

THE DEVELOPMENT OF A SITE CHARACTERIZATION FIELD MANUAL FOR
NEAR SURFACE GEOLOGIC DISPOSAL OF LOW-LEVEL NUCLEAR WASTE (LLNW)

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ABSTRACT

A manual was recently (1985) developed at The University of Arizona to aid government agencies in formulating a program for the detailed characterization of a proposed near-surface, low-level nuclear waste (LLNW) disposal site. Included in the manual are specific procedures for site characterization management, identification of pertinent technical parameters and methods for their determination, and the development of general procedures for conducting a site characterization study. This paper describes the general make up of the manual and presents an example of site characterization with respect to geotechnical engineering parameters. A brief description is also given of a general procedure for site characterization that can be used by planners, managers, and staff personnel to implement the process of evaluating the suitability of a site for LLNW disposal.

INTRODUCTION

The Low-Level Radioactive Waste Policy Act (Public Law 96-573), enacted by Congress in 1980, places the responsibility of low-level nuclear waste (LLNW) disposal on the states either individually or through regional compacts. The University of Arizona study was performed under the sponsorship of the United States Department of Energy (DOE) which is charged with the mission of aiding states in developing LLNW disposal sites. Accordingly, DOE contracted to have a Site Characterization Manual developed since one of the provisions of Subpart D, Section 61.50 of 10CFR61 (1) is that certain specified minimum characteristics of a proposed disposal site must be acceptable for the site to be used as a near-surface disposal facility. The manual (2) is directed primarily at planners, managers and staff personnel to give them an overall view of the site characterization parameters and the methods available for their evaluation. It is directed secondarily at experts in any given discipline to acquaint them with the requirements of other disciplines involved in site characterization. It is not designed to tell experts how to do their jobs within their own areas of expertise; however, it may serve as a guideline for them.

SITE CHARACTERIZATION PROCESS

The site characterization process consists of the detailed literature reviews and field and laboratory investigations that are required to define the site characteristics that affect the isolation of LLNW, the long-term stability of the site, and the environmental interactions between the site and its surroundings.

Objectives

The objectives of site characterization are to:

- 1) Provide the detailed information necessary for acceptance of the site for near-surface disposal of low-level radioactive waste.

- 2) Establish data collection points.
- 3) Develop baseline data on the site.
- 4) Develop a laboratory testing capability to support field tests.

Plan

A site characterization plan must be made prior to implementation of detailed site investigations. Once the site characterization plan has been approved and implemented, it should be reviewed and updated periodically. At a minimum, the plan must insure that:

- 1) All available existing data on the site are considered.
- 2) Unnecessary laboratory and/or field investigations are not done.
- 3) Required and/or desired data, that are not available, are obtained.
- 4) A proper sequencing and timely accession of the required/desired data is planned and executed.
- 5) Technical and administrative coordination of laboratory and field efforts is planned and executed.

Methodology

The methodology to implement the site characterization process is as follows:

- 1) Review all site selection information. It should be noted here that the site selection process, with all of its investigations, precedes the site characterization process. However, some of the data collected from the site selection phase may be used in the site characterization study.

- 2) Determine additional requirements for site characterization.
- 3) Determine sources for the site data base requirements such as laboratory tests, field tests or additional searching out of information from government and/or private documentation.
- 4) Prepare a site characterization plan with close attention to the priority of implementation considering the time period requirements of monitoring.
- 5) Continuously review the site data as the characterization proceeds with particular attention to any indication of a site disqualification characteristic which may require additional confirmatory efforts.
- 6) Prepare a comprehensive site characterization report.

SITE CHARACTERIZATION PARAMETERS

In order for the objectives of the site characterization process to be met, lists of site characterization parameters were drawn up for each of the following disciplines:

- 1) Geosciences
- 2) Hydrological Sciences
- 3) Engineering Disciplines
- 4) Radiology and Health Physics
- 5) Meteorology
- 6) Biology (ecological)
- 7) Anthropology
- 8) Demography

Subdisciplines within each of these areas were also defined so that the actual lists of site characterization parameters became quite extensive and contained considerable overlap. However, in drawing up the lists, no consideration was given to the relative importance of specific parameters since the importance of each would depend upon site-specific conditions. For example, the parameters that are important for an "arid" site might not be so important for a "wet" site and vice versa.

Once the site characterization parameters for a specific discipline had been established, the next step was to identify how each parameter could be evaluated in the field and/or in the lab. To this end, a list was compiled of the information required or test methods available to evaluate each parameter. Additional information was supplied for each test method with regard to one or more of the following items: equipment to be used, standards for conducting the test, and references in the literature that describe the test or applications of its use. In some instances, especially for highly specialized testing equipment, manufacturers' names were given; however, this was done for information purposes only and no endorsement of specific products was intended or implied. Indeed, the lists were compiled without regard to any preference, technical, economical or otherwise.

The purpose of these compilations was to provide a standard and integrated format that allows for interactions among technical areas and testing procedures. Such interactions are desirable since they tend to prevent duplication of effort. Also, they indicate where data collection in one technical

area would compliment testing in another area. For example, the same bore hole could be used to perform in situ pressure meter tests, up-hole or down-hole seismic tests, and pump tests for the evaluation of site characterization parameters related to three different disciplines. The results from one of these tests might suggest the use of a specific type of equipment in another test that would be better suited for obtaining good results under the conditions encountered.

Although the compilations were intended to follow the same format and have the same headings for each discipline so that interchange among compilations could be done easily, this was not always possible since some disciplines have rather unique ways of evaluating parameters. However, in general, the compilations for each discipline have the following major headings:

- 1) Factor or function to be investigated (task)
- 2) Parameter(s) to be evaluated
- 3) Technical area to which the function belongs
- 4) Equipment or method used to evaluate factor

It is envisaged that when these lists are actually being used, another column can be added in which other factors or functions can be listed for which the specific parameter being evaluated is also used and the corresponding technical area cross referenced.

FORMAT OF THE DOE/UA SITE CHARACTERIZATION MANUAL

The DOE/UA Site Characterization Manual was set up according to the following format:

- 1) Introductory Comments
- 2) A plan for site characterization management
- 3) The "working" technical portion
- 4) A general procedure for site characterization

The "working" technical portion is by far the largest section. It consists of chapters for each of the disciplines listed previously. Each chapter contains an introduction in which the purpose, scope and importance of the specific technical area are described. This is followed by a brief discussion of the parameters pertaining to that area. The discussion of each parameter includes a section on its importance, the area(s) of its application, and the techniques for data collection. The last section of each chapter contains cited and other relevant references. At the conclusion of each chapter there is a discipline-specific table that contains listings of tasks, parameters, test methods, and standards or references.

Because of the magnitude of information contained in the manual, it is impossible in the limited space allotted here to give even a summary for each of the technical areas considered in the Manual. However, to illustrate the general format an abbreviated example is given of the chapter dealing with site characterization with respect to geotechnical engineering parameters.

SITE CHARACTERIZATION WITH RESPECT TO GEOTECHNICAL ENGINEERING PARAMETERS

Among the factors to be evaluated in the characterization of a LLNW disposal site from the viewpoint of geotechnical engineering are:

- 1) The stability of soil masses including trench slopes and embankment slopes.

- 2) The stability of structural foundations and retaining structures.
- 3) The performance of engineered fills.
- 4) The volume change characteristics of site soils - consolidation and/or elastic settlement under load.
- 5) Surface and ground water movement.

The evaluation of these factors requires the determination of a number of parameters either by field tests, laboratory tests or a combination of the two. The following geotechnical characteristics and their associated parameters were identified as those required for a preliminary characterization of a LLNW disposal site:

- 1) Shear strength characteristics for specified loading and drainage conditions:
 - a) Angle of internal friction
 - b) Unit cohesion
- 2) Consolidation characteristics:
 - a) Maximum past effective stress
 - b) Compression index
 - c) Recompression index
 - d) Coefficient of primary consolidation
 - e) Coefficient of secondary consolidation
- 3) Collapse or swell characteristics:
 - a) Soil suction/moisture content relationship
 - b) Volumetric strain under load
 - c) Collapse index
 - d) Swell potential or swell pressure
- 4) Behavioral indices:
 - a) Atterberg limits
 - b) Grain size distribution and particle characteristics
 - c) Hydrometer analysis
 - d) Activity index
- 5) Moisture-density characteristics (compaction):
 - a) Compaction curve(s)
 - b) Maximum dry density and optimum moisture content
 - c) In situ dry density
- 6) Volumetric-gravimetric characteristics in situ:
 - a) Porosity/void ratio
 - b) Moisture content
 - c) Degree of saturation
 - d) Specific gravity of solids
 - e) Unit weight
- 7) Physicochemical characteristics:
 - a) Mineralogy
 - b) pH
 - c) Cation exchange capacity
 - d) Salt concentration
 - e) Fabric
- 8) Hydrological characteristics:
 - a) Hydraulic conductivity - saturated
 - b) Hydraulic conductivity - unsaturated
 - c) Pore water pressures

- d) Hydraulic gradients (surface)
- e) Erosion potential (surface)
- f) Roughness coefficients (surface)
- 9) Liquefaction potential
- 10) Elastic properties:
 - a) Elastic moduli
 - b) Poisson's ratio
 - c) Constitutive relationships
- 11) Physical characteristics of the site
 - a) Near surface soil profile
 - b) Topography
 - c) Depth to ground water table
 - d) Anomalies such as sink holes, subsurface voids, impermeable layers, etc.
 - e) Vegetation

The Manual contains a listing of the test methods and/or equipment currently available for the measurement of each of the parameters listed above as well as standards, references, and/or names of equipment manufacturers which may be consulted for details.

Table I presents the information contained in the Manual for "hydraulic conductivity - saturated" and "hydraulic conductivity - unsaturated". These are two of the parameters listed under hydrological characteristics found in the chapter dealing with geotechnical engineering. Table II presents a partial listing for the same parameters (with different names) as found in the chapter dealing with ground water hydrology. Note that although both tables address the same physical parameters, the names of the parameters are different as are the cited references. This is so because the chapters were written by two different people having different areas of expertise. However, both recognize the parameters as important for the characterization of a site for LLNW disposal. The value of the Manual, therefore, is to alert the planner to this fact and to allow him/her to schedule hydraulic conductivity tests in the field or in the lab with the knowledge that the results of the test will be useful to both the geotechnical engineer and the hydrologist. Duplication of effort is thereby avoided.

A GENERAL PROCEDURE FOR SITE CHARACTERIZATION

A procedure consisting of at least the following seven steps is recommended for characterizing a site for LLNW disposal:

- 1) Collection of existing data.
- 2) Evaluation of existing data.
- 3) Establishment of a pre-characterization data base for all disciplines from the existing information.
- 4) Development of a site-specific characterization plan.
- 5) Implementation of a site-specific characterization plan.
- 6) Final evaluation of suitability of site for LLNW disposal.
- 7) Development and implementation of a site-specific monitoring system.

TABLE I

Selected Geotechnical Engineering Parameters for Site Characterization

<u>GEO TECHNICAL PARAMETERS</u>	<u>PURPOSE/FUNCTION</u>	<u>AVAILABLE TEST METHODS AND/OR EQUIPMENT</u>	<u>STANDARDS/REFERENCES/EQUIPMENT MANUFACTURERS</u>
Hydraulic Conductivity a. Saturated	Permeability is a directional parameter. The water will always follow the direction of maximum permeability. Permeability is the ability of rock or soil to transmit fluids. Need to conduct seepage studies on ground water movement into and/or out of trenches.	FIELD: Falling Head Test	(3)
		Constant Head Test	(4), (5)
		Packer or Lugeon Test	(6)
		Instantaneous Profile Test	(7)
		LAB: Constant Head Test	(4)
		Falling Head Test	
b. Unsaturated (Relative)	This parameter is one of the most important properties for site characterization and is a measure of the rate at which fluids can pass through rock or soil. It is used to analyze partially saturated flow through trench cap materials and soils surrounding works.	FIELD: Piezometer	(8), (9), (10)
		Tensiometer	
		LAB: Pressure Plate Extractor	(11)
		Tensiometer	
			Soil Instruments, Ltd* Cat No 1600 * Equipment Manufacturer Catalog Number

TABLE II

Selected Hydrological Parameters for Site Characterization

<u>HYDROLOGICAL PARAMETERS</u> (Ground Water)	<u>PURPOSE/FUNCTION</u>	<u>TESTS/METHODS</u>	<u>REFERENCES</u>
Vadose (Unsaturated) Zone	Fluid (Hydraulic) conductivity is the ability of a material to transmit a specific fluid. It is an important parameter for flow of subsurface water, which incorporates characteristics of both the fluid and the solid material.	FIELD: Ring Permeameter	(12), (13)
		Shallow Well Pump-In	(12), (14)
		Air-Entry	(15)
		Double-Tube	(13)
		LAB: Constant Head	(5), (16)
	Falling Head	(16), (19)	
	Pressure or Tension	(18), (19), (20)	
Saturated Zone	Fluid (Hydraulic) conductivity is the ability of a material to transmit a specific fluid. It is an important parameter for flow of subsurface water, which incorporates characteristics of both the fluid and the solid material. Under saturated conditions this parameter is a constant for any relatively uniform material.	FIELD: Aquifer Tests (Pumping)	(21), (22)
		Constant Head	(23), (24)
		Variable Head	Same as above
		Constant Discharge	Same as above
		Instantaneous Discharge	Same as above
		Constant Discharge	Same as above
		Instantaneous Discharge	Same as above
		Recovery	Same as above
		LAB: Constant Head	(5), (16)
			Falling Head
	Pressure or Tension	(18), (19), (20)	

The UA/DOE Manual can be used as a guide in undertaking the first three steps. Its main impact, however, is in Steps 4 and 5. Indeed, if all of the parameters identified in the Manual for a specific discipline are evaluated, the site should be completely characterized with respect to that discipline. Step 6 can be completed only when the site has been characterized with respect to all technical areas. Here again, the Manual forms the basis for the final evaluation. Step 7 was included as an integral part of the general procedure for site characterization not only because of its obvious importance during the lifetime of the disposal site, but also because of the possibility of extending the use of instrumentation from the site characterization phase of the project to the operating and post-closure stages as well.

CONCLUSIONS

The development of a LLNW disposal site from inception through its operational stage and closure presents numerous problems, both technical and nontechnical, of a multi-disciplinary nature. The Manual developed by researchers at the University of Arizona for the U.S. Department of Energy provides managers, planners and technical staff of LLNW disposal agencies with a concise methodology for characterizing proposed or existing sites for final evaluation of their suitability for LLNW disposal. Because of its multi-disciplinary nature, and the manner in which it is formulated, the Manual is ideally suited for site characterization studies.

Since problems that involve determining one of many possible solutions are ideal candidates for expert systems, the use of the Manual as a basis for developing such a system for the characterization of a potential LLNW disposal site appears to be feasible.

ACKNOWLEDGEMENT

This paper is based on work supported by the U.S. Department of Energy under contract number DE-FG07-84ID12514. Those wishing to obtain a copy of the Manual should write directly to the U.S. Department of Energy, Idaho Operations Office, 550 Second St., Idaho Falls, Idaho, 83401.

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