for the disposal and isolation of the waste....In fractured media, studies should be performed to define fracture spacing, continuity, roughness, and aperture for analyses of slope stability and modeling of fluid flow and solute transport." (p. 22)				X			X
"Geomorphic investigations should include systematic analysis of landforms to give indirect evidence of destructive geomorphic processes." (p. 22)	X						
NRC Draft Technical Position Paper on Environmental Monitoring							
"Part 61 states the need to establish monitoring programs to obtain baseline information on....geology landl....seismology." (Section 2.2.1, p. 7 and 8)	+					X	+
NUREG-1199 (SAR Standard Format and Content)							
"The applicant should describe and discuss the tectonic history of the region, regional geomorphology, physiography, stratigraphy, and geochronology. All tectonic structures should be identified....and their geologic and structural history should be discussed. The relationship between seismicity and tectonic structures and the earthquake-generating potential of any active structures should be determined." (Section 2.3.1, p. 2-3)	X	X		X	X	X	+

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

PARAMETERS

REGULATORY GUIDANCE

Geomorphology Stratigraphy Lithology Structure Tectonics Seismology Geologic Hazards

NUREG-1199 (Continued)

"The applicant should discuss the relationship between the regional and site physiography. The structural geology of the region should be described, and its relationship to the site geologic structure should be discussed. Any faults, folds, open jointing, fractures, and shear zones in the region must be identified, and their significance to the facility... discussed. Also, the applicant should investigate the possible existence of crustal tilting, subsidence, karst terrain, landsliding, and erosion." (Section 2.3.1, p. 2-3)

"When a low-level waste disposal site is to be located within a region of active plate tectonics characterized by volcanism, the applicant should collect all available data resulting from geophysical and geodetic monitoring in the region. The sequence and ages of the volcanic flows should be described, and the potential for renewed volcanic activity and the effect on the site should be determined." (Section 2.3.1, p. 2-3 and 2-4)

"The applicant should describe the surface and subsurface geologic characteristics of the disposal site and its vicinity. The description should include local stratigraphic units and their accepted names, ages, genetic relationships, and lithologies." (Section 2.3.1, p. 2-4)

X

X

X

X

X

X

+

X

X

+

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE. GEOLOGY

PARAMETERS -

REGULATORY GUIDANCE	Geomorphology	Stratigraphy	Lithology	Structure	Tectonics	Seismology	Geologic Hazards
NUREG-1199 (Continued)							
"The applicant should describe the geomorphology of the disposal site.... Information should include descriptions of [geomorphic] processes such as mass wasting, erosion, slumping, landsliding, and weathering where appropriate. The discussion....should include their rates, frequencies of occurrence, and controlling mechanisms or factors." (Section 2.3.1, p. 2-4)	X						+
"The applicant should describe the location, attitude, and geometry of all known or inferred faults in the disposal site and vicinity. Those faults that can reasonably be expected to affect waste isolation should receive special emphasis. The applicant should discuss the relationship of these faults to the present-day local stress field. Fault displacements should be identified and potential recurrence intervals addressed. The applicant should identify any potential effects on the disposal site as a result of deformation during fault displacement." (Section 2.3.1, p. 2-4)				X	X		X
"The applicant should discuss the nature and rates of deformation such as folding within the disposal site and relate these to the local stress regime. Any joint sets within the disposal site including their densities and orientations (and remineralization and mineralization history) should be described, and their relative ages discussed. Solution cavities and crevices in bedrock should be described and discussed, if applicable." (Section 2.3.1, p. 2-4)				X	X		+

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

PARAMETERS

REGULATORY GUIDANCE	Geomorphology	Stratigraphy	Lithology	Structure	Tectonics	Seismology	Geologic Hazards
<p>MUREG-i199 (Continued)</p> <p>"The applicant should perform an evaluation, from an engineering-geology standpoint, of the geologic features that affect the waste disposal facilities, trenches, and borrow areas including descriptions of zones of alteration or weathering, zones of structural weakness, and all potentially unstable strata or soils...." (Section 2.3.i, p. 2-4 and 2-5)</p> <p>"The applicant should provide information on the seismological and geophysical investigations to be carried out at the site and the region surrounding the site.... Information about the following should be provided: 1. seismicity including a complete list and map of all historical earthquakes within 200 miles of the site that have a magnitude of 3 or more, or a modified Mercalli intensity of IV or more, with all available details; tectonic characteristics of the site and region including a map of all tectonic provinces within 200 miles of the site and the criteria used to delineate the provinces; correlation of earthquake activity with geologic structures and tectonic provinces including correlation of earthquakes, structures, and tectonic provinces within 200 miles of the site and the rationale behind the correlation; maximum earthquakes potential including identification of the maximum credible or maximum historical earthquake for each geologic structure or tectonic province, respectively, within 200 miles of the site and the ground motion at the site from the largest earthquakes; seismic wave transmission characteristics of the site</p>			X	X		+	X
				X	X	X	+

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

REGULATORY GUIDANCE	PARAMETERS						
	Geomorphology	Stratigraphy	Lithology	Structure	Tectonics	Seismology	Geologic Hazards
NUREG-1199 (Continued)							
including the velocity, density, and elastic modulus of the materials overlying bedrock at the site; design earthquake including the ground acceleration from the largest earthquake at the free surface and at the depth of concern for the facility, the magnitude of any earthquake associated with a geologic structure, and the potential for amplifications of the motion in the overburden materials; settlement and liquefaction potential; and geophysical methods for site characterization." (Section 2.3.2, p. 2-5 and 2-6)							
NUREG-1200 (SAR Standard Review Plan)							
"The information in the SAR should address the regional and site physiography, geologic history, geomorphology, stratigraphy, lithology, structure, and tectonics. Specifically, it should address the following site characteristics: Indications of liquefaction-induced flowage features, karst terrain, faulting, crystal (crustal) deformation and differential subsidence, mass wasting, regional stress regime, and the effects of human activities in the site area. With specific reference to site geology, the following subjects should be reviewed by the NRC staff as they relate to the above conditions: topography, slope stability, fluid injection or withdrawal, bedrock solutioning, shearing, jointing, fracturing, and seismicity." (SRP 2.3.1, Sec. 4.3, p. 2.3.1-4)	X	X	X	X	X	X	+

*Also addressed by parameter for geotechnical investigation (Table A-7)
**Also addressed by parameters for water resources and natural resources (Tables A-5 and A-6, respectively)

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

REGULATORY GUIDANCE	PARAMETERS						
	Geomorphology	Stratigraphy	Lithology	Structure	Tectonics	Seismology	Geologic Hazards

NUREG-1200 (Continued)

"The applicant should evaluate all available historical data and list all available parameters for earthquakes within 200 miles of the site having a modified Mercalli intensity (MMI) greater than or equal to IV or a magnitude greater than or equal to 3.0. The applicant should provide an epicentral map showing the distribution of these earthquakes and large-scale maps showing earthquakes within 50 and 5 miles of the site and areas of high seismicity. The listing should include origin time, focal depth, epicenter coordinates, highest intensity, magnitude, and distance from the site. The magnitude designations such as Mb, ML, and Ms should be identified, and the sources of this information should be indicated. Any other relevant information related to the occurrence of the earthquake such as information on landsliding, fracturing, and liquefaction should be mentioned." (SRP 2.3.2, Sec. 4.3.1, p. 2.3.2-3)

"The applicant should identify accurately all the geologic structures and the tectonic activity within the region that are important in determining the earthquake potential. On the basis of the geologic structure and the distribution of earthquakes in the area, the applicant should identify, with documentation, the tectonic provinces in the vicinity of the site. The tectonic provinces may be identified on the basis of seismicity study, differences in geologic history, and differences in the current tectonic regime. In addition, when capable faults are identified in the vicinity of the site, a regional map should be provided showing the tectonic provinces, the location of the earthquakes with respect to these faults, and the location of geologic structures associated with these faults." (SRP 2.3.2, Sec. 4.3.2, p. 2.3.2-3 and -4)

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

PARAMETERS

REGULATORY GUIDANCE

Geomorphology Stratigraphy Lithology Structure Tectonics Seismology Geologic Hazards

NUREG-1200 (Continued)

"Whenever the SAR demonstrates the association of earthquakes with either geologic structures or tectonic provinces, the applicant should provide the rationale for the association taking into consideration the characteristics of the geologic structures and the regional tectonic model and the historical seismicity of the area. The coordinates of the earthquake location and its focal depth should be provided, and the methods used to locate it should be identified. The presentation should be augmented by regional maps showing the tectonic provinces, the earthquake epicenters, the location of geologic structures, and measurements used to define tectonic provinces. All the maps should be of the same scale." (SRP 2.3.2, Sec. 4.3.3, p. 2.3.2-4)

The applicant should examine the literature to identify the maximum credible earthquake associated with each geologic structure or maximum historical earthquake associated with each tectonic province... When new geological or seismological evidence becomes available that may warrant the determination of an earthquake larger than the maximum historical earthquake, a discussion should be provided and the magnitude of such an earthquake should be estimated. When an earthquake is associated with geologic structure, the maximum earthquake that could occur on that structure should be estimated taking into consideration the earthquake rupture length and type of faulting (normal, reverse, etc.). Also, the frequency content of the earthquake should be discussed, when possible. For the maximum historical earthquakes associated with tectonic provinces within a 200-mile radius of the site, isoseismal maps should be presented for the earthquakes having a magnitude greater than or equal to 3. The ground motion at the site should be estimated using appropriate attenuation models for

X

X

X

X

X

X

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

REGULATORY GUIDANCE	PARAMETERS						
	Geomorphology	Stratigraphy	Lithology	Structure	Tectonics	Seismology	Geologic Hazards

NUREG-1200 (Continued)

the area. In the estimation of ground motion, the maximum earthquakes associated with these tectonic provinces should be placed where the tectonic province is closest to the site. For the floating earthquake within the same tectonic province of the site, the earthquake should be placed at an appropriate distance from the site and the acceleration should be estimated." (SRP 2.3.2, Sec. 4.3.4, p. 2.3.2-4)

"To estimate the ground motion at the site, a knowledge of the seismic wave transmission from the sources to the site is essential. In addition, material overlying the bedrock at the site should be described because this material will amplify or deamplify the upcoming seismic waves." (SRP 2.3.2, Sec. 4.3.5, p. 2.3.2-5)

"The applicant should describe the vibratory ground motion resulting from the maximum earthquake at the free surface and at the depth of concern for the location of the facility. For this earthquake, the peak horizontal and vertical accelerations at the site should be estimated by using applicable attenuation relationships...The potential for amplification of vibratory ground motion in the overburden should be addressed...If possible, probabilistic seismic hazard estimates should be provided. The assumptions and uncertainties associated with these estimates should be documented. The results from the probabilistic seismic hazard study should highlight which seismic sources are of significance to the site." (SRP 2.3.2, Sec. 4.3.6, p. 2.3.2-5)

X

X

X

*Also addressed by parameters for geotechnical investigation (Table A-7)

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

PARAMETERS

REGULATORY GUIDANCE	Geomorphology	Stratigraphy	Lithology	Structure	Tectonics	Seismology	Geologic Hazards
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NUREG-1200 (Continued)

"Deformation and differential settlement of subsurface and fill materials under both static and seismic conditions, analysis for liquefaction potential, and consequences of liquefaction of subsurface soil affecting the stability of the cover materials should be analyzed..." (SRP 2.3.2, Sec. 4.3.7, p. 2.3.2-5)

X

NUREG-1300 (ER Standard Review Plan)

"The detail required is a function of the complexity of the geology of the site, but information needed for the staff's review will usually include the following: (1) description of the tectonic province and regional geologic features, (2) geologic maps sufficiently detailed so that they show the major geologic units and structural features that could affect or be affected by the disposal site, (3) tables identifying the mineralogy, petrology, grain size, and hydrologic characteristics of major stratigraphic units, (4) description of major structural features including faults and folds, (5) description of small-scale structural features including joints, bedding surfaces, and metamorphic fabrics, (6) description of

X

X

X

X

X

X

*Also addressed by parameters for geotechnical investigation (Table A-7)

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

REGULATORY GUIDANCE	PARAMETERS						
	Geomorphology	Stratigraphy	Lithology	Structure	Tectonics	Seismology	Geologic Hazards

NUREG-1300 (Continued)

topographic features indicative of faulting and/or mass wasting including fault scarps, karst topography, and landslide scars, (7) description of paleontologic resources that could be affected by the disposal site.** (ESRP 3.5.1, Sec. 2., p. 3.5.1-2)

*The kinds of data and information needed for the review of soil conditions will vary depending on regional and site-specific factors and the anticipated magnitude of the proposed actions. Information needed for the staff's review will usually include the following: (1) Identification of soil series or broader class, as specifically as possible... (2) Description of physiographic settings, such as hillslopes, alluvial terraces, or floodplain... (3) Nature of bedrock and other underlying materials in the area... (4) Slopes; descriptions of approximate gradient or range of gradients... (5) Description of plant cover and vegetation at the site, such as pine forest, corn, and pasture... (6) Description of climate; annual and monthly precipitation and temperature data, including mean annual temperature, mean annual precipitation, and annual extremes... (7) Description of soil materials and horizons and whether they are products of weathered bedrock or surficial deposits. For the horizon descriptions, USDA nomenclature should be used... Soil profile descriptions for each soil unit would be expected to include horizon designation, depth, thickness, boundary, color, texture, structure, consistence, roots, pores, and reaction. Additional features in the description might include iron or carbonate concretions, effervescence with dilute hydrochloric acid, and cementation... (8) Maps and cross-sections of soil and

X

X

X

X

*Also addressed by parameters for ground-water hydrology (Table A-2)

**Addressed by parameters for land use and meteorology (Tables A-10 and A-11, respectively)

TABLE A-1
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGY

PARAMETERS

REGULATORY GUIDANCE	Geomorphology	Stratigraphy	Lithology	Structure	Tectonics	Seismology	Geologic Hazards
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NUREG-1300 (Continued)

bedrock distribution, showing differing soil types, if present. Diagrams should include the general soils of the region and specific soils of the site... (9) relationships between soils and surficial geologic processes, including erosion by wind or running water... (and the rates and recurrences of these processes), (10) susceptibility of soils to mass wasting through slow displacements, such as creep and solifluction, and fast movements, such as debris slides and flows and earthflow... (and the rates and recurrences of these processes) (11) (12) geochemical interactions between soil materials and percolating and interstitial waters in the vadose zone, and groundwater in the saturated zone... [**] (ESRP 3.5.2, Sec. 2., p. 3.5.2-2 and 3.5.2-3)

"The information needed for the NRC staff's review of seismic characteristics will include a description of the regional and local seismicity in relation to the alternatives... The potential for seismic impact is negligible.... Therefore, an environmental review of seismicity normally is not required." (ESRP 3.5.3, Section 2. and 3., p. 3.5.3-1)

X

* Also addressed by parameters for geotechnical investigation (Table A-7)
** Addressed by parameters for geochemistry/hydrochemistry (Table A-4)

TABLE A-1
PARAMETER DESCRIPTIONS - GEOLOGY

Geomorphology: The characteristics, origin, and development of the regional and site landforms, their relationships to underlying structures, and the history of geologic changes as recorded by these surface features. Topography, slopes, drainage basis, stream channels, mass wasting, weathering, and erosion, and the rate, frequencies, and controlling mechanisms of these processes are included in this parameter.

Stratigraphy: The classification, correlation, and interpretation of surficial and Quaternary deposits and underlying rocks. Stratigraphy is concerned with accepted unit names, genetic relationships, depositional environment, areal extent, unit depth, thickness, geometry, vertical and lateral extent and variations, heterogeneity, paleontology, age (geochronology), and the geologic history of the site area.

Lithology: The description of surficial and Quaternary deposits and underlying rocks based on visual and laboratory characteristics. Information such as the gross lithology, lithologic trends, color, mineralogy, grain-size distribution, texture/fabric, primary and sedimentary structures, facies changes and relationships, lithologic contacts, cementation, alteration, metamorphic grade, weathering, type of clay, inclusions, degree of devitrification of volcanic rocks, organic content, carbonate content, and natural radioactivity is part of a complete lithologic description.

Structure: The characteristics, origin, and development of the faults, folds, joints, solution cavities or crevices, and other discontinuities or zones of weakness within the region and site. This includes their location, orientation, relative position, length, spacing/density, relative age, aperture or infilling, roughness, mineralization history, type of structure, displacement history or deformation rate, potential recurrence intervals, relationship of structures to present-day local stress field, and capability or activity.

Tectonics: The large-scale structure of the Earth's crust and the nature and rates of the processes responsible for these structures. This parameter includes the tectonic provinces within 200 miles of the site and their history, uplift, subsidence, tilting, folding, faulting, nature of volcanism and volcanic history, the regional and local stress regime, and the potential for unrelieved stresses to produce creep and rebound within the time frame of interest (500 years).

Seismology: The study of earthquakes and their relationship to the tectonics and structure of an area by both natural and artificially generated seismic waves. This includes determining, within a 200-mile radius of site: the historical seismicity of magnitude 3 or greater, or of modified Mercalli intensity IV or greater, with all available details; the earthquake recurrence intervals; the correlation of earthquakes with structures or tectonic provinces and rationale; the maximum earthquake potential of each geologic structure or tectonic province, its frequency content, and the resulting

ground motion at the site; and the design earthquake and accelerations at the site developed, if possible, from probabilistic seismic hazard estimates. The seismic wave transmission characteristics of the site, including velocities, bulk densities, and the shear and elastic moduli, and historical and potential fault rupture, seismically-induced hillslope failure, and liquefaction or settlement are also included in this parameter.

Geologic Hazards: The potential natural or man-induced hazards that could present a risk or potential danger to the site or to life. Evaluation of fault displacement, seismicity, slope failures, landslides, renewed volcanism, subsidence, collapse, liquefaction, karst terrain, flooding, expanding clays and other unstable elements in near-surface stratigraphic units and soils, and corrosivity of soils should be part of the site geologic hazards assessment.

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY REQUIREMENT													
PARAMETERS													
UNSATURATED FLOW													
SATURATED FLOW													
Hydrogeologic Modeling													
Boundary Conditions													
Geometry													
Specific Storage													
Porosity													
Hydraulic Conductivity													
Hydraulic Head													
Hydrogeologic Modeling													
Boundary Conditions													
Geometry													
Porosity													
Hydraulic Conductivity													
Moisture Content													
Moisture Potential													
10 CFR 61 - NRC Licensing Requirements													
61.7(a)(2)													
61.12(a) and (1)													
61.13(a)													
61.41													
61.50(a)(2), (a)(7), (a)(8)													
61.53(a)													
10 CFR 51 - NRC Environmental Protection Regulations													
51.45(d)													
51.71(d)													
REGULATORY GUIDANCE													
NUREG-0902 (Site Suitability, Selection, and Characterization)													
"Site conditions should be such that well-documented analytical solutions or computer codes are available and applicable for modeling site performance. As a minimum, the modeling of site characteristics, such as infiltration or ground-water flow, should be able to reproduce natural steady-state conditions and perturbed conditions, such as responses to precipitation or stresses introduced by pumping during the site characterization investigations." (p. 5)													

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

PARAMETERS

UNSATURATED FLOW

SATURATED FLOW

Moisture Potential	Moisture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
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REGULATORY GUIDANCE

NI-REG-0902 (Cont.)

"...the site characteristics should vary within a sufficiently narrow range so that the input to the modeling is representative of the hydrogeologic units and the assumptions underlying the modeling are valid. For example, the hydrogeologic unit used for disposal should not have continuous permeable or impermeable enclosures such as faults or fracture zones, sand lenses, weathered horizons, or karstic features that provide preferential pathways for or barriers to ground-water flow." (p. 5)

"[10 CFR 61.50(a)(7)] related to the depth of the water table, indicates that, with few exceptions, near-surface disposal of low-level radioactive wastes will be in unsaturated soil deposits (regolith)....Alternatively....waste disposal may be below the water table at some sites if it can be conclusively shown that site characteristics will result in molecular diffusion being the predominant means of radionuclide movement and the rate of movement will result in the performance objectives being met. In no case, however, should waste disposal occur within the zone marked by fluctuations of the water table." (p. 7)

"At sites where disposal will be above the water table, seasonal fluctuations of the water table and capillary fringe

*Also addressed by parameters for geology (Table A-1)

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	UNSATURATED FLOW							SATURATED FLOW						
	Mol. Structure	Mol. Structure	Content	Hydraulic	Conductivity	Porosity	Geometry	Boundary	Conditions	Hydrogeologic	Modeling	Hydraulic	Head	Conductivity
<p>both prior and subsequent to waste disposal must be considered. The bottoms of the disposal unit must be, at all times, above the saturated zone in order to limit water contacting the wastes to that small portion which infiltrates through covers in disposal areas....In addition, the accumulation of water in the disposal unit (bath-tub effect) must be avoided." (p. 7 and 8)</p> <p>"For sites where disposal will be below the water table, the hydrogeologic unit used for disposal should have hydraulic properties, e.g. hydraulic conductivity and effective porosity, which essentially preclude ground-water flow. The hydraulic conductivity, as tested in-situ, should be less than 10^{-6} cm/sec. The effective porosity would be expected to be on the order of 0.01.</p> <p>Hydrogeologic units which meet these conditions generally cannot be tested by normal techniques requiring addition or withdrawal of water in wells. Methods of determining that molecular diffusion is the prevalent mechanism of solute transport include age-dating of ground water by isotopic ratios and radio-isotope methods to show that there has been no active circulation of ground water within the unit during the length of time determined by the age-dating."* (p.8)</p>														

*Also addressed by parameters for geochemistry/hydrochemistry (Table A-4)

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	UNSATURATED FLOW							SATURATED FLOW						
	Molsture Potential	Molsture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
NUREG-0902 (CONT.)														
"[10 CFR 61.50(a)(8)] related to ground-water discharge, stipulates that the hydrogeologic unit used for disposal will not discharge ground water to the ground surface within the disposal site....The site prefers long flow paths from the disposal site to the point of ground-water discharge in order to increase the amount of decay of the radionuclides, increase the hydrodynamic dispersion within the aquifer, and increase the likelihood of retardation of reactive radionuclides in the aquifer." (p. 8)	+	+	+	+	X	X	+	+	+	+	+	X	X	+
"[10 CFR 61.50(a)(11)] related to effects of nearby facilities or activities, is included so that the evaluation of any proposed disposal site will include not only the impacts of that disposal site on its surroundings but also the impacts of the surroundings on the disposal site. For example,....ground-water rises associated with heavy irrigation may adversely affect the ability of the site to meet the performance objectives." (p. 9)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
"Many of the site characteristics measured during the site characterization program will vary with time. Time-variant site characteristics may include....hydrological characteristics such as soil-moisture content, ground-water levels, and	X	X	X	+	X	X		X	X	+	+	X	X	

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	UNSATURATED FLOW							SATURATED FLOW						
	Mol. Potential	Mol. Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
ground-water quality...For example, the staff anticipates that data needed to determine the site water budget and fluctuations of ground-water levels would typically necessitate a minimum one-year period of measurement at the proposed disposal site. This minimal one-year period of record should be supplemented, where possible, with regional data covering a longer time period." (p. 13)														
"The site characterization studies should include an inventory of existing ground-water users within approximately two kilometers of the site...the inventory should include the location, type, and amounts of use; hydrogeologic unit used; typical well construction details; and ground-water quality...both ground-water wells and...springs (should be included). The inventory should identify...the nearest downgradient ground-water users and the nearest municipal supply relying on ground water." (p. 17 and 18)						X							X	
"The site characterization studies should identify all significant hydrogeologic units underlying the site to a depth on the order of 30 meters below the level of waste disposal...Reconnaissance-level information should be sufficient to provide necessary ground-water data for the hydrogeologic units more than 30 meters below the level of waste disposal." (p. 18)														
"The site characterization investigations of significant hydrogeologic units overlap with geologic and tectonic studies...Together they should identify the lithology, thickness, lateral	X	X	X	X	X	X		X	X	X	X	X	X	X

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS									
	UNSATURATED FLOW					SATURATED FLOW				
	Mol. Structure	Potential	Moisture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Conductivity
extent, continuity inclination, areas and modes of recharge and discharge, hydraulic properties, head, hydrochemistry, hydraulic communication with adjacent hydrogeologic units, and interrelationship with surface-water bodies....the presence of secondary permeability, such as solution features....fault zones or joint systems....(and) the presence of flow barriers, such as fault zones or dikes (should also be investigated)."										
"The site characterization studies should develop data needed to describe the occurrence and movement of water in both the unsaturated and saturated zones. The parameters which govern the rate, direction, and velocity of soil moisture movement and ground-water flow (such as hydraulic conductivity, head, hydraulic gradient, effective porosity, specific storage, saturated thickness, and compressibility (should be measured). The studies should establish mean and median values, ranges of values, and spatial and temporal variability for these parameters for the significant hydrogeologic units."	X		X	X	X	X	+		X	X
"Hydraulic conductivity may vary significantly above the water table as the moisture content and head change. Site characterization studies should define the relationship between these parameters, including the hysteresis. The water-holding parameters for soil above the water-table, such as specific retention, field capacity, and wilting point should also be measured."	X		X	X						

*Also addressed by parameters for geology (Table A-1)

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	Moisture Potential	Moisture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
NUREG-3902 (CONT.)														
"Analysis of the corrosivity of the fill to be used around the waste containers may necessitate the determination of...moisture content..." (Section 3.2.1, p. 23)	X													
MRC Draft Technical Position Paper on Environmental Monitoring														
"Part 61 states the need to establish monitoring programs to obtain baseline information on...hydrology (and) geology..." (Section 2.2.1, p. 7-8)	+		+	+	+	+	+	+	+	+	+	+	+	+
"During the pre-operational phase, ground-water levels and fluctuations will be measured and hydraulic gradients (including vertical gradients in the unsaturated zone) should be determined as part of site characterization. At this time, hydraulic and geochemical properties of soil and rock media should be measured in order to predict rates and directions of ground-water movement." (Section 3.2.1, p. 18)	X	X	X	X	+	+		X	X	X	X	+	+	+
"Pre-operational...ground-water data should also be gathered from domestic and/or municipal water supplies near the site." (Section 3.2.1, p. 19)						+						+		
NUREG-1199 (SAR Standard Format and Content)														
"The applicant should provide sufficient information to (1) describe the hydrogeology of the disposal	+	+	+	+	+	+	X	+	+	+	+	+	+	X
*Also addressed by parameters for geology and surface-water hydrology (Tables A-1 and A-3, respectively)														

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

PARAMETERS

UNSATURATED FLOW

SATURATED FLOW

Moisture Potential	Moisture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
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REGULATORY GUIDANCE

NUREG-1199 (CONT.)

site....(2) demonstrate that the disposal site is capable of being characterized, modeled, analyzed, and monitored...." (Section 2.4.2, p. 2-8)

"....(3) demonstrate whether the disposal site can provide sufficient depth to the water table so that groundwater intrusion, perennial or otherwise, into the waste will not occur....(4) demonstrate that the hydrogeologic unit used for disposal will not discharge groundwater to the surface within the disposal site...." (See on 2.4.2, p. 2-8)

"Data on the saturated zone should demonstrate that seasonal fluctuations of the water table will not result in groundwater interactions with the waste material and that groundwater discharge at the surface will not occur within the disposal site. The information....should describe all potentially affected aquifers, including the lateral extent, thickness, water-transmitting properties, recharge and discharge zones, groundwater flow directions and velocities, and other information that can be used to create an adequate conceptual model of the saturated zone." (Section 2.4.2, p. 2-8 and 2-9)

"Detailed descriptions should be included for all monitor wells, including location, elevation, screened intervals, depths, construction and completion details, and hydrogeologic units monitored. The description should include

X

X

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	UNSATURATED FLOW						SATURATED FLOW							
	Mol. Potential	Mol. Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
domestic, industrial and/or municipal wells.... Descriptions of all aquifer tests should also be provided, including test data and a discussion of the assumptions, analysis, and test procedures used." (Section 2.4.2, p. 2-9)														
"Physical parameters such as storage coefficients, transmissivities, hydraulic conductivities, porosities, and intrinsic permeabilities should be included. The applicant should provide an accurate description, to the extent practicable, of groundwater flow directions and velocities (horizontal and vertical) for each potentially affected aquifer." (Section 2.4.2, p. 2-9)	X	X	X	X	+	+	+	X	X	X	X	+	+	+
"Information on and descriptions of the unsaturated zone should be adequate so that a conceptual model of the unsaturated flow regime on site and in the vicinity can be obtained. To support these findings, the applicant should describe the lateral extent and thickness of permeable and impermeable zones, potential conduits of anomalously high flux, and direction and velocity of unsaturated flow. Information on all monitor stations including location and depth should be provided. Investigation of physical parameters includes, but is not limited to, the spatial and stratigraphic	X	X	X	X	X	X								

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	UNSATURATED FLOW							SATURATED FLOW						
	Molsture Potential	Molsture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
<p>distribution of the total and effective porosity; water content variations with time; saturated hydraulic conductivity; characteristic relationships between water content, pressure head, and hydraulic conductivity; and hysteretic behavior during wetting and drying cycles, especially during extreme conditions...." (Section 2.4.2, p. 2-9)</p> <p>"The description of the numerical analyses techniques used to characterize the unsaturated and saturated zones should include the model type, justification, documentation, verification, calibration and other associated information. The description should include the input data, data generation or reduction techniques, and any modifications to these data. To the extent practicable, the applicant should demonstrate that the results of the model adequately represent the physical system to determine if compliance with the applicable requirements of 10 CFR 61....is reasonably ensured." (Section 2.4.2, p. 2-9)</p> <p>"...the applicant should calculate potential radionuclide concentrations transferred to human access locations, including real and hypothetical groundwater discharge points such as streams, wells, springs, and seeps located downgradient from the</p>	+	+	+	+	+	+	X	+	+	+	+	+	+	X
	X	X	X	X	X	X	X	X	X	X	X	X	X	X

PARAMETERS

UNSATURATED FLOW		SATURATED FLOW	
Potential			
Moisture			
Content			
Hydraulic		Hydraulic	
Conductivity		Conductivity	
Porosity		Porosity	
Geometry		Geometry	
Boundary		Boundary	
Conditions		Conditions	
Modeling		Modeling	
Hydrogeologic		Hydrogeologic	

(See Page A-2-10)

REGULATORY GUIDANCE

NUREG-1199 (Cont.)

site....the applicant should provide all information needed to calculate radionuclide concentrations and groundwater travel time at appropriate distances downgradient from the site. This information should include a description of the conceptual model of the site groundwater flow system in relationship to the planned engineering design (including a summary of the regional groundwater flow system and its relationship to the site....The applicant should identify major hydrogeologic units and their stratigraphic relationships. For each hydrogeologic unit....list its hydrologic properties, radionuclide transport characteristics, flow directions and (flow) volumes, hydraulic gradients, principal zones of recharge and discharge, all known groundwater-surface water interactions, known leakage between units, water table fluctuation zones, and known groundwater residence times. The applicant's conceptual model should describe....the principal (horizontal and vertical) saturated flow pathways to the accessible environment....Including isolation features, fault zones, or joint systems, if present....and natural flow barriers, if present, such as fault zones or dikes....The applicant should discuss the potential for significant changes in flow directions and fluxes....The applicant should describe the numerical and/or analytical model(s) used to simulate flow and transport through the saturated and unsaturated zones at the site and predict radionuclide concentrations transferred to appropriate access locations downgradient from the site. The applicant should describe and justify the

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	UNSATURATED FLOW							SATURATED FLOW						
	Moisture Potential	Moisture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
<p>"Aspects of the site characterization of the saturated zone reviewed include the following....</p> <p>(3) the description of all potentially affected aquifer systems, the spatial and stratigraphic distribution of hydrologic parameters, and the lateral extent and thickness of all saturated strata....(4) the applicant's proposed conceptual model, including recharge and discharge zones, assessments of the lateral and stratigraphic extent of major aquifer systems, interactions (communication) between these aquifers, and the model's adequacy with respect to reaching conclusions relevant to the applicable siting guidelines of 10 CFR 61...." (SRP 2.4.2 Sec. 2.1, p. 2.4.2-1 and -2)</p>	X	X	X	X	X	X	X	X	X	X	X	X	X	X
<p>"Aspects of the site characterization of the unsaturated zone reviewed include the following....</p> <p>(3) the description of all potentially affected unsaturated zones and the spatial and stratigraphic distribution of hydrologic parameters, including the characteristic curves and infiltration rates....(4) The applicant's proposed conceptual model, including fluctuations in soil moisture, characteristic curves of the porous media both laterally and stratigraphically, infiltration and percolation rates, overall movement of the fluid in the</p>	X	X	X	X	X	X	X							

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	UNSATURATED FLOW							SATURATED FLOW						
	Moisture Potential	Moisture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling

NUREG-1200 (Cont.)

unsaturated zone, and the model's adequacy with respect to reaching conclusions relevant to the applicable siting guidelines of 10 CFR 61... (SRP 2.4.2, Sec. 2.2, p. 2.4.2-2)

"Aspects of the numerical analysis of the saturated zone reviewed include the following....(1) the methodology, rationale, and bases for the development of the numerical model, including documentation of the model type, verification, calibration....(2) the input data used in the model, including data recorded from field and laboratory measurements and analyses, data generated using geostatistical or other data generation techniques, data from outside sources, and any modifications to field data....(3) demonstration that the results of the model adequately represent, to the extent practicable, the physical system....(4) the results of modeling, including simulated head distributions, velocity distributions, and groundwater flow directions for all potentially affected aquifers adequate to reach conclusions relevant to the applicable parts of 10 CFR 61... (SRP 2.4.2, Sec. 2.3, p. 2.4.2-2 and -3)

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

PARAMETERS

PARAMETERS	UNSATURATED FLOW						SATURATED FLOW						
	Molsture Potential	Molsture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions

REGULATORY GUIDANCE

NUREG-1200 (Cont.)

"Aspects of the numerical analysis of the unsaturated zone reviewed include the following.... (1) the methodology, rationale, and basis for the use of an analytical model, or, if necessary, a numerical model, including the model type, documentation, verification, calibration, and other associated information....(2) the input data used in the model, any data generation or reduction requirements, data from outside sources, and any modifications to field or laboratory data....(3) simulation results, including direction of water movement, amount of infiltrated water, spatial and temporal distribution of deep percolation to the saturated zone, and zone of anomalously high or low infiltration.... (4) demonstration that, to the extent practicable, the results of the model represent the physical system." (SRP 2.4.2, Sec. 2.4, p. 2.4.2-3)

"Data requirements for saturated zone evaluation include, but are not limited to, location of all monitor wells....well drilling and construction information, water quality and water levels, hydrologic test data and results, storativity, transmissivity, and possible surface recharge or discharge features." (SRP 2.4.2, Sec. 4.3, p. 2.4.2-6)

X X X X X X X X

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	UNSATURATED FLOW						SATURATED FLOW							
	Molsture Potential	Molsture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
"Data requirements for unsaturated zone evaluation include, but are not limited to, sample locations, moisture content measurements, laboratory analyses techniques and results for obtaining the characteristic curves for soil cores, and results of infiltration, percolation, and saturated hydraulic conductivity tests." (SRP 2.4.2, Sec. 4.3, p. 2.4.2-6)	+	X	X	X	X	X								
"Information requirements for modeling both the saturated and unsaturated zones include, but are not limited to, a description of the conceptual model, equations, and computer code; verification and calibration procedures; descriptions of all data inputs and model outputs; and conclusions pertaining to compliance with relevant sections of 10 CFR 61...." (SRP 2.4.2, Sec. 4.3, p. 2.4.2-6)	+	+	+	+	+	+	X	+	+	+	+	+	+	X
"The applicant should describe, to the extent practicable, all possible groundwater pathways through which radionuclides could become accessible to humans, including all permeable layers between the surface and bedrock. The description of the conceptual models should include the physical environment and transport medium in relationship to the planned engineered design." (SRP 6.1.5.1, Sec. 3.2.1, p. 6.1.5.1-2)	+	+	+	+	X	+	X	+	+	+	+	X	+	X

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	UNSATURATED FLOW							SATURATED FLOW						
	Potential	Moisture	Content	Hydraulic	Conductivity	Porosity	Geometry	Boundary	Conditions	Hydrogeologic	Modeling	Hydraulic	Head	Conductivity
NUREG-200 (Cont.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
*The applicant should provide estimates of the input parameters (hydrogeologic, geochemical, and radionuclide release data) for the radionuclide transport analysis...[and] the computational methods and justification [of these parameters].** (SRP 6.1.5.1, Sec. 3.2.2, p. 6.1.5.1-2)														
*The staff must ensure that all potential groundwater pathways have been considered in the modeling effort. The staff must ensure that the applicant has considered in its analysis both potential radionuclide migration based on existing groundwater flow conditions...and potential radionuclide migration based on transient flow conditions resulting from potential groundwater exploitation...and other factors. The transport models will be evaluated for their defensibility, suitability, and basic conservatism and the conservatism of their application. The staff must ensure that the codes are based on sound physical, chemical, and mathematical principles (verified), and that the codes are correctly applied. The staff must also ensure that the codes are sufficiently documented... (SRP 6.1.5.1, Sec. 3.2.3, p. 6.1.5.1-3)														

*Also addressed by parameters for geochemistry/hydrochemistry (Table A-4)

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

REGULATORY GUIDANCE	PARAMETERS													
	UNSATURATED FLOW							SATURATED FLOW						
	Mol Structure Potential	Mol Structure Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
NUREG-1200 (Cont.)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
"The applicant should perform a technical analysis of groundwater pathways for contaminant migration and present the results of the analysis in terms of reasonably accurate conservative concentrations at the site boundary and appropriate groundwater user locations downgradient of the site....the applicant should provide....(1) a complete description of the contaminant transport pathways between the engineered disposal unit and the site boundary and existing or known future groundwater user locations....(2) estimates and justification for the physical and chemical input parameters used in the transport models....(3) a description of the contaminant transport models used in the analysis, including modeling procedures and complete documentation of the codes....(4) model output results in terms of radionuclide concentrations as a function of time and space, including....Inherent assumptions of the model, the effect of the assumptions on the model results, and other associated uncertainties." (SPP 6.1.5.1, Sec. 4.3, p. 6.1.5.1-4 and -5)														
NUREG-1300 (ER Standard Review Plan)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
"Information needed for the review will usually include the following: (1) areal extent of major hydrogeologic units, recharge and discharge areas,														

TABLE A-2
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GROUND-WATER HYDROLOGY

PARAMETERS

UNSATURATED FLOW

SATURATED FLOW

Moisture Potential	Moisture Content	Hydraulic Conductivity	Porosity	Geometry	Boundary Conditions	Hydrogeologic Modeling	Hydraulic Head	Hydraulic Conductivity	Porosity	Specific Storage	Geometry	Boundary Conditions	Hydrogeologic Modeling
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REGULATORY GUIDANCE

NUREG-1500 (Cont.)

"Information needed for the review will usually include the following....(1) descriptions of the hydrogeologic units and general stratigraphic units at the site and vicinity....(2) descriptions of the hydrologic properties and radionuclide transport characteristics of major hydrogeologic units at the site and vicinity....(3) principal saturated flowpaths at the site and vicinity and associated groundwater fluxes and travel times....(4) locations of groundwater users and natural groundwater discharge points located downgradient from the site where contaminants could become accessible to the public....(5) aquifer recharge areas located downgradient from the site that could become contaminated by either surface or subsurface releases from the disposal site....(6) Identification of potential alterations in locations and rates of groundwater recharge or discharge resulting from site activities....(7) description and analysis of groundwater migration pathways to demonstrate that potential radionuclide concentrations will be within acceptable limits. The analysis should include transient flow simulations resulting from known or potential future groundwater withdrawals..." (ESRP 4.3.2, Sec. 2., p. 4.3.2-2)

TABLE A-2(a)
PARAMETER DESCRIPTIONS - GROUND-WATER HYDROLOGY

UNSATURATED FLOW

Moisture Potential: Soil water moves in the direction of decreasing moisture potential. The moisture potential is the sum of gravitational, osmotic, and matric potentials. Osmotic potential is generally considered negligible. Gravitational potential is dependent on differences in elevation. Matric potential is a negative pressure potential that results from the capillary and adsorptive forces of the soil matrix. Information on moisture potential is needed for determining rates and directions of moisture movement.

Moisture Content: Moisture content is expressed as a dimensionless ratio either of water mass to dry soil mass or of water volume to total volume. It is usually reported as a percentage. The relation between moisture potential and moisture content is defined by a moisture characteristic curve. However, due to the hysteresis phenomenon, the curve for the wetting process is usually not identical to the curve for the drying process. A related parameter, the degree of saturation, is defined as the ratio of the water volume to the void volume. Information on moisture content is needed as a dependent variable of hydraulic conductivity.

Hydraulic Conductivity: Hydraulic conductivity is a measure of the ability of soil or rock to transmit water. Hydraulic conductivity depends on the specific weight and viscosity of the water, and the intrinsic permeability and moisture content of the material. Under unsaturated conditions, the hydraulic conductivity may not be constant and will vary with the degree of saturation. In general, hydraulic conductivity has directional variability (anisotropy). Information on hydraulic conductivity is needed for determining rates of moisture movement.

Porosity (Total and Effective): Total porosity is the ratio of the void volume to the total volume of a sample. Effective porosity is the ratio of interconnected void volume in which fluids are able to circulate, to the total volume of a sample. Information on porosity is needed for determining the transport of solutes in the unsaturated zone.

Geometry: The geometry includes the hydrostratigraphy (e.g., thickness, lateral extent, continuity), the depth of the water table, the thickness of capillary fringe, the location of the disposal facility, and the location of recharge and discharge zones. Information on geometry is needed to define the domain in which flow is studied.

Boundary Conditions: Boundary conditions are defined pressure heads or fluxes due to discharge from evapotranspiration, and to steady-state and/or transient recharge from both natural infiltration (dependent on infiltration rate and infiltration capacity of material) and infiltration trenches. Information on boundary conditions is needed to determine controls on flow within the domain defined by the geometry.

Hydrogeologic Modeling: A hydrogeologic model is a mathematical formulation of the hydrologic behavior of the system. The description of the model should include model type, justification, documentation of code, verification, validation, calibration, sensitivity analyses, underlying assumptions, associated uncertainties, limitations, physical laws considered, input data, data reduction and/or generation techniques, and discussion of suitability. Output may include simulated pressure heads, fluxes, discharge, and flow velocities and directions. Modeling is required to provide an integrated understanding for the unsaturated flow regime for site characterization, and to allow a variety of sensitivity and scenario options to be evaluated in support of site performance assessment.

TABLE A-2(h)
PARAMETER DESCRIPTIONS - GROUND-WATER HYDROLOGY

SATURATED FLOW

Hydraulic Head: The hydraulic head is the sum of the elevation of the point of measurement (elevation head) and the pressure head. Fluid will flow from higher hydraulic head to lower. The hydraulic gradient is the difference in hydraulic head divided by the distance over which it occurs. Information on hydraulic head is needed for determining rates and directions of ground-water flow.

Hydraulic Conductivity: Hydraulic conductivity is a measure of the ability of a material to transmit water. Hydraulic conductivity depends on the specific weight and viscosity of the water and the intrinsic permeability of the material. In general, hydraulic conductivity has directional variability (anisotropy). Information on hydraulic conductivity is needed for determining rates of ground-water flow.

Porosity (Total and Effective): Total porosity is the ratio of void volume to the total volume of a sample. Total porosity approximately equals the sum of two related parameters, specific yield (the amount of water released by a material due to the force of gravity) and specific retention (the amount of water retained by a material under the force of gravity). Effective porosity is the ratio of interconnected void volume in which ground water is able to circulate, to the total volume of a sample. Information on porosity is needed for determining the transport of solutes dissolved in the ground water.

Specific Storage: The specific storage is the amount of water in storage that is released from a unit volume of aquifer per unit decline in head. The related coefficient, storativity or storage coefficient, is the amount of water released from a column of aquifer with unit cross section under a unit decline of head. In unconfined aquifers, storage is measured in terms of the specific yield, a measure of the drainable porosity, whereas in confined aquifers, specific storage and storativity are functions of porosity (the proportion of void space in a sample), fluid compressibility, and medium compressibility. (Compressibility describes the change in volume induced in a material by an applied stress.) Information on specific storage is needed for determining rates and directions of ground-water movement when boundary conditions are changing with time.

Geometry: The geometry includes hydrostratigraphy (e.g., thickness, lateral extent, continuity, hydraulic interconnectivity, elevation, depth, stratigraphic relationships), location of pathways (e.g., faults, sand lenses, weathered horizons, karstic features, joint systems, solution features), location of barriers (e.g., fracture zones, dikes), location of recharge and/or discharge zones, location of wells and the location of the disposal facility. The geometry should be characterized to a depth of at least 30 m below the site. Information on geometry is needed to define the domain in which flow is studied.

Boundary Conditions: Boundary conditions are defined heads or fluxes due to steady state and/or transient recharge from infiltration and injection wells, and discharge from springs and domestic, industrial, irrigation and municipal wells. Information on boundary conditions is needed to determine controls on flow within the domain defined by the geometry.

Hydrogeologic Modeling: A hydrogeologic model is a mathematical formulation of the hydrologic behavior of the system. Proper model documentation should include model type, justification, documentation of code, verification, validation, calibration, sensitivity analyses, underlying assumptions, associated uncertainties, limitations, physical laws considered, input data, data reduction and/or generation techniques, and discussion of suitability. Output should include simulated heads and ground-water flow velocities, fluxes, discharge, and directions. Modeling is required to provide an integrated understanding of the saturated flow regime for site characterization, and to allow a variety of sensitivity and scenario options to be evaluated in support of site performance objectives.

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

REGULATORY REQUIREMENT

10 CFR 61 - NRC Licensing Requirements
61.50(a)(5)
61.50(a)(6)
61.50(a)(10)

10 CFR 51 - NRC Environmental Protection Regulations
(Does not specifically address surface water)

PARAMETERS

Hydrologic System
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Site Surface-Water Impact

REGULATORY GUIDANCE

NREG-0902 (Site Suitability, Selection, and Characterization)

"[10 CFR 61.50(a)(5)] consists of two components. The first component, related to drainage crossing the disposal site, primarily applies to the disposal site after construction of the near-surface disposal facility. However, natural areas of poor drainage or frequent ponding can be indicative of seasonally high ground-water levels and should be so noted by the applicant. In addition, areas of flash flooding, such as arroyos or dry washes, should be avoided. The second component, related to avoidance of the 100-year floodplain, coastal high-hazard area or wetland, implements Executive Order 11988,

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
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REGULATORY GUIDANCE

NUREG-0902 (Continued)

Floodplain Management Guidelines. This requirement can be applied to the disposal site at the site selection phase." (p.6)

"[10 CFR 61.50(a)(6)], related to upstream drainage areas contributing flow across the disposal site, can be applied to the site at the site selection phase. The staff will consider engineering modifications or diversion of natural drainage to lessen potential impacts of the upstream drainage area if these changes are long-term....and will not require ongoing active maintenance.... The consideration of upstream drainage areas should include the impact of potential modifications by others to the upstream drainage area, such as land clearing and cultivation or development of roads, which may occur after the near-surface disposal facility is in operation." (p. 7)

"....[10 CFR 61.50(a)(10)]....related togeomorphic processes....relate primarily to the stability of the disposal site. The natural processes affecting the disposal site should be occurring at a consistent and definable

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
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REGULATORY GUIDANCE

NUREG-0902 (Continued)

rate. In addition, these processes should not occur at a frequency, rate, or extent which can significantly change the stability of the site or the ability of the disposal site to isolate low-level radioactive wastes during the duration of the radiological hazard (approximately 500 years). Changes which occur due to these processes should not invalidate the results of any modeling and prediction of long-term impacts." (p. 9)

"...[10 CFR 61.50(a)(1)]....related to effects of nearby facilities or activities, is included so that the evaluation of any proposed disposal site will include not only the impacts of that disposal site on its surroundings but also the impacts of the surroundings on the disposal site." (p. 9)

X

X

X

X

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System	Water Users	Flood Studies	Drought Studies	Precipitation	Infiltration	Runoff	Discharge	Channel Characteristics	Stage	Flow Velocity	Erosion	Sedimentation	Hydrologic and Hydraulic Modeling	Site Surface-Water Impact
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REGULATORY GUIDANCE

NUREG-0902 (Continued)

"The site characterization program should include collection of the reconnaissance-level information needed for determining the extent of the 100-year floodplain....determining the flood-flow frequencies...., and determining the Probable Maximum Flood (PMF) and the Probable Maximum Precipitation (PMP) for the site...." (p. 16)

"Site characterization studies should also include aerial photography and topographic mapping of the site and adjacent drainage areas in order to identify features such as drainage divides, sizes of drainage areas, surface gradients and abrupt changes therein, areas of internal or closed drainage, areas of flash flooding, areas of scour or sedimentation, and areas suitable for future impoundments....This requirement calls for establishing three permanent survey control points....at the disposal site."* (p. 16)

* Also addressed by parameters for meteorology (Table A-11)

** Also addressed by parameters for geography (Table A-8)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

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REGULATORY GUIDANCE

NUREG-0902 (Continued)

"Site characterization studies should also include measurements of runoff coefficients, infiltration rates, and channel characteristics such as slope, profile, cross section, and roughness for drainage systems crossing the site. In order to determine, where appropriate, the flow velocities, depths, volumes, and durations. Parshall flumes and sediment samplers should be installed, where appropriate, to determine the rate of erosion of site soil deposits under varying gradients and conditions. Particle-size distribution, soil cohesion, and soil dispersion tests should be performed, as needed, to determine the erodibility of site soil deposits."* (p. 16)

NRC Draft Technical Position Paper on Environmental Monitoring

"Part 61 states the need to establish monitoring programs to obtain baseline information on.....hydrology....." (Section 2.2.1, p. 7 and 8)

* Also addressed by parameters for geotechnical investigation (Table A-7)
** Also addressed by parameters for ground-water hydrology (Table A-2)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

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REGULATORY GUIDANCE

NRC Draft Technical Position Paper (Continued)

"Because of siting requirements in Part 61, there is little likelihood that there will be perennial surface water within the low-level waste disposal facility. It is important that nearby off-site surface water be monitored.... If significant intermittent surface water flow occurs on-site, it should be included in the monitoring program." (Section 3.2.1, p. 20)

"Sampling of perennial surface water sources near the site should be representative of the flow regime. Therefore, flow measurement should be part of the monitoring program." (Section 3.2.1, p. 20)

NUREG-1199 (SAR Standard Format and Content)

"Sufficient graphical and quantitative data and information to fully characterize the site drainage and surrounding watershed fluvial features, including important water users should be provided. Water resource data, including maps, hydrographs, and stream records....should be cited and related to the site conditions." (Section 2.4.1, p. 2-7)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

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REGULATORY GUIDANCE

NUREG-1199 (Continued)

"The disposal site.....should be described. The applicant should provide topographic maps of the disposal site that show natural drainages and man-made features (and any proposed changes to them).... In accordance with 10 CFR 61.50(a)(5), the information should indicate that the site is generally well-drained and free of areas of frequent ponding." (Section 2.4.1, p. 2-7)

"The applicant should describe the surface water bodies of the disposal site and surrounding areas, including the location, size, shape, and other hydrologic characteristics of all streams, lakes, or coastal areas. A description of existing and proposed water control structures and diversions (both upstream and downstream that may influence the site) should be included. Flow-duration data that indicate minimum, maximum, and average historical observations for surface water bodies in the site areas should be included." (Section 2.4.1, p. 2-7)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

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REGULATORY GUIDANCE

NUREG-1199 (Continued)

"Using the guidance in Executive Order 11988, the information and analyses used to delineate the 100-year floodplain should be provided. Topographic and/or aerial photographs that delineate the 100-year floodplain at the disposal site should be included...." (Section 2.4.1, p. 2-8)

"The applicant should discuss the flood potential from streams, reservoirs, and adjacent watersheds. The probable maximum water level at the site (using Regulatory Guide 1.99, 'Design Basis Floods for Nuclear Power Plants,' for guidance) should be provided." (Section 2.4.1, p. 2-8)

"The applicant should describe any man-made changes to the surface water hydrologic system that may influence the potential for flooding at the site.... The description of these changes should include the proximity of the affected area to the site, the surface water bodies affected, the size of the area affected, and the potential effects at the site." (Section 2.4.1, p. 2-8)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System	Water Users	Flood Studies	Drought Studies	Precipitation	Infiltration	Runoff	Discharge	Channel Characteristics	Stage	Flow Velocity	Erosion	Sedimentation	Hydrologic and Hydraulic Modeling	Site Surface-Water Impact
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REGULATORY GUIDANCE

NUREG-1199 (Continued)

contaminant transport analyses for both the surface water and the source of contamination....the mathematical models and methods used to calculate radionuclide concentrations, and the calculated results (including associated uncertainties in the methods and data)." (Section 6.1.5.3, p. 6-10)

"The applicant should describe the conceptual model, addressing all significant pathways for surface water transport of radionuclides to the accessible environment. The applicant should identify the nearest use of surface water that could become contaminated and should describe any site features that could mitigate radionuclide releases to the surface water environment." (Section 6.1.5.3, p. 6-10)

"The applicant should describe the numerical and/or analytical model(s) used to simulate flow and transport at the site and to predict radionuclide concentrations at affected surface water locations. The applicant should describe and justify the type of model(s) used, the theoretical basis for

*Also addressed by parameters for geochemistry/hydrochemistry (Table A-4)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System	Water Users	Flood Studies	Drought Studies	Precipitation	Infiltration	Runoff	Discharge	Channel Characteristics	Stage	Flow Velocity	Erosion	Sedimentation	Hydrologic and Hydraulic Modeling	Site Surface-Water Impact
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REGULATORY GUIDANCE

NUREG-1199 (Continued)

each model, and the uncertainties and limitations of the model. The procedures used to verify the codes, and the results of model calibration should be described, including model validation techniques and sensitivity. The applicant should provide information on the modeling procedures (strategies and methods) used in the analyses, and provide complete documentation of the computer code(s).** (Section 6.1.5.3, p. 6-10)

*The applicant should list and justify all input parameters used in the contaminant transport analyses. Results of the transport analyses and radionuclide concentrations at surface water user locations and discharge points should be provided.... The applicant should perform a sensitivity analysis.... The uncertainties of the results and any anomalous behavior of the modeling analyses and model outputs should be discussed." (Section 6.1.5.3, p. 6-10)

*Also addressed by parameters for ground-water hydrology and geochemistry/hydrochemistry (Tables A-2 and A-4, respectively)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

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REGULATORY GUIDANCE

NUREG-1199 (Continued)

"The applicant should provide hydrologic analyses and design details of the site flood control system to demonstrate that the requirements of 10 CFR 61.23(e) and 61.44 are met. Those features that will provide protection against erosion and flooding during the postclosure period should be described in detail." (Section 6.3.1, p. 6-17)

"The applicant should provide detailed descriptions (plans, maps, and cross-sections) of the site drainage system, including channels, erosion protection, and diversion structures. The applicant should also provide detailed computations of peak flood flows, depths of flow, and velocities that constitute the bases for the design of protective features." (Section 6.3.1, p. 6-17)

"Estimates of rainfall intensity, infiltration rates, times of concentration, hydrographs, etc., should be provided in sufficient detail to allow independent evaluations to be made of the design criteria and technical analyses." (Section 6.3.1, p. 6-17)

*Also addressed by parameters for meteorology (Table A-11)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

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Hydrologic and Hydraulic Modeling
Site Surface-Water Impact

REGULATORY GUIDANCE

NUREG-1200 (Continued)

are of good quality and of sufficient scale to allow independent analysis of pre- and post-construction drainage patterns. The information presented (in the SAR) forms the basis for subsequent hydrologic engineering analysis.... Maps are adequate if they are legible and adequate in coverage to substantiate applicable data and analyses. The descriptions of the hydrologic characteristics of surface water features and water use are acceptable if they are detailed and generally correspond to those of the U.S. Geological Survey (USGS), National Oceanographic and Atmospheric Administration, Soil Conservation Service, Corps of Engineers, or appropriate State and River basin agencies. Adequate descriptions of existing or proposed reservoirs and dams that could influence conditions at the site may be obtained from reports of the USGS, U.S. Bureau of Reclamation, Corps of Engineers, and others; these descriptions normally include tabulations of drainage areas, types of structures, appurtenances, ownership, seismic and spillway design criteria, elevation-storage relationships, and short- and long-term storage allocations." (SRP 2.4.1, Sec. 4.3, p. 2.4.1-3)

(See Page A-3-14)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System	Water Users	Flood Studies	Drought Studies	Precipitation	Infiltration	Runoff	Discharge	Channel Characteristics	Stage	Flow Velocity	Erosion	Sedimentation	Hydrologic and Hydraulic Modeling	Site Surface-Water Impact
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REGULATORY GUIDANCE

NUREG-1200 (Continued)

"The staff will review the information in the SAR on the ability of the surface water environment to dilute normal or accidental radioactive liquid effluent releases from the low-level waste burial sites, particularly in regard to relating the effects of such releases to existing and known future uses of surface water resources. The staff will review the following areas: (1) the conceptual model that describes all potential surface water pathways for radionuclide migration, (2) surface water transport models used to analyze the spatial and temporal concentrations of radionuclides at appropriate distances downgradient from the site, (3) source term data used as input parameters to surface water transport models, particularly the release rate and source terms at groundwater interfaces, where applicable, (4) estimates of radionuclide concentrations calculated from surface water transport models." (SRP 6.1.5.3, Sec. 2., p. 6.1.5.3-1)

*Also addressed by parameters for ground-water hydrology and geochemistry/hydrochemistry (Tables A-2 and A-4, respectively)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System	Water Users	Flood Studies	Drought Studies	Precipitation	Infiltration	Runoff	Discharge	Channel Characteristics	Stage	Flow Velocity	Erosion	Sedimentation	Hydrologic and Hydraulic Modeling	Site Surface-Water Impact
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REGULATORY GUIDANCE

NUREG-1200 (Continued)

"Acceptable analyses of radionuclide migration will: (1) describe the dispersion characteristics and dilution capability of the surface water environment with respect to existing and known future users under both normal and accident conditions, (2) provide estimates and bases for annual average and maximum (for accidental releases) concentrations at the locations of existing or known future users under normal and accident conditions, (3) identify potential pathways of contamination to surface water users, and (4) describe and reference sources of data." (SRP 6.1.5.3, Sec. 4.3, p. 6.1.5.3-2 and -3)

"The INRC staff will review the applicant's assessment of the flooding potential for the site. This review will include a determination of the precipitation potential, the precipitation losses, the runoff response characteristics of the watershed, the accumulation of flood runoff through river channels and reservoirs, the magnitude of the probable maximum flood (PMF) or project design flood (if a flood less than the PMF was used) at the site, and the critical water levels and velocity

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System	Water Users	Flood Studies	Drought Studies	Precipitation	Infiltration	Runoff	Discharge	Channel Characteristics	Stage	Flow Velocity	Erosion	Sedimentation	Hydrologic and Hydraulic Modeling	Site Surface-Water Impact
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REGULATORY GUIDANCE

NUREG-1200 (Continued)

conditions at the site. If a flood less than the PMF was used, the analyses and justification for the use of such a flood will be reviewed. The probable maximum precipitation (PMF) potential and resulting runoff, for site drainage and for drainage areas adjacent to the site will also be reviewed." (SRP 6.3.1, Sec. 2.2, p. 6.3.1-1)

"The staff will review the applicant's assessment of peak water levels, flood routing procedures, and flood velocities associated with floods resulting from dam failures due to either seismic or hydrologic causes." (SRP 6.3.1, Sec. 2.3, p. 6.3.1-2)

"The staff will review the applicant's analyses and design details pertinent to...erosion protection.... The peak discharge rates, water level, and flood velocities, which constitute the design basis for the erosion protection, will be reviewed." (SRP 6.3.1, Sec. 2.4, p. 6.3.1-2 and -3)

*Also addressed by parameters for geology (Table A-1)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System	Water	Flood Studies	Drought Studies	Precipitation	Infiltration	Runoff	Discharge	Channel Characteristics	Stage	Flow Velocity	Erosion	Sedimentation	Hydrologic and Hydraulic Modeling	Site Surface-Water Impact
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REGULATORY GUIDANCE

NUREG-1200 (Continued)

"The selection of the flood event for the design of the protective cover usually should not be based on the statistical extrapolation of limited data bases because of the unreliability of such estimates. Rather....because the PMF and the PMF are based on site-specific meteorological limitations that eliminate the uncertainties associated with extensive extrapolation of limited data bases, the use of these deterministically derived phenomena for long-term design provides an acceptable design basis." (SRP 6.3.1, Sec. 4.3.2, p. 6.3.1-5)

"Although use of the PMF is clearly acceptable for design of low-level waste facilities, its use is not required. On a case-by-case basis, the staff will review site designs that are based on floods less than a PMF. The acceptability of using such floods must be documented by the applicant.... The analyses must conclusively document the long-term integrity of the site, particularly in light of the uncertainties associated with the magnitude and occurrence of rare floods." (SRP 6.3.1, Sec. 4.3.2, p. 6.3.1-6)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System	Water Users	Flood Studies	Drought Studies	Precipitation	Infiltration	Runoff	Discharge	Channel Characteristics	Stage	Flow Velocity	Erosion	Sedimentation	Hydrologic and Hydraulic Modeling	Site Surface-Water Impact
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REGULATORY GUIDANCE

NUREG-1200 (Continued)

"On the basis of the results of the geomorphic analyses, it may be necessary to compute water surface profiles and flood velocities for the revised flow regimes created by the geomorphic changes. Acceptance is based principally on the conservatism in the analysis and the sensitivity of the various parameters in the analysis." (SRP 6.3.1, Sec. 4.3.2, p. 6.3.1-6)

"....the staff will review the analyses provided in the application or will independently estimate the coincident river flows at the site and at the dams being analyzed. The acceptable 'worst conditions' that should be postulated in the analysis of upstream dam failures are (1) an approximate 25-year flood on a normal operating reservoir pool level coincident with the dam-site equivalent of the earthquake for which the project is designed, (2) a flood of about one-half the severity of a PMF on a normal reservoir pool level coincident with the dam-site equivalent of one-half of the earthquake for which the project is designed, and (3) a PMF on a normal reservoir pool." (SRP 6.3.1, Sec. 4.3.3, p. 6.3.1-6 and -7)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System	Water Users	Flood Studies	Drought Studies	Precipitation	Infiltration	Runoff	Discharge	Channel Characteristics	Stage	Flow Velocity	Erosion	Sedimentation	Hydrologic and Hydraulic Modeling	Site Surface-Water Impact
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NUREG-1200 (Continued)

"If applicable, the staff will assess the location of upstream dams, potentially 'likely' or severe modes of failure, potential for multiple dam failures (of closely spaced dams), and the domino failure of a series of dams. Results of analytical hydraulic failure models should be accompanied by complete model descriptions and documentation. A determination of the peak flow rate and water level at the site for the most critical combination of dam failures will be reviewed along with a description of all computations, coefficients, and methods used. Acceptance is based principally on the conservatism used in the analyses and the sensitivity of the analyses to small changes in the model input parameters....If it can be documented that the reservoir has been or will be designed for the damsite equivalent of the site design earthquake and the PMF, no dam failure and flooding analyses need be performed." (SRP 6.3.1, Sec. 4.3.3, p. 6.3.1-7)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
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PARAMETERS

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Users
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Precipitation
Infiltration
Runoff
Discharge
Channel Characteristics
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Flow Velocity
Erosion
Sedimentation
Hydrologic and Hydraulic Modeling
Site Surface
Water Impact

REGULATORY GUIDANCE

NUREG-1300 (ER Standard Review Plan)

[The scope of the NRC's review of surface water bodies that could affect or be affected by the alternatives] ".....will consist of an evaluation of regional and site-specific data on the physical and hydrological characteristics of the water bodies in sufficient detail to provide basic data to the staff reviewers responsible for the evaluation of impacts on surface water regime, quality, and use.... For the evaluation of alternatives other than the applicant's preferred site, reconnaissance-level data should be sufficient." (ESRP 3.4.1.1, Sec. 2., p. 3.4.1.1-1 and -2)

"Information needed for the review will usually include the following:

- (1) maps sufficiently detailed so that they show the major surface water systems that could be affected by the alternatives being considered
- (2) lists identifying the affected water bodies, their sizes and drainage areas, and their stream gradients or water surface elevations

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

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Flood Studies
Drought Studies
Precipitation
Infiltration
Runoff
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Channel Characteristics
Stage
Flow Velocity
Erosion
Sedimentation
Hydraulic Modeling
Site Surface-Water Impact

REGULATORY GUIDANCE

NUREG-1300 (Continued)

- (3) maximum, average-maximum, average, average-minimum, and minimum monthly temperatures of affected water bodies*
- (4) maximum, average-maximum, average, average-minimum, and minimum monthly flows of affected streams, and variations in water surface elevations of other affected water bodies
- (5) flood-frequency distributions and floodplain descriptions (following Executive Order No. 11988) for affected streams, including their relationships to the sites
- (6) historical drought stages or water surface elevations for affected water bodies, and 7-day, 10-year low flows for affected streams
- (7) description of hydrographic modifications....or flood-control measures....located on affected water bodies, including known future projects**

*Also addressed by parameters for geochemistry/hydrochemistry (Table A-4)

**Also addressed by parameters for water resources (Table A-5)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System
Water Users
Flood Studies
Drought Studies
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Infiltration
Runoff
Discharge
Channel Characteristics
Stage
Flow Velocity
Erosion
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REGULATORY GUIDANCE

NUREG-1300 (Continued)

(8) estimated erosion (e.g., wave and channel) and sedimentation characteristics, including rate, bed and suspended load fractions, and total sediment yield, of affected water bodies; also, the estimated sheet, rill, and gully erosion characteristics of sites under consideration*

(9) quantitative and qualitative descriptions of groundwater-surface water interactions (e.g., groundwater baseflow contributions to streamflow).*** (ESRP 3.4.1.1, Sec. 2., p. 3.4.1.1-2)

[Information needed for the NRC's analysis of the effects of the alternatives, including site preparation, construction, operation, and closure, on the regime, quality, and use of surface water bodies]".....will usually include the following for each of the alternatives:

(1) data on surface water regime, quality, and use....***

*Also addressed by parameters for geology (Table A-1)

**Also addressed by parameters for ground-water hydrology (Table A-2)

***Also addressed by parameters for geochemistry/hydrochemistry and water resources (Tables A-4 and A-5, respectively)

TABLE A-3
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

REGULATORY GUIDANCE	Hydrologic System	Water Users	Flood Studies	Drought Studies	Precipitation	Infiltration	Runoff	Discharge	Channel Characteristics	Stage	Flow Velocity	Erosion	Sedimentation	Hydrologic and Hydraulic Modeling	Site Surface-Water Impact
NUREG-1300 (Continued)															
(2) maps and lists identifying surface water bodies whose regime....would be affected by the alternatives....	X														X
(4) quantitative and qualitative descriptions of the impacts of site preparation, construction, operation, and closure on the regime....of surface water ^a	X														X
(5) quantitative and qualitative descriptions of natural or man-made features designed to minimize surface water impacts....	X	X													X
(6) description and analysis of surface water pathways to demonstrate that potential radiological and nonradiological effluent concentrations will be within acceptable limits**	X														X
(7) quantitative and qualitative descriptions of the impacts on groundwater-surface water interactions***	X														X

^aAlso addressed by parameters for water resources (Table A-5)

**Also addressed by parameters for geochemistry/hydrochemistry (Table A-4)

***Also addressed by parameters for ground-water hydrology (Table A-2)

TABLE A-3
 PRIMARY REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: SURFACE-WATER HYDROLOGY

PARAMETERS

Hydrologic System
 Water Users
 Flood Studies
 Drought Studies
 Precipitation
 Infiltration
 Runoff
 Discharge
 Channel Characteristics
 Stage
 Flow Velocity
 Erosion
 Sedimentation
 Hydraulic Modeling
 Site Surface-Water Impact

REGULATORY GUIDANCE

NUREG-1300 (Continued)

(8) local, State, and Federal regulations applicable to surface water regime, quality, and use** (ESRP 4.3.1, Sec. 2., p. 4.3.1-2 and -3)

X

X

*Also addressed by parameters for water resources (Table A-5)

TABLE A-3
PARAMETER DESCRIPTIONS - SURFACE-WATER HYDROLOGY

Hydrologic System: Hydrologic characterization of the site and adjacent watersheds. Identification and descriptions of the natural and man-made system components (i.e., streams, rivers, lakes, wetlands, coastal areas, soil, climate, dams, diversions, and land use) and their interrelationship.

Water Users: An inventory of past, present, and potential future surface-water users in the vicinity of the site and, in particular, within approximately 10 kilometers downstream of the site. Information should include the location, type and amount of use, number of users on the system, rate of withdrawal, percentage of stream flow withdrawn, sources of water supply, type of intake and pumping equipment, and surface water quality data. The inventory should identify the nearest down-gradient surface-water users and the nearest municipal supply relying on surface water.

Flood Studies: Evaluation of the flooding potential of the site and surrounding area to determine the Probable Maximum Flood (PMF). Information evaluated should include the date, water levels, peak discharge, and related information for major historic flood events in the region, including stream floods, surges, seiches, tsunamis, dam failures, ice jams, and floods induced by landslides.

Drought Studies: Evaluation of the occurrence of droughts at the site or surrounding areas. Historic drought water-surface elevations, specifically 7-day, 10-year low flows of affected streams and bodies of water, should be evaluated.

Precipitation: Rainfall and snowfall records that may be used to evaluate flooding and erosion potential. Characteristics to be evaluated include depth of precipitation, duration of storm, intensity of precipitation, recurrence intervals of precipitation, and Probable Maximum Precipitation (PMP).

Infiltration: The movement of water from precipitation into the soil. The infiltration rate of an area depends on the soil properties (e.g., grain size, density, porosity) and antecedent moisture conditions.

Runoff: The total amount of water flowing on the surface, commonly expressed as a depth of water over a specific area. This flow is usually either open channel flow if the water is confined to a channel, or overland flow if the water is flowing without a defined channel.

Discharge: The volumetric rate (flow rate) of runoff in a channel. Channel discharge commonly varies in response to storms. The discharge history of streams and rivers is statistically related to storm recurrence interval for use in evaluating flooding potential.

Channel Characteristics: The physical attributes of a channel (i.e., slope, cross sectional area, and roughness coefficient) that affect the channel's ability to convey a particular discharge.

Stage: The height of the water surface above an established datum; sometimes referred to as gage height because water-surface elevations are commonly made at stations by one of various gage types. River stage is commonly translated into discharge by stage-discharge relationships established for particular stations along a river or stream.

Flow Velocity: The velocity of water in a channel. An average velocity can be calculated for a specific discharge when particular channel characteristics are known. Flow velocity is commonly used to evaluate flooding by runoff, erosion by scouring, and the transport capability of a stream or river.

Erosion: The breakdown or weathering of geologic materials and the transport of these materials away from their origin.

Sedimentation: The deposition of particulate material after being transported by surface water.

Hydrologic and Hydraulic Modeling: Analytical and numerical methods to simulate flow and transport at the site. The theoretical basis for each model, the uncertainties and limitations of the model, procedures to verify the codes, and results of model calibration, including model validation techniques and sensitivity analyses, must be described and justified.

Site Surface-Water Impact: Qualitative and quantitative descriptions of the impact of the site on the surface-water system from construction to closure. This would include the impact of any man-made features to minimize surface-water impacts.

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS												
	Water Quality	Ion-exchange Capacity	Organic Content	pH	Distribution Coefficient	Temperature	Radiometric Dating	Isotope Content	Sol. Mineralogy	Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis
"The staff anticipates that ground-water chemistry will be measured, at least quarterly, for a minimum period of one year and will be compared to historic records, if available. In this manner, the applicant can estimate seasonal and long-term fluctuations of ground-water chemistry as a background for continuing monitoring of key indicators of ground-water quality and leachate (radiological and non-radiological) migration." (pp. 19 and 20)	X	X	X	X	+	X		+			+		
"For those sites where hydrodynamic dispersion and/or retardation will be considered in the transport analyses, the site characterization studies should include determination of the coefficient of dispersion and/or the distribution coefficients for radionuclides of interest in the ground water-soil system through which transport is expected to occur." (p. 20)					X						X		
"For sites where hydrodynamic dispersion is a primary mechanism for demonstrating that potential concentrations will be within acceptable limits, field dispersivity tests may be necessary to quantify the coefficient of dispersion. For sites where ground-water travel time is the primary mechanism and hydrodynamic dispersion is a secondary mechanism for demonstrating that potential concentrations will be within acceptable limits, the coefficient of dispersion may be estimated based on values reported in the literature or derived by empirical relationships." (p. 20)											X		

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS											
	Water Quality	Ion-exchange Capacity	Organic Content	Electrical Conductivity	Distribution Coefficient	Temperature	Radioactive Dating	Isotope Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis
NUREG-0902 (Continued)					X					X		
"For sites where retardation processes are relied upon to demonstrate that potential concentrations will be within acceptable limits, the distribution coefficients for the specific radionuclides should be determined by column tests, using site-specific ground water and undisturbed soil samples, or by field tracer tests." (p. 20)												
"Analysis of the corrosivity of the fill to be used around the waste containers may necessitate the determination of soil resistivity, pH, moisture content, and oxidation-reduction potential." (p. 23)	X					X						
NRC Draft Technical Position Paper on Environmental Monitoring								X				
"A program for determining background concentrations of radioactive contaminants should be initiated during the pre-operational phase....During the operational and post-operational phase, radiological constituents identified as important should be monitored in all potential media (particularly [in] soil and water)." (Section 3.2, p. 17)												

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS												
	Water Quality	Ion-exchange Capacity	Organic Content	Eh-pH	Distribution Coefficient	Temperature	Radiometric Dating	Isotope Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis	
NRC Draft Technical Position Paper (Continued)													
"Non-radiological constituents in groundwater should be monitored at a low-level radioactive waste site....These chemicals include both inorganic heavy metals, such as chromium, lead, arsenic, beryllum, and selenium, and organic compounds, such as those that appear on the EPA Hazardous Constituents list...." (Section 3.2, p. 17)	X	X	X										
"During the pre-operational phase, an investigation for the presence of chelating agents and known deleterious chemicals in the physical media (particularly soil and water) at the site should be made and background concentrations determined." (Section 3.2, p. 17)			X										
"Pre-operational, operational, and post-operational groundwater data should be gathered from domestic and/or municipal water supplies near the site....Routine samples should include radiological and chemical indicators such as tritium, gross alpha, gross beta, TOC, pH, COD and total alkalinity, and collected and analyzed on a quarterly basis." (Section 3.2.1, p. 19)	X	X	X	X				X					
"Pre-operational soil monitoring will be a part of site characterization....background levels of significant constituents including those that would indicate external or pre-existing contamination, should be determined. Naturally occurring radioactivity should be analyzed in addition to those chemical constituents which may effect site performance." (Section 3.2.1, p. 19)			X									X	

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS											
	Water Quality	Ion-exchange Capacity	Organic Content	Ln-pH	Distribution Coefficient	Temperature	Radioactive Dating	Isotopic Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis
<p>NRC Draft Technical Position Paper (Continued)</p> <p>"It is important that nearby off-site surface water be monitored....If significant intermittent surface water flow occurs on-site, it should be included in the monitoring program....Samples should be analyzed for the same radiological and non-radiological constituents that are included in ground-water sample analyses....Sediment samples from representative cross sections of nearby surface water courses should be taken and analyzed for the same radioactive and chemical constituents as soil samples...." (Section 3.2.1, p. 20 and 21)</p>	X	X	X	X				X	+			
<p>MUREG-1199 (SAR Standard Format and Content)</p> <p>"The applicant should provide information on the background and anticipated changes in water chemistry for groundwater and surface water systems that may be affected by site construction and waste disposal and precipitation. Data on and descriptions of the following parameters should be included: (1) concentrations of inorganic constituents (including important trace elements), complexing ligands, dissolved gases, organic constituents (including total organic carbon and total organic halogens), stable isotopes for concentration ratios, and background radionuclides, (2) pH, oxidation/reduction conditions determined by various methods, alkalinity, ionic strength, total dissolved solids, and density, (3) temperature, (4)</p>	X	X	X	X		X		X				

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS													
	Water Quality	Ion-exchange Capacity	Organic Content	Eh-pH	Distribution Coefficient	Temperature	Radiometric Dating	Isotopic Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis		
<p>nature of colloidal-sized materials, (5) observations of degassing. Data that assess seasonal variations should be provided. The applicant should also provide information on sampling, preservation, storage, and analytical procedures, including details on filter sizes used during sampling and analysis of water samples and analytical detection levels. Information on quality assurance and quality control procedures used during sampling, preservation, storage, and analysis, such as split, spiked, standard, blank samples, and ion balance calculations should also be provided." (Section 2.6, p. 2-12 and 2-13)</p> <p>"The applicant should provide information on the classification, identification of the mineralogy, and chemical characterization of the soils and rock units. The applicant should provide information describing sampling, preservation, storage, analytical and experimental procedures. Information on solubility, ion exchange, and sorption experiments should be provided, including the range of chemical and physical conditions used to bound the results. Information on quality assurance and quality control procedures used during sampling, preservation, storage, analysis, and experimentation should be provided." (Section 2.6, p. 2-13)</p>		X			+	+			X					

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS												
	Water Quality	Ion-exchange Capacity	Organic Content	pH	Distribution Coefficient	Temperature	Radioactive Dating	Isotope Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis	
NUREG-1199 (Continued)					X	+			X		X	+	
"The applicant should provide information on the conceptual models and documentation of codes used to model site geochemistry. Information on validation exercises, data bases (e.g., thermodynamic constraints for aqueous complexation, mineral solubility, and gas solubility reactions and binding constants or distribution coefficients for sorption models), input and output data, and interpretation of results should also be provided." (Section 2.6, p. 2-13)					+	+		X		+	X	X	
"...the applicant should provide all information needed to calculate radionuclide concentrations....this information should include....[the] chemical input parameters used in the contaminant transport analyses, the mathematical models and methods used to calculate radionuclide concentrations, and the calculated results, including associated uncertainties in the methods and data."* (Section 6.1.5.1, p. 6-7)					+	+		X		+	X	X	

NUREG-1200 (SAR Standard Review Plan)

"The staff will review the background water chemistry information for groundwater and surface water systems....including the sampling, preservation, storage, and analytical procedures and the quality assurance and quality control procedures used during sampling, preservation, storage, and analysis." (SRP 2.6, Sec. 2.1, p. 2-6-1)

* Also addressed by parameters for ground-water hydrology (Table A-2)

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROGEOCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS											
	Water Quality	Ion-Exchange Capacity	Organic Content	pH	Distribution Coefficient	Temperature	Radiometric Dating	Isotope Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis
<p>NUREG-1200 (SAR Standard Review Plan)</p> <p>"The staff will review the information on the classification, mineralogical identification, and chemical characterization of the soils and rock units, including the sampling, preservation, storage, analytical, and experimental procedures and the quality assurance and quality control procedures used during sampling, preservation, storage, analysis, and experimentation." (SRP 2.6, Sec. 2.2, p. 2.6-1)</p> <p>"The staff will review the development of conceptual models for site geochemistry and the selection and capabilities of codes used to develop these conceptual models." (SRP 2.6, Sec. 2.3, p. 2.6-2)</p> <p>"The information on water chemistry is acceptable if discussions of the water chemistry data are complete, compare well with studies conducted by others in the same area, and are supported by detailed investigations performed by the applicant. Procedures for sampling, preservation, and storage and analytical techniques and their associated detection limits should be acceptable to the technical community. Adequate quality assurance and quality control procedures....should be performed. Data should be collected at least quarterly for a minimum of 1 year to determine seasonal variations..." (SRP 2.6, Sec. 4.3.1, p. 2.6-4 and 2.6-5)</p>	+	+	+	+	+	+	+	+	+	+	x	+

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS											
	Water Quality	Ion-exchange Capacity	Organic Content	pH	Distribution Coefficient	Temperature	Radiometric Dating	Isotope Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis
NUREG-1200 (Continued)		X	+		+			+	X	+		
<p>"The information on the geochemistry of soil and rock units is acceptable if discussions of the classification, mineralogical identification, and chemical characterization and chemical stability of the soils and rock units are complete, compare well with studies conducted by others in the same area, and are supported by detailed investigations performed by the applicant. The sampling, preservation, storage, analytical, and experimental techniques should be acceptable to the technical community, and adequate quality assurance and quality control procedures should be performed. Solubility, ion exchange, and sorption experiments should be carried out by methods such as those suggested in NUREG-0902 and should represent a range of chemical and physical conditions in order to bound the results. Presentation of the experimental results should include a discussion of uncertainties and limitations of the procedures..." (SRP 2.6, Sec. 4.3.2, p. 2.6-5)</p>												
<p>"The information on geochemical modeling is acceptable if the discussions of geochemical modeling are complete and consistent with the detailed investigations performed by the applicant. The conceptual chemical models used must adequately represent the system being studied, and codes used to make predictions based on the conceptual chemical models must be properly verified and validated as defined in NUREG-0856. Any data used in the codes but not collected by the applicant should be consistent</p>												
											X	+

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS											
	Water Quality	Ion-exchange Capacity	Organic Content	Eh-pH	Distribution Coefficient	Temperature	Radiometric Dating	Isotope Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis
NUREG-1200 (Continued)												
with established and up-to-date data compilations. Input data and interpretations of the results should be consistent with data collected in field and/or laboratory investigations. The applicant should not draw conclusions based on modeling results that exceed the capabilities of the models and codes, and there should be a discussion of model and code uncertainties and limitations." (SRP 2.6, Sec. 4.3.3, p. 2.6-5)	+	+	+	+	+	+	+	+	+	+	X	X
"The applicant should provide estimates of the input parameters (hydrogeologic, geochemical, and radionuclide release data) for the radionuclide transport analysis....(and) the computational methods and justification [of these parameters]." (SRP 6.1.5.1, Sec. 3.2.2, p. 6.1.5.1-2)												

NUREG-1300 (ER Standard Review Plan)

"Information needed for the staff's review will usually include the following: (1) a complete set of site-specific surface water chemistry data. Data should assess seasonal variations and should include the mean, range, and temporal and spatial variations in water quality parameters such as (a) concentrations of major inorganic constituents (including important trace elements), dissolved gases, and radioactive elements, (b) concentrations of major organic constituents, dissolved organic

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS											
	Water Quality	Ion-exchange Capacity	Organic Content	pH	Distribution Coefficient	Temperature	Radiometric Dating	Isotope Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis
<p>NUREG 1300 (Continued)</p> <p>carbon, total organic halogens, and water quality indicator organisms (e.g., fecal coliforms and fecal streptococci), (c) pH, oxidation/reduction conditions, total dissolved solids, specific conductance, alkalinity, ionic strength, and density, (d) turbidity, and the nature of colloidal-sized materials, (e) temperature....(2) regional surface water quality data....(and) (3) descriptions of preexisting chemically stressed (i.e., contaminated) surface water environments, and sources of contamination to any water body that may affect local water quality or site construction, operations, or monitoring programs." (ESRP 3.4.1.2, Sec. 2, p. 3.4.1.2-2)</p> <p>"Information needed for the staff's review will usually include the following: (1) a complete set of site-specific groundwater chemistry data. Data should assess seasonal variations and should include the mean, range, and temporal and spatial variations in water quality parameters such as (a) concentrations of major inorganic constituents (including important trace elements), dissolved gases, and radioactive elements, (b) concentrations of major organic constituents, dissolved organic carbon, total organic carbon, total organic halogens, and water quality indicator organisms (e.g., fecal coliforms and fecal streptococci), (c) pH, oxidation/reduction conditions, total dissolved solids, specific conductance, alkalinity, ionic strength, and density, (d) turbidity, and the nature of colloidal-sized</p>	X	X	X	X	X	X		X				

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS											
	Water Quality	Ion-exchange Capacity	Organic Content	pH	Distribution Coefficient	Temperature	Radiometric Dating	Isotope Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis
NUREG 1300 (Continued)												
materials, [and] (e) temperature....												
(2) regional groundwater quality data....[and]												
(3) descriptions of preexisting chemically stressed (i.e., contaminated) groundwater environments, and sources of contamination to any water body that may affect local water quality or site construction, operations, or monitoring programs." (ESRP 3.4.2.2, Sec. 2., p. 3.4.2.2-2)	+	+	+	+	X	+		+	X	+		
"Information needed for the staff's review will usually include the following:....(12) geochemical interactions between soil materials and percolating and interstitial waters in the vadose zone, and groundwater in the saturated zone."* (ESRP 3.5.2, Sec. 2., p. 3.5.2-3)												
"Information needed for the review will usually include the following for each of the alternatives....(1) data on surface water....quality...., (2) maps and lists identifying surface water bodies whose....quality....would be affected by the alternatives...., (3) maps and lists identifying surface water users that would be affected by changes in surface water....quality caused by the alternatives...., (4) quantitative and qualitative descriptions of the impacts of site preparation, construction, operation, and closure on the....quality....of surface water...., (6) description and analysis of surface water pathways to demonstrate that potential radiological and nonradiological	+	+	+	+	+	+		+	+	+	X	X

* Also addressed by parameters for geology (Table A-1)

TABLE A-4
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

REGULATORY GUIDANCE	PARAMETERS											
	Water Quality	Ion-exchange Capacity	Organic Content	pH	Distribution Coefficient	Temperature	Radiometric Dating	Isotope Content	Soil Mineralogy and Mineral Solubility	Hydrodynamic Dispersion Coefficient	Geochemical Model	Transport Analysis
NUREG 1300 (Continued)												
effluent concentrations will be within acceptable limits....., (7) quantitative and qualitative descriptions of the impacts on groundwater-surface water interactions....., (8) local, State, and Federal regulations applicable to surface water....quality." (ESRP 4.3.1, Sec. 2., p. 4.3.1-2 and -3)	X	+	+	+		+	+	+				
"information needed for the review will usually include the following:....(9) State and Federal regulations applicable to water quality and water use...." (ESRP 4.3.2, Sec. 2., p. 4.3.2-2 and -3)												

*Also addressed by parameters for water resources (Table A-5)

TABLE A-4
PARAMETER DESCRIPTIONS - GEOCHEMISTRY/HYDROCHEMISTRY

Water Quality: The particular range of chemical attributes that is characteristic of a surface or ground water. Important chemical species for water-quality characterization include total dissolved solids, dissolved oxygen, carbon dioxide and fluoride, major ions, nutrients, dissolved iron and manganese, dissolved heavy metals, silica, oil and grease, and various toxicants. Major ions include the cations sodium, potassium, calcium, and magnesium, and the anions sulfate, chloride, bicarbonate, and carbonate. Nutrients typically include total and dissolved organic carbon, orthophosphate, total phosphorous, nitrate, ammonia, and total kjeldahl nitrogen. Heavy metals typically include copper, zinc, nickel, and hexavalent chromium. Toxicants that are present, are suspected as present, or potentially may be introduced to the water will be determined during site characterization. These may include both inorganic chemicals (e.g., dissolved arsenic, dissolved boron, radionuclides) and organic chemicals (e.g., herbicides, pesticides, volatile organics). Hardness, pH, alkalinity, water-quality indicator organisms, turbidity, and nature of colloidal materials in the water will also be determined in a complete water-quality assessment. The particular water characteristics to be determined during site characterization will be a function of site location and of the composition of the waste to be disposed.

Ion-Exchange Capacity: The extent to which a material will exchange ions that are adsorbed on its surface with dissolved ions that are present in a surrounding fluid. The ion-exchange capacity depends on a number of factors, including the material type, concentrations and number of dissolved species present in solution, and system pH. The cation-exchange capacity (CEC) is of particular interest in soil and subsurface environments. Soils with high clay content, and particularly with high organic content, typically will have a high CEC. Cations, such as many of the dissolved radionuclides that migrate through these materials, will be effectively retarded during transport as a result of ion exchange.

Organic Content: The proportion of organic matter present in soil. The organic matter may be comprised of living and decomposed plants, roots, and detritus. Organic constituents that may be quantified include total organic carbon (TOC), total and volatile organic acids, chelating agents, tannin, lignin, soil nutrients (e.g., nitrate, ammonia, phosphate), and microorganisms (e.g., total bacteria, coliforms). Constituents may be analyzed in soil and in soil gas. Organic matter, and particularly root systems, can provide pathways for chemical migration through soils and to the soil surface. The organic soil fraction typically has a high sorptive capacity and thus can increase the soil CEC. Organics also may leach and mobilize inorganic constituents in soil. Certain organics may behave as chelating agents, which can bind metallic ions (e.g., radionuclides). The chelating agents, when dissolved in water, may provide a transport mechanism for metals that are normally non-mobile.

Eh-pH: Eh is commonly referred to as the redox potential, and is a measure of the tendency of a solution to oxidize or reduce susceptible constituents. pH refers to hydrogen ion activity, and is a measure of the acidity of a solution. Both Eh and pH are typically measured using potentiometric probes. Eh may also be estimated from measured concentrations of both members of redox couples, such as iron species. To address possible redox disequilibrium, if a single Eh value is required for modeling purposes, that value should be determined from as many sources as is practical. The assumptions and methods used in defining an overall Eh for model calculations should be stated and justified. The relationship between Eh and pH in aqueous systems is commonly illustrated on Eh-pH diagrams. These diagrams can be used to predict stability fields of the various chemical species. Thus, for a given Eh and pH, species that are likely to exist and that contain elements of interest (e.g., radionuclides) can be determined. Eh-pH diagrams can be used to predict the behavior of elements such as radionuclides in the local environment.

Distribution coefficient: The ratio reflecting the allocation of a species between two phases in an aqueous or rock system. In particular, this parameter is useful for estimating the fraction of a species that will be allocated to the aqueous phase and therefore will remain mobile, and the fraction allocated to the solid phase that will be immobile. The distribution coefficient is an empirical parameter whose value is strongly dependent upon site specific or experimental conditions. The distribution coefficient includes the effects of ion exchange and other sorption reactions. This parameter can be used to estimate the extent of retardation of a dissolved species during transport, but the accuracy of that estimate will strongly depend upon the extent to which the conditions approximate those under which the distribution coefficient was measured.

Temperature: The temperature of both in-situ ground water and surface water. This parameter is important because the other parameters are temperature sensitive.

Radiometric dating: Determination of the age of the ground water or rock on the basis of radioisotope abundances.

Isotope Content: The quantity of radioactive and other isotope constituents present in the soil and water.

Soil Mineralogy and Mineral Solubility: The types of minerals present in a soil; also includes their weathering and engineering characteristics. Soil mineralogy is important as it relates both to radionuclide migration and to engineering behavior. Mineral solubility refers to the tendency of soil minerals to dissolve into aqueous phases present in the system. Description of mineral solubility should include the range of chemical and physical conditions bounding various stability fields.

Hydrodynamic Dispersion Coefficient: The hydrodynamic dispersion coefficient describes dispersion of a contaminant in ground water. Dispersion is a result of two processes: molecular diffusion and mechanical mixing. Diffusion is the process whereby contaminants move under the influence of their kinetic

activity in the direction of their concentration gradient. Mechanical mixing or mechanical dispersion is a result of velocity variations within the porous medium. The hydrodynamic dispersion coefficient is dependent on the diffusion coefficient, the concentration gradient, the longitudinal and transverse dispersivities, and the velocity field.

Geochemical Model: A mathematical formulation of predicted geochemical behavior of the rock-soil-ground-water system. Description of such a model should include information on the database used, validation exercises applied, and the capabilities and limitations of the model.

Transport Analysis: A mathematical formulation of predicted transport behavior in the saturated and unsaturated ground-water system. Processes of dispersion, diffusion, adsorption, degradation, and radioactive decay may be included in transport analyses.

TABLE A-5
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: WATER RESOURCES

REGULATORY REQUIREMENT	PARAMETERS						
	Past and Present Ground-water Usage	Past and Present Surface-water Usage	Ground-water Discharge Points	Projected Surface-water Usage	Projected Ground-water Usage	Water Rights and Legal Summaries	Site Water Resource Impact
10 CFR 61 - NRC Licensing Requirements 61.12(h) 61.50(a)(4)	X	X	X	X	X	+	X
10 CFR 51 - NRC Environmental Protection Regulations (Does not specifically address water resources)							
REGULATORY GUIDANCE							
NUREG-0902 (Site Suitability, Selection, and Characterization)							
<p>"[Part 61.50(a)(4)], related to known natural resources, includes such resources as mineral, coal, or hydrocarbon deposits, geothermal energy sources, timber, and water sources. The requirement applies to resource recovery that may occur at the ground surface, in the hydrogeologic units used for disposal and isolation, and at greater depths which require excavation or drilling through disposal units. Potential indirect effects caused by nearby exploitation, such as increased infiltration rates and steepened hydraulic gradients, should be evaluated. The primary concerns with respect to the presence of exploitable natural resources are the likelihood of inadvertent intrusion by a resource exploiter and the effects of development on the performance of the site after the period of active institutional control."* (p. 6)</p> <p>*The site characterization program should also include an inventory of existing surface-water users and municipal supplies within approximately 10 kilometers downstream of the site in order to determine the nearest surface-water users and the nearest municipal supply relying on surface water. For these locations, the inventory should include the location, type, and amount of use; source of supply; type of intake; and surface-water quality data as submitted to the EPA periodically for certification."* (p. 17)</p>							

TABLE A-5
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: WATER RESOURCES

REGULATORY GUIDANCE	PARAMETERS						
	Past and Present Ground-water Usage	Past and Present Surface-water Usage	Ground-water Discharge Points	Projected Surface-water Usage	Projected Ground-water Usage	Water Rights and Legal Summaries	Site Water Resource Impact
NUREG-0902 (Continued)							
"The site characterization studies should include an inventory of existing ground-water users within approximately two kilometers of the site. For these ground-water users, the inventory should include the location, type, and amounts of use; hydrogeologic unit used; typical well construction details; and ground-water quality. The inventory should include both ground-water wells and water users at points of ground-water discharge, e.g., springs. The inventory should identify for use in the ground-water pathway analysis, the nearest downgradient ground-water users and the nearest municipal supply relying on ground water." (p. 17 and 18)	X		X		+	+	
IRC Draft Technical Position Paper on Environmental Monitoring (Does not address water resources)							
NUREG-1199 (SAR Standard Format and Content)							
"The applicant should provide a description of water resources and a demonstration that exploitation of these resources will not result in failure to meet the performance objectives in 10 CFR 61.50(a)(4). A description of present and projected local and regional use of ground and surface waters should be included." (Section 2.7.2, p. 2-15)	X	X	X	X	X		X
"The applicant should provide a description of historical, present, and potential future local and regional groundwater use. Information pertinent to this section includes, to the extent practicable, location of points of groundwater withdrawal, discharge rates, and use of the groundwater. The description of water resources should also include information and ion/parched aquifer water use." (Section 2.7.2, p. 2-15)	X		X		X	+	

TABLE A-5
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: WATER RESOURCES

REGULATORY GUIDANCE	PARAMETERS						
	Past and Present Ground-water Usage	Past and Present Surface-water Usage	Ground-water Discharge Points	Projected Surface-water Usage	Projected Ground-water Usage	Water Rights and Legal Summaries	Site Water Resource Impact
<p>NUREG-1199 (Continued)</p> <p>"The applicant should describe the historical, present, and potential future use of surface water in the vicinity of the proposed facility, including present and potential rates of withdrawal, point of withdrawal, percentage of stream flow withdrawn, and the use of the resource whether it be for livestock, municipal, residential, or industrial uses. Recreational activities should also be described including swimming, fishing, boating, and other foreseeable activities." (Section 2.7.2, p. 2-15 and 2-16)</p>		X		X			
<p>NUREG-1200 (SAR Standard Review Plan)</p> <p>"The [NRC] staff will review the description of water resources including the following: (1) the description of the present and potential use of local and regional groundwater, including locations of wells both spatially and stratigraphically, and the potential rates of withdrawal from significant aquifer systems, including perched aquifer systems capable of yielding significant quantities of water, (2) the description of the present and potential use of surface water resources, including withdrawal for human or livestock consumption, industrial use, and/or any recreational activities, (3) the description of water resources related to the requirements of 10 CFR 61.12(h)." (SRP 2.7.2, Sec. 2.1, p. 2.7.2-1)</p> <p>"The staff will review the description of the effect of exploitation of water resources including the following: (1) the results of analyses associated with changes occurring to the flow regime as a result of exploitation, including groundwater travel time, flow velocity, and directions, (2) results of conservative scenarios and analyses illustrating the possible effects of exploitation with respect to the performance objectives of Subpart C of 10 CFR 61." (SRP 2.7.2, Sec. 2.2, p. 2.7.2-2)</p>	X	X	X	X	X		X

*Also addressed by parameters for ground-water and surface-water hydrology (Tables A-2 and A-3, respectively)

TABLE A-5
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: WATER RESOURCES

REGULATORY GUIDANCE	PARAMETERS						
	Past and Present Ground-water Usage	Past and Present Surface-water Usage	Ground-water Discharge Points	Projected Surface-water Usage	Projected Ground-water Usage	Water Rights and Legal Summaries	Site water Resource Impact
NUREG-1200 (Continued)							
"....The [NRC] staff will require information pertaining to (1) the description of the current uses of water resources (including locations of discharge points and withdrawal rates), which include residential, industrial, and municipal withdrawal for drinking purposes, irrigation, livestock watering, and recreational uses, and (2) the description of conceptual and numerical models used in the applicant's evaluation, including documentation, verification, calibration, and results." (SRP 2.7.2, Sec. 4.3, p. 2.7.2-3 and -4)	X	X	X				X
"Moreover, the staff will require information reviewed for (1)....'Geography, Demography, and Future Development,' referring to the projected use of all water resources in the vicinity of the proposed facility, (2)'Surface Water Hydrology,' referring to the description of surface water features, including location, volumes of water, and hydrologic characteristics of the features, and (3)'Groundwater Characterization,' referring to the description of the groundwater flow regime,....and data and results of the numerical simulation used to calibrate the physical system." (SRP 2.7.2, Sec. 4.3, p. 2.7.2-4)	+	+	X	X	X	+	X
NUREG-1300 (ER Standard Review Plan)							
"The scope of the NRC [....] staff's review of surface water uses that could be affected by the alternatives....will consist of (1) an evaluation of such water uses as domestic, municipal, agricultural, industrial, mining, recreational and navigational, and hydroelectric power generation; (2) identification of the water use locations; and (3) quantification of water diversions, consumption, and returns. The review will encompass past, present, and known future water uses." (ESRP 3.4.1.3, Sec. 2, p. 3.4.1.3-1)		X		X		X	X
"Information needed for the review will usually include the following: (1) maps sufficiently detailed so that they show the surface water systems that could be affected by the alternatives being considered"		X		X		+	X

*Also addressed by parameters for ground-water and surface-water hydrology (Tables A-2 and A-3, respectively)
**Also addressed by parameters for surface-water hydrology (Table A-3)

TABLE A-5
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: WATER RESOURCES

REGULATORY GUIDANCE	PARAMETERS						
	Past and Present Ground-water Usage	Past and Present Surface-water Usage	Ground-water Discharge Points	Projected Surface-water Usage	Projected Ground-water Usage	Water Rights and Legal Summaries	Site Water Resource Impact
NUREG-1300 (Continued)							
(2) Identification of locations and rates of groundwater recharge and groundwater discharge at the site and vicinity*	X		X				
(3) Inventory of existing groundwater users within the site and vicinity including location, type, amounts, and rates of use, hydrogeologic unit used, and typical well construction details; Identification of the nearest downgradient groundwater users and nearest supply well relying on groundwater	X		X			+	
(4) data on drawdown (or mounding) caused by withdrawals (or injections) of groundwater from neighboring major industrial, agricultural, and municipal wells, including extent of depression (or impression) cones*	X		X				
(5) description of future groundwater withdrawals based on past and present withdrawals and the potential for development of new groundwater withdrawals in the foreseeable future; description of groundwater uses and changes through time in potentiometric levels.** (ESRP 3.4.2.3, Sec. 2., p. 3.4.2.3-2)	X				X		
Information needed for the NRC's review of the effects of the alternatives, including site preparation, construction, operation, and closure, on the use of surface water bodies! "...will usually include the following for each of the alternatives:							
(1) data on surface water.....use		X		X		+	X
(2) maps and lists identifying surface water bodies whose.....use would be affected by the alternatives**		X		X			X
(3) maps and lists identifying surface water users that would be affected by changes in surface water regime or quality caused by the alternatives		X		X			X
(4) Quantitative and qualitative descriptions of the impacts of site preparation, construction, operation, and closure on the.....use of surface water.....[and]		X		X			X

*Also addressed by parameters for ground-water hydrology (Table A-2)

**Also addressed by parameters for surface-water hydrology (Table A-3)

TABLE A-5
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: WATER RESOURCES

REGULATORY GUIDANCE	PARAMETERS						
	Past and Present Ground-water Usage	Past and Present Surface-water Usage	Ground-water Discharge Points	Projected Surface-water Usage	Projected Ground-water Usage	Water Rights and Legal Summaries	Site Water Resource Impact
(8) local, State, and Federal regulations applicable to surface water....use." (ESRP 4.3.1, Sec. 2., p. 4.3.1-2 and -3)						X	
<p>[Information needed for the NRC's review of the potential impact of the alternatives selected for detailed consideration on the ground-water use]</p> <p>".....will usually include the following:</p> <p>(4) Locations of groundwater users and natural groundwater discharge points located downgradient from the site where contaminants could become accessible to the public,....</p> <p>(9) State and Federal regulations applicable to water quality and water use" (ESRP 4.3.2, Sec. 2., p. 4.3.2-2 and-3)</p>	X		X		X		X
						X	

*Also addressed by parameters for geochemistry/hydrochemistry (Table A-4)

TABLE A-5
PARAMETER DESCRIPTIONS - WATER RESOURCES

Past and Present Ground-water Usage: An inventory of past and present ground-water users within approximately 2 kilometers of the site. Information should include the location, type and amount of use, hydrogeologic unit used, sources of water supply, type of well and pumping equipment, maximum production rate of well, and water quality data. The inventory should identify the nearest down-gradient ground-water users and the nearest municipal supply relying on groundwater.

Past and Present Surface-water Usage: An inventory of past and present surface-water users in the vicinity of the site and, in particular, within approximately 10 kilometers downstream of the site. Information should include the location, type and amount of use, number of users on the system, rate of withdrawal, percentage of stream flow withdrawn, sources of water supply, type of intake and pumping equipment, and surface water quality data. The inventory should identify the nearest down-gradient surface-water users and the nearest municipal supply relying on surface water.

Groundwater-water Discharge Points: An inventory of all springs, seeps, etc., in the vicinity of the site and usage at these points. Information should include the location, type and amount of use, hydrogeologic unit used, flow rate, sources of water supply, type of well and pumping equipment, and water quality data.

Projected Surface-water Usage: The projected demand and usage of local and regional surface-water resources for domestic, municipal, agricultural, industrial, mining, recreational, and navigational needs. This projection will include geographic, demographic, and economic information and documentation as part of the evaluation.

Projection Ground-water Usage: The projected demand and usage of local and regional ground-water resources for domestic, municipal, agricultural, industrial, mining, and recreational needs. This projection will include the potential rates of withdrawal from significant aquifer systems, and geographic, demographic, and economic information and documentation as part of the evaluation.

Water Rights and Legal Summaries: A summary of statutory and other legal restrictions relating to surface-water and ground-water use as imposed by municipal, State, or Federal regulations.

Site Water Resource Impact: A qualitative and quantitative description of the present and projected surface-water and ground-water uses within the site vicinity that could affect or be affected by the site.

TABLE A-6
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

REGULATORY REQUIREMENTS

10 CFR 61 - NRC Licensing Requirements
61.12(h)
61.50(a)(4)

10 CFR 51 - NRC Environmental Protection Regulations

(Does not specifically address natural resources)

REGULATORY GUIDANCE

NUREG-0902 (Site Suitability, Selection, and Characterization)

"[Part 61.50(a)(4)], related to known natural resources, includes such resources as mineral, coal, or hydrocarbon deposits, geothermal energy sources, timber, and water resources. The requirement applies to resource recovery that may occur at the ground surface, in the hydrogeologic units used for disposal and isolation, and at greater depths which require excavation or drilling through disposal units. Potential indirect effects caused by nearby exploitation, such as increased infiltration rates and steepened hydraulic gradients, should be evaluated. The primary concerns with respect to the presence of exploitable natural resources are the likelihood of inadvertent intrusion by a resource exploiter and the effects of development on the performance of the site after the period of active institutional control." (p. 6)

NRC Draft Technical Position Paper on Environmental Monitoring

(Does not address natural resources)

PARAMETERS

Present and Past Resource Data	Mineral Rights/Lease Data	Borehole/Well Data	Potential Resource Location	Resource Quality and Quantity	Resource Value	Direct Effects of Exploitation	Indirect Effects of Exploitation	Natural Resources Impact
X	+	+	X	+	+	X	X	

TABLE A-6
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

REGULATORY GUIDANCE	PARAMETERS								
	Present and Past Resource Data	Mineral Rights/Lease Data	Borehole/Well Data	Potential Resource Location	Resource Quality and Quantity	Resource Value	Direct Effects of Exploitation	Indirect Effects of Exploitation	Natural Resources Impact
NUREG-1199 (SAR Standard Format and Content)									
"The applicant should describe natural resources occurring at or near the site. Resources include metallic and nonmetallic minerals and ores; fuels...; hydrocarbons...; geothermal resources; Industrial mineral deposits...; timber; agricultural lands; and waters in the form of brines. Description of these resources should include information on resource type, occurrence, location, extent, net worth, recoverability, and current and projected use. The applicant should address economic, marginally economic, or subeconomic known or identified natural resources as defined in U.S. Geological Survey Circular 831." (Section 2.7.1, p. 2-14)	X	+	X	X	X	X	+	+	
"The identification of mineral, fuel, and hydrocarbon resources should not be limited to the site and should include areas of known resources near and surrounding the site which, if exploited, would compromise the safety of the site....The SAR should include maps showing all active and abandoned wells, boreholes, and excavations at the site....Borehole logs should accompany maps. Maps depicting areal geology - including lithologic units, structure, and stratigraphic relationships; current land use; and locations of all active or abandoned mines, quarries, borrow pits, and prospects should be included with the SAR. The applicant should also provide reasonable assurance that indirect effects (such as erosion or alteration of surface water pathways) of the exploitation of nearby natural resources will not compromise the suitability of the site."* (Section 2.7.1, p. 2-14 and 2-15)	X	X	X	X	+	+	X	X	
"The applicant should provide the following....(4) summary of onsite natural and human-Induced effects (e.g., farming,....logging, grazing, and burning)...."*** (Section 2.8, p. 2-16)							X		X

*Also addressed by parameters for geology and land use (Tables A-1 and A-10, respectively)

**Also addressed by parameters for land use (Table A-10)

TABLE A-6
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

REGULATORY GUIDANCE	PARAMETERS								
	Present and Past Resource Data	Mineral Rights/ Lease Data	Borehole/ Well Data	Potential Resource Location	Resource Quality and Quantity	Resource Value	Direct Effects of Exploitation	Indirect Effects of Exploitation	Natural Resources Impact
NUREG-1200 (SAR Standard Review Plan)									
"The applicant must identify all known geologic resources and their types, location, and extent, as required in NUREG-1199, to satisfy 10 CFR 61.12(h). The applicant must also analyze the potential for resource exploitation on the basis of market values and current and projected demand for the resources in question. Together with this analysis, the location of the resources, and the methods of extraction, the applicant must show reasonable assurance that the performance objectives of the proposed facility will be met." (SRP 2.7.1, Sec. 4.3, p. 2.7.1-4)	X	+	+	X	X	X	X	X	
[The staff will review]...(4) summary of onsite natural and man-induced effects (e.g., farming,....logging, grazing, and burning)...." (SRP 2.8, Sec. 2.1, p. 2.8-2)							X	X	
NUREG-1300 (ER Standard Review Plan)									
[The scope of the NRC review of known or identified mineral resources that could be affected by the proposed action will include]...(1) economic, marginally economic, and subeconomic identified resources at the site; (2) the uses and net worth of such mineral resources; and (3) the locations of active or abandoned mines, prospects, quarries, borrow pits, wells, and excavations.... Only reconnaissance-level data and information will usually be needed for the review of alternative sites." (ESRP 3.5.4, Sec. 2., p. 3.5.4-2)	X	+	+	X	X	X			X
ISite-specific and regional information needs for the primary site include:									
"(1) Maps....sufficiently detailed so that they show all active and abandoned mines, prospects, borings, wells, borrow pits, quarries, and excavations and identify those that are currently active	X		X						

*Also addressed by parameters for land use (Table A-10)

TABLE A-6
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION:
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

REGULATORY GUIDANCE	PARAMETERS							
	Present and Past Resource Data	Mineral Rights/ Lease Data	Borehole/ Well Data	Potential Resource Location	Resource Quality and Quantity	Resource Value	Direct Effects of Exploitation	Indirect Effects of Exploitation
NUREG-1300 (Continued)								
(2) Lists...of commodity types of each mine, prospect, boring, well, borrow pit, quarry, and excavation	X		X	+	+	+		
(3) Detailed maps that show all workings such as shafts, pits, trenches, adits, slopes, and drifts at the proposed site	X							
(4) Maps with descriptions of geologic units that host all mines, prospects, quarries, borrow pits, and excavations	X							
(5) All available logs from wells and borings at the site			X					
(6) A listing of all completion practices on wells and drilled holes within the affected area			X					
(7) Quantitative information (if available) such as assays, tonnages, ore grades, and production amounts of active or previously active mines, wells, borrow pits, and quarries	X							
(8) Summary of ownership of mineral rights and leases held for exploratory rights" (ESRP 3.5.4, Sec. 2., p. 3.5.4-2)		X						
"Among the characteristics to be considered in the review will be the following:(6) agricultural and forested areas on or in the vicinity of each alternative...." (ESRP 3.1.2, Sec. 3., p. 3.1.2-2)	X							

*Also addressed by parameters for land use (Table A-10)

TABLE A-6
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

REGULATORY GUIDANCE	PARAMETERS									
	Present Resource Data	Mineral Rights/ Lease Data	Borehole/ Well Data	Potential Resource Location	Resource Quality and Quantity	Resource Value	Direct Effects of Explor- ation	Indirect Effects of Explor- ation	Natural Resources Impact	
<p>Information needed for NRC staff's review of the effects of the construction, operation, and closure of the alternatives on the quantity, production, and availability of mineral resources includes:]</p> <p>"(1) Maps sufficiently detailed so that they show the locations and types of mineral resources....(and) (2) lists identifying the availability and amounts of mineral resources that could be affected by the preparation, construction, and operation of the proposed disposal site." (ESRP 4.4.2, Sec. 2., p. 4.4.2-2)</p>	X			X	X	X			X	

NUREG-1300 (Continued)

TABLE A-6
PARAMETER DESCRIPTIONS - GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

Past and Present Resource Data: Location maps of active and inactive mines, prospects, exploration boreholes, geothermal and hydrocarbon wells, borrow pits, quarries, excavations, and timber and agricultural lands. Data compilations either on or accompanying the maps should include: the commodity occurring at the resource location; the geologic unit in which the present or past geologic resource occurs; quantitative data, if available, for geologic materials produced from active or previously active mines, wells, borrow pits, and quarries; quantitative data for agricultural and timber resources; and the mining, harvesting or extraction method (e.g., shaft mining, strip mining, quarrying, borehole injection or pumping, uprooting of vegetation, blasting, etc.). Commodities to be addressed should include: metallic and nonmetallic minerals and ores; fuels such as peat, lignite, and coal; industrial mineral deposits such as sand and gravel, clays, aggregate sources, shales, and building stone; hydrocarbons, including gas, oil, tar sands and asphalt; timber; agricultural lands; and waters in the form of brines.

Mineral Rights/Lease Data: The location, ownership, and types of exploration activity (e.g., drilling, trenching, etc.) carried out on mining claims or mineral leases on and near the site.

Borehole/Well Data: The location, depth, diameter, completion practices, current drilling activity, use, and geological and geophysical logs of exploration boreholes and geothermal, brine, and hydrocarbon wells on and near the site.

Potential Resource Location: Location maps of potential resources that may be exploited in the future. Data compilations either on or accompanying the maps should include: the commodity occurring at the resource location, and for geologic resources, the geologic unit in which the future resource occurs. Commodities to be addressed include: metallic and nonmetallic minerals and ores; fuels such as peat, lignite, and coal; industrial mineral deposits such as sand and gravel, clays, aggregate sources, shales, and building stone; hydrocarbons, including gas, oil, tar sands and asphalt; timber; agricultural lands; and waters in the form of brines.

Resource Quality and Quantity: The physical and/or chemical characteristics of the identified geologic resource in place, such as quantity (i.e., areal extent, thickness, and depth), tonnage, grade, and/or volume and quality, as applicable to the resource type, and the quantity, quality, and extent of timber and agriculture resources (such as board feet and arable areage, respectively).

Resource Value: The current net worth of resources, based on: 1) the resource quantity and quality as described above, and 2) profitability analyses based on the current market price, current use and/or demand, recoverability, extraction/harvesting methods and costs, transportation and mining/processing costs, and capital investment costs. Projected resource use should be determined based on assumptions and projections for future market conditions. Known or identified geologic resources should be classified into economic, marginally economic, and subeconomic components as defined in U.S. Geological Survey Circular 831, "Principles of a Resource/Reserve Classification for Minerals."

Direct Effects of Exploitation: The potential effects of geologic or timber resource exploration or exploitation/extraction at the ground surface, in the hydrogeologic units used for disposal and isolation, or at greater depths, caused by excavation, blasting, drilling, uprooting of timber, or other activities that directly intrude disposal units.

Indirect Effects of Exploitation: The potential effects of geologic, agricultural, or timber resource exploration or exploitation/extraction that would compromise the suitability of the site through such processes as increased infiltration rates, alteration of ground-water tables, increased runoff up-gradient of site, steepened hydraulic gradients, and creation or modification of surface-water or ground-water pathways. These processes may be affected by activities such as excavation, blasting, uprooting of vegetation, irrigation, pumping or injection, erosion control procedures, or other mining, logging, or agricultural activities that can affect the hydrologic regime.

Natural Resources Impact: Qualitative and quantitative descriptions of the impact of the site on natural resources from construction to closure, particularly the denial of resources.

TABLE A-7
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOTECHNICAL INVESTIGATION

REGULATORY REQUIREMENT	PARAMETERS				
	Soil Classification	Engineering Properties	Engineering Units	Ground-water Conditions	Engineering Analysis
10 CFR 61 - NRC Licensing Requirements 61.12(a),(b) 61.13(d) 61.50(a)(2) 61.51(a)(1),(a)(2)					
10 CFR 51 - NRC Environmental Protection Regulations (Does not specifically address geotechnical investigation)					
REGULATORY GUIDANCE					
NUREG-0902 (Site Suitability, Selection, and Characterization)					
"Site characterization studies related to geomechanics will provide data for major design-related analyses, such as slope stability, cover integrity, erosion, compaction characteristics for backfill materials, foundation analyses for any structures housing waste handling or repackaging facilities, gradations for proposed filter materials, and possible interactions between the soil and waste containers." (p. 22)	X	X	+	+	+
"Laboratory studies should include classification and tests, such as the Unified Soil Classification system and Atterberg limits, respectively...the coefficient of consolidation, minimum density, and void ratio of backfill should be determined as needed for settlement analysis. Organic content, particle-size distribution, Atterberg limits, and moisture-density relationships...should be determined for design of the backfill and the covers...freezing characteristics of the soil may be needed to determine freeze/thaw effects, particularly changes in volume and hydraulic conductivity...the cohesion, angle of internal friction, and unit weight...of the soils may be needed for analyses of slope stability for natural, cut, or fill slopes." (p. 22 and 23)	X	X			X
"Practice size distribution, dispersive characteristics and cohesion of surficial soils and covers should be determined to assist in the analysis of erosion resistance. Parameters such as the coefficient of consolidation, void ratio, cohesion, angle of internal friction, limit pressure, deformation modulus, or penetration resistance...should be determined as appropriate...to determine the bearing capacity of the subgrade soils and the settlement of structures." (p. 23)		X			X

TABLE A-7
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOTECHNICAL INVESTIGATION

REGULATORY GUIDANCE	PARAMETERS				
	Soil Classification	Engineering Properties	Engineering Units	Ground-water Conditions	Engineering Analysis
<p>NIPEG-0902 (Continued)</p> <p>"Analysis of the corrosivity of the fill to be used around the waste containers may necessitate the determination of soil resistivity, pH, moisture content, and oxidation-reduction potential." (p. 23)</p>		X			
<p>NRC Draft Position Paper on Environmental Monitoring</p> <p>(Does not address geotechnical investigation)</p>					
<p>NIPEG-1199 (SAR Standard Format and Content)</p> <p>"Information should be presented that thoroughly defines the conditions and engineering properties of both soil and/or rock at the facility. Information on the geotechnical characteristics of the disposal site should include (1) the scope and results of geotechnical and geophysical investigations conducted at the site, (2) the scope and results of field and laboratory tests conducted to determine the engineering properties of various materials at the site, (3) the groundwater conditions at the site, (4) the fill borrow materials proposed for the facility, and (5) interpretation of the site stratigraphy and selection of the design parameters on the basis of the data in the SAR." (Section 2.5, p. 2-10)</p>	X	X	X	X	X
<p>"The applicant should provide information on the long-term stability aspects of the proposed facility in accordance with the performance objectives and technical requirements of 10 CFR 61. The applicant should provide information on the long-term stability of all earth and rock slopes, both man-made and natural, whose failure under any of the conditions to which they could be exposed during the 500-year stability period of the facility could adversely affect the facility's meeting the performance objectives...." (Section 6.3.2, p. 6-18)</p>	+	X	+	X	X
<p>"The settlement and/or subsidence of the individual disposal excavation caps and the disposal site should be evaluated to determine if the settlement and/or subsidence would adversely affect the facility's meeting the performance objectives in Subpart C of 10 CFR 61." (Section 6.3.3, p. 6-22)</p>	+	X	+	X	X

*Also addressed by parameters for geochemistry/hydrochemistry (Table A-4)

**Also addressed by parameters for geology (Table A-1)

TABLE A-7
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOTECHNICAL INVESTIGATION

REGULATORY GUIDANCE	PARAMETERS				
	Soil Classification	Engineering Properties	Engineering Units	Ground-water Conditions	Engineering Analysis
<p>NUREG-1200 (SAR Standard Review Plan)</p> <p>"The objectives of the (NRC) review are to ensure that the (1) scopes of the geotechnical and geophysical field investigations and laboratory and field testing are adequate; (2) interpretations of the data to develop typical soil and rock layering, typical cross-sections, and design parameters for use in design are reasonable and conservative; and (3) geotechnical characterization of the site meets the guidance and acceptance criteria in this SRP. The staff will review the following items using information in the SAR and information available from other sources: (1) scope and results of the geotechnical and geophysical investigations conducted to characterize the disposal site and proposed borrow areas; (2) scope and results of the field and laboratory tests conducted to determine the engineering properties of various materials at the site and borrow materials; (3) groundwater conditions, including seepage conditions, pertaining to the design of the low-level waste disposal facility; (4) selection of borrow materials; and (5) interpretation of the site stratigraphy and selection of design parameters based on the data in the SAR."* (SRP 2.5, Section 2., p. 2.5-1,</p> <p>"The staff will review the following items using the data in the SAR and information from other sources: (1) the results of investigations for slope area characterization including data obtained from borings, test pits, trenches, and laboratory tests; properties of borrow materials; compaction criteria and provision for quality control; and (2) slope characteristics, design criteria, and slope stability analyses and results." (SRP 6.3.2, Section 2, p. 6.3.2-1)</p> <p>"The staff will review the following items using the data in the SAR and information from other sources: (1) results of site characterization, details of excavation and waste emplacement in the disposal excavation and their backfilling during the operations phase, and details of disposal excavation cap design and construction; (2) identification of areas potentially susceptible to long-term settlement and their modeling in the analyses; (3) settlement analyses; and (4) proposals for settlement and/or subsidence monitoring and remedial actions if they should be necessary." (SRP 6.3.3, Section 2., p. 6.3.3-1)</p>	X	X	X	X	X
	X	X	X	X	X
	X	X	X	X	X

* Also addressed by parameters for ground-water hydrology (Table A-2)

TABLE A-7
REGULATORY REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOTECHNICAL INVESTIGATION

REGULATORY GUIDANCE	PARAMETERS				
	Soil Classification	Engineering Properties	Engineering Units	Ground-water Conditions	Engineering Analysis
NUR(G-1300 (ER Standard Review Plan)					
"Information needed for the staff's review will be affected by regional and site-specific factors regarding soil materials and proposed site operations. Information needed for the review will usually include the following:					
(1) Calculation of volumes of soil materials isolated from future use at a proposed site and all borrow areas by excavation for backfill, trench caps, or removal from the site...					X
(2) Calculated predictions of volumes of soil material lost through erosion caused by land-use changes (procedures such as construction and excavation) based on the Uniform Soil Loss equation...					X
(3) Changes in susceptibility of soils to erosion and mass wasting during and after site construction caused by recontouring of the land, changes in surface drainage patterns, oversteeping of slopes, removal of stabilizing vegetation, and overburdening of top slopes by waste packages or facility buildings...					X
(4) Changes in rates and recurrence intervals of erosion and mass wasting events caused by proposed actions identified in item (3) above...					X
(5) Changes in soil-unit properties related to surface water and groundwater, and floral and faunal ecology, caused by soil disruption, compaction, erosion, or mass wasting...				X	X
(6) Changes in susceptibility of soil unit to structural failure, collapse, or liquefaction caused by disruption at the site. These processes would be expected to result from alterations of soil cohesion and pore-water pressures caused by compaction or excavation...		X			X
(7) Calculation of acreage of arable soils or foundation soils isolated from future use at the proposed site and all borrow areas as a result of anticipated radiological impacts and long-term institutional controls...					X
(8) Assessments of radiological pathways through contaminated soils to aquatic and terrestrial environments... (ESR 4.4.1, p. Section 2, 4.4.1-2 and 4.4.1-3)					X

*Also addressed by parameters for geology (Table A-1)

**Also addressed by parameters for ground-water hydrology (Table A-2)

TABLE A-7

PARAMETER DESCRIPTIONS - GEOTECHNICAL INVESTIGATION

Soil Classification: The system of classifying soil for engineering purposes, generally the Unified Soil Classification System. Laboratory tests required to confirm field soil classifications are grain-size distribution and Atterberg limits following ASTM test procedures.

Engineering Properties: The physical and chemical properties of soil materials that determine their engineering behavior. These properties, determined mostly by laboratory testing, are required for foundation and settlement analysis, slope stability, and the design and placement of structural fill. Engineering properties include: shear strength/internal angle of friction/unit cohesion, consolidation characteristics, shrink/swell characteristics, freeze/thaw characteristics, plasticity index/Atterberg limits, grain-size distribution, moisture-density/minimum dry density, in-situ weight/density, porosity, void ratio, moisture content, degree of saturation, specific gravity, permeability, relative hydraulic conductivity, liquefaction potential, soil pH, oxidation-reduction potential, clay mineralogy, dispersivity, deformation/Young's modulus, penetration resistance, soil resistivity, soil organics, and limit pressure. Other engineering properties may be appropriate depending on the soil conditions encountered at each site.

Engineering Units: An engineering unit consists of those geologic sections that share similar geotechnical characteristics or engineering properties. For example, a loess and underlying lacustrine silt may have similar moisture contents and strengths and could be incorporated into one engineering unit on the basis of their engineering behavior. Alternatively, a glacial till unit may contain a permeable sand and gravel layer that might be considered a separate engineering unit because of its engineering properties.

Ground-water Conditions: The location and range of seasonal fluctuations of the ground-water table and the design water level within the disposal site and borrow areas.

Engineering Analysis: The process of integrating the engineering units and their respective engineering properties with the site ground-water conditions, potential future geologic events, and conceptual facility design to develop geotechnical recommendations for slope stability, settlement/subsidence, liquefaction potential, freeze/thaw potential, active and passive earth pressures, bearing capacity, long- and short-term control of surface water, and fill-placement procedures. Other analyses may be appropriate depending on the soil conditions encountered at each site. The recommendations should also contain the following: detailed discussions of field and laboratory sample preparation and test procedures, interpretation of engineering characteristics for onsite and borrow area soils and rock, discussions of how and why specific strength parameters were chosen, factors of safety used, plans showing completed subsurface investigations, cross-sections, and proposed borrow area limits, grades, slopes, and locations of test pits and boreholes.

TABLE A-8
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: GEOGRAPHY

REGULATORY REQUIREMENTS	PARAMETERS					
	Geographic Location	Political Subdivision	Nearby Features	Site Area	Topography	Site Ownership
10 CFR 61 - NRC Licensing Requirements 61.11(c)(1) 61.12(a) 61.50(a)(11)						
10 CFR 51 - NRC Environmental Protection Regulations (Does not specifically address geography)						
NUREG-0902 (Site Suitability, Selection and Characterization) "Site characterization studies should also include...topographic mapping of the site and adjacent drainage areas...Survey control for the site topographic mapping should be coordinated with the survey control requirements for marking the boundaries and locations of each disposal unit. This requirement calls for establishing three permanent survey control points, referenced to USGS or National Geodetic Survey survey control stations, at the disposal site." (p. 16)	+	+	+		X	
NUREG-1199 (SAR Standard Format and Content) "The applicant should describe and display the boundary that encompasses the area owned and controlled by the applicant and indicate the existing and proposed fenced areas and the location and extent of the buffer zone." (Section 1.2, p. 1-1)	X	X	+	X	+	X

TABLE A-8
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: GEOGRAPHY

REGULATORY GUIDANCE	PARAMETERS					
	Geographic Location	Political Subdivision	Nearby Features	Site Area	Topography	Site Ownership
NUREG-1199 (Continued)						
"The applicant should describe the disposal site location by specifying the latitude and longitude as well as the universal transverse mercator (UTM) coordinates....what land is owned, as well as potential expansion areas and the legal status of the expansion areas, the State and county in which the disposal site is located....nearby towns and cities, and...prominent features such as rivers and lakes....Contiguous (USGS topographic) maps should be provided that show the upstream and downstream drainage areas and an approximate 10-km radius around the disposal site. A map also should be provided that shows the detailed topography of the disposal site." (Section 2.1.1, p. 2-1)	X	X	X	+	X	X
"The application should identify the significant facilities or activities near the site..." (Section 2.1.1, p. 2-1)			X			
NUREG-1200 (SAR Standard Review Plan)						
"The [NRC] staff will review the location of the proposed...facility with respect to (1) latitude and longitude as well as the universal transverse mercator (UTM) coordinate system, (2) political subdivisions and nearby cities and towns, and (3) prominent man-made and natural features in the vicinity of the site. The description of the site will be reviewed with respect to (1) area, (2) land ownership and/or status of the site and any potential expansion areas, and (3) detailed topography of the disposal site." (SRP 2.1.1, Sec. 2., p. 2.1.1-1)	X	X	X	X	X	X
"The staff may also need information obtained from U.S. Geological Survey (USGS) topographic maps, aerial photography or remote sensing imagery, and local and regional planning agencies and by visiting the site." (SRP 2.1.1, Sec. 2., p. 2.1.1-1)					+	
"Topographic maps of the site environs in an acceptable scale will be reviewed ...to augment a detailed description of site topography. The staff will review the applicant's data to ensure that sufficient information is contained to support a description of site topographic features such as elevation and relief, slope, and drainage." (SRP 2.1.1, Sec. 3.2, p. 2.1.1-2)			+		X	

TABLE A-8
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: GEOGRAPHY

REGULATORY GUIDANCE	PARAMETERS					
	Geographic Location	Political Subdivision	Nearby Features	Site Area	Topography	Site Ownership
<p>NUREG-1300 (ER Standard Review Plan)</p> <p>"Information needed for the staff's review will usually include the following:</p> <p>(1) site location: State, county, latitude and longitude, and universal transverse Mercator coordinates...</p> <p>(2) area of the site...</p> <p>(3) distance and direction from the nearest major city, nearby towns and readily recognized landmarks...rivers, and other bodies of water...</p> <p>(4) for geographical orientation, simplified maps centered on the site: one general map with a radius of approximately 50 kilometers and a second map with a radius of approximately 10 kilometers...</p> <p>(5) a topographic map of the site and environs." (ESRP 2.1.1, Sec. 2., p. 2.1.1-1 and -2)</p>	X	X				
				X		
	X	+	+	+		
			X			
						X

TABLE A-8

PARAMETER DESCRIPTIONS - GEOGRAPHY

Geographic Location: The location of the site in terms of latitude, longitude, universal transverse mercator (UTM) coordinates, and Public Land Survey designation (i.e., Township, Range and Section).

Political Subdivision: The State, county and/or other pertinent subdivision (e.g., township or municipalities) in which the site is located.

Nearby Features: Features in the vicinity of the site, including cities; readily recognized landmarks; rivers, lakes and other bodies of water; major highways; other prominent man-made and natural features; and significant facilities near the site.

Site Area: The amount of land surface included in the site (including buffer zone), measured in acres (hectares) and square miles (square kilometers).

Topography: The general configuration of the land surface, including its elevation and relief and the position of its natural and man-made features.

Site Ownership: The person or entity entitled to legal possession of the site and adjacent lands.

TABLE A-9
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: DEMOGRAPHY

REGULATORY REQUIREMENTS	PARAMETERS				
	Population Centers	Population Density	Residence Inventory	Transient Population	Projected Population
10 CFR 61 - NRC Licensing Requirements 61.12(a) 61.50(3)					
10 CFR 51 - NRC Environmental Protection Regulations (Does not specifically address demography)					
NUREG-0902 (Site Suitability, Selection and Characterization)					
"...the facility is to be selected so that projected population growth...[is] not likely to affect the ability of the disposal facility to meet the performance objectives." (p. 3)	+	+			X
"Disposal sites should be located in an area which has low population density and limited population growth potential. Disposal sites should be at least two kilometers from the property limits of the closest population centers." (p. 6)	X	X			X
"Site characterization studies should also include an inventory of residences within approximately two kilometers of the site and population centers within a radius of the order 10 kilometers from the site...The inventory should include the distance and direction of the residence or population center from the site...For the population centers, the inventory should also include the number of persons and areal size of the population center." (p. 25)	X	+	X		
ARC Draft Technical Position Paper on Environmental Monitoring (Does not specifically address demography)					
NUREG - 1199 (SAR Standard Format and Content)					
"The applicant should provide information on the natural and demographic characteristics of the site and vicinity. The information should include descriptions of the...present and projected population distribution..." (Section 2., p. 2-1)	X	X			X

TABLE A-9
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: DEMOGRAPHY

REGULATORY GUIDANCE		PARAMETERS				
		Population Centers	Population Density	Residence Inventory	Transient Population	Projected Population
NUREG-1199 (Continued)	"Population data should be based on the most recent U.S. Census data and State and local population projections available...A table...should provide the projected resident and transient populations within each area for (1) the expected first year of facility operation and (2) for census years through the operational lifetime of the facility...The distance to the nearest residence should be noted...The populations of any towns within 50 km of the site that exceed 10,000 persons should also be given." (Section 2.1.2, p. 2-1 and 2-2)	X	+	+	X	X
NUREG-1200 (SAR Standard Review Plan)						
	"The staff will review current and projected population distributions to a radial distance of 10 km from the proposed site, populations of cities and towns within a 10-km radius of the proposed site, distance to nearest resident, location and population of any cities and towns in excess of 10,000 persons within a radius of 50 km, and the location and nature of any significant transient populations within 10 km of the site." (SRP 2.1.2, Sec. 2., p. 2-1.2-1)	X	X	X	X	X
NUREG-1300 (ER Standard Review Plan)						
	"Information needed for the review for each alternative will usually include the following:					
	(1) On a map of suitable scale that identifies places of significant population groupings, such as cities and towns within a 10-kilometer radius, concentric circles should be drawn...A table appropriately keyed to the map should provide the current residential and transient populations within each area for (a) the expected first year of facility operation and (b) for decennial census years through the operational lifetime of the facility...	X	X		X	X
	(2) Distance and direction to nearest residence...			+		
	(3) Location and size of towns with populations greater than 10,000 within a 50-kilometer radius..." (ESRP 3.1.1, Sec. 2., p. 3.1.1-1 and 3.1.1-2)	X				

TABLE A-9
PARAMETER DESCRIPTIONS - DEMOGRAPHY

Population Centers: Population size and boundary locations of population places defined by the U.S. Census Bureau and as modified by State and local government agencies.

Population Density: Number of inhabitants per unit area (i.e., population per square kilometer).

Residence Inventory: Identification of occupied housing units (residences) closest to and within 2km of the site.

Transient Population: Estimates of population increases to the permanent baseline population resulting from transient influxes due to tourism, seasonal labor, or other factors.

Projected Population: Estimates of future resident and transient populations, in terms of both population density and population centers, for time periods coinciding with the expected first year of facility operation and for decennial census years through the operation lifetime of the facility.

TABLE A-10
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: LAND USE

REGULATORY REQUIREMENTS

10 CFR 61 - NRC Licensing Requirements
 61.50(a)(11)
 61.50(a)(13)

10 CFR 51 - NRC Environmental Protection
 Regulations

(Does not specifically address land use)

PARAMETERS

Residential Land Use Industrial Land Use Agricultural Land Use Recreational Land Use Special-Use Areas Zoning Restrictions Local Land-Use Plans Land Ownership Patterns USDA Land Use Classification Utility Land Uses

REGULATORY GUIDANCE

NUREG-0902 - (Site Suitability, Selection, and Characterization)

"Consideration should be given to the potential for future land use activities, such as residential, industrial, agricultural, and recreational development, that could adversely affect the disposal site. The consideration of future land use for the site and surrounding vicinity should include limitations imposed as conditions of land ownership and zoning restrictions." (p. 6)

"The...requirement, related to effects of nearby facilities or activities, is included so that the evaluation...will include not only the impacts of the disposal site on its surroundings, but also the impacts of the surroundings on the disposal site. For example, damming of downstream rivers, blasting associated with quarrying activities, subsidence and/or earth-fissuring caused by groundwater withdrawals, and groundwater rises associated with heavy irrigation may adversely affect the ability of the site to meet the performance objectives. Nearby sources of airborne radionuclides, drift from cooling towers at nearby electrical generating stations or other industries, adjacent hazardous waste disposal facilities, and injection of water and/or liquid wastes upgradient from the disposal site may adversely affect the ability to monitor the performance..." (p. 9)

TABLE A-10
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: LAND USE

PARAMETERS

REGULATORY GUIDANCE	Land									
	Residential Land Use	Industrial Land Use	Agricultural Land Use	Recreational Land Use	Special-Use Areas	Zoning Restrictions	Local Land-Use Plans	Land Ownership Patterns	USDA Land Use Classification	Utility Land Uses
NUEG-0902 (Continued)										
"The [land use] survey should include land use patterns within a radius of approximately 10 kilometers from the site. Land uses should be classified as agricultural, residential, industrial, woodland, commercial, institutional, transportation, special management areas (parks, scenic areas, military reservations, etc.) or other use categories...review and describe zoning categories of the site and the 10 kilometer radius of the study area. Trends in land use in the site vicinity should also be identified." (p. 25)	X	X	X	X	X	X	X	+	+	+

NRC Draft Technical Position Paper on Environmental Monitoring

(Does not specifically address land use)

NUEG-1199 (SAR Standard Format and Content)

"The applicant should provide a land-use survey based on local land-use plans, aerial photography, topographic maps, or other sources. The survey should include land-use patterns within approximately 10 km of the site. Trends in land use in the vicinity should be identified." (Section 1.2, p. 1-1)

"The applicant should identify and describe the utility supplies and systems,...including the location and purpose of...utility lines, if appropriate." (Section 1.2, p. 1-2)

"The applicant should identify the significant facilities or activities near the site and provide a justification for siting near these features." (Section 2.1.1, p. 2-1)

TABLE A-10
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: LAND USE

PARAMETERS

REGULATORY GUIDANCE	Land									
	Residential Land Use	Industrial Land Use	Agricultural Land Use	Recreational Land Use	Special-Use Areas	Zoning Restrictions	Local Land-Use Plans	Ownership Patterns	USDA Land Use Classification	Utility Land Uses
<p>NUREG-1199 (Continued)</p> <p>"The applicant should describe the effect (if any) on the disposal facility of the current and projected...land use." (Section 2.1.2, p. 2-2)</p>	X	X	X	X	X	X	X			X
<p>NUREG-1200 (SAR Standard Review Plan)</p> <p>"The staff will review the location of the...facility with respect to...land ownership and/or status of the site and any potential expansion areas..." (SRP 2.1.1, Sec. 2., p. 2.1.1-1)</p>								X		
<p>NUREG-1300 (ER Standard Review Plan)</p> <p>"The scope of the review will consist of the establishment of current land uses at the alternative sites and in their vicinity and project future land uses that might be affected or modified as a result of the construction, operation, and closure of a low-level radioactive waste disposal facility." (ESRP 3.1.2, Sec. 2., p. 3.1.2-1)</p> <p>"Information needed for the review will usually include the following:</p> <p>(1) Maps showing land use for the various alternatives and within a 10-kilometer radius of each alternative...Land-use categories should...show both general categories of use, patterns of ownership, and special-use areas such as national parks, military reservations, Indian reservations, or wilderness areas..."</p>	+	+	+	+	+	+	+	+	+	+
					X			X		

TABLE A-10
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: LAND USE

PARAMETERS

REGULATORY GUIDANCE	PARAMETERS									
	Residential Land Use	Industrial Land Use	Agricultural Land Use	Recreational Land Use	Special-Use Areas	Zoning Restrictions	Local Land-Use Plans	Land Ownership Patterns	USDA Land Use Classification	Utility Land Uses
NUREG-1350 (Continued)										
(2) Land areas devoted to major uses within the confines of the alternatives as well as within a 10-kilometer radius of each...	+	+	+		+				+	+
(4) Other-than-major land uses (e.g., recreation) for each alternative that could be significantly affected by the proposed action...				X						
(5) Land-use plans that include the alternative sites within their scope... (ESRP 3.1.2, Sec. 2., p. 3.1.2-1 and 3.1.2-2)						X				
"The staff will identify the present land use at each alternative (including the 10-kilometer radius)... The staff will also identify total area by land-use category." (ESRP 3.1.2, Sec. 2., p. 3.1.2-2)	+	+	+	+	+				+	+
"Among the characteristics to be considered in the review will be the following:										
(2) natural gas and electrical transmission and other utility lines										X
(3) recreational areas located at each alternative or in its vicinity				X						

TABLE A-10
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: LAND USE

PARAMETERS

REGULATORY GUIDANCE	Land									
	Residential Land Use	Industrial Land Use	Agricultural Land Use	Recreational Land Use	Special-Use Areas	Zoning Restrictions	Local Land-Use Plans	Ownership Patterns	USDA Land Use Classification	Utility Land Uses
NUREG-1300 (Continued)										
(5) residential areas,....and industrial or commercial facilities in the vicinity of each alternative	X	X								
(6) agricultural and forested areas on or in the vicinity of each alternative			X		X				+	
(7) land-use plans that include each alternative within their scope" (ESRP 3.1.2, Sec. 3., p. 3.1.2-2)							X			
"Information needed for the review will usually include the following:										
(1) maps showing land-use categories....for the various alternatives and within a 10-kilometer radius of each alternative....	+	+	+	+	+					+
(2) land areas devoted to major uses within the confines of the alternatives as well as within a 10-kilometer radius of each alternative....	+	+	+	+	+				+	+
(3) ...utilities of each alternative and in its vicinity...										X
(4) special land uses, such as recreation, for each alternative and its vicinity...				X	X					

TABLE A-10
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: LAND USE

PARAMETERS

REGULATORY GUIDANCE	PARAMETERS									
	Residential Land Use	Industrial Land Use	Agricultural Land Use	Recreational Land Use	Special-Use Areas	Zoning Restrictions	Local Land-Use Plans	Land Ownership Patterns	USDA Land Use Classification	Utility Land Uses
NURE-1300 (Continued)										
(5) local and regional land-use plans that include the alternatives within their scope...							X			
(6) proposed land restoration and management actions...and establishment of recreational areas... (ESRP 4.1, Sec. 2., p. 4.1-2)				X	+		+			
"Restrictions on the use of farmland, industrial areas, residential areas, and other areas will be reviewed." (ESRP 4.1, Sec. 3., p. 4.1-3)	X	X	X	X	+	X			+	
"The U.S. Department of Agriculture has developed two indices of land quality that may be used as guidance:			X		X					X
(1) Land Capability Classification: This classification places land in one of eight categories as defined in each State's "Conservation Needs Inventory" document...										
(2) "Prime" or "Unique" Classification: "Prime" land...is the most productive..."Unique" land...is suited to the production of a special crop that is not widely grown elsewhere..." (ESRP 4.1, Sec. 3., p. 4.1-3)										

TABLE A-10
PARAMETER DESCRIPTIONS - LAND USE

Residential Land Use: Current and projected uses of land on which the site is located and within 10km as housing, classified according to residential density and housing type.

Industrial Land Use: Current and projected uses of land on which the site is located and within 10km for manufacturing, processing, or other industrial purposes.

Agricultural Land Use: Current and projected uses of land on which the site is located and within 10km for crop production or domestic animal husbandry.

Recreational Land Use: Current and projected uses of land on which the site is located and within 10km for public recreational purposes, e.g., parks, trails, water courses, etc.

Special-Use Areas: Current and projected uses of land on which the site is located and within 10km for designated special-status uses such as national parks, military reservations, Indian reservations, and wilderness areas.

Zoning Restrictions: Local restrictions on land use promulgated by county, city, town, township, or other local jurisdictional planning entities, which designate land for specified uses or constrain certain types of uses.

Local Land-Use Plans: Existing plans prepared by local planning entities that codify land use status, constraints, and projected trends in land usage.

Land Ownership Patterns: Type of land ownership (e.g., public versus private) and specific entities that own the land on which the site is located and within 10km.

USDA Land Use Classification: Land parcels classified by the U.S. Department of Agriculture as being in one of eight categories of land capacity, or as being classified as prime or unique land on the site and within 10km.

Utility Land Use: Utility facilities, pipelines, transmission systems, and other utility uses of land on which the site is located and within 10km.

TABLE A-11
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: METEOROLOGY

REGULATORY REQUIREMENTS

10 CFR 61 - NRC Licensing Requirements
 61.12(a) and (d)
 61.53.a)

10 CFR 51 - NRC Environmental Protection
 Regulations

(Does not specifically address meteorology)

REGULATORY GUIDANCE	PARAMETERS									
	Wind Speed/ Direction	Atmospheric Pressure	Precipitation	Pan Evaporation	Humidity/ Dew-point/ Wet-Bulb	Air/Soil Temperatures	Frost Penetration	Snow Cover	Solar Radiation	Severe Weather
NUREG-0902 (Site Suitability, Selectic and Characterization)	X		X							X
"Regional meteorological data from recording stations near the proposed site will typically be analyzed...for extreme meteorological events such as hurricanes, tornados, and thunderstorms. The analyses should include the frequency and probability of occurrence, return intervals, predominant direction, and measured extremes for wind speed and precipitation." (p.14)	X	X	X		X	X	X	X		
"...site-specific meteorological data should ...include measurements of the amount, type, and temporal distribution of precipitation; dates and depth of frost penetration; and dates and thickness of snow cover. The site characterization program should also include continuous recordings of air and soil temperature, wind speed, wind direction, surface humidity, dew point, and atmospheric pressure. Air and soil temperatures are typically needed at several levels up to 1 meter above or below the ground surface, respectively...Atmospheric stability is typically estimated from wind speed and wind direction fluctuations at about 2 and 10 meters..." (p. 15)	X	X	X		X	X	X	X		

TABLE A-11
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: METEOROLOGY

REGULATORY GUIDANCE	PARAMETERS										
	Wind Speed/ Direction	Atmospheric Pressure	Precipitation	Pan Evaporation	Humidity/ Dew-point/ Wet-Bulb	Air/Soil Temperatures	Frost Penetration	Snow Cover	Solar Radiation	Severe Weather	
NRC Draft Technical Position Paper on Environmental Monitoring											
"Part 61 states the need to establish monitoring programs to obtain baseline information on...meteorology (and) climate..." (p. 7)	+	+	+	+	+	+	+	+	+	+	
"Along with surface temperature records, measurements of additional meteorological parameters are needed to determine the water budget...[including] the amount, rate, and type of precipitation...[and] the fraction of precipitation in the form of snow and rainfall...Depth of frost penetration...should...be monitored as well." (p. 21 and 22)			X			X	X	X			
"Pan evaporation can be measured at the site... Additional supporting data for quantifying evaporative processes may be derived from measurements of temperature within the soil, solar radiation (insolation), soil moisture, matric potential*, wind speed and relative humidity or dewpoint." (p. 22)	X			X	X			X	X		
"Quantitative estimates of gas venting rates may be made from a knowledge of the atmospheric pressure and air pressure gradient across the soil surface." (p. 22)		X									

* Addressed by parameters for ground water (Table A-2)

TABLE A-11
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: METEOROLOGY

REGULATORY GUIDANCE	PARAMETERS									
	Wind Speed/ Direction	Atmospheric Pressure	Precipitation	Pan Evaporation	Humidity/ Dew-point/ Wet-Bulb	Air/Soil Temperatures	Frost Penetration	Snow Cover	Solar Radiation	Severe Weather
NUREG-1199 (SAR Standard Format and Content)										
"The applicant should provide a general description, including regional averages and extremes of...air masses, high- and low-pressure patterns, temperature, humidity, and various forms of precipitation...The applicant should correlate...between regional atmospheric conditions and local meteorological conditions. The applicant should also provide the seasonal and annual frequencies of regional severe weather phenomena such as tornadoes, convective storms, hail, and waterspouts." (Section 2.2, p. 2-2)	X	X	X		X	X		X		X
"...local meteorological parameters...should include those used as a design basis and those used for performance assessment, including:										
(1) maximum snow, ice, and wind loads to which structures may be subjected	X						+	X		
(2) weather- and climate-related radionuclide transmission parameters including average and extreme duration and intensity of precipitation events	X		X							
(3) routine, chronic weather-related site deterioration parameters	+		+				+	+		
(4) extreme site deterioration parameters such as tornadoes, waterspouts, thunderstorms, and extreme forms of air pollution*." (Section 2.2, p. 2-2)										X

* Addressed by parameters for air quality (Table A-12)

TABLE A-11
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: METEOROLOGY

REGULATORY GUIDANCE	PARAMETERS									
	Wind Speed/ Direction	Atmospheric Pressure	Precipitation	Pan Evaporation	Humidity/ Dew-point/ Wet-Bulb	Air/Soil Temperatures	Frost Penetration	Snow Cover	Solar Radiation	Severe Weather
NUREG-1199 (Continued)										
"The applicant should also provide a general characterization of the local meteorology considering air flow vectors, temperature, precipitation, water vapor, atmospheric stability, evapotranspiration potential, and general air quality...based on at least 12 continuous months of site-specific data." (Section 2.2, p. 2-2)	X	X	X	X	X	X				
NUREG-1200 (SAR Standard Review Plan)										
"The INRC staff will review the averages and extremes of climatic conditions and regional meteorological phenomena..." (SRP 2.2, Sec. 2., p. 2.2-1)	+	+	+		+	+	+	+		+
<u>Regional Data</u>										
(1) "...the general climate of the region with respect to types of air masses, synoptic features (high- and low-pressure systems and frontal systems), general air-flow patterns (wind direction and speed), temperature and humidity, precipitation, and relationships between synoptic-scale atmospheric processes and local meteorological conditions.	X	X	X		X	X				
(2) seasonal and annual frequencies of severe weather phenomena including tornadoes, water spouts, thunderstorms, lightning, hail, and high air pollution potential." (SRP 2.2, Sec. 2.1, p. 2.2-1)										X

* Addressed by parameters for air quality (Table A-12)

TABLE A-11
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: METEOROLOGY

REGULATORY GUIDANCE	Wind Speed/ Direction	Atmospheric Pressure	Precipitation	Pan Evaporation	PARAMETERS					
					Humidity/ Dew-point/ Wet-Bulb	Air/Soil Temperatures	Frost Penetration	Snow Cover	Solar Radiation	Severe Weather
NUREG - 1200 (Continued)										
<u>Local Data</u>										
(1) meteorological conditions used as design operating and performance assessment bases including										
(a) the maximum snow and ice load									X	
(b) weather-related radionuclide transmission parameters including average and extreme wind vectors and average and extreme duration and intensity of precipitation events	X		X							+
(c) routine weather-related site deterioration parameters including precipitation intensity and duration, wind vectors, and temperature and pressure gradients	X	X	X					X		
(d) extreme weather-related site deterioration parameters including tornadoes, water spouts, thunderstorms, hail, and extreme air pollution (from offsite sources)*										X
(2) ...local (site) meteorology in terms of air flow, temperature, atmospheric water vapor, precipitation, fog, atmospheric stability, and air quality*	X	X	X			X				
(3) an assessment of the influence of the facility on the local meteorological parameters...including the effects of facility construction and operation, and terrain modification..." (SRP 2.2, Sec. 2.2, p. 2.2-1 and 2.2-2)										

* Addressed by parameters for air quality (Table A-12)

TABLE A-11
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: METEOROLOGY

REGULATORY GUIDANCE	PARAMETERS									
	Wind Speed/ Direction	Atmospheric Pressure	Precipitation	Pan Evaporation	Humidity/ Dew-point/ Wet-Bulb	Air/Soil Temperatures	Frost Penetration	Snow Cover	Solar Radiation	Severe Weather

NUREG-1300 (ER Standard Review Plan)

"The following categories of site-specific meteorological information (averaged for a collection period of not less than 1 year) are necessary to perform the [NRC] staff's review:

Meteorological parameters (such as joint-frequency distributions of wind speed/direction) as necessary to characterize the alternative sites...." (ESRP 3.2.1., Sec. 2., p. 3.2.1-2)

x

TABLE A-11
PARAMETER DESCRIPTIONS - METEOROLOGY

Wind Speed/Direction: The rate of air flow and its trajectory, measured continuously at various heights above ground level as hourly means (scalar speed and resultant vector speed and direction) and peak instantaneous gust speeds; hourly data calculated to long-term (monthly, seasonal, annual) summaries by joint frequency distributions using six speed categories and sixteen direction categories, average scalar speeds, and maximum gust speeds.

Atmospheric Pressure: Force per unit area exerted by overlying air mass at the earth's surface, typically as hourly values; calculated to monthly and annual averages.

Precipitation: Water particles that fall from the air and reach the ground including liquid (rain, drizzle) and frozen (snow, hail) water; measured as hourly or daily totals, and calculated to monthly and annual totals, both as water equivalent and depth of snow; also calculated to extreme values of precipitation rates and totals by various time periods.

Pan Evaporation: Amount of water evaporated daily from a standard pan, calculated to monthly and seasonal totals. Used as an indication of evaporation from free water surfaces (such as lakes, ponds) and with soil and vegetation information to estimate evapotranspiration.

Humidity/Dew-Point/Wet-Bulb: Measures of atmospheric water vapor; humidity is the water vapor fraction of saturation conditions; dew-point temperature is the air temperature at which ambient water vapor will condense on a surface; simply, wet-bulb temperature is the temperature measured as hourly average values and calculated to monthly, seasonal and annual averages, often for specific hours of the day.

Air/Soil Temperatures: Measurements of ambient air temperature at various heights above ground level, usually 2 meters and others as required; used in water and energy balance, and air quality dispersion analyses; measured as hourly values or daily maximum/minimum and average values by month, and annual average temperatures. Measurements of soil temperature made at selected depths within the soil, used in water and energy budget analyses.

Frost Penetration: Depth within the soil to which water is frozen, measured as depths by month or season.

Snow Cover: Snow depth in undisturbed areas, measured daily or less often; measured as occurrence of depths at least one inch, snow depth (both incremental storm events and cumulative depths), and water equivalent (obtained by weighing or melting a snow core); calculated to monthly or seasonal averages.

Solar Radiation: Total incoming solar radiation, typically measured at 2 meters above ground as hourly and daily total incoming energy, calculated to monthly totals: also can be used with terrestrial long-wave radiation to compute net radiation, measured as hourly average amounts; used in energy and water budget analyses.

Severe Weather: Occurrences of significant weather events such as tornadoes, hurricanes, thunderstorms, hail, blizzards, etc. Magnitude of events can be treated along with individual parameter, such as extreme temperature and precipitation events.

TABLE A-1
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: AIR QUALITY

REGULATORY REQUIREMENTS

10 CFR 61 - NRC Licensing Requirements
 61.50(a)(11)
 61.53(a)

10 CFR 51 - NRC Environmental Protection
 Regulations

(Does not specifically address air quality)

PARAMETERS

REGULATORY GUIDANCE

NUREG-0902 (Site Suitability, Selection and Characterization)

"Air quality parameters measured in the site characterization program should define the level of...suspended particulates...The measurement of air quality parameters should provide at least one-year record of site-specific information." (p. 24)

NRC Draft Technical Position Paper on Environmental Monitoring

"The staff recommends that ambient air quality levels be established early-on during the period of site characterization. Air quality parameters include carbon monoxide, oxides of nitrogen, sulfur dioxide, hydrocarbons, photochemical oxidants, and suspended particulates." (Section 3.2.1, p. 22)

NUREG-1193 (SAR Standard Format and Content)

"...local meteorological parameters should include...extreme site deterioration parameters such as...extreme forms of air pollution..." (Section 2.2, p. 2-2)

"The applicant should also provide a general characterization of...general air quality..." (Section 2.2, p. 2-2)

TABLE A-12
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: AIR QUALITY

REGULATORY GUIDANCE	PARAMETERS					
	Pollutant Type	Pollutant Concentrations	Regional Classification	Air Quality Control Region	Air Quality Ceiling	
NUREG-1200 (SAR Standard Review Plan)						
Regional Data						
(2) Seasonal and annual frequencies of...high air pollution potential." (SRP 2.2, Sec. 2.1, p. 2.2-1)	X	X				
Local Data						
(4) Extreme weather-related site deterioration parameters including extreme air pollution (from offsite sources)" (SRP 2.2, Sec. 2.2, p. 2.2-2)	X	X				
"A discussion and evaluation of the influence of the facility on local meteorological and air quality conditions, if any, should be provided." (SRP 2.2, Sec. 4.3, p. 2.2-4)			+	+		+
NUREG-1300 (ER Standard Review Plan)						
Information needed for the staff's review will usually include the following:						
(2) Identification of nonradiological airborne pollutants generated by processes such as onsite evaporation or incineration processes, contaminants dispersed to the disposal site as a result of nearby industrial and/or manufacturing processes, and those resulting from agricultural applications (such as spray application of fertilizers or pesticides).	X					
(3) Annual average concentration values for naturally-occurring nonradiological pollutants that the applicant expects may be associated with the proposed action...		X				
(4) Identification of the air quality control region, the air quality classification for the region, ambient air concentrations in the region, and air quality ceilings for regulated pollutants in the region." (ESRP 3.2.2, Sec. 2., p. 3.2.2-1 and 3.2.2-2)			X	X		X

TABLE A-12
PARAMETER DESCRIPTIONS-AIR QUALITY

Pollutant Type: The classification of non-radiological, airborne, pollutants likely to be found at a proposed site as existing background or expected to be present during site development, operation, or closure; includes EPA criteria pollutants (40 CFR 50); sulfur dioxide, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead. Also includes hydrocarbons that may cause health impacts.

Pollutant Concentrations: Measured or estimated amount of the pollutant types, based on averaging times corresponding to the ambient air quality standards.

Regional Classification: The designation given to the air quality control region through regulation or agency evaluation to denote attainment (i.e., compliance with the National Ambient Air Quality Standards) or non-attainment for each air pollutant. Special restrictions and control requirements for air pollution exist in the non-attainment areas.

Air Quality Control Region: The region of the country, as designated by U.S. EPA for control and management of air pollutants, within which the site is located.

Air Quality Ceilings: Upper limits on concentrations of non-radiologic air pollutants, as set forth in 40 CFR 50 (National Primary and Secondary Ambient Air Quality Standards) and State regulations.

TABLE A-13
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: RADIOLOGICAL ASSESSMENT

REGULATORY REQUIREMENTS	REGULATORY GUIDANCE	PARAMETERS						
		Direct Gamma Radiation	Airborne Radionuclides	Soil	Surface water	Ground water	Sediments	Flora Fauna Food
10 CFR 61 - NRC Licensing Requirements 61.12(e) and (f) 61.50(a)(11) 61.53(e)								
10 CFR 51 - NRC Environmental Protection Regulations (Does not specifically address radiological assessment)								
	NUREG-0902 (Site Suitability, Selection, and Characterization) "Nearby sources of airborne radionuclides...may adversely effect the ability to monitor the performance of the disposal site." (p. 9) "Air quality parameters...should define the level of airborne radionuclides contributed by atmospheric fallout, natural radiation released from the soil, and agricultural activities such as spray application of fertilizers or insecticides." (p. 24)	+	x					
		x	x	x				
	NRC Draft Technical Position Paper on Environmental Monitoring "In order to establish an adequate data base for pre-existing background concentrations of radioactive... constituents..., a pre-operational monitoring program should begin early in the site characterization process. The program should have at least one-year duration..." (Section 2.2.1, p. 8)	+	+	+	+	+	+	+

TABLE A-13
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: RADIOLOGICAL ASSESSMENT

REGULATORY GUIDANCE	Direct Gamma Radiation	Airborne Radionuclides	Soil	Surface Water	Ground Water	Sediments	Flora	Fauna	Food
NRC Technical Position Paper (Continued)	X								
"...Continuous measurements of direct gamma radiation should be made at locations selected for air sampling and at various other locations at the site and in the site environs." (Section 3.1, p. 16)									
"A program for determining background concentrations of radioactive contaminants should be initiated during the pre-operational phase...At a minimum, media should be analyzed for gross alpha, gross beta less K-40...and tritium in water and vegetation. Gamma-ray spectrometry should be performed to characterize the principal gamma-emitting radionuclides present." (Section 3.2, p. 17)		+	+	X	X	+	X	+	+
"The staff considers that radiological...constituents should be monitored in ground water, soil, surface water, sediments, air and flora and fauna..." (Section 3.2.1, p. 18)		X	X	X	X	X	X	X	X
"Monitoring of groundwater should include...sampling for radiological...constituents to correlate contaminant migration with the ground-water flow system. Routine samples should include radiological...Indicators such as tritium, gross alpha, gross beta...and [be] collected and analyzed on a quarterly basis." (Section 3.2.1, p. 18 and 19)					X				
"Pre-operational soil monitoring...samples should be taken from surficial soils as well as at depths which reflect the site's stratigraphy...Background levels of significant constituents, including those that would indicate external or pre-existing contamination, should be determined. Naturally occurring radioactivity should be analyzed..." (Section 3.2.1, p. 19)				X					

TABLE A-13
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: RADIOLOGICAL ASSESSMENT

REGULATORY GUIDANCE	PARAMETERS							
	Direct Gamma Radiation	Airborne Radionuclides	Soil	Surface Water	Ground Water	Sediments	Flora	Fauna

NRC Technical Position Paper (Continued)

"...surface water sampling locations should be selected upgradient adjacent and downgradient of the site in all subwatersheds to which the site may contribute. Nearby impoundments and surface water drinking sources should be included in the sampling program....Efforts should be made to sample ephemeral water courses during runoff periods...Samples should be analyzed for the same radiological constituents that are included in ground-water sample analyses." (Section 3.2.1, p. 20)

"...sediment samples from representative cross sections of nearby surface water courses should be taken and analyzed for the same radioactive constituents as soil samples." (Section 3.2.1, p. 21)

"...at least one continuous air sampler should be employed downwind of the site in the most prevalent wind direction...At least one background continuous air sampler should be located a suitable distance up-gradient of the most prevalent wind direction in an area which will remain undisturbed by site operations and which is not affected by other sources...Air filters should be analyzed for gross alpha, gross beta, and other indicators. A composite gamma scan should be performed at least quarterly." (Section 3.2.1, p. 23)

"...radiological monitoring of flora and fauna at or near the site should be a component of the monitoring program..." (Section 3.2.1, p. 23 and 24)

"...representative samples of local crops, livestock, dairy products and game species should be taken and analyzed quarterly. Analyses should include gamma scans of edible portions. When small mammals are sampled, the entire specimen should be included in the analysis. The monitoring program for flora should never involve the harvesting of rare, endangered or locally important species. Sampling of game animals should occur during the hunting season for each species." (Section 3.2.1, p. 25)

TABLE A-13
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: RADIOLOGICAL ASSESSMENT

REGULATORY GUIDANCE	PARAMETERS								
	Direct Gamma Radiation	Airborne Radionuclides	Soil	Surface Water	Ground Water	Sediments	Flora	Fauna	Food
NRC Technical Position Paper (Continued)									
"...vegetation...sampling should include all major species of vegetation characteristic of the site...Routine analysis should be made for gross alpha, gross beta and tritium (and) at least 2-3 samples at each location should be given gamma isotopic analysis." (Section 3.2.1, p. 25)							X		
NUREG-1199 (SAR Standard Format and Content)									
"The applicant should provide information on the background ...water chemistry for groundwater and surface water systems that may be affected by site construction and waste disposal ...Data and descriptions of the following parameters should be included: (1)...background radionuclides." (Section 2.6, p. 2-12)				X	X				
"[The] environmental monitoring and surveillance plan should consider both onsite and offsite measurements in air, water, soil, vegetation, local fauna, and local sources of food." (Section 2.9, p. 2-17)	+	X	X	X	X		X	X	X
NUREG-1200 (SAR Standard Review Plan)									
"The [NRC] staff will verify that the SAR contains the following information:...the identification of the monitored components (e.g., air, water, soil, and biota) of the program, including the description of the basis for the locations of the radiological...monitoring stations; the onsite and offsite environmental sampling program, and the rationale for the overall design of the sampling program..." (SRP 2.9, Sec. 2.3, p. 2.9-2)	+	X	X	X	X		X	X	X

TABLE A-13
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: RADIOLOGICAL ASSESSMENT

REGULATORY GUIDANCE	Direct Gamma Radiation	Airborne Radionuclides	Soil	Surface Water	PARAMETERS				
					Ground Water	Sediments	Flora	Fauna	Food
NUREG-1300 (ER Standard Review Plan)	+	X	X	X	X	X	X		X
"The scope of the [NRC] review will consist of an evaluation of the concentrations of radionuclides in the vicinity of the site for...air, surface water, groundwater, soil, vegetation, sediments, and possible sources of human food in the immediate area of the disposal site. Radiation fields produced by natural sources will also be evaluated." (ESRP 3.3, Sec. 2., p. 3.3-1 and 3.3-2)									
"The baseline data required from the applicant are long-term annual time-averaged values...Concentration values reported should be those obtained from isotopic analysis of samples using gamma spectroscopy. Water samples and potential food sources should also be analyzed for gross alpha and gross beta activity." (ESRP 3.3, Sec. 2., p. 3.3-2)				X	X				X

TABLE A-13
PARAMETER DESCRIPTIONS - RADIOLOGICAL ASSESSMENT

Direct Gamma Radiation: A measure of the ionization produced in air by x or gamma radiation. The special unit of exposure is the roentgen.

Airborne Radionuclides: The sampling of a known volume of air with subsequent identification of radionuclide and activity concentration (in picocuries per liter). These analyses will be for both naturally occurring and man-made radionuclides.

Soil: Identification of the radioactivity in soil. This includes direct or in vivo measurements of gamma-rays emitted from radionuclides in the surface soils (e.g., radium bearing soils) or by the collection of surface or subsurface samples with subsequent gamma-ray spectroscopy or radiochemical separation with alpha or beta counting techniques.

Surface Water: The sampling of flowing streams, ponds, lakes, and rivers with the subsequent analysis of radionuclide type and activity concentration in picocuries per liter recognizing the distinction between soluble species and suspended matter.

Ground Water: The sampling and subsequent analysis of groundwater to identify radionuclides and measure the activity concentration in picocuries per liter (pc/l), recognizing the distinction between soluble species and suspended matter.

Sediments: Sampling of loose, unconsolidated sediments (sand, gravel, silt, mud, etc.) including the suspended fraction with the subsequent identification of radionuclide and activity concentration in picocuries per gram of solid fraction.

Flora: Radionuclides in abiotic compartments can enter plants by uptake from soil, deposition from air, or sorption from water in the case of aquatic plants. Uptake implies internal incorporation within tissues of the plant. Frequently radioactive materials in soil adhere to the root or shoot surface of plants but are not actually incorporated into plant tissues. Radionuclides in air or water can be deposited on or otherwise attached to plant surfaces directly without passage through soil. Analyses should be made to identify the radionuclide and determine the activity concentration in picocuries per gram.

Fauna: Passage of radioactive material to terrestrial and aquatic species occurs primarily by ingestion and inhalation. Each step of the food chain provides some form of discrimination in that radionuclides are channeled physiologically into certain tissues, depending on their physical/chemical properties. Analyses of fauna can be organ specific (e.g., I-131 in the thyroid) depending on the radionuclide of concern, or whole body specific (e.g., Cs-137). Analyses should be made to identify the radionuclide and determine the activity concentration in picocuries per gram.

Food: Measurement of radioactivity in crops, livestock, dairy products and game animals consumed by humans including radionuclide and concentration.

TABLE A-14
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: ECOLOGY

REGULATORY GUIDANCE	PARAMETERS									
	Terrestrial Species (Fauna)	Terrestrial Species (Flora)	Aquatic Species	Live- Stock	Food Chain	Migratory Species	Game Animals	Habitat	Threatened/ Endangered Species	Disease Vector/ Pests
NRC Draft Technical Position Paper on Environmental Monitoring										
"Part 61 states the need to establish monitoring programs to obtain baseline information on...ecology." (Section 3.2.1, p. 7-8)	+	+	+					+		
"...flora and fauna at or near the site should be a component of the monitoring program...it is important that the monitoring program include analysis of abundance and characteristics of local species." (Section 3.2.1, p. 24)	X	X	X	X	+	X	+	+		X
"A pre-operational survey should...provide an inventory of the major flora and fauna of a site and identify any important species. A species is important...if:	X	X	X	X	X	X	X	X	X	X
a. The species is commercially or recreationally valuable,										
b. The species is threatened or endangered,										
c. The species affects the well-being of some species in a or b,										
d. The species is critical to the structure and functioning of the ecological system, or										
e. The species is a biological indicator of radiological and nonradiological constituents in the environment." (Section 3.2.1., p. 24 and 25)										
"...representative samples of local crops, livestock, dairy products, and game species should be taken..." (Section 3.2.1, p. 25)		X		X	+		X			
"...vegetation should be collected...Sampling should include all major species of vegetation characteristic of the site..." (Section 3.2.1, p. 25)		X								
"The initial faunal inventory should establish the identity of the major terrestrial and aquatic organisms on or near the site and their relative (qualitative) abundances. From this list, the "important" species should be identified and their quantitative abundances ascertained. The inventory should include species that migrate through the area. Any outstanding or unusual ecological characteristics of the site should also be noted such as habitats or nests of endangered species. The survey should consider the locations and numbers of domesticated animals, especially dairy cows and goats." (Section 3.2.1, p. 26)	X		X	X		X	X	X	X	

PARAMETERS

A-14-3

TABLE A-14
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: ECOLOGY

REGULATORY GUIDANCE	PARAMETERS									
	Terrestrial Species (Fauna)	Terrestrial Species (Flora)	Aquatic Species	Live- Stock	Food Chain	Migratory Species	Game Animals	Habitat	Threatened/ Endangered Species	Disease Vector/ Pests
NUREG-1199 (Continued)										
<u>Offsite Areas</u>										
(1) Major vegetation types hydraulically or ecologically downgradient...		X						+		
(2) List of commercially or recreationally important vertebrate animals known to occur ecologically and hydraulically downgradient of the facility to a distance of 5 km.	X		X	X		X	X			
(3) List of other vertebrate species important to facility performance known to occur within 25 km or migratory distance, whichever is less, from the facility.	X		X			X	X		X	
(4) List of invertebrate species of local importance or concern as disease vectors or pests. Detailed field surveys of insect populations are not needed." (Section 2.8, p. 2-17)	X		X							X
NUREG-1203 (SAR Standard Review Plan)										
"The [NRC] review will focus on terrestrial and aquatic species, and the habitats thereof, that may affect facility performance at some point after the commencement of operations or that may represent a direct pathway to man either as part of the food chain or through incidental contact." (SPE 2.8, Sec. 2, p. 2.8-1)	X	X	X	+	X	+	+	X	+	+

TABLE A-14
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: ECOLOGY

REGULATORY GUIDANCE		PARAMETERS									
		Terrestrial Species (Fauna)	Terrestrial Species (Flora)	Aquatic Species	Live- Stock	Food Chain	Migratory Species	Game Animals	Habitat	Threatened/ Endangered Species	Disease Vector/ Pests
NUREG-1200 (Continued)	<u>"Site and vicinity</u>										
	(1) a map of the site and vicinity showing the boundaries of major plant communities, the locations of minor communities, special habitats (e.g., spring seeps, bogs, sink holes, and cliff faces), any habitats used by species that affect facility performance; a map showing habitats used by "important" species in the vicinity of the site that are expected to be affected by facility construction and operation;...	+	X	X	+		+	+	X	+	
	(3) onsite data on the botanical species and the composition and relative abundance of the major vegetation layers (e.g., overstory and understory) in enough detail so that the communities can be identified as to dominant species...		X								
	(4) summary of onsite natural and man-made effects (e.g., farming, fishing, logging, grazing, and burning) and the successional stage (i.e., weed, brush, pole, and mature stages)...	+	X	+	+			+	X		
	(5) lists of vertebrate species important to facility performance known to occur...	X		X	X		X	X		X	
	(6) lists of invertebrate species of local importance or concern as disease vectors or pests;...detailed field surveys of all insect populations are not needed	X		X							X
	(7) estimates of the relative abundance of both commercially and recreationally important game and nongame vertebrates..." (SRP 2.8, Sec. 2.1, p. 2.8-1 and 2.8-2)	X		X	X		X	X		X	
<u>"Offsite areas</u>											
	(1) major vegetation type hydraulically or ecologically downgradient...		X						+		

TABLE A-14
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: ECOLOGY

REGULATORY GUIDANCE	PARAMETERS									
	Terrestrial Species (Fauna)	Terrestrial Species (Flora)	Aquatic Species	Live- Stock	Food Chain	Migratory Species	Game Animals	Habitat	Threatened/ Endangered Species	Disease Vector/ Pests
NUREG-1200 (Continued)										
(2) Lists of commercially or recreationally important vertebrate animals known to occur ecologically and hydraulically downgradient of the facility to a distance of 5 km	X		X	X		X	X			
(3) Lists of other vertebrate species important to facility performance known to occur within 25 km or migratory distance, whichever is less, from the facility.	X		X			X	X		X	
(4) Lists of invertebrate species of local importance or concern as disease vectors or pests;...detailed field surveys of insect populations are not needed." (SRP 2.8, Sec. 2.2, p. 2.8-2)	X		X							X
NUREG-1300 (ER Standard Review Plan)										
*The scope of the [terrestrial ecology] review will consist of the following:										
(1) ...Identification and description of terrestrial species (both wild and domestic), including the composition, spatial distribution, abundance, and other attributes of biotic assemblages that could be affected by the planned action for both the proposed and alternative sites.	X	X		X	+	+	+	+	+	
(2) ...Identification of any important* species, irreplaceable terrestrial natural resources, and the location of wildlife sanctuaries and natural areas that might be affected...	X	X		X		+	X	X	X	

*A species is 'important' if a specific causal link can be identified between the proposed project and the species and if one or more of the following criteria apply: (1) the species is commercially or recreationally valuable, (2) the species is threatened or endangered (Pub. Law 93-205, 87 Stat. 884), (3) the species affects the well-being of some important species specified within criteria (1) or (2), or (4) the species is critical to the structure and function of the ecological system or is a biological indicator of radionuclides in the environment." (ESRP 3.6.1, Sec. 2, p. 3.6.1-2)

TABLE A-14
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: ECOLOGY

PARAMETERS

REGULATORY GUIDANCE	Terrestrial Species (Fauna)	Terrestrial Species (Flora)	Aquatic Species	Live- Stock	Food Chain	Migratory Species	Game Animals	Habitat	Threatened/ Endangered Species	Disease Vector/ Pests

NUREG-1300 (Continued)

- (3) ...compliance with applicable Federal, State, and local ecological quality standards and regulations regarding, for example, endangered species, unique wildlife habitats, national parklands, and critical wildlife breeding areas." (ESRP 3.6.1, Sec. 2, p. 3.6.1-2)

*Information needed for the review will usually include the following:

- (1) Maps...showing the boundaries of major plant communities, the location of minor communities, special habitats (e.g., springs, seeps, bogs, sink holes, cliff faces, and rare or unique habitats) and any habitats used by "important" species...
- (2) ...composition and abundance of floral species...The identification of significant faunal exposure pathways will also be important...
- (3) Discussion of natural and man-induced effects resulting from activities such as farming, logging, grazing and burning. The successional stages (i.e., weed, brush, pole, and mature stages)...should be addressed.
- (4) ...locations of National, State, local, and private wildlife refuges or other land areas dedicated to the preservation, management, or study of wildlife and wildlife habitats.
- (5) List of important terrestrial vertebrate species known to occupy the site and vicinity (5-kilometer radius). The quantitative abundance of each important species should be estimated; determinations should include migratory species and species that only use the area for temporary breeding purposes...

TABLE A-14
REQUIREMENTS FOR SITE CHARACTERIZATION
DATA TYPE: ECOLOGY

REGULATORY GUIDANCE	PARAMETERS									
	Terrestrial Species (Fauna)	Terrestrial Species (Flora)	Aquatic Species	Live- Stock	Food Chain	Migratory Species	Game Animals	Habitat	Threatened/ Endangered Species	Disease Vector/ Pests
NUREG-1200 (Continued)										
(6) Lists of threatened or endangered species that are known to occur, and for any such species, their site-specific habitat. The relationships between threatened or endangered species and the environment should be discussed. This discussion should include a description of the use of the area by important species (i.e., nursery and breeding), their normal seasonal population fluctuations, and their habitat requirements. In addition, information on food chain and interspecies relationships should be provided.	X	X			X			X	X	
(7) ...number and distribution of important domestic fauna, particularly cattle and sheep and other meat animals... important game, dairy, recreational, and work animals should receive similar treatment... (ESRP 3.6.1, Sec. 2., p. 3.6.1-2 and -3)				X	+		X			
"The scope of the [aquatic ecology] review will consist of the following:										
(1) ...Identification and description of aquatic species including the composition, spatial distribution, abundance, and other attributes of biotic assemblages that could be affected...			X							
(2) ...Identification of any important species, irreplaceable aquatic natural resources, and the location of aquatic sanctuaries and natural areas that might be affected...			X			X		X	X	
(3) ...compliance with applicable Federal, State and local ecological quality standards and regulations regarding, for example, endangered species, unique aquatic habitats, and critical aquatic species breeding areas. (ESRP 3.6.2, Sec. 2., p. 3.6.2-2)			X					X	X	

TABLE A-14
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: ECOLOGY

REGULATORY GUIDANCE	PARAMETERS										
	Terrestrial Species (Fauna)	Terrestrial Species (Flora)	Aquatic Species	Live- Stock	Food Chain	Migratory Species	Game Animals	Habitat	Threatened/ Endangered Species	Disease Vector/ Pests	
NUREG-1300 (Continued)											
"...the following information provided by the applicant:											
(1) Maps...showing the locations of major aquatic communities and Important aquatic habitats...			X					X			
(2) ...composition, abundance, and seasonal variability of aquatic species...location of any harvested aquatic species used either for stock or human consumption within a 10-kilometer radius of the site...			X		X		X				
(3) ...relative significance of the various identified aquatic habitats in a regional context...important or irreplaceable aquatic resources such as wetlands, sanctuaries, or preserves...			X					X			
(4) ...temporal and spatial distribution of important fin-fish, shellfish, and other invertebrates, including benthos, and their quantitative abundance, where appropriate. Critical species habitats such as spawning areas, nursing grounds, food habitats, feeding areas, and wintering areas...			X		X	X		X			
(5) ...composition and distribution of any plankton communities... eggs and larvae of important fin and shellfish species. Information on physical, chemical, and biological factors, including nutrient concentrations known to influence species diets, distribution and abundance...			X		X			X			
(6) ...endangered or threatened aquatic species that are known to be present...and delineation of their specific habitat requirements." (ESRP 3.6.2, Sec. 2., p. 3.6.2-3)			X					X	X		

TABLE A-14
PARAMETER DESCRIPTIONS - ECOLOGY

Terrestrial Species (Fauna): Important wild and domestic animal species, including abundance, characteristics, distribution, ecological interrelationships, and breeding grounds.

Terrestrial Species (Flora): Major species of vegetation, including plant communities, species composition, relative abundance, successional stage, and vegetation types.

Aquatic Species: Aquatic species (flora and fauna), including composition, distribution, abundance, importance, seasonal variability, harvest, and nutrient concentrations.

Livestock: Domestic animals such as dairy cows and goats, with food chain significance.

Food Chain: An abstract representation of the passage of energy (or possible contaminants) through populations of terrestrial and aquatic organisms in a community.

Migratory Species: Species that migrate through the site or the vicinity.

Game Animals: Wild animal species (on the site and in the vicinity), which are hunted and potentially consumed.

Habitat: Habitats for important terrestrial or aquatic species, including location and area occupied; wildlife sanctuaries or natural areas; special, rare, unique habitats; and site-specific habitat for any identified threatened or endangered species.

Threatened/Endangered Species: Species existing in the site area or vicinity (or potentially present) that are designated by the U.S. Fish and Wildlife Service or a cognizant State agency as threatened or endangered.

Disease Vectors/Pests: Vertebrate and invertebrate species of local importance or concern as disease vectors or pests that could impact workers or operations on the site.

TABLE A-15
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: SOCIOECONOMICS

REGULATORY REQUIREMENTS	PARAMETERS					
	Labor Force	Housing	Health and Public Safety Systems	Education Systems	Tax Base	Sociocultural Characteristics
10 CFR 61 - NRC Licensing Requirements (Does not specifically address socioeconomic)						
10 CFR 51 - NRC Environmental Protection Regulations 51.45(c)						
REGULATORY GUIDANCE						
NUREG-0902 (Site Suitability, Selection and Characterization)						
"A description of the socioeconomic environment is needed...the applicant may need to survey the study area, usually defined on the basis of political jurisdictions such as counties, to establish data such as population, labor availability, labor skills,...historic commuting patterns, school systems, health system, public safety system, utilities,...tax base, commerce, and housing stock...and the ability of the subject region to accommodate a temporary or permanent influx of workers and their families." (p. 26)	X	X	X	X	X	
"A sociocultural analysis may also be appropriate. In such cases, attitudinal surveys should be performed...sociocultural dimensions to be surveyed may include community cohesion, family stability, local attitudes and lifestyle, and prevailing community problems...the project characteristics should be superimposed on the sociocultural dimensions to identify project-related impacts such as changes in community composition, marital and family status, cultural values, and other quality of life indicators." (p. 26)						X
NRC Draft Technical Paper on Environmental Monitoring (Does not address socioeconomic)						
NUREG-1199 (SAR Standard Format and Content) (Does not address socioeconomic)						

TABLE A-15
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: SOCIOECONOMICS

REGULATORY GUIDANCE	PARAMETERS					
	Labor Force	Housing	Health and Public Safety Systems	Education Systems	Tax Base	Sociocultural Characteristics
<p>NUREG-1200 (SAR Standard Review Plan)</p> <p>(Does not address socioeconomics)</p>						
<p>NUREG-1300 (ER Standard Review Plan)</p> <p>"The information needed for the [labor force and employment] review will usually include the following:</p> <p>(1) Identification of major industries in the region by category, including employment...</p> <p>(2) size and nature of the construction industry and construction labor force within the region...</p> <p>(3) size and nature of the total regional labor force...</p> <p>(4) regional unemployment levels and economic projection...</p> <p>(5) Identification and location of major competitors for the labor force, [i.e., large-scale, multiyear construction projects...]" (ESRP 3.7.1., Sec. 3., p. 3.7.1-2)</p> <p>"The information needed for the review [of infrastructure characteristics] will usually include the following:</p> <p><u>Housing</u></p> <p>(1) location and amount of existing and projected housing</p> <p>(2) characteristics of existing housing: types, age, size, and condition</p> <p>(3) trends in size of housing stock</p> <p>(4) turnover and vacancy rates</p> <p>(5) constraints on development of new housing (if any)" (ESRP 3.7.2, Sec. 2., p. 3.7.2-2)</p>	X					
	X					
	X					
	X					
	X					
	X					
		X				
		X				
		X				
		X				
		X				

TABLE A-15
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: SOCIOECONOMICS

REGULATORY GUIDANCE	PARAMETERS					
	Labor Force	Housing	Health and Public Safety Systems	Education Systems	Tax Base	Sociocultural Characteristics
NUREG-1300 (Continued)						
<u>"Health and Public Safety"</u>						
(1) present and projected water and sewer/sewage disposal facilities, including present capacity and projected percentage of use			X			
(2) present and projected police and fire capabilities			X			
(3) location of hospitals and number of physicians and specialized health facilities, including present and projected capacity." (ESRP 3.7.2, Sec. 2., p. 3.7.2-2)			X			
<u>"Education"</u>						
(1) regional private and secondary schools, including pupil-teacher ratios, capacity, and present percentage of use				X		
(2) regional junior colleges, technical schools, and higher institutions, including capacity and present percentage of use." (ESRP 3.7.2, Sec. 2., p. 3.7.2-2)				X		
"Information needed for the review [of tax base and revenues] will usually include the following:						
(1) regional political jurisdictions and tax districts, including the tax districts that will be directly affected by the construction, operation, closure, and long-term care of the proposed facility					X	
(2) regional tax structure and the distribution of present revenues to each jurisdiction and district." (ESRP 3.7.3, Sec. 2., p. 3.7.3-2)					X	
"Information needed for the review [of sociocultural characteristics] will usually include the following:						
(1) social structure and significant institutions of major communities within the region surrounding each alternative site						X
(2) identification and evaluation of significant community problems (i.e., crime, family stability, substance abuse, etc.)						X
(3) results of attitudinal surveys, if conducted, of local attitudes, lifestyle indicators, cultural values, community cohesion, etc." (ESRP 3.7.4, Sec. 2., p. 3.7.4-2)						X

TABLE A-15
PARAMETER DESCRIPTIONS - SOCIOECONOMICS

Labor Force: The size, composition, and availability of the labor force in the region, including the county in which the site is located and those specific portions of surrounding counties and urbanized areas (up to 40 km from the site) from which the work force would be principally drawn.

Housing: The types, amounts, age, condition, and availability (turnover rates, vacancy rates, price) of existing housing and the location and amount of projected housing in the region from which the work force would be principally drawn or which would be affected because workers changed residence.

Health and Public Safety Systems: Capacity of utilities (e.g., solid waste disposal, water and sewer), and capabilities of police, fire, hospitals, physicians, and specialized health facilities to meet projected needs in the region from which the work force would be principally drawn or which would be affected because workers changed residence.

Education Systems: Capacity and availability of primary and secondary schools, junior colleges, technical schools, and higher institutions in the region from which the work force would be principally drawn or which would be affected because workers changed residence.

Tax Base: The regional political jurisdictions and tax districts that will be affected by the facility, the regional tax structure, and present tax revenues.

Sociocultural Characteristics: The social structure (i.e., community composition and cohesion), local attitudes, cultural values, life style indicators, family stability, and community problems in major communities within the region around the site.

TABLE A-16

REQUIREMENTS FOR SITE CHARACTERIZATION

DATA TYPE: CULTURAL RESOURCES

REGULATORY REQUIREMENTS

10 CFR 61 - NRC Licensing Requirements

(Does not specifically address cultural resources)

10 CFR 51 - NRC Environmental Protection Regulations

(Does not specifically address cultural resources)

REGULATORY GUIDANCE

NUREG-0902 (Site Suitability, Selection, and Characterization)

"A cultural resources survey of the site and surrounding region to a radius of approximately 10 kilometers from the site should also be performed...to identify, via literature review, field reconnaissance, and limited surface testing (if necessary), the potential for encountering cultural resources of significance as defined by federal, state, and/or local historic preservation laws. Both historic and pre-historic resources should be considered..." (p. 25)

"The cultural resources survey...should include mapping of identified cultural sites and an evaluation of the potential of any cultural site for inclusion on the National Register of Historic Places or in any state or local registers...(and) a list of cultural sites within a radius of approximately 10 kilometers which are currently listed or nominated for inclusion on the National Register of Historic Places, the National Registry of Natural Landmarks, or any similar state or local lists." (p. 25)

NRC Draft Technical Position Paper on Environmental Monitoring

(Does not address cultural resources)

NUREG-1199 (SAR Standard Format and Content)

(Does not address cultural resources)

PARAMETERS

Historic Places	Archaeologic Sites	Other Cultural Resources
-----------------	--------------------	--------------------------

X

X

+

X

X

X

TABLE A-16

REQUIREMENTS FOR SITE CHARACTERIZATION

DATA TYPE: CULTURAL RESOURCES

REGULATORY GUIDANCE	PARAMETERS			
	Historic Places	Archaeologic Sites	Other Cultural Resources	
NUREG-1200 (SAR Standard Review Plan)				
(Does not address cultural resources)				
NUREG-1300 (ER Standard Review Plan)				
The scope of the INRCI review will consist of the following:				
"(1) evaluation of the methods used to identify and locate cultural, historic, and archaeological resources	X	X		X
"(2) evaluation of the results of the surveys conducted	X	X		X
"(3) confirmation of the location and significance of any properties that are listed or are eligible for inclusion in the National Register of Historic Places	X			
"(4) review of any additional information pertaining to the identification and description of cultural or historic resources that could be affected..."	X	X		X
Information needed for the review [of historic, archaeological, and cultural resources] will usually include the following:				
"(1) The applicant's detailed description of any archaeological or historical surveys (planned or ongoing) of the proposed and alternative sites and vicinity. The description should include a map outlining the physical extent of the survey and a brief discussion of survey techniques and the qualifications of the surveying party. If a "new" survey is planned, both historic and archaeological resources should be considered..."	X	X		X
"(2) The applicant's identification (on a map) and discussion of "important" sites. The applicant's determinations should be supported by (a) the State historic preservation officer (SHPO), (b) an extensive literature review, (c) field reconnaissance work, and (d) limited surface testing, if necessary..."	X	X		X
"(3) The results of the staff's consultation with the SHPO and the State archaeologist and/or State historian, if they exist, to determine if there are any additional comments or information concerning the proposed action..."	X	X		X

TABLE A-16
PARAMETER DESCRIPTIONS - CULTURAL RESOURCES

Historic Places: Districts, sites, buildings, structures or objects of historical significance listed or eligible for inclusion in the National Register of Historic Places, or of State or local significance.

Archaeologic Sites: Sites containing artifacts of the life and culture of ancient peoples.

Other Cultural Resources: Other sites, buildings, structures, or objects of historical, archaeological, architectural, scenic, cultural or landmark significance, including traditional folklife remnants, Native American religious or sacred sites, and paleontological (i.e., fossil) resources.

TABLE A-17
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: TRANSPORTATION

REGULATORY REQUIREMENTS	PARAMETERS					
	Major Highways	Local Highways and Roads	Navigable Waterways	Railroads	Rights-of-Way	Public Transportation
10 CFR 61 - NRC Licensing Requirements (Does not specifically address transportation)						
10 CFR 51 - NRC Environmental Protection Regulations (Does not specifically address transportation)						
REGULATORY GUIDANCE						
NUREG-0902 (Site Suitability, Selection, and Characterization)						
"The land use survey...should include land use patterns within...approximately 10 kilometers....classified as....transportation..." (p. 25)	+	+	+	+		
"A description of the socioeconomic environment is needed....the applicant may need to survey the study area....to establish data such as....transportation, historic commuting patterns...." (p. 26)	+	+	+	+		+
NRC Draft Technical Position Paper on Environmental Monitoring (Does not specifically address transportation)						
NUREG-1199 (SAR Standard Review Plan; (Does not specifically address transportation)						
NUREG-1200 (SAR Standard Review Plan) (Does not specifically address transportation)						
NUREG-1300 (ER Standard Review Plan) "Information needed for the staff's review will usually include the following: (3) Distance and direction from...nearby major highways, rivers, and other bodies of water..." (ESRP 2.1.1, Sec. 2., p. 2.1.1-1)	X		+			

TABLE A-17
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: TRANSPORTATION

REGULATORY GUIDANCE	PARAMETERS					
	Major Highways	Local Highways and Roads	Navigable Waterways	Railroads	Rights-of-Way	Public Transportation
"Information needed for the review will usually include the following...						
(3) Highway...Rights of way at each alternative and in its vicinity... (ESRP 3.1.2, Sec. 2., p. 3.1.2-2)	+	+			X	
"Among the characteristics to be considered in the review will be the following:						
(1) waterways, highways, roads, and railroads at each alternative, especially those that would be closed to public use" (ESRP 3.1.2, Sec. 3., p. 3.1.2-2)	X	X	X	X		
"The information needed for the review will usually include the following:						
<u>Highways and Transportation</u>						
(1) regional and local highway systems, including carrying capacity and condition of roads and highways	X	X				
(2) availability and type of public transportation						X
(3) modifications that might affect traffic flow to and from the alternatives" (ESRP 3.7.2, Sec. 2., p. 3.7.2-2)		X			X	
"Generic release and transport scenarios: Doses to general population along waste transport route" (ESRP 4.8.1, Table A-1, p. 4.8.1-6)	X	X	X	X	+	

TABLE A-17
PARAMETER DESCRIPTIONS - TRANSPORTATION

Major Highways: Major interstate, U.S. and State highways enroute to the site from centers of waste generation, statewide and/or regionwide, and in the vicinity of the site.

Local Highways and Roads: County and local highways and roads in the vicinity of the site, especially connectors to major highways.

Navigable Waterways: Rivers, canals, and other navigable waterways, statewide and/or regionwide, and in the vicinity of the site.

Railroads: Existing major and short line roads and classification yards enroute to the site from centers of waste generation, statewide and/or regionwide, and in the vicinity of the site.

Rights-of-way: Rights-of-way needed to provided access to the site from local transportation routes.

Public Transportation: Existing modes of public transportation (buses, trains, air service) providing access to the site.

TABLE A-18
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: AESTHETICS

REGULATORY REQUIREMENTS		PARAMETERS	
REGULATORY GUIDANCE		Visual Resources	Noise
10 CFR 61 - NRC Licensing Requirements 61.12(e)			
10 CFR 51 - NRC Environmental Protection Regulations (Does not specifically address aesthetics)			
NUREG-0902 (Site Suitability, Selection, and Characterization)			
"The land use survey...should include land use patterns within a radius of 10 kilometers from the site. Land uses should be classified as...special management areas (parks, scenic areas,..." (p. 25)			
NEC Draft Technical Position Paper on Environmental Monitoring			
(Does not address aesthetics)			
NUREG-1199 (SAR Standard Review Plan)			
(Does not address aesthetics)			
NUREG-1200 (SAR Standard Review Plan)			
(Does not address aesthetics)			

TABLE A-18
 REQUIREMENTS FOR SITE CHARACTERIZATION
 DATA TYPE: AESTHETICS

REGULATORY GUIDANCE	PARAMETERS	
	Visual Resources	Noise
<p>NUREG-1300 (ER Standard Review Plan)</p> <p>"Among the characteristics to be considered in the review [of land use] will be...(4) visually sensitive areas or view sheds that could be affected by construction or operation of the proposed facility..." (ESRP 3.1.2, Sec. 3., p. 3.1.2-2)</p> <p>"To assess the impacts [of onsite and offsite construction activities] the staff will evaluate...(7) the tolerances of and/or susceptibilities of "important" biota to physical and chemical pollutants resulting from construction activities...(and) (9)...important preexisting environmental stresses." (ESRP 4.5.1, Sec. 2., p. 4.5.1-2)</p> <p>"In addition, the staff will assess...(8) the effects of noise on important terrestrial biota." (ESRP 4.5.1, Sec. 3., p. 4.5.1-3 and -4)</p>	X	+
		X

TABLE A-18
PARAMETER DESCRIPTIONS - AESTHETICS

Visual Resources: Assessment of visual quality for specific geographic areas, based on numbers and types of viewers, uniqueness of the landscape; determined through viewsheds (i.e., depiction of what is seen from selected offsite viewer locations) and resource classifications (e.g., U.S. Forest Service Visual Resource Management System).

Noise: The measurement of background noise levels to support determinations of incremental noise impacts from facility construction and operation; measured in decibels.

REFERENCES CITED IN APPENDIX A

1. U.S. Nuclear Regulatory Commission, Licensing Requirements for Land Disposal of Radioactive Waste, Title 10 Code of Federal Regulations Part 61 (10 CFR 61), 1987.
2. U.S. Nuclear Regulatory Commission, Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions, Title 10 Code of Federal Regulations Part 51 (10 CFR 51), 1987.
3. D. Seifken et al., Site Suitability, Selection, and Characterization, NUREG-0902, U.S. Nuclear Regulatory Commission, Branch Technical Position - Low-Level Waste Licensing Branch, 1982.
4. U.S. Nuclear Regulatory Commission, Technical Position Paper, Environmental Monitoring of Low-Level Waste Disposal Facilities, Working Draft, Division of Waste Management, 1986.
5. U.S. Nuclear Regulatory Commission, Standard Format and Content of a License Application for a Low-Level Radioactive Waste Disposal Facility: Safety Analysis Report, NUREG-1199, Office of Nuclear Material Safety and Safeguards, 1987.
6. U.S. Nuclear Regulatory Commission, Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility: Safety Analysis Report, NUREG-1200, Office of Nuclear Material Safety and Safeguards, 1987.
7. U.S. Nuclear Regulatory Commission, Environmental Standard Review Plan for the Review of a License Application for a Low-Level Radioactive Waste Disposal Facility: Environmental Report, NUREG-1300, Office of Nuclear Material Safety and Safeguards, 1987.
8. U.S. Nuclear Regulatory Commission, Standard Format and Content of Environmental Reports for Near-Surface Disposal of Radioactive Waste, Regulatory Guide 4.18, Office of Nuclear Regulatory Research, 1983.

APPENDIX B

TECHNICAL ACTIVITIES/
STUDY METHODS TABLES

INSTRUCTION ON THE USE OF THE SITE CHARACTERIZATION TECHNICAL
GUIDANCE TABLES
IN APPENDIX B

The tables in this appendix contain technical information to support the eighteen data types included in the Regulatory Requirements Matrices in Appendix A. The purpose of these tables is to provide technical guidance on sources and methods of obtaining data specific to the 142 parameters identified in Appendix A. The tables are organized by data type as in Appendix A. References cited and parameter descriptions for each table follow the table.

The following information is provided for each parameter on the eighteen data type tables:

- o Parameter - The technical parameter identified in Appendix A. The parameter descriptions, which are the same as those in Appendix A, are included herein with each table to help the reader use the tables more efficiently.
- o Technical Activities/Study Methods - The technical activities and study methods that can be used to obtain and analyze the site characterization data specific to the technical parameter. Where possible, the activities are listed in a logical sequence of performance, beginning with the compilation of existing data and proceeding to original data collection activities on-site. It should be noted that the sequence of techniques described for each data parameter is not necessarily additive. For example, the compilation of existing data may preclude the need to conduct a field program. Conversely, existing data may be very sparse or nonexistent, requiring extensive field activities to confirm site suitability. In addition, the tables describe standard activities and recognized state-of-the-art study methods that are applicable to sites with widely varying geological, hydrogeological, and environmental characteristics, and are not intended to be prescriptive. The specific activities and methods selected for use at any region or site will depend on its particular physical, natural, and social environment.
- o Data Formats - The formats in which data may be obtained and/or displayed, as appropriate.
- o Data Sources - The commonly utilized sources of existing data and newly collected data during site characterization for the specific technical parameter.
- o References - Selected representative references that contain additional information on data collection and analysis techniques and methods. The references listed were selected because they provide useful background information; they do not comprise a comprehensive bibliography of available reference materials.

These tables summarize the technical activities for collection and analysis of the data defined in the NRC regulatory guidance documents listed in Appendix A as being necessary for site characterization. It is recommended that project staff involved in site characterization consult the NRC documents in their entirety, particularly the requirements for the 12-month monitoring studies, for technical guidance on data collection activities and data analysis.

It is important to note that some of the parameters and activities listed on the tables will only be evaluated if site characterization studies reveal conditions that require further analysis. For instance, the resource value parameter will be evaluated only if potential resources are identified. These tables can be used, therefore, as guidance in planning a site characterization program, but they should not be interpreted to be a prescriptive list of all the technical activities and parameters that will be necessary to characterize every site. It should also be noted that planning for a data collection program for many of the data types should involve one or more appropriate land management or regulatory agencies. These agencies can ensure that the techniques selected, the planned sampling intensity, and other technical factors are considered as suitable technical practice for the region and site(s) involved, and that the data obtained will be consistent in format with data bases maintained by the reviewing agencies.

Finally, it should be noted that the inherent differences in technical approach and complexity among the 18 data types are reflected in the varying levels of information presented in the tables. For this reason, some parameters are quite straightforward, and therefore relatively brief, whereas other parameters exhibit much more complexity and require lengthier explanation.

TABLE B-1
PARAMETER DESCRIPTIONS - GEOLOGY

Geomorphology: The characteristics, origin, and development of the regional and site landforms, their relationships to underlying structures, and the history of geologic changes as recorded by these surface features. Topography, slopes, drainage basis, stream channels, mass wasting, weathering, and erosion, and the rate, frequencies, and controlling mechanisms of these processes are included in this parameter.

Stratigraphy: The classification, correlation, and interpretation of surficial and Quaternary deposits and underlying rocks. Stratigraphy is concerned with accepted unit names, genetic relationships, depositional environment, areal extent, unit depth, thickness, geometry, vertical and lateral extent and variations, heterogeneity, paleontology, age (geochronology), and the geologic history of the site area.

Lithology: The description of surficial and Quaternary deposits and underlying rocks based on visual and laboratory characteristics. Information such as the gross lithology, lithologic trends, color, mineralogy, grain-size distribution, texture/fabric, primary and sedimentary structures, facies changes and relationships, lithologic contacts, cementation, alteration, metamorphic grade, weathering, type of clay, inclusions, degree of devitrification of volcanic rocks, organic content, carbonate content, and natural radioactivity is part of a complete lithologic description.

Structure: The characteristics, origin, and development of the faults, folds, joints, solution cavities or crevices, and other discontinuities or zones of weakness within the region and site. This includes their location, orientation, relative position, length, spacing/density, relative age, aperture or infilling, roughness, mineralization history, type of structure, displacement history or deformation rate, potential recurrence intervals, relationship of structures to present-day local stress field, and capability or activity.

Tectonics: The large-scale structure of the Earth's crust and the nature and rates of the processes responsible for these structures. This parameter includes the tectonic provinces within 200 miles of the site and their history, uplift, subsidence, tilting, folding, faulting, nature of volcanism and volcanic history, the regional and local stress regime, and the potential for unrelieved stresses to produce creep and rebound within the time frame of interest (500 years).

Seismology: The study of earthquakes and their relationship to the tectonics and structure of an area by both natural and artificially generated seismic waves. This includes determining, within a 200-mile radius of site: the historical seismicity of magnitude 3 or greater, or of modified Mercalli intensity IV or greater, with all available details; the earthquake recurrence intervals; the correlation of earthquakes with structures or tectonic provinces and rationale; the maximum earthquake potential of each geologic structure or tectonic province, its frequency content, and the resulting

ground motion at the site; and the design earthquake and accelerations at the site developed, if possible, from probabilistic seismic hazard estimates. The seismic wave transmission characteristics of the site, including velocities, bulk densities, and the shear and elastic moduli, and historical and potential fault rupture, seismically-induced hillslope failure, and liquefaction or settlement are also included in this parameter.

Geologic Hazards: The potential natural or man-induced hazards that could present a risk or potential danger to the site or to life. Evaluation of fault displacement, seismicity, slope failures, landslides, renewed volcanism, subsidence, collapse, liquefaction, karst terrain, flooding, expanding clays and other unstable elements in near-surface stratigraphic units and soils, and corrosivity of soils should be part of the site geologic hazards assessment.

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Geomorphology	Review regional and site specific geomorphic data and literature, and compile/evaluate existing data	Texts, publications, articles, reports, maps	U.S. Geological Survey State publications Colleges and Universities Theses and dissertations Professional journals Geologic textbooks Nuclear plant FSAR's and SER's	Avery (1968) Reeves (1975) Twidale (1976) Verstappen (1977) Way (1978) Lutton et al. (1982) University of Arizona (1985) Drury (1987)
	Topographic analysis and photogeologic interpretation of the site area to describe landforms and to locate and identify steep slopes, drainage basins, stream channels, and areas of mass wasting and erosion	Topographic maps Satellite imagery, radar imagery, and high- and low-altitude aerial photos Interpreted overlays to aerial photos	U.S. Geological Survey topographic maps U.S. Geological Survey EROS Data Center U.S. Dept. of Agriculture Commercial mapping contractor State and County Agencies Earth Observation Satellite Company (EOSAT)	
	Geomorphic mapping of the site area to locate, identify, and record the characteristics, origin, and history of geomorphic surfaces to confirm the location and identity of slopes, drainage basins, stream channels, areas of mass wasting, weathering, and erosion, and to determine their relationships to underlying structures	Geomorphic map Slope map Drainage basin and stream channel map	Field observations to confirm/revise existing data and photogeologic interpretation	Genek (1962) Charley et al. (1985) Compton (1985)
	If necessary, geologic logging of test pits, trenches, and borehole drilling to identify the characteristics, origin, and history of geomorphic units and surfaces	Test pit and trench logs Borehole logs	Results of site characterization investigations	Knill et al. (1970) Hatheway and Leighton (1979)

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Geomorphology (continued)	Relative age determinations of geomorphic surfaces and units from field relationships and absolute age determinations from laboratory techniques, such as: fossil identification K-AR Rb-SR U-Pb Th-Pb C14 paleomagnetic	Cross sections Fossil assemblage diagrams Radiolotope abundance graphs Stereonets	Results of site characterization Investigations Paleontological analysis Radiometric dating Paleomagnetic analysis	York and Fargnauer (1972) Kaufman and Hazel (1977) Murphy et al. (1979a) Compton (1985)
	Integrate geomorphic data with data from surface-water hydrology, stratigraphy, lithology, and tectonic parameters to determine the rates, frequencies, and controlling mechanisms or factors of active geomorphic processes, to determine the processes that created landforms in the site area, and to predict future geomorphic changes	Calculations Tables	Results of site characterization Investigations for geomorphology Data from stratigraphy, lithology, and tectonics (see this table) and surface-water hydrology (see Table B-3, Erosion)	Halls (1977) Brakensiek et al. (1979) Dunne and Leopold (1978) Swenson et al. (1982) Saunders and Young (1983) Charley et al. (1985)
	Integrate results of geomorphologic studies with other geologic parameters to develop a conceptual geologic model of the site and to provide geologic input to the surface-water hydrologic model (see Table B-3, Hydrologic Modeling)	Conceptual geologic model	Results of site characterization Investigations	

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Stratigraphy	Review regional and site specific stratigraphic data and literature, and compile/evaluate existing data, including borehole geologic and geophysical logs	Texts, publications, articles, reports, geologic maps, and geological and geophysical borehole logs	U.S. Geological Survey State publications and borehole/well records Colleges and universities Theses and dissertations Professional journals Geologic textbooks Nuclear plant FSAP's and SER's Company borehole/well records, if available	
	Photogeologic interpretation of the site area to determine the genetic relationships between the various stratigraphic units, their depositional environment, areal extent, and relative age, and the geologic history of the site area	Satellite imagery, radar imagery, and high- and low-altitude aerial photos U.S. Geological Survey EROS Data Center	U.S. Dept. of Agriculture Commercial mapping contractor State and County agencies Earth Observation Satellite Company (EOSAT)	Avery (1968) Reeves (1975) Key (1978) Drury (1987)
	Geologic mapping of the site surficial and Quaternary deposits and underlying rocks to visually record the genetic relationships, depositional environment, areal extent, geometry, lateral variations, heterogeneity, paleontology, relative age, and geologic history, to obtain representative samples for age determinations, and to characterize the environment and processes of deposition of surficial and Quaternary deposits at the site; apply geostatistical methods to estimate conditions between sampling or data points	Geologic map Stratigraphic section Cross sections Isopach Maps Soil and rock samples	Field observations to confirm/revise existing data and photogeologic interpretation	Lutton et al. (1982) Copton (1985) Davis (1986)

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Stratigraphy (continued)	<p>Surface geophysical investigations tailored to specific site conditions, such as:</p> <ul style="list-style-type: none"> seismic reflection and refraction electrical resistivity magnetic surveys gamma ray spectrometry surveys <p>to infer vertical and lateral changes in the extent, depth, thickness, geometry, and heterogeneity of the surficial and Quaternary deposits and underlying rocks at the site</p>	<p>Seismic velocity profiles</p> <ul style="list-style-type: none"> Electrical sounding or profiling plots Magnetic profile plots or contour maps Radiometric survey profiles or contour maps 	Results of site characterization investigations	<p>Teiford et al. (1976)</p> <p>Murphy et al. (1979)</p> <p>Clayton et al. (1982)</p> <p>University of Arizona (1985)</p>
	<p>Test pits, trenches, and borehole drilling to visually record, by geologic logging, the genetic relationships, depositional environment, areal extent, depth, thickness, geometry, vertical and lateral extent and variations, heterogeneity, paleontology, relative age, and the geologic history of surficial and Quaternary deposits and underlying rock units, to obtain representative samples for age determinations, and to characterize the environment and processes of deposition of surficial and Quaternary deposits at the site</p>	<p>Test pit and trench logs</p> <ul style="list-style-type: none"> Borehole logs Isopach Maps Cross sections Soil and rock samples 	Results of site characterization investigations	<p>Knill et al. (1970)</p> <p>Reiney and Leighton (1979)</p> <p>Compton (1985)</p>

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Stratigraphy (continued)	<p>Borehole geophysical logging program tailored to specific site conditions, such as:</p> <ul style="list-style-type: none"> spontaneous potential resistivity acoustic velocity gamma ray neutron density logs <p>to infer vertical and lateral changes in the depositional environment, including volcanic flow sequencing, extent, depth, thickness, geometry, and heterogeneity of the surficial and Quaternary deposits and underlying rocks at the site</p> <p>Age determinations of stratigraphic units from field relationships and laboratory techniques, such as:</p> <ul style="list-style-type: none"> fossil identification K-Ar Rb-Sr U-Pb Th-Pb C-14 palaeomagnetic <p>Integrate results of stratigraphic studies with other geologic parameters to develop a conceptual geologic model of the site and to provide geologic input to groundwater model (see Tables B-2(a) and (b), Hydrogeologic Modeling)</p>	<p>Borehole geophysical logs</p> <p>Stratigraphic section</p> <p>Cross sections</p> <p>Fossil assemblage diagrams</p> <p>Radioisotope abundance graphs</p> <p>Stereonet</p> <p>Geologic map</p> <p>Fence diagrams</p> <p>Cross sections</p> <p>Conceptual geologic model</p>	<p>Results of site characterization investigations</p> <p>Results of site characterization investigations</p> <p>Results of site characterization investigations</p> <p>Results of site characterization investigations</p>	<p>Pirson (1977)</p> <p>Crosby and Scott (1979)</p> <p>Brown (1981)</p> <p>York and Farquhar (1972)</p> <p>Kaufman and Hazel (1977)</p> <p>Murphy et al. (1979a)</p> <p>Compton (1985)</p> <p>Wolf (1976)</p>

TABLE S-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Lithology	Review regional and site specific lithologic data and literature, and compile/evaluate existing data	Texts, publications, articles, reports, geologic maps	U.S. Geological Survey State publications Colleges and Universities Theses and dissertations Professional journals Nuclear plant FSAR's and SER's	
	Geologic mapping of the site area to visually record, as applicable, the gross lithology, lithologic trends, color, mineralogy, grain-size distribution, texture/fabric, primary and sedimentary structures, facies changes and relationships, lithologic contacts, cementation, alteration, metamorphic grade, degree of deformation, weathering, type of clay, inclusions, organic content, and carbonate content of each surficial and Quaternary deposit and underlying rock unit, and to obtain representative samples for laboratory analysis	Geologic map Cross sections Soil and rock samples	Field observations to confirm/revise existing data Site area sampling	Lutton et al. (1982) Compton (1985)
	Surface geophysical investigation program tailored to specific site conditions, such as: seismic reflection and refraction electrical resistivity magnetic gamma ray spectrometry to infer vertical and lateral changes in the gross lithology, lithologic contacts, mineralogy, grain-size distribution, texture, cementation, alteration, weathering, and natural radioactivity of the surficial and Quaternary deposits and underlying rocks at the site	Seismic velocity profiles Electrical sounding or profiling plots Magnetic profile plots or contour maps Radiometric survey profiles or contour maps	Results of site characterization investigations	Telford et al. (1976) Murphy et al. (1979) Cleyton et al. (1982) University of Arizona (1985)

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Lithology (continued)	<p>Test pits, trenches, and borehole drilling to visually record, as applicable, by geologic logging, the gross lithology, lithologic trends, color, mineralogy, grain-size distribution, texture/fabric, primary and sedimentary structures, facies changes and relationships, lithologic contacts, cementation, alteration, metamorphic grade, degree of deformation, weathering, type of clay, inclusions, organic content, and carbonate content of each subsurface surficial and Quaternary deposit and underlying rock unit, and to obtain representative samples for laboratory analysis</p> <p>Borehole geophysical logging program tailored to specific site conditions, such as: spontaneous potential resistivity acoustic velocity gamma ray neutron density spectral to infer vertical changes in the gross lithology, lithologic contacts, mineralogy, grain-size distribution, cementation, alteration, weathering, type of clay, and natural radioactivity of the surficial and Quaternary deposits and underlying rocks at the site</p>	<p>Test pit and trench logs Borehole logs Cross sections Soil and rock samples</p> <p>Borehole geophysical logs</p>	<p>Results of site characterization investigations</p> <p>Results of site characterization investigations</p>	<p>Kalil et al. (1970) Hatheway and Leighton (1979) Luffon et al. (1982) Compton (1985)</p> <p>Pirson (1977) Crosby and Scott (1979) Brown (1981)</p>

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Lithology (continued)	<p>Laboratory analysis of representative soil and rock samples, such as:</p> <ul style="list-style-type: none"> optical microscopy petrographic microscope with thin or polished sections wet chemical analysis X-ray diffraction X-ray fluorescence scanning electron microscopy atomic absorption sieve and hydrometer analyses to determine their color, mineralogy, grain-size distribution, cementation, inclusions, degree of devitrification of volcanic rocks, alteration, weathering, type of clay, organic content, carbonate content, and natural radioactivity <p>integrate results of lithologic studies with other geologic parameters to develop a conceptual geologic model of the site and provide geologic input to ground-water model (see Tables B-2(a) & (b), Hydrogeologic Modeling)</p>	<p>Mineral abundance tables</p> <p>Chemical abundance tables</p> <p>Grain-size graphs</p>	<p>Microscopy</p> <p>Laboratory analyses</p> <p>Sieve/hydrometer tests</p>	<p>Williams et al. (1954)</p> <p>Dene and Hurlbut (1965)</p> <p>Heinrich (1965)</p> <p>El-Hinnawi (1966)</p> <p>Jeffery (1970)</p> <p>Hutchinson (1974)</p> <p>VanOlphen and Fripiat (1973)</p> <p>Fripiat (1982)</p> <p>ASTM (1985)</p>
Structure	<p>Review regional and site specific structural data and literature, and compile/evaluate data</p>	<p>Geologic map</p> <p>Fence diagrams</p> <p>Cross sections</p> <p>Conceptual geologic model</p>	<p>Results of site characterization investigations</p>	<p>Wolf (1976)</p>
	<p>Review regional and site specific structural data and literature, and compile/evaluate data</p>	<p>Texts, publications, articles, reports, geologic maps</p>	<p>U.S. Geological Survey</p> <p>State publications</p> <p>Colleges and Universities</p> <p>Theses and dissertations</p> <p>Professional journals</p> <p>Geologic textbooks</p> <p>Nuclear plant FSAR's and SER's</p>	

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Structure (continued)	<p>Photogeologic Interpretation of the site area to identify structures and lineaments that may be structurally controlled, and record their location, orientation, length, spacing/density, relative age, type of structure, and displacement history</p> <p>Geologic mapping of the site area to visually record the presence of any folds, faults, joints, solution cavities or crevices, other discontinuities or zones of weakness, and note their location, orientation, length, spacing/density, relative age, aperture or infilling, roughness, mineralization history, type of structure, displacement history or deformation rate, potential recurrence intervals, and capability or activity</p> <p>Surface geophysical investigation program tailored to specific site conditions, such as: seismic reflection and refraction electrical resistivity magnetic gravity gamma ray spectrometry to infer the location, orientation, and length of buried structures</p>	<p>Satellite imagery, radar imagery, and high- and low-altitude aerial photos</p> <p>Geologic map Cross sections Stereonets</p> <p>Seismic velocity profiles Electrical sounding or profiling plots Magnetic profile plots or contour maps Gravity profile plots or contour maps Radiometric survey profiles or contour maps</p>	<p>U.S. Geological Survey EROS Data Center U.S. Dept. of Agriculture Commercial mapping contractor State and County agencies Earth Observation Satellite Company (EOSAT)</p> <p>Field observations to confirm/revise existing data and photogeologic interpretation</p> <p>Results of site characterization Investigations</p>	<p>Avery (1968) Reeves (1975) Stemmons (1977) Way (1978) McElowney and Pascucci (1979) Drury (1987)</p> <p>Billings (1972) Hills (1972) Stemmons (1977) Brown (1981) Park (1983) Compton (1985)</p> <p>Telford et al. (1976) Murphy et al. (1979b) Clayton et al. (1982) University of Arizona (1985)</p>

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Structure (continued)	<p>Test pits, trenches, and corehole drilling to visually record, by geologic logging, the presence of faults, folds, joints, solution cavities or crevices, other discontinuities or zones of weakness, and note their location, orientation, length, spacing/density, relative age, aperture or infilling, roughness, mineralization history, type of structure, displacement history or deformation rate, potential recurrence interval, and capability of activity</p> <p>Borehole geophysical logging program tailored to specific site conditions, such as: spontaneous potential dipmeter resistivity sonic acoustic seismometer gamma ray spectral neutron density borehole television logs to identify the presence of faults, joints, solution cavities or crevices, other discontinuities or zones of weakness, and their location, orientation, and spacing/density</p>	<p>Test pit and trench logs Borehole logs Cross sections</p> <p>Borehole geophysical logs</p>	<p>Results of site characterization investigations</p> <p>Results of site characterization investigations</p>	<p>Knill et al. (1970) Hatheway and Leighton (1979) Compton (1985)</p> <p>Pirson (1977) Crosby and Scott (1979) Brown (1981)</p>

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Structure (continued)	<p>Age determinations of structures from field relationships and laboratory analyses of materials within or overlying structures, such as:</p> <ul style="list-style-type: none"> fossil identification K-Ar Rb-Sr U-Pb Th-Pb C14 paleomagnetic analyses <p>Integrate results of structure studies with other geologic parameters to develop a conceptual geologic model of the site and to provide geologic input to ground-water model (see Tables B-2(a) & (b), Hydrogeologic Modeling)</p>	<p>Stratigraphic section</p> <ul style="list-style-type: none"> Cross sections Fossil assemblage diagrams Radioisotope abundance graphs Stereonets 	<p>Results of site characterization investigations</p> <ul style="list-style-type: none"> Paleontological analysis Redionetric dating Paleomagnetic analysis 	<p>York and Farquhar (1972) Kauffman and Hazel (1977) Murphy et al. (1979a) Compton (1985)</p>
		<p>Geologic map</p> <ul style="list-style-type: none"> Cross sections Fence diagrams Conceptual geologic model 	<p>Results of site characterization investigations</p>	<p>Wolf (1976)</p>
Tectonics	<p>Review and compile regional and site specific tectonic data and literature to determine the large-scale structure of the crust, the nature and rates of the processes responsible for the structures, the tectonic provinces within 200 miles of the site and their history, uplift, subsidence, tilting, folding, faulting, nature of volcanism and volcanic history, the regional and local stress regime, and the potential for unrelieved stresses to produce creep and rebound</p>	<p>Texts, publications, articles, reports, tectonic province maps</p>	<p>U.S. Geological Survey State publications Colleges and Universities Theses and dissertations Professional journals Geologic textbooks Nuclear plant FSAR's and SER's</p>	<p>Billings (1972)</p>

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Tectonics (continued)	Integrate results of tectonic studies with the structure parameter to develop a conceptual geologic model of the site	Conceptual geologic model	Results of site characterization investigations	
Seismology	<p>Review regional and site specific seismological data and literature, and compile/evaluate data</p> <p>Photogeologic Interpretation of the site area to locate areas of historical or potential liquefaction, settlement, and fault rupture</p> <p>Geologic and structural mapping of the site area to identify and locate areas of historical or potential liquefaction, settlement, hillslope failure, and fault rupture</p> <p>Surface and borehole geophysical investigation program tailored to specific site conditions, such as: seismic refraction survey utilizing downhole and cross hole techniques, to measure seismic wave transmission characteristics of the site, including velocities, bulk densities, and the shear and elastic moduli. Evaluate possibility of amplification of seismic response of site area via standing wave generation.</p>	<p>Texts, publications, articles, reports, seismicity maps Historical earthquake list</p> <p>Satellite imagery and high- and low-altitude aerial photos</p> <p>Geologic map Cross sections</p> <p>Seismic velocity profiles</p>	<p>U.S. Geological Survey State publications Colleges and universities Theses and dissertations Professional journals Geologic textbooks Nuclear plans FSAR's and SER's</p> <p>U.S. Geological Survey EROS Data Center U.S. Dept. of Agriculture Commercial mapping contractor State and County agencies Earth Observation Satellite Company (EOSAT)</p> <p>Field observations to confirm/revise existing data and photogeologic interpretation Data from geomorphic and structural studies (see this table) and geotechnical studies (see Table B-7)</p> <p>Results of site characterization investigations</p>	<p>Avery (1968) Reeves (1975) Way (1978) Vogel (1985) Drury (1987)</p> <p>Compton (1985)</p> <p>Telford et al. (1976) Murphy et al. (1979b) Clayton et al. (1982) Lutton et al. (1982) University of Arizona (1985)</p>

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Seismology (continued)	Seismic hazard analysis of the site to develop seismic design parameters for a 500-year period, including determining, within a 200-mile radius of the site: the historical seismic events of magnitude 3 or greater or of modified Mercalli intensity IV or greater with all available details; the earthquake recurrence intervals; the correlation of earthquakes with structures or tectonic provinces and rationale; the maximum earthquake potential of each geologic structure or tectonic province and its frequency content and resulting ground motion at the site; and the design earthquake and accelerations at the site developed, if possible, from probabilistic seismic hazard estimates	Earthquake list Seismicity maps Tectonic province maps Structure maps Earthquake recurrence plots Remote sensing maps showing relationships of regional features to site	Data from the literature review and from the site investigations for geomorphology, stratigraphy, lithology, tectonics, and structure parameters (see this table), and geotechnical parameters (see Table B-7)	Stiemmons (1977) Hays (1980) Coppersmith (1982) Sheriff (1982) Bernreuter et al. (1984) NRC (1985)
Geologic Hazards	Review regional and site specific geologic hazards data and literature, and compile/evaluate existing data Photogeologic interpretation of the site area to locate and identify any faults, slope failures, landslides, volcanic vents or fissures, areas of subsidence, collapse, and liquefaction, karst terrain, and flood plains	Texts, publications, articles, reports, geologic maps Satellite imagery, radar imagery, and high- and low-altitude aerial photos	U.S. Geological Survey State publications Colleges and universities Theses and dissertations Professional journals Geologic textbooks Nuclear plant FSAR's and SER's U.S. Geologic Survey EROS Data Center U.S. Dept. of Agriculture Commercial mapping contractor State and county agencies Earth Observation Satellite Company (EOSAT)	Avery (1968) Reeves (1975) Stiemmons (1977) Versteppen (1977) Key (1978) McElowney and Pascucci (1979) Drury (1987)

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Geologic Hazards (continued)	Geologic mapping of the site area to visually inspect faults, slope failures, landslides, volcanic vents or fissures, areas of subsidence, collapse, and liquefaction, karst terrain, and flood plains, and assess the potential impact to the site from these geologic hazards	Geologic map Cross sections Stereonets/Field observations to confirm/ revise existing data and photogeologic interpretation	Flawn (1970) Stemmons (1977) Brown (1981) Compton (1985)	
	Surface geophysical investigation program tailored to specific site conditions, such as: seismic reflection and refraction electrical resistivity magnetic gravity gamma ray spectrometry to infer the location of buried faults, the depth and extent of slope failures and landslides, and the location of potential collapse areas and karst terrain	Seismic velocity profiles Electrical sounding or profiling plots Magnetic profile plots or contour maps Gravity profile plots or contour maps Radiometric survey profiles or contour maps	Results of site characterization investigations	Teiford et al. (1976) Murphy et al. (1979b) Clayton et al. (1982) University of Arizona (1985)
	Test pits, trenches, and borehole drilling, if necessary, to identify, by geologic logging, the location of buried faults, the depth and extent of slope failures and landslides, and the location of potential collapse areas and karst terrain	Test pit and trench logs Borehole logs Cross sections	Results of site characterization investigations	Knill et al. (1970) Hatheway and Leighton (1979) Compton (1985)

TABLE B-1
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Geologic Hazards (continued)	<p>Borehole geophysical logging program tailored to specific site conditions, such as:</p> <ul style="list-style-type: none"> spontaneous potential resistivity acoustic velocity gamma ray neutron spectral density <p>to infer the location of buried faults, the depth and extent of slope failures and landslides, and the location of potential collapse areas and karst terrain</p>	Borehole geophysical logs	Results of site characterization investigations	Crosby and Scott (1979) Brown (1981)
	<p>Geologic hazard assessment of the site for a 500-year period to assess the potential impact to the site from fault displacement, seismicity, slope failures, landslides, renewed volcanism, subsidence, collapse, liquefaction, karst terrain, flooding, expanding rock and soil components, and corrosivity of soils, and to provide geologic input to surface-water and ground-water models (see Tables B-2(a) and (b) and B-3)</p>	Geologic maps Cross sections Tables	Data from the literature review and from the site investigations for geomorphology, stratigraphy, lithology, tectonics, structure, seismology parameters (see this table), and for surface-water hydrology parameters (see Table B-3, Flood Studies, Erosion), and geotechnical parameters (see Table B-7, Engineering Properties)	Flawn (1970) Schuster and Krizek (1978)

TABLE B-1
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TABLE B-2(a)
PARAMETER DESCRIPTIONS - GROUND-WATER HYDROLOGY

UNSATURATED FLOW

Moisture Potential: Soil water moves in the direction of decreasing moisture potential. The moisture potential is the sum of gravitational, osmotic, and matric potentials. Osmotic potential is generally considered negligible. Gravitational potential is dependent on differences in elevation. Matric potential is a negative pressure potential that results from the capillary and adsorptive forces of the soil matrix. Information on moisture potential is needed for determining rates and directions of moisture movement.

Moisture Content: Moisture content is expressed as a dimensionless ratio either of water mass to dry soil mass or of water volume to total volume. It is usually reported as a percentage. The relation between moisture potential and moisture content is defined by a moisture characteristic curve. However, due to the hysteresis phenomenon, the curve for the wetting process is usually not identical to the curve for the drying process. A related parameter, the degree of saturation, is defined as the ratio of the water volume to the void volume. Information on moisture content is needed as a dependent variable of hydraulic conductivity.

Hydraulic Conductivity: Hydraulic conductivity is a measure of the ability of soil or rock to transmit water. Hydraulic conductivity depends on the specific weight and viscosity of the water, and the intrinsic permeability and moisture content of the material. Under unsaturated conditions, the hydraulic conductivity may not be constant and will vary with the degree of saturation. In general, hydraulic conductivity has directional variability (anisotropy). Information on hydraulic conductivity is needed for determining rates of moisture movement.

Porosity (Total and Effective): Total porosity is the ratio of the void volume to the total volume of a sample. Effective porosity is the ratio of interconnected void volume in which fluids are able to circulate, to the total volume of a sample. Information on porosity is needed for determining the transport of solutes in the unsaturated zone.

Geometry: The geometry includes the hydrostratigraphy (e.g., thickness, lateral extent, continuity), the depth of the water table, the thickness of capillary fringe, the location of the disposal facility, and the location of recharge and discharge zones. Information on geometry is needed to define the domain in which flow is studied.

Boundary Conditions: Boundary conditions are defined pressure heads or fluxes due to discharge from evapotranspiration, and to steady-state and/or transient recharge from both natural infiltration (dependent on infiltration rate and infiltration capacity of material) and infiltration trenches. Information on boundary conditions is needed to determine controls on flow within the domain defined by the geometry.

Hydrogeologic Modeling: A hydrogeologic model is a mathematical formulation of the hydrologic behavior of the system. The description of the model should include model type, justification, documentation of code, verification, validation, calibration, sensitivity analyses, underlying assumptions, associated uncertainties, limitations, physical laws considered, input data, data reduction and/or generation techniques, and discussion of suitability. Output may include simulated pressure heads, fluxes, discharge, and flow velocities and directions. Modeling is required to provide an integrated understanding for the unsaturated flow regime for site characterization, and to allow a variety of sensitivity and scenario options to be evaluated in support of site performance assessment.

TABLE B-2(b)
PARAMETER DESCRIPTIONS - GROUND-WATER HYDROLOGY

SATURATED FLOW

Hydraulic Head: The hydraulic head is the sum of the elevation of the point of measurement (elevation head) and the pressure head. Fluid will flow from higher hydraulic head to lower. The hydraulic gradient is the difference in hydraulic head divided by the distance over which it occurs. Information on hydraulic head is needed for determining rates and directions of ground-water flow.

Hydraulic Conductivity: Hydraulic conductivity is a measure of the ability of a material to transmit water. Hydraulic conductivity depends on the specific weight and viscosity of the water and the intrinsic permeability of the material. In general, hydraulic conductivity has directional variability (anisotropy). Information on hydraulic conductivity is needed for determining rates of ground-water flow.

Porosity (Total and Effective): Total porosity is the ratio of void volume to the total volume of a sample. Total porosity approximately equals the sum of two related parameters, specific yield (the amount of water released by a material due to the force of gravity) and specific retention (the amount of water retained by a material under the force of gravity). Effective porosity is the ratio of interconnected void volume in which ground water is able to circulate, to the total volume of a sample. Information on porosity is needed for determining the transport of solutes dissolved in the ground water.

Specific Storage: The specific storage is the amount of water in storage that is released from a unit volume of aquifer per unit decline in head. The related coefficient, storativity or storage coefficient, is the amount of water released from a column of aquifer with unit cross section under a unit decline of head. In unconfined aquifers, storage is measured in terms of the specific yield, a measure of the drainable porosity, whereas in confined aquifers, specific storage and storativity are functions of porosity (the proportion of void space in a sample), fluid compressibility, and medium compressibility. (Compressibility describes the change in volume induced in a material by an applied stress.) Information on specific storage is needed for determining rates and directions of ground-water movement when boundary conditions are changing with time.

Geometry: The geometry includes hydrostratigraphy (e.g., thickness, lateral extent, continuity, hydraulic interconnectivity, elevation, depth, stratigraphic relationships), location of pathways (e.g., faults, sand lenses, weathered horizons, karstic features, joint systems, solution features), location of barriers (e.g., fracture zones, dikes), location of recharge and/or discharge zones, location of wells and the location of the disposal facility. The geometry should be characterized to a depth of at least 30 m below the site. Information on geometry is needed to define the domain in which flow is studied.

Boundary Conditions: Boundary conditions are defined heads or fluxes due to steady state and/or transient recharge from infiltration and injection wells, and discharge from springs and domestic, industrial, irrigation and municipal wells. Information on boundary conditions is needed to determine controls on flow within the domain defined by the geometry.

Hydrogeologic Modeling: A hydrogeologic model is a mathematical formulation of the hydrologic behavior of the system. Proper model documentation should include model type, justification, documentation of code, verification, validation, calibration, sensitivity analyses, underlying assumptions, associated uncertainties, limitations, physical laws considered, input data, data reduction and/or generation techniques, and discussion of suitability. Output should include simulated heads and ground-water flow velocities, fluxes, discharge, and directions. Modeling is required to provide an integrated understanding of the saturated flow regime for site characterization, and to allow a variety of sensitivity and scenario options to be evaluated in support of site performance objectives.

TABLE B-2(a)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Unsaturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Moisture Potential	Review literature and compile data for previous site-specific work	Laboratory reports Field test reports	Federal, State, and county water surveys and hydrologic studies Graduate theses Articles in professional journals American Water Works Association National Water Well Association	
	Estimate gravitational potential from elevation differences on topographic maps	Topographic maps, graphs, tables	U.S. Geological Survey topographic maps	Richards (1965) Phene et al. (1971a,b) Brown and van Haveren (1972) Hillel (1980) ASTM (1987b) ASTM (1987d) Wilson (1981) University of Arizona (1985)
	Perform field studies of matric potential. Equipment used depends on the expected range of values of pressure or suction and depth of instrumentation below land surface. Measurements in lower ranges (0 - 0.8 bar) may be made using porous cup tensiometers; for higher ranges (0 - 50 bars), thermocouple psychrometers may be used. Electrical resistance blocks (electrodes embedded in gypsum, nylon, or fiberglass) can also be used to measure in situ matric suction. Blocks made of fiberglass are highly sensitive to small variations in salinity of the soil solution. Gypsum blocks buffer this effect but are soluble and deteriorate in the soil. These blocks tend to be more dependable in the drier than in the wetter range. Heat dissipation sensors may also be used.	Field reports	Results of site characterization investigations	

TABLE B-2(a)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Unsaturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Moisture Potential (Cont.)	Integrate results of studies with other parameters in hydrologic model to predict water retention, moisture content, infiltration rates, fluid conductivity and direction of water movement in the unsaturated zone	Mathematical models	Results of site characterization investigations	Van del Heljide et al. (1985)
Moisture Content	<p>Perform literature review and compile data for previous site-specific work</p> <p>Perform laboratory measurements of moisture content on soil samples retrieved for geotechnical and geological investigations (See Tables B-1 and B-2) using gravimetric techniques. Develop soil-moisture characteristic curves using a porous-plate assembly for in the low suction range or a pressure-membrane apparatus for the higher suction range (greater than 1 bar).</p> <p>Perform field measurement of moisture content by neutron scattering, gamma-ray attenuation, electrical capacitance, ultrasonic waves, and/or by determining the dependence of soil thermal properties on water content. Soil moisture can also be measured indirectly from electrical resistance methods described for moisture potential measurements above.</p>	<p>Laboratory reports Field test reports</p> <p>Laboratory reports</p> <p>Field Reports</p>	<p>County soil surveys Siting studies for other sites in area Agricultural extensions Commercial laboratories</p> <p>Results of site characterization investigations</p>	<p>U.S. Department of the Interior (1977) Hillel (1980) University of Arizona (1985) ASTM (1987a)</p> <p>U.S. Department of the Interior (1977) Hillel (1980) Morrison (1983) University of Arizona (1985) ASTM (1987a)</p>

TABLE B-2(a)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Unsaturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Moisture Content (cont.)	Monitor fluctuations in moisture content due to seasonal variations and to extreme wet or dry conditions for a minimum period of one year	Field reports	Results of site monitoring	DOE (1983)
	Integrate estimates of moisture content with other hydrologic parameters in hydrologic model to predict fluid conductivity, hydraulic gradients and, hence, direction of moisture movement and vapor transport	Mathematical models	Results of site characterization investigations	Van der Heljide et al. (1985)
Hydraulic Conductivity	Review literature and compile data for previous site-specific studies (Note that unsaturated hydraulic conductivity must be derived as a function of moisture content and pressure using moisture characteristic curves, and is temporally and spatially variable)	Numerical estimates of conductivity	State and county water surveys and hydrologic investigations Graduate theses U.S. Geological Survey Water Supply Papers American Water Works Association National Water Well Association Articles in professional journals U.S. Geological Survey Water Supply Papers State and county water surveys and hydrologic investigations	Gardner (1956) American Society of Agronomy (1965) Watson (1966) U.S. Bureau of Reclamation (1978) Hillel (1980) DOE (1983) University of Arizona (1985) ASTM (1987c)
	Perform laboratory measurements of porous media samples, using: constant-head tests pressure-chamber/pressure-plate tests outflow tests "instantaneous profile" techniques gamma-ray scanning	Laboratory reports Charts, graphs	Commercial laboratories	

TABLE B-2(a)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (unsaturated flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Hydraulic Conductivity (cont.)	Perform field measurements, using: auger-hole methods piezometer methods single-well drawdown tests slug tests ring and double-ring permeameter tests shallow-well pump-in tests air-entry method sprinkling infiltration instantaneous profile crust impedance draining profile	Field test reports	Results of site characterization Investigations	American Society of Agronomy (1965) Watson (1966) Hillel and Gardner (1970) DOE (1983) Gardner (1970) Hillel (1980) University of Arizona (1985)
	Integrate data from geologic mapping to determine presence of fracture systems that could have major effects on permeability	Geologic maps Geologic reports	Site and area geologic studies (see Table B-1, Structure)	Lutton et al. (1982)
	Integrate estimates of hydraulic conductivity with other hydrologic parameters in hydrologic model to determine hydraulic gradients, flow directions, flow velocities, and quantities; use estimates in geotechnical evaluations and engineering design studies (see Table B-7)	Mathematical models Design studies	Results of site characterization Investigations	Van der Heide et al. (1985)
Porosity (Total and Effective)	Review literature and compile data for previous site-specific studies	Laboratory reports Field reports	Local, county, and state hydrologic studies Graduate theses Professional journals U.S. Geological Survey Water Supply Papers Agricultural extensions	

TABLE B-2(a)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Unsaturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Porosity (cont.)	Perform laboratory analysis using: bulk-density methods soil core methods air-pressure methods	Laboratory reports Numerical estimates of porosity	Commercial laboratories	American Society of Agronomy (1965) U.S. Army Corps of Engineers (1970) Lutton et al. (1982) DOE (1983)
	Make field measurements using: geophysical logging techniques (attenuation of neutron gamma or sonic transmissions) electrical resistivity studies tracer tests	Geophysical logs Well logs	Results of site characterization investigations	Lenda and Zuber (1970) U.S. Army Corps of Engineers (1970) Keys and McCary (1971)
	Incorporate data from geologic studies to characterize potentially anisotropic fracture patterns that may affect porosity	Geologic maps Geologic reports	Site geologic studies (See Table B-1, Structure)	Lutton et al. (1982)
	Integrate porosity estimates into hydrologic models for simulating transient flow behavior and advection of solutes	Mathematical models	Results of site characterization investigations	Van der Heldje et al. (1985)
Geometry	Review literature and compile data for previous site-specific studies	Maps showing locations of wells Maps showing depth to water table Geological maps and cross sections	State and county water surveys and hydrologic studies U.S. Geological Survey Water Supply Papers Graduate theses Hydrologic atlases Previous site investigations Articles in professional journals U.S. Department of Agriculture National Oceanic and Atmospheric Administration (NOAA) WATSTORE data	

TABLE B-2(a)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Unsaturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Geology (cont.)	Perform field studies including site mapping of stratigraphy, soil types, locations of recharge and discharge zones, and sampling of soil and water for the water chemistry and geochemical geotechnical and geological studies (see Tables B-4, B-7, and B-1, respectively), as well as measuring water levels.	Well logs Potentiometric maps Geophysical logs	Results of site characterization investigations	U.S. Department of the Interior (1977)
	For at least one year monitor seasonal changes in depth to the water table, thickness of capillary fringe, locations of recharge and discharge zones	Maps and charts showing seasonal variations	Results of site characterization investigations	Lutton et al. (1982) Lutton et al. (1983) Compton (1985)
	Synthesize results of geometric studies to determine hydrogeologic unit of origin of any ground-water discharges to the surface and to characterize configuration of units within the disposal site	Reports Maps showing unit locations Maps showing ground-water discharge zones Hydrogeologic maps and cross-sections	Site and area geologic studies (see Table B-1, Structure)	Lutton et al. (1982)
	Integrate results of studies with other hydrologic parameters in a hydrologic model to define the shape and extent of the flow domain under investigation	Mathematical model	Results of site characterization investigations	Van der Heldje et al. (1985)
Boundary Conditions	Review literature and compile data for site-specific studies	Maps showing configuration of water table Maps showing well locations	Local, county, and state ground-water studies U.S. Department of Agriculture National Oceanic and Atmospheric Administration (NOAA)	Compton (1985)
	Perform field studies involving infiltration tests, evapotranspiration and precipitation studies (see Table B-11); measure depth to water table	Meteorological reports Maps showing evapotranspiration rates Well logs Hydrogeologic maps	Results of site characterization investigations	Compton (1985)

TABLE B-2(a)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Unsaturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Boundary Conditions (cont.)	Integrate results of studies with other hydrologic parameters in a hydrologic model to define external controls on the flow regime under investigation	Mathematical model	Results of site characterization investigations	Van der Heijde et al. (1985)
Hydrogeologic Modeling	<p>Survey ground-water users to determine characteristics of points of extraction, productive aquifers, and water quality</p> <p>Review literature for applicable models</p> <p>Devise the conceptual model of the system including any important processes and boundaries. Define information needs and collect field and laboratory data including the parameters discussed in this table. Based on the conceptual model, implement the desired mathematical model. For relatively simple processes and boundary conditions, analytical solutions can be used. For more complex problems, numerical codes are available. Perform model calibration based on field and laboratory data and perform sensitivity analyses and predictive studies.</p>	<p>See Table B-5</p> <p>Documentation of computer models</p> <p>Well logs Geophysical logs Sample data Input parameters may include any of the parameters described in this table</p>	<p>See Table B-5</p> <p>Federal and State site studies that include documentation of models used</p> <p>Results of site characterization investigations</p>	<p>See Table B-5</p> <p>Oster (1982)</p> <p>Lutton et al. (1982) Oster (1982) DOE (1983) Van der Heijde et al. (1985)</p>

TABLE B-2(b)

SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Saturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Hydraulic Head	Review literature and compile data for previous site-specific measurements of hydraulic head	Laboratory reports Field test reports	Federal, State, and local water surveys and hydrologic investigations Graduate theses American Water Works Association National Water Well Association Articles in professional journals	Lutton et al. (1983) DOE (1983) University of Arizona (1985)
	Measure piezometric head in new and existing wells on and offsite for at least one year. Early in site characterization, readings may be taken continually to establish baseline measurements; later in the program, readings may be taken less frequently; use for understanding hydraulic interrelationships between hydrogeologic units, and for comparison with heads calculated during hydrogeologic model simulations	Well logs Vertical profiles of head variations, including changes with lithology Potentiometric maps for each hydrogeologic unit	Results of site characterization investigations	
Hydraulic Conductivity	Review literature for previous site-specific studies	Numerical estimates of conductivity	State and county water surveys and hydrologic investigations Graduate theses U.S. Geological Survey Water Supply Papers American Water Works Association National Water Well Association Articles in professional journals State, county, and local hydrologic studies	
	Perform laboratory measurements of aquifer samples, using constant-head or falling-head permeameter tests	Laboratory reports	Commercial laboratories	American Society of Agronomy (1965) Lohman (1979) DOE (1983) University of Arizona (1985)

TABLE B-2(b)

SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Saturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Hydraulic Conductivity (continued)	Perform field measurements, using: constant-head aquifer tests constant flow rate aquifer tests sing Injection/withdrawal tests and/or drill-stem tests	Charts, graphs, field reports	Results of site characterization investigations	Lohman (1979) Lutton et al. (1982) DOE (1983)
	Integrate data from geologic mapping to determine presence of fracture systems that could have major effects on permeability	Geologic maps Geologic reports	Site geologic studies (See Table B-1, Structure)	Lutton et al. (1982)
	Integrate estimates of hydraulic conductivity with other hydrologic parameters in hydrologic model to determine flow velocities and flux rates; use estimates in geotechnical evaluations and engineering design studies	Hydrologic models	Results of site characterization investigations	Van der Hende et al. (1985)
Porosity (Total and Effective)	Review literature and compile data for previous site-specific studies	Laboratory reports Field reports	Local, county, and state hydrologic studies Graduate theses Professional journals U.S. Geological Survey Water Supply Papers Agricultural extensions	American Society of Agronomy (1965) U.S. Army Corps of Engineers (1970) Lutton et al. (1982) DOE (1983)
	Perform laboratory analysis using: bulk-density methods soil core methods air-pressure methods	Laboratory reports Numerical estimates of porosity	Commercial laboratories	

B-2(b)-2

TABLE B-2(b)

SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Saturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Porosity (continued)	Make field measurements using: geophysical logging techniques (attenuation of neutron, gamma, or sonic transmissions) electrical resistivity studies tracer tests	Geophysical logs Well logs	Results of site characterization Investigations	Lenda and Zuber (1970) U.S. Army Corps of Engineers (1970) Keys and MacCary (1971)
	Incorporate data from geologic studies to characterize potentially anisotropic fracture patterns that may affect porosity	Geologic maps Geologic reports	Site geologic studies (See Table B-1, Structure)	Lutton et al. (1982)
	Integrate porosity estimates into hydrologic models to determine solute transport velocities from flux rates	Mathematical models	Results of site characterization Investigations	Van der Helder et al. (1985)
	Review literature and compile data for previous site-specific studies	Laboratory reports Field test reports	U.S. Geological Survey Water Supply Papers Student theses State and county water survey and hydrologic investigations Professional journals	
Specific Storage	Perform field investigations through aquifer pumping tests; Integrate into hydrologic models to define transient response to changes in hydraulic head	Field test reports	Results of site characterization Investigations	Lohman (1979)

TABLE B-2(b)

SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Saturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Geometry	Review literature and compile data for previous site-specific studies	Reports Hydrologic maps	U.S. Geological Survey Water Supply Papers WATSTORE data (computerized) Professional journals Graduate theses State, local, and county water studies Agricultural extensions U.S. Department of Agriculture NOAA	
	Perform field studies including site mapping of stratigraphy and lithology (see Table B-1), drilling of monitoring wells, and sampling water and soil. Specific activities may include water-level measurements, well-discharge measurements, construction of well logs, and location of possible fault zones (see Table B-1, Structure) or other potential recharge or discharge boundaries	Maps showing locations of wells, ground-water discharge sites, and the disposal facility Maps showing depth to the water table Hydrogeologic maps and cross-sections Well logs	Results of site characterization investigations	U.S. Department of the Interior (1977)
	Measure depth to the water table to monitor seasonal changes and changes due to recharge and discharge for at least one year	Meteorological charts, graphs	Results of site characterization investigations	Lutton et al. (1982) Lutton et al. (1983)
	Synthesize results of geometric studies to characterize configuration of units and boundary conditions within the disposal site and relationship between units	Flow nets Flow analyses Well logs Geologic maps Structure maps Hydrogeologic maps and cross-sections Maps showing unit locations and ground-water discharge zones	Site geologic studies (see Table B-1, Stratigraphy, Structure)	Lutton et al. (1982) Compton (1985)

TABLE B-2(b)

SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Saturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Geometry (continued)	Integrate results of studies with other hydrologic parameters in a hydrologic model to define the shape and extent of flow domain under investigation	Mathematical model	Results of site characterization investigations	Van del Heide et al. (1985)
Boundary Conditions	<p>Review literature and compile data for site-specific studies</p> <p>Perform field studies; may include:</p> <ul style="list-style-type: none"> Infiltration tests precipitation and evapotranspiration studies (see Table B-11) streamflow measurements discharge data for nearest domestic and municipal wells (historic, current, and projected) (see Table B-5, Water Resources) depth-to-water measurements 	<p>Maps showing configuration of water table</p> <p>Maps showing well locations</p> <p>Maps showing depth to water table</p> <p>Meteorological reports</p> <p>Field reports</p> <p>Stream-gage reports</p>	<p>Local, county, and state ground-water studies</p> <p>U.S. Department of Agriculture</p> <p>NOAA</p> <p>Results of characterization investigations</p>	<p>Lutton et al. (1982)</p> <p>Compton (1985)</p>
Hydrogeologic Modeling	Integrate boundary conditions with other parameters in hydrologic model to define external controls on the flow regime under investigation	Mathematical model	Results of site characterization investigations	Van del Heide et al. (1985)
	Survey ground-water users to determine characteristics of points of extraction, productive aquifers, and water quality	See Table B-5	See Table B-5	See Table B-5

TABLE B-2(b)

SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GROUND-WATER HYDROLOGY (Saturated Flow)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Hydrogeologic Modeling (continued)	<p>Review literature for applicable models</p> <p>Devise the conceptual model of the system including any important processes and boundaries. Define information needs and collect field and laboratory data including the parameters discussed in this table. Based on the conceptual model, implement the desired mathematical model. For relatively simple processes and boundary conditions, analytical solutions can be used. For more complex problems, numerical codes are available. Perform model calibration based on field and laboratory data and perform sensitivity analyses and predictive studies.</p>	<p>Documentation of computer models</p> <p>Well logs Geophysical logs Sample data Input parameters may include any of the parameters described in this table</p>	<p>Federal and State site studies that includes documentation of models used</p> <p>State, county, and local water studies</p> <p>Articles in professional journals</p> <p>Results of site characterization investigations</p>	<p>Lutton et al. (1982) DOE (1983) Van de Heidje et al. (1985)</p>

TABLE B-2
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TABLE B-3
PARAMETER DESCRIPTIONS - SURFACE-WATER HYDROLOGY

Hydrologic System: Hydrologic characterization of the site and adjacent watersheds. Identification and descriptions of the natural and man-made system components (i.e., streams, rivers, lakes, wetlands, coastal areas, soil, climate, dams, diversions, and land use) and their interrelationship.

Water Users: An inventory of past, present, and potential future surface-water users in the vicinity of the site and, in particular, within approximately 10 kilometers downstream of the site. Information should include the location, type and amount of use, number of users on the system, rate of withdrawal, percentage of stream flow withdrawn, sources of water supply, type of intake and pumping equipment, and surface water quality data. The inventory should identify the nearest down-gradient surface-water users and the nearest municipal supply relying on surface water.

Flood Studies: Evaluation of the flooding potential of the site and surrounding area to determine the Probable Maximum Flood (PMF). Information evaluated should include the date, water levels, peak discharge, and related information for major historic flood events in the region, including stream floods, surges, seiches, tsunamis, dam failures, ice jams, and floods induced by landslides.

Drought Studies: Evaluation of the occurrence of droughts at the site or surrounding areas. Historic drought water-surface elevations, specifically 7-day, 10-year low flows of affected streams and bodies of water, should be evaluated.

Precipitation: Rainfall and snowfall records that may be used to evaluate flooding and erosion potential. Characteristics to be evaluated include depth of precipitation, duration of storm, intensity of precipitation, recurrence intervals of precipitation, and Probable Maximum Precipitation (PMP).

Infiltration: The movement of water from precipitation into the soil. The infiltration rate of an area depends on the soil properties (e.g., grain size, density, porosity) and antecedent moisture conditions.

Runoff: The total amount of water flowing on the surface, commonly expressed as a depth of water over a specific area. This flow is usually either open channel flow if the water is confined to a channel, or overland flow if the water is flowing without a defined channel.

Discharge: The volumetric rate (flow rate) of runoff in a channel. Channel discharge commonly varies in response to storms. The discharge history of streams and rivers is statistically related to storm recurrence interval for use in evaluating flooding potential.

Channel Characteristics: The physical attributes of a channel (i.e., slope, cross sectional area, and roughness coefficient) that affect the channel's ability to convey a particular discharge.

Stage: The height of the water surface above an established datum; sometimes referred to as gage height because water-surface elevations are commonly made at stations by one of various gage types. River stage is commonly translated into discharge by stage-discharge relationships established for particular stations along a river or stream.

Flow Velocity: The velocity of water in a channel. An average velocity can be calculated for a specific discharge when particular channel characteristics are known. Flow velocity is commonly used to evaluate flooding by runup, erosion by scouring, and the transport capability of a stream or river.

Erosion: The breakdown or weathering of geologic materials and the transport of these materials away from their origin.

Sedimentation: The deposition of particulate material after being transported by surface water.

Hydrologic and Hydraulic Modeling: Analytical and numerical methods to simulate flow and transport at the site. The theoretical basis for each model, the uncertainties and limitations of the model, procedures to verify the codes, and results of model calibration, including model validation techniques and sensitivity analyses, must be described and justified.

Site Surface-Water Impact: Qualitative and quantitative descriptions of the impact of the site on the surface-water system from construction to closure. This would include the impact of any man-made features to minimize surface-water impacts.

TABLE B-3
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SURFACE-WATER HYDROLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Hydrologic System	Review regional and site-specific hydrologic, geographic, meteorological, and land use data and literature, and compile existing data relevant to the natural man-made components of the surface-water hydrologic system	Tests, publications, articles, reports, maps	U.S. Geological Survey U.S. Army Corps of Engineers U.S. Bureau of Reclamation U.S. Department of Agriculture State agencies and publications Colleges and Universities Theses and dissertations Professional journals Hydrologic texts/atlasses Nuclear plant FSAR's and SER's Data collected for geography, meteorology, and land use data types (see Tables B-8, B-9, B-10, B-11, B-12, B-13, B-14, B-15, B-16, B-17, B-18, B-19, B-20, B-21, B-22, B-23, B-24, B-25, B-26, B-27, B-28, B-29, B-30, B-31, B-32, B-33, B-34, B-35, B-36, B-37, B-38, B-39, B-40, B-41, B-42, B-43, B-44, B-45, B-46, B-47, B-48, B-49, B-50, B-51, B-52, B-53, B-54, B-55, B-56, B-57, B-58, B-59, B-60, B-61, B-62, B-63, B-64, B-65, B-66, B-67, B-68, B-69, B-70, B-71, B-72, B-73, B-74, B-75, B-76, B-77, B-78, B-79, B-80, B-81, B-82, B-83, B-84, B-85, B-86, B-87, B-88, B-89, B-90, B-91, B-92, B-93, B-94, B-95, B-96, B-97, B-98, B-99, B-100, B-101, B-102, B-103, B-104, B-105, B-106, B-107, B-108, B-109, B-110, B-111, B-112, B-113, B-114, B-115, B-116, B-117, B-118, B-119, B-120, B-121, B-122, B-123, B-124, B-125, B-126, B-127, B-128, B-129, B-130, B-131, B-132, B-133, B-134, B-135, B-136, B-137, B-138, B-139, B-140, B-141, B-142, B-143, B-144, B-145, B-146, B-147, B-148, B-149, B-150, B-151, B-152, B-153, B-154, B-155, B-156, B-157, B-158, B-159, B-160, B-161, B-162, B-163, B-164, B-165, B-166, B-167, B-168, B-169, B-170, B-171, B-172, B-173, B-174, B-175, B-176, B-177, B-178, B-179, B-180, B-181, B-182, B-183, B-184, B-185, B-186, B-187, B-188, B-189, B-190, B-191, B-192, B-193, B-194, B-195, B-196, B-197, B-198, B-199, B-200, B-201, B-202, B-203, B-204, B-205, B-206, B-207, B-208, B-209, B-210, B-211, B-212, B-213, B-214, B-215, B-216, 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TABLE B-3
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SURFACE-WATER HYDROLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Water Users (Cont.)	Inventory of past, present, and potential future surface-water users in the site vicinity and, in particular, within approximately 10 km downstream of the site to obtain the location, type and amount of use, number of users on the system, rate of withdrawal, percentage of stream flow withdrawn, sources of water supply, type of intake and pumping equipment, and water quality data	User location maps User data tables	Results of data collection for water resources parameter (see Table B-5)	Linsley et al. (1982)
Flood Studies	Review regional and site-specific flood data and literature, and compile existing flood data, including the date, water levels, peak discharge, and related information for major historic flood events in the region, including stream floods, surges, seiches, tsunamis, dam failures, ice jams, and floods induced by landslides	Topographic maps Flood hydrographs Publications, maps, articles, reports	U.S. Geological Survey U.S. Army Corps of Engineers U.S. Bureau of Reclamation Federal Emergency Management Agency State/County agencies and publications Colleges and Universities Theses and dissertations Professional journals Hydrologic texts/atlasses Nuclear plant FSAR's and SER's	
	Aerial photo interpretation and hydrologic mapping to locate and identify floodplain boundaries in the site area	Aerial photos Hydrologic maps	U.S. Geological Survey Commercial mapping contractor State and County agencies Field observations to confirm/revise existing data and aerial photo interpretation	Avery (1968) Reeves (1975) Way (1978) Compton (1985)

TABLE B-3
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SURFACE-WATER HYDROLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Flood Studies (Cont.)	Evaluation of the flooding potential and Probable Maximum Flood (PMF) for the site considering the date, water level, and peak discharge for major historic floods in the area	Text, tables, maps, cross sections	Results of site characterization investigations Data from precipitation parameter on Probable Maximum Precipitation to estimate PMF U.S. Army Corps of Engineers computer models HEC-1 for estimating peak flood discharges and HEC-2 for estimating water surface profiles and velocities	NRC (1977) ACE (1979) ACE (1981)
Drought Studies	Review regional and site-specific drought data and literature to obtain the historic drought water-surface elevations of nearby streams and water bodies, specifically the 7-day, 10-year low flows if historic drought data are not available, water surface elevations may be obtained by mathematical models using historic precipitation data; tree ring measurements can be used to correlate with precipitation data	Drought hydrographs Publications, maps, articles, reports Drought hydrographs	U.S. Geological Survey U.S. Army Corps of Engineers U.S. Bureau of Reclamation U.S. Department of Commerce U.S. Department of Agriculture State/County agencies and publications Colleges and universities Theses and dissertations Professional journals Hydrologic texts/atlas Nuclear plant FSAR's and SER's Data from precipitation parameter	

TABLE B-3
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SURFACE-WATER HYDROLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Precipitation	Review regional and site-specific meteorological data and literature to obtain precipitation depth, precipitation intensity, and recurrence interval of precipitation events, storm duration, and Probable Maximum Precipitation (PMP)	Rainfall and snowfall records	Data from meteorology data type (see Table B-11, Precipitation) National Weather Service Hydrometeorological Reports for estimating the PMP	Linsley et al. (1982)
Infiltration	Review regional and site-specific infiltration data and literature, and compile existing data	Tables Calculations	U.S. Geological Survey U.S. Department of Agriculture State/County agencies and publications Colleges and universities Theses and dissertations Professional journals Hydrologic texts/atlasses	Musgrave and Holton (1964) U.S. Geological Survey (1977) Dunne and Leopold (1978) Luffon et al. (1982) ASTM (1985)
	Measure infiltration at site with infiltrometers or tensiometers in different geologic/engineering units, and determine the infiltration rate, incorporating the potential effects of vegetational succession on water infiltration	Tables Calculations	Results of characterization investigations and site monitoring Results of data collection for terrestrial flora species (see Table B-14, Ecology)	
Runoff	Review regional and site-specific runoff data and literature, and compile existing data	Tables Calculations	U.S. Geological Survey U.S. Department of Agriculture State/County agencies and publications Colleges and universities Theses and dissertations Professional journals Hydrologic texts/atlasses	

TABLE B-3
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SURFACE-WATER HYDROLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Runoff (cont.)	Calculate runoff at site using published precipitation and infiltration data collected during site characterization, or measure runoff from isolated soil plot into a volumetric tank or flume	Tables Calculations	Results of data collection for precipitation and infiltration parameters Results of site characterization investigations and site monitoring	Nusgrave and Holton (1964) U.S. Geological Survey (1977) Dunne and Leopold (1978) Linsley et al. (1982) Lutton et al. (1982)
Discharge	Review regional and site-specific discharge data and literature, and compile existing data	Tables Hydrographs	U.S. Geological Survey U.S. Department of Agriculture U.S. Army Corps of Engineers U.S. Bureau of Reclamation State/County agencies and publications Colleges and universities Theses and dissertations Professional journals Hydrologic texts/atlas	
	Calculate discharge in site area channels at site-specific gaging stations or measure discharge with weirs or flumes in site area channels	Tables Calculations Hydrographs	Results of site characterization investigations and site monitoring	U.S. Bureau of Reclamation (1967) Buchanan and Somers (1968b) Carter and Davidian (1968) ASTM (1975a and b) U.S. Geological Survey (1977) Dunne and Leopold (1978) Brakensiek et al. (1979) Linsley et al. (1982) Lutton et al. (1982)
Channel Characteristics	Measure channel slope, cross sectional area, and shape using tag line, transit-stadia, or sounding methods, and estimate roughness for site area channels	Topographic maps Cross sections Channel profiles	Results of site characterization investigations	Chow (1964) Barnes (1967) U.S. Geological Survey (1977) Dunne and Leopold (1978) Fetter (1980)

TABLE B-3
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SURFACE-WATER HYDROLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Stage	Review regional and site-specific stage data and literature, and compile existing data	Tables Hydrographs	U.S. Geological Survey U.S. Department of Agriculture U.S. Army Corps of Engineers U.S. Bureau of Reclamation State/County agencies and publications Colleges and universities Theses and dissertations Professional journals Hydrologic texts/atlasses	Buchanan and Soopers (1968a) U.S. Geological Survey (1977) Dunne and Leopold (1978) Linsley et al. (1982)
	Measure stage in site area channels using recording gages at site-specific gaging stations	Tables Calculations Hydrographs	Results of site characterization investigations and site monitoring	
Flow velocity	Review regional and site-specific flow velocity data and literature, and compile existing data	Tables	U.S. Geological Survey U.S. Department of Agriculture U.S. Army Corps of Engineers U.S. Bureau of Reclamation State/County agencies and publications Colleges and universities Theses and dissertations Professional journals Hydrologic texts/atlasses	Chow (1964) U.S. Bureau of Reclamation (1967) Carter and Davidson (1968) Buchanan and Soopers (1968b) Smoot (1974) U.S. Geological Survey (1977) Linsley et al. (1982) DOE (1983)
	Measure flow velocity in site area channels with current meters, acoustic velocity meters, drag-body-type meters, floats, or tracers at site-specific gaging stations	Tables Calculations	Results of site characterization investigations and site monitoring	

TABLE B-3
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SURFACE-WATER HYDROLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Erosion	Review regional and site-specific erosion data and literature, and compile existing data	Hydrologic atlases Soil maps and charts Publications and reports	U.S. Geological Survey U.S. Department of Agriculture U.S. Army Corps of Engineers U.S. Bureau of Reclamation State/County agencies and publications Colleges and universities Theses and dissertations Professional journals Hydrologic texts/atlasses	Hubbel (1964) Gref (1971) U.S. Geological Survey (1977) Dunne and Leopold (1978) University of Arizona (1985)
	Measure sediment load in site area channels with Parshall flume or sediment sampler to determine erosion characteristics	Tables Calculations	Results of site characterization investigations and site monitoring	
	Compute erosion rates using models based on the Universal Soil Loss Equation (U.S. Agricultural Research Service, 1961) or physically based models such as CREAMS (Chemical Runoff Erosion from Agricultural Management Systems) (Knisel, 1980); incorporate the potential effects of vegetational succession on soil erosion	Tables Calculations Models	Results of site characterization investigations and site monitoring Results of data collection for terrestrial flora species (see Table B-14, Ecology)	Musgrave (1947) U.S. Agricultural Research Service (1961) Knisel (1980)

TABLE B-3
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SURFACE-WATER HYDROLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Sedimentation	Review regional and site-specific sedimentation data and literature, and compile existing data	Hydrologic atlases Soil maps and charts Publications and reports	U.S. Geological Survey U.S. Department of Agriculture U.S. Army Corps of Engineers U.S. Bureau of Reclamation State/County agencies and publications Colleges and universities Theses and dissertations Professional journals Hydrologic texts/atlasses	Hubbel (1964) Gret (1971) U.S. Geological Survey (1977) Dunne and Leopold (1978) Kaisel (1980) Wilson et al. (1981) University of Arizona (1985)
	Measure sediment load in site area channels with Parshall flume or sediment samplers to determine sedimentation characteristics and the rate of sediment transport and deposition	Tables Calculations	Results of site characterization investigations and site monitoring	ACE (1977)
	Compute sediment transport capacity and deposition using computer models such as HEC-6	Tables Calculations Models	Results of site characterization investigations and site monitoring	
Hydrologic and Hydraulic Modeling	Review potential analytical and numerical methods for modeling surface water flow and radionuclide transport	Reports, publications, equations, computer codes	U.S. Geological Survey U.S. Army Corps of Engineers U.S. Bureau of Reclamation U.S. Department of Agriculture U.S. Nuclear Regulatory Commission State agencies and publications Colleges and universities Theses and dissertations Professional journals and organizations	

TABLE B-3
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SURFACE-WATER HYDROLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Hydrologic and Hydraulic Modeling (cont.)	Verify and calibrate the model, establish uncertainties and limitations of the model, and run the model	Input data collected for meteorology, surface water, ground-water, and geochemistry/hydrochemistry parameters. Output data may be tables, graphs, or maps	Results of surface-water investigations, and geology (see Table B-1, Geomorphology, Geologic Hazards), meteorology (see Table B-11, Precipitation), ground-water (see Table B-2, Hydrogeologic Modeling), and geochemistry/hydrochemistry (see Table B-4, Geochemical Model, Transport Analysis) studies	American Nuclear Society (1982)
	Perform sensitivity analyses of model output	Input range of data values collected for meteorology, surface water, ground-water, and geochemistry/hydrochemistry parameters. Output data may be tables, graphs, or maps	Results of surface-water investigations, and geology (see Table B-1, Geomorphology, Geologic Hazards), meteorology (see Table B-11, Precipitation), ground-water (see Table B-2, Hydrogeologic Modeling), and geochemistry/hydrochemistry (see Table B-4, Geochemical Model, Transport Analysis) studies	McCuen and Snyder (1986)
Site Surface-Water Impact	Describe, both qualitatively and quantitatively, the impact of the site facility on the surface-water system from construction until closure, specifically the impact on discharge, velocities, flooding potential, and water quality (i.e., total suspended solids, turbidity)	Text, maps, cross sections, tables, graphs Mathematical models	Facility designer/engineer Results of surface-water site characterization investigations	NUS Corporation (1985) Torno (1985)

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TABLE B-4
PARAMETER DESCRIPTIONS - GEOCHEMISTRY/HYDROCHEMISTRY

Water Quality: The particular range of chemical attributes that is characteristic of a surface or ground water. Important chemical species for water-quality characterization include total dissolved solids, dissolved oxygen, carbon dioxide and fluoride, major ions, nutrients, dissolved iron and manganese, dissolved heavy metals, silica, oil and grease, and various toxicants. Major ions include the cations sodium, potassium, calcium, and magnesium, and the anions sulfate, chloride, bicarbonate, and carbonate. Nutrients typically include total and dissolved organic carbon, orthophosphate, total phosphorous, nitrate, ammonia, and total kjeldahl nitrogen. Heavy metals typically include copper, zinc, nickel, and hexavalent chromium. Toxicants that are present, are suspected as present, or potentially may be introduced to the water will be determined during site characterization. These may include both inorganic chemicals (e.g., dissolved arsenic, dissolved boron, radionuclides) and organic chemicals (e.g., herbicides, pesticides, volatile organics). Hardness, pH, alkalinity, water-quality indicator organisms, turbidity, and nature of colloidal materials in the water will also be determined in a complete water-quality assessment. The particular water characteristics to be determined during site characterization will be a function of site location and of the composition of the waste to be disposed.

Ion-Exchange Capacity: The extent to which a material will exchange ions that are adsorbed on its surface with dissolved ions that are present in a surrounding fluid. The ion-exchange capacity depends on a number of factors, including the material type, concentrations and number of dissolved species present in solution, and system pH. The cation-exchange capacity (CEC) is of particular interest in soil and subsurface environments. Soils with high clay content, and particularly with high organic content, typically will have a high CEC. Cations, such as many of the dissolved radionuclides that migrate through these materials, will be effectively retarded during transport as a result of ion exchange.

Organic Content: The proportion of organic matter present in soil. The organic matter may be comprised of living and decomposed plants, roots, and detritus. Organic constituents that may be quantified include total organic carbon (TOC), total and volatile organic acids, chelating agents, tannin, lignin, soil nutrients (e.g., nitrate, ammonia, phosphate), and microorganisms (e.g., total bacteria, coliforms). Constituents may be analyzed in soil and in soil gas. Organic matter, and particularly root systems, can provide pathways for chemical migration through soils and to the soil surface. The organic soil fraction typically has a high sorptive capacity and thus can increase the soil CEC. Organics also may leach and mobilize inorganic constituents in soil. Certain organics may behave as chelating agents, which can bind metallic ions (e.g., radionuclides). The chelating agents, when dissolved in water, may provide a transport mechanism for metals that are normally non-mobile.

Eh-pH: Eh is commonly referred to as the redox potential, and is a measure of the tendency of a solution to oxidize or reduce susceptible constituents. pH refers to hydrogen ion activity, and is a measure of the acidity of a solution. Both Eh and pH are typically measured using potentiometric probes. Eh may also be estimated from measured concentrations of both members of redox couples, such as iron species. To address possible redox disequilibrium, if a single Eh value is required for modeling purposes, that value should be determined from as many sources as is practical. The assumptions and methods used in defining an overall Eh for model calculations should be stated and justified. The relationship between Eh and pH in aqueous systems is commonly illustrated on Eh-pH diagrams. These diagrams can be used to predict stability fields of the various chemical species. Thus, for a given Eh and pH, species that are likely to exist and that contain elements of interest (e.g., radionuclides) can be determined. Eh-pH diagrams can be used to predict the behavior of elements such as radionuclides in the local environment.

Distribution coefficient: The ratio reflecting the allocation of a species between two phases in an aqueous or rock system. In particular, this parameter is useful for estimating the fraction of a species that will be allocated to the aqueous phase and therefore will remain mobile, and the fraction allocated to the solid phase that will be immobile. The distribution coefficient is an empirical parameter whose value is strongly dependent upon site specific or experimental conditions. The distribution coefficient includes the effects of ion exchange and other sorption reactions. This parameter can be used to estimate the extent of retardation of a dissolved species during transport, but the accuracy of that estimate will strongly depend upon the extent to which the conditions approximate those under which the distribution coefficient was measured.

Temperature: The temperature of both in-situ ground water and surface water. This parameter is important because the other parameters are temperature sensitive.

Radiometric dating: Determination of the age of the ground water or rock on the basis of radioisotope abundances.

Isotope Content: The quantity of radioactive and other isotope constituents present in the soil and water.

Soil Mineralogy and Mineral Solubility: The types of minerals present in a soil; also includes their weathering and engineering characteristics. Soil mineralogy is important as it relates both to radionuclide migration and to engineering behavior. Mineral solubility refers to the tendency of soil minerals to dissolve into aqueous phases present in the system. Description of mineral solubility should include the range of chemical and physical conditions bounding various stability fields.

Hydrodynamic Dispersion Coefficient: The hydrodynamic dispersion coefficient describes dispersion of a contaminant in ground water. Dispersion is a result of two processes: molecular diffusion and mechanical mixing. Diffusion is the process whereby contaminants move under the influence of their kinetic

activity in the direction of their concentration gradient. Mechanical mixing or mechanical dispersion is a result of velocity variations within the porous medium. The hydrodynamic dispersion coefficient is dependent on the diffusion coefficient, the concentration gradient, the longitudinal and transverse dispersivities, and the velocity field.

Geochemical Model: A mathematical formulation of predicted geochemical behavior of the rock-soil-ground-water system. Description of such a model should include information on the database used, validation exercises applied, and the capabilities and limitations of the model.

Transport Analysis: A mathematical formulation of predicted transport behavior in the saturated and unsaturated ground-water system. Processes of dispersion, diffusion, adsorption, degradation, and radioactive decay may be included in transport analyses.

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Water Quality	Literature review for previous studies of areas with similar geologic and ground-water conditions, to establish a site ground-water and surface-water monitoring system on the basis of expected conditions	Laboratory reports Water-quality tabulations	Agricultural laboratories State soil and water surveys U.S. Geological Survey State, county, and local water agencies	
	Field Activities: Sampling of surface-water bodies receiving site drainage Sampling of on-site and near-site water bodies Establishment of ground-water monitoring wells (coordinate with ground-water saturated flow studies, see Table B-2(b)) Sampling of ground-water monitoring wells	Maps, field reports	Results of field investigations	U.S. Dept. of the Interior (1977a) Gibb et al. (1981) Scalf et al. (1981) Thornton et al. (1982) Lutton et al. (1983) Casey et al. (1983) DOE (1983) Korte and Kearn (1985)

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Water Quality (continued)	<p>Laboratory testing to quantify important chemical species. The field sampling program should reflect the complexity of the local hydrologic regime, with more sampling stations for more complex systems. It is important to avoid perturbing the system before baseline parameters have been established, and to avoid loss of volatile components. Sampling frequency should be sufficient to quantify seasonal variations in water quality parameters. At a minimum, baseline parameters should be sampled quarterly for a period of at least one year. Specific items that should be sampled include: total dissolved solids, dissolved oxygen, carbon dioxide and fluoride, major ions, nutrients, dissolved iron and manganese, dissolved heavy metals, silica, oil and grease, and various toxicants. Hardness, pH, alkalinity, water-quality indicator organisms, turbidity, and nature of colloidal materials in the water should also be determined.</p> <p>Analytical methods may include:</p> <ul style="list-style-type: none"> Atomic absorption spectrophotometry Flame photometry Emission spectrophotometry Polarography Potentiometric infiltration Specific ion electrodes and probes Gas chromatography 	Laboratory reports, tables, graphs	Commercial laboratories	<p>U.S. Dept. of the Interior (1977a, b) Lutton et al. (1982) ASTM (1982) EPA (1983) American Public Health Association (1985)</p>

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Ion-exchange Capacity	Literature review for previous tests performed on site soils	Laboratory reports Site and area soils maps	Theses and dissertations State and county soil surveys U.S. Dept. of Agriculture Agricultural laboratories State, county, and local soil and water agencies State, county, and local planning departments	Hesse (1971) American Society for Agronomy (1965a) Lutton et al. (1982) EPA (1983) Davis et al. (1984)
	Laboratory testing of site soils sampled for geotechnical and geological analysis (see Table B-7, Soil Classification and Engineering Properties; see Table B-1, Stratigraphy and Lithology) for cation- and anion-exchange capacity, using saturation method or Mehlich method	Laboratory Reports Site and area soils maps	Commercial laboratories	
Organic Content	Literature review for previous estimates of organic content of soils in site or vicinity	Numeric estimates Reports, charts, maps	Theses and dissertations Previous site investigations for soil and soil gas reconnaissance Agricultural laboratories State soil surveys Power-plant Preliminary and Final Safety Analysis Reports (PSARs and FSARs)	Gibb et al. (1961) Sealf et al. (1961) DOE (1983) Lutton et al. (1983)
	Field Activities: Soil gas sampling Soil sampling (coordinate with Soil Classification and Engineering Properties, see Table B-7; Stratigraphy and Lithology, see Table B-1)		Results of site investigations	

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Organic Content (continued)	Laboratory analysis may include ignition of acid-treated samples; gas chromatography on soil or gas samples from site. Characteristics of interest include total organic carbon (TOC), volatile acids, total organic acids, chelating agents, tannin, lignin, nitrate, ammonia, phosphate and total and coliform bacteria	Laboratory reports Soil maps	Commercial laboratories	American Society of Agronomy (1965b) U.S. Dept. of the Interior (1977a, 1977b) ASTM (1982) EPA (1983) American Public Health Association (1985)
Eh-pH	Literature review for previous estimates of Eh-pH of site soils and water Field measurements with potentiometric measuring devices: Eh may also be approximated by measuring both members of a redox couple. To address possible redox equilibrium, if a single Eh value is required for modeling purposes, that value should be determined from as many sources as is practical. Assumptions and methods used in defining an overall Eh for model calculations should be explicitly stated and justified.	Laboratory reports, tables Borehole logs, charts Laboratory reports	Agricultural extension services State soil and water surveys U.S. Geological Survey State, county, and local water agencies Results of site investigations	Lindberg and Runnells (1984) University of Arizona (1985)
	Soil sampling (coordinate with Soil Classification and Engineering Properties, see Table B-7; Stratigraphy and Lithology, see Table B-1); Water Sampling (coordinate with Water Quality)		Results of site investigations	Gibb et al. (1981) Scalf et al. (1981) DOE (1983) Lutton et al. (1983)

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Eh-pH (cont.)	Laboratory analysis of soil and water samples using potentiometric measuring devices, or tests that quantify redox couples. To address possible redox equilibrium, if a single Eh value is required for modeling purposes, that value should be determined from as many sources as is practical. Assumptions and methods used in defining an overall Eh for model calculations should be explicitly stated and justified.	Laboratory reports, charts, graphs, Eh-pH diagrams	Commercial laboratories	American Society of Agronomy (1965a,b) ASTM (1982) Lutton et al. (1982) Davis et al. (1984) Lindberg and Runnells (1964) EPA (1986)
Distribution Coefficient	Literature review for previous site-specific estimates of distribution coefficients Soil sampling (coordinate with Soil Classification and Engineering properties, see Table B-7, Stratigraphy and Lithology, see Table B-1); water sampling (coordinate with water quality)	Reports	State soil and ground water reports Studies for landfill siting (from city and county planning and engineering departments) Agricultural laboratories Environmental impact statements Results of site investigations	Gibb et al. (1981) Scall et al. (1981) DOE (1983) Lutton et al. (1983)

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Distribution Coefficient (cont.)	<p>For sites where retardation processes will be relied upon, determine equilibrium distribution of elements of interest (not proxles) between undisturbed site soil samples and local ground water, using column tests or field tracer tests (in the case of field tracer tests, use of elements of interest should only be undertaken after consideration of the potential impacts of these radionuclides on future monitoring). For sites where transport analyses will consider hydrodynamic dispersion, distribution coefficients should be determined in the soil-water system through which transport may occur. The usefulness of distribution coefficients obtained in this manner is dependent on the extent to which the experimental conditions reflect field conditions. Because of this dependence, a literature survey for previously measured distribution coefficients (except for site-specific measurements) is not appropriate.</p>	Numerical estimates of distribution coefficients	Results of site investigations and literature review	DOE (1983) Davis et al. (1984) NEC (1987)

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Distribution Coefficient (continued)	Distribution coefficients are dependent on a number of site-specific factors, including pH, redox potential, solute chemistry, ion concentration, chemistry of leachate, and water content. Tests should be performed to determine the ranges of these variables likely to be encountered by migrating radionuclides. Caution should be exercised in that, within the current state of knowledge concerning the mechanisms of sorption processes, it is difficult to demonstrate that empirical distribution coefficients will be realistic, or even conservative, when applied to conditions outside of the specific experimental conditions and time frame of the sorption test			
Temperature	Literature review for previous site-specific investigations Direct field measurements of temperature; downhole measurements yield the most detailed data, and are usually made with sensors that detect changes in electrical resistivity	Numerical reports on borehole temperatures and variations Borehole logs Charts, tables	U.S. Geological Survey and State geothermal investigations Theses and dissertations Results of site investigations	Lutton et al. (1982)

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Radiometric Dating	Literature review for previous site-specific age determinations	Numerical age estimates	U.S. Geological Survey Theses and dissertations in geology, hydrology, environmental sciences Articles in professional journals State geological survey reports State hydrological survey reports	DOE (1983) Lutton et al. (1983)
	Soil sampling (coordinate with Soil Classification and Engineering properties, see Table B-7, Stratigraphy and Lithology, see Table B-1), water sampling (coordinate with Water Quality)		Results of site investigations	
	Laboratory isotopic analyses of water and soil samples to make age determinations. Methods used for water depend on its estimated age: Tritium: To determine whether water is less or more than 30 years old 14C: for water less than 40,000 years old Another method that may be used is based on 36Cl. Radiometric dating of soils may be done using 14C dating on caliche deposits; for reliable dating, these may not have incorporated younger carbon	Laboratory reports	Commercial laboratories	Feure (1977)

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Isotope Content	<p>Literature review for previous site-specific measurements</p> <p>Soil Sampling (coordinate with Soil Classification and Engineering Properties, see Table B-7; Stratigraphy and Lithology, see Table B-1); Water sampling (coordinate with Water Quality)</p> <p>Laboratory analysis for abundances of isotopes of interest:</p> <p>Oxygen 22Rn Hydrogen 226Ra 14C 228Ra 134Cs 3H 137Cs Thorium Series 60Co Uranium Series 131I Pu 90Sr</p>	<p>Numerical estimates of isotope contents</p>	<p>Theses and dissertations Articles in professional journals U.S. Geological Survey</p> <p>Results of site investigations</p>	<p>DOE (1983) Lutton et al. (1983)</p> <p>U.S. Dept. of the Interior (1977a, 1977b) American Public Health Association (1985) ASTM (1982) Lutton et al. (1982) Davis et al. (1984)</p>

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Soil Mineralogy and Mineral Solubility	<p>Literature search for previous descriptions of soil mineralogy in site area</p> <p>Laboratory analysis of site soils sampled for geotechnical, geochemical, and geological analyses (see Table B-7, Soil Classification and Engineering Properties; Table B-1, Stratigraphy and Lithology); Identify soil minerals through visual, petrographic, and X-ray diffraction (XRD) techniques. XRD is essential for identification of clays and other fine-grained soil minerals. Correlate grain-size distribution and mineral composition; determine mineral solubilities.</p>	<p>Lists and descriptions of minerals present and their relative solubilities</p> <p>Lists and descriptions of minerals present and their relative solubilities. Numerical estimates of solubilities of minerals present</p>	<p>U.S. Dept. of Agriculture Theses and dissertations State soil surveys Landfill studies Power-plant Preliminary and Final Safety Analysis Reports Site Investigations</p> <p>Commercial laboratories</p>	<p>Lutton et al. (1982) EPA (1983) ASTM (1987a) ASTM (1987b) ASTM (1987c)</p>
Hydrodynamic Dispersion Coefficient	<p>Literature review for previous estimates of hydrodynamic dispersion coefficient, and estimation of coefficients from values reported in the literature (for sites where ground-water travel time will be relied upon to limit potential radionuclide concentration)</p>	<p>Reports</p>	<p>State and county water-resource departments Agricultural laboratories</p>	

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Hydrodynamic Dispersion Coefficient (cont.)	Field analysis using single- or multiple-well tracer methods (In field tracer tests, use of elements of interest should only be undertaken after consideration of the potential impacts of these radionuclides on future monitoring); tracer tests are more difficult to perform in fine-grained soils	Field reports	Results of site investigations	Lenda and Zuber (1970) Gelhar and Collins (1971) Gelhar (1982) Lutten et al. (1982) DOE (1983)
	Laboratory analysis of aquifer materials; results from laboratory analyses must be used with caution because samples' properties may be significantly changed during retrieval. The values obtained from laboratory analysis are commonly much lower than those obtained from field measurements	Laboratory reports	Commercial laboratories	Lutten et al. (1982)

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Geochemical Model	<p>Define objectives of analysis and devise the conceptual model of the system to be modeled, including the important chemical processes to be considered. Define information needs and input field and laboratory data including geometry and parameters discussed in this table, as well as ground-water flow parameters and modeling results (see Table B-2). Based on the desired analysis and conceptual model, implement the desired mathematical model. For relatively simple processes, analytical solutions can be used. For more complex processes, several geochemical codes are available and should be chosen based on chemicals and processes to be modeled. Data base Quality Assurance and code validation should be thoroughly addressed in the application of these models. Perform model calibrations based on field and laboratory data and perform sensitivity studies</p>	<p>Input parameters may include all water quality and soil parameters described in this table</p>	<p>Results of site investigations Articles in professional journals Federal and State site studies Including documentation of models used</p>	<p>Mosler et al. (1980) Parkhurst et al. (1980) Ball et al. (1981) Intera (1983) NRC (1983)</p>

TABLE B-4
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOCHEMISTRY/HYDROCHEMISTRY

Parameter	Technical Activities/Study Methods	Data Formats	Data Source	References
Transport Analysis	<p>Define objectives of analysis and devise a conceptual model of the system including boundaries, recharge and discharge, and important processes to be considered. Define information needs and input field and laboratory data, including geometry, boundary conditions, and water quality parameters discussed in this table, as well as geochemical model results and ground-water flow parameters and modeling results (see Table B-2). Based on the conceptual model, implement the desired mathematical model. For relatively simple geometries and processes, analytical solutions could be used. For more complex processes, transport codes are available. Data base Quality Assurance and code validation should be thoroughly addressed in the application of these models. Perform model calibration based on field and laboratory data and perform sensitivity analyses</p>	<p>Input parameters may include all water quality parameters described in this table, as well as ground-water flow parameters and modeling results (see Table B-2)</p>	<p>Results of site investigations Articles in professional journals Federal and state site studies including documentation of models used</p>	<p>Mosler et al. (1980) DOE (1983) Savandek et al. (1984) NRC (1983) NRC (1984)</p>

TABLE B-4
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TABLE B-5
PARAMETER DESCRIPTIONS - WATER RESOURCES

Past and Present Ground-water Usage: An inventory of past and present ground-water users within approximately 2 kilometers of the site. Information should include the location, type and amount of use, hydrogeologic unit used, sources of water supply, type of well and pumping equipment, maximum production rate of well, and water quality data. The inventory should identify the nearest down-gradient ground-water users and the nearest municipal supply relying on groundwater.

Past and Present Surface-water Usage: An inventory of past and present surface-water users in the vicinity of the site and, in particular, within approximately 10 kilometers downstream of the site. Information should include the location, type and amount of use, number of users on the system, rate of withdrawal, percentage of stream flow withdrawn, sources of water supply, type of intake and pumping equipment, and surface water quality data. The inventory should identify the nearest down-gradient surface-water users and the nearest municipal supply relying on surface water.

Groundwater-water Discharge Points: An inventory of all springs, seeps, etc., in the vicinity of the site and usage at these points. Information should include the location, type and amount of use, hydrogeologic unit used, flow rate, sources of water supply, type of well and pumping equipment, and water quality data.

Projected Surface-water Usage: The projected demand and usage of local and regional surface-water resources for domestic, municipal, agricultural, industrial, mining, recreational, and navigational needs. This projection will include geographic, demographic, and economic information and documentation as part of the evaluation.

Projection Ground-water Usage: The projected demand and usage of local and regional ground-water resources for domestic, municipal, agricultural, industrial, mining, and recreational needs. This projection will include the potential rates of withdrawal from significant aquifer systems, and geographic, demographic, and economic information and documentation as part of the evaluation.

Water Rights and Legal Summaries: A summary of statutory and other legal restrictions relating to surface-water and ground-water use as imposed by municipal, State, or Federal regulations.

Site Water Resource Impact: A qualitative and quantitative description of the present and projected surface-water and ground-water uses within the site vicinity that could affect or be affected by the site.

TABLE B-5
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: WATER RESOURCES

Parameter	Technical Activities/Study	Data Formats	Data Sources	References
Past and Present Ground-water Usage	<p>Review area and site-specific ground-water use data and literature, and compile existing data on ground-water usage within approximately 2 km of the site</p> <p>Inventory past and present ground-water users within approximately 2 km of the site to obtain the location, type and amount of use, hydrogeologic unit used, sources of water supply, type of well and pumping equipment, maximum production rate of the well, and water quality data (coordinate collection of water quality data with geochemistry/hydrochemistry water quality studies, see Table B-4). Identify the nearest down-gradient ground-water users and the nearest municipal supply relying on ground water.</p>	<p>Water-use permits, reports, maps</p> <p>User location maps</p> <p>User data tables</p>	<p>U.S. Geological Survey U.S. Army Corps of Engineers U.S. Bureau of Reclamation U.S. Department of Agriculture State, County, and local water agencies</p> <p>State, County, and local water agencies</p> <p>Interviews with local land owners with wells, local drillers, and municipal ground-water users</p>	Linsley et al. (1982)
Past and Present Surface-Water Usage	<p>Review area and site-specific surface-water use data and literature, and compile existing data on surface-water usage in the site vicinity and, in particular, within approximately 10 km downstream of the site</p>	<p>Water-use permits, reports, maps</p>	<p>U.S. Geological Survey U.S. Army Corps of Engineers U.S. Bureau of Reclamation U.S. Department of Agriculture U.S. Department of Commerce U.S. Fish and Wildlife Service State, County, and local water agencies</p>	

TABLE B-5
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: WATER RESOURCES

Parameter	Technical Activities/Study	Data Formats	Data Sources	References
	Inventory past and present surface-water users in the site vicinity and, in particular, within approximately 10 km downstream of the site to obtain the location, type and amount of use, number of users on the system, rate of withdrawal, percentage of stream flow withdrawn, sources of water supply, type of intake and pumping equipment, and water quality data (coordinate collection of water quality data with geochemistry/hydrochemistry water quality studies, see Table B-4). Identify the nearest down-gradient surface-water users and the nearest municipal supply relying on surface water.	User location maps User data tables	State, County, and local water agencies Interviews with local land owners and municipal surface-water users	Linsley et al. (1982)
Ground-water Discharge Points	Review regional and site-specific hydrologic data and literature, and compile existing data on ground-water discharge points	Texts, publications, articles, reports, maps, water-use permits	U.S. Geological Survey U.S. Army Corps of Engineers U.S. Bureau of Reclamation U.S. Department of Agriculture State agencies and publications Colleges and universities Theses and dissertations Professional journals Hydrologic texts/articles Nuclear plant FSAR's and SER's	
	Aerial photo interpretation of the site area to locate springs and ground-water seeps	Aerial photos	U.S. Geological Survey U.S. Department of Agriculture Commercial mapping contractor State and County Agencies	Avery (1968) Reeves (1975) Key (1978)

TABLE B-5

SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: WATER RESOURCES

Parameter	Technical Activities/Study	Data Formats	Data Sources	References
	Hydrologic mapping and ground-water discharge point inventory to locate all springs and ground-water seeps in the site area and to obtain the location, type and amount of use, hydrogeologic unit used, flow rate, sources of water supply, type of well and pumping equipment, and water quality data	Hydrologic map User location map User data tables	Field observations to confirm/revise existing data and aerial photo interpretation Interviews with local land owners and municipal water users	Compton (1985)
Projected Surface-Water Usage	Evaluate future local and regional surface-water demand and usage for domestic, municipal, agricultural, industrial, mining, recreational, and navigational needs, considering geography and demographic and economic projections	Text, maps, cross sections, tables, graphs	U.S. Army Corps of Engineers U.S. Bureau of Land Management U.S. Department of Commerce U.S. Department of Agriculture U.S. Fish and Wildlife Service State, regional, county, and local planning agencies Data collected for the geography, demography, and socioeconomic data types (see Tables B-8, Geography; B-15, Housing; and B-9, Projected Population)	NUS Corporation (1985) Torno (1985)
Projected Ground-Water Usage	Evaluate future local and regional ground-water demand and usage for domestic, municipal, agricultural, industrial, mining, and recreational needs, and the potential rates of withdrawal from significant aquifer systems, considering geography and demographic and economic projections	Text, maps, cross sections, tables, graphs	U.S. Army Corps of Engineers U.S. Bureau of Land Management U.S. Department of Commerce U.S. Department of Agriculture U.S. Fish and Wildlife Service U.S. Geological Survey State, regional, county, and local planning agencies Data collected for the geography, demography, and socioeconomic data types (see Tables B-8, Geography; B-15, Housing; and B-9, Projected Population)	Walton (1970) Prickett and Lonquist (1971) Butke and Vaccaro (1981)

TABLE B-5
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: WATER RESOURCES

Parameter	Technical Activities/Study	Data Formats	Data Sources	References
Water Rights and Legal Summaries	Review and summarize statutory and legal restrictions relating to surface-water and ground-water use	Text, tables	Federal, State, County, and local statutes, codes, and ordinances	
Site Water Resource Impact	Describe, both qualitatively and quantitatively, the impact of the site facility on the present and projected surface- and ground-water use, and the impact of present and projected surface- and ground-water use on the site facility, using computer modeling done for the surface-water and ground-water studies	Text, maps, cross sections, tables, graphs Computer models	Facility designer/engineer Results of site characterization investigations Surface- and ground-water models (see Tables B-2 and B-3, Hydrogeologic Modeling)	Walton (1970) Prickett and Lonquist (1971) Bolke and Vaccaro (1981) NUS Corporation (1985) Torno (1985)

TABLE B-5
REFERENCES - WATER RESOURCES

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TABLE B-6
PARAMETER DESCRIPTIONS - GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

Past and Present Resource Data: Location maps of active and inactive mines, prospects, exploration boreholes, geothermal and hydrocarbon wells, borrow pits, quarries, excavations, and timber and agricultural lands. Data compilations either on or accompanying the maps should include: the commodity occurring at the resource location; the geologic unit in which the present or past geologic resource occurs; quantitative data, if available, for geologic materials produced from active or previously active mines, wells, borrow pits, and quarries; quantitative data for agricultural and timber resources; and the mining, harvesting or extraction method (e.g., shaft mining, strip mining, quarrying, borehole injection or pumping, uprooting of vegetation, blasting, etc.). Commodities to be addressed should include: metallic and nonmetallic minerals and ores; fuels such as peat, lignite, and coal; industrial mineral deposits such as sand and gravel, clays, aggregate sources, shales, and building stone; hydrocarbons, including gas, oil, tar sands and asphalt; timber; agricultural lands; and waters in the form of brines.

Mineral Rights/Lease Data: The location, ownership, and types of exploration activity (e.g., drilling, trenching, etc.) carried out on mining claims or mineral leases on and near the site.

Borehole/Well Data: The location, depth, diameter, completion practices, current drilling activity, use, and geological and geophysical logs of exploration boreholes and geothermal, brine, and hydrocarbon wells on and near the site.

Potential Resource Location: Location maps of potential resources that may be exploited in the future. Data compilations either on or accompanying the maps should include: the commodity occurring at the resource location, and for geologic resources, the geologic unit in which the future resource occurs. Commodities to be addressed include: metallic and nonmetallic minerals and ores; fuels such as peat, lignite, and coal; industrial mineral deposits such as sand and gravel, clays, aggregate sources, shales, and building stone; hydrocarbons, including gas, oil, tar sands and asphalt; timber; agricultural lands; and waters in the form of brines.

Resource Quality and Quantity: The physical and/or chemical characteristics of the identified geologic resource in place, such as quantity (i.e., areal extent, thickness, and depth), tonnage, grade, and/or volume and quality, as applicable to the resource type, and the quantity, quality, and extent of timber and agriculture resources (such as board feet and arable areage, respectively).

Resource Value: The current net worth of resources, based on: 1) the resource quantity and quality as described above, and 2) profitability analyses based on the current market price, current use and/or demand, recoverability, extraction/harvesting methods and costs, transportation and mining/processing costs, and capital investment costs. Projected resource use should be determined based on assumptions and projections for future market conditions. Known or identified geologic resources should be classified into economic, marginally economic, and subeconomic components as defined in U.S. Geological Survey Circular 831, "Principles of a Resource/Reserve Classification for Minerals."

Direct Effects of Exploitation: The potential effects of geologic or timber resource exploration or exploitation/extraction at the ground surface, in the hydrogeologic units used for disposal and isolation, or at greater depths, caused by excavation, blasting, drilling, uprooting of timber, or other activities that directly intrude disposal units.

Indirect Effects of Exploitation: The potential effects of geologic, agricultural, or timber resource exploration or exploitation/extraction that would compromise the suitability of the site through such processes as increased infiltration rates, alteration of ground-water tables, increased runoff up-gradient of site, steepened hydraulic gradients, and creation or modification of surface-water or ground-water pathways. These processes may be affected by activities such as excavation, blasting, uprooting of vegetation, irrigation, pumping or injection, erosion control procedures, or other mining, logging, or agricultural activities that can affect the hydrologic regime.

Natural Resources Impact: Qualitative and quantitative descriptions of the impact of the site on natural resources from construction to closure, particularly the denial of resources.

TABLE B-6
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Past and Present Resource Data	Review literature to obtain data on locations, assays, tonnage, ore grade, production amounts, and extraction methods for active or previously active geologic resources at and near the site, and quantity, quality, production data, and harvesting methods for timber and agriculture resources within the watershed or drainage basin	Publications, articles, reports, maps, tables	U.S. Geological Survey U.S. Bureau of Mines Professional Journals Theses and dissertations State and county publications and records Mining company data Commercial resource data bases Maps and data on timber and agriculture from land use studies (See Table B-10, Agricultural Land Use and USDA Land Use Classification)	Peters (1978) Bradley (1984) Held and Visser (1984)
	Perform field walkover to verify active or previously active resource locations	Base map showing resource locations	Field observations to confirm/revise existing data	Peters (1978)
	Compile and tabulate resource data, including locations, commodities, extraction/harvesting methods, and quantitative data for mineral, timber, and agriculture resources, and compile geologic units for geologic resources	Geologic maps and/or base maps showing geologic resource data Base maps showing timber and agriculture resources Tables showing resource data Maps of mine workings	Maps and data from literature review and field walkover Geologic map developed from geologic characterization studies (see Table B-1, Stratigraphy, Lithology, Structure)	Peters (1978) Bradley (1984) Held and Visser (1984)

TABLE B-6
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Mineral Rights/ Lease Data	Collect mineral rights and lease data, and prepare maps and tabulations showing locations and ownership of mineral rights and leases held for exploratory rights at and near site, the commodities of interest, and types of exploration activity carried out on leases/claims at and near site, if available	Claim records and maps Lease records and maps	U.S. Bureau of Land Management County mining records State mining records	Rocky Mountain Mineral Law Foundation (1960) Parr and Ely (1973) Peters (1978)
Borehole/Well Data	Compile information on exploration borehole and geothermal/hydrocarbon/brine well location, depth, diameter, completion practices, current drilling activity, and use on and near site	Borehole/well log records	State borehole/well records Company borehole/well records, if available Commercial well data bases, such as Petroleum Information Service and University of Oklahoma Petroleum Data System Data collected for water resources, as applicable (see Table B-5, Past and Present Surface- and Ground-Water Usage)	Peters (1978)
	Compile and evaluate for geologic resource potential existing geological and geophysical borehole log from boreholes/wells on and near site collected for geologic studies (see Table B-1, Stratigraphy)	Geological borehole logs Geophysical borehole logs	State borehole/well logs Company borehole/well logs, if available U.S. Geological Survey Theses and dissertations Commercial well data bases, such as Petroleum Information Service and University of Oklahoma Petroleum Data System	

TABLE B-6
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Potential Resource Location	<p>Review literature on regional and site-specific data to identify potential geologic environments favorable for resources, and evaluate data collected for "past and present resource data", "mineral rights/lease data", and "borehole/well data" parameters to locate areas of exploration interest or potential</p> <p>Review literature and maps on regional and site-specific data and products of land use characterization to identify areas favorable for future timber or agriculture resources that may affect site suitability</p> <p>Evaluate geologic data collected during site characterization studies, including stratigraphic, lithologic, and structural data from geologic mapping and borehole logging, petrographic analyses, chemical analyses, surface geophysics, and borehole geophysics, to identify potential geologic environments favorable for resources</p> <p>Photogeologic interpretation to evaluate features indicative of geologic resources, including structural features, alteration zones, leached capping, and vegetation changes</p>	<p>Publications, articles, reports, maps, state and lease records, borehole and well logs</p> <p>Publications, articles, reports, maps</p>	<p>U.S. Geological Survey U.S. Bureau of Mines Professional journals Theses and dissertations State publications and records Maps and data from "past and present resource data", "mineral rights/lease data" and "borehole/well data" parameters</p> <p>U.S. Department of Agriculture U.S. Forest Service State resource agencies County extension agents Maps and data of timber and agriculture from land use studies (see Table B-10, Agricultural Land Use; USDA Land Use Classification)</p> <p>Site investigations performed during geologic characterization studies (see Table B-1, Stratigraphy, Lithology, Structure)</p> <p>U.S. Geological Survey EROS Data Center U.S. Dept. of Agriculture Commercial mapping contractor State and County agencies Earth Observation Satellite Company (EOSAT)</p>	<p>Peters (1978)</p> <p>Bradley (1984) Held and Visser (1984)</p> <p>Peters (1978)</p> <p>Cole and Owen-Jones (1974) Reeves (1975) Peters (1978) Drury (1987)</p>

TABLE B-6
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Potential Resource Location (cont.)	<p>If potential resources are identified as a result of the above studies, then compile and tabulate potential resource locations, commodities, and geologic units, as applicable, and evaluate parameters for "resource quantity and quality" and "resource value" described below</p>	<p>Geologic maps and/or base maps showing future geologic resource locations</p> <p>Tables showing future resource data</p> <p>Base maps showing future timber and agricultural resource locations</p>	<p>Maps and data from literature review, mineral rights/lease data review, borehole/well data review, and geologic characterization studies (see Table B-1, Stratigraphy, Lithology, Structure)</p> <p>Maps developed as a result of air photo analyses</p> <p>Maps and data on timber and agriculture from land use studies (see Table B-10, Agricultural Land Uses; USDA Land Classification)</p>	<p>Stewart (1968) Peters (1978)</p>
Resource Quantity and Quality	<p>If potential geologic resources are identified, perform detailed field mapping to collect data on stratigraphic sequence, lithologic units, structural features, and type of cover, and perform sampling for geochemical and petrographic analysis</p> <p>Surface geophysical investigations using:</p> <ul style="list-style-type: none"> magnetics gravity electrical electromagnetic APMAG radioelectric seismic <p>or other techniques appropriate for the commodity of interest to delineate ore materials</p>	<p>Geologic map and sections</p> <p>Base map with geochemical and petrographic sample locations</p> <p>Magnetic profile plots or contour maps</p> <p>Gravity profile plots or contour maps</p> <p>Electrical contour maps, profiles, sounding curves</p> <p>Electromagnetic contour maps, profiles, vector maps</p> <p>Audio frequency magnetic (APMAG) contour maps, profiles, vector maps</p> <p>Radioactive contour maps, profiles, ratio maps</p> <p>Seismic sections</p>	<p>Results of site characterization field investigations for geologic resources</p> <p>Results of site characterization geophysical investigations for geologic resources</p>	<p>Parks (1957) Ginzburg (1960) Boyle (1971) Bradshaw et al. (1971) Brooks (1972) Levinson (1974) Peters (1978)</p> <p>Brant (1965) Parasnis (1973) Telford et al. (1976) Peters (1978)</p>

TABLE B-6
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Resource Quality and Quantity (cont.)				
	Borehole drilling and geologic logging to evaluate resource location, extent, and depth, and to obtain rock and/or fluid samples for laboratory analysis	Borehole geologic logs	Results of site characterization drilling and logging investigations for geologic resources	McGregor (1967) Peters (1978)
	Borehole geophysical logging using: nuclear seismic electrical electromagnetic temperature or other logging methods, depending on specific commodity of interest, to delineate ore materials	Borehole geophysical logs	Results of site characterization borehole logging investigations for geologic resources	Tixier and Alger (1970) Scott and Tibbetts (1974) Dyck (1975) Peters (1978)
	Field tests using: colorimetric test cold extractable total heavy metal test portable ion electrodes for fluoride portable X-ray fluorescence survey radiometric detection survey portable radon counter survey or other tests appropriate for geologic commodity of interest to define anomalies and background concentrations	Data tabulations and maps	Results of site characterization field investigations for geologic resources	Peters (1978)
	Petrographic and mineralogic analysis using thin or polished sections to determine ore and gangue mineralogy, mineral abundance, and sequence of mineral deposition	Mineral abundance tables Descriptions of ore and gangue mineralogy	Microscopy	Bates (1960) Ramdohr (1969) Galopin and Henry (1972) Stanton (1972) Hutchinson (1974) Lefond (1975) Nichol (1975) Peters (1978)

TABLE B-6
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Resource Quality and Quantity (cont.)	<p>Sample analysis using:</p> <ul style="list-style-type: none"> metal assays X-ray fluorescence atomic absorption wet chemical and emission spectrography hydrocarbon source rock analysis thermal conductivity electron microprobe chromatography ion electrodes neutron activation fluorometry nuclear activation analysis or other analyses appropriate for geologic commodity of interest to define anomalies and background concentrations <p>Integrate data and define geologic resource areal extent, thickness, depth, tonnage, grade and/or volume, and quality, as applicable to resource type, using geostatistical methods where applicable</p> <p>If potential timber or agricultural resources that may utilize management techniques that could affect the site are identified within the watershed or drainage basin, investigate the quantity, quality, and extent of such resources</p>	<p>Chemical abundance tables and maps</p> <p>Tables and graphs</p>	<p>Commercial laboratories</p>	<p>Weinert and Uken (1971)</p> <p>Levinson (1974)</p> <p>Peters (1978)</p>
	<p>Integrate data and define geologic resource areal extent, thickness, depth, tonnage, grade and/or volume, and quality, as applicable to resource type, using geostatistical methods where applicable</p> <p>If potential timber or agricultural resources that may utilize management techniques that could affect the site are identified within the watershed or drainage basin, investigate the quantity, quality, and extent of such resources</p>	<p>Plan maps, cross sections, tables, calculations</p>	<p>Maps and data from geologic mapping, borehole logging, geophysical surveys, petrographic analysis, sample analysis, and field testing for geologic resources</p>	<p>Popoff (1966)</p> <p>Canadian Institute of Mining and Metallurgy (1968)</p> <p>Koch and Link (1970 and 1971)</p> <p>Cummins and Given (1973)</p> <p>Peters (1978)</p>
	<p>Integrate data and define geologic resource areal extent, thickness, depth, tonnage, grade and/or volume, and quality, as applicable to resource type, using geostatistical methods where applicable</p> <p>If potential timber or agricultural resources that may utilize management techniques that could affect the site are identified within the watershed or drainage basin, investigate the quantity, quality, and extent of such resources</p>	<p>Plan maps, acreage tables, calculations, text</p>	<p>Results of site characterization investigations</p> <p>Maps and data on timber and studies (see Table B-10, Agricultural Land Uses; USDA Land Use Classification)</p> <p>U.S. Forest Service</p> <p>U.S. Department of Agriculture</p> <p>U.S. Soil Conservation Service</p> <p>State forest and agriculture resource agencies</p> <p>College and universities</p> <p>County extension agents</p> <p>Timber and agriculture industry</p>	<p>Stewart (1968)</p>

TABLE B-6
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Resource Value	If potential resources are identified as a result of site characterization studies, and after "resource quality and quantity" parameter has been defined, perform profitability analysis based on current market price, extraction/harvesting methods and costs, recoverability, current use and/or demand, transportation and mining/processing costs, timber growth rate, and capital investment costs, to determine net present value of resource	Tables, graphs, calculations	U.S. Bureau of Mines Mining Industry Journals Annual statistical publications for resources by Federal and Commercial Agencies U.S. Forest Service U.S. Department of Agriculture U.S. Soil Conservation Service	Woodruff (1966) Brant (1968) Canadian Institute of Mining and Metallurgy (1968) Zimmerman (1968) Stewart (1968) Megill (1971) Johnson and Scheurman (1977) Peters (1978)
	Estimated projected resource use by assigning assumptions and projections for alternative market prices, improved recoverability, changes in demand, and any other conditions that could impact future use	Tables, graphs, calculations, models	U.S. Bureau of Mines Mining Industry Journals Annual statistical publications for resources by Federal and Commercial Agencies U.S. Forest Service U.S. Department of Agriculture	Stewart (1968) Megill (1971) Brinck (1972) Vogely (1976) Johnson and Scheurman (1977) Peters (1978)
	Classify geologic resources into economic, marginally economic, and subeconomic components	Tables and graphs	Results of investigations for resource quantity, grade and/or quality, and value parameters	U.S. Bureau of Mines and U.S. Geological Survey (1980)

TABLE B-6
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOLOGIC/TIMBER/AGRICULTURAL RESOURCES

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Direct Effects of Exploitation	Determine the potential direct effects of exploration and exploitation activities on the performance of the site, caused by penetration/excavation of disposal units, given the resource locations, extent, depth, and potential exploration and extraction methods, and provide input to computer modeling for surface-water (see Tables B-3), ground-water (see Tables B-2 1a) and 1b), and geochemistry/hydrochemistry (see Table B-4) studies	Tables, maps, calculations, models	Results of site investigations for past and present resource data, potential resource location, resource quality and quantity, resource value, mineral rights/ lease data, and borehole well data parameters	Cranwell et al. (1987)
Indirect Effects of Exploitation	Determine the potential indirect effects of exploration and exploitation activities on the performance of the site (e.g., creating or modifying surface-water and ground-water pathways), given the resource location, extent, depth, and potential exploration and extraction/harvesting methods, and provide input to computer modeling for surface-water (see Table B-3), ground-water (see Tables B-2 1a) and 1b)), and geochemistry/hydrochemistry (see Table B-4) studies	Tables, maps, calculations, models	Results of site investigations for past and present resource data, potential resource location, resource quality and quantity, resource value, mineral rights/ lease data, and borehole/ well data parameters	Cranwell et al. (1987)
Natural Resources Impact	Describe, both qualitatively and quantitatively, the impact of the site facility on natural resources from construction unit closure	Text, maps, tables, graphs	Results of site investigations for past and present resource data, potential resource location, resource quality and quantity, and resource value parameters	Brinck (1972) Yogely (1976) Johnson and Scheurman (1977) Peters (1978)

TABLE B-6
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TABLE B-7

PARAMETER DESCRIPTIONS - GEOTECHNICAL INVESTIGATION

Soil Classification: The system of classifying soil for engineering purposes, generally the Unified Soil Classification System. Laboratory tests required to confirm field soil classifications are grain-size distribution and Atterberg limits following ASTM test procedures.

Engineering Properties: The physical and chemical properties of soil materials that determine their engineering behavior. These properties, determined mostly by laboratory testing, are required for foundation and settlement analysis, slope stability, and the design and placement of structural fill. Engineering properties include: shear strength/internal angle of friction/unit cohesion, consolidation characteristics, shrink/swell characteristics, freeze/thaw characteristics, plasticity index/Atterberg limits, grain-size distribution, moisture-density/minimum dry density, in-situ weight/density, porosity, void ratio, moisture content, degree of saturation, specific gravity, permeability, relative hydraulic conductivity, liquefaction potential, soil pH, oxidation-reduction potential, clay mineralogy, dispersivity, deformation/Young's modulus, penetration resistance, soil resistivity, soil organics, and limit pressure. Other engineering properties may be appropriate depending on the soil conditions encountered at each site.

Engineering Units: An engineering unit consists of those geologic sections that share similar geotechnical characteristics or engineering properties. For example, a loess and underlying lacustrine silt may have similar moisture contents and strengths and could be incorporated into one engineering unit on the basis of their engineering behavior. Alternatively, a glacial till unit may contain a permeable sand and gravel layer that might be considered a separate engineering unit because of its engineering properties.

Ground-water Conditions: The location and range of seasonal fluctuations of the ground-water table and the design water level within the disposal site and borrow areas.

Engineering Analysis: The process of integrating the engineering units and their respective engineering properties with the site ground-water conditions, potential future geologic events, and conceptual facility design to develop geotechnical recommendations for slope stability, settlement/subsidence, liquefaction potential, freeze/thaw potential, active and passive earth pressures, bearing capacity, long- and short-term control of surface water, and fill-placement procedures. Other analyses may be appropriate depending on the soil conditions encountered at each site. The recommendations should also contain the following: detailed discussions of field and laboratory sample preparation and test procedures, interpretation of engineering characteristics for onsite and borrow area soils and rock, discussions of how and why specific strength parameters were chosen, factors of safety used, plans showing completed subsurface investigations, cross-sections, and proposed borrow area limits, grades, slopes, and locations of test pits and boreholes.

TABLE B-7
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOTECHNICAL INVESTIGATION

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Soil Classification	Obtain soil samples from surface exposures, test pits, trenches, and boreholes, and classify soils on-site and adjacent critical areas using the Unified Soil Classification System	Soil samples Site soil map	Site Investigations	ACE (1972) NRC (1979) Clayton et al. (1982) ASTM (1985a)
	Perform laboratory index tests to confirm field soil classifications, using grain-size, hydrometer, and Atterberg limits. Some of the factors that should be considered in soil classification are classification subgroup and family, thickness of horizons, dominant particle size, common impurities, and associations.	Tables, graphs, charts, calculations	Soil testing laboratories	NRC (1978) Lutton et al. (1982) ASTM (1985a,b)
Engineering Properties	Obtain soil samples from surface exposures, test pits, trenches, and boreholes	Soil samples	Site Investigations	ACE (1972) NRC (1979) Clayton et al. (1982)

TABLE B-7
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOTECHNICAL INVESTIGATION

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Engineering Properties (Cont.)	Field and laboratory test program tailored to specific site conditions to determine the engineering properties of the soil and rock units. The engineering properties and the types of common tests used to determine these properties (shown in parentheses after each property) are listed below:	Tables, graphs, charts, calculations	Site investigations Soil testing laboratories	Hvorslev (1949) Cadling and Odenstad (1950) Wilson (1950) Hansbo (1957) Bishop and Bjerrum (1960) Florin and Ivanov (1961) Govinda and Balakrishna (1961) Scherer (1961) Warlam (1961) Bishop and Henkel (1962) Seed et al. (1962) Black et al. (1965) Hardin and Muslic (1965) Heinenlund (1965) Watson (1965) Rice (1969) Sowers and Sowers (1970) ACE (1970b) Schmertmann (1970) DeMello (1971) Seed and Idriss (1971) Seed and Peacock (1971) Bjerrum (1972) Hardin and Drnevich (1972) Sanglerat (1972) Janbu and Senneset (1973) Poulos and Davis (1974) Jennings and Knight (1975) Menard (1975) Mitchell and Gardner (1975) Schmertmann (1975) Winland (1975) Winterkorn and Fang (1975) Mitchell (1976) Kovacs et al. (1977) Ladd et al. (1977)
	shear strength/internal angle of friction (field: Dutch Cone Penetrometer, Standard Penetration Test, dilatometer, screw plate, plate load, pressure meter, Iowa borehole shear; laboratory: direct shear, triaxial, California Bearing Ratio, torsional or ring shear)			
	shear strength/unit cohesion (field: triaxial field apparatus, pocket penetrometer, torvane, vane shear, Standard Penetration Test, Dutch Cone Penetrometer, pressuremeter, screw plate compressor, Iowa borehole shear; laboratory: direct shear, triaxial, unconfined compression, Swedish fall-cone, vane shear)			

(continued on next page)

TABLE B-7
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOTECHNICAL INVESTIGATION

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Engineering Properties (Cont.)	<p>consolidation characteristics (field: settlement gauges, pore water pressure gauges, pneumatic/hydraulic pressure gauges; laboratory: floating ring, fixed ring)</p> <p>shrink/swell characteristics (field: piezometers, magnetic probe extensometer, single or multiple rod extensometers, settlement plate; laboratory: one-dimensional expansion test, double oedometer test, collapse potential, one-dimensional expansion)</p> <p>freeze/thaw characteristics (laboratory: see analyses for grain size and moisture content)</p> <p>plasticity Index/Atterberg limits (field: remolded strength; laboratory: liquid limit, plastic limit and plastic Index, shrinkage limit of soils, fall cone, one point liquid limit, static cone penetration)</p> <p>grain-size distribution (field: dilatancy, dry strength, toughness; laboratory: grain-size analysis, sieve analysis [coarse], hydrometer analysis [fine])</p> <p>moisture-density/minimum dry density (field: gamma ray attenuation; laboratory: standard Proctor test, modified Proctor test, Harvard miniature)</p>			<p>(continued from page 7-2) Baguelin et al. (1978) NRC (1978) Ghadeil and Tijman (1981) Holtz and Kovacs (1981) Lutton et al. (1982) ASTM (1985c-r) University of Arizona (1985)</p>

TABLE B-7
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOTECHNICAL INVESTIGATION

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Engineering Properties (Cont.)	in-situ weight/density (field: sand cone, nuclear, rubber balloon)			
	porosity (laboratory: floating ring, fixed ring)			
	vold ratio (laboratory: floating ring, fixed ring)			
	moisture content (field: acoustic logging, nuclear logging; laboratory: moisture content analysis)			
	degree of saturation (field: acoustic logging, nuclear logging; laboratory: moisture content analysis)			
	specific gravity (laboratory: specific gravity of soil solids)			
	permeability (field: falling head test, constant head test, packer or Lugeon test, instantaneous profile test, pump test; laboratory: constant head test, falling head test)			
	relative hydraulic conductivity (field: piezometer, tensiometer; laboratory: pressure plate extractor, tensiometer)			

TABLE B-7
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOTECHNICAL INVESTIGATION

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Engineering Properties (Cont.)	liquefaction potential (field: standard blasting test; laboratory: liquefaction potential, cyclic loading triaxial compression, cyclic simple shear, ground response analyses)			
	soil pH (laboratory: pH analysis)			
	oxidation-reduction potential (laboratory: resistivity analysis)			
	clay mineralogy (laboratory: x-ray diffraction)			
	dispersivity (laboratory: hydrometer with and without dispersant)			
	deformation/Young's modulus (field: seismic refraction; laboratory: triaxial compression)			
	penetration resistance (field: Standard Penetration Test or Cone Penetration)			
	soil resistivity (laboratory: soil resistivity test)			

TABLE B-7
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOTECHNICAL INVESTIGATION

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Engineering Properties (Cont.)	<p>soil organics (laboratory: organic content analysis)</p> <p>illit pressure (field: pressure meter)</p> <p>Laboratory tests should follow the American Society of Testing and Materials (ASTM) procedures, as applicable. Other engineering properties and testing methods may be appropriate depending on the soil conditions encountered at each site.</p>			
Engineering Units	<p>Review site geologic data to obtain information on the site stratigraphy</p> <p>Examine the engineering properties of the site stratigraphy to identify engineering units</p>	<p>Geologic maps, cross sections, geophysical profiles and maps, test pit and trench logs, borehole logs, stereonet, mineral and chemical abundance tables</p> <p>Tables, graphs, charts, calculations</p> <p>Stratigraphic section</p>	<p>Literature review and site investigations for geology parameters (see Table B-1, Stratigraphy, Lithology)</p> <p>Investigations for engineering properties and stratigraphy parameters (see Table B-1, Stratigraphy)</p>	<p>Krynine and Judd (1957) Hartney (1982)</p>
Ground-water Conditions	<p>Review regional and site ground-water conditions and facility design plans to determine the location and range of seasonal fluctuations of the ground-water table and the design water level within the disposal site and borrow areas</p>	<p>Water table contour maps</p> <p>Facility design plans</p>	<p>Literature review and site investigations for ground-water parameters (see Table B-2, Geometry, Boundary Conditions)</p> <p>Facility designer/engineer</p>	

TABLE B-7
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOTECHNICAL INVESTIGATION

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Engineering Analysis	Review facility design plans, ground-water conditions, engineering units, and their engineering properties	Facility design plans Water table contour maps Engineering unit maps and cross sections Field and laboratory test results	Facility designer/engineer Literature review and site investigations for ground-water parameters Site investigations for engineering units and engineering properties	
	Integrate the engineering units and their respective engineering properties with the site ground-water conditions, potential future geologic events, and conceptual facility design, to develop short- and long-term geotechnical recommendations for slope stability, settlement/subsidence, liquefaction potential, freeze/thaw potential, active and passive earth pressures, bearing capacity, control of surface water, and fill-placement procedures. Other analyses may be appropriate depending on the soil conditions encountered at each site.	Graphs, reports, tables, calculations Maps and cross sections showing completed subsurface investigations, proposed borrow area limits, grades, slopes, and locations of test pits and boreholes	Literature review and site investigations for geology (see Table B-1, Geologic Hazards), ground water (see Table B-2, Geometry, Boundary Conditions), surface-water (see Table B-3, Water Users, Flood Studies, Site Surface-Water impact), and geotechnical parameters	Terzaghi and Peck (1967) Lambe and Whitman (1968) ACE (1970a) Duncan and Buchignani (1975) Andersland and Anderson (1978) Bowles (1982)

TABLE B-7
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TABLE B-8

PARAMETER DESCRIPTIONS - GEOGRAPHY

Geographic Location: The location of the site in terms of latitude, longitude, universal transverse mercator (UTM) coordinates, and Public Land Survey designation (i.e., Township, Range and Section).

Political Subdivision: The State, county and/or other pertinent subdivision (e.g., township or municipalities) in which the site is located.

Nearby Features: Features in the vicinity of the site, including cities; readily recognized landmarks; rivers, lakes and other bodies of water; major highways; other prominent man-made and natural features; and significant facilities near the site.

Site Area: The amount of land surface included in the site (including buffer zone), measured in acres (hectares) and square miles (square kilometers).

Topography: The general configuration of the land surface, including its elevation and relief and the position of its natural and man-made features.

Site Ownership: The person or entity entitled to legal possession of the site and adjacent lands.

TABLE B-8
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOGRAPHY

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Geographic Location	<p>Plot site location in relation to specific latitude and longitude coordinates as well as Universal Transverse Mercator grid coordinates, using appropriate statewide, regional and localized base map series. A boundary survey is not necessary to address this parameter, but is included under "Site Area" below. At a minimum, a general map encompassing a 50km radius from the site and a second map with a radius of 10km should be prepared.</p> <p>Prepare digital cartographic data base to support analysis and display of site characterization spatial data</p>	<p>Planimetric or topographic base maps</p> <p>Computer files containing spatial data referenced to horizontal reference system</p>	<p>U.S. Geological Survey or state-specific map series as appropriate</p> <p>U.S. Geological Survey Local survey contractors</p>	<p>Robinson and Sale (1969) Muehrcke (1978) Steger (1982)</p> <p>Monmonier (1982) U.S. Geological Survey (1986a)</p>
Political Subdivision	<p>Identify and plot site location with respect to State, county, township, municipality and any other appropriate political unit boundaries</p>	<p>Planimetric or topographic base maps</p>	<p>U.S. Geological Survey or state-specific map series as appropriate</p>	<p>Robinson and Sale (1969) Muehrcke (1978) Steger (1982)</p>
Nearby Features	<p>Plot locations and type of prominent local features (both natural and man-made) such as cities and towns, highways and roads, and rivers and lakes, using appropriate regional and localized base map series.</p>	<p>Planimetric or topographic base maps</p>	<p>U.S. Geological Survey or state-specific map series as appropriate</p>	<p>Robinson and Sale (1969) Muehrcke (1978) Steger (1982)</p>

TABLE B-8
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOGRAPHY

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Nearby Features (Cont.)	Plot boundaries of surface drainage basins related to the site (both upstream and downstream)	Planimetric or topographic base maps	U.S. Geological Survey	Way (1978) Steger (1982)
	Verify feature locations and types using aerial photo interpretation and field reconnaissance	Aerial photos and orthophoto maps	U.S. Geological Survey Local Planning Agencies Aerial Photo Contractors Results of field reconnaissance	Avery (1969) Steger (1982) Wright (1982)
Site Area	Plot site boundaries and calculate area in acres (hectares) and square miles (square kilometers) using local area base maps supplemented as required by aerial photo interpretation and field reconnaissance	Planimetric or topographic base maps and aerial photos or orthophoto maps	U.S. Geological Survey or state-specific map series as appropriate Results of field reconnaissance Federal (e.g., U.S. Forest Service) and State land management agencies	Avery (1969) Robinson and Sale (1969) Muehrcke (1978) Steger (1982)
	Conduct boundary surveys, referenced to local geodetic control network, using standard land survey methods	Site-specific planimetric map with back-up survey data	Local geodetic survey control agency, local survey contractors	Johnson (1954) Breed et al. (1971) Federal Geodetic Control Committee (1974)
Topography	Plot site boundaries on existing topographic base map	Topographic base map	U.S. Geological Survey	Way (1978) Steger (1982)
	Construct site-area topographic map using photogrammetric methods, vertical control field surveys, or combination thereof	Topographic contour map supplemented by vertical control data; scale and contour interval determined by size of site area and degree of topographic relief present	U.S. Geological Survey Local geodetic control survey agency Local survey or photogrammetric contractors Results of field surveys	Johnson (1954) Breed et al. (1971) Federal Geodetic Control Committee (1974) Anonymous (1978) Stana et al. (1980)

TABLE B-8
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: GEOGRAPHY

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Topography (Cont.)	Construct digital elevation model by converting topographic contours to computer-compatible formats	Computer files containing digital elevation data expressed as vertical elevations referenced to (X,Y) coordinates	U.S. Geological Survey Local survey contractors	Slane et al. (1980) Monmonier (1962) U.S. Geological Survey (1986b)
Site Ownership	Identify persons or entities entitled to legal possession of site through review of tax or land title documents (coordinate with land ownership data collection activities described in Table B-10 under Land Ownership Patterns)	Plot maps, legal descriptions of property ownership	County or municipal tax assessor's offices. For cases in which site ownership is highly complex or questionable, it may be necessary to obtain data from local land title insurance companies or through interviews of area residents	International Association of Assessing Officers (1978) Almy (1979)

TABLE B-8
REFERENCES - GEOGRAPHY

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TABLE B-9
PARAMETER DESCRIPTIONS - DEMOGRAPHY

Population Centers: Population size and boundary locations of population places defined by the U.S. Census Bureau and as modified by State and local government agencies.

Population Density: Number of inhabitants per unit area (i.e., population per square kilometer).

Residence Inventory: Identification of occupied housing units (residences) closest to and within 2km of the site.

Transient Population: Estimates of population increases to the permanent baseline population resulting from transient influxes due to tourism, seasonal labor, or other factors.

Projected Population: Estimates of future resident and transient populations, in terms of both population density and population centers, for time periods coinciding with the expected first year of facility operation and for decennial census years through the operation lifetime of the facility.

TABLE B-9
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: DEMOGRAPHY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Population Centers	<p>Compile boundary maps and population data for populated places defined by the U.S. Census Bureau (latest decennial census) and as modified by state or local government agencies; plot locations in relation to 2km, 10km, and 50km radial distances from site; calculate areal size of each identified population center</p> <p>Update population data from latest decennial census using postcensal estimates of population change</p>	<p>Map overlays and tabular listing providing populated area place names and population data from latest decennial census; tabular listing of areal size of each populated place</p> <p>Tabular listing of populated area place, names and population estimates of change from latest decennial census</p>	<p>U.S. Census Bureau State and local planning agencies</p> <p>U.S. Census Bureau State and local planning agencies</p>	<p>Spiegelman (1968) Bogue (1969) Wunsch and Termote (1978) U.S. Department of Commerce (1979, 1980a, 1982, 1984, 1987a) National Research Council (1980) U.S. Department of Commerce (1987b)</p>
Population Density	<p>Compile latest decennial census population data for census tracts wholly or partially within a 10km radius of the site; update if necessary with estimates of postcensal changes; compute the number of persons per square km for appropriate subdivisions of the radial distance (e.g., Minor Civil Divisions) and the 10km circle overall)</p>	<p>Map overlay depicting appropriate census tract boundaries and 10km radial boundary from site; population data for census tracts depicted; tabulations of persons per unit area; map of existing population densities</p>	<p>U.S. Census Bureau</p>	<p>Spiegelman (1968) Bogue (1969) Wunsch and Termote (1978) National Research Council (1980) U.S. Department of Commerce (1979, 1980a, 1982, 1984, 1987a)</p>

TABLE B-9
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: DEMOGRAPHY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Population Density (continued)	Develop direct estimates of population density within a 10km radius of the site or for a portion thereof for which existing data are incomplete or out-of-date by applying aerial survey/remote sensing methods. The "dwelling unit" technique, which identifies the number of residences and multiplies by an average number of inhabitants per dwelling unit derived from the latest decennial census, offers the potential for highest accuracy.	Map overlays, remote sensing imagery, and tabular summaries	Aerial photo interpretation/image analysis, in combination with U.S. Census Bureau data	Avery (1969) Estes et al. (1964)
	Compile projected population data (see "Projected Population" data parameter below); relate those data to the census tract geographic boundaries used above or to appropriate future census tract boundaries within a 10km radius of the site; compute the projected number of persons per unit area	Map overlay depicting Census tract boundaries used for population projections and 10km radial boundary from site; projected population data for census tracts depicted; tabulations of projected population per unit area; map of estimated population densities	U.S. Census Bureau State and local planning agencies	Shorter (1974) Kukuk and Flynn (1977) Ascher (1978) National Research Council (1980)
Residence Inventory	Obtain data on housing location and occupancy from latest decennial census (if data are available for specific geographic area) and/or local agencies, and transfer to map overlay within 2km radius of site (coordinate with Residential Land Use data collection activities described in Table B-10)	Map overlay and tabular listing of residential housing units by location	U.S. Census Bureau County agencies (e.g., Assessor's Office) Public utility companies	U.S. Department of Commerce (1979, 1980a, 1980b, 1982, 1984, 1987a)

TABLE B-9
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: DEMOGRAPHY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Residence Inventory (continued)	Identify and map all occupied residential housing units within 2km of site boundary, including the residence closest to the site, using aerial photo interpretation or remote sensing imagery analysis, verified by direct field reconnaissance	Map overlay and tabular listing of residential housing units by location	County agencies (e.g., Assessor's Office) Aerial photos Results of the direct field reconnaissance	Avery (1969) Joyce (1973) Anderson et al. (1976) Estes et al. (1984)
Transient Population	Obtain estimates of transient populations (rate of change or absolute number per unit time) and calculate increases to baseline population data (population centers and population density) Prepare original estimates of transient populations through direct census techniques or indirect estimation methods (e.g., occupancy of second homes). In some cases, aerial photo interpretation or remote sensing imagery analysis techniques may be used in conjunction with direct census and indirect estimation methods.	Tabular listings and/or published reports Tabular listings supported by map overlays	Federal, State, and local planning agencies Tourism bureaus State or local industry groups (e.g., agricultural grower's association) U.S. Census Bureau Results of the direct field census U.S. Census Bureau	Spiegelman (1962) Bogue (1969) Wunsch and Termote (1978) Bogue (1969) Wunsch and Termote (1978) Estes et al. (1984)
Projected Population	Compile series of population projections (if available) prepared by U.S. Census Bureau using different methodological assumptions and select projection(s) most appropriate to site planning	Tabular listing of population projections supported by narrative explanation of basis for selecting specific Census Bureau projection(s)	U.S. Census Bureau	U.S. Department of Commerce (1967a, 1979) Ascher (1978)

TABLE B-9
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: DEMOGRAPHY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Projected Population (continued)	Modify U.S. Census Bureau population projections by using projections prepared by others and relate to baseline data compiled for the population density, population centers and transient population data parameters; review and critique underlying assumptions used in preparing projections	Tabular listing of population projections supported by narrative description of completeness, accuracy and other attributes of the projections used	U.S. Census Bureau State and local planning agencies Business organizations	Shorter (1974) Kukuk and Flynn (1977) Ascher (1978) National Research Council (1980) U.S. Department of Commerce (1987a)
	Prepare new population projections for baseline populations and geographic units compiled for population density, population centers and transient population data parameters using extrapolation of growth rates calculated from past census data (Note: this technique is generally considered to be relatively crude in application to most areas, and the methods listed below may be preferred)	Tabular listing of population projections supported by narrative explanation of data and method of calculation used for extrapolations	U.S. Census Bureau State and local planning agencies Business organizations	Shorter (1974) Kukuk and Flynn (1977) Ascher (1978) U.S. Department of Commerce (1987a)
	Prepare new population projections for baseline populations and geographic units compiled for population density, population centers and transient population data parameters using more complex and sophisticated techniques such as cohort analysis (i.e., separate projections of births, deaths, and migration for each age-sex-rate group combined for specific future time periods)	Tabular listing of population projections supported by narrative explanation of data and projection methodology used	U.S. Census Bureau State and local planning agencies Business organizations	Shorter (1974) Ascher (1978) U.S. Department of Commerce (1987a)

TABLE B-9
REFERENCES - DEMOGRAPHY

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TABLE B-10
PARAMETER DESCRIPTIONS - LAND USE

Residential Land Use: Current and projected uses of land on which the site is located and within 10km as housing, classified according to residential density and housing type.

Industrial Land Use: Current and projected uses of land on which the site is located and within 10km for manufacturing, processing, or other industrial purposes.

Agricultural Land Use: Current and projected uses of land on which the site is located and within 10km for crop production or domestic animal husbandry.

Recreational Land Use: Current and projected uses of land on which the site is located and within 10km for public recreational purposes, e.g., parks, trails, water courses, etc.

Special-Use Areas: Current and projected uses of land on which the site is located and within 10km for designated special-status uses such as national parks, military reservations, Indian reservations, and wilderness areas.

Zoning Restrictions: Local restrictions on land use promulgated by county, city, town, township, or other local jurisdictional planning entities, which designate land for specified uses or constrain certain types of uses.

Local Land-Use Plans: Existing plans prepared by local planning entities that codify land use status, constraints, and projected trends in land usage.

Land Ownership Patterns: Type of land ownership (e.g., public versus private) and specific entities that own the land on which the site is located and within 10km.

USDA Land Use Classification: Land parcels classified by the U.S. Department of Agriculture as being in one of eight categories of land capacity, or as being classified as prime or unique land on the site and within 10km.

Utility Land Use: Utility facilities, pipelines, transmission systems, and other utility uses of land on which the site is located and within 10km.

TABLE B-10
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: LAND USE

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Residential Land Use	Obtain and review land use and general plans for the site area, targeting the area within 10km of the site; plot residences or residential land use patterns on regional and localized base map series	Planimetric or topographic maps Mapped information representing projections of changes through facility closure period	County/local planning agencies Federal and State land management agency planners Developers	Chaplin (1965) Clawson (1965) Goodman and Freund (1968) Anderson et al. (1976) Rodgers (1976) Edlington and Edlington (1977) Malone (1977) Lounsbury et al. (1981) Patricios (1986) USGS (1986)
	Verify and update residential land use classifications using aerial photography and field reconnaissance (coordinate with residence inventory described in Table B-9)	Orthophoto maps; revised planimetric or topographic maps; field notes and sketches; descriptive information (text)	U.S. Geological Survey State/County/local planning agencies Aerial photo contractors Results of field reconnaissance	Avery (1969) Anderson (1973) Paine (1975) Lounsbury and Aldrich (1979) Telchoiz and Berry (1983) ASPRS (1987)
	Prepare original residential land use inventory using aerial photo interpretation verified through direct field reconnaissance	Planimetric or topographic maps Mapped information representing projections of changes through facility closure period	Aerial photo contractors Results of field reconnaissance	Paine (1975) Borella et al. (1982) Campbell et al. (1983) Estes et al. (1984)
Industrial Land Use	Obtain and review land use and general plans for the site area, targeting the area within 10km of the site; plot industrial landholders and use categories on regional and localized base map series	Planimetric or topographic maps Projections of changes through facility closure period	County/local planning agencies Federal and State land management agency planners Developers, major land owners	Chaplin (1965) Clawson (1965) Goodman and Freund (1968) Anderson et al. (1976) Rodgers (1976) Edlington and Edlington (1977) Malone (1977) Lounsbury et al. (1981) Patricios (1986) USGS (1986)

TABLE B-10
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: LAND USE

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Industrial Land Use (continued)	Verify and update industrial land use classifications shown on existing plans using aerial photography and field reconnaissance	Orthophoto maps Revised planimetric or topographic maps Field notes and sketches, descriptive information (text)	U.S. Geological Survey State/County/local planning agencies Aerial photo contractors Results of field reconnaissance	Avery (1969) Anderson (1973) Paine (1975) Malone (1977) Lounsbury and Aldrich (1979) Borella et al. (1982) Campbell et al. (1983) Teicholz and Berry (1983) Estes et al. (1984) ASPRS (1987)
	Prepare original industrial land use inventory using aerial photo interpretation and verify through field reconnaissance	Planimetric or topographic maps Mapped information representing projections of changes through facility closure period	Aerial photo contractors Results of field reconnaissance	Paine (1975) Borella et al. (1982) Campbell et al. (1983) Estes et al. (1984)
Agricultural Land Use	Obtain and review land use and general plans for the site area within 10km; plot agricultural landholdings and use categories (including lands used for growing food crops, timber and forage for livestock) on regional and localized base map series (coordinate with data collection activities described in Table B-14 under livestock and Table B-6 for timber and agricultural resources)	Planimetric or topographic maps Projections of changes through facility closure period	County/local planning agencies Federal and State land management agency planners County Extension agents	Chaplin (1965) Clawson (1965) Goodman and Freund (1968) Anderson et al. (1976) Rodgers (1976) Edgington and Edgington (1977) Malone (1977) Lounsbury et al. (1981) Patricios (1986) USGS (1986)
	Verify agricultural land uses using field reconnaissance and aerial photography	Orthophoto maps Revised planimetric or topographic maps Field notes and sketches, descriptive information (text)	U.S. Geological Survey U.S. Department of Agriculture State/County/local planning agencies and extension agents Aerial photo contractors Results of field reconnaissance	Avery (1969) Anderson (1973) Paine (1975) Lounsbury and Aldrich (1979) Teicholz and Berry (1983) ASPRS (1987)

TABLE B-10
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: LAND USE

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Agricultural Land Use (continued)	Prepare original agricultural land use inventory using aerial photo interpretation and verify through field reconnaissance	Planimetric or topographic maps Mapped information representing projections of changes through facility closure period	Aerial photo contractors Results of field reconnaissance	Paine (1975) Borella et al. (1982) Campbell et al. (1983) Estes et al. (1984)
	Identify and transfer to site maps USDA agricultural land quality classifications pertinent to site, including land capability and special designations for prime or unique farmland. It will also be necessary to assess environmental impacts on timber and agricultural productivity of site lands to be withdrawn from production, through comparison with standard crop yields for soil classifications present, field surveys, and consultation with agencies and timber and agricultural landowners (coordinate with studies for Natural Resources Impact, Table B-6)	Map designations of USDA classifications Tabular listing of potential crop yields or other productivity index supported by map designations of corresponding areas	USDA Soil Conservation Service County extension agents Local farmers Results of field surveys	USDA (1971) Olson (1981)
Recreational Land Use	Obtain and review land use and general plans for the site area and available maps and literature, targeting the area within 10km of the site; plot public recreation facilities (parks, trails, watercourses), noting multiple uses	Planimetric or topographic maps Projections of changes through facility closure period	County/local planning agencies Federal/State/local agencies (e.g., U.S. Forest Service, State Parks Departments, County Parks Boards, and Municipal Parks Departments)	Chapin (1965) Clawson (1965) Goodman and Freund (1968) Anderson et al. (1976) Rodgers (1976) Edlington and Edlington (1977) Malone (1977) Lounsbury et al. (1981) Patricios (1986) USGS (1986)

TABLE B-10
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: LAND USE

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Recreational Land Use (continued)	Verify recreational land uses using field reconnaissance and aerial photography	Orthophoto maps Revised planimetric or topographic maps Field notes and sketches, descriptive information (text)	U.S. Geological Survey State/County/local planning agencies Aerial photo contractors Results of field reconnaissance	Avery (1969) Anderson (1973) Paine (1975) Lounsbury and Aldrich (1979) Teicholz and Berry (1983) ASPRS (1987)
	Prepare original recreational land use inventory using aerial photo interpretation and verify through direct field reconnaissance	Planimetric or topographic maps Mapped information representing projections of changes through facility closure period	Aerial photo contractors Results of field reconnaissance	Paine (1975) Borella et al. (1982) Campbell et al. (1983) Estes et al. (1984)
Special Use Areas	Obtain and review land use and general plans for the site area and available maps and literature, targeting the area within 10km of the site; identify and plot locations of special use areas, and identify ownership and uses	Planimetric or topographic maps Projections of changes through facility closure period	County/local planning agencies Federal/State/County/local agencies (e.g., Department of Defense, National Park Service, State lands agencies, Bureau of Indian Affairs)	Chapin (1965) Clawson (1965) Goodman and Freund (1968) Anderson et al. (1976) Rodgers (1976) Edlington and Edlington (1977) Malone (1977) Lounsbury et al. (1981) Patricios (1986) USGS (1986)
	Verify special use areas using field reconnaissance and aerial photography	Orthophoto maps Revised planimetric or topographic maps Field notes and sketches, descriptive information (text)	U.S. Geological Survey State/County/local planning agencies Aerial photo contractors Results of field reconnaissance	Goodman and Freund (1968) Avery (1969) Anderson (1973) Paine (1975) Lounsbury and Aldrich (1979) Borella et al. (1982) Campbell et al. (1983) Teicholz and Berry (1983) Estes et al. (1984) ASPRS (1987)

TABLE B-10
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: LAND USE

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Zoning Restrictions	Obtain and review zoning information for the site and the area within 10km to identify existing zoning categories and the restrictions and permissible uses that accompany each category, and plot zoning classifications on site maps	Zoning maps and plans	County and local planning agencies	U.S. Dept. Commerce (1966) Malone (1977) Robinson (1977) Patterson (1979) Schultz and Kasen (1984) Galley (1985)
	Consult with planning staffs regarding status of zoning plans, proposed or expected revisions	Interview notes Revised maps	County and local planning agencies	
Local Land-Use Plans	Obtain and review county and local land use plan for the site and the area within 10km of the site; ascertain trends in lands uses	See land use parameters (residential, agricultural, recreational)	County and local planning agencies	See land use parameters (residential, industrial, agricultural, recreational)
	Consult with planning staffs regarding land use trends	Interview notes Mapped information representing projections of changes through facility closure period	County and local planning agencies	See land use parameters (residential, industrial, agricultural, recreational)
Land Ownership Patterns	Obtain and review land use, general and other plans, and tax records for public/private land ownership; plot land ownership on maps	Planimetric or topographic maps displaying ownership types Plot maps Legal descriptions of property ownership	County and local planning agencies Federal and State land management agencies County or municipal tax assessor's offices	International Association of Assessing Officers (1978) Almy (1979)
	Survey site area within 10km for ownership information (coordinate with site ownership data collection activities described in Table B-8 under Site Ownership)	Names of owners to be added to maps Supporting lists of contacts, addresses	Results of field reconnaissance and landowner interviews	International Association of Assessing Officers (1978) Almy (1979)

TABLE B-10
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: LAND USE

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
USDA Land Use Classification	Review USDA land capacity classification and prime/unique agricultural land use designation for presence on site and within 10km	Planimetric or topographic maps displaying USDA designations	USDA Soil Conservation Service offices County Extension agents Colleges and universities	Center (1977) Rau and Wooten (1980) Casley and Lury (1982)
Utility Land Uses	Obtain and review maps and plans on utility facilities, rights-of-way, and other uses on site and within 10km; plot utility land uses and easements on site maps Verify locations of utility features through aerial photo interpretation, field reconnaissance, and assistance from utility staff	Planimetric or topographic maps displaying utility features Revised maps Field sketches and notes Descriptive information (text)	County/local planning agencies Utility Companies (electric, power, telephone, water/sewer, etc.) Results of field reconnaissance	See land use parameters (residential, industrial, agricultural, recreational) U.S. Forest Service (1975) Macaulay (1976)

TABLE B-10
REFERENCES - LAND USE

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TABLE B-11
PARAMETER DESCRIPTIONS - METEOROLOGY

Wind Speed/Direction: The rate of air flow and its trajectory, measured continuously at various heights above ground level as hourly means (scalar speed and resultant vector speed and direction) and peak instantaneous gust speeds; hourly data calculated to long-term (monthly, seasonal, annual) summaries by joint frequency distributions using six speed categories and sixteen direction categories, average scalar speeds, and maximum gust speeds.

Atmospheric Pressure: Force per unit area exerted by overlying air mass at the earth's surface, typically as hourly values; calculated to monthly and annual averages.

Precipitation: Water particles that fall from the air and reach the ground including liquid (rain, drizzle) and frozen (snow, hail) water; measured as hourly or daily totals, and calculated to monthly and annual totals, both as water equivalent and depth of snow; also calculated to extreme values of precipitation rates and totals by various time periods.

Pan Evaporation: Amount of water evaporated daily from a standard pan, calculated to monthly and seasonal totals. Used as an indication of evaporation from free water surfaces (such as lakes, ponds) and with soil and vegetation information to estimate evapotranspiration.

Humidity/Dew-Point/Wet-Bulb: Measures of atmospheric water vapor; humidity is the water vapor fraction of saturation conditions; dew-point temperature is the air temperature at which ambient water vapor will condense on a surface; simply, wet-bulb temperature is the temperature measured as hourly average values and calculated to monthly, seasonal and annual averages, often for specific hours of the day.

Air/Soil Temperatures: Measurements of ambient air temperature at various heights above ground level, usually 2 meters and others as required; used in water and energy balance, and air quality dispersion analyses; measured as hourly values or daily maximum/minimum and average values by month, and annual average temperatures. Measurements of soil temperature made at selected depths within the soil, used in water and energy budget analyses.

Frost Penetration: Depth within the soil to which water is frozen, measured as depths by month or season.

Snow Cover: Snow depth in undisturbed areas, measured daily or less often; measured as occurrence of depths at least one inch, snow depth (both incremental storm events and cumulative depths), and water equivalent (obtained by weighing or melting a snow core); calculated to monthly or seasonal averages.

Solar Radiation: Total incoming solar radiation, typically measured at 2 meters above ground as hourly and daily total incoming energy, calculated to monthly totals; also can be used with terrestrial long-wave radiation to compute net radiation, measured as hourly average amounts; used in energy and water budget analyses.

Severe Weather: Occurrences of significant weather events such as tornadoes, hurricanes, thunderstorms, hail, blizzards, etc. Magnitude of events can be treated along with individual parameter, such as extreme temperature and precipitation events.

TABLE B-11
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: METEOROLOGY

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Wind Speed/Direction	<p>Compile representative existing historical data to determine fit and representativeness of site-specific data with regional setting and record; data needed on prevailing wind direction and resultant speed, mean speed, extreme speed; Stability Array (STAR) format stability/wind speed and direction joint frequency distributions</p> <p>Establish on-site monitoring program to develop data for modeling airborne pathway; install anemometer and wind direction and temperature on meteorological tower (single tower generally satisfactory for site characterization). This and other monitoring equipment on the tower and other locations may be connected to digital data acquisition system; measurements at least 10m above ground; also at 2m advisable. Need for additional towers dependent on complexity of terrain and agency review.</p> <p>Formulate database by preparing summaries of data collected on-site</p>	<p>Data tables/tabular summaries on paper or microfiche, and magnetic tapes supported by map displays</p> <p>Data tables/tabular summaries of hourly values of vector resultant direction and speed; scalar mean speed and peak gusts, hourly values of standard deviation of wind direction (σ_{wind} theta); EPA preferred measure of atmospheric stability and temperature differences between 10 and 2 meters is advisable</p> <p>Data tables/tabular summaries of hourly listings of scalar and vector wind and sigma theta and temperature difference; STAR joint frequency distribution, monthly average scalar speed and peak gust</p>	<p>State & Federal climatic data summaries (NOAA/NESDIS/NCDC)</p> <p>Results of on-site data collection</p> <p>Results of on-site data collection</p>	<p>Warren (1983)</p> <p>DOE (1984) NRC (1986) EPA (1987)</p> <p>DOE (1984) NRC (1986) EPA (1987)</p>

(1) Note: Throughout the meteorological tables, the terms "historical" and "long term" (applied to existing data) refer to a period of record of five years or a minimum; a 30-year period of record is normal and preferred. "Representative" sources usually means the nearest location for which the proper records exist, though judgement is required not to select a location with a significantly different exposure and/or surroundings that would make the location likely to experience different meteorological conditions than at the proposed LIA site.

TABLE B-11:
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: METEOROLOGY

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Atmospheric Pressure	Compile representative existing data on long-term monthly mean values of atmospheric pressure to define regional and historical setting	Data tables/tabular summaries and magnetic tapes supported by map displays	State and Federal climatic data summaries (NOAA/NESDIS/NOGC)	Warren (1983)
	Establish on-site monitoring program to support modeling of airborne pathway by installing continuously-recording barometer on meteorological tower; measurements at 2m above ground	Data tables/tabular summaries of hourly mean values	Results of on-site data collection	DOE (1984) EPA (1987)
	Formulate database by preparing summaries of data collected on-site	Data tables/tabular summaries of hourly listings; summarize to monthly averages of daily max/min/mean values	Results of on-site data collection	DOE (1984)
	Compile representative existing data to determine fit of site-specific data with historic record; data needed on: Long-term mean values Long-term extremes	Data tables/tabular summaries of long-term averages of monthly and annual total precipitation; same for separate snowfall totals Data tables/tabular summaries of long-term occurrences of max/min 24-hour (and shorter), monthly and annual totals of precipitation and snowfall; occurrences of days with precipitation and snowfall over various amounts	State and Federal climatic data summaries (NOAA/NESDIS/NOGC) State climatologists	Warren (1983)

1) See Footnote, Page 1.

TABLE B-11
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: METEOROLOGY

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Precipitation (cont.)	Establish on-site monitoring program to support modelling of site water budget; install surface-mounted precipitation collection gauge	Data tables/tabular summaries of hourly values of total precipitation; daily values of snowfall and snow depth	Results of on-site data collection	DOE (1984) NEC (1986) EPA (1987)
	Formulate database by preparing summaries of data collected on-site	Data tables/tabular summaries of hourly and daily listings of measured values, also summarized as daily and monthly max and means	Results of on-site data collection	DOE (1984) NEC (1986) EPA (1987)
	Integrate with hydrology study (coordinate with hydrologic and hydraulic modelling activities described in Table B-3)	Data tables/tabular summaries of hourly and daily listings of measured values, also summarized as daily and monthly max and means	On-site database	
Pan Evaporation	Compile representative existing data on daily, monthly and seasonal total evaporation; long-term averages of monthly and seasonal evaporation; compare with site-specific data to determine representativeness of site data	Data tables/tabular summaries of daily totals of Pan evaporation	State climatologists Representative State and Federal climatic data summaries (NOAA/NESDIS/NCDC);	Warren (1983)
	Establish on-site monitoring program to support modelling of site water budget; install surface mounted Pan evaporation system (coordinate with activities to define boundary conditions for ground water in Table B-21a)	Data tables/tabular summaries of daily totals of Pan evaporation	Results of on-site data collection	Rosenberg (1974) DOC/DOG/DOE (1982) DOE (1984)
	Formulate database by preparing summaries of data collected on-site	Data tables/tabular summaries of monthly and seasonal total evaporation	Results of on-site data collection	

TABLE B-11
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: METEOROLOGY

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Pan Evaporation (Cont.)	Relate Pan evaporation data to evapotranspiration (ET) estimates using empirical relationships between evaporation and soils (coordinate with activities to define boundary conditions for ground water in Table B-2(a) and engineering properties of soils as discussed in Table B-7)	Data tables/tabular summaries of monthly and seasonal ET estimates	Results of on-site data collection	Rosenberg (1974) DOC/DOO/DOOT (1982) DOE (1984)
Humidity/Dew-Point/Wet-Bulb	Compile representative existing humidity/dew-point/and temperature/wet bulb data to determine representativeness of site-specific data in regional and historic setting (long-term monthly averages by hour of day; frequency of occurrences of each parameter as a function of air temperature);		State and Federal climatic data summaries (NOAA/NESDIS/NCDC) State climatologists	Warren (1983)
	Relative humidity data	Data tables/tabular summaries of monthly and annual averages for 4 specific hours of day		
	Dew-point temperature data	Data tables/tabular summaries of monthly and annual averages by 3 hour period (10 yr. period)		
	Wet-bulb temperature data	Data tables/tabular summaries of monthly and annual averages by 3 hour period; statistical summaries, with air temperature		
	Establish on-site monitoring program to support airborne pathway modeling by installing dewcell; measure at 2m above ground with air temperature	Data tables/tabular summaries of hourly dew-point temperature	Results of on-site data collection	DOE (1984) NRC (1986) EPA (1987)

TABLE B-11
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: METEOROLOGY

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Humidity/Dew Point/Wet Bulb (Cont.)	Formulate database by preparing summaries of data collected on-site	Data tables/tabular summaries of hourly listings and monthly averages by hour of day	Results of on-site data collection	DOE (1984) NRC (1986) EPA (1987)
Air/Soil Temperatures	Compile representative existing air and soil temperature data to determine if site-specific data are typical of regional and historical patterns including: Air temperature data	Data tables/tabular summaries of long-term averages of daily air temp max/min/means by month and annual State Climatologists	State and Federal climatic data summaries (NOAA/NESDIS/NCDC)	Warren (1983)
	Soil temperature data	Data tables/tabular summaries of daily max/min soil temps at selected depths, monthly and annual averages	State and Federal climatic data summaries (NOAA/NESDIS/NCDC)	Rosenberg (1974)
	Establish on-site monitoring program for air and soil temperature to support modeling of site water budget and airborne pathway by installing thermalist probes on meteorological tower for air measurements and in subsurface locations (selected depth) for soil measurements	Data tables/tabular summaries of hourly values; calculate daily max/min/means at selected depths	Results of on-site data collection	DOE (1984) NRC (1986) EPA (1987)
	Formulate air soil temperature database by preparing summaries of data collected on-site	Data tables/tabular summaries of monthly averages of max/min/means	Results of on-site data collection	

TABLE B-11
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: METEOROLOGY

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Frost Penetration	Compile representative existing data on seasonal average depth of frozen water in soil; compare with site-specific data to determine representativeness of onsite data	Tabular summaries	State and Federal data summaries (NOAA/NESDIS/NCDC)	Warren (1983)
	Perform on-site measurements of frost penetration for analysis of site water budget and design recommendations on a seasonal basis using borehole or test pit (coordinate with activities to define engineering properties of soils discussed in Table B-7)	Data tables/tabular summaries of depth of frozen water in soil	Results of on-site data collection	Andersland and Anderson (1978)
Snow Cover	Compile representative existing data on long-term averages of snow cover occurrence (days with depth >1"); snow depths and water equivalent; compare with data from onsite monitoring to determine fit with historical patterns	Tabular summaries	State and Federal climatic data summaries (NOAA/NESDIS/NCDC)	Warren (1983)
	Establish on-site monitoring program by taking depth and cover observations to support analysis of site water budget and design recommendations	Tabular summaries	Results of on-site data collection	DOC/DOO/DOE (1982)
	Formulate snow cover database by preparing monthly summaries of occurrences, depths and water equivalent	Tabular summaries	Results of on-site data collection	Rosenberg (1974)

TABLE B-11

SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: METEOROLOGY

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Solar Radiation	Compile representative existing data (long-term monthly means) on solar radiation to compare site-specific data with prevailing conditions	Tabular summaries	State and Federal data summaries (NOAA/NESDIS/NCDC)	
	Establish on-site solar radiation monitoring program to support quantification of evaporative processes; install surface mounted pyranometer	Data tables/tabular summaries of hourly total incoming solar; hourly net (solar-terrestrial) radiation	Results of on-site data collection	DOE (1984) NRC (1986) EPA (1987)
	Formulate solar radiation database by preparing summaries of data collected on-site	Data tables/tabular summaries of monthly and hourly totals of total incoming solar and net radiation	Results of on-site data collection	DOE (1984)
Severe Weather	Compile representative existing data on occurrences of severe weather events, including tornadoes, hurricanes, blizzards, and lightning to support design recommendations and emergency procedures	Tabular summaries supported by map displays	State and Federal climatic data summaries (NOAA/NESDIS/NCDC)	Warren (1983)
	Integrate with existing and on-site data for extremes of temperature, precipitation and wind	Data tables/tabular summaries of max/min temperature extremes; significant precipitation events, daily or month totals, hourly (or less) precipitation rates, snow depths; fastest mile wind speed	Existing data and results of on-site data collection	Simiu et al. (1979) ANSI (1982)

TABLE B-12
PARAMETER DESCRIPTIONS-AIR QUALITY

Pollutant Type: The classification of non-radiological, airborne, pollutants likely to be found at a proposed site as existing background or expected to be present during site development, operation, or closure; includes EPA criteria pollutants (40 CFR 50); sulfur dioxide, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead. Also includes hydrocarbons that may cause health impacts.

Pollutant Concentrations: Measured or estimated amount of the pollutant types, based on averaging times corresponding to the ambient air quality standards.

Regional Classification: The designation given to the air quality control region through regulation or agency evaluation to denote attainment (i.e., compliance with the National Ambient Air Quality Standards) or non-attainment for each air pollutant. Special restrictions and control requirements for air pollution exist in the non-attainment areas.

Air Quality Control Region: The region of the country, as designated by U.S. EPA for control and management of air pollutants, within which the site is located.

Air Quality Ceilings: Upper limits on concentrations of non-radiologic air pollutants, as set forth in 40 CFR 50 (National Primary and Secondary Ambient Air Quality Standards) and State regulations.

TABLE B-12
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: AIR QUALITY (NON-RADIOLOGICAL)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Pollutant Type (non-radiological)	<p>Compile representative existing ambient data for criteria pollutants by inventorying local, State and Federal air quality data bases.</p> <p>Identify emissions from proposed facility, such as combustion sources, material handling operations, and facilities which utilize volatile organic compounds.</p> <p>Identify other emissions that may cause short-term or long-term health impacts</p>	<p>Data tables/tabular summaries on paper or microfiche, and magnetic tapes</p> <p>Tabular summaries</p> <p>Tabular summaries</p>	<p>Local agency reports, state reports, and EPA SAROAD files</p> <p>Preliminary design plans</p> <p>Emissions data maintained by U.S. EPA, State and local air quality regulatory agencies, and U.S. EPA health manuals</p>	<p>EPA (1986) Contact local State agency responsible for environmental control</p> <p>EPA (1986)</p>
Pollutant Concentrations (non-radiological)	<p>Compile representative existing data on criteria pollutants to compare with site-specific data, including local, State and Federal data summaries on:</p> <ul style="list-style-type: none"> Sulfur dioxide (SO₂) Particulate matter (PM-10) Carbon monoxide (CO) Ozone (O₃) Nitrogen dioxide (NO₂) Lead (Pb) 	<p>Tabular summaries providing:</p> <ul style="list-style-type: none"> 3-hr, 24-hr, annual averages 24-hr annual averages 1-hr, 8-hr averages 1-hr average Annual average Calendar quarter average 	<p>Local agency reports, state reports, and EPA SAROAD files</p>	<p>EPA (1986)</p>

TABLE B-12
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: AIR QUALITY (NON-RADIOLOGICAL)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Pollutant Concentrations (non-radiological) (cont.)	<p>Compile other representative data on non-criteria pollutants, such as organic compounds and metals</p> <p>Establish on-site monitoring program for required pollutants to establish a baseline for monitoring during construction and operations; install EPA approved continuous monitoring instrumentation for gaseous pollutants, and by 24-hour integrated samples on filters (high-volume air sampling equipment) for particulate matter and lead</p> <p>Formulate pollutant concentration data base</p>	<p>Tabular summaries</p> <p>Hourly listings; summarize to averages corresponding to averaging times of standards</p> <p>Hourly listings; summarize to averages</p>	<p>University research Local agency reports</p> <p>Results of on-site data collection</p> <p>Results of on-site data collection and appropriate existing data</p>	<p>EPA (1986)</p> <p>Stern (1968) EPA (1984) 40 CFR Part 50 40 CFR Part 58</p> <p>40 CFR Part 50 40 CFR Part 58</p>
Regional Classification	Determine standard attainment status of area (attainment, non-attainment, or unclassifiable) by pollutant to identify constraints on facility releases	Tabular designations supported by maps	U.S. EPA	40 CFR 81
Air Quality Control Region (AQCR)	Determine which AQCR contains proposed site	Tabular designations supported by maps	U.S. EPA	40 CFR 81

TABLE B-12
 SITE CHARACTERIZATION TECHNICAL GUIDANCE
 DATA TYPE: AIR QUALITY (NON-RADIOLOGICAL)

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Air Quality Cellings	<p>Comply Federal and State (if different) standards for pollutant types of concern to compare with potential facility releases; Include:</p> <ul style="list-style-type: none"> Sulfur dioxide (SO₂) Particulate matter (PM-10) Carbon monoxide (CO) Ozone (O₃) Nitrogen dioxide (NO₂) Lead (Pb) 	<p>Concentrations by averaging times corresponding to various standards:</p> <ul style="list-style-type: none"> 3-hr, 24-hr, annual averages 24-hr, annual averages 1-hr, 8-hr averages 1-hr average Annual average Calendar quarter average 	<p>U.S. Environmental Protection Agency</p>	<ul style="list-style-type: none"> 40 CFR 50.4 and 50.5 40 CFR 50.6 40 CFR 50.8 40 CFR 50.9 40 CFR 50.11 40 CFR 50.12

TABLE B-12
REFERENCES-AIR QUALITY

CFR; see Code of Federal Regulations.

Code of Federal Regulations, Title 40; Subchapter C-Air Programs. Part 50 - National Primary and Secondary Air Quality Standards. Part 58 - Ambient Air Quality Surveillance, Part 81 - Designation of Areas for Air Quality Planning Purposes.

EPA; see U.S. Environmental Protection Agency.

A.C. Stern, Air Pollution, 2nd Ed., Vol. II; New York: Academic Press, 1968.

U.S. Environmental Protection Agency, Ambient Monitoring Guidelines for Prevention of Significant Deterioration, EPA-450/4-80-012, November 1980, also Draft Revision, August 1984.

U.S. Environmental Protection Agency, Superfund Public Health Evaluation Manual, EPA 540/1-86-060, October 1986.

TABLE B-13
PARAMETER DESCRIPTIONS - RADIOLOGICAL ASSESSMENT

Direct Gamma Radiation: A measure of the ionization produced in air by x or gamma radiation. The special unit of exposure is the roentgen.

Airborne Radionuclides: The sampling of a known volume of air with subsequent identification of radionuclide and activity concentration (in picocuries per liter). These analyses will be for both naturally occurring and man-made radionuclides.

Soil: Identification of the radioactivity in soil. This includes direct or in vivo measurements of gamma-rays emitted from radionuclides in the surface soils (e.g., radium bearing soils) or by the collection of surface or subsurface samples with subsequent gamma-ray spectroscopy or radiochemical separation with alpha or beta counting techniques.

Surface Water: The sampling of flowing streams, ponds, lakes, and rivers with the subsequent analysis of radionuclide type and activity concentration in picocuries per liter recognizing the distinction between soluble species and suspended matter.

Ground Water: The sampling and subsequent analysis of groundwater to identify radionuclides and measure the activity concentration in picocuries per liter (pc/l), recognizing the distinction between soluble species and suspended matter.

Sediments: Sampling of loose, unconsolidated sediments (sand, gravel, silt, mud, etc.) including the suspended fraction with the subsequent identification of radionuclide and activity concentration in picocuries per gram of solid fraction.

Flora: Radionuclides in abiotic compartments can enter plants by uptake from soil, deposition from air, or sorbtion from water in the case of aquatic plants. Uptake implies internal incorporation within tissues of the plant. Frequently radioactive materials in soil adhere to the root or shoot surface of plants but are not actually incorporated into plant tissues. Radionuclides in air or water can be deposited on or otherwise attached to plant surfaces directly without passage through soil. Analyses should be made to identify the radionuclide and determine the activity concentration in picocuries per gram.

Fauna: Passage of radioactive material to terrestrial and aquatic species occurs primarily by ingestion and inhalation. Each step of the food chain provides some form of discrimination in that radionuclides are channeled physiologically into certain tissues, depending on their physical/chemical properties. Analyses of fauna can be organ specific (e.g., I-131 in the thyroid) depending on the radionuclide of concern, or whole body specific (e.g., Cs-137). Analyses should be made to identify the radionuclide and determine the activity concentration in picocuries per gram.

Food: Measurement of radioactivity in crops, livestock, dairy products and game animals consumed by humans including radionuclide and concentration.

TABLE B-13
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: RADIOLOGICAL ASSESSMENT

Parameter	Technique: Activities/Study Methods	Data Formats	Data Sources	References
Direct Gamma Radiation	Perform aerial radiological survey to identify and map the presence of natural gamma ray emitting radionuclides within a 70 sq. km area centered on the site using helicopter-mounted scintillation detection equipment	Isometric contour map of entire area in millirem per hour	Results of aerial radiological survey	Jobst (1979) DOE (1983) Shipman (1985)
	Perform ground-based gamma ray radiological survey using a pressurized ionization chamber at locations identified during the aerial survey as exhibiting natural background radiation and where elevated radiation levels were found. (Note: This survey will provide ground truth for the aerial measurements; support selection of locations for air monitoring stations; and guide soil sampling for radionuclides)	Tables indicating exposure rate in millirem per hour supported by maps displaying sampling grid locations	Results of onsite gamma ray radiological survey	NCRP (1976) DOE (1983)

TABLE B-13
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: RADIOLOGICAL ASSESSMENT

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Direct Gamma Radiation (Cont.)	Perform ground-based gamma-ray radiological measurements using thermoluminescent dosimetry (lithium fluoride TLD-700 dosimeters) to provide at least one year of continuous sampling data to establish baseline conditions both on-site and at background locations. Samples are analyzed quarterly	Tables indicating exposure rate in millirem per hour, supported by maps displaying sampling grid locations	Results of onsite radiological measurements	NCRP (1976) DOE (1983)
Airborne Radionuclides	Install equipment and conduct continuous air monitoring for at least one year to measure baseline concentrations of airborne particulate radionuclides; monitoring stations up and downwind from the site and around the site perimeter, based on meteorological setting; measure for: Cs-137 Sr-90 Pu-238 Pu-239 U-234 U-235 U-238 Co-60	Tables showing airborne activity concentrations (pico curies per liter) as a function of sampling location	Results of onsite monitoring program	NCRP (1976) DOE (1981) DOE (1983) University of Arizona (1985)
	Install radon track-etch detectors and monitor for radon-222 to establish baseline concentrations at perimeter locations and up and downwind of site; one year minimum duration	Tables showing airborne radon activity concentrations (pico curies per liter) as a function of sampling location	Results of onsite monitoring program	NCRP (1976) DOE (1981) DOE (1983) Hard and Fleisher (1981)

TABLE B-13
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: RADIOLOGICAL ASSESSMENT

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Airborne Radionuclides (continued)	Install equipment and conduct continuous air monitoring for at least one year for radioactive gases to establish baseline concentrations H-3 C-14 Kr-85	Tables showing airborne activity concentrations (picocuries per liter) as a function of sampling location	Results of onsite monitoring program	DOE (1981) DOE (1983) University of Arizona (1985)
	Install equipment and conduct monitoring for I-131 for at least one year to establish baseline concentrations	Tables showing airborne activity concentrations (picocuries per liter) as a function of sampling location	Results of onsite monitoring program	DOE (1981) DOE (1983)
Soil	Perform surface soil sampling on the site and at up and downwind locations to establish baseline concentrations for: Sr-90 H-3 Isotopic Pu Cs-137 Tc-99 Isotopic uranium Isotopic thorium Ra-226 (Coordinate with activities for radiometric dating and isotope content described in Table B-4)	Tables showing radionuclides present and activity concentrations as a function of locations	Results on onsite soil sampling	DOE (1979) DOE (1983) Fleischer (1985) University of Arizona (1985)

TABLE B-13
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: RADIOLOGICAL ASSESSMENT

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Soil (cont.)	<p>During stratigraphic sampling (test pits, trenches, boreholes, described in Table B-1), sampling of subsurface soils for radionuclides should also be performed at varying depths; sample for radionuclides, including:</p> <ul style="list-style-type: none"> Isotopic uranium Ra-226 Sr-90 H-3 Isotopic Pu Cs-137 Tc-99 Isotopic uranium Isotopic thorium 	Tables showing radionuclides present and activity concentrations as a function of depth and locations	Results of sampling onsite subsurface soils	DOE (1983) University of Arizona (1985)
Surface Water	<p>Perform quarterly sampling of all surface waters within 10km of the site over a one year period using grab sampling or peristaltic pump techniques. (Coordinate with activities for water quality analysis and radiometric dating in Table B-4). Analyze samples for H-3, gross alpha and gross beta activity; perform routine gamma spectral analysis to identify gamma-ray emitting radionuclides. Samples having elevated gross alpha and gross beta should be analyzed for:</p> <ul style="list-style-type: none"> Sr-90 Tc-99 C-14 Isotopic uranium Isotopic thorium Isotopic plutonium 	Tabular listing of radionuclide activity concentrations (picocuries per liter) as a function of water depth and location, including filtered and non-filtered components	Results of site characterization surface-water sampling	<p>Jeffe et al. (1982) Thornton et al. (1982) Casey et al. (1983) DOE (1983) Korte and Keadl (1985) University of Arizona (1985)</p>

TABLE B-13
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: RADIOLOGICAL ASSESSMENT

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Ground Water	<p>Conduct groundwater sampling program using monitoring wells developed for groundwater hydrology test (see Table B-2) in vadose zone and ground water is to establish baseline concentrations (coordinate with activities for water quality analysis and radiometric dating in Table B-4). Radiologic constituents of interest include:</p> <p>H-3 C-14 Sr-90 Tc-99 Isotopic uranium Isotopic thorium Isotopic plutonium Ra-226 Cs-137</p>	<p>Tables of radionuclides and activity concentrations as a function of depth and location</p>	<p>Results of onsite ground-water sampling</p>	<p>Wood (1976) Scalf et al. (1981) Volchok and Planque (1982) DOE (1983) Korte and Kearl (1984) University of Arizona (1985)</p>

TABLE B-13
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: RADIOLOGICAL ASSESSMENT

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Sediments	<p>Sample sediments up and downstream from the site to develop baseline activity concentrations. Sampling considerations will include particle size variation, seasonal changes in discharge, and organic matter production. Recommended procedures include grab sampling using a teflon scoop or trowel and rapid shallow coring using a PVC pipe. Analysis should include:</p> <ul style="list-style-type: none"> Isotopic uranium <ul style="list-style-type: none"> Ra-226 Sr-90 H-3 Isotopic plutonium <ul style="list-style-type: none"> Cs-137 Tc-99 	<p>Tables showing radionuclide and activity concentrations as a function of locations for each particle size</p>	<p>Results of site characterization sediment sampling National Uranium Resource Evaluation (NURE) Sediment Reconnaissance (HSSR) U.S. Geological Survey</p>	<p>USDI (1977) DeVera et al. (1980) DOE (1983) Fleischauer and Engelder (1984)</p>

TABLE B-13
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: RADIOLOGICAL ASSESSMENT

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Flora (Vegetation, Forage)	<p>Sample vegetation in monitored plots on the site, upwind and downwind to identify baseline concentrations. Initial sampling performed at locations identified during the gamma ray measurements program. Plant species sampled should reflect regional variation and forage species (coordinate with activities to characterize flora in Table B-14).</p> <p>Preparation for analyses will include distillation to drive off water vapor and H-3 and subsequent dry ashing.</p>	<p>Tables showing radionuclide and activity concentration as a function of location for composite vegetation and for specific forage species</p>	<p>Results of onsite vegetative sampling</p>	<p>DOE (1983) University of Arizona (1985)</p>
Fauna (Terrestrial)	<p>Identify and sample important* or representative species indigenous to the site area to identify baseline concentrations (coordinate with activities to characterize terrestrial fauna in Table B-14). Analysis will include:</p> <ul style="list-style-type: none"> Isotopic uranium Isotopic thorium Re-226 Cs-137 K-40 Tc-99 H-3 Isotopic plutonium 	<p>Tables showing radionuclide and activity concentration as a function of location and species/type</p>	<p>Results of onsite sampling of faunal species</p>	<p>DOE (1983) University of Arizona (1985)</p>

*As specified in NRC regulatory guidance, a species is "important" if a specific causal link can be identified between the the proposed project and the species and if one or more of the following criteria apply: (1) the species is commercially or recreationally valuable, (2) the species is threatened or endangered (Pub. Law 93-205, 87 Stat. 884), (3) the species affects the well-being of some important species specified within criteria (1) or (2), or (4) the species is critical to the structure and function of the ecological system or is a biological indicator of radionuclides in the environment.

TABLE B-13
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: RADIOLOGICAL ASSESSMENT

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Fauna (Aquatic)	Identify and sample important* or representative faunal species indigenous to the wetlands or streams in the vicinity of the site, if any. Sample for a minimum of one year to account for temporal variations in species (coordinate with activities to characterize aquatic fauna in Table B-14). Preparation for analysis of faunal samples will depend on site-specific species. Small mammals or fish may be dissected with certain portions (organs) dry ashed. Benthic organisms from nearby streams or other bodies of water may be dry ashed in their entirety.	Tables showing radionuclide and activity concentration as a function of location and species/type	Results of site characterization sampling program	DOE (1983) University of Arizona (1985)
Food	Inventory all farmland and dairies in the vicinity of the site as well as the private properties with livestock or gardens (coordinate with activities to characterize livestock and food chain in Table B-14). Sample according to site-specific factors, up and downwind of the site. Collect milk from dairies and analyze for I-131 and Sr-90. Crops may include grains,	Tables showing radionuclides and activity concentration as a function of location and food type, including milk, crops and livestock	Results of site characterization sampling of livestock, crops, and foodstuff	Kahn (1965) DOE (1983) University of Arizona (1985)

*As specified in NRC regulatory guidance, a species is "important" if a specific causal link can be identified between the proposed project and the species and if one or more of the following criteria apply: (1) the species is commercially or recreationally valuable, (2) the species is threatened or endangered (Pub. Law 93-205, 87 Stat. 884), (3) the species affects the well-being of some important species specified within criteria (1) or (2), or (4) the species is critical to the structure and function of the ecological system or is a biological indicator of radionuclides in the environment.

TABLE B-13
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: RADIOLOGICAL ASSESSMENT

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Food (cont.)	<p>vegetables, fruit, etc. Preparation for H-3 analysis will include driving off water vapors through distillation and subsequent liquid scintillation analysis of the water. For analysis of other radionuclides, vegetables and grain may be dry ashed and analyzed using alpha and gamma spectroscopy. Large animals (cows) may be whole-body counted (gamma spectroscopy) or edible portions may be analyzed similarly. Small animals may be dissected so that only edible portions (organs) are analyzed or dry ashed and counted using alpha or gamma spectrometry.</p>			

TABLE B-13
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TABLE B-14
PARAMETER DESCRIPTIONS - ECOLOGY

Terrestrial Species (Fauna): Important wild and domestic animal species, including abundance, characteristics, distribution, ecological interrelationships, and breeding grounds.

Terrestrial Species (Flora): Major species of vegetation, including plant communities, species composition, relative abundance, successional stage, and vegetation types.

Aquatic Species: Aquatic species (flora and fauna), including composition, distribution, abundance, importance, seasonal variability, harvest, and nutrient concentrations.

Livestock: Domestic animals such as dairy cows and goats, with food chain significance.

Food Chain: An abstract representation of the passage of energy (or possible contaminants) through populations of terrestrial and aquatic organisms in a community.

Migratory Species: Species that migrate through the site or the vicinity.

Game Animals: Wild animal species (on the site and in the vicinity), which are hunted and potentially consumed.

Habitat: Habitats for important terrestrial or aquatic species, including location and area occupied; wildlife sanctuaries or natural areas; special, rare, unique habitats; and site-specific habitat for any identified threatened or endangered species.

Threatened/Endangered Species: Species existing in the site area or vicinity (or potentially present) that are designated by the U.S. Fish and Wildlife Service or a cognizant State agency as threatened or endangered.

Disease Vectors/Pests: Vertebrate and invertebrate species of local importance or concern as disease vectors or pests that could impact workers or operations on the site.

TABLE B-14
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: ECOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Terrestrial Species (Fauna)	Collect species-specific site or regional data on faunal species likely to occur in site area	Tabular species lists, maps of their distribution	Federal agencies (e.g., U.S. Fish and Wildlife Service) State agencies (e.g., Fish and Game departments, Natural Areas or Natural Heritage Programs, State zoologists) American Indian agencies Colleges and universities Theses and dissertations Professional journals Environmental impact studies for nearby projects Resource Management Plans Local conservation groups Unpublished reports Regional species lists and field guides Personal communications with local authorities	Schemnitz (1980)
	Conduct site reconnaissance surveys to prepare site-specific species lists and determine species or species groups to study quantitatively	Maps which include area surveyed, survey route, and location of trap lines; report giving methods and results (i.e., species observed, relative abundance, habitat preference, resident or transient seasonal use patterns)	Data sources obtained during literature and agency contact phase of work Results of onsite reconnaissance surveys	Kendeigh (1944) Wright and Wright (1949, 1957) Howell (1951) Carr (1952) Bond (1957) Bishop (1969) Henry et al. (1973) Conant (1975) Tilus and Mosher (1981) Cell (1982) Rosenfield et al. (1985)

TABLE 3-14 (Continued)

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Terrestrial Species (Fauna) (Cont.)	<p>Quantitative wildlife surveys that may include:</p> <ul style="list-style-type: none"> Population density estimates Relative density estimates Home range and habitat use patterns Movement patterns Territory size Seasonal use characteristics <p>These surveys to be done on species or species groups identified during the site reconnaissance surveys should be detailed enough to be able to detect changes that may be the result of facility operation</p>	<p>Data for population density estimates, including numbers marked (i.e., mammals and reptiles), number heard (i.e., nesting birds), number of recaptures, and assumptions and limitations of methodology. Map showing study area, grid location, locations of capture and/or observation points, home range size, habitat characteristics, and movement patterns.</p>	<p>Results of onsite wildlife surveys</p>	<p>Williams (1936) Schubel (1938) Jolly (1965) Wear (1969) Emlen (1971) Seber (1973) Otis et al. (1978) Devils and Winstead (1980) Robbins and Dowell (1986)</p>
Terrestrial Species (Flora)	<p>Compile site and/or regional plant species lists and vegetation studies</p> <p>Floristic surveys (site-specific ground surveys conducted periodically throughout the growing season)</p>	<p>Tabular lists of species which may grow in the area, and maps of their general distribution patterns</p> <p>List plant species found at the study site by habitat type</p>	<p>Federal agencies (e.g., U.S. Fish and Wildlife Service) State agencies (e.g., Fish and Game Departments, State botanists, State Forest Services, State Agricultural Services) American Indian agencies Colleges and universities Theses and dissertations Professional journals Published species lists Botanical references and keys Resource management plans Local conservationists and conservation groups</p> <p>Results of onsite floristic survey</p>	<p>Schemnitz (1980)</p> <p>Fernald (1950) Gleason and Cronquist (1963)</p>

TABLE B-14 (Continued)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: ECOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Terrestrial Species (Flora) (Cont.)	Vegetation mapping—use existing aerial photography, and ground check to produce a vegetation map of site. Determine area of each plant community by type.	Map of major plant community types from aerial photostatic survey. List species and relative abundance for each vegetation type. Provide acreage of each plant community type.	Existing or new aerial photos; field reconnaissance	Braun (1950) Schemnitz (1980)
	Quantitative vegetation studies (upland plant communities). Sample the frequency, density, and dominance of major plant species in each plant community type to determine the successional nature and structure of plant communities	Map showing location of study plots. Quantitative data tabulations obtained from sampling	Results of onsite quantitative vegetation studies	Cotton and Curtis (1956) Shimwell (1971) Grime (1979)
	Quantitative vegetation studies (wetlands). Sampling must occur periodically throughout the growing season to provide data on above ground (and below ground if needed) vegetation standing crop and/or productivity	Maps showing location of sample grids or transects. Tabular summaries of data collected including biomass and final standing crop and/or productivity	Data from site characterization studies	Larson (1976) Good et al. (1978)
	Sample and analyze vegetation in monitored plots for environmental contaminants that may be taken up by plants (coordinate with activities for radiological assessments of vegetation in Table B-13)	Maps and tabulations of pre-construction levels of contaminants in the vegetation, if any	Data from site characterization studies	Whicker and Schultz (1981) DOE (1983)
Aquatic Species	Collect site or regional data on aquatic species likely to occur in site area	Same as for terrestrial species (fauna)	Same as for terrestrial species (fauna)	

TABLE B-14 (Continued)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: ECOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Aquatic Species (Cont.)	Collect site specific data (fauna) by netting and trappings including: gill nets trammel nets strap nets seines funnel traps dip nets	List species observed, relative abundance, and habitat preference for each species Map showing sampling locations with information on species or aquatic habitat types that may require more detailed analysis	Data from site characterization studies	Belley (1970) Hubbs and Lagler (1970) Scott and Crossman (1973) Mason (1977) USFWS (1982)
	Determine habitat parameters (Coordinate with activities to characterize water quality in Table B-4). Habitat features to include water depth and velocity and substrate measurements. Analyze sediments for constituents of importance	Maps and tables according to habitat type	Data from site characterization studies	Rutber (1968)
	Sample for fish to observe short term (i.e., daily or weekly) and long-term (i.e., seasonal) variations in species composition and abundance	Text and tables on short-term and long-term trends	Results of site characterization studies	Picker (1975)
	Determine physical characteristics of fish, including total length and weight, to provide data on the condition of the fish before site construction. Remove stomachs of dead fish for analysis to provide data on food habits which relate directly to possible contaminant pathways.	Text and tables	Results of site characterization studies	Mason (1977)
	Conduct invertebrate sampling using nets and grab samples to provide data on common species and indicators of habitat quality. Analyze invertebrates for contaminants of concern.	List species by habitat and describe contaminant levels, if any	Results of site characterization studies	Pennak (1953) Swenson and Meyer (1973) Mason (1977) Merritt and Cummins (1978)

TABLE B-14 (Continued)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: ECOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Livestock	Determine species and number of animals likely to occur at and in area of proposed site	List number of animals per species and estimates of grazing pressure	State Agricultural Agency Federal land management agencies Local American Indian tribal agencies Local ranchers and farmers	Lephoe et al. (1986)
	Site reconnaissance survey to verify the occurrence of domestic livestock at and near the proposed site (coordinate with activities to characterize agricultural land uses in Table B-10)	Reports, maps, tables	Results of site characterization studies	
	Sample vegetation used by domestic livestock in monitor plots to provide information on pre-construction levels of environmental contaminants, if any. (Coordinate with activities for radiological assessments of food in Table B-13)	Reports, maps, tables	Results of site characterization studies	Lephoe et al. (1986)
Food Chain	Identify potential important food chains relative to contaminants that may be generated by a site to help identify habitats and/or species that need to be monitored during and after construction. Provide a preliminary analysis of possible habitats and species that may be impacted on site	Reports, maps, tables	Data sources include all those listed for terrestrial species (fauna) during the literature review and agency contact phase Other data sources may be: U.S. Department of Energy (DOE) U.S. Department of Defense (DOD) Contractors working for DOE and DOD State public service commissions State hazardous or radioactive waste departments Public and private utilities	Dahi et al. (1967) O'Farrell and Gilbert (1975) Halford et al. (1981) Whicker and Schultz (1981) Blus (1985) Dillon and Gibson (1985) Eisler (1985) Stoner et al. (1985) Beyer (1986) Jacakow et al. (1986) Lephoe et al. (1986) Ohtendorf et al. (1986)

TABLE B-14 (Continued)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: ECOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Food Chain (Continued)	<p>Determine food chain parameters to be analyzed based on the above analyses (i.e., invertebrates, sediments, and/or vegetation in a wetland may accumulate contaminants which may pass up the food chain via such species as waterfowl, and aquatic turtles) to provide evidence why a particular species or group of species or habitat should be included in the analysis</p> <p>Sample for contaminants of concern in food chain element of concern to provide data on contaminant levels at various levels within the habitat starting with soil or water/sediments moving to primary producers, grazers, and predators. Also provide preconstruction levels in control sites and sites that may be impacted (Coordinate with radiological assessments in Table B-13)</p>	<p>Map showing location of habitats to be included in study</p> <p>Tabulated results of analysis for various contaminants of concern within the various components of the food chain</p>	<p>Results of site characterization studies</p> <p>Results of site characterization studies</p>	<p>Whicker and Schultz (1981)</p> <p>Dahl et al. (1967) O'Ferrell and Gilbert (1975) Heitford et al. (1981) Whicker and Schultz (1981) Bius (1985) Dillon and Gibson (1985) Ellis (1985) Stoner et al. (1985) Beyer (1986) Jackow et al. (1986) Lapham et al. (1986) Ohlendorf et al. (1986)</p>
migratory Species	<p>Collect and site and/or regional data on migratory species likely to occur in area</p> <p>Conduct site reconnaissance surveys to determine migratory species in site area. Conduct ground surveys in upland habitat to determine terrestrial wildlife (principally bird species) that migrate through or winter in the area. Conduct surveys during spring and fall migration</p>	<p>Same as that listed for Terrestrial Species (Fauna) Text and tables</p> <p>Map showing area surveyed and important habitat areas of upland migratory species List species by habitat type and relative abundance</p>	<p>Same as that listed for Terrestrial Species (Fauna) Results of site characterization studies</p> <p>Results of site characterization studies</p>	<p>Schemnitz (1980) Cell (1982)</p> <p>Schemnitz (1980)</p>

TABLE B-14 (Continued)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: ECOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Migratory Species (Continued)	<p>Ground surveys in wetland and riparian habitats to provide data on principal migratory species. Conduct surveys during spring and fall periods for waterfowl and shore birds. Surveys should be conducted periodically throughout migratory period and during winter if wintering areas are present</p> <p>Aerial surveys: Use this method if there are large areas that may have large concentrations of water birds to provide species compositions, distribution, and abundance data for large areas in a relatively short time. Conduct during spring and fall migrations and winter if appropriate</p>	<p>Map showing area surveyed and migratory species concentration area</p> <p>Text and tables on species observed, abundance, arrival and departure periods, and period of peak abundance</p> <p>Maps of area surveyed identifying concentration areas</p>	<p>Results of site characterization studies</p> <p>Results of site characterization studies</p>	<p>Schemnitz (1980)</p> <p>Schemnitz (1980)</p>
Game Animals	Collect species-specific site or regional data on game species likely to occur in site area	Same as for Terrestrial Species (Fauna)	Same as for Terrestrial Species (Fauna) except that Natural Heritage Programs and Biological Assessments generally do not have data on game species	Schemnitz (1980)

TABLE B-14 (Continued)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: ECOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Game Animals (Continued)	Conduct site reconnaissance surveys of upland game birds, nesting waterfowl, and big game	Maps showing areas surveyed and location of species observed in relation to habitat types Tables showing species observed, habitat preference, and relative abundance	Results of site characterization studies	Blakenship et al. (1953) Southwick (1953) Taylor (1956) Weller (1956) Keith (1961) Progulskie and Duerre (1964) Dealy (1966) Moore (1973) Dickinson (1976) McCauley (1976) Bookhout (1979) Tookum (1980) Kerr (1981) Smith and Flate (1985) Klett et al. (1986) Mitchell (1986a,b)
	Conduct quantitative studies of upland game, nesting waterfowl, and big game. Determine distribution, abundance, and habitat using (as applicable to the species): auditory counts radiotelemetry line transects nesting pair surveys nest and brood surveys aerial surveys tagging pellet and track counts browse surveys	Data tables, text and maps	Results of site characterization studies	Severinghaus (1947) Blakenship et al. (1953) Southwick (1953) Weller (1956) Shafer (1963) Teifer (1970) Pilton and Knight (1971) Verme (1973) Dickinson (1976) McCauley (1976) Burnham et al. (1980) Cochran (1980) Mitchell (1986a)

TABLE B-14 (Continued)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: ECOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Habitat	Map and determine acres of each major plant community in site area	Same as Terrestrial Species (Flora) for data format for this activity	Same as Terrestrial Species (Flora)	Braun (1950) Schemnitz (1980)
	Collect qualitative site specific data on terrestrial flora and fauna. Use methods as given under Terrestrial Species (Fauna), Terrestrial Species (Flora), and endangered and threatened species, and game species. Compare published information on specific habitat requirements to site-specific species habitat use	Map of site specific habitat use for individual or groups of species Text analyzing seasonal changes in species habitat use	Results of site characterization studies	See Terrestrial Species (Flora) and Terrestrial Species (Fauna)
	Detailed quantitative wildlife habitat analysis for important species (coordinate with activities to characterize threatened and endangered species and game species)	Tabulations of number of individuals per important habitat type (i.e., number of winter bald eagle at a nocturnal roost site, number of ducks produced at wetland, an estimate of the number of T & E plants in a given area, etc.) Text identifying important characteristics of habitat for a species and seasonal use of a habitat	Results of site characterization studies	Shimwell (1971) Moen (1973) Larson (1976) Good et al. (1978) Bookhout (1979) Schemnitz (1980) Call (1982) Klett et al. (1986)
Threatened and Endangered (T & E) Species and Other Species of Concern	Consultation with U.S. Fish and Wildlife Service (in accordance with Section 7 of the Endangered Species Act of 1973, as amended)	Species lists, maps, status reports, narratives regarding species listed for a given location	U.S. Fish and Wildlife Service Regional Endangered Species Office	Armbruster (1983) USFWS (1986, 1985a,b)

TABLE B-14 (Continued)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: ECOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Threatened and Endangered (T & E) Species and Other Species of Concern (Continued)	Consult with other Federal agencies and State T & E species departments	Species lists, maps, reports	U.S. Bureau of Land Management U.S. Forest Service State T & E species department State Natural Areas Program or Natural Heritage Program (often in association with the Nature Conservancy) State zoologist and/or botanist at State natural history museum	Armbruster (1983) USFWS (1986, 1985a,b)
	Collect information and data from other sources	Species, lists, maps, status reports	Colleges and universities Theses and dissertations Professional journals Environmental Impact Statements (EIS) and Environmental Assessment (EA) Back up reports for EIS and EA's Resource management plans Local conservationist and conservation groups	
	Site reconnaissance surveys for existence of T & E species or appropriate habitat	Field notes, field maps, progress reports	Results of site characterization surveys Site vegetation maps USGS maps Maps from Federal and State agencies	
	T & E plant agencies surveys typically conducted on the ground following identification of appropriate habitat. Survey must be conducted during appropriate time of year by qualified botanist	Report presenting results of study including survey methods, results, and discussion Map outlining extent of population if applicable	Results of site characterization surveys	

TABLE B-14 (Continued)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: ECOLOGY

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Threatened and Endangered (T & E) Species and Other Species of Concern (Continued)	T & E wildlife species surveys - conduct aerial or ground surveys, or a combination thereof, to identify and map populations, habitat relationships, and home range of reptiles and amphibians, nesting raptors, migratory and wintering raptors, and mammals	Tabular summaries, maps, text	Results of site characterization studies	Spencer (1976) Call (1978) Bury et al. (1980) Bury (1982) Evan (1982) Griffin et al. (1982) Oldendorff et al. (1982) Scott (1982) Clark et al. (1984) USFWS (1984)
Disease Vectors/Pests	Collect site specific and regional (within 10km) data on vertebrate and invertebrate species likely to be disease vectors or pests	Species lists, maps	U.S. Department of Agriculture Federal agencies (e.g., U.S. Fish and Wildlife Service, U.S. Bureau of Land Management) State agencies (e.g., State zoologist, State health departments) County health departments Colleges and universities Theses and dissertations Biological assessments	

TABLE B-14
REFERENCES - ECOLOGY

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TABLE B-15
PARAMETER DESCRIPTIONS - SOCIOECONOMICS

Labor Force: The size, composition, and availability of the labor force in the region, including the county in which the site is located and those specific portions of surrounding counties and urbanized areas (up to 40 km from the site) from which the work force would be principally drawn.

Housing: The types, amounts, age, condition, and availability (turnover rates, vacancy rates, price) of existing housing and the location and amount of projected housing in the region from which the work force would be principally drawn or which would be affected because workers changed residence.

Health and Public Safety Systems: Capacity of utilities (e.g., solid waste disposal, water and sewer), and capabilities of police, fire, hospitals, physicians, and specialized health facilities to meet projected needs in the region from which the work force would be principally drawn or which would be affected because workers changed residence.

Education Systems: Capacity and availability of primary and secondary schools, junior colleges, technical schools, and higher institutions in the region from which the work force would be principally drawn or which would be affected because workers changed residence.

Tax Base: The regional political jurisdictions and tax districts that will be affected by the facility, the regional tax structure, and present tax revenues.

Sociocultural Characteristics: The social structure (i.e., community composition and cohesion), local attitudes, cultural values, life style indicators, family stability, and community problems in major communities within the region around the site.

TABLE B-15
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SOCIOECONOMICS

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Labor Force	Compile census tract data on major industries in the region, by category (i.e., construction, mining, manufacturing, wholesale trade, services, other) and determine associated employment within county and 40km radius offsite to identify potential competition for labor force. Identify primary sector employers and size of their employment. Calculate primary/secondary employment multiplier	Tables, reports	U.S. Bureau of Census County planning agencies Municipal governments	USDOC (1976) Dickinson and Blackmarr (1977) USDOC (1979) De Souza (1979) Thompson et al. (1982)
	Compile time-series census tract data on size of employment by industrial sector (i.e., construction, mining, agriculture, manufacturing, services, trade, and other) and total employment within county and 40km radius of site to identify the potential labor force	Tables, reports	U.S. Bureau of Census County planning agencies State employment office U.S. Bureau of Economic Analysis Municipal governments	USDOC (1976) Dietz (1977) USDOC (1979) De Souza (1979) Thompson et al. (1982)
	Compile time-series census tract data on unemployment levels by industrial sector and projections of future unemployment to define potential labor availability	Tables, reports	State employment agencies County planning agencies Regional planning agencies U.S. Bureau of Census U.S. Bureau of Economic Analysis	Chapin (1965) Dietz (1977) De Souza (1979) Thompson et al. (1982)
	Compile census tract data on occupations and classes of workers in area of interest (i.e., managerial, professional, technical, sales, administration, skilled laborer, unskilled laborer, etc.) to define labor availability and in-migration required	Tables, reports	U.S. Bureau of Census State employment agencies County/regional planning agencies U.S. Bureau of Economic Analysis	Dietz (1977) Thompson et al. (1982)

TABLE B-15
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SOCIOECONOMICS

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Housing	Compile and tabulate census tract data on the location and amount of existing and projected housing to support analysis of incremental project impacts (coordinate with residence inventory in Table B-10)	Real estate maps, tables, and reports	Inventory of residences within 10km of site Local real estate offices U.S. Bureau of Census County planning agencies Municipal governments	Dietz (1977) De Souza (1979) Thompson et al. (1982) University of Arizona (1985)
	Compile and tabulate census tract statistics on the types (single-family, multifamily, etc.), age, size, and condition of existing housing	Tables, reports	U.S. Bureau of Census Local real estate offices County planning agencies Municipal governments	Dietz (1977) De Souza (1979) Thompson et al. (1982)
	Tabulate and calculate trends in size of housing stock, using historic records and building permits	Tables, reports, lists	U.S. Bureau of Census Local real estate offices County planning agencies County building and land development agencies Municipal governments	Dietz (1977) Thompson et al. (1982)
	Compile census tract data on housing turnover and vacancy rates	Tables, reports	U.S. Bureau of Census Local real estate offices County planning agencies Municipal governments	Dietz (1977) Thompson et al. (1982)
	Interview local official to determine if any constraints exist on development of new housing	Reports, zoning maps	County planning agencies County building and land development agencies Local real estate offices Municipal governments	Dietz (1977) Thompson et al. (1982)
	Compile and tabulate census tract data on housing sale prices and rents (ranges and average)	Tables, reports	U.S. Bureau of Census Local real estate offices Local newspaper classified advertisements	Dietz (1977) Thompson et al. (1982)
Health and Public Safety Systems	Compile existing statistics on present capacity and projected usage of utilities (i.e., water and sewer/sewage disposal) to support analysis of incremental project impacts	Reports	County public works department Utility commissions	Dickinson and Blackmar (1977) De Souza (1979) Thompson et al. (1982)

TABLE B-15
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SOCIOECONOMICS

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Health and Public Safety Systems (continued)	Compile data on size of staff, amount and size of emergency response vehicles and equipment, extent to which staff are trained in emergency response, and jail capacity. Identify any mutual aid agreements.	Tables, reports	Local fire department Local police department Sheriff's office State Patrol	Dickinson and Blackmarr (1977) Thompson et al. (1982)
	Compile data on the location and bed capacity of area hospitals, type and location of specialized health care facilities, and the number and specialties of physicians to support analysis of incremental project impacts	Reports, tables	County health department Local hospital association Local Chamber of Commerce	Dickinson and Blackmarr (1977) De Souza (1979) Thompson et al. (1982)
Education Systems	Identify the number and locations of public and private primary and secondary schools within 40km. Tabulate existing data on current enrollment, capacity, present percentage of use, and pupil-teacher ratios to identify capability to absorb project in-migration impacts	Reports, tables, local maps	State education department Local School districts	Dietz (1977) De Souza (1979) Thompson et al. (1982)
	Identify the types and locations of junior colleges, technical schools, and higher institutions in the region. Tabulate current enrollment, capacity, and present percentage of use to identify capability to absorb project in-migration impacts	Tables, reports	State education department	Dietz (1977) Thompson et al. (1982)
Tax Base	Identify the political jurisdictions (counties, townships, etc.) and tax districts in the region. Define in which the proposed facility is located	Maps, reports	State revenue agencies County and local tax assessors office	Dickinson and Blackmarr (1977)

TABLE B-15
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: SOCIOECONOMICS

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Tax Base (continued)	Interview local officials on the mix of property, sales, business, and income taxes; compile existing data on present revenues and expenditures in each jurisdiction and district to identify incremental impacts of project	Tables, reports	County and local tax assessors office	Dickinson and Blackmarr (1977) C. Souza (1979)
Sociocultural Characteristics	<p>Compile census tract data on the social structure of the major communities in the area, including age and gender composition, ethnic groups, minorities, education levels, and household incomes</p> <p>Compile census tract data and interview local officials on significant community problems, including crime rates, divorce rates, families with incomes below poverty level, population over 65, worker mobility, and substance abuse</p> <p>Attitudinal survey to determine local attitudes, life style indicators, cultural values and community cohesion that may be impacted by the project</p>	<p>Tables, reports</p> <p>Tables, reports, interviews</p> <p>Survey questionnaires Tables, reports</p>	<p>U.S. Bureau of Census</p> <p>U.S. Bureau of Census Local social service agencies Local law enforcement agencies University sociology departments State health department</p> <p>Results of the attitudinal survey</p>	<p>Sheldon and Moore (1968) University of Texas (1973) Papageorgiou (1974) Thompson et al. (1982)</p> <p>Sheldon and Moore (1968) University of Texas (1973) Papageorgiou (1974) Thompson et al. (1982)</p> <p>Fishbein (1967) Saroff and Lavitan (1969)</p>

TABLE B-15
REFERENCES - SOCIOECONOMICS

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TABLE B-16
PARAMETER DESCRIPTIONS - CULTURAL RESOURCES

Historic Places: Districts, sites, buildings, structures or objects of historical significance listed or eligible for inclusion in the National Register of Historic Places, or of State or local significance.

Archaeologic Sites: Sites containing artifacts of the life and culture of ancient peoples.

Other Cultural Resources: Other sites, buildings, structures, or objects of historical, archaeological, architectural, scenic, cultural or landmark significance, including traditional folklife remnants, Native American religious or sacred sites, and paleontological (i.e., fossil) resources.

TABLE B-16
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: CULTURAL RESOURCES

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Historic Places	Review lists of historic places to identify eligible and potentially eligible historic sites in region or on site, including National Historic Landmarks	Lists of districts, sites, buildings, structures, or objects of Federal, State, or local concern Maps Descriptive information (text, reports)	State Historic Preservation Offices (SHPO) Federal land management agencies (e.g., Bureau of Land Management and U.S. Forest Service)	National Park Service (1982) AHP (1986) 36 CFR 60, National Register of Historic Places 36 CFR 65, National Historic Landmarks Program 36 CFR 800, Protection of Historic Properties
	Consult with SHPO regarding historic site status, identity of proposed or potential historic places, other data sources	Lists, maps, information	SHPO	AHP(a) AHP(b)
	Conduct site survey for historic resources as part of Class III archaeological resources survey (100% pedestrian survey)*	Survey report that includes discussion of sites, site types, maps, sketches, photographs, field determination of eligibility	Results of onsite survey of historic resources	AHP(a) AHP(b)
Archaeologic Sites	Review existing literature and archaeological records for the region within 10 km of the site for eligible and potentially eligible sites	Lists of archaeological sites Maps of locations Descriptive information (text, reports)	SHPO State Office of Archaeological Inventory Federal land management agencies (Bureau of Land Management, U.S. Forest Service, National Park Service) State land management agencies (e.g., Departments of Natural Resources) State/County historical societies and museums Colleges and universities	McGimsey (1972) AHP (1980)

* For the proper methods of conducting a Class III survey, the State Historic Preservation Office should be consulted. Different areas of the U.S. require different techniques.

TABLE B-16 (Continued)
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: CULTURAL RESOURCES

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Archaeologic Sites (Continued)	Perform Class III cultural resources survey* (100% pedestrian survey) of site(s) and immediate surrounding area	Survey report that includes discussion of sites and site types Site sketches, maps, field observations, photographs Field determination of eligibility	Results of Class III survey	ACRP(a)
Other Cultural Resources	Review existing literature and records on ethnographic resources in the site region	Description of existence of Native American groups in area Identification of important and/or sacred sites to specific Native American groups	Individual Tribal Councils Bureau of Indian Affairs Other Federal and State agency publications Historical archives Professional journals Colleges and university anthropology departments Theses and dissertations	ACRP (1985)
	Ethnographic survey; consult with identified Native American groups via mailings, interviews, field investigations, questionnaires	Lists and locations of items or areas of ethnographic or ethnohistoric value Maps, text, accounts, transcripts, reports, oral histories	Ethnographic groups Bureau of Census	ACRP (1985)
	Review existing literature and records on paleontological resources in site area and on site (coordinate studies with geology, Table B-1)	Geologic reports, fossil locality records Maps	SIFU Federal and State land management agencies U.S. Geological Survey Colleges and universities State/County historical societies and museums	
	Perform visual ground surveys during geologic mapping and drilling, including soil exposures, excavations, and installation of at-depth soil probes, if geologic conditions are conducive to fossil presence	Fossil locations Maps Photography and field sketches	Results of visual ground surveys	

* See footnote on p. B-16-1

TABLE B-16
REFERENCES - CULTURAL RESOURCES

ACHP; See Advisory Council on Historic Preservation.

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36 CFR Part 65, National Historic Landmarks Program, National Park Service.

36 CFR Part 800, Protection of Historic Properties, Advisory Council on Historic Preservation.

TABLE B-17
PARAMETER DESCRIPTIONS - TRANSPORTATION

Major Highways: Major interstate, U.S. and State highways enroute to the site from centers of waste generation, statewide and/or regionwide, and in the vicinity of the site.

Local Highways and Roads: County and local highways and roads in the vicinity of the site, especially connectors to major highways.

Navigable Waterways: Rivers, canals, and other navigable waterways, statewide and/or regionwide, and in the vicinity of the site.

Railroads: Existing major and short line roads and classification yards enroute to the site from centers of waste generation, statewide and/or regionwide, and in the vicinity of the site.

Rights-of-way: Rights-of-way needed to provided access to the site from local transportation routes.

Public Transportation: Existing modes of public transportation (buses, trains, air service) providing access to the site.

TABLE B-17
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: TRANSPORTATION

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Major Highways	<p>Identify locations of centers of waste generation in State and compact region. Map major Federal and State highways enroute to the site from centers of waste generation. Identify primary routes projected to be used for waste shipments (Computer models such as HIGHWAY may be used). Identify any planned construction to improve or add new roads. Determine distance from site.</p> <p>Evaluate the highway carrying capacity considering type of roadway, number of lanes, and turning movements to support analysis of incremental project impacts and risk factors</p> <p>Compile available data (e.g., annual surveys) on traffic volumes to support analysis of incremental project impacts and risk factors, including: average daily traffic peak hour traffic type of traffic (i.e., trucks, automobiles, slow moving farm vehicles, school buses, and other vehicles) If data do not exist, perform traffic counts at key locations along the routes using Moving Vehicle Method. Obtain State data on statewide Vehicular Miles Traveled projections for future years.</p>	<p>Maps Tables Discussion (text)</p> <p>Calculations of physical capacity Report Tables</p> <p>Tables Traffic count forms</p>	<p>Facility designers State waste management authorities Compact commission Road atlas State highway maps</p> <p>State transportation agencies Department of Transportation</p> <p>State transportation agencies County roads departments Results of site characterization traffic counts</p>	<p>Joy et al. (1982)</p> <p>Oglesby (1975) Homburger (1976) Transportation Research Board (1985)</p> <p>AASHTO (1965) AASHTC (1967) Oglesby (1975) Homburger (1976) Transportation Research Board (1985)</p>

TABLE B-17
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: TRANSPORTATION

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Major Highways (cont.)	<p>Identify limitations or restrictions (load limits, height limits, hazardous material restrictions) along routes.</p> <p>Identify locations and nature of hazardous conditions, including steep grades, winter icing conditions, and mountain passes, to support analysis of transportation risk factors</p> <p>Compile accident records for the primary routes, including: types of accidents kinds of vehicles involved severity and frequency location (e.g., sharp curves, intersections, level crossings)</p> <p>Obtain or calculate fatalities and injuries per year and per mile to support analyses of transportation risk factors.</p>	<p>Discussion (text) Reports Visual inspection report</p>	<p>State transportation agencies Sheriff's departments State highway patrol County roads departments Visual inspection of routes during site characterization</p>	<p>AASHTO (1965) AASHTO (1967) Homburger (1976) Joy et al. (1982)</p>
Local Highways and Roads	<p>Map county and local highways and roads connecting major highways to the site. Determine distance from site</p> <p>Evaluate the highway carrying capacity to absorb project-related traffic considering: type of roadway number and width of lanes turning movements land separations signals/stops</p>	<p>Accident reports Computer analyses Statistical tables</p> <p>Calculations of physical capacity Reports Tables</p>	<p>State transportation agencies State highway patrol Local police Sheriff's offices</p> <p>County roads departments</p>	<p>Oglesby (1975) Homburger (1976) Schott (1977) NRC (1977) NRC (1983)</p> <p>Estes et al. (1984)</p> <p>AASHTO (1965) Oglesby (1975) Homburger (1976) Transportation Research Board (1985)</p>

TABLE B-17
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: TRANSPORTATION

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Local Highways and Roads (cont.)	<p>Compile available data or perform traffic counts for: average daily traffic peak hour traffic type of traffic</p> <p>Identify route limitations and restrictions (load limits, height limits, and rights-of-way). Identify locations and nature of hazardous conditions, including steep grades and icing conditions.</p> <p>Compile accident records, including: accident type severity frequency and location type of vehicles involved</p> <p>Obtain or calculate fatalities and injuries per year and per mile to support analysis of transportation risks.</p>	<p>Survey reports Traffic count forms Tables</p> <p>Discussion (text) Visual inspection report</p> <p>Accident reports Statistical tables</p>	<p>County roads departments Results of traffic counts during site characterization</p> <p>County roads departments Local police and sheriff's office Visual inspection of route during site characterization</p> <p>County roads departments Local police and sheriff's offices</p>	<p>AFSHO (1965) Oglesby (1975) Homburger (1976) Transportation Research Board (1985)</p> <p>AASHTO (1965) Homburger (1976)</p> <p>Oglesby (1975) Homburger (1976) NRC (1977) Schott (1977) NEC (1983)</p> <p>Homburger (1976)</p>
Navigable Waterways	<p>Identify and map navigable waterways (rivers, canals) in the vicinity of the site and transportation modes connecting to site</p>	<p>Map</p>	<p>State transportation agencies Local port commissions Barge and tanker operators</p>	<p>Homburger (1976)</p>

TABLE B-17
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: TRANSPORTATION

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Navigable Waterways (cont.)	Evaluate traffic volumes and types (e.g., container ships, tankers, barges, pleasure craft). Identify limitations or restrictions (weight limits, height limits, etc.) along waterway. Describe port and offloading facilities to support analysis of capability to absorb project related shipments. Compile accident records, including: types severity frequency and location types of boats involved	Discussion (text) Tables of traffic volumes Accident reports Statistical tables	State transportation agencies Local port commissions Barge and tanker operators Local port commissions State transportation agencies	Homburger (1976) Homburger (1976) NRC (1977) NRC (1983)
Railroads	Identify and map major and short-line rail lines leading to or near the site and classification yards near the site. Computer models such as INTERLINE may be used. Describe railroad ownership. Obtain data on traffic volumes: number of trains/day average length type of service such as passenger, freight, or other). Identify limitations and restrictions, structural conditions, and planned improvements. Identify hazardous conditions such as highway crossings and bridges.	Map Discussion (text) Tables Discussion (text)	State transportation agencies State railroad commissions Interstate commerce commissions State transportation agencies State railroad commissions Rail companies	Peterson (1984) Homburger (1976) ICC (1977) Peterson (1984)

TABLE B-17
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: TRANSPORTATION

Parameter	Technical Activities/ Study Methods	Data Formats	Data Sources	References
Railroads (cont.)	Compile accident records, to support analysis of transportation risks, including: type severity frequency location and types of trains involved	Accident reports Statistical tables	National Transportation Safety Board State transportation agencies State railroad commissions Rail companies	ICC (1977) NRC (1977) NRC (1983)
Rights-of-Way	Identify and map any rights-of-way to be obtained to provide access to site from local highways, rail lines, or waterways. Describe length of access route and ownership of right-of-way	Maps Discussion (text)	Local land title offices	
Public Transportation	Identify existing modes of public transportation (buses, trains, air service), passenger capacity, average daily ridership, and service routes to support analysis of capability to absorb project-related traffic	Discussion (text) Tables Maps	Local public transit authorities Private bus and rail companies in area Local airport commissions	Homburger (1976)

TABLE B-17
REFERENCES - TRANSPORTATION

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U.S. Nuclear Regulatory Commission, The Transportation of Radioactive Material to and from U.S. Nuclear Power Plants - Draft Environmental Assessment, NUREG/CR-2325, 1983.

TABLE B-18
PARAMETER DESCRIPTIONS - AESTHETICS

Visual Resources: Assessment of visual quality for specific geographic areas, based on numbers and types of viewers, uniqueness of the landscape; determined through viewsheds (i.e., depiction of what is seen from selected offsite viewer locations) and resource classifications (e.g., U.S. Forest Service Visual Resource Management System).

Noise: The measurement of background noise levels to support determinations of incremental noise impacts from facility construction and operation; measured in decibels.

TABLE B-18
SITE CHARACTERIZATION TECHNICAL GUIDANCE
DATA TYPE: AESTHETICS

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Visual Resources	Identify and plot on site area base maps qualitative and quantitative landscape quality parameters (e.g., relief, diversity, vegetative cover, man-made alterations); obtain photographs of representative landscape types in the site area	Maps supported by narrative descriptions and photographs	Federal and State land management agencies Federal and State departments of transportation U.S. Geological Survey Results of field photography	Litton (1968) U.S. Forest Service (1973) U.S. Forest Service (1974) Elsner (1976) Elsner and Snaadon (1979)
	Identify and map points and features in site area of significant visual sensitivity (e.g., travel routes, scenic viewpoints)	Maps supported by narrative descriptions and photographs., supplemented by quantitative summaries of traffic volumes	Federal and State agencies Results of field surveys	Litton (1968) Jacobs and May (1969) U.S. Forest Service (1973) U.S. Forest Service (1974) Elsner (1976)
	Prepare "seen areas" of "viewshed" map overlays by plotting lines-of-sight from the site area on topographic base maps and verify using field surveys	Topographic map overlays	Topographic map analysis Results of field surveys	Litton (1973) U.S. Forest Service (1973)
	Prepare a digital elevation model of the site area by converting topographic contours to digital formats and compute lines-of-sight and "viewsheds" from selected vantage points or from specific locations of proposed facility structures	Computer Plots - maps, perspective views, and terrain profiles	U.S. Geological Survey Results of field surveys	Travis et al. (1975) Entzinger (1976) U.S. Geological Survey (1986)
	Perform qualitative evaluation of sources and levels of existing noise, quantify through comparison of existing land use patterns with "standard" noise level measurements associated with the land uses (e.g., transportation)	Tabular listing of noise intensity levels expressed in A-weighted decibels (dBA), a standard approximating the sensitivity of the human ear, supported by map of noise source locations	Local, State environmental agencies Nearby private industries with noise monitoring programs	Schultz and McMahon (1971) Fed. Hwy. Admin. (1973) Jones (1976) Canter (1977) Greenberg et al. (1979) Miller (1980)

TABLE B-18 (Continued)
 SITE CHARACTERIZATION TECHNICAL GUIDANCE
 DATA TYPE: AESTHETICS

Parameter	Technical Activities/Study Methods	Data Formats	Data Sources	References
Noise (continued)	Measure existing background noise levels, including unique sources, as well as unique areas where noise levels must be minimized	Tabular listing of noise levels (dBA) supported by map of noise source locations	Results of field surveys	EPA (1971) Schultz and McMahon (1971) EPA (1974) Jones (1976) Greenberg et al. (1979) Miller (1980)

TABLE B-18
REFERENCES - AESTHETICS

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U.S. Geological Survey, Digital Elevation Models, Data Users Guide 5, 1986.

APPENDIX C
PHASING OF SITE CHARACTERIZATION
ACTIVITIES

APPENDIX C PHASING OF SITE CHARACTERIZATION ACTIVITIES

Site characterization can be divided into multiple phases. The following discussion has assumed three phases to demonstrate the groupings of strategic decision points prior to completion of the program. The description of phases and the structure of the program are offered only as an example of many generic activities and the thought processes most common to site characterization studies.

Phase 1, Reconnaissance, is designed to: 1) quickly and economically assess the site for fatal flaws, 2) develop the basic parameters for the geologic models, and 3) begin the hydrologic and meteorologic characterization and monitoring programs. Phase 1 also develops an extensive data base on the site and region from published and unpublished sources. The combined results of Phase 1 becomes the basis for planning the details for Phase 2 activities.

Phase 2, Exploration, will only proceed if the site has no obvious fatal flaws. Phase 2 comprises a more comprehensive subsurface investigation designed to expand the understanding of the geologic, hydrologic, and environmental model. The activities focus on investigating any anomalous conditions revealed in Phase 1, adding to the density of subsurface information in a selected area of the site (identifying and partially investigating a facility location), and conducting field and laboratory testing.

Phase 3, Confirmation, completes the field investigation program by increasing the density of subsurface information (especially at a facility location), performing the analytical and numerical modeling, and completing the testing required to determine site parameters important to analyzing site performance objectives. Phase 3 also establishes the requirements for long-term monitoring for the hydrologic program. Phase 3 usually concludes with the preparation of technical reports for input to design and licensing documents.

Each of these phases may have an expanded or reduced scope depending on the character, size, and number of sites. In addition, each phase must remain flexible to potential changes in the investigation results and the necessity for redirecting the effort. Phase 1, Reconnaissance, may also be applied all or in part to alternate sites that require some site-specific data for general characterization.

Reconnaissance Phase

Planning Access:

Based upon review and revisions to the Site Characterization Plan, detailed plans for Phase 1, Reconnaissance, can include preparation of specific schedules, logistical planning, planning for obtaining access to the

site to carry out field activities, and application for the permits required to initiate various field activities.

Pre-Field Research:

Pre-field research can include review of background information developed during site selection, as well as collection and review of additional regional and site-specific published and unpublished data and maps on geology, hydrology, resources, meteorology, demography, ecology, and other relevant disciplines to confirm that the site has no known fatal flaws, and to provide a data base upon which to plan the subsequent field evaluation and monitoring programs.

Pre-Monitoring Surveys:

Activities that can be carried out in the field prior to the initiation of the field studies and monitoring include: performance of a cultural resources (primarily archaeology) survey and an environmental review prior to any surface-disturbing activities; performance of a general field reconnaissance to assess the general physical characteristics of the site and the access to the site; performance of a land survey, including the establishment of permanent survey marker control points for horizontal and vertical control, and preparation of a site topographic maps; and installation of monitoring wells and meteorological/air quality stations.

Field Monitoring Surveys:

The NRC requires a pre-operational monitoring and sampling program to establish a statistical data base for pre-existing background concentrations of radioactive and chemical constituents and other time variant data. This monitoring program should have at least a one-year duration to account for seasonal variations. Environmental monitoring initiated during the pre-operational phase should be continued during the operational phase to evaluate whether background concentrations have been exceeded.

Activities carried out during the pre-operational monitoring program should include measurements of direct gamma radiation, as well as sampling to determine background concentrations of radioactive contaminants and non-radiological constituents in ground water, surface water, soil, sediments, air, and flora and fauna. The NRC recommends continuous sampling where practicable during the one-year monitoring period (e.g., air sampling), but prefers discrete sampling at selected intervals for media affected by random climatological events (e.g., surface-water quality and quantity). Specific NRC guidance for pre-operational monitoring activities can be found in the NRC (1986) "Working Draft, Technical Position Paper on Environmental Monitoring of Low-Level Waste Disposal Facilities".

Pre-operational monitoring activities include: ground-water monitoring to measure ground-water levels and fluctuations and to determine hydraulic gradients, and sampling for radiological and non-radiological constituents; collection of site-specific and regional long-term meteorological data, measurements of meteorological parameters to determine the water budget, and

air quality monitoring; installation of soil monitoring probes to measure temperature, moisture, etc., and soil sampling for radiological and non-radiological constituents; surface-water monitoring of flow, and sampling of surface water and stream sediments for radiological and non-radiological constituents; and environmental monitoring, including radiological monitoring of flora and fauna, and inventory and analysis of the abundance and characteristics of local species.

Time-variance site characteristics requiring monitoring may include: hydrological characteristics such as soil moisture content, ground-water levels, surface- and ground-water quality; meteorological characteristics such as temperature, wind direction, and precipitation; and ecological characteristics such as the presence of migratory species. The pre-operational monitoring program can be ongoing with other site characterization field studies, and it should begin as early as possible in the site characterization program to allow adequate time for the minimum one-year requirement to account for seasonal variations.

Field Surveys:

For purposes of this example, field surveys are considered to be those activities exclusive of monitoring that are necessary to fully define that surface and subsurface characteristics of the site and surrounding area. Field exploration activities can be ongoing with or precede the pre-operational monitoring program. Field activities that precede the monitoring program can provide input to the selection of sites for the monitoring wells and other subsurface boreholes.

Field surveys during the reconnaissance phase can include: geologic and geomorphic mapping; performance of reconnaissance surface geophysical surveys; performance of a surface-water hydrology evaluation; drilling and logging of reconnaissance boreholes supplemental to the monitoring boreholes; performance of a borehole geophysical survey; evaluation of natural resources (geologic and water); performance of a ground-water hydrology evaluation; performance of a reconnaissance-level geotechnical engineering (geoengineering) evaluation; demographic data collection and synthesis; performance of a socioeconomic evaluation; land use mapping; performance of an aesthetics evaluation; and performance of a transportation analysis. Specific components of these field activities are described further in Appendix B.

Activities for natural resources, demography, land use, aesthetics, and transportation studies under the field survey program can be started during the reconnaissance phase if desired, but are not necessarily required to be carried out in this phase. Depending upon local or site-specific conditions, they could be deferred to later phases as the schedule permits. Most field activities can be carried out simultaneously during this phase, with the exception of those activities that supercede the drilling of boreholes, such as borehole geophysical logging and hydrologic testing.

Laboratory Testing and Analysis:

Laboratory testing and analysis can be ongoing with all the stages of the reconnaissance field surveys and the pre-operational monitoring activities, and will include testing and/or analysis of rock, soil, sediment, water, air, flora, and fauna samples. Analyses and tests should be performed by qualified laboratories that follow accepted industry and quality control procedures. Adequate time should be allowed in the schedule for analysis and reporting of sample results by the laboratories.

Data Analysis:

Data evaluation and analysis can be ongoing during each phase of the program, but should be performed in depth at the completion of each phase in order to develop models of site characteristics, and to integrate the results among disciplines for planning the next phase of the program.

Reporting/Decision Points:

The data evaluation will result in the identification of any fatal flaws or the determination that the site is suitable for further site characterization studies. If the site is considered suitable, recommendations can then be made for the initiation of Phase 2. If part of the overall program plan is to reduce the size of the area to be characterized after the reconnaissance phase, identification of a smaller area to be studied in greater detail in subsequent phases of the investigation could be done at this point. The Phase 1 analyses can result in a synthesis of data collected to date, which can in turn provide input to a reconnaissance interim report and various programmatic documents. The final products of the Phase 1 reconnaissance program can become the basis for preparation of a refined Site Characterization Plan for the Phase 2 exploration program and the Phase 2 QA/QC Plan.

Exploration Phase

Planning/Access:

Based upon the Phase 1 program, detailed plans for Phase 2 exploration can be prepared, including preparation of schedules and logistical planning.

Field Monitoring Surveys:

The field monitoring surveys in Phase 2 are a continuation of the pre-operational monitoring surveys begun in Phase 1. These surveys will generally be carried out for a minimum of twelve months from the date of their initiation in Phase 1.

Field Surveys:

The field surveys carried out during the exploration phase can be used to develop more confidence about site characteristics and to investigate any

anomalies revealed in Phase 1. This phase should be performed in greater detail than Phase 1 and should be designed to increase the density of data points across the site. Field surveys during the exploration phase of the program can include detailed: surface geophysical surveys; surface-water hydrology evaluation; exploratory drilling and logging; borehole geophysics; exploratory trenching in selected areas to investigate subsurface deposits; natural resources (geologic and water) evaluation if indications of resources are present; ground-water hydrology evaluation; geoengineering evaluation for near-surface materials; socioeconomic evaluation; land use mapping; demographic data collection and sampling; aesthetics evaluation; and transportation analysis.

Laboratory Testing and Analysis:

Laboratory testing and analysis can be ongoing with the exploration field surveys and the pre-operational monitoring activities, and will include testing and/or analysis of rock, soil, sediment, water, air, flora, and fauna samples.

Data Analysis:

Data analysis can be ongoing during Phase 2, but should be performed in depth at the completion of the phase in order to further refine site models and to integrate the results among disciplines for planning Phase 3 investigations.

Reporting/Decision Points:

The data evaluation will result in the identification of any fatal flaws or the determination that the site is suitable for further site characterization studies. The synthesized Phase 2 data can provide input to an exploration interim report and various programmatic documents. The final results of the Phase 2 exploration program will become the basis for preparation of a refined Site Characterization Plan for the Phase 3 confirmation program and the QA/QC Plan.

Confirmation Phase

Planning/Access:

Based upon the Phase 2 program, detailed plans for Phase 3 confirmation can be prepared.

Field Monitoring Surveys:

The field monitoring surveys in Phase 3 are a continuation of the pre-operational monitoring surveys begun in Phase 1. These surveys will generally continue for a minimum of twelve months from the date of their initiation in Phase 1.

Field Surveys:

The field surveys carried out during the confirmation phase can be used to develop more confidence about site characteristics and to complete the testing required to evaluate site parameters important to site performance objectives. This phase should be designed to increase the density of subsurface information, particularly at the facility location. Field surveys during the confirmation phase of the program can include detailed: exploratory drilling and logging; borehole geophysics; exploratory trenching in selected areas to investigate subsurface deposits; ground-water hydrology evaluation; geoenvironmental evaluation of near-surface materials; socioeconomic evaluation; land use mapping; demographic data collecting and sampling; aesthetics evaluation; and transportation analysis. Among the various environmental activities, the bulk of the work may be completed in Phases 1 or 2, but there may be some additional site-specific data that may not be available until Phase 3.

Laboratory Testing and Analysis:

Laboratory testing and analysis can be ongoing with the exploration field surveys and the pre-operational monitoring activities, and will include testing and/or analysis of rock, soil, sediment, water, air, flora, and fauna samples.

Data Analysis:

Data analysis can be ongoing during Phase 3, but should be performed in depth at the completion of the phase in order to complete site models and performance assessment studies. The data evaluation will also result in determination of the requirements for long-term monitoring activities.

Reporting/Decision Points:

The final results of the Phase 3 monitoring program will become the basis for input to the SAR, ER, and other programmatic documents.

APPENDIX D
FEDERAL DATA SOURCES

APPENDIX D
FEDERAL DATA SOURCES

Federal Aviation Administration
800 Independence Avenue SW
Washington, DC 20591
(202) 426-8058

Federal Emergency Management Agency
500 C. Street SW
Washington, DC 20472
(202) 646-4600

National Advisory Council on Historic Preservation
Room 809, 1100 Pennsylvania Avenue NW
Washington, DC 20004
(202) 786-0503

National Bureau of Standards
Gaithersburg, MD 20899
(301) 921-1000

National Oceanic and Atmospheric Administration (NOAA)
Department of Commerce
Washington, DC 20230
(202) 377-2985

National Park Service
Department of the Interior
P.O. Box 37127
Washington, DC 20013-7127
(202) 343-7394

National Transportation Safety Board
800 Independence Ave. SW
Washington, DC 20594
(202) 382-6600

National Weather Service
National Oceanic and Atmospheric Administration
Department of Commerce
Washington, DC 20230
(202) 377-2985

Office of the Chief of Engineers
Department of the Army
Washington, DC 20314
(202) 693-6136

U.S. Army Corps of Engineers
Headquarters, Department of the Army
Washington, DC 20314
(202) 272-0001

U.S. Bureau of the Census
Washington, DC 20233
(301) 763-4640

U.S. Bureau of Economic Analysis
Department of Commerce
Washington, DC 20230
(202) 523-0777

U.S. Bureau of Indian Affairs
Department of the Interior
Washington, DC 20240
(202) 343-7445

U.S. Bureau of Land Management
Department of the Interior
Washington, DC 20240
(202) 343-9435

U.S. Bureau of Mines
Department of the Interior
2401 E Street NW
Washington, DC 20241
(202) 634-1004

U.S. Bureau of Reclamation
Office of Public Affairs
Department of the Interior
Washington, DC 20240
(202) 343-4662

U.S. Department of Agriculture Stabilization and Conservation Service
14th Street and Independence Avenue SW
Washington, DC 20250
(202) 447-2971

U.S. Department of Commerce
14th Street and Constitution Avenue SW
Washington, DC 20230
(202) 377-2000

U.S. Department of Defense
The Pentagon
Washington, DC 20301
(202) 545-6700

U.S. Department of Energy
1000 Independence Avenue SW
Washington DC 20585
(202) 252-5000

U.S. Department of Housing and Urban Development
451 Seventh Street SW, Room 1202
Washington, DC 20410
(202) 655-4000

U.S. Department of Transportation
4000 Seventh Street SW
Washington, DC 20590
(202) 426-4000

U.S. Environmental Protection Agency
401 M Street SW
Washington, DC 20410
(202) 382-2090

U.S. Fish and Wildlife Service
Department of the Interior
Washington, DC 20240
(202) 343-5634

U.S. Forest Service

Aerial photographs:

U.S. Department of Agriculture
2222 West 2300 Street
Salt Lake City, UT 84119
(801) 524-5856

U. S. Geological Survey
119 National Center
Reston, VA 22092
(703) 648-4460

Aerial photographs:

National Cartographic Information Center
U.S.G.S
507 National Center
Reston, VA 22092

Books, other publications:

Text Products Sections
Eastern Distribution Branch
U.S.G.S
604 South Pickett Street
Alexandria, VA 22304-4658
(703) 756-6141

LANDSAT photographs:

User Service Unit
EROS Data Center
Sioux Falls, SD 57198
(605) 594-6151

Maps:

U.S.G.S.
Box 25286, Federal Center
Denver, Co 80225
(303) 234-3832

U.S. Nuclear Regulatory Commission
Washington, DC 20555
(301) 492-7715

U.S. Soil Conservation Service
Department of Agriculture
P.O. Box 2890
Washington, DC 20013
(202) 447-4543

U.S. Water Resources Council
1025 Vermont Avenue NW
Washington, DC 20025
(202) 382-6104

Other National Data Sources

American Water Works Association
Government Affairs Office
1010 Vermont Avenue NW, Suite 810
Washington, DC 20005
(202) 628-8303

Earth Observation Satellite Company (EOSAT)
1901 North Moore Street
Arlington, VA 22209

National Water Well Association
88 East Broad Street
Columbus, OH 43215
(614) 224-6241

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