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Proceedings of the

Symposium on Low-Level Waste Disposal

Site Suitability Requirements

Held at
Crystal City, Virginia
December 8-9, 1981

Compiled by M. G. Yalcintas, D. G. Jacobs

Sponsored by
Office of Nuclear Material Safety and Safeguards
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and
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M. G Yalcintas, Oak Ridge National Laboratory
D. G. Jacobs, Evaluation Research Corporation

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Washington, D.C. 20555
and
Oak Ridge National Laboratory
Oak Ridge, TN 37830

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FOREWORD

A series of three symposia is being cosponsored by the U.S. Nuclear Regulatory Commission (NRC) and Oak Ridge National Laboratory (ORNL) to provide a forum for wide-ranging discussion of the proposed rule, 10 CFR Part 61, and associated technical position papers. The regulation (Federal Register/Vol. 46, No. 142/Friday, July 24, 1981) is entitled, "Licensing Requirements for Land Disposal of Radiactive Waste."

Site suitability requirements were the subject of the first symposium in this series. Technical requirements were described in invited formal presentations. Representatives of federal and state government agencies, industry, and various scientific disciplines made valuable contributions during the discussion periods. One goal of the panel discussions was to identify types of sites that satisfy the technical requirements of the proposed rule. This identification provided input to the NRC in determining whether the proposed rule and the technical position papers are reasonable and appropriate.

The papers in these proceedings are being published in the same order in which they were presented at the symposium from camera-ready material submitted by the authors. All papers have been reviewed and cleared as necessary by the institutions with which the authors are affiliated. The comments made during the discussion periods were summarized from a court reporter's transcript and were reviewed by the individuals who responded to questions. I appreciate the assistance of R. E. Browning who substituted for John B. Martin. It was unfortunate that Hayward Shealy was unable to attend the meeting.

A list of attendees follows the text.

The success of this symposium was a direct result of the cooperative efforts of many individuals. I would like to acknowledge the enthusiastic response of the following individuals to my pleas for help during the preparation of the program: Rowena Chester, Charles Miller, Craig Little, Robert Lowrie, and Leroy Stratton of ORNL; Don Jacobs of Evaluation Research Corporation (ERC); and Maxine Dunkelman, David Siefken, and Edward Hawkins of NRC. I would like to recognize the speakers and the session chairmen for their valuable contributions. A special thanks to Joann Epler, Mary Gene Ryan, and Reeta Fletcher of ERC; to Bonnie Reesor, Joy Simmons, and Patricia Garnet of the ORNL conference office for their essential contribution to this symposium; and to Vivian Jacobs, Carol Johnson, and Wilma Minor of ORNL for the preparation of these proceedings.

M. G. Yalcintas
Conference Chairman

PROGRAM

Tuesday, December 8, 1981

MORNING

8:00 **Presiding:** *M. Güven Yalcintas,* Conference Chairman, Oak Ridge National Laboratory, Oak Ridge, Tennessee

Welcome: *John B. Martin,* U.S. Nuclear Regulatory Commission, Washington, D.C.

Introduction: *A. L. Lotts,* Session Chairman, Oak Ridge National Laboratory, Oak Ridge, Tennessee

8:30 **Introduction to 10 CFR Part 61,** *R. Dale Smith,* U.S. Nuclear Regulatory Commission, Washington, D.C.

9:00 **DOE Low-Level Waste Long-Term Technology Development,** *Michael J. Barainca,* U.S. Department of Energy, Idaho Falls, Idaho

9:30 **EPA Views on Selection of Sites for Land Disposal of Low-Level Waste,** *G. Lewis Meyer,* U.S. Environmental Protection Agency, Washington, D.C.

10:00 BREAK

10:30 **A State Government's Point of View on 10 CFR Part 61,** *Hayward Shealy,* South Carolina Department of Health, Columbia, South Carolina

11:00 **A View from the Ground,** *Georgia Yuan,* Washington State University, Pullman, Washington

11:30 **Site Suitability Considerations—An Industry Perspective,** *Glenn Bradley,* Chem-Nuclear Systems, Inc., Bethesda, Maryland

AFTERNOON

12:00 LUNCHEON
Political Implications of Siting, *Philip F. Gustafson,* Illinois Department of Nuclear Safety, Springfield, Illinois

2:00 **Panel Discussion with Tuesday-Morning Speakers,** Moderator, *A. L. Lotts,* Oak Ridge National Laboratory, Oak Ridge, Tennessee

3:30 BREAK

3:45 **Panel Discussion, Continued**

5:00 Conclusion of Tuesday sessions

Wednesday, December 9, 1981

MORNING

8:00 **Introduction:** *Donald G. Jacobs,* Session Chairman, Evaluation Research Corporation, Oak Ridge, Tennessee

8:10 **Geohydrologic Problems at Existing Low-Level Radioactive Waste Sites and Implications for Future Sites,** *John B. Robertson,* U.S. Geological Survey, Reston, Virginia

8:30 **Surface Water Hydrology Experience at Existing Low-Level Radioactive Waste Disposal Sites as a Basis for Selecting Future Sites,** *David L. Schreiber,* Schreiber Consultants, Coeur d'Alene, Idaho

8:50 **Geographic Factors Related to Site Suitability of Low-Level Waste Disposal,** *H. E. Zittel,* Oak Ridge National Laboratory, Oak Ridge, Tennessee

9:10 **Application of Ecological Mapping,** *Albert Sherk,* U.S. Fish and Wildlife Service, Washington, D.C.

9:30 **Meterological Considerations for Low Level Waste Disposal,** *Isaac Van der Hoven,* National Oceanic and Atmospheric Administration, Silver Spring, Maryland

9:50 **Soil Mechanics Siting Considerations,** *Don Banks,* U.S. Army Corps of Engineers, Vicksburg, Mississippi

10:10 BREAK

10:30 **Panel Discussion with Wednesday-Morning Speakers,** Moderator, *Donald G. Jacobs,* Evaluation Research Corporation, Oak Ridge, Tennessee

AFTERNOON

12:00 BREAK

1:30 **Overview—A Panel Discussion with Representatives of NRC, DOE, EPA, USGS, and State Government,** Moderator, *Donald G. Jacobs,* Evaluation Research Corporation, Oak Ridge, Tennessee

3:00 **Closing Remarks,** *M. Güven Yalcintas*

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OPENING OF THE SYMPOSIUM

M. G. Yalcintas
Conference Chairman
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

Welcome to the first symposium on low-level waste disposal. This symposium will focus on the site suitability requirements in the proposed rule on land disposal of low-level radioactive wastes, 10 CFR Part 61, and associated technical position papers. This symposium is sponsored and organized by the U.S. Nuclear Regulatory Commission (NRC) and Oak Ridge National Laboratory (ORNL) to provide a forum for examination of the proposed rule and the technical position papers that support it.

To accomplish this goal we have invited speakers to address a number of topics related to site suitability. Technical requirements in various disciplines will be described in formal presentations and will be followed by panel discussions. These presentations and discussions will provide input to the NRC about whether the proposed rule and the technical position papers are reasonable and appropriate.

This is the first of three symposia on low-level waste disposal. The second symposium will address the site characterization and site monitoring programs, and the third will cover facility design, construction, and operating practices.

On behalf of the NRC and ORNL, I want to thank our speakers and session chairmen for their contributions. I also want to thank each of you for attending this symposium. I'm certain that with your participation, this symposium will achieve its stated purpose and provide additional insight to questions relating to low-level waste disposal.

WELCOMING ADDRESS

R. E. Browning

Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C.

Welcome to the NRC's symposium on site suitability requirements. This is intended to be the first in a series of NRC symposia on various aspects of low-level waste disposal. Site suitability was selected as the subject of this first symposium because this area is the first step which must be addressed in the sequence of steps required to develop a low-level waste disposal site.

As I am sure you are all aware, the current commercial low-level waste disposal situation must be reversed so that additional new sites are developed close to the sources of the wastes. The NRC has been taking action to be responsive to this need by developing licensing procedures and requirements that will assure adequate protection of the public health and safety and the environment without creating unnecessary regulatory impediments to the licensing of such disposal sites.

As early as October 1979, the then-Chairman of the NRC, Dr. Hendrie, sent a telegram to the Governors of all the States noting the need for additional regionally disposed low-level waste disposal sites and emphasized that the NRC stood ready to work with applicants and States to license low-level waste disposal sites and provide technical assistance to Agreement States for the same purpose. In February 1980, the NRC staff announced availability of a preliminary draft regulation for disposal of low-level waste (10 CFR 61). Subsequently, in July 1981, the proposed regulation for low-level radioactive waste disposal was published for comment. The proposed regulation included consideration of comments which had been made on the preliminary draft as well as comments obtained during public meetings held throughout the country.

Site suitability constitutes only one of many parts of an overall disposal system which must all be controlled to assure isolation of the low-level radioactive waste for the duration of the radiological hazard and to provide stability of the disposal site after closure. Other parts included in the proposed regulation are site design, operation, and closure; waste characteristics and classification; and institutional controls.

Since license applications are anticipated from various regions of the country, sites are expected to exhibit a wide range of conditions and characteristics. The staff recognizes that the contribution of the site characteristics toward meeting the overall performance objectives may vary from site to site. A disposal site with less than outstanding site characteristics may require greater reliance on waste form, design features, and facility operation.

Since the staff fully anticipates any proposed disposal site will meet the minimum technical requirements, it is very important that there be a technical consensus that the requirements are technically sound, reasonable, and capable of being met within the States or compacts which take the initiative to develop new sites. One of the major goals of this symposium is to ensure that this consensus is developed and can be used to support the site suitability criteria which are ultimately included in the final rule which will be published in 1982. This technical consensus is essential, if the licensing process on any new application is to proceed smoothly and rapidly.

INTRODUCTION TO PART 61

R. Dale Smith

Low-Level Waste Licensing Branch
U.S. Nuclear Regulatory Commission
Washington, DC 20555

ABSTRACT

Comments received on proposed Part 61 are discussed briefly. The role of site suitability requirements as the screening mechanism for site selection is one of the more important applications of the requirements. A comparison of site suitability requirements to performance objectives and key aspects of the role is made. It is shown that site suitability requirements contribute to the achievement of more than one performance objective.

COMMENTS ON PART 61

As of November 19, 1981, we have received comments from 57 persons and organizations. The commenters represent a variety of interests and commented on a wide range of issues. Commenters have included state groups, utilities, industrial entities, individuals, federal agencies or laboratories, medical groups, surety groups, engineering firms, public interest groups, the ACRS, and one international commenter.

Some commenters offered one comment, others as many as 18-20. The topics covered thus far have dealt with a wide variety of issues and have covered most aspects of the rule. We have identified about 100 different issues. Points were raised covering the procedural aspects of site suitability, design, operations, and closure, environmental requirements, state and tribal participation, institutional requirements, and the manifest system. The areas of greatest concern to the commenters relate to waste classification and characteristic requirements. A numerical breakdown is shown in Table 1.

Table 1

PROPOSED 10 CFR PART 61

Overview of Comment Distribution

Aspect of rule	Number of comments	Issues
Procedural	21	13
Manifests and transfers	16	3
Performance objectives	22	4
Site suitability	13	8
Site design	4	3
Operations and closure	13	6
Environmental monitoring	6	2
Waste classification	37	8
Waste characteristics	31	12
Financial	11	9
State/Tribal	4	1
Institutional	16	9
Assorted and editorial	55	21

We received 13 comments on site suitability. Comments were offered by states, a public interest group, a university, utilities, and an international commenter. Both support and criticism of the flooding requirement in 61.50 (a)(5) was offered. The criticism favored more absolute requirements and a 500-year vs. 100-year floodplain specification. The necessity of 61.50(a)(9) was challenged on the basis that even major faulting would not be a problem. Specific requirements on access of ground water to the waste and ground water discharge were opposed as unduly restrictive. A numerical specification on depth to watertable was requested. Concerns about site complexity were the vagueness and subjectiveness. Additional siting factors offered were transportation accessibility and other institutional requirements such as relationship to public water supplies and population density. Less stringent suitability requirements if a facility will be used for Class A or A and B wastes only was suggested. Flexibility to use the site for disposal of certain hazardous wastes are also suggested.

We also received a few editorial comments on site suitability and design which focused primarily on absolute language. For example changing "prevent" to "minimize" in 61.51(a)(6) was suggested.

SITE SELECTION

The site selection process used by any applicant, individual state, or regional compact of states may vary considerably due to a wide variety of factors such as geographical distribution of low-level radioactive waste generators; diverse geologic, hydrologic, meteorologic, climatic, ecologic, and socioeconomic settings; and provisions on site selection in the compact charters. However, the site selection processes followed in separate applications will share the same basic steps.

The first step will consist typically of defining the region of interest, such as the area within the geographic boundaries of an individual state or regional compact. The second step will consist of screening the region of interest to identify potential sites. In the third step, the potential sites will be screened against a common set of criteria, including the minimum technical requirements in 10 CFR Part 61 and the environmental standards in 10 CFR Part 51. The third step is envisioned as a coarse screening process which will identify a slate of candidate sites for more detailed review.

The fourth step will consist typically of a detailed review of the slate of candidate sites identified through the coarse screening. The first four steps will relay primarily upon available reconnaissance level information. The primary differenaces between the steps will be the level of detail of the review and the inclusion of additional items to be evaluated in each step. For example, the fourth step may include items such as conceptual designs, preliminary cost estimates, release scenarios and pathway studies which were not inlcuded in the previous steps. The fourth step will conclude with the selection of a preferred site from among the candidate sites.

Thus, it is in the site selection process that the site suitability requirements play their first and perhaps most important role. These requirements are the sieves through which potential sites must pass before they can receive serious consideration. It is vital, therefore, that this screening process does not eliminate useful sites and, just as important, does not let unsuitable sites pass through.

Limited investigations of site characteristics at some or all of the candidate sites may be needed during the fourth step, in some cases, to evaluate these additional items and to adequately distinguish between the candidate sites such that a preferred site can be identified. However, the major portion of the site characterization studies will be performed at the preferred site after selection from among the candidate sites. Only if the detailed site characterization studies identify unanticipated adverse conditions at the preferred site would detailed investigations be performed at more than one site. These investigations will be the subject of a future symposium in this series.

PERFORMANCE OBJECTIVES

Part 61 establishes four performance objectives for the safe disposal of radioactive waste. These are set forth in sections 61.41 through 61.44. In these sections, objectives are stated for (1) the protection of the general population from releases of radioactivity, (2) protection of individuals from inadvertent intrusion, (3) protection of individuals during operations, and (4) stability of the disposal site after closure.

Disposal of radioactive waste is a complex system that depends upon the proper combination of a number of factors. Because disposal is a system, there are probably an infinite number of combinations of factors that could result in safe disposal; however, in real life, we do not find anyone in charge of all of the system. Various factors are controlled by the waste generator while others are under the control of the disposal site operators. In order for each party to know what to expect from the other, Part 61 establishes minimum technical criteria for each component of the system. These are found in Subpart D of Part 61. There are set forth technical requirements for (1) site suitability, (2) design and operation of the facility, (3) waste classification and characteristics, and (4) institutional requirements. Each of these technical components contributes to the system's ability to meet the overall performance objectives. Certain waste characteristics, for example, contribute greatly to preventing offsite migration and protection of the public while at the same time helping to assure the long term stability of the site and also protection against inadvertent intrusion.

So it is also with the site suitability requirements. Site suitability requirements set forth conditions which enhance the system's ability to control off-site exposures by radioisotope migration, to assure long term stability, and to reduce the liklihood of intrusion.

The minimum requirements for site suitability are directed at four key aspects that are directly related to assuring that the overall performance objectives for migration, long-term maintenance, and intrusion protection are met. These are:

1. Eliminate, to the extent practicable, the contact of water with waste during operations and after closure to reduce the potential for migration.

2. Assure long-term stability of the site and facility to to eliminate the need for constant care and maintenance over the long-term with attendant uncertain high costs and long-term commitment of social resources.
3. Improve confidence in the predictability of the long-term performance capability of the facility.
4. Site facilities in locations where there is little liklihood of future human activities that could result in human intrusion.

SITE SUITABILITY REQUIREMENTS

Site suitability requirements for land disposal of low-level radioactive waste are presented in Section 61.50 of the proposed rule. The site suitability requirements identify certain characteristics which should be present at any proposed near-surface disposal facility. The site suitability requirements are intended to function collectively with requirements on site design, facility operations, site closure, waste classification and segregation, waste form and packaging, and institutional controls to help assure isolation of the low-level radioactive wastes for the duration of the radiological hazard and to provide stability of the disposal site after closure.

The site suitability requirements in Section 61.50 of the proposed rule are minimum technical requirements related to the geologic, hydrologic, and demographic characteristics of a disposal site. It is expected that any proposed disposal site will meet these minimum technical requirements. The staff forsees very few instances where proposed disposal sites not meeting the minimum technical requirements would be acceptable. Such sites would be evaluated on a site-by-site basis and would require that an exception to the rule be granted.

The specific site suitability requirements in Section 61.50 of the proposed rule are as follows:

61.50(a)

(1) Purpose of the section
(2) The disposal site shall be capable of being characterized, modeled, analyzed, and monitored.
(3) Within the region or state where the facility is to be located a disposal site should be selected so that projected population growth and future developments are not likely to affect the ability of the disposal facility to meet the performance objectives.
(4) Areas must be avoided having economically significant natural resources which, if exploited, would result in failure to meet the performance objectives.
(5) The disposal site must be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-year flood plain, coastal high-hazard area or wetland.

(6) Upstream drainage areas must be minimized to decrease the amount of runoff which could erode or innundate waste disposal units.

(7) The disposal site must provide sufficient depth to the water table that ground-water intrusion, perennial or otherwise, into the waste will not occur. The Commission will consider exceptions to this requirement if it can be conclusively shown that disposal site characteristics will result in diffusion being the predominant means of radionuclide movement and the rate of movement will result in the performance objectives being met.

(8) Any ground-water discharge to the surface within the disposal site must not originate within the hydrogeologic unit used for disposal.

(9) Areas must be avoided where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives or may preclude defensible modeling and prediction of long-term impacts.

(10) Areas must be avoided where surface geologic processes as mass wasting, erosion, slumping, landsliding, or weathering occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives or may preclude defensible modeling and prediction of long-term impacts.

(11) The disposal site must not be located where nearby facilities or activities could adversely impact the ability of the site to meet the performance objectives or significantly mask the environmental monitoring program.

In the following figure is shown the correlation between each of the site suitability criteria and the key aspects stated earlier.

Figure 1. Correlation Between Each of the Site Suitability Criteria and Key Aspects Stated Above

CRITERIA FROM § 61.50 (A)	ELIMINATE CONTACT WITH WATER	ASSURE LONG-TERM STABILITY	IMPROVE CONFIDENCE IN PREDICTABILITY	PROTECT THE INTRUDER
(2)			X	
(3)		X	X	X
(4)		X	X	X
(5)	X	X		
(6)	X	X		
(7)	X		X	
(8)	X		X	
(9)		X	X	
(10)		X	X	
(11)			X	

There are several interesting observations from this matrix. First, the criteria contribute more to the assurance of long-term stability and confidence in predictability than they do to the other factors. While some criteria contribute to protecting the intruder and preventing water contact and subsequent migration, most of the crtiteria are intended to assure that these conditions remain constant and predictable.

Second, it is noted that most of the criteria contribute to more than one objective. Avoiding areas of possible future populatior growth and development obviously minimizes the liklihood of human intrusion into the site in the future. But it also reduces the chance of human activities in the area causing changes that could affect the stability of the site (e.g., changing surface drainage causing site erosion) or actions that could affect the long-term predictability of the site, such as significantly altering the groundwater characteristics of the site.

The third observation derives from preparing the matrix in the first place. With few exceptions, each criterion was seen to contribute directly or indirectly to all of the objectives. This is due to the fact that violation of the site stability tends to lead to both consequence events such as migration or intrusion and concomitantly, loss of confidence in predictability.

All of this leads us to conclude, as we have in Part 61, that stability of the disposal facility may be the single most important aspect and is related directly to the achievement of the performance objective.. Stability of the facility is controlled primarily by the stability of the site. Thus, the selection and application of criteria that assure this stability is of the greatest importance.

Therefore, when proper site criteria are joined with requirements on waste characteristics, facility design and operations, and institutional controls, low-level radioactive waste can be effectively removed from the biosphere until it is no longer a health and safety concern.

We believe that the site suitability requirements in the proposed 10 CFR Part 61 are useful in identifying sites and are appropriate in providing for protection of the public health and safety. We believe that the main task facing us at this symposium is the pulling together of the technical communities' views on the requirements and converging on a consensus set of site suitability criteria for the final rule to be published in 1982.

We believe that a consensus of the technical community will greatly facilitate the licensing process in two ways. First, the consensus set of site suitability criteria will assist future applicants in finding suitable sites. Second, our experience indicates that when the technical community agrees on the suitability of a proposed site, the public concerns and potential intervention are moderated and tend to melt away. On the converse, public concern and intervention appear to be fueled by disagreement and controversy within the technical community.

Therefore, our task at this symposium is to work together through constructive comments and discussion to reach a concensus on a comprehensive set of site suitability requirements. These requirements must be technically sound, reasonable, and workable in identifying sites which are suitable for near-surface disposal of low-level radioactive waste.

DISCUSSION OF PAPER BY R.D. SMITH

W. Hipsher: Mr. Smith, when you refer to one of the objectives as being to eliminate the need for constant maintenance at the site, that's a change from 10 CFR Part 61. Did you receive a lot of comments on that area that would indicate that was a stringent requirement? There's going to be maintenance on each site after it's closed.

R.D. Smith: The performance objective, as stated in 10 CFR Part 61, deals with the need for long term active maintenance as compared to normal routine upkeep. Our performance objective is aimed at precluding the need for such things as trench pumping, or constant replacement of trench caps.

We recognize that there will be need for routine upkeep, such as fence mending, vegetative cover maintenance, perhaps minor repairs to drainage features and perhaps repairs to the surface of the trench caps.

W. Hipsher: Maybe it's just an interpretation of what "active maintenance" means, because I was assuming that you're not talking about any earth-work

R.D. Smith: We'd like to say that there should not be any major earth-work involved. But maintenance of surface features, such as drainage ditches, isn't considered to be major maintenance.

W. Staub: I would like to ask a question, or perhaps offer a comment, about the 500 year flood plain.

In the work that I have done I find numerous references to 100 year flood plains that can be identified. I have not seen anywhere where a 500 year flood plain has been identified.

Would you care to comment on that?

R.D. Smith: I think you've given the reason why we have proposed a 100 rather than 500 year flood plain in the regulation. The 100 year flood plain requirement, besides being a common sense requirement, is intended to implement an executive order that would preclude use of flood plains for any activity such as this. We could specify a 500 year flood plain just to make sure, but we haven't found anyone who can tell us with any confidence what a 500 year flood plain is. Historical records don't substantiate such a thing. So we've stuck with the 100 year flood plain and probably will, even in response to the one comment we got.

DOE LOW-LEVEL WASTE
LONG TERM TECHNOLOGY DEVELOPMENT

M.J. Barainca
Low-Level Waste Management Program
U.S. Department of Energy
Idaho Falls, Idaho 83401

ABSTRACT

The objective of the Department of Energy's Low-Level Waste Management Program is to provide a low-level waste management system by 1986. Areas of concentration are defined as: (1) Waste Generation Reduction Technology, (2) Process and Handling Technology, (3) Environmental Technology, (4) Low-Level Waste Disposal Technology. A program overview is provided with specific examples of technical development.

DOE'S LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT TECHNOLOGY/DEVELOPMENT PROGRAM

Introduction

Today I will discuss the Department of Energy's Low-Level Radioactive Waste Management Program's technology development program. I will briefly provide an overview of the technical program and then more fully discuss those programs which are more germane to the subject at hand; site selection. Prior to discussing the Department of Energy's technology development programs, I would like to make a few brief comments on two related topics; the emerging position of the Department of Energy on the Nuclear Regulatory Commission's proposed rule 10 CFR Part 61 and the Department of Energy's approach to developing criteria for the management of the Department's low-level radioactive waste.

The Department of Energy is currently reviewing 10 CFR 61 and its Environmental Impact Statement. It is anticipated that these comments will be formally transmitted to the Nuclear Regulatory Commission in mid January 1982.. Based on information to date, the Department's position on 10 CFR 61 is a generally favorable one. The proposed rule goes a long way in clarifying the requirements necessary to site and license a commercial low-level radioactive waste disposal facility. But the Department also believes that there are several areas where further clarification would be useful. In these areas the Department is reviewing its own capabilities and experience to determine what, if any, assistance the Department may be able to provide to the Commission.

Early Site Selection

Since defense programs and associated facilities generate large volumes of radioactively contaminated solid wastes requiring disposal, the AEC, now the Department of Energy (DOE), recognized the need to develop a local dispos.. ground for these wastes at the laboratories. The United States Geological Survey (USGS) was consulted in the selection of a disposal site on the National Reactor Testing Station (NRTS), now the Idaho National Engineering Laboratory (INEL). The following criteria were used in the selection process.

1) An area of not less than 10 acres
2) Accessibility without extensive road construction
3) An area with not less than 15 and preferably 20 ft. of unconsolidated sedimentary overburden
4) Appreciable amounts of clay in the disposal sediments
5) Overburden sufficiently cohesive to stand a short period in vertical or nearly vertical walls
6) An area not directly up stream of the groundwater flow from existing or potential reactor sites
7) Good surface drainage

A 100-acre area, located in the southwestern corner of the NRTS and characterized by fine-grained sediments deposited by the Big Lost River was proposed as suitable for disposal operations. In May 1952, a 13-acre tract of this area was established as the NRTS Burial Ground for solid waste disposal. At that time, the area was also being considered as a disposal site for solid waste generated at nuclear facilities in other parts of the country.

During 1952, the USGS performed a more intensive investigation of the geology and hydrology of the larger 100-acre area. A USGS report, published in 1953, stated that the area was generally favorable for the disposal of limited quantities of short-lived radioactive waste material and that its sediments would have greater ion-exchange capacity than sediments nearer to the Big Lost River. The report stated that the surficial sediment was more than 9 ft. thick over much of the site.

The report also indicated a potential concern relative to the aquifer under the NRTS by pointing out that water in contact with contaminated material might carry contaminants downward to the water table. Contamination was thought unlikely, however, since percolating water would be subject to ion-exchange processes and local precipitation would contribute little recharge water. While not all the initial site criteria, such as sediment thickness, were fully satisfied when AEC approved the site location, 28 years of operating experience at INEL and other DOE burial grounds has demonstrated that low-level waste can be safely disposed of by shallow land burial.

Program Overview

A brief description of the Low-Level Waste Management Program's present approach to the development of criteria for the management of low-level waste at Department facilities is now warranted. The criteria development program, like draft 10 CFR 61, uses performance objectives versus prescriptive standards. Performance objectives are being used to develop criteria for application to shallow land burial operations and for application to operations which will provide waste confinement greater than that provided by shallow land burial. Technology development work in the greater confinement area is in a very early stage. A systems approach examining waste form, packaging, and disposal method is presently being used. The criteria developed for both shallow land burial and greater confinement similarly cover all elements in the disposal system. That is, criteria are being developed for site selection, design, operation and closure/post closure and for waste form, handling, packaging, and testing. It is the Low-Level Waste Management Program's intention that once finalized, these criteria will be applied uniformly throughout the Department of Energy's low-level waste disposal facilities.

The Low-Level Radioactive Waste Management Program's technology development efforts are concentrated in four areas; Waste Reduction Technology, Process and Handling Technology, Environmental Technology, and Low-Level Waste Disposal Technology. I will discuss in detail, work being conducted in the latter two areas; Environmental Technology and Low-Level Waste Disposal Technology as work in these areas has the most bearing upon site selection. However, I would like to briefly touch upon activities being undertaken in the Waste Reduction, Process and Handling Technology areas.

Technical Program

The goal of Waste Reduction Technology efforts is to document, and where necessary, improve technology and procedures which reduce the amount of waste generated. (Technologies and procedures used by government and commercial facilities are being examined.) The Electric Power Research Institute is planning a similar effort directed solely for application to commercial power reactors. The State of Maryland is developing waste management procedures for institutions generating biomedical low-level radioactive waste. These biomedical procedures are intended to reduce the amount of waste which must be handled and disposed of as low-level radioactive wastes. As a first step, a waste generation reduction manual is being compiled. The manual will be an up-to-date compilation of available technologies, along with a cost/benefit assessment of the various processing or procedural options.

Specific work in the area of Process and Handling Technology covers a wide range of technologies. The work is not only to examine and research waste treatment technologies, but to also demonstrate some of these on a prototype scale. Technologies subject to examination, improvement, and demonstration include:

- o Incineration of institutional-type waste
- o Use of a glass furnace for treatment of power reactor wastes
- o Ultrafiltration and reverse osmosis for processing large volumes of contaminated fluid
- o Use of smelter technology to reduce the volume of contaminated scrap metals
- o Use of microwave plasma incineration for radioactive organic liquids

We are planning to document the results of DOE demonstrating more cost effective technologies for the treatment of reactor wastes and to also demonstrate the use of on-site incineration of DOE wastes. Work in the area of waste form development and testing is also being conducted. This work is being coordinated with similar work being done by the Nuclear Regulatory Commission. Technologies to treat radioactive wastes containing elemental sodium thereby making such waste acceptable for shallow land burial are also being examined. And, finally, a cooperative information exchange program with the Federal Republic of Germany is being considered covering these and other areas of waste treatment technology.

I would like to now discuss technology development which will more directly impact future site selection: Environmental Technology and Low-Level Waste Disposal Technology. Rather than discuss all the work in these areas, only the most significant will be described. Generally, the work to be described is in one of three areas: modeling, data collection, or environmental transport processes.

Site performance modeling is one of the keys to the licensing of commercial low-level waste disposal sites. The approval or denial of any license application will rest upon an applicant's ability to predict the site's long-term performance.

There are over 400 radionuclide transport models. Few have been validated. The Low-Level Radioactive Waste Management Program's modeling efforts are directed toward establishing uniform model evaluation and documentation guidelines. The guidelines will detail the information that is necessary to analyze the abilities and limitations of models describing environmental transport of radionuclides. The accuracy and correctness of a model can be partially tested by making comparisons of specific analytical solutions to fundamental equations. The validity of a model's physical assumptions can be tested by making comparisons with experimenta data. Analytical solutions of model equations and experimental data set will be compiled to provide a systematic procedure for evaluating a model. Use of such a procedure will allow comparison of the abilities and limitations of different models. Both generic and more site specific models can therefore be more easily identified for use in a DOE selection model. The validity of such models may still be questioned. This is partially due to incomplete documentation of the model's development. Establishment of uniform documentation guidelines and model validation should help resolve this.

Regardless of which models are identified as having the greatest potential for use in site selection, models' precision can be improved by a better understanding of information requirements. Information is required to support not only model variables, but also model assumptions. Figure 1 is an example of some of the ground zero level information required to judge site suitability. Figure 2, a list of the input parameters required for the model, is a subset of this listing. Work is underway to better understand the processes that models approximate. Work to improve technology for data collection is being conducted. Seven specific technology projects in these areas are:

FIGURE 1. TECHNICAL INFORMATION TO SUPPORT SELECTION OF SHALLOW LAND BURIAL SITES

LOCATION	LAND USE
SIZE	NATURAL RESOURCES
TRENCH DESIGN	DISTANCE TO SURFACE WATER
WASTE VOLUME PROJECTIONS	VEGETATIVE COVER
LEACHATE CHARACTERISTICS	TOPOGRAPHIC DATA
WATER TABLE	POPULATION DISTRIBUTION
CAPILLARY FRINGE LOCATION	GROUNDWATER CHEMISTRY
THICKNESS OF EXCAVATABLE MATERIAL	TECTONICS
GEOLOGY OF BEDROCK	SOIL MECHANICS
HYDRAULIC CONDUCTIVITY	FLOODING HAZARDS
STRATIGRAPHY	METEOROLOGY
HYDROLOGIC BUDGET	TRANSPORTATION
FLOW NETWORKS	WASTE FORM CHARACTERISTICS
DIFFUSION PROPERTIES	
SOIL PROPERTIES	

FIGURE 2. INPUT PARAMETERS TO MODELS FOR SHALLOW LAND BURIAL

NUCLIDE QUANTITY	EQUIVALENT VEGETATIVE COVER
DURATION OF WET PERIOD	GEOMETRY OF TRENCH CAP
RAINFALL	SOIL SURFACE RIDGE HEIGHT
EVAPOTRANSPIRATION	SOIL SURFACE RIDGE SPACING
WATER TURNOVER	SOIL SURFACE ROUGHNESS
WIND DATA	AGGREGATE INFORMATION
TEMPERATURES	SOIL IN SUSPENSION
LENGTH OF AQUIFER	POPULATION DISTANCE ARRAY
VELOCITY OF AQUIFER	EFFECTIVE STACK HEIGHT
DISPERSION COEFFICIENT	HEAT RELEASE
EQUILIBRIUM CONSTANTS	CROP PRODUCTION
NUMBER OF LAYERS IN SOIL COLUMN	FRACTION OF LAND WITH CROPS
GEOMETRY OF SOIL LAYERS	NUMBER OF HARVESTS
STABILITY OF NUCLIDES	ANIMAL DENSITY INFORMATION

1) Well-logging instrumentation

2) Borehole geophysics

3) Barrier testing

4) Ground and surface water management systems

5) Release/transport arid

6) Humid site migration

7) Site selection criteria evaluation

I will now briefly describe each of these efforts.

A well-logging instrumentation project is being planned by Pacific Northwest Laboratory. The project is to develop appropriate equipment capable of determining strontium-90, tritium and transuranics at sensitivity levels which will provide useful information for the proper operation of shallow land burial sites. Technologies involving solid state gamma-ray spectroscopy, neutron activation, beta particle spectroscopy, ..s spectroscopy, mass spectrometry, laser excitation, active and passive neutron detection, and X-ray fluorescence spectroscopy will be examined. Methods and equipment for cased and uncased wells will be examined but cased wells will be emphasized. The goal of this work is to be better able to determine if radionuclide migration is occurring, and if so, its nature and degree.

The Denver office of the USGS is conducting a borehole geophysics project. The project's goal is development of <u>in situ</u> measuring techniques which provide data that can be interpreted in terms of lithology, elastic modulus, bulk density, porosity, moisture content, water quality, and the location and orientation of fractures. Borehole geophysics provides the most economical techniques for obtaining these data on a broad scale. Specific items being accomplished are: development of quantitative analysis techniques for borehole spectra, development of nuclear magnetic resonance techniques for the relative measure of permeability, improvement in field reliability of neutron generators in logging probes, development of advanced phase acoustic fracture logging probes, and improvement of interpretation of well log data for input to site selection and predictive models.

The Los Alamos National Laboratory is involved in barrier testing. Testing of both biointrusion and migration barriers is being conducted. The goal of this work is to provide data to better design a disposal facility so as to prevent intrusion of plants and animals into the waste and minimize radionuclide migration through the water pathway. Field experiments to quantify biointrusion barrier performance are being conducted. Accurate definition of the migration potential of radionuclides through such barriers as clay, sand-clay, and clay-tuff will be measured. Determination will be made by measurement of the hydraulic conductivity in situ using the instantaneous profile method. The movement of both water and tracers will be measured. The variables to be tested include barrier geometry, effects of organics on the barrier materials, and the effects of mechanical stress on barrier performance. Proven biointrusion and migration barriers will then be designed for emplacement at shallow land burial facilities.

Tests of the wick system for directing water away from burial wastes are the emphasis of the ground and surface water management system tests. These tests are also being conducted by Los Alamos National Laboratory. In a wick system, a layer of finer-grained material is placed over a layer of coarser grained material. The difference in the matric potential of the two layers holds the water in the finer-grained layer. Water is then diverted by the controlled design of the wick system. Site designs employing such a wick system may be of a high potential for low-level waste disposal sites.

Pacific Northwest Laboratory is conducting studies to characaterize radionuclide transport at arid sites. The release/transport-arid project is designed to evaluate arid zone water balance with the precision necessary to quantify transport rates under nonisothermal dynamic conditions. The mass and energy balance of arid region radioactive waste disposal sites are being assessed and specific rates of radionuclide/water transport in the partially saturated ground zone are being determinend. Laboratory analysis of hydraulic transport parameters and field tracer studies are being conducted. By making laboratory measurements and comparing them to field measurements, the applicability of laboratory characterizations will be more clear. The results of this work will determine what, if any, further work is required for the study of bare soil evaporation. A conclusive resolution to the processes involved will open the way to study evaporation from vegetated surfaces. The influence of vegetation on water flow patterns is already under study.

A humid site migration project is being conducted by Oak Ridge National Laboratory to continue to define and refine the understanding of migration pathways of radionuclides at an operating shallow land burial site. Improved information will serve as input for the siting, designing, operation, and closure of a shallow land burial facility in the humid eastern United States. Long-term leaching and migration studies of radionuclides from typical solid wastes will provide a means of assessing the long-term hazard potential of such waste. This will clarify the radionuclide input rate to the surrounding soil and therefore better bound the potential for in-soil migration. Soil/waste chemical studies are also being conducted. The effects of physical and chemical soil properties, aerobic and anaerobic conditions and microbiological actions on the migration of radionuclides will be assessed. Engineering studies to control surface and ground water are being conducted. The effects of perched water tables, trench subsidence and trench cover are being examined.

The final area of technology development related to site selection is the site selection criteria evaluation project. Oak Ridge National Laboratory has recently completed a preliminary site selection study for a future shallow land burial facility. The selection was conducted without the benefit of the Department's site selection criteria which were at the time under development. The work involved in this project is to evaluate the criteria for key site specific data needs, review these needs for their adequacy in characterizing sites, and to review these needs relative to the technology required to acquire the data. A second task which is being considered is to use the site selection criteria to locate the most favorable sites on the Oak Ridge Reservation for a future disposal site. Results of this search will be compared with the one conducted without use of the selection criteria.

Summary

To summarize, the Department of Energy has several projects which will directly benefit the use of site selection criteria. Efforts in the area of modeling will increase the credibility of site selection models. A better understanding of relative strength, weaknesses, and adaptability of each model will also be achieved. Improved data collection and measurement techniques are being developed. Improved instrumentation goes hand-in-hand with a better understanding of the interrelationships and effects of actual field conditions. Research is underway to clarify these interrelationships and quantify the effects of various environmental processes. The goal being to better understand each process, and then determine what is needed, and in what degree of detail and precision the data is wanted.

DISCUSSION

F. Killar: Do you have a schedule for completion of these various projects?

M. Barainca: Yes, we do have time tables. I don't have a detailed schedule, in the form of vu-graphs, with me. However, I think I can describe the general program very simply by saying that our major thrusts are to document the existing technology in a series of manuals. The first of these series of manuals should be available in September 1983.

It is then the intent to document the studies of improved technologies which we are conducting in a second version of that manual. These technologies should all be documented by September 1984.

C. Jupiter: I noticed that in your modeling program you used about 30 or so parameters. Is there an expectation that you may be able to reduce those to a smaller number that one can work with, those which are dominant? What's the status now of this type review of the usefulness of the parameters?

M. Barainca: I haven't personally evaluated each of the models to see if the list of parameters can be reduced. I think the list of input parameters which I identified in Figure 1 is consistent with the data which is being used for input to the DOE model that is documented in the appendices of the EIS supporting 10 CFR 61.

An analysis of existing models has been compiled and is documented in the results of the Interagency Workshop which was convened in Denver in December 1980. I believe the report was issued in September and is available through R.S. Lowrie, ORNL, me at the Idaho Operations Office, or for purchase from TIC.

I think there were about five or six copies that were sent to various members of the Nuclear Regulatory Commission, and Dale Smith should have copies of those.

R. Wood: Your presentation indicated substantial analytical sophistication in this area. I wonder if you're at all concerned about developing a situation of analytical overkill in which the analytical capabilities spawn more uncertainties which spawn more need for analytical capabilities to nail down predictions to the last decimal place and an ultimate inability to come up with anything that we can stand on to document compliance with 10 CFR Part 61?

M. Barainca: I don't think I'm particularly concerned with analytical overkill at the present time. I think I am more concerned with the ability of the geotechnical community to document the results of the data that they need and that they obtain the needed data in a manner which meets quality assurance requirements.

I have identified the data requirements by name, and I think that you could obtain data under each of these different categories by various methods. Some methods would be more cost effective for site screening and others more cost effective for site qualification.

One of the goals of one of the manuals, the one being prepared by Argonne Laboratory, is to evaluate some of the techniques for obtaining this information and to give the commercial sector DOE's view of what the costs will be for obtaining these types of information and how it will be used by some of the models.

R. Wood: For the record, I would just like to say I'm somewhat dismayed by this two stage manual process, and particularly by the schedule involved, with target dates of 1983 and 1984. For those of us who are facing the inability to dispose of wastes by January 1, 1986, unless new sites are established, it doesn't add up to a viable schedule for getting sites in place.

M. Barainca: Your concern is also the concern that has been expressed by several utilities and a few of the state organizations. Until six months ago the thrust of the program was to have these documents available in the 1984-85 time frame. And we've tried to schedule these documents for an earlier time frame.

When drafts of these documents are in an appropriate form it's our intention to share them with state officials. I've been to several state meetings and any time any of the states or any of the people ask us for information we try to be responsive.

L. Skoblar: Some of this program sounds like it could cost a lot of money, and I was curious to know whether there will be an attempt to put the thousand-dollar-a-man-rem tag on some of the work that's going to be done, or is this a blank check kind of a thing?

M. Barainca: I'm afraid I really don't understand the thrust of your question. The NRC in the EIS has indicated that the cost of site qualification is in the range of $600,000. Our preliminary evaluation is that the costs may be a little more, but within that order of magnitude.

L. Skoblar: There's a general number, about $1000 per man-rem, used in power plant licensing for normal operation, and it seems appropriate to spend money if there is a big risk involved.

In the case of burial of low-level waste, there doesn't seem to be that great a risk, and I'm wondering how spending money on all these kinds of analyses can be justified on a cost-benefit basis.

M. Barainca: We've reviewed all of our programs at the DOE sites and each one of us is very concerned that our programs be cost effective. I have recently gone through an exercise in evaluating all of the programs and I think that there are going to be reductions in some of our programs.

We have two parts in the DOE program. One is the defense program and one is commercial. I think that those of us who have been working on the defense programs have always felt that we would like to try to improve the technology so that we're not passing down burdens to future generations.

EPA VIEWS ON SELECTION OF SITES FOR LAND DISPOSAL OF LOW-LEVEL WASTE

G. Lewis Meyer

Criteria and Standards Division
Office of Radiation Programs
U. S. Environmental Protection Agency
Washington, D. C. 20460

The Environmental Protection Agency (EPA) published a report containing site selection criteria for low-level waste (LLW) disposal sites in 1974. Many of these criteria have been included in site selection criteria of the U. S. Geological Survey, the U. S. Nuclear Regulatory Commission and the International Atomic Energy Agency. Additional criteria have evolved as more has been learned about the hydrogeological, climatic, ecological, human and political processes which affect LLW management and disposal. This paper presents: (a) a brief historical perspective of the development of site selection criteria for LLW disposal sites; (b) a review of EPA documents which relate to or may affect site selection criteria; (c) a comparison of the site selection criteria in the EPA report with site selection criteria developed by others; (d) some practical aspects of applying site selection criteria; and (e) several unanswered questions about site selection.

INTRODUCTION

The Environmental Protection Agency (EPA) has been interested in criteria for the selection of low-level radioactive waste (LLW) disposal sites since the beginning of its LLW program in 1972 (1). Choosing a site with good natural hydrogeological conditions for containing LLW was considered an important first and basic step in environmental protection for LLW disposal.

A review of the physical characteristics of the six commercial LLW disposal sites operating in the United States in 1972 showed a wide range of geologic, hydrologic and climatic conditions. A review of the history and bases of how each site was chosen by State and Federal authorities showed no consistent set of criteria or guides for their selection. In each case, site evaluation studies were conducted before a site was established and such studies became more detailed with time. However, clear minimum criteria for choosing the sites were lacking. The most prominent connecting links seemed to be the availability of land on or near a nuclear facility and government ownership of the land. The site at Maxey Flats, Kentucky, was an exception because it was not near a nuclear facility.

Federal and State regulations were also reviewed for site selection criteria. In 1972, U.S. Atomic Energy Commission (AEC) regulations for obtaining a license to operate a LLW disposal site were terse, consisting of two short paragraphs (2). A license applicant was required to: (1) furnish an analysis and evaluation of pertinent information as to (a) the nature of the environment (geology, hydrology, climate, topography), (b) usage of ground and surface waters in the area, (c) nature and location of other potentially affected facilities, and (2) locate the site on Federal or State land. Other than government ownership, little guidance was given as to what constituted an acceptable site.

Discussion with State authorities who had actually been involved with the siting and licensing of the six commercial LLW sites failed to identify consistent site selection critria other than (1) the natural characteristics of the site were to safely contain the radioactive wastes disposed therein and (2) government ownership of the land.

In view of the above, EPA signed an Interagency Agreement with the U.S. Geological Survey (USGS) in 1973 for the USGS to furnish assistance in developing an understanding of the hydrogeological processes important to the ground disposal of LLW and the siting of LLW disposal facilities (3). Under this agreement, the USGS has conducted field studies for us and furnished review and consulting services. The first specific output was the 1974 report, Storage of Low-Level Radioactive Wastes in the Ground: Hydrogeologic and Hydrochemical Factors by Papadopulos and Winograd (4).

BACKGROUND AND HISTORY OF LLW SITE SELECTION CRITERIA

The Papadopulos and Winograd report (4) presents hydrogeologic site selection criteria for both intermediate- and long-term disposal. These continue to furnish the basis for hydrogeologic criteria which EPA would recommend to others for selecting a LLW disposal site. They incorporate hydrogeologic criteria presented by Cherry and others (5) with slight modifications. The report also examined the LLW disposal site at Maxey Flats, Kentucky, as a specific test example for applying the criteria.

The USGS has also used the criteria set forth in the 1974 Papadopulos and Winograd report (4) as the basis for hydrogeologic site selection criteria which they would recommend to others interested in locating a LLW disposal site(6). The USGS realizes that these criteria are not complete and do not address all facits of site selection (7).

The AEC, in commenting on the performance of commercial LLW disposal faclilities in 1974 (8), gave the following additional performance requirement (criterion) which was used for selecting a disposal site:

"...Authorization to operate a commercial land burial facility is based on an analysis of the nature and location of potentially affected facilities: of the site topographical, geographical, meteorological and hydrological characteristics; and of ground water and surface water use in the general area which must demonstrate that buried radioactive waste will not migrate from the site."

In the early 1970s, Western Federal Region IX had large volumes of Federally-owned hazardous and toxic wastes and no Federal disposal facilities. The Federal Task Force for Hazardous Materials Management of the Western Federal Regional Council was established in 1973; its work was completed in 1977. A special subcommittee was established for the specific task of developing criteria for selecting sites for the land disposal of hazardous wastes. Selection criteria and a methodology for selecting suitable sites for processing and packaging hazardous wastes and for disposing of them were developed and published in the Final Report of the Task Force in 1978 (9). Later in this report, some of the practical problems and considerations that were encountered while developing these criteria and methodology are discussed.

In 1976, the International Atomic Energy Agency (IAEA) started a project to prepare a guide for the shallow ground disposal of radioactive wastes. Through the use of international consultants and a special Advisory Group , the IAEA prepared a draft guide during 1977 and 1978. This draft guide was reviewed by the IAEA's Technical Review Committee on Underground Disposal of Radioactive Wastes in late 1978 and was approved for editing in preparation for publication. In 1981, the IAEA published, Recommendations: Shallow Ground Disposal of Radioactive Wastes, A Guidebook (10). This guidebook contains criteria and a methodology for selecting shallow ground disposal sites very similar to those of EPA (4), the USGS (6), and the Western Federal Region IX Task Force (9).

In support of its efforts to develop generally applicable environmental standards for the disposal of all radioactive wastes, EPA began a project in 1977 to develop criteria that, "...establish the basic principles which should be applied in the formation of policies, plans, programs and decisions involving management and disposal of radioactive wastes." In November, 1978, the Agency published, Criteria for Radioactive Wastes, Recommendations for Federal Radiation Guidence (11). Portions of these criteria have direct application to the selection of LLW disposal sites. They underwent extensive governmental, public and Agency review before and after their publication. These "recommended criteria" were officially withdrawn by EPA in 1981 (12). However, they still occupy an important place in our thinking on LLW disposal.

Other listings of criteria for selection of LLW disposal sites have also been developed. Papadopulos and Winograd noted that criteria for the evaluation of the suitability of a site for land disposal operations had been presented in reports by Peckham and Belter in 1962 (13), Richardson in 1962 (14,15), Mawson and Russell in 1971 (16), in addition to those by Cherry and others (5). The Subcommittee on Site Selection of the Region IX Task Force found useful criteria for site selection in the reports by LeGrand in 1964 (17), Swift in 1973 (18), and Williams and Wallace in 1970 (19) and useful ideas for criteria from the general literature on siting and field studies at sanitary landfills for rubbish.

The earliest set of criteria for selecting a LLW disposal site known to me was found accidentally during EPA work at the Beatty, Nevada, disposal site. These criteria were appended to a 1960 AEC press release announcing a new policy for the land disposal of LLW. For convenience, these criteria are labeled "1960 AEC Criteria" (20). They are interesting because they reflect most of the criteria believed to be important today but have several small but important differences.

The most recent set of criteria covered in this review are those presented by the Nuclear Regulatory Commission (NRC) in their proposed Licensing Requirements for Land Disposal of Radioactive Waste (10CFR61) (21).

Table 1 lists in summary the sets of site selection criteria included in this review and comparison and their approximate dates of origin.

One basic assumption I believe EPA will make in developing its LLW standard is that sites with good natural characteristics will be used. Therefore, we have reviewed and compared the criteria available from EPA, NRC, USGS, IAEA, Region IX and even the "1960 AEC Criteria" to determine what constitutes a good site. It was extremely encouraging to find unusually good agreement between the various sets of criteria. More details on this comparison are presented later.

EPA VIEWS ON SITE SELECTION CRITERIA

Although EPA does not expect to have a programatic role in selecting LLW disposal sites, our viewpoint on appropriate site selection criteria will certainly have a strong influence on the environmental standards and guides which we develop. Also, we might aid the States in the endeavor if requested to. I have just presented some of the documents which have been instrumental in formulating our viewpoint in their historical perspective. Now, let us look at the EPA documents which relate to or may affect site selection.

TABLE 1. SITE SELECTION CRITERIA FROM DIFFERENT SOURCES COMPARED IN THIS REVIEW

USAEC	PRE-1960	SITE SELECTION CRITERIA FOR LLW DISPOSAL SITES (ORIGIN UNKNOWN)
USAEC	1972	10CFR20: STANDARDS FOR PROTECTION AGAINST RADIATION (WASTE DISPOSAL)
USEPA	1974	STORAGE OF LOW-LEVEL RADIOACTIVE WASTES IN THE GROUND: HYDROGEOLOGICAL AND HYDROCHEMICAL FACTORS
USGS	1974	SAME AS EPA 1974
USEPA	1978	CRITERIA FOR RADIOACTIVE WASTES, RECOMMENDATIONS FOR FEDERAL GUIDANCE
FEDERAL REGION IX	1978	FINAL REPORT OF THE WESTERN FEDERAL REGIONAL COUNCIL TASK FORCE ON HAZARDOUS WASTE MANAGEMENT
IAEA	1981	RECOMMENDATIONS: SHALLOW GROUND DISPOSAL OF RADIOACTIVE WASTES, A GUIDEBOOK
USNRC	1981	10CFR61: LICENSING REQUIREMENTS FOR LAND DISPOSAL OF RADIOACTIVE WASTE

EPA Site Selection Criteria

The site selection criteria we published in 1974 (4) have undergone extensive national and international review. They have been used by the the USGS (which developed them for EPA) (6) and have been used in part or whole by the IAEA (10) and a Federal Regional Interagency Task Force on Hazardous Materials Management (9).

Criteria for Intermediate-Term Burial Sites

(1) Land surface should be devoid of surface water and not located in flood plains, swamps, bogs, or other very wet terrane.

(2) Burial zone should be separated from fractured bedrock by an interval of geologic deposits sufficient to prevent migration of radionuclides into the fractured zone.

• Direction and rate of ground-water flow as well as the retardation effects of the hydrogeologic system of the site should be known or predictable.

(3) Predicted rate of radionuclide transport in shallow deposits at site should be slow enough to provide 10s of years of delay before contaminints would reach public waterways or other areas considered hazardous in the biosphere; possibility of applying remedial measures is desirable.

(4) Site should have sufficient depth to water to permit all burial operations above water table, or the site should be suitable for adequately modifying water-table depth by flow system manipulation.

(5) Site should be well suited for monitoring and for containment by flow-system manipulation.

Criteria for Long-Term Burial Sites

(1) Land should be generally devoid of surface water and relatively stable geomorphically (erosion and weathering should not significantly affect the land surface for hundreds of years.)

(2) Subsurface flow patterns in area must be known and flow lines from the burial zone should not lead to undesirable areas such as fractured bedrock, waterways used by man, water supplies.

(3) Predicted residence time of radionulcides must remain within an acceptable part of subsurface flow system for hundreds of years. Hydrogeologic conditions must be simple enough to make reliable residence-time predictions.

(4) Natural water table should be below burial zone several meters; large fluctuations of water table should be unlikely.

• Site should have a buffer zone 20-50% greater than calculated length of ground-water flow path needed to permit critical radionuclides to decay to safe levels.

The information available on the natural processes affecting waste disposal and the performance of disposal sites under actual conditions has literally expanded more than 1,000 percent since EPA's criteria were developed. In light of this, some updating and modification of the existing criteria may be useful. On the whole, however, the present criteria cover the most important hydrogeological factors which should be considered when selecting a LLW disposal site.

EPA Radioactive Waste Criteria

In 1978, EPA recommended six environmental protection criteria which should be applied in the formulation of policies, plans, programs and decisions involving the management and disposal of radioactve waste (11). They establish ground rules for developing generally applicable environmental standards for radioactive wastes sources. These criteria:

• Define radioactive wastes;

• State the goals of radioactive waste management and define limitations on institutional and other controls over certain time periods;

• Identify the factors which should be considered in assessing the risk to the general public and general environment from a radioactive waste disposal site.

• Present factors which would result in unacceptable risk for any method of disposal;

• Require that the selection, design and operation of a disposal site must enhance isolation of wastes; and

• Recommend retrievability of waste, if possible, and communication of waste disposal locations to future generations.

Criteria 2, 3, and 5 directly relate to the selection and adequacy of LLW disposal sites.

Criterion 2: (1) A site, and any engineering or waste barriers to augment its retention, should provide complete isolation over the hazardous lifetime of the waste* and (2) institutional and

*Many of the public review comments received on this criterion indicated that it was (1) ambiguous or (2) implied that a site should have "zero" release. This brief review cannot go into an interpretation of this particular criterion.

engineering controls which require maintenance by man should not be relied on to provide isolation for longer than 100 years.

Criterion 3: Radiation protection requirements for radioactive wastes should be based on an assessment of risk to individuals and populations. This should include:

1. Amount and location of radioactive waste in a location, including physical, chemical and radiological properties.

2. Projected effectiveness of alternative control methods.

3. Potential adverse health effects to individuals and populations for 1000 years (or shorter period if persistance of hazard is less).

4. Estimates of environmental effects or health effects for as long as wastes pose a hazard.

5. Probabilities of releases to general environment due to failure of natural or engineered barriers, loss of institutional controls, or intrusion.

6. Uncertainties in risk assessments and models used in determining them.

Criterion 5: Locations for radioactive waste disposal should be chosen (1) to avoid adverse environmental and human impacts and, wherever possible, (2) to enhance isolation over time.

In summary, the radioactive waste criteria are very specific about: (1) the purpose of a disposal site is isolation of the waste over its hazardous lifetime; (2) not relying on institutional and other man-dependent controls for more than 100 years; and (3) the types and depth of risk analyses which must be made before finally establishing a disposal site. Although these "Recommended criteria" were officially withdrawn by EPA in 1981 (12), they still continue to influence our thinking on radioactive waste disposal.

Region IX Site Selection Criteria

The Region IX site selection criteria (9) were specifically developed for selecting a disposal site in an arid climate. They are, however, a logical extension of the EPA 1974 criteria which have been modified based on recent experience, new data and a different climate. In addition, it was found necessary to add criteria for ecology/biology, land use and status, and socio-economics.

Other Factors Affecting EPA Stand on Site Selection

Other factors which may affect our stand on the selection of LLW disposal sites include "Super Fund" authority (22), ground-water protection under the Drinking Water Act (23,24), the Resources Conservation and Recovery Act (25), and the High Level Waste Standard and Guidance (26). The ramifications and potential impacts of these authorities are beyond the scope of this paper.

In summary, the Agency has been particularly clear in the area of site selection. It published criteria in 1974 (4) and has participated nationally and internationally in the development of criteria (9,10). It has published papers and reports on site characteristics and performance including what constitutes bad performance, and has stressed the need to analyze the total impact of a disposal site including its hydrogeoelogy and climate, the wastes, and the emplacement engineering and all of their interactions (27, 28, 29, 30, 31).

LESSONS LEARNED FROM SELECTING SITES IN FEDERAL REGION IX

The experience of Western Federal Region IX in developing a hazardous waste management program has some useful lessons for those selecting future LLW disposal sites. Site selection was taken from the level of abstract criteria to the practical working level of specific regional needs. I would like to share some of the lessons learned from a personal perspective.

Federal Region IX takes in Arizona, California and Nevada. It contains vast areas of relatively uninhabited Federally-owned land. A primary reason for the low population density is that large areas are either mountainous or are deserts or semi-arid and do not have sufficient natural water supplies locally to support large populations without elaborate water importation schemes. Region IX also had large volumes of Federally-owned hazardous and toxic wastes to treat and dispose of but no facilities for doing so.

The Western Federal Regional Council, which includes more than 50 agencies and separate organizations, established the Federal Task Force for Hazardous Waste Management. EPA's Region IX Office acted as the Chair and Secretariat for the Task Force. The Task Force took an overall management approach of (1) determining the kinds and amounts of wastes requiring disposal, (2) trying to find a use for each waste, if possible, and (3) treating and disposing of the residual wastes. (There is much truth in the saying, "One man's trash is another man's treasure because there was some success in finding potential users for some classes of waste. For example, slightly contaminated solvents from electronics clean-up were quite useable for some other industrial applications.)

A Subcommittee on Site Selection was formed to develop criteria for selecting disposal sites and waste treatment and processing facilities. The ten members of this subcommittee came from six agencies and separate offices and represented nine technical and professional areas. The multidisciplinary and interagency mix was very fortunate and, we found, necessary. The members were all technically oriented and represented both the land "owners" and the "evaluators" and "protectors" of the land. It was one of the best-working, smoothest-running groups I have worked with. Since all of the concerned agencies were involved(land-owners, evaluators, environmental protection, etc.), interagency questions did not arise in a harmful way but from a point of clarification and resolution.

Important points we learned while developing the criteria included:

• Hydrogeologic criteria, alone, were not sufficient guidance for selecting a disposal site. Additional criteria were needed for the areas of ecology and biology and for the more secular areas of land use and status, sociology and economics. (For example, if you can't aquire the land because of an existing mineral claim, if snail darters or pup fish abound on it, i.e., endangered species, or if pocket gophers are present to "ravage" the trench covers, a site with outstanding hydrogeologic characteristics may not be useful.)

• It soon became apparent that site selection criteria, alone, would not provide all the help the Task Force(or other regional group) needed to bring a disposal site on line. The Task Force had no central authority. It had no dedicated permanent technical staff which it could direct towards organizing a program to select and acquire land for a site. Therefore, with the Task Force's approval, the Subcommittee expanded its scope of work to include developing a methodology for selecting a site which included (1) recommendations for organization of the site selection team, (2) use of a phased site selection scheme, (3) guidance on conducting the site evaluation, (4) identification of important factors which should be evaluated during the screening and selection of a site, and (5) guidance on the range of desirable and undesirable values for each factor.

• Either State or Federally-owned land should be used.

• A disposal site should be treated as a system which included (1) site characteristics, (2) waste characteristics, (3) site engineering and (4) pathways for the movement of contaminants.

• It was clearly brought home that few sites are perfect but that some weaknesses can (and should) be compensated for by site engineering and waste modification to ensure that the site would safely contain the wastes.

•. The approach to selecting the site consisted of three phases - area survey, preliminary site selection and site confirmation. Once set in motion, the screening and selection process would be a continuous, iterative, evaluational process which rejected unsuitable sites and carried forward for additional investigation those sites that were apparently suitable.

• After a site had been analyzed and selected, and the operational phase had begun, it was important that site evaluation studies continue to determine whether the original analyses were correct and whether interactions between the natural characteristics of the proposed site and man-made alterations due to trenching and emplacement of waste have caused unexpected and undesirable changes in site performance.

COMPARISON OF AVAILABLE SITE SELECTION CRITERIA

Seven years have passed since EPA published its criteria for selecting LLW disposal sites. The interest of the public the States and regional, Federal and scientific organizations and groups in LLW disposal has expanded almost exponentially since 1974. For example, annual expenditures on research and development and field studies of all types related to waste disposal have expanded by 2,000 to 5,000 percent. The availability of data has expanded at a like rate. Additional work on site selection has been done at regional, national and international levels. Public atttitudes have changed from an almost total lack of awareness to acute sensitivity.

How have these profound changes affected the validity of EPA's 1974 criteria? Are the criteria complete? Do they need revision or updating? To answer the above questions, we have compared the 1974 criteria with other known sets of criteria, including the criteria NRC recently published in proposed 10CFR61 (21). An analysis of how these criteria compare follows.

A matrix-type chart (Figure 1) has been prepared comparing the various criteria from different sources. Each distinct criterion or factor which should be taken into account when selecting a potential site is listed down the side of the chart. Across the chart, one column identifies the origin of the criterion (according to the order in which the set of criteria is listed in the table, not when it was first noted in the literature); then, it is indicated whether each set of criteria (1) includes or uses the particular criterion (yes or implied positively), (2) was silent on the criterion or (3) disagreed with the criterion.

In listing each criterion, it was necessary to shorten or paraphrase their wording to bring the comparison chart down to a manageable size. In some cases, inclusion of one criteria in a set was strongly implied by other criteria or guidance in the document (i.e., if to comply with A, you first had to do or learn B, I considered that B was implied.) In such cases, credit was given and listed as "implied."

There were some factors and elements which are not, by strict definition, measurable or definable criteria. Yet one would be imprudent not to consider these factors or elements when selecting a site. Many of this type factor have a range of values which make the site more -- or less -- desirable. Many of these factors are people-related, dealing with land status and use, social and economic issues. They are included because they are useful, even necessary points to consider when selecting a site, even if one were surveying the moon for a site.

Areas of General Agreement in Criteria

The degree of agreement between the seven sets of criteria from different sources is, in my opinion, unusually good. Out of 53 separate criteria identified in this comparison, there was general agreement on all but four criteria, except where the criteria had not been considered. Important observations which can be made from comparing the criteria in Figure 1 follow:

- There is a very strong agreement on almost all points between the various Federal, regional and international sets of criteria.

- EPA's site selection criteria are in close agreement with other sets of criteria developed by Federal, regional, and international organizations.

- Site selection criteria should be expanded to include ecological/biological, land use/status, and socio/economic factors and elements, in addition to hydrogeological factors.

- There is a very strong correlation between the site selection methodologies used by Western Region IX, IAEA and NRC's 10CFR61.

FIGURE 1. COMPARISON OF LLW SITE SELECTION CRITERIA FROM DIFFERENT SOURCES, 1960 - 1981.

			IS CRITERION OR FACTOR IN CRITERIA SET						
NO.	CRITERION	ORIGIN	EPA SSC 1974	NRC P.61 1981	USGS 1974	IAEA 1981	EPA RWC 1978	FED REG9 1978	AEC 1960
1.	NATURAL CHARACTERISTICS OF SITE SHOULD PREVENT MOVEMENT OF CONTAMINANTS TO PLACES WHICH ADVERSELY AFFECT MAN.	EPA SSC	●	●	●	●	●	●	●
2.	SITE SHOULD HAVE SIMPLE HYDROGEOLOGIC SETTING & SYSTEM.	"	●	●	●	●	—	●	—
3.	SITE SHOULD BE DEVOID OF SURFACE WATERS & FLOOD PLAINS.	"	●	●	●	●	—	●	●
4.	BURIAL ZONE SHOULD NOT BE IN FRACTURED ROCK & SHOULD BE SEPARATED FROM FRACTURED BEDROCK (IMPLIES INTERGRANULAR PERMEABILITY).	"	●	⊙	●	●	—	●	△
5.	MOVEMENT OF CONTAMINANT IN SHALLOW ZONE SHOULD BE SLOW (DECADES OF DELAY).	"	●	⊙	●	●	—	⊙	●
6.	DISPOSAL ZONE SHOULD BE SEVERAL METERS ABOVE WATER TABLE.	"	⊙	⊙	⊙	⊙	—	⊙	⊙
	OR								
7.	DISPOSAL ZONE MAY BE BELOW WATER TABLE IF HYDROGEOLOGIC CONDITIONS ARE FAVORABLE.	"	●	●	●	●	—	△(1)	●
8.	HYDROGEOLOGIC SYSTEM SHOULD BE PREDICTABLE (ABLE TO MODEL).	"	●	●	●	●	●	●	—
9.	SITE CAN BE MONITORED.	"	●	●	●	●	⊙	●	—
10.	STABLE GEOMORPHOLOGY AND LOW EROSION RATES AND POTENTIAL.	"	●	●	●	●	—	●	●
11.	SUBSURFACE FLOW SYSTEM MUST BE KNOWN (3-DIMENSIONAL HEAD DISTRIBUTION, ETC.).	"	●	⊙	●	●	⊙	●	—
12.	SUBSURFACE GROUND-WATER FLOW NOT TO UNDESIRABLE AREAS (PUBLIC WATER SUPPLIES, FRACTURED ROCK).	"	●	●	●	●	●	●	●
13.	CONTAMINANTS SHOULD BE RETAINED WITHIN SITE 100s OF YEARS.	"	●	●	●	●	—	●	—
14.	LARGE FLUCTUATIONS IN WATER TABLE UNLIKELY.	"	●	●	●	●	—	△(1)	—
15.	FLOW PATTERNS OF REGIONAL HYDROGEOLOGIC SYSTEM SHOULD BE KNOWN OR DETERMINED.	"	●	●	●	●	⊙	●	—
16.	PREDICTIONS OF SYSTEM PERFORMANCE SHOULD INCLUDE MATHEMATICAL SIMULATION MODELING.	"	●	●	●	●	●	●	—
17.	POSSIBILITY OF TAKING REMEDIAL/MITIGATING ACTION DESIRABLE.	"	●	⊙	●	●	—	●	—
18.	CONTACT BETWEEN WASTE AND WATER SHOULD BE MINIMIZED.	"	●	●	●	●	—	●	—
19.	BUFFER ZONE SHOULD BE 20-50% GREATER THAN EXPECTED MOVEMENT OF CONTAMINANT (FOR SAFETY AND SITE EXPANSION).	"	●	△	●	●	—	●	●
20.	SITE SHOULD NOT BE IN 100-YEAR FLOOD PLAIN & NOT SUBJECT TO FLOODING.	NRC P61	⊙	●	⊙	●	—	●	—
21.	GROUND-WATER DISCHARGING TO SURFACE OF SITE MUST NOT ORIGINATE FROM DISPOSAL FORMATION	"	—	●	—	—	—	—	—
22.	AREAS WITH DISTRUCTIVE TECTONIC PROCESSES SHOULD BE AVOIDED.	"	⊙	●	⊙	●	—	●	—
23.	RETENTION CAPACITY OF SITE FOR SPECIFIC RADIONUCLIDES SHOULD BE DETERMINED.	IAEA 1981	⊙	⊙	⊙	●	—	⊙	—
24.	SELECTION OF SITE IS SUBJECT TO ACCEPTANCE THROUGH PROCESS THAT REVIEWS POTENTIAL ENVIRONMENTAL IMPACT.	"	●	●	●	●	●	●	—(2)
25.	USE OF ENGINEERING AND WASTE BARRIERS TO COMPENSATE FOR LACK OF SOME NATURAL SITE BARRIERS CAN BE CONSIDERED.	"	●	●	●	●	●	●	●
26.	NO RELIANCE ON ENGINEERING/INSTITUTIONAL CONTROLS REQUIRING MAINTENANCE BY MAN FOR MORE THAN 100 YEARS.	RWC EPA	—	●	—	—	●	—	—

LEGEND

- ● YES, INCLUDED
- ⊙ YES, IMPLIED
- — SILENT ON MATTER
- △ AREA OF SIGNIFICANT CHANGE OR POTENTIAL DISAGREEMENT

27. HYDROGEOLOGIC CONDITIONS SHOULD ENHANCE ISOLATION OF WASTES OVER TIME.	EPA RWC	—	—	—	—	●	—	—
28. HYDROGEOLOGIC, ECOLOGIC, LAND-USE AND SOCIO-ECONOMIC ELEMENTS OF SITE SHOULD BE DESCRIBED.	REG9 1978	⊙	⊙	⊙	●	⊙	●	—
29. NO WATER-USE POINTS SHOULD BE CLOSE BY.	AEC 1960	⊙	⊙	⊙	⊙	—	⊙	●
30. PREDOMINANTLY SHALEY BEDROCK IS DESIRABLE, "THE THICKER, THE BETTER."	"	△	△	△	△	—	△	●
31. CLAY OR CLAY-RICH OVERBURDEN AT LEAST 20 FEET THICK DESIRABLE.	"	△(3)	△(3)	△(3)	△(3)	—	△(3)	●
32. GROUNDWATER AT SITE SHOULD BE HYDRAULICALLY ISOLATED FROM GROUNDWATER OF SURROUNDING TERRANE.	"	—	—	—	—	—	—	●
33. MILD CLIMATE AND MODERATE RAINFALL ARE DESIRABLE.	"	—	—	—	—	—	—	●
ECOLOGICAL/BIOLOGICAL CRITERIA AND FACTORS								
34. TOTAL ECOLOGICAL IMPACT OF ESTABLISHING SITE SHOULD BE PREDICTABLE.	REG9 1978	⊙	⊙	⊙	●	—	●	—
35. POTENTIAL EFFECTS ON EACH ECOLOGICAL ELEMENT/ FACTOR CAUSED BY DISPOSAL ACTIVITIES, DIS-PLACEMENT BY SITE OR PROTECTION BY SITE SHOULD BE ASSESSED.	"	⊙	⊙	⊙	●	—	●	—
36. BIOLOGICAL COMMUNITIES, ECOLOGICAL RELATION SHIPS & CRITICAL POPULATION GROUPS SHOULD BE ASSESSED.	"	⊙	⊙	⊙	●	—	●	—
37. RELATIVE SIGNIFICANCE OF ABOVE CHANGES SHOULD BE EVALUATED.	"	⊙	⊙	⊙	●	—	●	—
38. FACTORS CRITICAL TO CONTAINMENT AND TRANSLOCATION OF WASTE SHOULD BE EVALUATED (RUDERAL OR DEEP-ROOTED PLANTS, BURROWING ANIMALS, ETC.)	"	⊙	⊙	⊙	●	—	●	—
LAND USE AND STATUS CRITERIA AND FACTORS								
39. WATER RESOURCES MANAGEMENT.	"	—	—	—	●	—	●	●
40. MINING CLAIMS AND OPERATIONS.	"	—	—	—	●	—	●	—
41. PERMITS, EASEMENTS AND WITHDRAWALS.	"	—	—	—	●	—	●	—
42. OUTDOOR RECREATION.	"	—	—	—	●	—	●	—
43. ESPECIALLY DESIGNATED AND SPECIAL INTEREST AREAS.	"	—	—	—	●	—	●	—
44. STATE AND LOCAL ZONING AND LAND USE PLANS.	"	—	—	—	●	—	●	—
45. AGRICULTURAL USE AND ACTIVITIES.	"	—	—	—	●	—	●	—
SOCIO-ECONOMIC CRITERIA AND FACTORS								
46. PROXIMITY OF SITE TO WASTE GENERATORS.	"	—	—	—	●	—	●	—
47. ADEQUACY OF TRANSPORT SYSTEMS AND NETWORKS.	"	—	—	—	●	—	●	●
48. EFFECTS OF RESOURCES FOREGONE BY COMMITMENT OF LAND TO WASTE DISPOSAL SHOULD BE CONSIDERED (ECONOMIC LOSS AND INTRUSION.)	"	—	●	—	●	●	●	—
49. LOW POPULATION DENSITY IS DESIRABLE.	"	●	●	●	●	—	●	●
50. LAND SHOULD BE FEDERAL OR STATE OWNED.	"	—	●	—	●	—	●	●
51. IMPACT ON COMMUNITY AND EMPLOYMENT.	"	—	●	—	●	●	●	—
52. POLITICAL AND INSTITUTIONAL CONSTRAINTS (INCLUDING PUBLIC ACCEPTANCE.)	"	—	—	—	●	—	●	—
53. LAND VALUES SHOULD BE LOW AND SITE SHOULD NOT DEPRESS VALUES OF PERIPHERAL PRIVATE LAND.	AEC 1960	—	⊙	—	⊙	—	—	●

(1) Not necessary because large areas with deep water table are available .
(2) Requirement for EIS did not exist.
(3) Not unless extensive site and trench engineering and/or waste conditioning is done.

• Protection of the public health is of paramount importance.

• The natural character of the site should prevent movement of contaminants to places which adversely affect man.

• The site should have a simple hydrogeologic setting and system in which the potential movements of contaminants is predictable and capable of being modeled and monitored.

• Predictions are needed for movement of contaminants in the near surface deeper ground-water and regional flow systems; predictions of system performance should include mathematical simulation modeling.

• The site should be devoid of surface water and swamps and not be located in flood plains.

• The site should be geomorphically stable and not subject to erosion, tectonism and other destabilizing events.

• The disposal zone should normally be several meters above the water table; however, the disposal zone may be below the water table if hydrogeologic conditions are suitable.

• Few sites are perfect and use of engineering and waste barriers can be considered to compensate for the lack of some natural site barriers.

• Predictions are needed for the impact of the proposed disposal facility on the ecology, biology, land use and status, and socio-economic elements of the site.

Areas of Potential Disagreement or Significant Change

Several significant differences between individual criterion from the different sets of criteria were noted. These differences resulted primarily from (1) increased knowledge of processes which affect waste disposal and (2) changes in philosophic approaches to wastes management and public health protection. A brief discussion of these differences follows.

Use of Shale Versus No Fractured Rock: The 1960 AEC criteria (20) advocate the use of shale as a disposal medium. Shale is by definition a jointed, fractured rock. Later investigators (4,5,32,33) found that disposal in or near fractured rock, such as shale, made prediction of the rate and direction of radionuclide transport very questionable. Thus, later criteria (4,9,10) recommend that, at least in the humid eastern United States, fractured rock and shale should be avoided whenever possible. When fractured rock is used, plans should be made to use special engineering and waste conditioning precautions.

Use of Disposal Medium with Low Permeability: The 1960 AEC criteria (20) advocates the use of at least 20 feet of unconsolidated overburden of clay or clay-rich material for the disposal medium. Three disposal sites in the humid eastern United States have over 20 feet of clay-rich overburden with very low permeablility. However, experience at them has not been good -- primarily because site engineering did not keep rain water from infiltrating into the trenches. Infiltrating rain water has soaked the wastes, formed radioactive leachates, and overflowed from the trenches to ground surface (32,33,34). At another disposal site, also in the humid eastern United States, which has a more permeable disposal medium, no significant problem has been encountered with the collection of leachate in the trenches or with the overflow of leachate. Rather, infiltrating waters percolate downward through the trench to the water table (29). Therefore, if use of a clay-rich disposal formation is being considered, especially in a humid region, allowances should be made for the extensive use of site and trench engineering to keep water out of the trenches.

Size of Buffer Zone: The Papadopulos and Winograd criteria (4) recommend that a buffer zone several thousand feet to several miles be established around a site. The minimum width of the buffer zone at each site would be governed by the calculated length of the groundwater flow path needed to permit decay of critical radionuclides to safe levels. A buffer zone 20-50 percent greater than calculated would provide for (a) a safety factor if unkown heterogenieties result in longitudinal dispersion considerably greater than calculated and (b) possible expansion of the site if predictions of solute transport prove to be conservative. The 1960 AEC criteria (20) also recommend acquiring sufficient land for safety and expansion. The approach of NRC (21) is somewhat different in that a buffer zone of only 100 feet is required. This allows little room for error or expansion. NRC does, however, require that the waste containers, hydrogeology and site design must contain radioactive materials to specified offsite limits.

No Reliance on Institutional Controls for More than 100 Years: A new criterion and concept that has been introduced into waste management philosophy is that active institutional controls for a disposal system which requires maintenance by man cannot be relied on indefinitely. The criterion has been put forth that 100 years should be the maximum time governmental institutions should be relied on to carry out active controls for protecting the public and the environment from disposal site releases (11, 21). This criterion stems from concern that over time, a disposal facility may be forgotten or lost because of changes in social or political order, loss or distruction of records, or major changes in economic priorities.

Many catagories LLW remain hazardous longer than 100 years. Therefore, it has be proposed that any disposal system should remain intact and fully functional to retain the wastes for their hazardous lifetime -- without the benefit of active maintenance by man or institutional control after 100 years (11, 21)*. The choice of 100 years, rather than 50, 150 or other time period, although judgemental, has been discussed extensively in several public forums. It should be pointed out, however, that the concept that institutional controls cannot be depended upon for more than 100 years is not accepted by all. A number of review comments received on EPA's recommended criteria for radioactive waste pointed out that institutional controls have, in fact, been maintained for 200 years in the United Stated and for much longer elsewhere.

The practical effect of this new "100 year" criterion is to place increased reliance on the stability of the natural characteristics of the site, as well as permanent engineering controls.

Intrusion by Man: Intrusion by man, either deliberately or inadvertently, has been elevated to a major potential pathway and concern in managing LLW and other radioactive wastes (11, 21). It is related in some degree to the previously mentioned "100 year" criterion wherein the reliability of institutional controls over long periods of time has been questioned. Concern has been expressed that when institutional control is lost, man may intrude into a disposal site deliberately in search of artifacts or useful items or inadvertently during farming, in construction of dwellings or in search of minerals and water. It is not clear yet how this criterion will affect site selection criteria . Approaches taken thus far have been to recommend avoiding areas known to contain natural resources, burying wastes deeper, and constructing intruder barriers. The first of these would certainly affect the depth of the water table (Criterion 6) and the second has already been included (Criterion 48).

SUMMARY AND CONCLUSIONS

EPA published site selection criteria for LLW disposal sites in 1974. Since then, many advances have been made in disposal technology and in understanding the processes which affect shallow land disposal. Therefore, EPA has reviewed more recent sets of criteria from other sources to evaluate whether its 1974 criteria are still valid and complete. Conclusions from this review include:

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*As mentioned earlier, EPA's recommended criteria for radioactive wastes (11), which contained this "100 year" criterion, were officially withdrawn in 1981 (12).

• There is very strong agreement on almost all points between the various Federal, regional and international sets of criteria.

• Site selection criteria should include biological, ecological, land use/status and socio-economic factors.

Further work still appears to be needed in the following areas:

• Use of shale or other fractured bedrock as a disposal medium.

• Use of a disposal medium with a very low permeablility in a humid region.

• Purpose, definition and size of buffer zones around the disposal trenches and site.

• Length of time which institutional controls can be relied on.

• How to plan and deal with potential intrusion by man.

Overall, it appears that within the technical community and Federal and regional organizations involved with LLW disposal, we are at a point where we can agree on an overall set of site selection criteria for national use -- having already done so individually.

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DISCUSSION

J. Wallach: So far this morning we've been talking about low-level radioactive waste and about land disposal. You just put up a criterion early on about the requirement that the site must totally contain or totally isolate all radionuclides for the hazardous lifetime of the waste.

I'm wondering, first of all, are you talking about long-lived, low-level radioactive waste or short-lived; and second, what does the word "hazardous" mean? Does that refer to radioactivity?

G.L. Meyer: To get to number two first, I'm a geologist-hydrologist. I would have to ask some of my health physics peers to answer that question for you; possibly someone else would care to address that. I mean it in a general sense, not in a technical sense.

As far as number one, I would say if one were not concerned with intruders -- and this is an interpretation -- and did not have to deal with that scenario, then shallow ground disposal that would contain longer-lived radionuclides within the buffer zone would be suitable. It's clear to me that if a site or a system has a capability to retain a waste with a certain half-life and a certain concentration, it is suitable and you need not exceed that.

J. Wallach: I think there's a whole spectrum of things that come into play here. One, the desire to eliminate institutional controls after 100 years, a number which I'm not sure of is something that might be of concern. And in making the statements or asking the questions, I am, in part, reflecting the philosophy that we use in Canada, which is to stay away from the numbers because we're not sure what those numbers might be.

Getting back to a statement that you just made about no fear of human intrusion if we're talking about long-lived radionuclides, I'm thinking in terms of uranium mine tailings, for instance, which are defined as low-level radioactive waste, but which are very long-lived. Over the long term, which may be several hundred thousand years, we don't know necessarily what the groundwater conditions may be in certain areas.

Perhaps that's okay in the western United States where the water table is so low -- I'm not sure. But in areas where there are fluctuations in the water table or in areas where there may be a certain amount of tectonic instability which would have some sort of impact, I would think there might be difficulty in trying to guarantee containment of radioactivity.

G.L. Meyer: As I stated, the philosophy was there is no guarantee that the site is going to do everything it's supposed to. You try to pick the site with the best characteristics possible, and watch it and monitor it closely.

As far as numbers, my experience working with the IAEA on the guide book, the Canadians were pushing for 50 years as a reasonable duration for institutional controls. This is not an appropriate position. I can only say the agency's position is 100 years. And the site characteristics should be capable of adequate containment of the waste thereafter. You shouldn't need to tend the site after 100 years.

J. Wallach: Yes, I respect the desire to remove institutional controls or not to have to rely on them. The Atomic Energy Control Board, which is the Canadian regulatory body, is not using a number of 50 years.

Our position is sort of a general one, that if you could demonstrate that reliance on institutional controls would be needed for 100 years, that's a lot better than if you stated that reliance on institutional controls would have to last 1000 years. There's a very broad spectrum in there.

J. Shapiro: I think if we rely on complete isolation as a buzz word we are just going to hang ourselves, just as when in radiation protection we used to say that any bit of radiation is harmful. I think the point you made is that you cannot have complete isolation, and that permissible leakage is a very important philosophy.

But my question, related to that, is:

As part of EPA you're really responsible for the most notorious violator in our society, Mother Nature. There is a lot of data available from geology on the behavior of hazardous materials in the ground, on hazardous ore bodies, on leaching rates, on a comparison of the behavior of soluble material and insoluble material. I'm sure this is discussed in your reports, but I haven't seen them. I think we need perspectives from government agencies in looking at what's happening in the ground and then being able to relate that to man-made problems. I would like to see more design data derived first from nature, and then, secondly, from industrial activities.

G.L. Meyer: Thank you for calling to my attention a couple of important points that I left out of my presentation but which are in the written paper.

First, in 1973 we wrote what I believe to be one of the first public papers calling attention to some of the issues involved in management of low-level waste. One, the wastes themselves are unsuitable for disposal, both from an engineering point of view, and also with respect to the possibility for migration.

Secondly, we called attention to the fact that the ground is a porous medium, by and large, and to say that you can put something in the ground and it will stay there forever is, putting it mildly, ridiculous, if you have an understanding of geology and hydrology.

Thirdly, we called for better site engineering, and fourth, for development of a model to analyze the total facility.

We have called attention in the technical reports we have published to the similarity of the commercial low-level waste sites to normal garbage dumps, or sanitary landfills. We got much of our first insight into potential problems from looking at corollary type facilities.

PUBLIC PARTICIPATION IN LICENSING DECISIONS - A NECESSARY PARTNER FOR TECHNICAL SITE SUITABILITY

G. Yuan
Department of Geology
Washington State University
Pullman, Washington 99164

ABSTRACT

The technical siting requirements proposed by the Nuclear Regulatory Commission (NRC) are sufficiently general to allow consideration of a site for radioactive waste disposal in almost any part of the country. The requirements eliminate only extreme conditions which common sense would dictate unsuitable and emphasize flexibility in choosing a site and designing a facility. Although this approach encourages the development of new radioactive waste disposal sites, the NRC has not paid adequate attention to the political and social context in which the development of new sites must occur. The need to gain public acceptance of and participation in the licensing process is treated cursorily by the NRC. Provisions for public hearings and State and Tribal reviews of siting issues in the licensing process are limited and ill-suited to identifying and resolving sources of controversy. The Commission must seek a constructive relationship with the public through its licensing requirements and by reconsidering the goals and mechanisms it utilizes in seeking public opinion. Both clear definition of technical siting requirements and public acceptance of radioactive waste disposal must be addressed if low-level radioactive waste disposal is to continue.

INTRODUCTION

Licensing proceedings for nuclear facilities are well known for stirring controversy and capturing front-page headlines which polarize public opinion. Even though the di sal of low-level radioactive waste has been practiced for nearly 20 years, it still raises controversy today. Recently, low-level radioactive waste disposal has drawn increased attention from State governments anxious to have greater control over waste transportation and from Congress which passed the Low-Level Radioactive Waste Policy Act (Public-Law 96-573) calling on States to be "responsible" for disposing of low-level radioactive waste generated within their borders. Increased restrictions at existing burial sites coupled with a growing public awareness of the disposal problem have created a sense of urgency about the need to expand available disposal space for low-level radioactive waste.

Meeting these demands for expanded space requires: (1) a clear definition of where radioactive wastes can be safely buried; and (2) public acceptance of disposal facilities. Until these two requirements are addressed, continued public mistrust will plague radioactive waste disposal. In an effort to expedite the opening of new disposal sites, the Nuclear Regulatory Commission (NRC) has amended its licensing regulations for low-level radioactive waste disposal.(1) Unfortunately, these amendments neither define the characteristics of a good site nor provide mechanisms for increasing public acceptance of disposal facilities. The discussion below reviews the problems with the Commission's amendments and the consequences for radioactive waste disposal.

SITE SUITABILITY REQUIREMENTS

Among its licensing amendments, the NRC has introduced "technical requirements for site suitability", an expression implying a recipe or guide for choosing locations which will safely confine radionuclides throughout their hazardous lifetime. Site suitability is a primary factor in the licensing decision, yet the Commission's requirements do not define site suitability so that this aspect of the licensing decision is clear. Instead, the Commission relies on "performance objectives", stated in terms of annual doses of radioactivity to create a standard for judging site characteristics. The NRC expects that site characteristics combined with engineered barriers and a compatible waste form will all contribute to meeting the performance objectives. This approach provides greater flexibility to the applicant in proposing a site and design for low-level radioactive waste disposal.

The utilization of both technical requirements for site suitability (prescriptive requirements) and performance objectives were discussed in the Draft Environmental Impact Statement (hereinafter "Draft EIS") prepared by the NRC in support of the licensing amendments:

> "Performance objective requirements, by their nature in establishing overall objectives, would allow maximum flexibility in the application of new technology and innovative solutions to assuring safety in the disposal of [low-level radioactive waste]. ...Performance objective requirements , however, require more effort and time in development as well as in licensing of specific facilities due to the large number of factors that must be considered to determine compliance. ...
> It would be easy for an applicant or licensee to

demonstrate compliance with prescriptive requirements...since engineering limits are established which can be readily measured or calculated and the specific requirements for the design and operation of a [low-level radioactive waste] disposal facility would be clearly defined and readily apparent to an applicant or licensee". (2)

Although the performance objectives achieve their goal of providing flexibility, the technical site suitability requirements are not true prescriptive requirements as defined above, and do not make demonstrating compliance "easy" as indicated in the Draft EIS. In fact the technical site suitability requirements will be just as difficult to apply as the performance objectives since in most cases the requirements rely on compliance with the performance objectives to define suitability. The Draft EIS further stated that the site suitability requirements are merely "common sense". Rather than defining suitable characteristics, the NRC plans to eliminate bad sites with the application of its technical requirements reserving judgement on what is suitable for the licensing process:

"NRC has set out what are believed to be common sense site suitability requirements that can be consistently applied throughout the country. ...The requirements are intended to eliminate,...certain characteristics that are known to or have potential to lead to long-term problems." (2)

Thus, the NRC has not defined a suitable site but has underscored some characteristics of an unsuitable site. However, the Commission's attempt to define unsuitability is too general to be very useful in identifying sites which cannot be considered for licensing.

A brief review of some of the technical requirements illustrates this point. One requirement is: "The site shall be capable of being characterized, modeled, analyzed and monitored." This requirement does not significantly narrow the spectrum of sites which the NRC could judge as suitable. Presumably, the NRC is implying that it favors sites which are geologically and hydrologically "simple" so that models can be relied upon to predict and monitor the transport of radionuclides from the site. However, this requirement places no bounds on how simple a site must be nor on how well characterized, reliably modeled, thoroughly analyzed or carefully monitored. Furthermore, this requirement merely restates the need to comply with the performance objectives since compliance with the objectives already requires utilization of predictive transport models which themselves must be derived from accurate characterization, analysis and monitoring of the site.

Another requirement is: "Upstream drainage areas must be minimized to decrease the amount of runoff which could erode or inundate the disposal cells." This requirement, aptly characterized as common sense, relies on the NRC interpretation of "minimize" and does not constitute a truly prescriptive requirement since no limit is set on either the size of the drainage basin or the anticipated erosion rate at the site. Until the NRC reviews a specific site the applicant does not know whether runoff has been sufficiently minimized for the purposes of obtaining a license.

Another requirement states that: "Areas must be avoided where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur with such frequency and extent to significantly affect the ability of the disposal site to meet the performance objectives...or may preclude defensible modeling and prediction of long-term impacts". This requirement relies on application of the performance objectives to determine if tectonic processes at the site make the site unsuitable. Reliance on the performance objectives makes the requirement difficult to apply and redundant. The requirement only guides site selection if the NRC can describe tectonic conditions which deem the site unsuitable independent of compliance with the performance objectives. Otherwise, the NRC is only providing a glimpse at which site characteristics are important to the licensing decision.

Finally, the NRC requires that: "The disposal site must be generally well drained and free of areas of flooding or frequent ponding. Waste disposal shall not take place in a 100-year flood plain, coastal high-hazard area or wetland." The latter part of this requirement is prescriptive in that it states clearly a condition which is not suitable for waste disposal. However, the first part of the requirement again sets no standard for what is acceptable. The frequency of allowable ponding is not specified and well drained is not defined.

The technical requirements, including those discussed briefly above, in practice warn applicants to be wary of certain site characteristics which the Commission has highlighted but, do not provide a clear definition of suitable site characteristics. This need to maintain technical requirements which are general in nature results directly from the "systems approach" which emphasizes the interactions and strengths of all the components in a disposal system (site, engineered barriers, waste form etc.) to contribute to the overall goal of waste disposal-confining radionuclides.(3) Site suitability defined in this context allows each site to be judged in light of the entire disposal system being proposed rather than representing an ideal site. The necessity of this approach is supported most clearly by considering its alternative. If the NRC issued technical requirements which rigidly defined an ideal site it would severely limit the possible number of acceptable sites in the country. Future sites might be concentrated by necessity in arid regions of the western U.S. Since most low-level radioactive waste is generated in the eastern half of the country, this siting pattern would result in increased transportation distances, costs and risks from accidents. In addition, as recognized in the Draft EIS, prescriptive requirements focus on components of the disposal system deemphasizing the importance of the system as a whole.

However, although more flexibility in locating sites for radioactive waste disposal is attained by emphasizing the entire disposal system and identifying only general technical requirements, other problems are created. Since site suitability for radioactive waste disposal cannot be more specifically stated using this approach, controversy over its meaning will likely surface during the licensing process. Understanding the political context in which the licensing decision will be made sheds light on this problem.

THE POLITICAL CONTEXT

Radioactive waste disposal is a politically charged social issue. Low-level radioactive waste disposal like all nuclear issues is a problem with national and local tensions. At the national level, it is inextricably linked to the debate over nuclear power. This debate enters low-level radioactive waste decisions because 50% of all low-level radioactive waste is produced by commercial power reactors. A recent voter initiative (Initiative 383) in the State of Washington noted this fact and attempted to ban the disposal of low-level radioactive waste from power reactors while allowing the disposal of non-reactor waste. At the local level, the public is concerned about low-level radioactive waste because the major impacts from disposal activities will be born by citizens living near disposal sites. Increased traffic, potential leakage of radionuclides, the dedication of land in perpetuity, these are all consequences a local population bears. The strength of the sentiments felt by State government in dealing with these problems was seen in October, 1979 when the possible closure of all three disposal facilities was threatened. The Governors of Washington, Nevada and South Carolina cited careless packaging and transportation practices as threatening the safety of waste disposal in their States. Temporary closure of two of these disposal operations created concern that nuclear activities might have to cease until disposal capacity could be made available again. Limited storage capacity at hospitals and universities received widespread media attention. South Carolina has since halved the amount of waste it will allow buried in the State each year and the State of Nevada struggled in court for the right to close down the site at Beatty, Nevada. Finally, the passage of the Low-Level Radioactive Waste Policy Act last year, focused national attention on State responsibility and rights in providing waste disposal.

THE PROBLEM

The NRC licensing process addresses this complex social issue by emphasizing technical requirements and providing highly formal and limited opportunities for public participation. The licensing process does not take into account heightened public awareness of the political and health questions related to radioactive waste disposal. Thus, the major problem with relying on the licensing process to apply loosely defined technical requirements in the regulations is the inevitable controversy that will result when the public challenges the acceptability of radioactive waste disposal and asserts its rights to be part of the licensing process. Interpretations of the general language used in the requirements are easily challenged, hence the determinations of site suitability based on those requirements are likewise easily challenged. Controversy will shape the debate over site suitability.

The licensing proceeding for the Diablo Canyon nuclear power plant in California serves as an example of this problem. The major technical issue is whether the plant's location 2.5 miles from a fault could cause failure of essential safety mechanisms in the reactor during a major earthquake. Experts in active faulting and seismology have argued on both sides while the Pacific Gas and Electric Company, owner of the plant, has weathered 8 years of construction, 36 federal hearings, 4 state hearings, 3 licensing appeals and 2 Congressional inquiries.(4) Resolving the seismic issue is complicated by the incomplete development of the science and the discovery of the problem after more than 75% of the reactor had been built.(4) The late recognition of the problem and reliance on a licensing process which utilizes formal hearings to resolve controversial issues only contributed difficulties to an already intractable problem. The uncertainties in the technical data fuel the controversy and the NRC has yet to devise a way of increasing public trust in its decisions or judgement.

PUBLIC ACCEPTANCE

Lessening public opposition to agency activities is often the primary motivation for including the public in decision making. The NRC recognized the need to provide public participation opportunities in its licensing process and attempted to channel public concern into aiding the licensing decision. The licensing process has been amended to include several opportunities for formal hearings and a mechanism for States and Tribes to participate in the technical review of the site proposed for waste disposal. However, these mechanisms do not address public acceptance of waste disposal and are not adequate for conflict resolution or identification at any stage of the licensing proceeding. A brief summary of the NRC provisions for State and Tribal participation provides some insight to the weaknesses of these mechanisms.

Opportunities for State and Tribal participation begin after submission of an application for a license. Following formal notification in the Federal Register, a State or Tribe has 120 days to submit a proposal for participation in the review of the license. The proposal must include:

* a description of how the State or Tribe wants to participate;
* a description of the material the State or Tribe wishes to submit to the NRC for inclusion in the review;
* a description of the work the State or Tribe wishes to perform for the NRC; and
* a preliminary estimate of the types and extent of the impacts the State or Tribe anticipates as a result of the waste disposal activities. (1)

This provision invites States or Tribes to assist the NRC in its licensing decision but does not give them any decision making power, nor does it guarentee them any influence over the NRC's decision. It is not clear what standard the NRC will use for granting these opportunities and it is not clear how the NRC will weigh the information gathered in this manner in the licensing decision. In addition to these disadvantages, this mechanism for participation appears particularly weak in contrast to the opportunity to participate in the Agreement State program. In this program, a qualified State can regulate radioactive waste disposal itself and discretion over the issuance of licenses is transferred from the NRC to the appropriate State agency. The possible advantages of merely assisting in an NRC decision do not clearly outweigh the option of attaining Agreement State status. Although the NRC amendment allows participatory rights to Tribes which currently can not attain Agreement State status, the type of participation proposed by the

Commission remains a weak and uncertain mechanism for influencing the decision making process.

The public participation methods proposed by the NRC reinforce the existing pattern in nuclear facility licensing, relying on formal public hearings to both gather and disseminate information and initiating formal contact with the public only after an application for a license has been made. Public hearings offer only limited one-way communication. The agency presents its proposal and receives formal testimony that tends to summarize positions rather than resolve issues.(5) This highly formal process frustrates the public which may be hearing about the proposal for the first time and does not provide the agency with the type of information it can use in making a decision. The public's comments often seem unsophisticated and ill-informed, a direct consequence of their limited opoortunities to learn about and take part in planning up to the hearing stage.

A recent Congressional investigation of Federal regulations pointed out two major hinderances to effective public participation in the existing regulatory process related to the timing of public participation long after the beginning of informal discussions between the applicant and the NRC:

> " By the time notice is posted in the Federal Register, the staff of the Nuclear Regulatory Commission typically will have worked with the applicant...for a year or two on the technical details of the application.
>
> Not only does this process give the agency staff vested interest in the application as it stands, but the public is usually shut out of the early, and often determinative, stages of the process. ...
>
> By the time the public can get involved in a decision, so much money has usually been spent by the [applicant]...in planning and studying the site that it becomes uneconomical to change the course of action."(6)

The NRC amendments continue to provide too few opportunities too late for meaningful public participation. The need for public participation and the lack of public acceptance of agency decisions stem in part from lack of communication between the agency and the public:

> "Concern for participation arises almost entirely in the context of real or imagined failure of government to respond appropriately to the more competitive needs and demands of citizens, some of whom feel that the response would have been more satisfactory had their values been given an assured fair hearing." (7)

If the NRC is to encourage public participation, it must develop with the public a relationship akin to the one it has with the industry it regulates. The NRC should begin informing the public about radioactive waste disposal plans when it begins discussing those plans informally with the applicant.

The Commission should require the applicant to identify local concerns and to inform the public and its representatives in government about the type of facility which is being proposed. The NRC recognized the potential for early public participation in its regulations when it considered an option requiring a notice of intent to file an application 3 to 6 months prior to the actual filing. This requirement encourages early participation and could result in early identification and factoring in of public concerns in the applicant's proposal. The NRC rejected this option for the following reasons:

> "...(1)it added an administrative burden on the applicant; (2)from a practical standpoint, it is probably not needed to assure early state input; and (3)its purpose can be accomplished by other means." (2)

These reasons for rejection must be balanced by the benefits of of the requirement. Although the applicant may already have reasons for seeking State input, there is little incentive to seek local or citizen input. Documentation of how the applicant sought public participation prior to submitting an application and reasons for incorporating or rejecting these concerns are important to building a credible record with the public and in gaining acceptance of the facility. The NRC should reconsider this option in a form that would go beyond public hearings and formal testimony to one which would incorporate an interactive approach for gathering and disseminating information about the proposal.

Beyond the formal requirements and review of specific aspects of a license there are other considerations in increasing public participation in agency decisions. How the public contributes, who should represent the public and how the NRC plans to use the information it receives should be primary considerations in the development of a relationship with the public. Of course, it cannot be expected that increased public participation will necessarily result in easier decision making. More likely, the NRC will find itself responding to increased pressures to decide issues in a greater variety of ways while being pulled in conflicting directions by new constituencies. However, Congress recognized that relying on a more varied constituency and a larger information base can yield positive results for the agency:

> "Specifically the presentation of alternative viewpoints which is a consequence of broader participation checks possible imbalance in several ways. First, agency decision makers are provided with a greater range of alternatives and information. Second, participation promotes agency autonomy by

widening the official perspective of agencies and providing an alternative basis of support." (6)

Finally, it should be emphasized that greater public participation although commonly viewed as a cause of delay in the licensing process, must be also viewed as a necessary means to seeking acceptance of waste disposal. In some cases public participation may actually speed up controversial proceedings by avoiding the lengthy alternatives of litigation and appeals:

> "[In the view of the Senate Committee on Governmental Affairs], the fact that an additional party participates in an...agency proceeding does not mean that the proceeding will be delayed. ...Ultimately...the over all time elapsed may in fact be lessened, since if all relevant issues are resolved in the initial proceeding, the likelihood of a subsequent court reversal to consider relevant issues is substantially reduced and along with it the risk that the agency will simply have to go through its paces all over again." (6)

With these caveats in mind, suggestions for constructing a successful public participation program can be made. The NRC should identify its primary goals in seeking information from the public, for example:

* identification of public opposition or support and its causes;
* identification of local or State preferences for locations within the State or region for radioactive waste disposal;
* identification of preferences for State or Federal ownership after disposal operations have ceased; and
* identification of the need to compensate the local population for increased risks resulting from waste disposal.

In addition, the NRC should initiate educational opportunities for local, State or Tribal governments so that they are better equipped to understand information in the licensing process.

This information exchange will improve citizen participation by providing a clearer concept of the disposal facility and its potential problems.

Who represents the public has always been a problem in designing public participation programs. The NRC has restricted its public participation to State governments and Tribal representatives. These representatives of the public contribute a limited perspective on public concerns and must themselves incorporate balancing decisions in order to fairly represent the geographic regions which define their constituencies. While State concerns may be focused more on financial problems, long-term monitoring responsibilities and ownership, the concerns of local citizens may tend to emphasize impacts on the community from construction, the influx of labor, demands on housing and social services and increased health hazards. The NRC should expect to include a variety of representatives of the public so that the perspectives and interests of those both directly and indirectly affected by radioactive waste disposal can be heard in the licensing process.

Finally, perhaps the most significant aspect of seeking public participation is how the NRC uses public opinion in formulating its licensing decisions. The history of public involvement in federal agency decision making is so infested with failure to consider public opinion that researchers have coined the term "coopt-tion" for the usual outcome of the heavily relied on public hearing :

> "A public hearing serves a cooptation function when the goal of the hearing is to let irate citizens and interest groups let off steam and complain about the project. The posture of the decision makers may be

one of responsiveness. While it is implicit that public input will have no impact on the program or on policy, people are formally given a chance to have a say so they may not take the agency to court for failure to provide public involvement. By attending and presenting their case to an unresponsive agency, the opposition has been unwittingly coopted into serving the goals of the agency."(8)

Until the Commission is able to gain public trust in its judgement and until the public accepts radioactive waste disposal, the NRC may find it impossible to license a radioactive waste disposal site without coopting or appearing to coopt the public. The NRC is afterall a regulatory agency mandated to regulate in the public interest. Definition of the public interest requires a broad disinterested view of the public opinion and welfare. The Commission must seek a more interactive relationship with a broad spectrum of the public before it can begin to define the public interest and rely on it in its licensing decisions.

CONCLUSIONS

The NRC licensing process ensures that low-level radioactive waste disposal sites can be considered for licensing in almost any area of the country. The technical siting requirements eliminate only extreme consitions which common sense would dictate unsuitable. Yet the Commission has overlooked a key problem in its licensing process - likely public opposition to decisions which are based on technical adequacy with no meaningful opportunities for public expression of acceptance or opposition and no provisions for conflict resolution. The remedy lies in equal attention to the political and social context in which the questions of technical adequacy are answered. Public concerns over non-technical issues as well as public understanding of what site suitability means must influence the licensing decision if low-level radioactive waste disposal is to continue.

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DISCUSSION

K. Ross: I agree wholeheartedly with your assessment that the public is too often poorly informed about various issues related to nuclear waste, and in particular low-level waste, which is the topic of this seminar.

One concern I have is that the public is apt to tune out to dialogue about low-level waste management because it is too technnical or too complicated, or simply too scary. I'm wondering if you can suggest some methods of how the utilities, the federal government, and other organizations might address the problem of educating the public.

It seems to me that frequently the public really isn't interested in obtaining information until it's a big issue. I'm wondering how we might educate the public a little further in the process.

Also, you mentioned that you thought that the NRC might try to develop better relations with the public in this area. It seems to me that we've gotten to a point where there is a great deal of mistrust in the public sector about the information that we've received from the federal government. How would you get around that?

G. Yuan: I think that's appropos.

It's true, I think the public -- and you are all members of the public -- recognizes that when something is happening in its community it concerns you a lot more than if it's happening in even a neighboring community or the next state or the next country. There is a feeling that you have to be involved and there has to be something at stake for you as an individual before you become concerned about a problem, which is one of the reasons why I stress the need to get in at the local level.

People who live or may live near radioactive waste disposal sites are going to be more interested in finding out about them when they are aware that there is something going on than they will be beforehand. Again that's the reason that I stress early participation.

I believe that the problem of public relations and the problem of building trust is something that must be done slowly over time. My point really is that we have to start somewhere.

We heard from the Department of Energy representative this morning. I believe the Department is really helping in that effort in that they have tried, through their low-level waste program, to develop material that the public can read easily and understand about low-level radioactive waste. But, I think the real issue arises when a community is confronted with a licensing decision and it is often viewed as us versus them. There is someone making a decision about my future, about the future of an area near my community. The only way of really dispersing or coping with that kind of opposition is to understand its source and then to try to incorporate into the licensing decision a sincere interest in how you can reorient waste disposal activities so that they don't step on everybody's toes; so that the main transportation routes aren't the exact routes that everyone has had opposition to; so that the locations fit into local land-use plans; and so that people don't have a sense that well, we came in and we said these are our six points and the agency had already decided four months ago that too much money had been spent developing another site and they can't possibly consider it.

I think, especially in the very next licensing proceeding, the very first site that comes up for licensing under these new regulations, that these sorts of questions will arise and the kind of relationship that the licensing decisionmakers have with the public will be critical.

L. Skoblar: As someone involved with public information programs, I can share a lot of sympathies with what you say. But it seems to me that one of the terms in need of definition perhaps most of all is what you mean by the public.

When I've been talking to groups I find there is no single group that could legitmately claim to represent the majority of a population in any given area. For example, in coming up with a routing regulation the people along that route perhaps may not be too thrilled that the route may be near their homes, but the overall town or city may think that it is fine if it goes through the west part of town.

How do you claim to resolve that kind of thing by the term public participation? When can you ever feel you're to the point where you can legitimately say, "the public supports this," because there will always be a residual group that doesn't care for what you've decided. Unless you define your term by what the public is, I don't know that we can come to a resolution.

G. Yuan: I understand what you're saying. I don't really think that the burden of proof is on the public. In fact, I believe that's why we have a government. The government acts in the public interest. The government defines who the public is.

If you review political science you learn that this is a democratic society; we vote for our representatives, who represent us in Congress, so what Congress does represents the public.

Well, you and I as taxpayers don't often believe that.

But, I think when you try to define what the public is, you can't try to embody public opinion in one person or one organization and you cannot really say that there is a magic number of organizations or people that can be said to adequately represent public opinion.

I believe that what you have to do is develop enough interest in the project and enough of a relationship with the public so that there is a wide spectrum of people that come forward, so that you do have a sense that there are going to be opposing views. That in fact would define, in part, the public. If you didn't have opposing views, I think you might be concerned you really weren't reaching the public.

Then I think from there it is up to the agency to define for itself what is in the public interest. This is why I stress that until the Commission, and until any federal agency can gain public trust in their decision, there is no definition of public interest because it is the agency that must act in the public interest.

No one within the public tries to represent everyone in the public. I think we all recognize that our views differ widely. We rely upon our representatives within federal government, state government, and local government to try to sort out from the variety of points of view that they are confronted with what really is in the interest of most of the people.

L. Skoblar: It seems to me, though, there are people who try to represent the interests of the public because they call themselves the Public Information Research Group or the National Resources Defense Council, and they do claim to speak for the public. I find in talking to the general public in my local place of work that these groups don't reflect the views of a lot of people. In fact, most national polls show that there is more of a public acceptance of a solution for the radioactive waste problem than there is an opposition.

When do you decide -- a 51-49 vote, is that enough to call off the opposition?

G. Yuan: Let me clarify one point you made.

I think there is a large misunderstanding on the historical context of the meaning of the words "public interest groups". When public interest groups were first defined, or categorized as such, I think they were meant to represent views which were not commonly heard within federal decisionmaking because they did not have the kind of financial support or organizational support that, say, the nuclear industry, or the logging industry, or the mining industry has; views that, because they're not organized around a particular commodity or around a particular service, get lost in the shuffle. I think now we're seeing so-called public interest groups that represent a very wide spectrum of political views. That's the first point.

I think the other question you were asking is, "where do you draw the line?" Again, I must throw the ball back at you and say that I don't really think that the line is drawn by the public, but by the decisionmaker. I'm not suggesting that the decisionmaker must start changing the ways in which he or she decides. What I'm saying is that it's necessary for a decisionmaker, in order to make decisions in the public interest, as we suspect they should, to avail themselves of a wider spectrum of opinion.

L. Skoblar: As a final statement I'd like to say that it has not been my sense in working with so many of the people here that any of them wants to keep information from the public or that any of them wants to put something over on the public.

What we're missing, I think that perhaps only you from your perspective can help us solve, is the question, "How much is enough and exactly what is necessary?" If you could define for us the kinds of things you'd like to see done for the public, perhaps the rest of us then can marshal our energies into that area.

But we've been trying, and we still hear that it's not enough or the public's needs are not being served.

So if you can help us somehow in teaching us when the public's interests will be served I think you'll be doing us all a favor.

J. Shapiro: I did want to say something in favor of the proposed rule. You found some things wrong with it, and I must admit I looked at it for the first time last night and it really made one control paramount, in the form of a very positive statement of what you need to see in a waste disposal site. It says:

> "A cornerstone of the system to control the migration of radionuclides offsite is stability, the stability of the waste and the disposal site so that once in place and covered the access of water to the waste can be eliminated or minimized."

The whole rule talks about keeping water away from the waste.

What I would like to see in the workshops and in the further discussion is, first, "Is water the paramount consideration?", because we are given so many considerations in these discussions it's been pointed out it's hard to select one from the other.

And, second, in terms of experience, have we been able to keep water away from the waste or do we think we can?

And, third, when water is kept away from the waste, is the waste in fact confined?

These are points that come to mind as I read this for the first time. It made clear to me how important water is in this whole problem.

SITE SUITABILITY CONSIDERATIONS: AN INDUSTRY PERSPECTIVE

R.G. Bradley

Chem-Nuclear Systems, Inc.
Bethesda, Maryland

ABSTRACT

An industry reaction is provided concerning the site suitability requirements of the proposed 10 CFR Part 61. On the basis of current understandings of the proposed regulations, the compatibility of draft Part 61 with industry's current concepts for selecting a licenseable site leading to deployment of existing technologies for establishing new waste disposal facilities is discussed. Selected elements of the proposed regulations are identified for early clarification by NRC to facilitate implementation of site selection processes.

INTRODUCTION

The Nuclear Regulatory Commission is to be commended for its approach to the development and promulgation of 10 CFR Part 61, "Licensing Requirements for Land Disposal of Radioactive Waste". It is my impression that the NRC staff has been guided in this effort by a strategy of producing a regulatory framework consisting of licensing procedures, performance objectives and technical criteria that would detail and quantify these regulatory elements sufficiently to permit license applicants and regulators to perform their respective roles in the licensing process, while avoiding undue inflexibility and constraints for the development of optimized site-specific disposal systems. Moreover, the NRC has performed these tasks with ample opportunity for external review and comment on the evolving product.

It must be a great temptation to expand the list of quantitative performance standards and technical requirements, thereby minimizing the concerns of industry about the magnitude of uncertanties concerning acceptable waste forms, containers, etc., and, at the same time, making life easier for the regulators that must process license applications. Current impressions generally reflect that proposed Part 61 provides a reasonable balance between use of performance objectives and prescriptive requirements. It appears that the proposed prescriptive requirements applied to individual components of the disposal system are not so extensive as to preclude a systems-type approach in formulating an appropriate disposal system based on deployment of existing technologies responsive to site-specific environmental conditions. I suspect the proposed Part 61 approximates as closely as could have been reasonably expected a "systems approach" for licensing the waste disposal activities, given the inherent health and safety constraints associated with current technologies, practices and regulatory philosophy for near-surface land disposal of radioactive wastes.

I hope I have not been premature in my plaudits to the NRC; I have not yet seen any of the technical position papers or guides which I understand are under development in support of selected portions of Part 61. Moreover, Part 61 has not yet been put to the test of implementation. Unquestionably, additional technical detail and guidance will be helpful, if not necessary, for implementation of some aspects of Part 61. (More about this later.) However, I trust that those guides ultimately promulgated will not unduly undermine the reasonably balanced approach and healthy degree of system flexibility currently incorporated in Part 61.

The announcement for this symposium is a bit ambiguous about the scope of coverage intended for this meeting. The title of the symposium, "Low-Level Waste Disposal: I. Site Suitability Requirements", would appear to constrain the discussions to matters pertaining to site suitability considerations. However, the for the second symposium planned for next June will include, according to the announcement, site characterization considerations, which I would have normally viewed to be an integral part of efforts to determine site suitability.

The announcement went on to state that this first symposium will focus on the proposed NRC rule,10 CFR Part 61, without limiting the scope of that focus to any one portion of the proposed regulations. I concluded that the announcement had been carefully worded to provide the participants at this first symposium significant latitude in selecting the elements of the proposed Part 61 they wished to discuss. I was particularly pleased to be able to arrive at this conclusion since I perceive an interdependence, to varying degrees, between site suitability and all other phases of the life cycle of a land disposal facility for radioactive wastes (for any type of hazardous wastes).

The overall site selection process and its results, including site suitability determinations and detailed characterization and analyses of the preferred candidate site, is influenced by or influences the types, quantities and concentrations of wastes ultimately disposed at the site. The site selected will have an impact on the design and construction of the disposal facility, the disposal operations and supporting equipment, the site closure plan and activities, and the nature of the post-closure programs.

In order to forestall the probable mounting alarm on the part of the symposium organizers, I do not plan to discuss today all elements of Part 61. I will attempt to focus my comments on site suitability considerations and touch upon these other areas only as necessary to the discussion of site suitability considerations. Moreover, while my comments are billed to provide industry's views about Part 61, most of what I have to say today reflects my personal observations as a member of waste management industry. To a lesser degree, I can represent them as being the views of Chem-Nuclear Systems, but I have no basis for presenting them to you as a concensus of industry's views. On the other hand, the limited opportunity I have had to discuss the proposed Part 61 with representatives of other industrial organizations have not revealed significant variations to the obs /ations I will present today.

The development of governmental regulations is usually for the purpose of providing effective control of some element of societal activities such that, among other things, those activities do not endanger the health and safety of the public. The activities proposed by society that inspired the need to develop and promulgate the licensing and regulatory requirements of Part 61 are of course the establishment and operation of facilities for land disposal of radioactive wastes.

Knowing why Part 61 is needed, what do we perceive to be the timing of the societal activities to be served by Part 61 and the manner in which its effective implementation can best serve to facilitate these societal activities proceeding in a timely fashion? Perhaps the summary observations in Tables 1 and 2 will help put these considerations in perspective.

The activities depicted in Table 2 are not listed in the chronological order of occurrence. Obviously many of these efforts could and are proceeding in parallel. The availability of final regulations would be useful to varying degrees for all phases of work associated with the establishment of the regional compacts. In this connection, I was disappointed that the subsequent two workshops on site characterization and facility design and operation were not scheduled for earlier dates.

Table 1. Incentives For Prompt Establishment of New LLW Disposal Facilities

1) Availability of Current Disposal Capacity Susceptible to Abrupt Disruptions

2) Trend Toward Regionalization of LLW Management

3) Avoid Potential Adverse Impacts on Nuclear Applications

4) Minimize ES&H Risks Arising From Proliferation of Storage & Treatment Facilities

Table 2 Prerequisites To Establishing New LLW Disposal Facilities

1) Establish Regional Compacts

   a) Complete Enabling Legislation of States

   b) Complete Regional Waste Management Plans

   c) Complete Inter-State Negotiations of Compacts

   d) Complete Strategies and Programs for Implementing Waste Management Plans

   e) Complete Legislative Actions on Compacts - States and Congress

2) Establish Regulatory Frameworks for Licensing and Regulating Disposal Facilities

   a) Issue Final Part 61

   b) Document Regulatory Technical Positions & Guides

   c) Establish Any Additional State-Region Regulatory Requirements

3) Establish Effective Working Relationships Among Appropriate Federal, State, Regional, and Industry Parties Involved in the Process

Turning to the specific topic of today's meeting, Part 61's treatment of the site suitability considerations, I sense there is universal agreement that the quality of the overall site selection process is the paramount activity in determining the long-term performance of the disposal facility for effective isolation of the wastes from the human environment. The participants in this process are not only required to make technical decisions leading to a safe and licenseable waste disposal system, but they must also effectively accommodate and resolve local and regional concerns and issues relating to the siting, operation, and long-term management of the waste disposal facility. They must employ credible techniques as a basis for technical judgements about the proposed system's vulnerability to potential future developments and events - both those that occur as a result of human initiatives, e.g. changing demographic distributions with time, and those resulting from natural phenomena, e.g. adverse geological and/or hydrologic developments. The initial challenge for the participants in the site selection process therefore, is to develop a suitable administrative framework and technical program to be employed in the site selection process. One major test of the suitability or acceptability of the process is the degree of credibility it enjoys with those in society who pass judgement on the process and its results and, thereby, influence the ultimate success or failure of the process.

Even a more basic issue to be resolved before a site selection process can be deployed and meaningfully implemented in any State or Region is a determination of the roles to be performed in the site selection and licensing process by governmental and industry organizations. The nature and degree of participation in the process by these parties could vary significantly from region to region.

To date the establishment of facilities for land disposal of commercial low-level wastes has generally resulted from activities undertaken by private companies to identify, evaluate, and select suitable sites for these facilities. The burden of financing these activities and of assuming the attendent risks of failure in achieving the objectives of these activities has been borne by the private firms engaged in such activities. This is not a surprising arrangement since the activities were initiated and implemented by private firms who felt the potential for making reasonable profits from the waste management services was sufficiently great to outweigh the estimated costs and risks associated with the effort.

It is less certain today to what extent these arrangements of the past will pertain for the foreseeable future to the establishment of new low-level waste disposal facilities. This uncertainty is a product of the current situation within this country with respect to the adequacy and potential vulnerability of current capabilities for managing commercial low-level wastes,and recent trends that have evolved for the avowed purpose of assuring the existance of adequate waste management capabilities.

The states, having requested and formally received prime responsibility for managing their low-level wastes,are, to varying degrees, examining a variety of options for discharging this responsibility. These options contemplate a variety of state-industry roles in the implementation of waste management activities.

This body of uncertainty about industry's role, responsibilities, and risks in establishing new disposal facilities, when coupled with the uncertanties of how portions of the proposed Part 61 will be interpreted and implemented by the regulatory authorities, foretells one element of certainty: waste management firms in the business for the purpose of making profits will not be aggressively committing funds to establish new disposal facilities until significant progress is made in illuminating and resolving the aforementioned uncertanties.

SITE SELECTION CONSIDERATIONS

Irrespective of the type of organization assigned responsibility for selecting a suitable site for a near-surface radioactive waste disposal facility, it will likely utilize a structured site selection process and be guided by a set of specific site selection criteria. The inventory of generic technical and socio-economic considerations addressed in the siting process would probably not vary that much from organization to organization, given the attention that this subject has received in recent years. A private waste management firm would probably scruitnize more carefully than others the siting considerations relevant to the economic viability of the facility and might assign different weightings and relative importance to selected siting criteria on the basis of operating experience.

We have heard references from various quarters about conducting a site selection demonstration. These proposals are spawned from the frustrations most of us have experienced from the difficulties of recent times in making progress toward the establishment of new waste disposal facilities. It is argued that such a demonstration would serve to educate and inform those organizations inexperienced in the field but potentially involved in the site selection process about the options for structuring an appropriate site selection program, the issues and considerations to be addressed in the program, and techniques for addressing and resolving these issues.

One should keep in mind that the delays to date in initiating projects to select sites for new commercial waste disposal facilities have resulted from not having established the political and public acceptance requisites necessary to these projects. In other words, what has been missing to date are viable institutional frameworks within which technical programs can be implemented for selecting waste disposal sites. The knowledge, experience, and ability to provide suitable site selection processes and the criteria to support these processes have not been on the critical path to initiating site selection projects.

The orchestration of the political and public concensus necessary to the conduct of these site selection activities would probably pose a similar challenge for pursuing either a so-called demonstration or a project designed to result in a new commercial disposal facility. Moreover, a siting demonstration involves inherent risks for early establishment of new disposal capacity. For example, those states or regions that are currently at advanced stages in the process for initiating projects to provide new disposal facilities may feel compelled to await the results of the demonstration before embarking upon their site selection programs.

Those of us in industry with established site selection programs and technical and non-technical criteria to guide the implementation of these programs, all of which are based on years of waste management experience, have followed the evolution of Part 61 with great interest. In the case of Chem-Nuclear, our site selection procedures and criteria have undergone some modifications as a result of deliberations attendant to the development of Part 61.

There may be further revisions necessary as additional insights are obtained about the intent and interpretations of certain elements of Part 61. However, based upon present understandings of Part 61, we feel our current procedures and criteria for selecting a site for a near-surface waste disposal facility are consistent with NRC's proposed Part 61 requirements.

The site selection process is guided by certain obvious objectives predicated upon c nsiderations relating to:

1) the protection of the environment and the health and safety of workers and the public;
2) the design and operation of the disposal facility, including effective barriers to possible inadvertent intrusion into the wastes in the future;
3) effecting appropriate closure of the facility at the termination of the active operations at the site; and
4) minimizing the need for long-term maintenance and surveillance of the site.

These objectives ,we feel ,can best be met by a systems approach to optimizing the overall performance of the site during both active and passive operational phases. The systems approach inherently contemplates the ability to effect trade-off's among the natural site characteristics, site design, waste characteristics, operational procedures, closure techniques, and site monitoring, surveillance, and maintenance. The integration of these elements should result in a disposal system that satisfies the overall waste management objectives. Fortunately, the requirements of Part 61 are compatible with a systems approach to constituting a licensable facility through deployment of current technologies.

Site Selection: Generic Approach

Conceptually, site selection activities generally proceed or are contemplated to proceed pursuant to a stepwise or phased approach, somewhat analogous to the process developed for siting a deep geologic repository for high-level waste disposal. The degree of formalization of a structured framework to guide the implementation of these activities can, of course, vary markedly. In any case, one normally starts with a defined region or regions of interest, say a specific state or group of states, targeted for selecting a suitable site for a waste disposal facility.

The target region is then subjected to a systematic screening process to identify candidate areas that merit further investigation. This initial screening would, among other factors, involve those site suitability requirements reflected in Part 61. These are largely site characteristics that common sense would dictate avoiding in siting a disposal facility, such as:

- Areas susceptible to flooding or containing large surface water sources;
- Areas with significant potential for natural resource development or other competing uses of the land;
- Areas of undue geohydrologic complexity and, therefore, difficult to characterize and analyze appropriately; and
- Areas suspect in terms of long-term stability.

There would undoubtedly be considerations important to this screening process introduced by the state or region, e.g. any existing land-use legislation. Chem-Nuclear has, as do others undoubtedly, an inventory of criteria for screening out unsuitable areas for siting disposal facilities. This list of criteria would be augmented, as appropriate, by additional state or region-specific constraints. Moreover, the application of the criteria is based upon use of existing and available reconnaissance-level information.

From the initial or screening phase of the site selection process one would expect to obtain a slate of candidate areas that have met the "thou shall not" criteria and therefore, merit further evaluation against specific categories of siting considerations that include: geology, topography, hydrology, climate, land uses in the vicinity, and transportation and demography. There are detailed technical criteria for each of the categories of siting considerations.

The evaluation of the candidate areas against the siting criteria will be conducted by supplementing existing information about the aforementioned categories of technical considerations with appropriate field reconnaissance studies. In some cases, it may be necessary to augment these efforts with additional techniques for obtaining necessary information for this level of screening about the geology, hydrology and topography of the candidate areas, e.g. aerial photography and remote sensing techniques.

Moreover, the application of the technical criteria for evaluating these areas will take cognizance of any compelling non-technical considerations, such as socio-economic implications of a disposal facility for the area. The technical criteria inherently reflect important considerations for all downstream activities important to the life-cycle of the site, e.g.: detailed characterization of the preferred site; licensing; design, construction, and operation of the disposal facility and any planned supporting activities; closure of the facility; and surveillance and monitoring of the site in the post-closure period.

Completion of the second phase of the siting process should result in the identification of a preferred site for detailed investigation. The objectives of the in-depth investigation of the selected site are to compile the necessary comprehensive data base about the important characteristics of the site through an extensive series of field and laboratory studies. The results of these studies not only facilitate the evaluation of the site for its use in waste disposal, but also provide inputs necessary to the licensing process and guide the design, construction, operations, closure and post-closure efforts.

Chem-Nuclear has developed, as perhaps others have, an inventory of the site-specific data which we feel must be compiled to perform an in-depth evaluation of the preferred site, as well as the types of field and laboratory studies necessary to obtain these data. Having completed this exercise, we feel we have a much better understanding of the program elements necessary to the entire site suitability screening and site selection process pursuant to current requirements and related considerations.

We may, and probably will, be making some revisions to the data base requirements and techniques for obtaining the data as greater understandings evolve about the application of Part 61 in the licensing process. For example, as NRC provides additional information about the methodology it intends to use for evaluating the long-term performance of a proposed disposal system and the requirements of that methodology, we may find it necessary to modify some of our analysis and data requirements. I suspect any such changes would relate principally to quality of data.

Site Selection: Additional Considerations

The site selection process which I have described is designed to identify a single preferred site for in-depth characterization and evaluation. It is our understanding that this approach would satisfy the intent of Part 61. However, I sense there is some confusion about this point, having heard references in recent meetings by non-regulatory representatives to the need for detailed characterization of multiple sites to satisfy the licensing process. Early clarification of NRC's intent on this issue would be most helpful. Obviously there are significant time and cost differences between the two approaches. In some instances, depending upon the relative geohydrologic complexity of the target area, it may be deemed prudent to perform additional characterization of multiple sites in order to enhance the probability of success in having one acceptable site. It is important to know whether multiple site characterization is a requirement or left to the judgement of the applicant.[1/]

1/ Since preparing these comments, I have had an opportunity to review the DEIS in support of the proposed Part 61. The discussion in this document of site selection activities indicates that detailed investigation of a site is required only for that site selected for the proposed disposal facility.

Another element of uncertainty about the licensing requirements with respect to the site selection process relates to the body of information developed and used in the process leading to the selection of a site for in-depth evaluation. Will this type of information be required by NRC in support of the license application? If so, insights are needed promptly about the types of information and level of detail required from the phases of the site selection process leading to the identification of a site for detailed characterization.

There has been interest expressed in obtaining more explicit insights about the type of information needed by NRC in response to the disposal site suitability requirements of Section 61.50(a)(3) and (4). These requirments pertain to evaluations of candidate sites in terms of projected population growth and future developments and of existing economically significant natural resources.

Those elements of the proposed Part 61 that address waste classification and the technical requirements relating to the waste characteristics for each of the waste classes have generated considerable interest in industry circles. It is not my intent today to discuss the relatively numerous questions and concerns inspired by these portions of Part 61; NRC has undoubtedly received extensive comments from industry on this subject. I would, however, like to make a few observations about the waste classification requirements that pose potential implications for facility siting activities.

The technical requirements of Part 61 establish upper limits on the concentrations of specific radioisotopes and of chelating agents allowable for disposal in near-surface disposal facilities.

NRC has indicated that its analyses, based on assumptions about deployment of treatment technologies, indicate that no more than 1% of the volumes of commercial low-level wastes generated will exceed these requirements and necessitate disposal by means other than in near-surface facilities. There may also be upper limits on the inventory of selected isotopes that may be disposed of in specific facilities. There is some concern that a significantly larger volume of wastes than that estimated by NRC may exceed these limitations in the relatively near-term due to possible increased use of volume reduction technologies, to possible increased concentrations of isotopes from leaking fuel elements, and to possible increased employment of chem-decon technologies.

Should these initial industry guesstimates, supported by more detailed analyses than exists today, prove to be more credible than NRC's projections for the waste volumes that exceed the waste classification limits, one may wish to expand his siting criteria to include those requirements relevant to land disposal facilities other than near-surface. This suggests the desirability of having early guidance from NRC about site suitability requirements for land disposal facilities for emplacement of wastes exceeding the waste classification requirements of Section 61.55.

Section 61.51(a)(7) provides that the disposal site shall be used exclusively for the disposal of radioactive wastes. Perhaps this restriction is designed to exclude the colocation of operations for disposing radioactive and non-radioactive wastes, such as chemical hazardous wastes. It might also be interpreted to prohibit radioactive waste management operations at the site other than those directly relating to disposal of the wastes. The interpretation of this requirement could have potential implications for siting objectives and criteria.

SUMMARY

The technical requirements governing disposal site suitability for near-surface disposal facilities of proposed Part 61 (Section 61.50) are not, in my judgement unduly restritcive for selecting suitable sites based upon my present understanding of how these requirements would be implemented. It appears reasonable to conclude that sites satisfying the technical requirements of Part 61 and acceptable for deployment of existing waste disposal technologies can be identified for near-surface waste disposal facilities in the currently postulated waste compact regions in the U.S. (The challenge posed by the likely non-technical requirements may be more formidible.)

There are certain implications of Part 61 for which formal clarifications by NRC should facilitate the site selection process of potential license applicants. It would be helpful to know what NRC considers to be acceptable models and analytical methodology for evaluating the long-term performance of a proposed disposal facility and site. The demands of these analyses on the type and quality of data required could influence the site selection process.

There should be a clear understanding about the level of evaluation required by NRC for several candidate sites leading to the applicant's selection of a proposed site for the license application.

It will also be helpful to have additional NRC guidance at an early date on the following Part 61 requirements or their consequences which have potential implications for the site selection process:

1) Identification of acceptable options for land disposal of those traditional low-level wastes which do not meet the proposed waste classification criteria; and
2) What constitutes adequate 500 year barriers to inadvertent intrusion into the disposed wastes (as an alternative to deeper disposal which may not be a preferred option in some areas).

POLITICAL IMPLICATIONS OF SITING

Philip F. Gustafson
Illinois Department of Nuclear Safety
Springfield, Illinois 62704

ABSTRACT

The political and social climate in Illinois in regard to siting and operating a new LLW disposal facility is fairly typical of that in any other state which is a major producer of LLW, and is not eligible to be a member of a regional LLW compact which already has an operating LLW disposal facility. There are several options open to Illinois including joining a compact or going our independent way. Details of these options will be discussed. The rapidity of development of a new LLW site in Illinois, and perhaps in the region, will depend upon substantive progress in the decommissioning of the closed LLW facility at Sheffield.

Illinois is proposing to form a Site Selection Review Committee which will oversee the siting process and will propose incentives for a potential host community. In conclusion the probability of developing a new site within the 1986 time-frame will be discussed.

POLITICAL IMPLICATIONS OF SITING

The technology is available for the proper management of LLW from generator to final disposal. 10 CFR Part 61 presents a systematic approach to the siting design and operation of a LLW facility keeping decommissioning and long-term care in mind from the start. Although the trauma of developing a new LLW facility lies at the front end, experience to date indicates that the real uncertainties -- including financial, lie in the post-operation perpetual care phase.

In developing a new LLW site the stark reality is that no one wants it in their backyard, community, or political subdivision. Such public reaction is not limited to LLW but covers the spectrum from sanitary land-fills to HLW and sewage treatment plants. Such reaction is part of the evolution of societal environmental awareness, an awareness now focusing on the future impact of today's actions. That todays garbage dump may haunt us for decades syndrome.

Be that as it may, as a nation we have a LLW problem. We would need additional LLW sites even if the National LLW Policy Act did not exist. As a state which is not eligible to join a compact with an operational LLW site, Illinois accutely shares in this problem. Illinois in a sense represents on a macroscale the national problem, with some unique aspects thrown-in. We are a major LLW producer, the bulk of which in terms of radioactivity rather than volume, comes from nuclear power generation. Hospitals, industry, academic institutions make up the remainder. Our nuclear generating capacity is first among the 50 states, and our total LLW volume generation is among the top 3 or 4 states annually.

We have closed the LLW site at Sheffield which contains about 3 million cubic feet of waste and is in the process of being decommissioned. There is a school of thought in the state that holds that if you have had an active LLW facility you have paid your dues already. We also have at GE Morris the only AFR licensed not only to store the fuel already in the facility, but to accept more for storage. Morris is approximately half filled to capacity. Sheffield and Morris make for a social and political climate that is not overly condusive to development of a new LLW site.

Faced with the 1986 deadline for new site development which will be difficult to meet under ideal circumstances, there appear 4 options open to us. First, to stop or materially reduce the generation of LLW. The hardship involved in the loss of benefits far outweighs the hardship of developing a new site. The option is unreasonable.

Second, do nothing hoping Congress will modify the Act, or DOE will accept commercial LLW, or that some act of God will get us off the hook. This option is irresponsible.

The next two options are feasible and responsible we believe. The third is to develop a site for Illinois generated waste only. Our generation appears adequate to support such a program. It would involve not only state ownership of the land, but for legal reasons probably also state ownership and operation of the entire facility.

The fourth option is to help form a LLW management compact, join the compact, and use the LLW management facilities provided under the compact.

We are currently pursuing the third and fourth options. To follow either option, however, we need up-to-date site selection and operating criteria, as well as a sound method for financing the entire operation including closure and long-term care.

In 1963 the Illinois legislature passed what was called the Radioactive Waste Act of 1963 which authorized the Department of Public Health to acquire land and to operate or contract for the operation of a low-level waste burial facility. This is the law under which the Sheffield facility came into being.

This authority now rests with the Department of Nuclear Safety. Although there is proposed legislation which would modify this authority by requiring that the Legislature approve any new LLW site selected by the Department.

Because the 1963 Act is rather primative by today's standards and we have issued proposed rules in the Illinois Register, proposed rules for the siting, the design, construction and operation of a low-level facility in Illinois. Our proposed rules largely adopt the principles of Part 61 but provide for some flexibility in terms of local needs as far as the State is concerned.

Along with issuance of proposed rules we also issued what we termed the criteria which we feel a commercial operator should meet in terms not only of financial capabilities but technical competence and experience. This commercial entity could be either the facility operator, as was the case at Sheffield, or it could be literally a partner with the State.

Along with the issuance of these rules we printed a map from a recent publication by the Illinois State Geological Survey. The map came from a document entitled "Regions of Illinois Suitable for the Shallow Land Burial of Hazardous Waste." There is a statement in the report that included in "hazardous waste" is low-level radioactive waste. The map describes four fairly broad regions, two in the central part, two in the southern part of the State, and also there's another caveat in the report which says that this map does not mean that there are not regions in other parts of the State that may well be suitable for shallow land burial.

The map has provided fuel for a good bit of excitement, particularly in the southern part of the State. Illinois is basically divided in two parts: Chicago and the rest of the State. And Chicago has threatened on occasion to secede (and there are some people who would like to see that happen). The southern part of the State does not relish the thought of taking the waste that is really produced to the benefit of the northern part of the State.

There are also other groups that take great satisfaction in seeing that northern Illinois does not have a circle any place that indicates, according to the map anyway, that there are suitable sites there. We have explained to anyone who asks that there is no rural area on the map that has a free pass yet.

Part of the proposed scheme in Illinois, in addition to the actual siting criteria themselves, is the creation of a Site Selection Review Committee which will include two members of the Senate, two members of the House of Representives, hopefully one of each political persuasion from each House, representatives from the generators, principally the utility industry and the hospitals, representatives from other involved State agencies such as the Illinois EPA, the Illinois State Geological Survey, the Illinois Commerce Commission (which may have a role in rate setting, fee setting), and the Department of Transportation.

There will also be representatives from the public on this Review Committee, and actually here we're breaking the public down into two segments. One segment is public interest groups: the League of Women Voters, Citizens for a Better Environment, etc. The other public entity involved will be people from the regions that are under consideration. This would mean then that if one were considering an area in the southern part of the State and an area in the northern part of the State that there would be different representatives, or at least there would be representatives from both of those regions present on the Review Committee.

We are also examining various incentives which might be made available to a local community or other political entity which agreed to host a LLW disposal or treatment facility. These incentives might be in the form of reduced taxes, road improvements, or upgrading local school, fire, and police facilities. There are also possible incentives at the state level for a state which hosts a disposal facility for a regional compact. Here such things as direct financial aid to assist in prison maintenance, or flood and erosion control. The state-level incentives might take the form of reduced LLW burial fees for radioactive materials left over from a now defunct (bankrupt) operation. The type of incentives and their application would be specified and approved by the Site Selection Review Committee.

Another activity that Illinois has been involved in is helping to develop a Midwest compact. There have been 13 states participating with "Midwest" defined as running all the way from Ohio on the East to the Dakotas on the West, and from Kentucky to Minnesota.

As an aside it should be mentioned that the trigger mechanism for getting these states together came not from any of the states involved but from a letter from Governor Riley of South Carolina to the Governors of the States asking them to send representatives to a Low-Level Workshop in Dearborn, Michigan, last June. As a result of that gathering, this group has begun to jell, and we were recently joined by three mid-Atlantic States at our last meeting. We are to the stage where we hope to have the legal language worked out for a draft compact some time early in calendar 1982.

Even under the most optimistic curcumstances, if the LLW siting climate were totally favorable, anybody starting a new site today is going to have a very difficult time making the 1986 deadline. In Illinois we expect to start the actual preliminary screening process early next year.

If we can avoid the situation where an actual site (or three or four sites) are identified and any real detailed work starts, until after the election, the whole process can be greatly depoliticized. This is something which cannot be minimized or overlooked. As a scientist I have difficulty accepting the fact that election dates have a tremendous influence on what we do as a nation.

In conclusion we are approaching the problem -- in the way that we as scientists know how to approach it, namely, on technical bases. But really all the geological, hydrological, and demographic criteria are going to be bent in the direction of those places that seem to have some local receptivity to accepting a site.

I don't know how you quantify this. I don't know how you really get such local receptivity, but unless and until this kind of thing comes to pass, we are not going to have a new low-level site in Illinois.

DISCUSSION

B. Fish: I have a comment on how you can gauge public opinion of the most receptive public. You count the bullet holes in the State car, and the smallest number wins.

R. Wood: With regard to the receptivity issue, have you ever thought of the idea of putting the matter out for bids? That is, presumably if you pay any community enough they'll take it.

P. Gustafson: I've thought of that one, yes.

R. Wood: Are there ways, in your view, to turn the issue around from the thought, "No, it cannot be here," to the idea of "What will it take to make it acceptable here?"

P. Gustafson: Yes, I think that there are ways. Not being totally facetious, in some ways bidding might not be a bad way to go, once people got a feeling for what is involved.

I told Governor Thompson a few months ago that when it came time to make the choice there were going to be six or seven places that were going to be crawling to his door, wanting to get there. And he said, "Oh, God, I hope so."

But there are benefits to a community, in my opinion, and there are regions in Illinois which are economically depressed. We've got a lot of coal, but we're not mining it because it's too high in sulfur. A well-run low-level waste management operation is going to employ 100 to 200 people. The bulk of these people are going to come from the local community, and it is going to mean jobs to that local community, and it's going to last for 30 or 40 years.

That in itself is something that I think some community leaders would like to see happen. In addition, there will be purchases of the material to run the operation from the local community. So I believe it's not all bad.

R. Wood: Have you come up with any ways of conveying this and getting that kind of a thought out on the table to people who might seriously entertain the motion?

P. Gustafson: What I have done recently, at the Governor's suggestion is visit various editorial boards of newspapers around the State, and this is one approach that I have discussed with them. As you might imagine, I've gotten a mixed reaction.

Some of them feel that that is an appropriate way to approach such things--be positive about it. Others merely say you're trying to buy them off. It was said here earlier that you can buy anything in this country if you go about it right.

But I hope reason will prevail. I hope also that it is approached in our State, as well as in other States, on a bipartisan basis so it doesn't really become a political hot potato--but that may be too idealistic for reality.

PANEL DISCUSSION TUESDAY AFTERNOON

The panel discussion section has been edited and represents a summary of the technical questions and responses. Also questions and answers addressing the same categories have been grouped together.

The panel discussion has been recorded in its entirety and a transcript is available from the U.S. Nuclear Regulatory Commission.

The panel consisted of:

A.L. Lotts - Chairman, Oak Ridge National Laboratory, TN
G. Bradley - Chem-Nuclear, Inc., Bethesda, MD
P. Gustafson - Department of Nuclear Safety, Springfield, IL
B. Fish - Low-Level Radioactive Waste Program, Frankfort, KY
R.D. Smith - U.S. Nuclear Regulatory Commission, Washington, DC
M. Barainca - U.S. Department of Energy, Idaho Operations Office, Idaho Falls, ID
G. Yuan - Washington State University, Pullman, WA
G.L. Meyer - U.S. Environmental Protection Agency, Washington, DC

R. Murray: What connection is there, if any, between the present plans to modify 10 CFR Part 20 and the status of 10 CFR Part 61?

The problem of waste disposal is affected by the change in regulations on dose as based on new ICRP documents.

R.D. Smith: There is a very direct connection between 10 CFR Part 61 and planned modifications of 10 CFR Part 20 in that one of the performance objectives relates to occupational exposures of workers being controlled by the limits given in 10 CFR Part 20. If 10 CFR Part 20 limits change, that will affect the rules under which site operations have to be carried out. It is not sure how 10 CFR Part 20 will be revised. If the 10 CFR Part 20 approach is changed to the whole body dose equivalent following the recent recommendations of ICRP, it i likely that the numbers we use now for whole body or critical organ would very likely conform to the whole body dose equivalent approach.

K.L. Ross: We have discussed some incentives for local communities to host a low-level waste facility, and some of the benefits that might be derived through hosting such a facility. What other mechanisms can be used for obtaining local acceptance for a low-level waste site?

G. Yuan: There's a real Catch-22 in incentives. If done well, you would not expect large, adverse impacts from radioactive waste disposal to a local community. We're all acting on the premise that we can manage radioactive waste safely. On the other hand if you provide monetary incentives to a community, you're implying that the impacts are so adverse that we have to pay people to allow disposal grounds to be built and operated. It's not like a local shopping center where the benefits are obvious. That's a problem because the necessity for incentives will come up in the conflict or in the discussion of benefits, especially if you couch it in monetary terms. It is difficult to determine how to gain public acceptance.

It's the kind of problem which, over time, is solvable. What is required is that the very first site that comes up for licensing must be handled well, not only technically but with a real effort to discuss it with the public so that people don't cc out with a feeling that they have been co-opted, and, therefore, are able to use that experience in educating other communities about how not to get co-opted the way they were.

The public has experienced a lot of negative things and is falling back on those negative experiences to justify its opposition. Until we provide positive experiences, they don't have any way of justifying a positive attitude either.

P. Gustafson: I would like to have a little better definition of "co-opted." In some encounters in the State of Illinois with concerned citizenry, we get to the point where they begin to understand what the realities of various problems are, and they may feel ultimately co-opted.

With one individual, I could see that person's mind turning almost in saying, "Oh, oh, now I understand and now my position is untenable.."

G. Bradley: We may be talking about potentially at least two tiers of incentives.

We have progressed in recent times to a certain level of acceptance and an effort is underway to develop regional approaches. Some of the first things you hear in negotiating compacts almost invariably seem to assume that an element of the compact would have to address the question of a potential incentive package to the host state or region or locality in that region if it were to accept the disposal facility.

There may be one set of issues or options at that level. A better development or identification of a waste management plan or strategy for a region is needed that provides not just for the consideration of a low-level waste site in isolation, but for a number of other waste management capabilities that are perceived to be needed in the region. There may be other onerous types of activities that need to be sited in the region, such as chemical hazardous waste management disposal facilities.

In other words, there may be quite an inventory of these sites and facilities that have some similarity in siting difficulties that provide the State administrations the opportunities to get into their horse-trading at the State level within a regional context. This would put into sharper focus the need for the kinds of incentives that we have talked about here, the financial packages or the incentives for individual localities.

The second tier of incentives may or may not be influenced by this regional horse-trading about what may be required by way of incentive packages for localities. That particularly looks to be an important factor for consideration if you haven't addressed the first tier of considerations.

You have to provide those Governors with a salable and marketable package to carry to their constituents. It affords some level of comfort to be able to talk to them about the kinds of quid pro quo's that can be developed among the participating states that may assist selling that package for a low-level waste disposal site or whatever facility you're trying to sell.

G.L. Meyer: One can probably site a facility satisfactorily from a technical point of view using a mix of good site characteristics and technical improvements such as waste and engineering barriers. But radioactive wastes, hazardous wastes and just plain old garbage have a bad odor to them. People try to avoid things that seem to be unpleasant. How do we persuade people to take responsibility for some of the unpleasant things in life? It is probably much more dangerous and unpleasant to avoid siting a reasonably good facility, the best we can do today, and trying it out with reasonable assurance of success than to keep this large pool of waste moving around the country or in storage.

A.L. Lotts: At the risk of not being impartial, as I'm supposed to be, I would like to make this remark about bribing the public. People do things in this country for two reasons. They do it for love or they do it for money. You have to rationalize which one they're going to do it for. You can get a whole lot done with money that you can't get done for love.

Maybe one ought to think about financial incentives and bidding system, as suggested during the luncheon.

In Knox County, when we have to get a new garbage disposal site, we pick on the politically weaker part of the county, or we pick on the county next to us. It is not a very good system and I think we could do better than that by creating an institution or procedure to do it better.

J. Fowler: There is evidence to suggest that a mix of incentives is effective. At Lyons, Kansas, enough trust was built up in that community during Project Salt Vault and there was enough realization of benefits of continuing the project and building a repository that in 1972 when the AEC got booted out of Kansas, the people of Lyons still wanted the repository. In 1981 they want it as a low-level waste disposal site.

A similar situation occurred in Hartsville, Tennessee with a reactor. In a study in Wisconsin, it was found that 23 percent of the people polled would change their mind about the location of a high-level site if monetary incentives were provided. Another 21 percent would be persuaded by that plus a free flow of information. About 60 percent would be persuaded by the first two, and some sort of say in the process.

So there is a possibility of combining the incentives -- I wouldn't call them incentives, but developing the process.

P. Hunter: There are many of us in the scientific community that feel that we really have no major technical issues with respect to low-level waste disposal and that it remains more a problem of implementation, than one of research and development and resolution of issues.

In terms of implementation, there is a communication gap or an understanding gap that exists between the public sector and the technical community. We have technical people saying, with some good reason and justification, that the problems are not major, that the problems are resolved, that we can get onto the business at hand of disposing of low-level waste. On the other hand, in the public sector we have some people saying that we're deceiving the members of the public by underestimating the danger and the risk of this material and that there's a much greater hazard that we don't want to tell them about.

So you have this communication or understanding gap, my question is what do we have to do when we want to share all the information we have and yet we miss the bout in presenting our case to the public?

G. Yuan: I think again we're suffering from an inability to define accurately who is the public. In the example of Lyons, Kansas, we have local community acceptance. But I'm sure that we could still identify sectors of the public who would be opposed to that activity at that site.

Part of the communication gap is identifying who you want to fill the gap with. If you're convincing a local community that this activity, be it radioactive waste disposal or something else, is going to benefit them, then you have a specific goal which you can achieve.

Getting rid of all opposition to radioactive waste disposal in this country from any sector of the public is an unreasonable goal. It is unreasonable to think that through education alone the entire country will give full support to development of nuclear power and radioactive waste disposal. There is always going to be some opposition, and it is doubtful that education overcomes opposition.

However, if it's true that radioactive waste disposal from a technical point of view, can be safely accomplished then through education you can convince a local community to live near a radioactive waste disposal site and expect to see no tremendous increases in cancer rates or whatever it is that is really being feared by that community.

It is unreasonable to anticipate that closing the communication gap will somehow get rid of opposition or dilute opposition to the point where you won't see it again.

The short answer is that working with the local community is in some ways a lot easier than expected. The kind of opposition that people have been referring to has been a much larger political force which we can maybe characterize as an antinuclear position, and that is a very difficult one to try to overcome through an educational process.

K.L. Ross: Another point, in terms of making low-level waste siting more acceptable in a local community, is to remind the community that it is not directly related only to nuclear power and elecrical generation. Low-level waste is generated from a number of other activities, many of which society generally favors, particularly radionuclear medicine and radiopharmaceuticals, so try to break it out of just the nuclear power mode.

G. Yuan: Of course, that is what is being attempted in the State of Washington through the recent initiative to ban disposal of nuclear power waste and not other forms of radioactive waste.

As a technical person, that really seems to me an unreasonable solution to the problem. As a political question it's an obvious solution. I think it's what most of the nuclear community thinks in terms of now. They recognize that, nationally speaking, an average of 50 percent of the low-level waste is generated from sources other than commercial nuclear power plants, and they are willing to accept facilities which would dispose of that waste exclusively.

I agree that it's a short-term political solution, but I don't really think that it gains us something in the long-term.

A.L. Lotts: Have you some suggestions as to what types of things need to be done in order to gain acceptance?

G. Yuan: The concrete suggestions I can make are related to some very limited experience in doing research with acceptance of hazardous facilities in rural communities. The kinds of mechanisms that have been used there have been entering a community fairly early in the process of trying to develop a site. Obviously it's hard to define when "early" is.

At some point you decide you are fairly certain you would like to site a facility in a locale. Then you can approach whatever concentrations of population there are near the site. You must identify the leaders in the community such as the local political leaders, the editorial writers in the newspapers, the mayor, the City Council people. Have discussions, active participation and workshops with them as to what is being proposed, what the options are, whether there are further options, what the alternatives are to doing things the way that you, the company or the applicant or the Commission would like to do them. Then identify sources of conflicts, questions, and problems. In many cases, there won't be that many problems at a local levcl if what you're proposing can be identified as safe, if you can educate people about why it's safe, and if it will have positive benefits for a rural community or a community that may need jobs and would like the influx of income and activity.

There has to be an early identification of any sources of conflict. Once things are underway, and people have thought about it more, they may change their minds. They've read other things. Some outside agitator or someone else is coming in with information that changes people's minds.

Continuous contact akin to the kind of informal process that goes on between an applicant and the Nuclear Regulatory Commission now. For example, if someone plans to apply for a license, they go to the Commission and get the regulations. They ask for clarification of points, with informal questions: this back and forth clarifies things before they get to a formal stage.

That's what the public is asking for. And so we're going beyond what we would classically call "education." It's not just a matter of handing out pamphlets or writing articles in the local newspaper, but an interactive process in which everyone is being influenced by each others' opinions.

A lot of people would say that ultimately anyone who is proposing a facility and entering this type of situation has to be prepared to walk out of it without what they want. That's a very difficult thing to accept. I'm not sure it's something that I could support, understanding the economics and the need for radioactive waste disposal. But it is something that could happen and, you know, if you're prepared to enter a community and to really enter into an interactive process, you have to also be prepared to walk away without your facility.

B. Fish: From our experience at Maxey Flats, whether you are a con man or a true public servant, you're going to find at an early stage that before you can sell whatever you have to sell, you have to have credibility. Let me tell you where we stand.

When Maxey Flats was shut down in 1977, we collected less than $300,000 on that site. That's ten cents per person in the State of Kentucky profit that we had made off that site. To date it has cost us close to nine million dollars, or about $3 per person. Thus, we've made a negative profit of about $2.90 per person.

If you come into Kentucky or any other state that has heard of Kentucky and of Maxey Flats and tell them that you're going to make a profit without having resolved this outstanding problem, you won't have credibility.

In World War II we managed to win a lot of battles by bypassing pockets of resistance, but you can bypass Sheffield and you can bypass Maxey, but when you try to get the public to believe that your technology will work, and that your resolve will work, without having addressed these oustanding problems, you're going to have a credibility problem.

Resolving outstanding problems should be one of the first places to start in trying to establish credibility with the public. I haven't seen any movement at all in 10 CFR Part 61 or in the enabling Act for the regionalization of sites, nor any other public statement on resolving the outstanding problems of the existing shutdown, but not decommissioned commercial, sites. They are part of the credibility problem.

P. Buckingham: In the hazardous chemical waste management business, the approach has been to try to enter the community early. In that case the private sector attempts to do it, and if they announce these plans they find it very difficult later on, when they've chosen their site, to reach an agreement to purchase the land from an individual after it's become a very heated point in the community.

If the State then comes in and attempts to do the same thing, the public is skeptical because they wonder who is going to watch the State? The State makes a number of promises, and if something goes wrong the State would never admit that they were at fault.

P. Gustafson: We are continuing to look at the option in Illinois of operating our own site, and one reason for doing this is that in meeting with political types and the citizenry as a whole, they have reservations about the federal government, about the state government, and about industry. Emerging from this seems to be the fact that the least undesirable of the three is the state. So the credibility factor creeps in.

I would certainly hope that the state would be able to maintain that position, but there are things in the past that the State of Illinois, and I'm sure other states, have done, that make one ask questions.

J. DiNunno: We have talked a great deal about incentives to have a repository located in a locale. These are incentives that pertain to the public. Why should they accept a repository in a particular locale?

But I've heard very little in terms of incentive as to why the industry should proceed down this path, given the uncertainties the schedules and the headaches that locating and actually developing a site really entail.

The pace of legislation that has been going on -- the spectrum ranges from Texas, which has a waste management authority authorized with the requirement that they develop a site, to most of the states that appear to simply be developing legislation that will allow, an industrial facility to come into their state -- suggests that most think that all they have to do is open the floodgate and industry will immediately pounce on the opportunity.

It isn't that clear. With that sort of a background I would like to have Glenn Bradley talk more about the uncertainties that industry sees in collaborating with the state.

Phil Gustafson, from your discussions with the industry groups, what do you see that a state can offer in terms of assurances to have industry put up the tremendous amount of front-end capital that would be required before the first drum of waste would ever be put on a site?

G. Bradley: I rather superficially alluded to some of those uncertainties this morning. Obviously, the incentive for private industry is to make a profit on the business undertaking.

If there is no reasonable potential for profit in a viable business undertaking, then there will be difficulty getting private industry to take a very aggressive role in committing its resources on a risk basis. Circumstances have changed in recent times as contrasted to the conditions or circumstances under which the earlier commercial sites were established. Part of that uncertainty relates to a better understanding of what the respective roles of the parties involved in the process might be on a state-by-state or region-by-region basis, and certainly that of industry and what it's being asked to bring by way of risk resources to the undertaking. Industry needs some opportunity to assess the strategy and some frame of reference has to be established in order to draw certain conclusions about the probability of success and the viability of the business undertaking.

That may be quite different from region to region. There are some very real questions about how the states or the regions that have asked for the responsibility of managing their wastes and have been supported by the enabling legislation to facilitate arrangements under which they wanted to proceed to take that responsibility, to develop their strategies, and discern what roles they expect industry to play, if any. This could range from establishing some very general framework at the front end to essentially turning it over to the private sector to take the risk and provide the resources and the wherewithall to select the sites and move it through the licensing process, at the other extreme.

Each of these represent weightings about how that looks to the industry and its interest in participating in the whole process.

We need an early definition of strategies and roles for the players in the process, which inherently then begins to identify the advocates for the process and what role they plan to function in as advocates in trying to move the process to its fruitful conclusion.

Right now many of us in states and industry feel that our hands are a little bit tied in the absence of having some of these front-end things sharply defined and focused, and the advocacy role really defined for the areas of participation.

Moreover, some of the attitudes on the state-only approaches, depending upon the regions to be served and the volumes projected, raise some economic viability questions.

Those are generally the factors and the considerations but you have to approach them almost on a case-by-case basis in a negotiation of the potential players in order to define the interest in partipating and what the limits of that participation might be.

Obviously industry is very interested. In fact, you see it escalating across industry to a very great extent, but I don't think many are in a position to really do the level of assessment or evaluation to reach that final decision for a specific undertaking. They don't know whether or not they're that interested in participating under the ground-rules that may be negotiated with the governmental entities that are involved and, obviously, in today's environment are going to take a very active role in establishing frames of reference under which these undertakings will proceed.

That makes a lot of these issues, such as public acceptance, how you approach localities, incentive packages, all rather vague as to a strategy for approaching a particular region with the intent of trying to establish a facility.

Somebody talked about the impact on prices of land, or access to it. That's all a function of strategies and who is playing what role and under what frame of reference you're approaching the problem.

Until you can get a better handle on some of the front-end elements of the process, it's very difficult to talk in definitive terms on optimum strategy for a particular region.

For any region that is contemplating doing this, the development of a coherent overall waste management plan and strategy is a very important first ingredient. It facilitates the whole process, including the ability to complete the compact negotiation process through the state legislatures.

You have to be able to talk in fairly specific terms about the degree of challenge in the waste management area for the target region, the waste management capabilities you plan in that region, the waste management capabilities you plan in that region as a part of the process of being able to push these compacts through the legislatures and ultimately through the Congress.

Without it, it's very difficult to provide the level of comfort or the warm feeling in the legislators that you really are on top of the situation, have assessed the issues, and have developed the strategy for addressing those issues and resolving them in an appropriate way in the best interests of the region.

There's piecemeal movement in that direction, and maybe they feel that's as far as they can go. They know better than I what their constraints are.

It makes it very difficult to come down to the fine-tuning of the roles of the players and the kinds of incentives that are there for those players in the roles that are being prescribed for them.

P. Gustafson: To be successful in developing a new site, in whatever state it is, there has got to be a strong, earnest and honest participation on the part of the state bodies that have such authority or need.

The State of Illinois solicited some interest on the part of industry in developing a site in Illinois, either for our own use or for the use of the Midwestern Compact. We have gotten a healthy response, but this is only interest, not signing on the dotted line.

If I were a commercial entity, if the state were not interested, I would not be interested either because there are considerable risks involved, financial risks and others.

One of the problems that we have in the State of Illinis is the front-end financing of site development. The Department of Nuclear Safety has essentially no money budgeted for site selection/site development. The financial climate in Illinois is not one where we are going to go to the legislature this coming session and ask for money to do that.

There is a generator community that is willing to put in front-end money, but there's a problem in getting that front-end money into the state system.

There is also the matter in the long-run of fees, and if it is going to be an industrial/commercial operation, there should be a profit in it. Different segments of society are going to look at that differently.

In the past in Illinois the fees that were set for burial did not really include the long-term care to a sufficient degree, and the fees were fixed and the operator then had to make some trade-offs in terms of how the money that they were collecting was used.

One of the things that we've been discussing is, "Should we pay a management fee to a commercial operator so that they don't have to worry about any of the other exigencies?" The state will take care of those things.

Another feature is that to obtain and maintain public credibility, you must have competent, qualified personnel running the operation. One of the problems that the State of Illinois has, and I'm sure it is shared by our sister states, is that state salaries are not competitive with industry and it's difficult to keep good people because they get more money working for industry or for federal agencies.

The regulators frequently discuss problems of those they regulate, but they don't communicate as frequently or with equal intensity with the general public, and I think this should be done.

In this whole matter of site development it behooves the states or the compacts to keep up a running dialogue with the segment of industry that we are likely to be partners with, so that we try to resolve some of these things. It's a multifaceted problem and there are all kinds of way to go.

There probably isn't a truly "right" way, but there must be an optimal way, and I hope we can find it.

H. Althouse: The local communities where U.S. Ecology operates sites and those where we had operated sites have supported us, with the exception of a few individuals.

A real estate survey in Illinois revealed that in the sale of land near the Sheffield site, the fact of the site's existence never even came up in any of the transactions. Land values there have steadily increased immediately adjacent to the site.

Many of the local populace have toured our sites and have had their questions answered. Now obviously we can't extend that same courtesy to the whole U.S. population. But Dr. Gustafson had touched on a solution to the education problem and that is the use of organizations such as the League of Women Voters, the Sierra Club, the Audubon Society, the Isaac Walton League--organizations of long-standing and good public credibility. The education of the people may best be carried out by those long-established citizens organizations once their questions have been answered.

Instead of direct incentive payments, or maybe even in addition to direct incentive payments to the community, perhaps funding should go to support the publicity efforts of properly informed public interest groups.

M. Barainca: The Department of Energy has two elements in its program. The defense activities of the existing DOE sites and the commercial program for assisting the commercial sector with the waste, primarily through demonstrations and technology transfer. DOE also has as a grants programs, to assist the states that request it.

Several grants are in place and some of the grants are being processed.

The State of Illinois and the Midwest group have come to the Department of Energy for assistance with some front-end planning for the compact. DOE plans to support that activity.

In the information area, there is not one single public but there are several publics. Each group seems to communicate best with its own members. Recognizing this fact early in the program, EG&G set up a program review committee that is comprised of members from industry, state representatives, universities, and intervenor groups. This group has provided a good perspective for the program. One of their first thrusts was identification of the problem of communication with various publics.

Since that time we have initiated a series of documents to provide information to the public. One is a series of briefing books to assist the states, which identifies the amount of wastes that exists in the states, and the issues within the particular state. The briefing books are complete.

DOE has also assisted with strategy review and issued a strategy document in August. This was commented upon by a Conference of Mayors, the National Conference of State Legislators, and the National Governors Association. Many of the recommendations from this strategy review were considered during the promulgation of public law 96-573 in December, 1980.

DOE has conducted information studies in various sectors. The American College of Nuclear Physicians prepared a series of videotapes which are interviews with various physicians, describing issues related to low-level waste. DOE has funded the American Planning Association, which has representatives here, and the State of Wisconsin was funded for a siting criteria exercise. Other DOE funding has been for biomedical waste procedures at the University of Maryland; a conference of National State Radiation Directors; and a variety of other university activities.

DOE will provide a series of pamphlets, which are not available yet, for the public, such as "Planning State Policy" and "Involvement in the Public Planning Process."

These documents are the companion documents to the DOE technical handbook and will provide both a "technical portion and an institutional portion."

Most of these activities have involved state agencies and we're trying to provide this material to other states. While much of the material hasn't been approved by the Department of Energy for general distribution to the public, it has been made available to the various states.

We are in the process of revising our distribution list to make them more useful to the public. Our program is one of trying to inform the public. When the public is informed, they make better decisions.

R. Diehl: The question I have is related indirectly to site suitability requirements. There are waste classifications set up in 10 CFR Part 61. How are these classifications of segregated waste, stable waste, and intruder waste related to the DOT requirements and their classifications, or has anyone taken this into consideration?

R.D. Smith: The waste classifications of 10 CFR Part 61 are normalized to a constant exposure risk to an intruder under several different scenarios. The classifications in the DOT/NRC regulations are normalized to protection of vehicle operators and of people along the way. Thus, the two classifications are different because they are intended to do different things.

One of the differences is in the area of low specific activity (LSA). DOT looks upon LSA wastes in terms of its risk from airborne releases and would only require a strong, tight container for shipping. Under 10 CFR Part 61 it would likely fall into Class B.

NRC has made no attempt to normalize or correlate the two because there was no particular reason to.

R. Diehl: Will the classifications in 10 CFR Part 61 lead to new regulations on transportation of this material, based on your classifications?

R.D. Smith: It is not sure what the response of the Department of Transportation will be to the 10 CFR Part 61 waste classification. There would be no particular reason to change the shipping regulations simply because you were shipping something that was classified as a Class A, Class B, Class C or high-level waste for disposal.

The principles for protection during transportation are based on package design and limitations on the contents such that the package can be handled like other items of freight. There are a few exceptions in the single-use type of shipment. The contents of the package in terms of long-term versus short-term hazard, is not of particular concern to the transportation people. A Memorandum of Understannding between NRC and DOE assigns responsibility for developing radiation protection standards to NRC.

W. Hipsher: The premise of 10 CFR Part 61 is that it does not conflict with any other regulations. In DOT regulations the definition of "radioactive" is 2 nanocuries per gram. However, the NRC classification has no de minimis quantity; thus there is a conflict with the DOT regulations. Class A material containing less than 2 nanocuries per gram is not required by DOT to be packaged in any particular sort of way.

Further, the A, B, C classification of 10 CFR Part 61 could be confused with the Type A and Type B packages in DOT regulations. There may be the connotation that Class A segregated in 10 CFR Part 61 is equivalent to Type A packaging, and the same with Class B and type B packaging.

R.D. Smith: 10 CFR Part 61 probably conflicts with other regulations. As far as the nomenclature is concerned, Type A is a quantity of material under DOT regulations, but Class A is a concentration under 10 CFR Part 61. NRC has stated that a de minimis level waste is one that is insufficiently radioactive to be of regulatory concern; for example, this includes carbon-14 and tritium contained in liquid scintillation wastes. But in this case, DOT requires a radioactive shipping label on the package of scintillation waste. The hazardous waste site operator cares because he cannot accept the package. Thus, there may be confusion in terminology and inconsistencies among the federal regulations.

W. Hipsher: A recommendation for avoiding confusion might be instead of saying "Class A segregated" say "segregated", and instead of "Class C intruder" say "intruder." This would eliminate A and C and imply the same thing. It is difficult to advise a customer whether or not his waste with one nanocurie per gram is going to be a Class A segregated waste material or not when the DOT regulations do not specify any packaging requirements; they don't call it radioactive.

Some isotopes of less than two nanocuries per gram should be considered radioactive, regardless of what DOT regulations say, but there are no guidelines. And my recommendation is that there be some sort of de minimis quantity in the 10 CFR Part 61 A category because almost everything has carbon-14 and tritium in it and, therefore, would be in Class A of 10 CFR Part 61 unless a lower limit is specified.

R.D. Smith: 10 CFR Part 61 does not establish de minimis levels. Rather, it deals with specific waste streams. Studies are underway to establish de minimis levels for specific waste products and waste streams so they can be handled.

J. Clark: Does the Department of Energy expect to open new burial sites and if not, are the criteria applicable for the existing sites?

M. Barainca: DOE intends to open new burial sites at some of the existing DOE reservations, and DOE criteria will apply. DOE is updating its orders and criterion for use on DOE sites.

E. Helminski: For what purpose will DOE open new sites?

M. Barainca: In most cases it will be expansion of existing burial capacity. Oak Ridge and Richland are considering this at present.

E. Helminski: What I really want to clarify is that this is for DOE waste.

M. Barainca: Yes.

E. Helminski: There is a feeling by some that somewhere down the line, if we don't do our job, DOE is going to save our little fannies. I have been told categorically by the Secretary's office that this is not true at all.

M. Barainca: That's what I understand also.

A. Wegele: The 10 nanocurie per gram transuranic limit has been mentioned. The draft environmental impact statement points out various suggestions as to how one could determine compliance with the concentration limits for non-gamma-emitting isotopes, but there is none currently stipulated for the transuranic isotopes. There is a need for a practicable method to demonstrate whether one is or is not above the limit of 10 nanocurie per gram of transuranics.

R.D. Smith: NRC is presently distributing a Branch Technical Position paper that addresses the subject of measurements to show conformance with the concentrations in Table 1 of 10 CFR Part 61. The basis of this Branch Technical Position is that inferential measurements are acceptable. For example, some measurements are made at a reactor on a reasonably detailed basis to establish the characteristics of a particular waste stream, and after that, inferential measurements are made to show that it complies with the concentrations. That is, a ratio is established between the characteristics that are easy to measure and those that are difficult, and then routine measurements are made of those that are easier. Most of the transuranics are alpha-emitters with not very much gamma or X-ray activity and passive, non-destructive assay is rather difficult. If there were careful control over the composition of waste, and no other gamma-emitters at a plutonium fabrication facility the activity could be measured.

NRC expects to have the first Branch Technical Position on Waste Classification out within calendar year 1982 for selected comment. The schedule for making it generally available for the public will be in about two or three months.

T. Smith: There is likely to be considerable controversy over the standards, and probably a need for clarification of terminology in 10 CFR Part 61. In particular, the rules state that there is to be selected a "region of interest," and it is not sure what that means. 10 CFR Part 61 also says that a number of disposal sites should be considered but no appropriate number is specified. There are no standards specified for narrowing down the number of sites. With respect to population growth projections, it is not specified whose projections are to be used.

Additionally 10 CFR Part 61 mentions nearby facilities which might affect the site's ability to meet certain performance standards, or to be monitored. How in the long-term does the NRC anticipate insuring that nearby facilities don't affect the site's ability to be monitored?

R.D. Smith: The winnowing process for site selection has its roots in the National Environmental Policy Act (NEPA), which requires alternatives to be considered. NEPA doesn't really specify what alternatives or how many. There are some guidelines that say the alternatives have to be reasonable; they cannot be hypothetical strawmen. NRC has attempted to define this process as it relates to low-level waste site selection.

In the legal proceedings attendant to the application from Nuclear Engineering Corporation (NECO, now U.S. Ecology) to expand the Sheffield site, lawyers within NRC advised NRC staff and the Hearing Board that the region of interest could be the whole United States, that NECO should consider the whole United States as the region of interest. The Low-Level Waste Policy Act talks about establishing compacts which, de facto, establish a region. In view of this, some states, particularly large states like Texas and California intend to go it alone. So they "region of interest" is now being defined in terms of compact areas and states.

With respect to the number of potential sites, to satisfy the spirit of NEPA and to satisfy the present thinking of NRC, enough alternative sites should be presented to assure a basis for judgement, but it is difficult to give a specific numbers.

As far as the projections for growth and what happens with nearby facilities, the applicant should use the best demographic information available. You try to pick the least likely site to be in the way of future expansion based on current population trends, foreseeable land use development, and available resources. NRC will evaluate the source and apparent validity of any data or projections used. Those from the applicant's survey may carry a different weight than those of an economic development council with a state, for example.

So I would ask that you send us the best available predictions. There is no guarantee implied that things will turn out the way that we think they will a hundred years from now.

W. Staub: The conventional wisdom of around 1960 was that we should bury the waste in shale, and the thicker the better, based on the assumption of total containment, is that not correct?

G.L. Meyer: The rest of the criteria was that there should be enough land available to accomodate any migration of contaminants, so that releases to uncontrolled areas would be kept within public health and safety requirements.

W. Staub: No one presently feels that that wisdom was correct, presumably based on some bad experiences of the '60s and early '70s. Are we prepared to accept greater releases to the environment now than we were in 1960? Or am I reading it incorrectly?

G.L. Meyer: I think you're reading it incorrectly. One of the major problems with fractured rock -- shale is by definition a fractured rock -- is the inability to predict where contaminants may migrate.

W. Staub: In 1960 it was not perceived as a fractured rock, and was selected because of its impermeability.

G.L. Meyer: It is fractured and it is not impermeable. However, there was migration from the disposal facilities in shale.

An implicit assumption is that if you avoid fractured rock, you're dealing with porous media, something that has some homogeneity, some porosity and some permeability. There probably will be some migration, in any case. The rate of migration and knowing where the contaminants will migrate are the important things.

W. Staub: People have thought that they could avoid the so-called bathtub effect, which turned out to be total containment until the bathtub filled to the top -- and that's not precisely true either because there is some leakage through the fractures as the hydrostatic head built up. To avoid the bathtub effect you select a host material that drains to some extent, which would prevent the bathtub effect from taking place.

Could the public accept some measure of leakage from a low-level waste impoundment as opposed to total containment?

G. Yuan: The public is asking an applicant, "What is it you want to do?"

If you say, "The best thing we can do for radioactive waste disposal is to allow some radionuclides to escape," and give some specific migration rate, and can convince them that this is not going to create any health problems for 20 years after they have drunk the water, or it's not going to come up in a well in a concentrated form, certainly a reasonable person may find that acceptable.

W. Staub: In order to avoid the bathtub effect, you must find some way to remove any leachate that might encounter the trench, and prevent it from standing in the bottom of the trench. To do this you must allow for some leakage.

R.D. Smith: NRC has not received very many comments that would indicate an objection to some release of radioactivity. 10 CFR Part 61 is based on a premise that we are not able to achieve total containment and, therefore, the objective is to set an acceptable limit and design to it. The few comments that took exception with this approach also took exception to nuclear power in general.

There was a fairly high level of either acceptance or acquiescence by the public that has commented on 10 CFR Part 61.

G.L. Meyer: Is a disposal medium which has very low permeability, wherein a trench that tends to fill up with water like a bathtub worse or more acceptable than a disposal medium that tends to let enough water pass through so that the trenches don't fill up?

We have some experience at the commercial sites at West Valley and Maxey Flats, where the trenches tend to fill with water, and at Barnwell, where the water probably penetrates and passes through the trenches and out the bottom to the groundwater table, but carries very little radioactivity with it.

As far as the criteria, is there any preference?

A.L. Lotts: We've had ample opportunity to discuss our frustrations and I would like to move on to consideration of what advice ought to be given to the NRC concerning the technical requirements.

For example, the balance of performance objectives versus the prescriptive requirements. A couple of the speakers this morning said that they were not specific enough. If they're not, what should be said? What type of requirements ought to be put in? Or maybe some of you think that prescriptive requirements ought to be eliminated leaving only performance objectives.

I would like to steer most of the questions and comments in that direction for the rest of the afternoon.

R. Wood: There is concern that there may be a problem in doing anything that could be considered acceptable in the way of analyzing sites until the technical documents on modeling the behavior of a repository waste form system are actually out. Perhaps even after they're out on the street they will go through lengthy comment and iteration.

No one in the utility industry has a great love for Regulatory Guides. Nevertheless, it might be helpful to establish a basis for acceptable approaches for modeling or other calculations to demonstrate the acceptability of the system in advance of these modeling documents. Even something as simple as a few case examples based on hypothetical sites could be extremely helpful in showing acceptable approaches for this kind of modeling. These types of models have been developed and used; for example, the one presented at Tucson by Nuclear Safety Associates. Any indication of acceptable analyses would be extremely useful.

R.D. Smith: Before we get to the point of issuing Regulatory Guides like those that tell you how to model reactors we need to have the in-house capability.

NRC is trying to develop an in-house capability to do performance assessment modeling and has developed a repertoire of models which consists of a number of the more conventional models, or pairs of models, on groundwater movement and radioactive material transport.

These are now operable at at least a couple of levels of sophistication and have actually been applied to a real site at Barnwell as part of the NRC technical assistance to the State of South Carolina.

M. Barainca: DOE is compiling a series of handbooks, actually a series of chapters, with one specific chapter being prepared by Oak Ridge that will identify the information required for site characterization, design and performance assessment.

A.L. Lotts: DOE, NRC, and EPA are attempting to coordinate their modeling efforts. In December 1980, an Interagency meeting was held in Denver to convene the modelers to compare models and to discuss the overall subject of site modeling. One of the conclusions of that conference was that we have enough models, but we need to validate them.

It may be worthwhile to convene a follow-on to this earlier meeting at the interagency level (EPA, USGS, DOE and NRC) to address what is being done, what should be done in the way of model verification, measurements and monitoring data.

Exchanges by the people that are actually doing the work, and the people that are using the results of the work that's being done, are needed to best determine how various models can be used, and what their limitations are.

L. White: The state of the art in modeling far exceeds our ability to get meaningful information about what's going on, understanding the geology and the physics of the problem. If the NRC is going to give guidance it probably should be aimed more at site characterization rather than site screening or modeling.

P. Hunter: Part B of the disposal site suitability requirements deals with land disposal other than near surface, that is, "greater confinement disposal." In addressing that section is there any attempt to try to utilize some of the data, for example the criteria development work, that has been done for DOE, at the Nevada test site?

It seems that there really wouldn't be much difference between requirements for non-near surface disposal and for near surface disposal in terms of the characteristics which are identified in this section.

Perhaps it might be more appropriate to place it under the waste characterization or classification where there may be a trade-off between stable Class B, Column 2 numbers versus going deeper in depth so as not to require that kind of stabilization.

There also should be consideration given to facility design and operation and perhaps to institutional controls. The minimum technical requirements are fairly clear on such things as shallow-land burial and conventional technology.

Any kind of alternative to this, whether it be mine cavity, an engineered structure or ocean disposal, would require another look at what the criteria should be for each of the four components, the waste form, the site, the design and operations of the site, and perhaps institutional controls.

M. Barainca: There are two issues associated with greater confinement. First, you need to demonstrate that the technology exists, and second, you want to determine, if the technology exists, if you want to use it. DOE is now in the process of determining if the technology exists and if there are any requirements for greater confinement of DOE waste.

Ford, Bacon and Davis is preparing conceptual designs for the Nevada Operations Office, funded by the DOE Low-Level Waste Management Program. These designs include a six to eight foot diameter borehole drilled to 100 to 150 feet for greater confinement.

There are other alternatives to shallow land burial, such as mined facilities or deep injection into shale. These alternatives are being studied at Los Alamos, through the Albuquerque Operations Office, and reports ld be available within a few months.

I'm not sure we need greater confinement. Less than one percent of the existing Department of Energy's waste exceeds levels specified by the NRC for Class C waste. Some of this waste is activated materials and may be quite satisfactorily handled by shallow-land disposal, particularly if enhanced packaging is used.

There is some attempt to validate some of these packages, but I'm not very familiar with this work yet.

G. Bradley: There may be a semantic problem with the term "greater confinement." The category of waste that may require greater confinement represents something less than one percent of the volumes of low-level wastes that are being generated that would fall into classifications that might require some type of disposal other than near surface disposal facilities.

The DOE program is largely influenced by a desire to manage those portions of wastes that have been identified at the various DOE laboratories that they would not today propose to dispose of in shallow-land burial.

With respect to modeling, there is an interest in guidance on the NRC repertoire of models and analytical methodology in assessing long-term performance of disposal system.

There has been perhaps a rather loose use of the term validation. Models and analytical methodologies have not been validated in the sense that most in the technical community uses the word; a series of laboratory and/or field experiments are needed to validate models.

On the other hand, NRC, EPA and DOE have developed a repertoire of models that are used in the development of the EIS and in the proposed Part 61, but are not validated models in the accepted sense of that term.

However, this is not critical for receiving and processing applications, but tools for the NRC or state to use in judging the adequacy of the proposed facility in protecting the health and safety of the public and the environment.

G.L. Meyer: At the Denver Symposium or Workshop on Modeling, the chairman of the Workshop on Validation and Verification didn't really want to define the difference between the two because they mean different things to different people. The terms are used in different contexts, and sometimes used quite loosely.

EPA has a policy of translating quantities released to the environment or dose limits into health risk. Existing models do not make these calculations in the same way as EPA. Thus, EPA is developing a model which would use Agency practices and calculational methods. The model will be tested using data from three existing sites: Barnwell, West Valley and Beatty. Later, these results will be compared with estimates of transport at the Barnwell site from the NRC model.

Oak Ridge National Laboratory is developing the EPA model. This has a benefit for DOE in that a National Laboratory will thoroughly understand our model and will have been using the EPA model to evaluate releases from their sites.

The EPA model is relatively simple and it will be made available to industry, the States, other Federal agencies, environmental groups, and engineering firms. It is a one dimensional, analytical model, that industry or the states could use without any great expense. It only costs $12 per run from the beginning of infiltration of water into the trenches to the end when health risks are calculated from estimated releases.

M. Barainca: What does model validation really mean? There is a discussion of verification in ANSI NQA-1 under Design Control, and there has been some discussion in the technical community concerning application of these design principals to achieve model validation.

A model can be verified by hand calculator, and compared against another model to determine if one obtains the same results. Secondly, one should compare actual performance data to model output and validate that it performs its function. The Department of Energy has conducted modeling at all of its sites that I'm familiar with, and the data from the existing sites has been analyzed with existing models. That's one form of validation.

We don't know all the concerns related to validation of models and before we start an interactive process we are asking Pacific Northwest Laboratories to develop uniform guidelines for Verification and Validation.

After we obtain this input, we intend to consult with the EPA, USGS, and the NRC, and apply this approach at a site.

The EPA has asked the Department to test the EPA model at the DOE sites, and I would like to do that.

P. Hunter: Where do we go from here with 10 CFR Part 61 as far as additions or modifications after January 14th? Presumably you will have our comments in by that time. Will those comments be included in a modification or an amendment to 10 CFR Part 61 to address non-near surface disposal in terms of those four areas we talked about, the waste form, the engineering and so forth?

R.D. Smith: Our schedule calls for completing the rule-making process in the basic 10 CFR Part 61 by October of 1982, including issuing a Final Environmental Statement and promulgation of an effective rule.

The next will be to propose amendments to 10 CFR Part 61 and to issue a Supplement to the EIS in 1983 that would address those wastes that we want to add to 10 CFR Part 61 that are not suitable for near-surface disposal. These additions will likely include the wastes that may require disposal in mined cavities, engineered structures, or some other method providing additional confinement. They may also include the wastes that can be dealt with in a less rigorous manner. The NRC schedule, as now set forth, anticipates proposed amendments to 10 CFR Part 61 in 1983, with the final rule becoming effective in 1984.

J. Shapiro: On the one hand, everyone gets up and says that you have the whole waste disposal problem solved, that there's no problem about giving adequate protection; as far as low-level wastes are concerned, it is well-solved. And on the other hand there is long-term technology development. The models are elegant from a computer point of view but have perhaps a tenuous base as far as what's going into them.

Like the Emperor's new clothes, we're all convincing each other that everything is great, when in fact there are problems.

The problem certainly is solvable. We need low-level waste disposal sites. We don't have the technical basis to really tell them that in fact it is all safe. There is a tremendous amount of data which has not been put into a form where people in the communities can understand it.

I can easily make up a talk which perhaps, because people respect my credentials, I can convince them this is okay, but I don't think the data has been presented to the technical community who has to go out and do this. If I'm wrong I hope you'll tell me.

There's a lot of experience at NRC and EPA which can be used to distill all this data. People have had years of experience who can look at geology. My own experience has been that when I've gone to a community to present some interesting data and good data, I think the community is responsive. If I'm just trying to win a debate, I think they pick that up, too.

There's a lot of homework to be done there to prepare data so it can be used for Regulatory Guides, not only to solve your own problems but for the public relations work which has to be done and has to be done to technical people.

The public interest groups have technical people that you can talk to, and if you can convince the technical people of the Union of Concerned Scientists and other public interest groups that in fact you do have a technical base, I think you have a very strong support system.

The other suggestion I have is that this data does require a lot of thought, and you really can't afford the money that goes into all this thought at commercial prices. And so I would suggest that the government should again start to fund the universities to try to have some graduate students who have lots of time and can think at night and think in the daytime, who don't have to punch a time clock.

It's time that you consider the universities as a partner in trying to distill some of this data. Probably the rest of the world is doing this. The people who come to our university from other countries seem to have a lot more support than our own government gives us.

There has to be a change of attitude so that we can not only generate loads of computer data but also do something with it.

M. Barainca: As far as the status of technology, a review of the program was conducted approximately a year ago by the conservation foundation, an independent review group. The conclusions were that appropriate technology existed and if properly applied, waste could be properly disposed of. It was also recommended that remedial action programs be conducted at some of the existing sites, such as Maxey Flats and Sheffield, to demonstrate to the public that these sites could be effectively controlled. My own conclusion is that the technology exists.

A very small percent of the DOE Low-Level Waste Management Program research is actually in terms that universities consider research. The Department of Energy's program consists of application of well-recognized concepts and development of standard techniques. Some people feel the installation of barriers will improve site performance and various barrier materials such as clay sheath or plastic have been suggested. We are conducting some demonstrations at Los Alamos and Oak Ridge to determine the performance of these barriers, and we are conducting demonstrations of cobble gravel systems for improving the site performance.

The next question was the involvement of the university. DOE has a universities program. One is NORCUS, which is funded through the Richland Opeations Office and another is funded through the Chicago Operations Office. Approximately $220,000 is earmarked for specific involvement of the universities.

Along the general thrust of all these comments, I sense that there is some frustration on the part of industry, that they feel the various federal agencies have not been communicating on a lot of these areas and working together as a cooperative team.

A.L. Lotts: The site suitability criteria of 10 CFR Part 61 could be characterized as site unsuitability criteria.

Some of the speakers indicated that they need to be more specific to enhance the ability to meet the performance objectives. Can we put better numbers on performance?

W. Staub: ORNL is providing technical assistance in a regional screening activity for the State of Tennessee through the DOE Low-Level Waste Management Program. A number of these geologic screening criteria are being used. It has been asked, why don't you put specific numbers on some of these geologic screening criteria?

It is a difficult matter to assign specific numbers because it is not always evident what the numbers should be. When someone is looking at an individual site, these criteria become site specific.

There is a matrix of geologic screening criteria which, collectively, can be used to determine whether a site is suitable or unsuitable. Perhaps there is a range of numbers that might be acceptable.

With respect to seismic risk, it is believed that the threshold for major damage from an earthquake is about 0.2g. If we use Algernissen and Perkins' ideas concerning the probabilistic theory of seismic events, we find that there's a 10 percent probability that, within a 50-year period, along the Mississippi River in western Tennessee, there will occur an earthquake that has a horizontal acceleration greater than 0.2g.

That does not mean that major damage cannot occur at 0.1g; major damage might occur at a site located on soils that are subject to liquefaction. Therefore, in one case the criterion might be 0.2g; for another it might be 0.1g. Thus, the number could be a variable depending upon site characteristics.

We might require that the watertable never be closer to the bottom of a trench than 20 feet. This might be a perfect site in every way except for the fact that the watertable will come within five feet of the floor of the trench. Then we will have excluded a site that is in every way acceptable except for one, and it might turn out to be the best overall site available. Yet we might have to settle for something that is not quite as good because it failed to meet the numerical criteria specified.

These are some reasons why it may be counterproductive to specify absolute numbers in some of these geologic screening criteria. Technical experts are trying to select the optimum site, and when we do that we expect it to be politically acceptable. But if the public isn't willing to have it put in their back yard, you must realize that the politicians aren't willing to have it on their back, either. They would like to be able to claim that something out of their control, such as nature or the NRC, was responsible for the decision. Thus, site selection criteria have a very up-front impact. If they do not meet that need, you don't need site suitability criteria at all.

After the site is operating, it is likely that our technical capability is good enough, from a theoretical standpoint, to operate a site nearly anywhere, whether it is humid or dry.

The question is, do we have performance criteria that require people to do what we know they can do? The experience of the past is that sites haven't been operated properly because they haven't been made to operate properly where they could have been.

The bathtub effect didn't have to occur. It takes two features to cause the bathtub effect: an impervious bathtub and a leaky faucet. If you don't have a leaky faucet and if you can manage to make the cap as impervious as the site and bottom of the bathtub, you don't have a problem.

Where our technology is lacking, and the proof of the technology is almost impossible, is the one hundred to five hundred year period of time, postoperationally, in which the politician doesn't have control. Technical competence and operation don't have anything to do with it.

When we're not actively operating the facility and it's sitting there passively and must not leak, not run over, and not bathtub, that's when site suitability criteria are really important, because that's what you must rely on.

It seems that technology is lacking in terms of the really long-term structural integrity of our designs. If we had strictly adhered to the maps of earthquake potential, Maxey Flats would have drawn a very high grade because it was in an area of almost no seismic potential, one of the second-lowest in the country. In July 1980 there was an earthquake of about 5.2 on the Richter scale with the epicenter 19 miles from Maxey Flats. It was not expected at all.

The criteria that we might have used in site selection really wouldn't have been useful to us because our data for predicting the probability of such an event isn't all that great.

Kentucky is humid with about 48 to 50 inches of precipitation a year. There is a shale formation called the Kindrick S-faulted shale, which contains some shells that are five hundred million years old, and they still have their pearly luster. The area has been protected effectively without man's help for five hundred million years, which should be enough time to satisfy almost any criteria for time of containment, including that required for TRU. Engineers, physicists, and technologists should be able to learn how to adapt that type of protective mechanism to our own use. Unfortunately we're not going to live long enough to prove whether it works or not, but we do have to address the question.

We have to compress geological time into time that we can handle, and that costs money.

A.L. Lotts: Glen, would you elaborate on your statement in your talk that some of the criteria needed to be more specific?

G. Bradley: In no way was I advocating a higher degree of quantification of the technical criteria or performance objectives. Proposed rule 10 CFR Part 61 gives us a great deal of flexibility in performing a systems approach to the establishment of a low-level waste disposal facility. What is necessary in additional guidance is not to unduly undermine that flexibility but to make it possible to truly take a systems approach.

It is desirable to consider trade-offs among the various facets of site selection in terms of the source term inventories, what one knows or can project about the waste forms, packages, the operational mode, and the passive operation in post-closure, such that these trade-offs can be made to result in an optimum system. This system obviously would have to provide the level of confidence needed by the regulatory body in judging whether it adequately protects the health and safety of the public and the environment.

The flexibility between the components of the system should be such that we are not unduly constrained by individual components in the system by having quantitative standards imposed upon them. Because then you really remove a lot of the flexibility.

We would all feel a little more comfortable sometimes in having more definitive guidance or standards to meet because it makes it a little bit easier to approach the problem, and it certainly makes it easier for the regulator to review and draw their technical judgements about the application.

But I'm not a proponent for introducing a greater degree of quantitative requirements in the regulations.

G. Yuan: I find myself in one of those rare moments when I'm in total agreement with someone from Chem. Nuclear. The kind of flexibility that is being sought in the regulations is necessary at this time for moving ahead with respect to locating sites for low-level waste facilities. The reason this flexibility works in these regulations is because there are performance objectives. Without the performance objectives the flexibility fails because you don't really have a goal. With the performance objectives, there is a goal in mind, an underlying quality control, which allows you to judge whether or not the site is meeting some objective. Because they are quantitative, and because there is a feeling that we have the model capability to show confidence that we have met performance objectives.

That's what gives the backbone to the process, and allows us to be flexible in the suitability requirements.

J. Wallach: It is doubtful that we know the appropriate specific numbers for the various geological conditions. There is a definite need for flexibility because that is true systems analysis. If there's a requirement that the seismic conditions must be such, or hydrogeologic conditions must be such, then it doesn't seem like it's a system any more. It's a system made up of individual components. If one component does not meet the criteria, then the site would be rejected if there is some rigid limit.

There are technical and scientific members of public interest groups who understand good data and good analyses. In that context, even though perhaps politicians have groups of people who do not want a waste disposal site in their back yards and, therefore, are looking to the NRC or some other force to blame for the implementation or the development of a waste disposal facility in that area, perhaps there are technical and scientific members of these interest groups who can be talked to if the data are there. Then the data could be put together in such as way that at the far end, one could show that although not ideal and even though it wouldn't satisfy certain conditions, the whole system together works well.

The approach used in Canada is that the regulatory body does not specify numbers for the proponents because they aren't known and the regulators probably know less about it than the people who are actually doing the work.

The approach that we are considering today is that we will develop a number based on studies that are being done for us now, and that number will be dose to individuals or the collective dose. The numbers will be expressed in terms of natural background in a particular area. How the proponent gets to that point is up to the proponent. But it is up to the proponent to demonstrate to us that that system will work. In the long term, we cannot hope to measure whether the geological conditions we anticipated did materialize, so we must rely on models.

L. White: One additional piece of information that may be put into a rule that will still allow flexibility but tie things down a little better would be to specify confidence limits. This could go so far as the level of risk, but that requires calculating health effects, but it can also be stated in terms of the confidence limits for releases, and that will allow flexibility.

If Site A is the best site technically but it just happens to be in downtown Chicago, and Site B is in Springfield, Illinois, and the people are willing to take the facility and it could be an acceptable site with more engineering, there would be flexibility to trade-off between what is known about the site and the engineering required to meet a standard.

It also provides an opportunity to describe not only what is known about the site and the design but what is not known. The same problem occurred in licensing reactors. The applicant would tell everything he knew about the site, but the regulatory process was looking for negative information.

GEOHYDROLOGIC PROBLEMS AT LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITES

By John B. Robertson

U.S. Geological Survey

Reston, Virginia 22092

ABSTRACT

Less-than-desirable geohydrologic performance has occurred at three commercially operated and three Department of Energy (DOE) operated low-level radioactive waste sites in the United States. Studies of these sites indicate that the problems fall into eight general categories: bathtub effect, (Water accumulation in filled trenches), trench cap integrity, erosion, high-water table, hydrogeologic complexity, flooding, leachate chemistry, and rapid radionuclide migration in ground water. Problems have been encountered in both high-permeability and low-permeability material. All these problems appear avoidable by applying more practical, comprehensive, and common sense earth-science guidelines for site selection and design:

- A very arid environment eliminates most problems.
- The bathtub effect can be avoided by using physically stable waste forms and improved trench capping.
- Acceptable humid-zone sites can be constructed in permeable media if the water table is sufficiently deep and capillary forces (the wick effect) are used to divert percolating water away from waste.
- One important feature for site performance predictability is geohydrologic simplicity.

INTRODUCTION

The United States has been generating low-level radioactive waste since the "atomic age" dawned in the 1940's. Most of this waste has been disposed of by crude, shallow land-burial techniques, although prior to 1970, significant quantities were also dumped at sea. The term "low-level waste" is a catch-all classification lacking specific definition; it includes a diverse variety of radioactive materials which do not fall into one of three other more specifically defined catagories of waste: high-level wastes, transuranic wastes, and uranium mill tailings. Some "low-level" wastes are extremely radioactive and may contain relatively large quantities of fission products, such as strontium-90, with half-lives longer than 25 years. Prior to 1970, low-level wastes were also allowed to contain significant quantities of long-lived transuranic isotopes such as plutonium-239 (half-life of 24,000 years).

Until 1962, all low-level waste was disposed of by the Federal government at federally operated facilities such as Oak Ridge National Laboratory, Tennessee. With the commercialization of nuclear power and expanded use of nuclear medicine and other waste generation activities, the private sector was given the responsibility for waste disposal, with State or Federal regulation.

Between 1962 and 1967, five commercially operated shallow-land burial sites for low-level waste opened for business at Beatty, Nevada; Maxey Flats, Kentucky; West Valley, New York; Richland, Washington; and Sheffield, Illinois (Fig. 1). Three of those five sites are now closed due to various technical and legal problems. A sixth commerical site was opened in 1971 at Barnwell, South Carolina and currently remains open. That site plus the Beatty and Richland sites now handle all of the Nation's commercially generated low-level wastes, which amounts to some 75,000 m^3 per year.

In addition, Federal government nuclear research and defense activities generate approximately an equal volume of low-level wastes per year which are buried at five major Department of Energy (DOE) facilities and several minor sites (Fig. 1).

Because the three currently operating commercial sites do not represent a political, or geographically equitable distribution, and because their limited capacity is not adequate for anticipated waste generation rates, there has been a recognized need for additional sites over the past few years. Congress passed the Low-Level Waste Policy Act in 1980, which mandates that States establish additional sites on a regional basis before 1986. The Department of Energy will also require additional burial sites within the next several years. It would therefore seem prudent to apply the best earth-science criteria to the screening, selection, and design of new sites. The source of some of

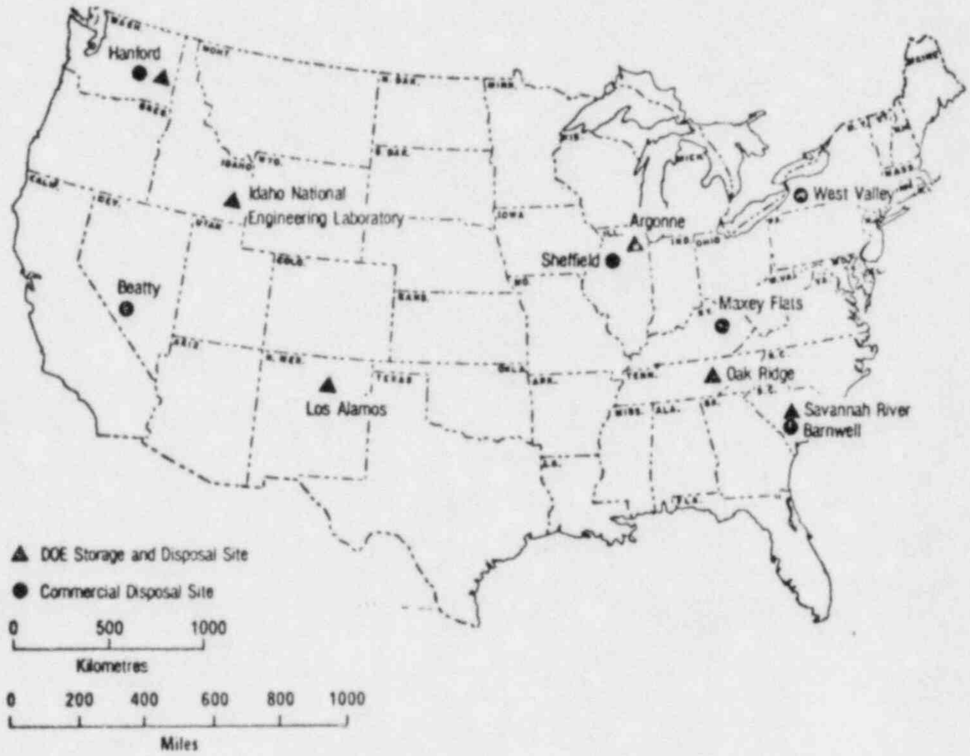

FIG. 1 Locations of principal low-level waste disposal sites in the USA.

our best geohydrologic information for that purpose is the performance record of the older sites. The principal concern, of course, is to protect ground-water and surface-water supplies from contamination.

SITE SELECTION CRITERIA FOR EXISTING SITES

During the period when the six existing commercial disposal sites were chosen, there were no uniform regulations providing comprehensive site-specific geohydrologic criteria to be applied to the selection and operation of disposal sites. The Atomic Energy Commission had some general guidelines and performance standards for low-level sites and allowed States to set their own standards, if they assumed responsibility for regulating sites.

It is not clear what specific geohydrologic criteria (if any) were applied to each of the six sites. It is apparent that the criteria were simplistic and that the dominant philosophy for the humid zone sites was that they be placed in low-permeability, clay-rich sediments or shale. A second prominent criterion was easily excavatable material. The West Valley, New York site is in fairly uniform, clay-rich glacial till; the Maxey Flats, Kentucky site is in a low-permeability (but fractured) shale. The Sheffield, Illinois site was apparently intended for clay-rich, glacial tills, which turned out to contain some permeable gravelly-sand lenses; the Barnwell, South Carolina site was placed in sandy, clayey coastal plain sediments, which have somewhat higher permeability than the tills and shales of the other eastern sites.

For the two arid western sites, (Richland, Washington and Beatty, Nevada) low rainfall rate appears to be the dominant geohydrologic criterion applied. Those sites have an average annual rainfall of 165 and 101 mm (6.5 and 4 inches) respectively, and are both situated in mixed coarse-grained unconsolidated sediments (Robertson, 1980).

The Department of Energy sites were apparently selected with even less definitive and documented earth-science criteria. The dominant philosophy appears to have been that the sites had to be conveniently located within the bounds of the facility reservation and that geohydrologic considerations were secondary.

Some examples of geologic media and hydrologic settings selected for Federal sites are: mixed glacial tills, coastal plain sediments, thin flood plain sediments on permeable basalt, coarse-grained glacio-fluvial sediments, fractured permeable shales, fractured tuff, and rock quarries. Permeability of these materials range from about 10^{-9} cm/sec to perhaps 10 cm/sec. Annual precipitation rates range from about 101 mm to 1370 mm (4 inches to 54 inches). Water table depths range from less than 2 m to a few hundred meters (Robertson, 1980).

PROBLEMS ENCOUNTERED AT EXISTING SITES

Several geohydrologic problems have been encountered at existing sites which can be partially attributed (with 20-20 hindsite) to inadequate earth-science criteria in site selection, characterization, and design. Nearly all these problems or shortcomings can be classified into eight types or causes: Bathtub effect, trench cap integrity, erosion, high-water table, hydrogeologic complexity, flooding, leachate chemistry, and rapid radionuclide migration. Nearly all these subproblems are interrelated and interdependent.

Bathtub Effect

This effect occurs in wet-climate, low-permeability sites such as West Valley, New York and Maxey Flats, Kentucky. For various reasons the trench-capping material on waste-filled tenches becomes more permeable than the undisturbed media, thus enhancing infiltration of precipitation. Ground water then accumulates in the trenches, sometimes to the point of seeping out on the ground surface, carrying leached radionuclides with it. This problem has often been blamed on the low permeability of the natural media, rather than on the high permeability of trench caps and backfill material, where it more properly belongs.

Trench Cap Integrity

This problem is closely related to the bathtub effect. As wastes and backfill material decompose and compact, settlement cracks and holes develop in the capping material providing ready avenues of water infiltration. Desiccation cracks can also develop in the cap during extended dry periods, with the same hydrologic effect.

Erosion

Erosion has been a problem or potential problem at some sites. At the Sheffield, Illiinois site for instance, unanticipated rapid runoff from large snow accumulation caused undesirable erosion and piping problems in 1979 (James B. Foster, oral communication, 1979). Questions on potential long-term erosion problems have been raised at sites such as West Valley, Beatty, and Idaho National Engineering Laboratory.

High-Water Table

In a few cases, (Oak Ridge National Laboratory and West Valley, for instance) burial trenches were excavated below the water table, thus providing constant submergence and leaching of some wastes. Although, that condition might be undesirable, it is not necessarily detrimental if ground-water flow rates are sufficiently slow. At the Oak Ridge site, raising the ground surface by fill material actually induced the water table upward into the waste, in some cases (Webster, 1979).

Hydrologic Complexity

This has been a problem of varying magnitude at many sites. It simply means the sites turned out to be physically more complex than originally anticipated, so that long-term (or even short-term) performance predictions were found to be in error. An example is the complex glacial-fluvial stratigraphy of the Sheffield, Illinois site (Foster and Erickson, 1979). The original site characterization wells were not adequate to define the distribution of permeable sand units Another example is the Maxey Flats, Kentucky site, where ground-water flow is controlled by fractures (Zehner, 1979). Although the flow rate may be very low, it is not feasible to characterize the system quantitatively.

Flooding

Flooding has been a problem at at least one DOE site-Idaho National Engineering Laboratory. On two occasions, in 1962 and 1969, the site has been inundated by local runoff from unusual storm conditions. (Barraclough and others, 1976). Remedial engineering measures have since been taken, to reduce the likelihood and magnitude of further occurrences. Although this is an arid site (203 mm or 8 inches annual rainfall) the problem resulted in open burial trenches being filled with water and considerable infiltration of water over the entire site. Causes of the flooding were a combination of unusual meteorologic conditions and the location of the site within a local topographic basin.

Leachate Chemistry

Because of the variety and complexity of low-level waste, the chemical characteristics of leachates from buried wastes are comparably variable and complex. Many non-radioactive organic and inorganic compounds are buried with the waste or result in the biological and chemical decomposition of trash materials. This results in unpredictable oxidation states of some nuclides and chemical complexation with chelating agents and other ligands. Such complexes can be more mobile in ground water than uncomplexed cations. At the Maxey Flats site, plutonium has been observed in trench lechates and ground water in chemically complexed forms (Cleveland, 1981).

Rapid Radionuclide Migration

All the above mentioned problems can and have contributed to the migration of waste radionuclides away from trenches at faster rates or in different directions than expected. Contributing to this problem is the effect of relatively high-permeability media. This has been a concern at Oak Ridge, Maxey Flats, Sheffield, Barnwell, and INEL, among others. Plutonium and other isotopes have migrated laterally through a permeable fractured sandstone bed at Maxey Flats (Richard Perkins, oral communication, 1981). Tritium has migrated vertically and laterally through permeable sand layers at Sheffield and Barnwell and several isotopes have migrated vertically through permeable basalt at INEL.

Thus, an apparent dilema arises; if both low-permeability and high-permeability sites have problems, are both conditdions unacceptable or is one preferrable to another?

POSSIBLE ANSWERS TO THE QUESTIONS

None of the problems observed at existing sites have been disastrous in terms of harm to human life--there is no evidence of public drinking water contamination nor harmful exposure to humans due to ground-water contamination from these sites. However, the problems are nonetheless undesirable. Essentially, all of them appear to be amenable to practical solutions at future sites by applying more sensible and appropriate earth-science criteria to site selection, characterization, and operation.

Bathtub Effect and Trench Cap Integrity

There are at least three potential solutions to the bathtub effect:

1. Require stable non compactable waste forms and backfill, combined with more stable, low-permeability trench capping.
2. Place trenches in permeable media (above water table) with low-permeability trench cap.
3. Place site in a very arid environment.

These options are all specified in the newly proposed NRC low-level waste management regulations (10 CFR Part 61). It is generally agreed that low-permeability clay-rich sediments can be good burial media with improvements in waste form and capping technology.

Geohydrologic Complexity

Problems related to these conditions can, of course, be reduced by avoiding media dominated by secondary permeability features or complex stratigraphy. This is a subjective criterion, requiring judgment on a relative scale.

High-Water Table

In addition to specifying minimum depth to the saturated ground-water zone, this problem can be avoided by reducing permeability of trench caps, providing good land surface drainage, and avoiding large increases in land surface elevation from backfilling. If the hydraulic conductivity of the medium is below 10^{-6} or 10^{-7} cm/s, ground-water flow rates will be slow enough so that radionuclide migration is dominated by molecular diffusion. In such circumstances, it is not really important to exclude ground water from the waste. In Canada, for instance, burial below the water table is permitted in glacial clays with low hydraulic conductivity.

Complex Leachate Chemistry

This problem can also be reduced by simplifying waste forms; requiring more stable, less leachable wastes; and excluding potential complexing agents from the waste.

Rapid Radionuclide Migration in High-Permeability Media

This problem can be avoided by applying the following guidelines:

1. Waste must be placed well above water table.
2. Contact of waste with infiltrating water must be minimized by stable, low-permeability trench covers or by effective

use of "the wick" effect. The wick effect results from natural capillary suction of certain types of unsaturated sediments which draws water away from wastes rather than through them. This principal has been effectively demonstrated in the field by French researchers (Rancon, 1980). The Barnwell, South Carolina, site appears to be benefited by this effect but conclusive evidence is not yet available.

CONCLUSIONS

The key to good low-level radioactive waste (or any hazardous waste) site performance is minimizing water contact with the waste and minimizing migration rates in ground water. Perhaps the most fundamental lesson learned from examining the history of earth-science aspects of existing sites is that no single dominant geohydrologic criterion is more critical than others for every site. Criteria for all facets of the system must be considered together to obtain good performance. Reliance on a single criterion, such as low-permeability clay, while ignoring others, such as waste form and trench caps, can lead to failure. It is apparent that both the Nuclear Regulatory Commission and the Department of Energy have recognized these problems and the potential solutions. Consequently, both organizations are incorporating, in one form or another, the solutions recommended here into their respective regulatory criteria and technical guidelines. Because of lessons learned on previous sites, the next generation of low-level radioactive waste sites promise to be much more reliable from an earth-science point-of-view.

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SURFACE WATER HYDROLOGY EXPERIENCE AT EXISTING LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITES AS A BASIS FOR SELECTING FUTURE SITES

David L. Schreiber
Schreiber Consultants, Inc.
303 Park Drive - P. O. Box 1087
Coeur d'Alene, Idaho 83814

ABSTRACT

The surface water hydrology conditions at the six existing commercial low-level radioactive waste disposal sites (four humid and two arid) are reviewed. Then the proposed site suitability requirements for surface water conditions are discussed and applied to the six existing sites. Finally, the applicability of the proposed surface water hydrology requirements to future site selection problems is discussed. In particular, the need for additional requirements, the restrictiveness of the proposed requirements, and the availability of sites that will meet the proposed requirements are presented.

INTRODUCTION

This paper focuses on the surface water hydrology site suitability requirements in the proposed rule on land disposal of low-level radioactive wastes. There are three major sections in this paper:

1. Survey of surface water hydrology conditions at existing commerical low-level radioactive waste disposal sites
2. Application of proposed site suitability requirements to existing waste disposal sites
3. Applicability of proposed requirements to future siting of low-level radioactive waste disposal sites.

The survey of existing conditions includes brief descriptions of surface water hydrology at the six existing commercial low-level radioactive waste disposal sites:

1. West Valley, New York
2. Barnwell, South Carolina
3. Maxey Flats, Kentucky
4. Sheffield, Illinois
5. Beatty, Nevada
6. Hanford, Washington

Of these sites, the first four are located in the humid eastern United States, and the last two are located in the arid Western United States.

The surface water hydrology requirements in the proposed rule, 10 CFR Part 61, include three minimum technical requirements and one additional characteristic that may promote site suitability as follows:

1. Well-drained areas devoid of flooding or ponding
2. Minimum upstream drainage areas
3. Elimination of areas within the 100-year floodplain, coastal high-hazard zones, and wetlands
4. Avoidance of topographic features with the potential for the formation of impoundments

After presenting discussions of the four above site suitability requirements, the proposed requirements are applied to the six existing sites. The purpose of this particular exercise is to test the generic applicability of the proposed requirements to see if additional criteria are needed, if the requirements are too restrictive, and if it is possible to find sites which will meet the proposed requirements.

SURFACE WATER HYDROLOGY CONDITIONS AT EXISTING SITES

There are two general categories of waste disposal site locations in the United States. These are namely the humid eastern U.S. and the arid western U.S. The six existing sites are discussed below.

Humid Sites in the Eastern United States

There are four existing commercial low-level radioactive waste disposal sites in the humid eastern U.S. The surface water hydrology conditions at these four sites are summarized below.

West Valley, New York. This low-level waste disposal site is located on a ridge in the Appalachian uplands 48 km south of Buffalo at an elevation of about 360 m (1200 ft) above mean sea level (MSL) and 210 m above Lake Erie. The annual precipitation is about 102 cm (40 in.), of which about one-fourth falls as snow (1).

Since deglaciation about 12,000 years ago, surface streams have eroded into unconsolidated materials. In general, a dendritic drainage pattern has developed, which bears no relationship to the preglacial system. Buttermilk Creek receives the drainage from the West Valley site and flows into Cattaraugus Creek a few kilometers downstream. Cattaraugus Creek discharges into Lake Erie, which is about 50 km away.

Since the stream channels are deeply incised, there is essentially no possibility of stream flooding on the disposal site. However, because of the topographic relief, intense rainstorms can produce overland flow that will cause short-term flooding across the site. In addition, melting snow pack has caused problems in the past. These two types of flooding have resulted in ponding of water in waste disposal trenches, erosion on the steep slopes on the north and east leading to Buttermilk Creek and land slides on the steep slopes.

Barnwell, South Carolina. The Barnwell Low-Level Waste Disposal Facility is located about 68 km southeast of Augusta, Georgia in the Upper Atlantic Coastal Plains province. Gently rolling hills characterize the surrounding areas.

The summers are long and humid with many thunderstorms. The heaviest rainfall of the year occurs during the summer season. The average annual precipitation at Barnwell is about 118 cm (46 in.). Snowfall is not unusual, but it seldom covers the ground for more than a few days.

The major rivers near the Barnwell site are the Savannah River about 22 km to the southwest and the Salkehatchie River about 4 km to the northeast. The site is located on the boundary of the Lower Three Runs Creek. About 98% of the runoff flows down Lower Three Runs to the Savannah River. The other 2% flows towards the Salkehatchie River. Lower Three Runs Creek is about 5 km south of the Barnwell site and about 43 km in length.

The site topography is gently rolling with elevation ranging from 73 to 80 m (240 to 260 ft)MSL. The elevation of Lower Three Runs Creek is about 43 m (140 ft) MSL. Therefore, stream flooding of the site is considered next to impossible. The topography is such that no obvious gullies, washes, or man-made pathways exist or have been developed as a result of surface water runoff (2).

Maxey Flats, Kentucky. The Maxey Flats Radioactive Waste Burial Site is located near Morehead, Kentucky and is situated on a flat-topped, highly dissected ridge in the Knobs region on the eastern flank of the Cincinnati arch. The ridge rises about 100m above the wide alluvial-filled valleys. The upland surface is generally less than 600 m wide and is gently rolling (3). The mean annual precipitation is about 117 cm (46 in.).

Surface water drainage ways at Maxey Flats are mapped, and streamflow is measured continuously on Rock Lick Creek downstream of the waste disposal site. Surface water runoff drains from the site by way of Drip Springs Hollow to the west, Rock Lick Creek to the south, and an unnamed stream to the east. These drain through Fox Creek to the Licking River and on to the Ohio River. Rock Lick Creek is an intermittent stream with a mean daily discharge of about 0.30 m^3/sec (10 cfs) and a range in daily discharges from 0 to about 6 m^3/sec (200 cfs) (4). Because of elevation differences, stream flooding at the site is essentially impossible.

Sheffield, Illinois. The Sheffield Low-Level Waste Disposal Site is located about 5 km southwest of the town of Sheffield, Illinois, and a short distance north of the crest of the surface drainage divide between the Green River Lowland at the north and the Spoon River at the south (5).

All streams in the vicinity of the site are classified as intermittent; however, the stream crossing the southeast portion of the site, an unnamed tributary to Lawson Creek, has been observed to flow much of the time. The small stream on the north side of the site, which drains the north side of the site and collects most of the runoff, flows eastward for about 0.7 km before joining the main creek. This stream flows on eastward and joins Lawson Creek about 0.6 km to the east of the site. The water then flows on to Coal Creek, then to Mud Creek, to the Green River, and to the Rock River which joins the Mississippi River at Moline, Illinois (6).

The annual precipitation at the site averages about 89 cm (35 in.). The topographic relief and well-developed drainage provide rapid runoff (7).

There is no historical record of stream flooding near the site. However, the site is located at the higher elevations of the drainage divide between the Mississippi and Illinois Rivers. Therefore, flooding of major streams, such as Green River, will not reach the site (8).

Arid Sites in the Western United States

There are two existing commercial low-level radioactive waste disposal sites in the arid western U.S. The surface water hydrology conditions at these two sites are summarized below:

Beatty, Nevada. This site is located about 18 km southeast of Beatty, Nevada and is part of the Basin and Range physiographic province.

The site lies in the Amargosa Desert, which is characterized by an arid climate. The average annual precipitation over a 60-year period at the town of Beatty, which should be representative of the site, is about 11.4 cm (4.5 in.) (9). In 1962, Clebsch, (10) estimated that the average evaporation for the site is about 254 cm (100 in.) per year. Potential evapotranspiration for the site was estimated by Law Engineering in 1981 to be about 91 cm (36 in.) per year (9). Thus, the area is constantly water deficient, since potential evapotranspiration exceeds precipitation by about an order of magnitude.

There are no streams of any significant size in the vicinity that could cause flooding of the site. The natural slope of the site is relatively flat (from 0.5 to 1 percent); therefore, local cloudbursts should result in only minor erosion, at most, even though some surface runoff can occur. The slope is steep enough to prevent ponding, but mild enough to preclude erosion (9).

The Amargosa River channel and its tributaries drain any runoff from the site. The Amargosa is an intermittent stream; flows usually occur only during periods of heavy precipitation. The site is located on an elevated portion of the valley which lies between two tributaries of the Amargosa River. These channels isolate the site from runoff from the mountains and from any streamflow in the Amargosa River. When surface runoff does occur, it only persists for a short period of time and over short distances before being absorbed into the soil (9).

Hanford, Washington. The Hanford low-level waste disposal site is located in the Columbia Plateau on the U.S. Department of Energy's radioactive waste management facility at the Hanford site in south central Washington. The low-level waste site is about 30 km northwest of Richland, Washington.

The disposal site lies within the Pasco Basin, which is a topographic low within the Columbia Plateau, into which drains the Columbia, Snake and Yakima Rivers. The climate in the site vicinity is characterized by very mild temperatures and is dry. Average annual precipitation is about 16 cm (6.3 in.). The distribution of precipitation is such that more falls in the winter than the summer. Thus, precipitation is least when potential evapotranspiration is greatest and vice versa. This results in making both the mean annual surplus and deficits larger than if precipitation were uniformly distributed in time (11).

The low-level waste disposal site is located near the topographic divide between the Columbia River to the north and east and the Yakima River to the south. The Columbia River is located about 13 km to the north and 16 km to the east of the site. The Yakima River is located about 20 km to the south.

The site is located well above (on the order of 30 m) the probable maximum flood levels on either the Columbia or Snake Rivers (11). Thus, the site is not subject to stream flooding.

Local thunderstorms could result in some surface runoff, but slopes are steep enough to prevent ponding and mild enough to prevent significant erosion. As in the case of the Beatty site, Hanford is located in a desert-like environment with sandy surface soils. When surface runoff does occur, it only persists for a short time and over short distances before being absorbed into the soils.

PROPOSED SITE SUITABILITY REQUIREMENTS APPLIED TO EXISTING SITES

The six existing commercial low-level radioactive waste disposal sites described above are used in this section to test the proposed site suitability requirements in 10 CFR Part 61. The requirements are first summarized and then applied to the six existing sites.

Proposed Surface Water Hydrology Requirements

Potential erosion and inundation of the waste disposal areas are considered by the staff as the most significant aspects of surface water hydrology (12). Surface waters may also provide a potential pathway for radioactivity to reach the general population. There are three minimum technical requirements and one additional characteristic that may promote site suitability from the standpoint of surface water hydrology. These requirements and characteristics are summarized below.

Well Drained Areas Devoid of Flooding or Ponding. The proposed rule stipulates that the disposal site must be generally well drained and free from areas of frequent ponding. Therefore, areas subject to flash flooding, such as arroyos, and depressional areas subject to ponding should be avoided.

Minimal Upstream Drainage Areas. The purpose of this proposed requirement is to decrease the amount of runoff which could erode or inundate the disposal areas. This requirement, as well as the previous one, should be applied during the site selection process before construction. The staff has indicated a willingness to consider engineering modifications of natural drainage if the changes are permanent and will not require active maintenance during the duration of the radioactive hazard (12).

Flood Plains, Coastal Areas, and Wetlands. The third proposed requirement related to surface water is that waste disposal shall not occur in 100-year floodplains, coastal high hazard areas, or wetlands. This requirement stems from Executive Order 11988, Floodplain Management Guidelines. The 100-year floodplain is therein defined as the lowland and relatively flat areas adjoining inland and coastal waters subject to a one percent or greater chance of flooding in any given year. A coastal high hazard area is that area subject to high velocity waters, such as hurricane wave wash or tsunamis. Wetlands are those areas that are inundated or saturated at a frequency and duration sufficient to support a prevalence of vegetative or aquatic life. Swamps, marshes, and bogs are examples of wetlands (12).

Topographic Features Indicating Potential for Impoundment. This is a site characteristic promoting site suitability -- not a minimum technical requirement. It may by itself or in combination with other site characteristics significantly help in demonstrating site suitability. An area with topographic features that suggests the possibility for a man-made or natural impoundment could adversely affect the ability of the disposal site to isolate the wastes.

Application of Requirements to Existing Sites

In the following discussion, the proposed surface water hydrology requirements discussed above are applied to the six existing commerical low-level radioactive waste disposal sites.

West Valley, New York. Of the three proposed surface water hydrology requirements, this site should be considered marginal on the first two and acceptable on the third. On the basis of site operation experience, the site is not as well drained as it should be. There have been problems with trenches becoming filled with water and overflowing following storms and/or snow melt events. To some extent this is an operational problem (trench cap stability) and it also involves hydrogeology ("bathtub effect" resulting from impermeable trench bottoms). However, better surface drainage would help alleviate the water collection problem.

The second requirement, minimal upstream drainage area, is also considered marginal. Even though the disposal site is located on a ridge, there is a relatively large upgradient area, including hillslopes, that drain down over the ridge top.

The third requirement is satisfactory for this site. It is well above the 100-year floodplain on Buttermilk Creek. Furthermore, it is not in an area subject to high velocity coastal waters, nor is it located in a wetland.

Finally, the site vicinity has no topographic features that appear conducive to the formation of natural or man-made impoundments. Thus, this site characteristic promotes the suitabiltiy of the site.

In retrospect, application of the proposed surface water hydrology requirements to the West Valley site may have resulted in a conclusion that it is a marginally acceptable site.

Barnwell, South Carolina. On the basis of surface water hydrology requirements, Barnwell is an acceptable site. It is located near the watershed boundary between the Salkehatchie and Savannah Rivers, and the site topography is gently rolling. Therefore, it is a well drained site devoid of flooding or ponding. Upstream drainage area is minimized as a result of locating the site near a watershed divide. Furthermore, it is well above the 100-year floodplains of nearby streams; it is not in a coastal area, and it is not a wetland. Finally, there are no nearby topographic features that are conducive to the formation of impoundments that would jeopardize the stored wastes.

Maxey Flats, Kentucky. With one possible exception, Maxey Flats meets the proposed surface water hydrology requirements. The possible exception is that of surface water drainage. Some of the trenches collected water and had to be pumped during operation. As at West Valley, this is the "bathtub effect," which is really a combination of poor drainage, poor trench cap integrity, and impermeable trench bottoms. Otherwise, the Maxey Flates site is acceptable from a surface water standpoint. The upstream drainage area is minimal since it is located on a ridgetop. Furthermore, it is well above the 100-year floodplains of the adjacent streams; it is not in a coastal area, and it is not a wetland. In addition, there are no topographic features conducive to formation of impoundments that would endanger the site.

Sheffield, Illinois. From the standpoint of surface water hydrology considerations, this site is acceptable under the proposed requirements. The only possible detracting factor may be that the surface slopes on part of the site may be a little steeper than desired, thus promoting erosion. Otherwise, it is a well drained area devoid of flooding or ponding. The upstream drainage area is minimal because of the location near a watershed divide. Furthermore, the site is well above the 100-year floodplain on the adjacent streams, and it is not in a coastal area or a wetland. Finally, there are no topographic features in the site vicinity that are conducive to the formation of impoundments that would endanger the site.

Beatty, Nevada. On the basis of surface water hydrology, the Beatty site is acceptable under the proposed requirements. It is a well drained area devoid of ponding or flooding. Its gentle slopes promote runoff without inducing erosion. Furthermore, the site soils are such that most precipitation is absorbed. As a result of adjacent tributary stream channels, runoff from the upgradient mountains is diverted around the site. Thus, upstream drainage area is minimized. The site is not within a 100-year floodplain, a coastal area, or a wetland. Furthermore, there are no topographic features in the site vicinity that are conducive to the formation of impoundments that would endanger the stored wastes.

Hanford, Washington. The Hanford low-level waste disposal site is acceptable on the basis of the proposed surface water hydrology requirements. As a result of its location near a watershed divide and on a desert, it is well drained and devoid of areas subject to flooding or ponding. In addition, the upstream drainage area is minimal. This site is located far above the 100-year floodplains on either the Columbia or Yakima Rivers. Furthermore, it is not located in a coastal area or a wetland. Finally, there are no topographic features that are conducive to the formation of an impoundment that would jeopardize site safety.

APPLICABILITY OF PROPOSED REQUIREMENTS TO FUTURE SITING

The proposed site suitability requirements associated with surface water hydrology have been applied above to the six existing commercial low-level radioactive waste disposal sites. As a result of that exercise, this section will explore the needs for additional criteria, the restrictiveness of the proposed requirements, and the effects of the requirements on availability of sites.

Need for Additional Requirements

Potential erosion and inundation of the waste disposal areas are considered by the staff to be the most significant aspects of surface water hydrology relative to the suitability of sites for disposal of low-level radioactive waste. Another concern expressed by the staff is that surface water may be a potential pathway for radioactivity to reach the general population. The three proposed surface water hydrology minimum technical site requirements and one additional site characteristic promoting site suitability discussed earlier in this paper are the staff's suggested means of assuring minimal risk resulting from the siting of a low-level radioactive waste disposal site.

These suggested health and safety requirements are consistent with current regulations that apply to the siting of other nuclear facilities, such as power reactors and uranium mill tailings disposal areas. For example, the primary surface water hydrology concerns in the siting of a nuclear power reactor are:

1. protection of safety-related facilities from flooding
2. adequate safety-related water supply
3. potential pathway to the general population

In the case of a low-level waste disposal site, a safety-related water supply is not necessary. The other two concerns are appropriate and have been addressed in the proposed rule. Therefore, it is this writer's opinion that additional minimum technical requirements pertinent to surface water hydrology are not necessary.

Restrictiveness of Proposed Requirements

The proposed surface water hydrology requirements for site suitability are to be judged with regard to whether or not they are too restrictive. This question is best answered by referring to the earlier application in this paper of the proposed requirements to existing sites. In this writer's opinion, five of the six existing sites are definitely acceptable in terms of surface water hydrology considerations, and the other site is marginally acceptable. Therefore, the proposed requirements are not too restrictive.

Site Selection Problems in Meeting Proposed Requirements

Can sites be found which meet the proposed surface water hydrology requirements? Based on the assessment provided earlier in this paper, the answer is "yes." When the proposed requirements were applied to the six existing sites, five of them were definitely acceptable. Therefore, it follows that surely there are other sites available in the United States that will satisfy the proposed requirements for surface water hydrology.

SUMMARY AND CONCLUSIONS

In order to evaluate the staff's proposed surface water hydrology site suitability requirements for low-level radioactive disposal sites, a three-step procedure was followed. First, the surface water hydrology conditions at the six existing commerical low-level radioactive waste disposal sites were reviewed and summarized. Four of these sites are located in the humid eastern United States, and two are located in the arid western U.S. Second, the proposed surface water hydrology requirementswere applied to the existing disposal sites to test their generic applicability. There are three minimum technical requirements and one additional site characteristic that promote site suitabiltiy from a surface water hydrology standpoint. Third, the applicability of the proposed surface water hydrology requirements to future siting was evaluated. This evaluation was based on three questions:

1. Are additional requirements needed?
2. Are any requirements too restrictive?
3. Can sites be found to meet the requirements?

In conclusion, the above questions were answered and bases provided. Additional requirements are not needed, since those proposed are consistent with those currently in use for selecting sites for other types of nuclear facilities. The proposed requirements are not too restrictive, since five of the six existing disposal sites satisy the requirements. Since the latter was demonstrated, it follows that other sites exist that will surely satisfy the proposed criteria.

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GEOGRAPHIC FACTORS RELATED TO SITE SUITABILITY OF LOW-LEVEL WASTE DISPOSAL

H. E. Zittel
Energy Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

ABSTRACT

A number of factors related to the site suitability of low-level waste disposal sites are discussed. The factors are a combination of those which might be considered "environmental" and those dealing with site criteria.

Among the factors covered are: possible population criteria, alternative site selection, transportation criteria and community involvement considerations. All these factors are discussed in a manner based on the premise that the technology exists to carry out low-level waste disposal in a manner such that public health and safety can be insured. The conclusion of the discussion is that problems encountered in siting low-level waste facilities will be largely societal and political in nature.

INTRODUCTION

Since the purpose of this symposium is to help generate a technical basis for those parts of proposed 10 CFR Part 61 and the supporting technical positions and regulatory guides that deal with site suitability requirements, I have chosen to draw heavily on our experience in power reactor siting. While the two activities, i.e. reactor siting and low level waste disposal siting, are obviously an order of magnitude or more apart in size, they also have a number of common concerns. First and foremost they must both be in conformance with 10 CFR Part 51, "Licensing and Regulatory Policy and Procedures for Environmental Protection". In saying this I am obviously equating to some extent the proposed 10 CFR Part 61 to 10 CFR Part 100 "Reactor Site Criteria".

My remarks are based upon some basic assumptions:

1) That the technology is available to carry out low level waste disposal in a manner such that public health and safety can be ensured.

2) That therefore the problems encountered in siting will be largely societal and political in nature.

3) That the low level waste disposal site wherever sited will be subject to controversy and possible intervention.

4) That such controversy and intervention will result in ASLB hearings.

Keeping the above assumptions in mind, the points I wish to pursue are a mixture of those arising from 10 CFR Part 51, as modified by current CEQ regulations, and those which could be termed "site suitability criteria".

SITE SUITABILITY CRITERIA

Population Criteria

The first question I would pose is "should 10 CFR Part 61 contain any population criteria, both current and projected, surrounding proposed sites?" The arguments for siting a low level waste repository in a low population zone include the following:

1) The effects of any releases both accidental and routine would be minimized.

2) The committed land requirements could more easily be met. Since such commitments could be fairly long-time (up to 500 years) the socioeconomic impact of withdrawal of the dedicated land would have less impact.

3) Both accidental and intentional intrusion would tend to be less.

4) Last but not least the political and societal impact would tend to be less severe in absolute terms.

There are, of course, arguments which can be made in the opposite direction including:

1) The direct socioeconomic impact in a sparsely populated community might be more severe in terms of housing, impact on schools, etc.

2) The needed utilities, construction materials, transportation routes, etc., may not be as readily available.

Possibly the answer to this question is that no absolute population criterion need be set but that population should be a key factor in any site selection process.

An ancillary question could be posed in terms of whether or not there should be some control of offsite activities after licensing. This could include not only population control but also the siting of certain types of facilities which could either by themselves or in combination with the waste repository pose a potential safety hazard. Examples of such facilities are:

1) Airports,

2) Pipe lines and gas terminals,

3) Storage facilities for large amounts of toxic or explosive materials.

Probably the answer to this question is that the NRC does not have the legal authority to control such activities and that local planning authorities would have to make decisions.

Alternative Sites

The current regulations promulgated by the CEQ emphasize considerations of alternatives as a critical component of the EIS process. Section 1502.14 of the CEQ regulations requires that the EIS "present the environmental impacts of the proposal and the alternatives in comparative form". This has been interpreted by some as requiring "equal treatment" of alternatives or, in site selection, a full environmental analysis for each alternative site identified. Such an interpretation would obviously mean more than reconnaissance level information for the alternative sites. Such an approach has been resisted successfully in the past and I have no doubts that reconnaissance level data as proposed in 10 CFR Part 61 is adequate. However, I would like to pose the following questions: In the siting of low level waste repositories is the concept of "an obviously superior site" as enunciated in CLI-77-8[1] to be used? We have found consistently in our experience that the site selection process has posed some of our more difficult problems. Intervenors have insisted that the selected site should be the "best" site while we feel that there is no "best site". Rather, we have taken the approach that, if the primary or selected site exhibits no serious or "fatal" flaw, the alternative sites would not be "obviously superior". This, of course, requires that the suite of sites from which the final site selection is made be viable sites meeting site suitability and environmental criteria even though on only a reconnaissance basis. It is also vital that, whatever site selection procedure is carried out by an applicant, it be thoroughly documented and demonstrate sincere effort. In other words, selecting a site and then setting up a number of "strawman" alternative sites leads only to trouble. Again I will pose a number of ancillary questions: Should terms such as "region of interest" and "buffer zone" be more closely defined? Should there be a recommended methodology for site selection? Should a suite of acceptable models be set forth for meeting the "complexity" site requirements? Should we use the "capable fault" criterion for geologic hazards?

Highway and Other Transportation Considerations

To what degree shall the consideration of transport routes and means enter into site selection? It is obvious that both cost and risk of accidents are a function of how far the waste must be transported. Since most of the power reactors generating low level waste are in the eastern U.S. it would seem logical to try to site low level waste repositories in the same region. However the societal and political realities may alter this seemingly obvious conclusion. In any case the following should be factored into any site suitability criteria:

1) Transportation systems available.

2) Location of waste producers with respect to the site.

Community Involvement

Last but not least I would like to raise the questions that I am sure any sociologist would raise.

1) Who is going to bear the impact of low level waste siting in a given area?

2) Who is going to be the primary beneficiary?

This is a recurring question in every siting study with which I have been involved and I know the answers to the above two questions seem self evident. I raise them only because time and time again I have been told by my social science friends that the ease of siting of any nuclear facility depends upon convincing those bearing the major impacts that they will also benefit. This implies either some sort of "in lieu of taxes" payment or some direct payment to the community and/or individual. Since the land being used will be withdrawn from any other use for a fairly long period, most communities will see the siting as a detriment rather than an asset unless they see some other obvious benefit to them.

This raises the question as to when in the total siting procedure should the affected community or communities become involved. Should the licensee be required to involve the community from the very beginning, when he starts his application, or only when the EIS process forces him to do so? It would seem that early community involvement would make the siting process more palatable to the affected community because of the sense of having some control of its own fate. On the other hand, early knowledge might catalyze a more substantial resistance to the project. From experience I would say that involvement of only the political and business sectors will not decrease the resistance appreciably. Perhaps the local community would wish to vote on the issue, i.e. hold a referendum. Perhaps a commission of local non-political individuals could be appointed to represent the community. The answer to this problem is not simple but it is an area that must be addressed and some methodology found to best find an answer.

In closing I might say that I obviously have not covered details such as the necessity for adherence to Federal Laws and Regulations which are well covered in existing documents. I would also say that I am convinced that low level waste siting can be done in a socially, technologically, and economically acceptable manner.

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APPLICATION OF ECOLOGICAL MAPPING

J. Albert Sherk

Office of Biological Services
U. S. Fish and Wildlife Service
U. S. Department of the Interior
Washington, D. C. 20240

ABSTRACT

The U. S. Fish and Wildlife Service has initiated the production of a comprehensive ecological inventory map series for use as a major new planning tool. Important species data along with special land use designations are displayed on 1:250,000 scale topographic base maps. Sets of maps have been published for the Atlantic and Pacific coastal areas of the United States. Preparation of a map set for the Gulf of Mexico is underway at the present time. Potential application of ecological inventory map series information to a typical land disposal facility could occur during the narrowing of the number of possible disposal sites, the design of potential disposal site studies of ecological resources, the preparation of the environmental report, and the regulatory review of license applications.

INTRODUCTION

The U. S. Fish and Wildlife Service Initiated the production of an ecological inventory map series in 1979 as a major new planning tool depicting fish and wildlife and their habitats and major land use designat' ns. The first set of maps in this comprehensive series was prepared for the Atlantic coast and published in 1980 (Figure 1.). A second set of maps in this series has been prepared for the Pacific coast and published in 1981 (Figure 2). At the present time preparation of the third set in the series is underway for the coast of the Gulf of Mexico (Figure 3) with completion scheduled for August 1982.

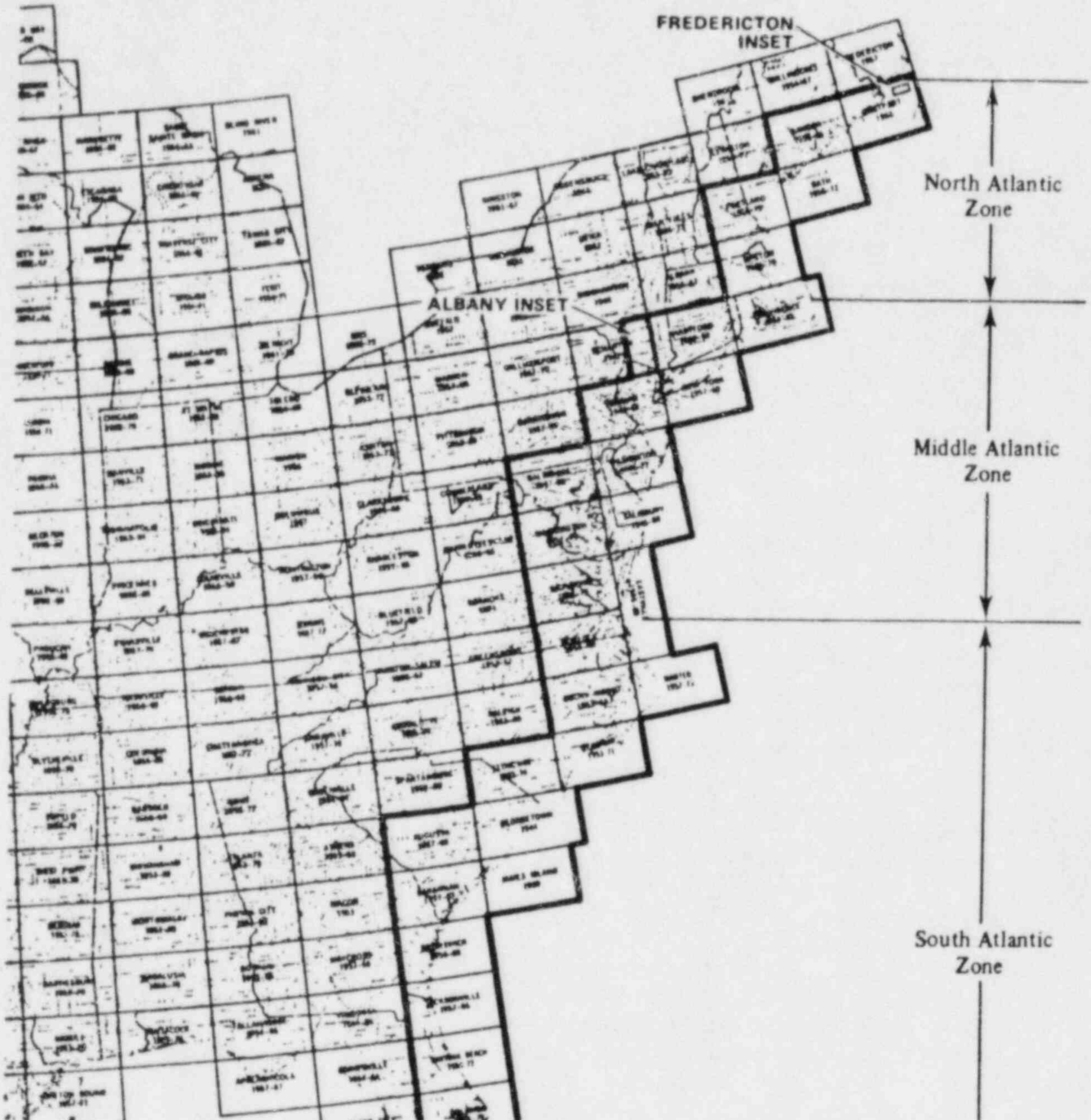

Figure 1. Index to map sheets and major zones of the Atlantic Coast Ecological Inventory.

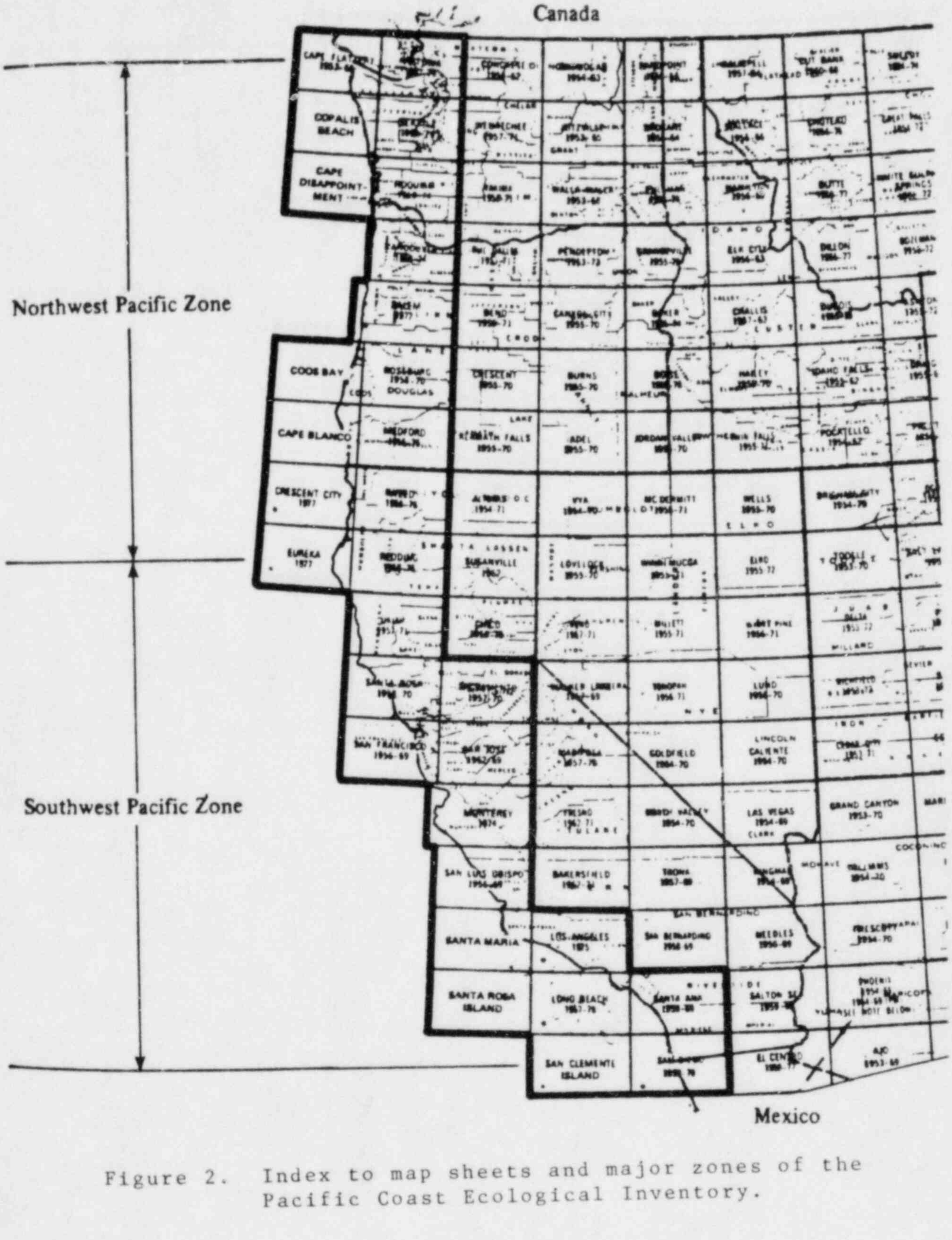

Figure 2. Index to map sheets and major zones of the Pacific Coast Ecological Inventory.

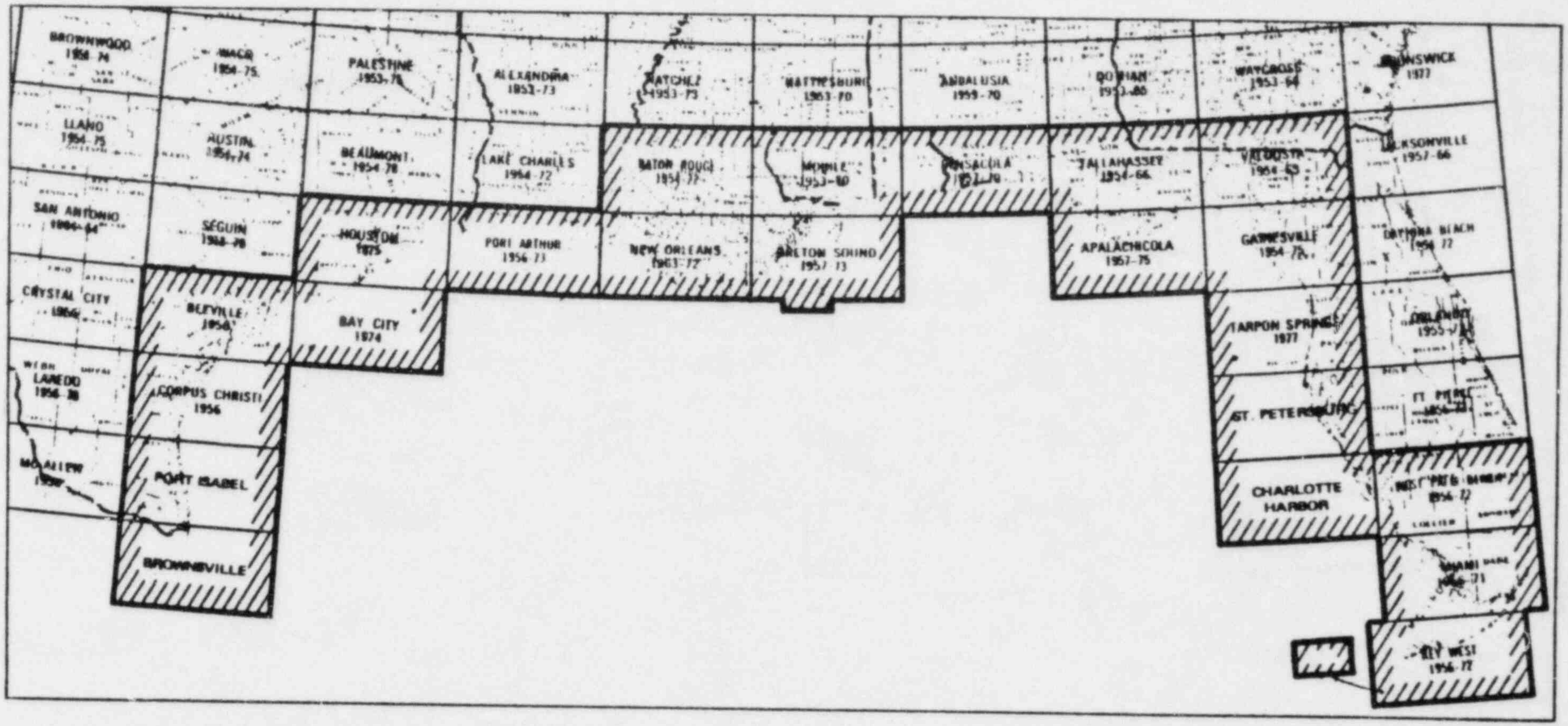

Figure 3. Index to map sheets for the Gulf of Mexico Ecological Inventory.

The inventory and mapping activity was centered first on the Atlantic coastal zone in order to provide information which would help resolve significant environmental and energy issues for that coastal area by reducing resource conflicts with construction and energy-producing companies at the planning stage before decisions are made, and to facilitate leasing processes, oil spill contingency planning, and other aspects of coastal zone management. Subsequently, because of its usefulness, the inventory and mapping activity was extended to include other coastal areas of the United States.

The inventory efforts have focused on ecological resources subject to the provisions of the Fish and Wildlife Coordination Act, the Endangered Species Act, and related Federal legislation. To enhance the utility of the inventory information for Federal, State, and local planners as well as industry, sets of ecological resource inventory graphics were prepared using National Topographic Maps (1:250,000 scale series) provided by the U. S. Geological Survey as a base. Because of the relatively small scale of the maps, the inventory was restricted to identifying and displaying important fish and wildlife species and their habitats (highest priority was given to endangered and threatened species); special land use areas (e.g. refuges and parks); and areas of particular biological concern (e.g. Federal Class I air quality areas, reefs, beaches, and marshes).

SCOPE OF THE INVENTORY FOR COASTAL AREAS

Data Collection

Data compiled by the inventory were collected from numerous Federal, State, local and private organizations such as the U. S. Fish and Wildlife Service, the National Marine Fisheries Service, the U. S. Environmental

Protection Agency, Bureau of Land Management, National Oceanic and Atmospheric Administration, the various state departments of natural resources and environmental protection and conservation, private organizations, such as the Atlantic States Fisheries Commission, regional commissions, environmental research foundations, universities and local experts. Special emphasis was given to collecting that information which had already been assembled by the States for use in their coastal zone planning activities.

Three major categories of information were compiled by the inventory as follows:

- o Important coastal fish and wildlife species, especially those with special designations ("endangered," "migratory," etc.) or high commercial, recreational, and esthetic value;

- o Habitats of these species; and

- o Special land use designations in the coastal area (National Wildlife Refuges, National Parks, and State wildlife management areas, for example).

Inventory Graphics

The base maps on which the inventory information was displayed were prepared from a combination of the black (culture, roads), blue (drainage) and light blue (open water) feature separation plates for the USGS

National Topographic Map Series, 1:250,000 scale, the largest scale available in a complete set for the United States. The set for the Atlantic coast contains 31 maps (Table 1). The Pacific coast set contains 30 maps (Table 2). The Gulf of Mexico set will contain 22 maps (Table 3).

On each base map the study area was highlighted in yellow. The type of detail shown on each map varies from resource to resource and map to map, and was dependent on the type and amount of information available. Locations of threatened and endangered species (shown in red) and other species of special interest, as well as special land use designations (shown in green) were the key features presented. Within the biological groups other than those with endangered status, the population size of a particular species generally determined the priorities for display to prevent the map from becoming too cluttered. Large populations had the highest priority and small populations had the lowest priority. For example, on the Washington (D.C., MD., VA.,) map (see Table 1) it was impractical to display the precise location of individual pairs of dabbling ducks, but known major dabbling duck nesting areas were mapped.

In other cases, for example, the display of meadow voles on the Providence (RI., MA., CT., NY.,) map (See Table 1) where the uniqueness of a particular species to an area was significant regardless of its abundance, these species were mapped also. For all important species the main classifications for the display of resource information were the fish and wildlife resources. For aquatic resources (fish and marine

Table 1. List of USGS 1:250,000-scale maps used in the Atlantic Coast Ecological Inventory.

1. Eastport, ME., US; NS., NB., CAN (includes portion of Fredericton, NB., CAN; ME., US.
2. Bangor, ME.
3. Bath, ME.
4. Portland, ME., NH.
5. Boston, MA.; NH., CT., RI., ME.
6. Providence, RI., MA., CT., NY.
7. Hartford, CT., NY., NJ., MA. (includes portion of Albany, NY., CT., MA., NH., VT.
8. New York, NY., NJ., CT.
9. Newark, NJ., PA., NY.
10. Wilmington, DE., NJ., PA., MD.
11. Salisbury, MD., DE., NJ., VA.
12. Baltimore, MD., PA., VA., WV.
13. Washington, DC., MD., VA.
14. Richmond, VA., MD.
15. Norfolk, VA., NC.
16. Eastville, VA., NC., MD.
17. Manteo, NC.
18. Rocky Mount, NC.
19. Beaufort, NC.
20. Florence, SC., NC.
21. Georgetown, SC., NC.
22. James Island, SC.
23. Augusta, GA., SC.
24. Savannah, GA., SC.
25. Brunswick, GA.
26. Jacksonville, FL., GA.
27. Daytona Beach, FL.
28. Orlando, FL.
29. Fort Pierce, FL.
30. West Palm Beach, FL.
31. Miami, Fl.

Table 2. USGS maps (1:250,000) used in the Pacific Coast Ecological Inventory.

1. San Diego, CA.
2. San Clemente Island, CA.
3. Santa Ana, CA.
4. Long Beach, CA.
5. Santa Rosa Island, CA.
6. Los Angeles, CA.
7. Santa Maria, CA.
8. San Luis Obispo, CA.
9. Monterey, CA.
10. San Jose, CA.
11. San Francisco, CA.
12. Sacramento, CA.
13. Santa Rosa, CA.
14. Ukiah, CA.
15. Redding, CA.
16. Eureka, CA.
17. Weed, CA., OR.
18. Crescent City, CA., OR.
19. Medford, OR., CA.
20. Cape Blanco, OR.
21. Roseburg, OR.
22. Coos Bay, OR.
23. Salem, OR.
24. Vancouver, OR., WA.
25. Cape Disappointment, WA., OR.
26. Hoquiam, WA., OR.
27. Copalis Beach, WA.
28. Seattle, WA.
29. Cape Flattery, WA.
30. Victoria, WA.

Table 3. List of USGS 1:250,000-scale maps used in the Gulf of Mexico Ecological Inventory.

1. Brownsville, TX.
2. Port Isabel, TX.
3. Corpus Christi, TX.
4. Beeville, TX.
5. Bay City, TX.
6. Houston, TX.
7. Port Arthur, TX., LA.
8. Baton Rouge, LA.
9. New Orleans, LA.
10. Mobile, AL., LA.
11. Breton Sound, LA.
12. Pensacola, FL., MS.
13. Tallahassee, FL., GA.
14. Apalachicola, FL.
15. Valdosta, FL., GA.
16. Gainesville, FL.
17. Tarpon Springs, FL.
18. St. Petersburg, FL.
19. Charlotte Harbor, FL.
20. West Palm Beach, FL.
21. Miami, FL.
22. Key West, FL.

mammals), subdivisions (shown in blue) included spawning areas, nursery areas, shellfish bed locations, and fishing areas and ranges. For wildlife resources, the subdivisions (shown in brown) included nesting areas, wintering areas, migration routes, and habitats for furbearing animals. Because many species were located in a range of areas and not in just one specific area, a notebox on each map contains information on the distribution and habitat uses of organisms which could not be mapped. Areas of special biological concern, such as reefs, seagrass beds, beaches, dunes, offshore islands, marshes, and Class I shellfish waters have been indicated depending on their size, and on their economic, ecological, or scientific importance. Each of these designations, for example, species habitat, range, or status, has been shown on the maps by a combination of symbols keyed to alphanumeric descriptions and color.

In the collection, review, and analysis of the literature for this inventory, certain facts about the adequacy, reliability, and timeliness of the information became apparent. Primarily, the information portrayed on the maps was obtained from a variety of sources through personal communications with Federal and state government agencies and several private institutions; therefore, the data are only as reliable as the source material. In addition, due to the scale (1:250,000) of the base maps, and in some cases, to the large amount of information which could not be portrayed at a single location without cluttering the map, only significant species locations and distributions were presented.

There have been only two consistent criticisms of the Ecological Inventory. One is the inadequacy of the maps' scale and the accompanying lack of detailed information, rendering the maps of limited use to some environmental planners. The second deficiency is a lack of population numbers on the maps. Population counts are especially critical when one is assessing the impact of oil spills and other activities.

The 1:250,000 base maps were selected for numerous reasons, the most important of which is that 1:250,000 is the largest map scale completed for the entire United States. Many contributors felt that existing research would not support more precise display of natural resources. Others felt the information should not be shown at a larger scale in order to protect the resources (e.g. aerie sites of the Peregrine falcon) from further perturbation.

To portray as much information as accurately as possible, draft copies of each inventory graphic were reviewed by key personnel with state organizations as well as personnel from regional and field offices of the U.S. Fish and Wildlife Service. During this final review phase, all comments were checked and verified, and then incorporated on the final maps. Therefore, the information presented on the inventory graphics represents the most reliable information available to date which can be displayed on maps at this scale.

Narrative Report

The format and organization of the narrative report which accompanies each map set in the series is structured geographically on a number of discrete intervals. Each of these intervals covers about 78 to 260 square kilometers (30 to 100 square miles). The base map series (the USGS National Topographic Map Series, 1:250,000 scale) contains a Universal Transverse Mercator (UTM) grid with 10,000 meter centers which has been employed to provide the basic reference system for describing the biological resources within discrete intervals or bands. All resources displayed on the map series were described and located according to this reference system in the narrative report. A complete list of all information sources contacted is included at the end of the report.

Availability of Products

Maps produced for Ecological Inventory Series are for sale by the U.S. Geological Survey. The narrative reports "Atlantic Coast Ecological Inventory" and "Pacific Coast Ecological Inventory" are available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

MAP USES

Site and land-use planners have found the maps useful in designating areas to avoid when planning development of various kinds. Regulatory agencies reviewing permits have used the maps to verify the accuracy of environmental impact statements. The maps have provided an alternative to site visits for some reviewers, saving both time and money in the permit review process. The maps have been especially helpful to upper level decisionmakers reviewing the recommendations of field personnel.

Wildlife biologists have found the information on refuges and other special management areas to be particularly useful, both for work in protecting species and for coordinating their efforts with others in the area.

Park and refuge personnel appreciate the educational aspects of the maps: they can refer to the maps in explaining the presence of particular species or habitats to visitors. The maps are helpful to educators in showing the interaction of ecosystems and in preparing students for field trips by alerting them to species and habitats in the area. The maps are invaluable in allowing a newcomer to become familiar with a site. They are also useful in recreational pursuits, by locating areas where specified animals may be viewed or hunted.

Users find the maps valuable for an overview of an area. When used in conjunction with more detailed mapping projects, the Inventory maps give a more regional perspective, putting larger scale maps into context.

The contribution of the Ecological Inventory Series to coastal planning and resource protection may never be fully assessed, but users have accepted the maps as a valuable screening tool and nearly all have proposed that the effort be continued and updated as a basic inventory of natural resource locations.

POTENTIAL APPLICATION TO 10 CFR

The Ecological Inventory Map Series could be most useful as an integral part of an information system consisting of numerous data sources during the preoperational phase of a typical land disposal facility. The applicant would select a region of interest and apply the Ecological Inventory as one piece of information to help narrow the number of possible disposal sites. Because of the rarity of compilations of this sort, a significant saving in manhours required for the collection of reconnaissiance level information could be achieved with the Ecological Inventory Map Series already available. The information provide by the Map Series would be useful also in guiding the design of potential disposal site studies of important ecological resources in the area, the design of preoperational monitoring activities, the preparation of the environmental report, and in the regulatory review of the license application.

ACKNOWLEDGEMENTS

Data collection, basic design of inventory graphics, and narrative report preparation for both the Atlantic and Pacific Coast Ecological Inventory were performed by Dames & Moore, Bethesda, Maryland, under contract to the U.S. Fish and Wildlife Service. Mr. Larry Shanks was the Fish and Wildlife Service Project Officer for both efforts. Basic design of the map collar as well as final cartographic control and map publication were provided by the U.S. Geological Survey, Reston, Virginia.

METEOROLOGICAL CONSIDERATIONS FOR LOW-LEVEL WASTE DISPOSAL

I. Van der Hoven

Air Resources Laboratories
National Oceanic and Atmospheric Administration
8060 13th Street
Silver Spring, Maryland 20910

ABSTRACT

The assessment of long-term atmospheric transport and diffusion of radioactive effluents emanating from low-level waste burial sites is discussed. A widely-used, gaseous diffusion model is presented. The required input to the model by means of hourly meteorological measurements and diffusion parameterization is listed. An example of the average annual effluent concentration around an actual site is related to prevailing wind direction, atmospheric stability and topography. Climatological factors are also discussed.

INTRODUCTION

The Nuclear Regulatory Commission (NRC) licensing requirements for near-surface disposal of radioactive wastes (1) specifies that the general public must be protected from harmful releases of radioactivity to the environment. These release pathways may appear in the surface water, ground water, soil, plants, animals, or as an effluent in the atmosphere. Total containment of the radioactive waste within the confines of the burial site is not thought to be attainable, especially when the hazard is assumed to extend over a time frame of several hundred years.

The concern in this paper is the atmospheric release pathway of the radioactivity. Specifically, an assessment of the long-term atmospheric transport and diffusion of radioactive effluents emanating from the burial site is required. The end result of such an assessment is the determination that the downwind concentration of the radioactive material which may be released to the air does not result in an average annual radiological dose to the general public that exceeds specified limits.

ATMOSPHERIC DISPERSION MODELS

Regulatory agencies such as the NRC and the Environmental Protection Agency (EPA) have long used atmospheric transport and diffusion models to determine site or facility suitability from an environmental point of view. In the case of light water reactor facilities the NRC (2) suggests the use of computed average annual concentrations to determine allowable routine effluent release limits such that radiological dose limits are not exceeded. These annual average concentrations are a function of release height, wind direction and speed, vertical diffusion rate, and the effluent release rate. The computational expression for long-term average concentration over 22½ degree wind sectors is

$$\overline{X}_D = 2.03\ F\ Q\ (x\sigma_z u)^{-1}\ \exp\ (-H^2/2\sigma_z{}^2) \qquad (1)$$

where

$\overline{X}_D$ = average ground level concentration (Bq/m^3) at a downwind distance of x (m) and wind direction sector D,

F = joint fractional frequency of stability, wind speed, and wind direction classes,

Q = uniform radionuclide release rate (Bq/sec),

σ_z = vertical dispersion coefficient (m) for a given stability class and distance,

u = wind speed ($m\ sec^{-1}$),

H = effective stack height (m).

Numerous computer codes, such as that of Sagendorf (3), utilize this expression to compute long-term downwind average concentration patterns.

ONSITE MEASUREMENTS

Before burial site is selected and burial begins, meteorological measurements from the site or from a location considered to be representative of the site need to be collected for at least one year in order to provide the input for the diffusion model discussed in the previous section. Instrumentation capable of measuring wind speed and direction and the difference in temperature between two heights should be provided on a tower or mast. The NRC (4) suggests that the wind and the lower height temperature be measured at 10 m above the ground which is the standard meteorological reference level generally accepted throughout the world to measure near surface conditions. The upper temperature level should be at a height of about 30 m above the ground. The wind speed and direction measurements are direct input to the model while temperature difference measurements determine a stability class which in turn defines the vertical diffusion coefficient as a function of distance from the release. Another technique in determining the stability class is to use the standard hourly weather observations taken at a nearby and topographically comparable National Weather Service Station. As described by Pasquill (5) the stability class determination is a function of the time of day, amount of solar insolation, amount of cloudiness, and wind speed. Using this technique, the National Climatic Center in Asheville, NC, by means of their Stability Array computer program (6), can provide joint frequency tables of wind speed versus direction as a function of stability class for numerous weather stations in the United States.

DISPERSION ASSESSMENT

The frequency distribution of wind speed classes versus 22½ degree wind sectors as a function of stability class serves as the required input to equation (1). Also, Q, the radiological source term is needed if an assessment of downwind concentration, χ, is desired. Alternatively, one can express equation (1) in terms of relative concentration, that is, χ divided by Q which has units of sec m^{-3}. An example of such a calculation by Yanskey et al (7) for the Idaho National Engineering Laboratory assuming a 23 m elevated source at the Central Facilities Area is shown in figure 1 for 16 wind sectors and for a series of distances to 50 km. Ten years of onsite meteorological data was used. To obtain the average annual radiological dosage the χ/Q values in figure 1 should be multiplied by the release rate of the particular nuclide in question and by the appropriate dose conversion factor.

The shape of the isopleths of constant relative concentration shown in figure 1 indicates higher values in the upper right hand and lower left hand sectors. This in large part can be explained by the seasonal and annual wind direction frequencies (commonly called wind roses) in figure 2. The data covers hourly values over a 12-year period taken at the CFA meteorological tower. The prevailing wind direction is from the southwest and west southwest with a combined frequency of 35 percent. A secondary prevailing direction is from the northeast and north northeast. This helps explain the southwest-northeast orientation of the isopleths.

Wind rose data and accompanying relative concentration patterns can be helpful in determining the most advantageous location of the burial site with

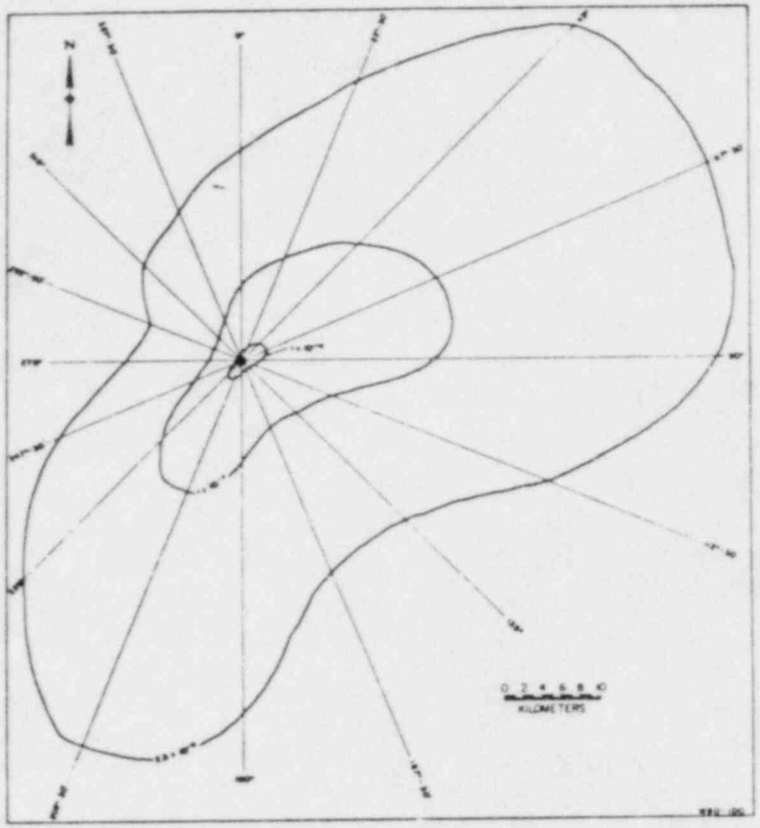

Fig. 1. Mean annual relative concentration, 23 m source height.

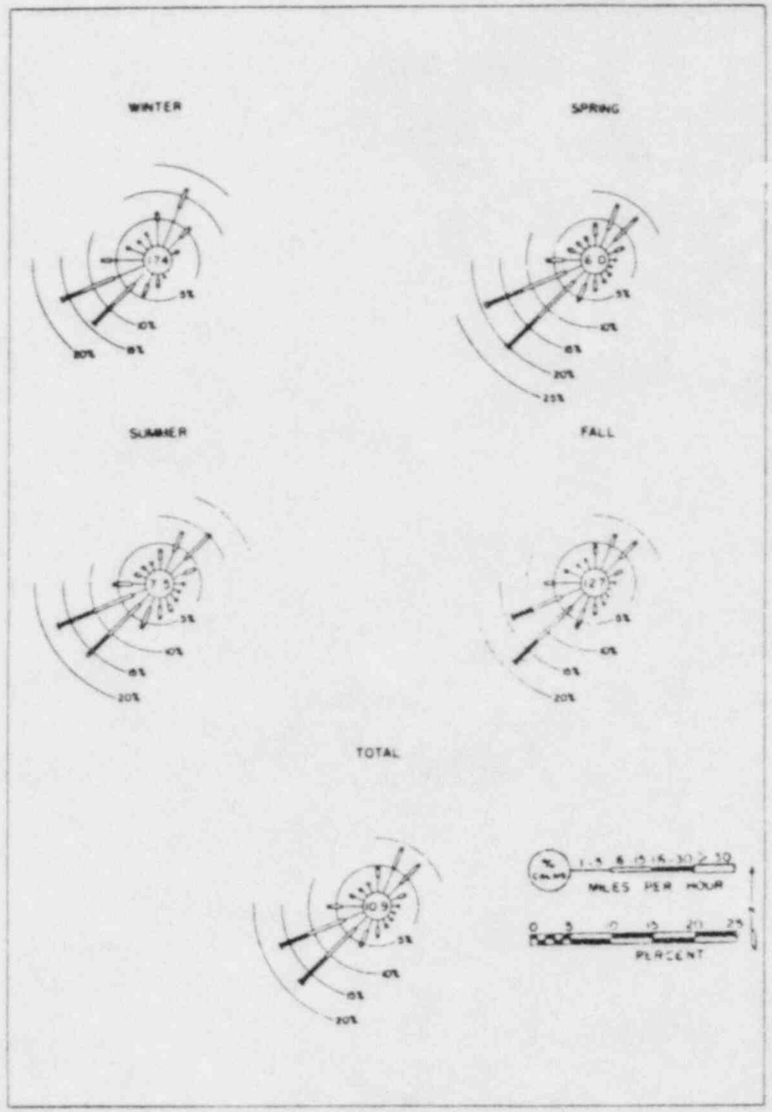

Fig. 2. CFA 20-ft level wind roses, January 1950 through May 1962.

respect to nearby population centers. It can also be helpful in placing temporary or permanent radiological monitoring sites once the disposal operation has begun. Valley sites, in particular, often show preferred up-valley transport in the daytime and downvalley at night. Although the Snake River valley in southwestern Idaho is about 100 km wide, it nevertheless shows this phenomenon. The much narrower river valleys in the eastern part of the United States show this feature even more. Consequently, since population centers are often located on the flat terrain along rivers, particular care should be exercised in locating burial sites in these areas.

OTHER CLIMATIC CONSIDERATIONS

Burial failure modes such as surface erosion, floods, and settlement are, in part, related to climatic factors. These include the frequency of occurrence of high winds, the amount and intensity of precipitation, and the frequency of extreme surface temperatures. Hurricanes, tornadoes, and thunderstorms, in particular, are meteorological phenomena which combine extreme wind speeds with heavy rainfall. Hurricanes can cause additional flooding along ocean coastal areas because of storm surges combined with high tides. A significant increase in average precipitation amounts may also have effects on ground water flow rates. Extreme high temperatures may have an effect on soil moisture retention, thus making the ground surface more susceptible to soil erosion.

Climatic information on these extreme conditions is usually not available from the site itself because it takes a record of tens of years to obtain usable statistics on these events. However, such information is available from official government weather stations. Studies on extreme wind speeds (8) precipitation extremes (9), temperature extremes (10), and an evaluation of extreme meteorological events in nuclear facilities (11) are a few examples.

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GEOTECHNICAL SITING CONSIDERATIONS

Don Banks

U. S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, Mississippi

ABSTRACT

The U. S. Nuclear Regulatory Commission has a statutory obligation to license and regulate facilities used to receive and store radioactive wastes, including low-level materials. Rules and position papers have been issued to address the public's concern and rightful demand for a guaranteed, safe disposal of the radioactive wastes. Performance objectives and technical requirements in the proposed rule 10 CFR 61 that deals with the disposal of low-level radioactive wastes contain several areas in which geotechnical engineering will play a most prominent role.

INTRODUCTION

As the people of the United States view the national needs of the 1980's and beyond, there is a continued awareness that these needs must be solved by programs that are worthwhile (i.e., in the nation's best interests) and result in projects that can be completed in a safe, economical, and timely manner. Many needs exist such as in transportation systems, defense installations, energy resource development and recovery, and the disposal of the hazardous by-products of our industries. Industrial wastes can be classified in various ways; however, while the volume of that portion classified as being radioactive is small, the public's concern and rightful demand for a guaranteed, safe disposal of the radioactive wastes is perhaps the greatest.

By statutory obligations the U. S. Nuclear Regulatory Commission (NRC) has been directed to license and regulate facilities used for the receipt and storage of all forms of radioactive wastes. The broad range in concerns over the hazards associated with radioactive wastes has led the NRC to divide their efforts into considering disposal of high-level wastes and low-level wastes (LLW) separately. The NRC has prepared rules and position papers applicable to both divisions of radioactive wastes with the intent of addressing the public's concern over safe disposal. At the same time, there is concern that the rules and papers ensure that disposal is achieved in accordance with state-of-the-art/state-of-practice techniques but with adequate flexibility to allow engineering judgments to be made and, as identified, research and development activities to be pursued where technological gaps or constraints exist.

This symposium focuses on site suitability requirements in the proposed rule on land disposal of low-level radioactive wastes and associated technical position papers as issued for public review by the NRC. The papers in the proceedings of this symposium respond to the rule and papers from several technical viewpoints. This paper, which gives a geotechnical response, does not go into technical detail but is intended to stimulate discussion with respect to these questions: Are additional criteria needed and, if so, what are they? What criteria are too restrictive? Can sites be found which meet the criteria?

Geotechnical engineering provides the bridge between the broad fields of geology and civil engineering by making use of the principles of soil mechanics, rock mechanics, engineering geology, and hydrogeology. Geotechnical engineering provides the means by which site screening, site selection, site investigation, characterization, and evaluation/assessment can proceed through the design, construction, operation, and maintenance phases of any project (Figure 1). Depending upon the nature of the project, geotechnical engineering can play a role ranging from one of decisiveness to one of passiveness. In the problem of the disposal of low-level radioactive waste (near surface; soil environment), geotechnical engineering will be an area of consideration of utmost importance to ensure safe disposal.

GEOTECHNICAL ACTIVITIES

The life cycle of a typical land disposal facility can be broken into five phases: preoperational, operational, closure, postclosure observation, and maintenance and institutional control. The geotechnical activities of site screening, site investigation/characterization (preliminary and detailed),

GEOTECHNICAL ENGINEERING

- Bridges between geology and civil engineering

- Makes use of principles of
  - soil mechanics
  - rock mechanics
  - engineering geology
  - hydrogeology

- Provides means to perform
  - site screening
  - site selection
  - site investigation, characterization, evaluation/assessment
  - design
  - construction
  - operation
  - maintenance

- of worthwhile projects in a timely, safe, and economical manner.

Figure 1. Definition of Geotechnical Engineering

design, construction, operation, and maintenance are related to all life cycle phases to varying degrees of importance. The relationships are illustrated in Table 1.

Site Screening Activity

In this activity (Figure 2), geotechnical engineers and engineering geologists will usually concentrate efforts on review of existing data to describe the conditions at several candidate sites. Onsite reconnaissance-level surveys will be conducted to verify the accuracy of the existing data. Through this activity sites will be categorized as to their ability to meet the requirements of a land disposal facility.

Site Investigation/ Characterization (Preliminary)

In this activity (Figure 3), suitable sites will be investigated/ characterized in detail sufficient to determine the best of the sites. The geotechnical personnel will perform preliminary geologic mapping and commonly will follow up with limited surface geophysical surveys, a limited number of borings, and then a limited number of tests on the materials.

Site Investigation/ Characterization (Detailed)

In this activity (Figure 3), detailed geotechnical investigations will be conducted at the selected site(s). Detailed geologic mapping will be performed, followed by the main boring program to describe subsurface conditions, to obtain test samples, and to provide access for possible downhole geophysical logging and in situ testing equipment and for installation of preoperational groundwater monitoring devices. Additional surface geophysical surveys may be conducted to extend the subsurface information between borings. Necessary material testing will be performed.

Design Construction and Operation Activities

The design of features of the disposal facility will proceed from geotechnical information and data collected from the site investigation/

Life Cycle of Typical Disposal Facility	Geotechnical Activities: Site Screening	Site Investigation/ Characterization (Preliminary)	Site Investigation/ Characterization (Detailed)	Design	Construction	Operation	Maintenance
A. Preoperational Phase							
i. Disposal site selection							
a. Data gathering	•	•					
b. Planning	•	•					
ii. Site characterization							
a. Data gathering		•	•	•			
b. Planning		•	•	•			
iii. Licensing	Considered						
B. Operational Phase							
i. Construction			•	•	•		
ii. Receipt of radioactive waste						•	•
C. Closure Phase			Considered				
D. Postclosure Observation and Maintenance Phase			•	•	•	•	•
E. Institutional Control Phase			Considered				

Table 1. Relationship Among Geotechnical Activities and Life Cycle Phases

SITE SCREENING ACTIVITY

TASK: Categorize suitability of candidate sites to meet performance objectives and technical requirements.

APPROACH:

Use existing information
- Geologic maps
- Geologic reports
- Remote imagery
- Groundwater surveys
- Boring logs
- Seismic surveys
- Engineering reports

to describe
- Regional information
- Topography
- Soil stratigraphy
- Soil types
- Hydrogeology
- Engineering properties

followed by
- Geologic reconnaissance for verification of accuracy

PRODUCT: Reports in which candidate sites are categorized as being

- likely suitable
- possibly suitable
- marginally suitable

Figure 2. Stages of the Site Screening Activity

SITE INVESTIGATION/CHARACTERIZATION ACTIVITY

TASK: Determine if selected candidate site(s) meet performance objectives and technical requirements.

APPROACH:

Perform detailed geologic mapping	Material types at sites Site/material conditions Stratification Characterization Hydrogeologic features Tectonic activity Geologic processes
with borings	Description of subsurface Test samples Access for downhole geophysical logging Access for downhole in situ tests Access for hydrogeologic monitoring
and surface geophysical surveys	Subsurface structure/interfacing Material types Material continuity Material properties
with numerous tests	Both downhole in situ and laboratory to determine design properties • porosity • saturation • density • strength • permeability • compressibility • compaction behavior

PRODUCT: Report(s) necessary to proceed with design, construction, operation, and maintenance activities

Figure 3. Stages of the Site Investigation/Characterization Activity

characterization activity (Figure 4). State-of-practice design techniques should be used because of the long experience with their application to geotechnical problems. Where performance objectives or minimum technical requirements cannot be met using state-of-practice techniques, the identified technology gap may require research and development studies or the application of novel design techniques. However, in this situation, before the design activity can be completed, the design results should be verified by full-scale field performance demonstrations.

Once the design has been completed, specifications for construction methods and operational and maintenance procedures can be made. Further, plans can be made for quality control programs and for continued geotechnical data collection during construction. In particular, plans to continue to collect geotechnical data must be made to ensure that subsurface conditions as revealed by trenching are the same as determined during site investigation; if not, additional tests and continued assessment must be made to determine the correctness of the design. Geotechnical data will be available to correctly plan for closure, postclosure observation, and maintenance and institutional control of the facility.

Importantly, upon completion of the design and planning activities an application for a construction and operation license can be made with assurance that the public's health and safety is protected in accordance with stated performance objectives and minimum technical requirements.

RELATIONSHIP BETWEEN GEOTECHNICAL ACTIVITIES AND THE PROPOSED RULE

The previous discussion has centered on geotechnical activities and their relationship to the life cycle phases of land disposal facilities. The NRC has proposed to add a new Part 61 to the rules in 10 CFR that describes licensing requirements for land disposal of radioactive waste. Specifically, when adopted, the rule will establish:

- Performance objectives for land disposal of wastes.
- Technical requirements for the siting, design, operations, and closure activities for a near-surface disposal facility.

DESIGN ACTIVITY

TASK: Using information provided by site investigation/characterization activities, design a facility using state-of-the-practice techniques to ensure that low-level radioactivity waste can be disposed in near-surface facilities in such a manner so as not to endanger the public's health and safety. Provide specifications for site construction, operation, and maintenance.

APPROACH: Use state of the practice to design an operational facility. Identify areas where technology gaps exist. Make plans for quality control program and continued geotechnical data collection. Prepare plans for closure, postclosure observation, and maintenance and institutional control.

PRODUCT: Application for construction and operational license.

Figure 4. Function of Design Activity

- Technical requirements concerning the waste form that waste generators must meet for the land disposal of waste.
- Classification of waste.
- Institutional requirements.
- Administrative and procedural requirements for licensing a disposal facility.

Many portions of the proposed rule require a knowledge of geotechnical engineering, both on the part of the applicant and the NRC. Specifically, the following paragraphs of the proposed rule require geotechnical consideration to varying degrees to be properly addressed.

- Subpart A - General Provisions

  para. 61.2 - Definitions

  para. 61.7 - Concepts

  The geotechnical considerations are shown on Figure 5.

- Subpart B - Licenses

  para. 61.10 - Content of application

  para. 61.11 - General information

  para. 61.12 - Specific technical information

  para. 61.13 - Technical analyses

  para. 61.23 - Standards for issuance of a license

  para. 61.28 - Content of application for closure

  para. 61.29 - Postclosure observation and maintenance

  The geotechnical considerations are shown on Figure 5.

- Subpart C - Performance Objectives

  para. 61.40 - General requirement

  para. 61.41 - Protection of the general population from releases of radioactivity

  para. 61.42 - Protection of individuals from inadvertent intrusion

  para. 61.44 - Stability of the disposal site after closure

  The geotechnical considerations are shown on Figure 6.

Subpart A - General Provisions (pg 38089 ff)

para 61.2
Definitions - General knowledge of geotechnical engineering practice required. For example
"Active maintenance"
"Buffer zone"
"Commencement of construction"
"Disposal site"
"Disposal unit"
"Hydrogeologic unit"
"Monitoring"
"Site closure and stabilization"

para 61.7
Concepts - General knowledge of geotechnical engineering practice required

Subpart B - Licenses (pg 38092 ff)

para 61.10
Content of application - General knowledge of geotechnical engineering practice required

para 61.11
General information - General knowledge of geotechnical engineering practice required

10 CFR Part 61
Licensing Requirements for Land Disposal of Radioactive Waste
Federal Register/Vol 46 No 142/24 July 1981/Proposed Rules/pg 38081 ff

Figure 5. Relationship between Geotechnical Engineering and Subparts A and B; 10 CFR 61 (Continued)

para 61.12 Specific technical information -	Detailed knowledge of geotechnical engineering parameters, design procedures, construction techniques, and monitoring techniques required. Specifically,
(a) Site description	Geologic features.
(b) Design features	Infiltration of water Integrity of covers Stability of backfill and covers Contact with standing water Site drainage Site closure and stabilization Site maintenance Site monitoring
(c) Design criteria to meet performance objectives	
(d) Design basis of natural events	
(e) Applicable codes and standards	
(f) Construction and operation	Methods of construction Drainage systems both to control surface and groundwater
(g) Closure plan	
(h) Natural resources	
(j) Quality assurance program	
(l) Environmental monitoring program	

10 CFR Part 61
Licensing Requirements for Land Disposal of Radioactive Waste
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Figure 5. Relationship between Geotechnical Engineering and Subparts A and B; 10 CFR 61 (Continued)

para 61.13

Technical analyses - Detailed knowledge of geotechnical engineering parameters, design procedures, construction techniques, and monitoring techniques required. Specifically,

(a) Analyses of migration of radioactivity in groundwater

(b) Analyses of long-term stability

- Erosion
- Mass wasting
- Slope failure
- Settlement of backfill
- Infiltration
- Surface drainage

para 61.23

Standards for issuance of a license - Requires a sufficient knowledge of geotechnical considerations on the part of the applicant that he may properly document the license application to assure the NRC that risk to the public's health and safety will not be endangered.

10 CFR Part 61

Licensing Requirements for Land Disposal of Radioactive Waste

Federal Register/Vol 46 No 142/24 July 1981/Proposed Rules/pg 38081 ff

Figure 5. Relationship between Geotechnical Engineering and Subparts A and B; 10 CFR 61 (Continued)

para 61.28 Content of application for closure	-	Detailed knowledge of geotechnical considerations required.
(a) Additional geologic data		
(b) Results of tests, experiments, and analyses relating to		backfill of excavated areas closure and sealing migration
(c) Revised plans for		backfilling stabilization
para 61.29 Postclosure observation and maintenance	-	Knowledge of geotechnical considerations necessary to carry out observation and monitoring activities and perform necessary maintenance and repairs.

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Licensing Requirements for Land Disposal of Radioactive Waste
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Figure 5. Relationship between Geotechnical Engineering and Subparts A and B; 10 CFR 61 (Concluded)

Subpart C - Performance Objectives (pg 38095 ff)

para 61.40 General requirement

para 61.41 Protection of the general population from releases of radioactivity

para 61.42 Protection of individuals from inadvertant intrusion

para 61.44 Stability of the disposal site after closure

These general statements of performance will require detailed knowledge and application of geotechnical principles in order to provide the necessary assurance to the NRC.

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Figure 6. Relationship between Geotechnical Engineering and Subpart C; 10 CFR 61

- Subpart D - Technical Requirements

  para. 61.50 - Disposal site suitability

  para. 61.51 - Disposal site design

  para. 61.52 - Land disposal facility operation and closure

  para. 61.53 - Environmental monitoring

  The geotechnical considerations are shown on Figure 7.

- Subpart E - Financial Assurances
- Subpart F - Participation by State Governments and Indian Tribes
- Subpart G - Records, Reports, Tests, and Inspection

  The geotechnical considerations of these subparts require only general knowledge of geotechnical practices.

DESCRIPTIONS OF GEOTECHNICAL CONSIDERATIONS

The previous discussions have made broad references to geologic parameters, design procedures, quality control, groundwater monitoring, etc., without much detail as to what is involved. The NRC through contract with engineering firms and interagency work agreements with other government agencies is in the process of providing the necessary definitions. One such agency is the U. S. Army Engineer Waterways Experiment Station. Through agreements with the NRC studies are being conducted in the Geotechnical Laboratory as follows:

- Technical Assistance on Site Characterization and Monitoring

  Task 1. Identify Site Parameters for Investigation

  Site parameters will be identified that should be investigated and evaluated to demonstrate the suitability of a site for the disposal of LLW and to provide information needed for design and construction of a near-surface disposal facility.

  Report date . . . . 31 Jan 1981

Subpart D - Technical Requirements (pg 38095 ff)

para 61.50

Disposal site suitability - Detailed knowledge of geotechnical engineering screening and site characterization techniques required. Specifically,

(2) Site shall be capable of being characterized, modeled, analyzed, and monitored.

(4) Avoidance of areas with economically significant natural resources.

(5) Site must be well drained and free of flooding and ponding.

(6) Upstream drainage areas must be minimized.

(7) Water table at such depth to prevent intrusion into waste.

(8) Groundwater discharge must not originate in hydrogeologic unit.

(9) Avoidance of areas of active surface geologic processes such as mass wasting, erosion, slumping, landsliding, weathering.

10 CFR Part 61

Licensing Requirements for Land Disposal of Radioactive Waste

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Figure 7. Relationship between Geotechnical Engineering and Subpart D; 10 CFR 61 (Continued)

para 61.51
Disposal site design - Detailed knowledge of geotechnical engineering parameters design procedures and construction techniques required. Specifically,

(4) Covers must be designed to prevent water infiltration, to direct percolating or surface water away from the buried waste and to resist degradation by surface geologic processes.
(5) Surface features must direct surface water away from disposal units.
(6) Site must be designed to eliminate the contact of water with waste during storage, the contact of standing water with waste during disposal, and the contact of percolating or standing water with wastes after disposal.

para 61.52
Land disposal facility operation and closure - General knowledge of geotechnical engineering parameters required. Specifically,

(5) If void spaces between waste packages are filled with soil.
(9) To provide adequate closure and stabilization measures.

para 61.53
Environmental monitoring - Detailed knowledge of geotechnical parameters and monitoring techniques required. Specifically data required to characterize site in terms of geology and seismology and to provide data that can be evaluated in terms of groundwater migration of radioactive elements.

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Licensing Requirements for Land Disposal of Radioactive Waste
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Figure 7. Relationship between Geotechnical Engineering and Subpart D; 10 CFR 61 (Concluded)

Task 2. Identify Recommended Laboratory and Field Testing Techniques to Investigate the Site Parameters

The recommended laboratory and field testing techniques needed for investigation of site parameters (identified by Task 1) will be described.

Report date . . . . 28 Feb 1982

Task 3. Identify a Comprehensive Program for Monitoring

A recommended program and appropriate instrumentation for monitoring the site will be identified.

Report date . . . . 30 Sep 1982

- Trench Design and Construction Techniques

Task 1. Identify Practices Currently In Use

A review and evaluation of domestic and foreign publications on the disposal of low-level radioactive wastes, hazardous wastes, and sanitary landfills will be made, with an assessment of state-of-the-art practices.

Report date . . . . (draft) . . . 15 Dec 1981
(final) . . . 30 Sep 1982

Task 2. Assess Feasibility of Using Existing Practices

The feasibility of using each of the practices identified above will be assessed for existing disposal sites.

Report date . . . . (draft) . . . 28 Feb 1981
(final) . . . 30 Sep 1982

Task 3. Assess Engineered Improvements

The feasibility of using various engineered modifications to improve the expected performance of the recommended designs and construction techniques (from Task 2) will be evaluated.

Report date . . . . (draft) . . . 30 Apr 1982
(final) . . . 30 Sep 1982

Task 4. Develop Review Procedures and Industry Guidance

A Technical Position Paper will be prepared to provide for distinguishing among different types of sites with a recommendation of trench design and construction technique appropriate for each type of site.

A Standard Review Plan will be prepared to detail the critical parameters for review in each of the trench designs, construction techniques, and engineered modifications.

Report date . . . . (draft) . . . 31 Jul 1982
(final) . . . 30 Sep 1982

- Geotechnical Quality Control (pending)

Task 1. Identify Site Parameters

Site geotechnical parameters that should be tested, observed, and documented during construction, operation, and closure of the site will be identified.

Report date (tentative) . . . . 31 May 1982

Task 2. Identify Testing Techniques

Recommended laboratory and field testing and observation techniques needed for investigation of the parameters listed above will be identified.

Report date (tentative) . . . . 30 Sep 1982

Task 3. Identify a Quality Control Program

Recommended quality control programs and documentation to be used during site construction, operation and closure of a low-level waste disposal facility and during construction of waste retention systems at uranium recovery facilities will be identified.

Report date (tentative) . . . . 31 Dec 1982

CONCLUSIONS

The safe disposal of low-level radioactive wastes in near-surface land disposal facilities is a pressing national need. The NRC has acted in a responsive manner to identify problems associated with disposal and has formulated rules by which disposal will be accomplished in such a manner as not to endanger the public's health and safety. Several areas of consideration in licensing a disposal facility involve geotechnical engineering. Such areas are divided between performance objectives and technical requirements. The NRC has commissioned studies that will provide technical reports, position papers, and review plans dealing with various geotechnical aspects but including:

- Site Parameters for Investigations
- Trench Design and Construction
- Geotechnical Quality Control

PANEL DISCUSSION WEDNESDAY MORNING

The panel discussion section has been edited and represents a summary of the technical questions and responses. Also questions and answers addressing the same categories have been grouped together.

The panel discussion has been recorded in its entirety and a transcript is available from the Nuclear Regulatory Commission.

The panel consisted of:

D. Jacobs - Chairman, Evaluation Research Corp., Oak Ridge, TN
- J. Robertson - U.S. Geological Survey, Reston, VA
- D. Schreiber - Schreiber Consultants, Coeur d'Alene, ID
- H. Zittel - Oak Ridge National Laboratory, Oak Ridge, TN
- A. Sherk - U.S. Fish and Wildlife Service, Washington, D.C.
- I. Van der Hoven - National Oceanic and Atmospheric Administration, Washington, D.C.

F. Galpin: Wind may be one factor of interest, but a more vital meteorological parameter is precipitation. Can you comment on the availability of measurements for precipitation, the suitability of transferring the results of such measurements from one location to another, and how one might go about that? How representative is precipitation data over time, especially considering that the maximums and minimums may be critical in this instance?

I. Van der Hoven: Our national record for precipitation is much better than for wind direction and wind speed. All you really need to measure precipitation is a bucket. There are thousands of co-operative observers in the national system. They usually have an instrument shelter with a barograph to measure pressure and maybe a thermograph to measure temperature. They also have a rain gauge, but no anamometry or exotic instruments. Thus, we have many points of precipitation collection over many years, and we're in good shape with regard to precipitation. We have many more points than we do for wind and speed.

There's always a question as to whether you can find a station or a collecting point that is representative of your site. The chances are a lot better for data on precipitation than for wind speed and wind direction.

F. Galpin: Into what time span is the precipitation data broken down?

I. Van der Hoven: Most of it is hourly. Some stations just require a daily reading, so you get daily precipitation amounts. Those that have recording gauges give it by hour, or by minute, because it's recorded on a chart.

J. Hill: Dale Smith mentioned that the roots of the review process are in NEPA. Is the licensing of a regional compact facility by an Agreement State considered a major federal action?

H. Zittel: Actually, that is a legal question, and, by definition, I am not competent to answer it. It is my guess that the NRC would consider it a major federal action and would require an EIS. Only the licensing agency can make this decision.

J. Hill: A number of states are negotiating compacts, and I think this is a very important consideration for those compacting groups.

One of the things that has been considered in the draft language is that all members would become Agreement States. If language like that is adopted by these various compact commissions, the question will need to be addressed.

H. Zittel: I agree with that. We have done work with a number of Agreement States, but in each case they have asked the NRC for help. The question as to what the route would be under NEPA for such a compact is strictly a legal question.

J. Hill: If the roots of the whole site suitability issue are in NEPA, and we're basing technical criteria on that process, I would like clarification.

R.D. Smith: I could give you a definite "I don't know." The question, as I understood it, was that if an Agreement State issues a license, is this a major federal action? On the surface, the answer is obviously no, because it's a state action.

The Uranium Mill Tailings Control Act requires Agreement States to go through a process to license uranium mills that is comparable to that of the NEPA process that the federal agency would have to go through. Language to that effect has been introduced in various bills in Congress, none of which have become law.

There are no requirements for an Agreement State to conform to the NEPA process. Some states have equivalent state laws; for example, Washington requires a process similar to the federal NEPA process.

There are questions that could be examined as to the congressional approval of the formation of a compact. An interesting question is: Is the formation of a compact a major federal action for which there should be an environmental impact statement written? But, a state license does not require the NEPA process to be followed.

E. Watson: A much larger problem than low-level waste disposal is the one of non-radioactive or chemical, waste disposal. Is there a regulation for chemical waste dumps? And, is the proposed 10 CFR 61 parallel or consistent with that regulation?

P. Skinnar: Presently, there are no landfill requirements under the Resource Conservation and Recovery Act promulgated by EPA, because the proposed ones were withdrawn by EPA. If at any future time they are reproposed, it's questionable whether they will mirror the work done by NRC.

Having been through the agonies at West Valley in the last decade, there seem to be some important issues that this conference has not addressed in detail; namely, although the site may be qualified for the disposal of low-level waste, the performance of that isolation system seems to be determined more by the materials emplaced than the geo-technical characteristics of the site.

Does anyone on the panel have any observations that might shed some light on the question of such issues as settlement, infiltration of water which becomes leachate, removal of the leachate, and those items which have geo-technical ramifications, and operation ramifications as well?

The experiences at Maxey Flats, Sheffield, and at West Valley, all mirror particularly difficult problems associated with differential settlement, slumping and cap repair, which has caused tremendous expenses.

J. Robertson: I think the NRC recognizes that problem in the proposed new regulation by specifying criteria for waste form and the waste segregation classification system. The waste form has obviously been a factor in terms of the bathtub effect and trench cap integrity. West Valley could be a good site if it were not for the settlement of the waste, the compaction of the waste after burial.

We know that compaction and degradation processes last for decades. Sites that have been operating for decades, such as Oak Ridge and INEL, they continue to require trench cap maintenance from continued settlement. So the degradation process is a slow one. It's important to eliminate the combustible, compactable materials at least for longer-lived isotopes. That can be done fairly easily with some engineering and some money. I think better trench caps are possible to enhance runoff and decrease infiltration. There hasn't been much incentive to build better trench caps. I think the incentive will be in the regulations and meeting the criteria.

I don't think there are overwhelming problems. They involve a total systems approach to the criteria, not just a geologic approach.

L. Mezga: Do you feel if we apply these criteria to the existing sites which have been closed, that any of those sites would not be acceptable at this time?

J. Robertson: The USGS will never make a judgement on whether the site meets legal criteria, because we enjoy the position of not being a regulatory body.

It's possible that some of the closed sites could meet the geo-technical criteria. It's obvious that the waste content criteria cannot be met in some cases. Transuranics are no longer allowed, but Maxey Flats and some of the other sites have transuranics in them. I think some of the waste forms may not qualify at any of the existing sites.

D. Banks: I mentioned some of the studies that we were doing at the Corps of Engineers. A certain part of that is to re-visit some of the six sites, and to apply the criteria to those. We're just now starting in those studies. We hope to have an answer to that question by the end of this fiscal year. Right now I have no basis for answering the question.

D. Jacobs: The site suitability requirements apply to the original selection of the site. But the site may not continue to perform satisfactorily. On the other hand, 10 CFR Part 61 would allow trade-offs between the native suitability of the site and engineered changes in the site that would last for the hazardous lifetime of the waste.

In your judgement, do you think you could come up with geo-technical improvements to a site that would allow a marginal site to become a suitable site?

D. Banks: We always like to think that this is possible. That is to correctly assess the site characteristics, and to engineer a solution that will allow the project to operate over its lifetime.

There are problems that can be engineered around, such as drainage and infiltration. But one of the problems in addressing that particular problem is the use of man-made materials. Some of the proposed solutions may require materials for which the life cycle knowledge of performance is not known. In other words, if we use geo-technical styles or filter fabrics, there hasn't been adequate experience to know if they will hold up for a hundred years or five hundred years or whatever the requirements may be.

But if natural materials, such as sands and gravels, can be used for drainage or leachate collectors, there is no reason to suspect that they will deteriorate with time. It may be possible, through using systems that have been in use for many years, to engineer around problems that arise. The word "marginal" may not mean that same thing to everyone. There may be a definition: likely suitable, probably suitable, etc. That is said in the context that a likely suitable site is one in which you have thought through the entire engineering process, and from indications that you see from the site screening or the site selection stage, that it is possible to overcome any of the problems you've identified in a manner that uses a construction technique or a design practice in which there has been a lot of experience, and that you know will work from your engineering experience.

G.L. Meyer: I would like to respond to the question about whether, if they could have avoided some of the problems, the existing sites would be satisfactory. I would like to review a little a history during the period when the sites started, and the practices in the earlier days of disposal. As I understand it, the containers were not supposed to provide containment after emplacement: there was not much thought to the retention of the waste by its waste form. Also, the engineering of the trench caps probably wasn't as good as it could be.

The sites were not really looked at as a system. Talking informally with people involved with waste disposal, the attitude was "Kick it in the trench and cover it up," and the ground would take care of the entire problem. I think we found that isn't exactly true.

We had a team from the Office of Solid Waste visit a commercial site that was a dual chemical and radioactive waste disposal site. In their visit, they looked at the radwaste site and reported on the practices they were using, and concluded that the site "wouldn't make a very good sanitary landfill."

I think the current regulations as proposed, and the people and organizations involved with disposal are realizing that a disposal site is a system which involves hydrogeology, the waste form itself, and site engineering. I am hopeful that, considering these factors as a whole, great improvements could be made, and we could get a satisfactory site located.

D. Jacobs: The sense of my question was not so much whether these sites were performing satisfactorily, but if they would meet the criteria in 10 CFR Part 61. We don't want to lull ourselves into a false sense of security that just because a site meets the minimum requirements of 10 CFR Part 61 it will perform satisfactorily over the lifetime required. There are some other factors involved, such as site design and operation, that are also of importance.

Obviously, there are going to be some trade-offs. It's very difficult to visualize problems occurring at some sites, despite the degree of control of operation. At other sites more careful control will be required because they may be more fragile with respect to long term stability.

J. DiNunno: Yesterday it was mentioned that three different agencies are working on hydrologic or transport models. Have those models been applied to the existing sites, and, if so, what do they show? Have we learned anything from the existing sites that could be applied to future sites?

I'm under the impression that an attempt to do some modeling at Maxey Flats was not very successful; that observations and predictions from models didn't match very well. There was also some translocation of material at Beatty that I don't think was very well modeled. We are developing and appear to be putting a lot of work into models that we will be applying in the future. We talk about confirmation and this seems to be an opportunity.

In the same vein, discussions about airborne dispersion leave me a little bit troubled. In 10 CFR Part 61, the emphasis is on hydrologic transport, and I think that's correct. But have there been any airborne transport measurements, or any indications of airborne transport of materials at these low-level waste sites? To my knowledge, the answer is no, but I may not be totally informed. If the answer is no, then should this be emphasized at all in 10 CFR Part

61 or is it included because we have done this so thoroughly, largely in connection with nuclear reactor facilities?

I raise these questions in the context that we seem to be applying to a 20-to-50-acre facility the same sort of concern, ecologically, demographically, hydrologically, to much larger complexes with much greater public health and safety risks. It behooves us of the technical community not to make this a bigger problem than it actually is. We should not underestimate it, but certainly we should not exaggerate it.

Have we done anything in the way of modeling on existing sites, both air and water, that would tie in with requirements we're proposing down the road?

D. Schreiber: I'm not really familiar with the modeling that's going on at EPA. I know the USGS has been involved in modeling at some of the low-level waste sites. And NRC, obviously, is setting up some models and doing some work.

To my knowledge, most of the work has been developmental in nature, and the ultimate objective is to try to validate, or verify the models with field data. I would have to cut off my answer at that point, in that that's my viewpoint of where hydrologic modeling stands.

C. Little: ORNL is developing the assessment model for EPA. To date, we have not applied it to existing sites. We are developing data sets for Beatty, West Valley, and Barnwell, and in the next few months we will apply it to those sites.

EPA will run the code to estimate the health risk, under certain scenarios, to populations residing around those three facilities.

D. Siefken: NRC has been developing an in-house capability for modeling. The USGS has been modeling groundwater flow at Barnwell, and will, in the near future, publish an open file report. NRC has a contract with USGS to investigate the groundwater flow system and develop a modeling capability for Sheffield, and off-site from Sheffield to the east, to the natural groundwater discharge areas.

Specifically, NRC is just getting started in developing a modeling capability. We've looked at models in two different groups; overall systems type models and models for site specific application.

The overall systems type models will consist of the SAI model which was published last fall and a modified version of the Dames and Moore model prepared for the Atomic Industrial Forum. The modified model was used to support the draft environmental impact statement which is currently out for public comment.

With respect to site specific modeling, we have a modified version of what we call the CODELL model, which was presented at the Waste Management Symposium in Atlanta in 1977. It is a one-dimensional flow and transport model.

Our major emphasis to date has been the groundwater pathway. In the future, we will include other pathways, such as the atmospheric pathway, to see what's happening with respect to trench gases that are generated at the existing and future sites.

With respect to two-dimensional groundwater flow and transport, we've tried to concentrate initially on models which are well documented and generally available to the public. In January 1982, we will publish in a NUREG document a modified version of the USGS two-dimensional finite difference method of characteristics code that was published by Lenny Konokow and John Bredehoeft. A contractor has modified the documented version of that code to include radionuclide decay and sorption, so that we can look specifically at transport of radionuclides.

We also have brought in-house two codes that George Yeh has developed at the Oak Ridge National Laboratory, the FEMWATER and the FEMWASTE codes, which are two-dimensional finite element models for groundwater flow and transport.

Other NRC activities are somewhat more specific in their application. We are sponsoring next March 23rd and 24th in Seattle a two-day symposium on the state-of-the-art of Unsaturated Flow and Transport Modeling. As in our criteria in the regulation, we're primarily looking for disposal above the water table, with the one specific exception of when molecular diffusion dominates groundwater flow.

The unsaturated flow and transport modeling will be very significant. It is a developmental art, and we're reviewing the status of that art and what the model capabilities are. We have a contract with Battelle Pacific Northwest Laboratory to make this review and they will host the symposium in March.

In addition, looking at even more specific applications, NRC has a contract with the Illinois State Geological Survey in Champaign/Urbana to consider the movement of moisture through trench caps, particularly trench caps made of layered earth materials. We're essentially testing the wick effect. They have applied three or four different unsaturated flow models to the movement of moisture under varying temperature conditions which would simulate natural temperature and moisture changes in the field for trench caps that were in place. The initial portion of the study, the mathematical simulation, is completed. They're now moving into large scale laboratory testing of trench cap systems, and, in spring, we will build some trench caps in the field and monitor the movement of moisture and temperature through those trench caps to confirm the results of modeling.

Right now we really don't have a single model, and we really don't ever anticipate it being a single, unified model. We're looking at overall systems models and models for site specific applications. We will have to have a model where the assumptions that lie behind the model are met at that particular site, and the data requirements that the model demands can also be satisfied through characterization.

There will be different parts of the site that require different models. In the Branch Technical Position which was circulated in draft form today, for instance, water budget would be one of the items which would typically require modeling at a site. In January we will have a NUREG report prepared by a staff member on calculation of a water budget for a low-level waste disposal facility.

So we have some documentation which will be available very shortly, and several symposia like the one in Seattle should help. I would note that next May and June in Philadelphia the American Geophysical Union will have a session on radwaste and the unsaturated zone which will include modeling applicable to low-level waste disposal sites.

J. Robertson: The USGS has done modeling work on several sites. We have successfully modeled the saturated flow system at West Valley in two-dimensional cross-section form. And that's "verified" by matching model generated data with field data in two-dimensional vertical fashion.

We have had some successful modeling at Barnwell that's not published yet. But it appears to look good in terms of a two-dimensional flow system.

We worked on unsaturated zone modeling at Beatty, Nevada. It's crude but it seems to be going well.

We successfully modeled the ground water flow system at the old Argonne National Laboratory site at Palos Hills, Illinois, and are in the process of modeling the transport of tritium at that site. it looks very amenable to good modeling, with verified data.

We haven't modeled Oak Ridge, and we're in the process of doing some modeling at Sheffield.

R. Wood: The gentleman from NRC didn't respond to the part of the question having to do with model verification based on the incidents and performance we've seen at existing sites. This is being done by USGS, which is good, but the NRC people are ultimately the ones who must determine whether a modeling effort, from the input data to the end result, is or is not satisfactory; that is, capable of making predictions that are adequate for licensing use.

What will the NRC be looking for in model validation before models can be relied on for regulatory purposes? And, what is NRC doing to get us to the point where we can produce what it is they'll be looking for?

D. Siefken: With respect to model validation, the first thing NRC has tried to do, since we really are just beginning to internalize the modeling capability within our group, is look at models which are available, that have been widely used, and that are well documented in the literature. They have been tested against both the mathematical solutions and, in the case particularly of the two-dimensional finite difference code from the USGS for groundwater flow and the transport modeling we are using, against field measurements of actually released contaminants.

We feel that the codes we have selected to date are useful, given the restrictions that the data necessary to satisfy the modeling needs for the specific site can be characterized, that the assumptions underlying the model are met by the physical conditions at the site, and that we have the appropriate boundary conditions and homogeneity that the model demands.

The first task in the contract with Battelle Northwest Laboratory on the unsaturated flow and transport modeling will specifically review the existing models and the available documentation. We're not looking at models that aren't documented, because we don't feel they would provide adequate guidance to the user. We're looking at those models where there is a likelihood that we won't argue with the licensee as to the selection of the model, and which we would accept if the licensee demonstrates the applicability to his site.

The symposium which will be convened in March will specifically have sections with respect to mathematical consistency with field data, that is, previous migration.

USGS and NRC have modeled Barnwell using the method of characteristics flow and transport modeling. The results indicate that there will not be releases at points of interest which would exceed the appropriate standards.

As far as migration at the site which would match the modeling results, our modeling is relatively conservatiive, and we do not anticipate releases at the concentration levels predicted by our modeling.

At this time the monitoring system for the site does not show any concentrations which would approach the concentrations that were predicted by the models. We anticipate that the results of modeling will be continually compared to the monitoring data for any particular site, to continue to confirm that point.

I. Van der Hoven: Long term atmospheric dispersion models have been tested on identifiable releases. One example is a rather routine release from the Savannah River plant. We tested models against that release and have come within a factor of 2 of agreeing with the monitoring data downwind to a distance of 130 kilometers. We will not need to consider this great a distance in the case of near-surface burial.

I feel fairly confident that if we had such data, routine releases from a burial site would match with the model results. But as far as I know, that type of monitoring data is not available, primarily because the levels are so low they can't be distinguished from background and you can't get reliable measurements.

D. Jacobs: One of the points mentioned in the question was, have emission rates been measured? To my knowledge, there have been measurements made of the presence of gaseous materials above a shallow land burial trench. But I don't know of any measurements that have been made of the rate of emission.

P. Lohaus: There have been some experimental data developed at at least three of the commercial sites regarding gaseous releases. As a part of the environmental impact statement, we looked at those pathways of potential release, and keyed in on three key pathways: water, plant and animal intrusion, and gaseous releases.

In Appendix M to the EIS, we looked at some of the existing data. For example, Matuszek, with the New York State Department of Health, has analyzed the concentrations found above a trench. He developed a procedure and measured methane and tritium.

Measurements made of trench gas were made at Maxey Flats and Beatty. They were not rate measurements but concentrations.

W. Thompson: In 1978 EPA issued regulations on hazardous waste disposal, addressing design of trenches using liners of different designs; one was a synthetic polymer plastic with a clay barrier, and one was just a five-foot clay barrier. In NRC's initial drafts of 10 CFR Part 61, there was a discussion of siting in soils with in situ permeabilities on the order of these recommended by EPA for hazardous waste disposal. I could discuss several instances where you might want cut-off walls to stop the horizontal migration of water.

Can you identify any instance when you'd want to use a total liner, for, both the bottom and the sides of a disposal trench.

P. Lohaus: I want to respond to the question in terms of the relationship of NRC's 10 CFR Part 61 requirements and the requirements which EPA is developing through RCRA.

NRC tried to consider all of the various rules, regulations, and criteria that we could identify, both on the part of the states and also other federal agencies, including EPA, as a part of the background in developing 10 CFR Part 61. Appendix N of the EIS contains a review of many of the documents we considered.

The primary difference, at least one of the differences that I feel is significant, is the concept of a liner in the proposed RCRA regulations. We've tried to avoid that type of situation because of the potential of creating a long term water management problem where you would need to pump, collect, and treat trench leachates. Our approach has been to achieve a stable site so that the need for collection and treatment of leachates would not be required.

The Corps of Engineers has designed a complete cut-off liner for certain instances, not for the hazardous waste problem but for problems such as the Rocky Mountain Arsenal, in which there is chemical migration beyond the boundary of the arsenal. A 6500-foot long complete cut-off trench was installed into the bedrock to completely isolate the alluvial aquifer. It's being treated as an underground dam. The complete success of the system requires that water be pumped out from behind the barrier, treated, then re-injected on the other side of the barrier, mainly to keep the groundwater flow as it was before being interrupted by the cut-off.

If such total cut-off systems are designed for shallow land burial facilities, they will require pumping and treatment of any leachate that gets into the holding area. There might be some possibility of designing a cap, with a filter placed in the cap so that water does not run off but infiltrates into the cap. It would be caught before it reaches the bottom of the cap and be drained off by gravity.

PANEL DISCUSSION WEDNESDAY AFTERNOON

The panel discussion section has been edited and represents a summary of the technical questions and responses. Also questions and answers addressing the same categories have been grouped together.

The panel discussion has been recorded in its entirety and a transcript is available from the Nuclear Regulatory Commission.

The panel consisted of:

D. Jacobs - Chairman, Evaluation Research Corp., Oak Ridge, TN
- J. Robertson - U.S. Geological Survey, Reston, VA
- G.L. Meyer - Environmental Protection Agency, Washington, D.C.
- B. Fish - Manager of Maxey Flats Project, State of Kentucky, Frankfort, KY
- L. Mezga - Oak Ridge National Laboratory, Oak Ridge, TN

D. Jacobs: We have one residual question from yesterday that was not answered: What are the respective responsibilities of EPA and NRC with respect to setting criteria and standards for protection of public health and environmental quality?

G.L. Meyer: Somebody used the expression "speed limit": The position of EPA is to establish what a safe speed limit is; we expect NRC to enforce that speed limit. That is, EPA would determine what would be an acceptable release to the environment because we realize that there probably is no perfect site.

We recognize that one can modify or compensate for the characteristics of a site using waste form and engineering, but we will try to define acceptable levels by taking into account social and economic considerations. It would also have to meet basic public health standards. EPA would not regulate in any way.

The NRC would have the responsibility to make sure that the sites licensed by them or Agreement States would meet these limits.

R.D. Smith: I think that's a fairly accurate description of the way NRC sees it as well. EPA has responsibility for establishing generally applicable environmental standards; that is, standards of radiation that are intended to apply to the broad spectrum of the public rather than occupational workers and persons inside the facility.

A specific example is already in place, the EPA standard for fuel cycle facilities in 40 CFR Part 190 which establishes the maximum level of exposure that an individual may receive offsite as a result of the operation of any kind of facility in the nuclear fuel cycle. In evaluating the facility, NRC would consider, among other things, the ability of that facility to comply with the EPA standard. We would consider the effluent treatment system, the equipment and procedures that are used.

The parallel in low-level waste management would be our performance objectives which relate to the protection of offsite populations from releases of radioactive materials, a standard which would be set by EPA for the acceptable exposure limits for a person in the general population from the operation of a low-level waste facility.

NRC, as explained in the EIS, has chosen a value as a surrogate EPA standard pending the development of such a standard by EPA. The surrogate dose limits are 25 millirem whole body dose or 75 thyroid dose at the site boundary. The EPA standard would impinge on 10 CFR Part 61 at the site boundary of a low-level waste facility.

Over the last couple of years that I have been involved in the NRC low-level waste program I've taken a second look at what we're doing in NRC.

The program plans for DOE, for EPA and for NRC, are similar but there is not really a correlated, coordinated plan. DOE is conducting studies to develop technology and information, EPA is developing a standard and NRC is going to implement all of that knowledge and standards through regulations. The only thing is when you look at the program the schedule looks like a mirror image. NRC has issued a regulation, but EPA will not have its standard until some time in the future. DOE has confirmatory studies that go on years beyond that.

It causes me to feel uncomfortable, yet at the same time I feel some degree of confidence. NRC is motivated to get out of the way in terms of getting this process moving.

We think that the technical knowledge of low-level waste disposal is sufficient to promulgate regulations or we wouldn't have done it. It may not be complete or the most sophisticated, and it may not have all the answers; but it is sufficient.

To the extent that this facilitates the process I feel good. I am sometimes uncomfortable when I read and hear reports and descriptions of all the great work that's being conducted to establish the technical basis for things we've already written down on paper.

I came away from this meeting with a feeling that in site suitability we either knew what we were doing or we guessed the right things. I also hear that there are a lot of things that could be more complete and that we could know more about it. But we're going to have an effective regulation on the books as law in less than a year. I made a commitment to have this done before the end of October, and I see no reason why it won't happen.

From then on it's going to be a matter of NRC doing our job to carry out the licensing process. I don't know what that will take. We've never licensed a site. The last site was licensed by the State of South Carolina in 1971, and it was not licensed to these standards and criteria, and not in the kind of mood and arena we have today. I've got to admit it's nothing but a guess at this point but from the time somebody walks in the front door with an application until they walk out with a license will probably be about two years. We will look at ways that this can be speeded up, but the process involves action, such as the NEPA process, and that has built-in times that are inviolable. Public comment requires a certain period of time, and certain actions have to take place.

Even that two-year period assumes that the people who came in with their application did their homework and they've brought us an application that can be technically analyzed. More importantly they must have done convinced the people in the area that this is a facility that is going to be of some benefit to them so that you don't face the specter of long, drawn-out public hearings and intervention actions that could make this process go on. How long has Midland, Michigan, been on line trying to get a reactor license? It can go on forever.

Public participation is as important an aspect as the proper preparation of the application.

You've heard some comments on what we're trying to do to get ourselves geared up. We are like the dog that chased the streetcar, once he caught it he didn't know what to do with it. We're frantically chasing the streetcar called licensing and we hope that when somebody comes in the door with an application that we're prepared to do something about it.

D. Jacobs: NRC does not intend to wait until after the last of these meetings to finalize 10 CFR Part 61, but a large part of this information will feed into the regulatory guides and the technical position papers that will be prepared in support 10 CFR Part 61.

J. Sedlet: Before I came to the meeting I had a pretty good feeling about 10 CFR Part 61, but maybe I was just being naive. I thought it was a very reasonable roadmap to get a new waste disposal site licensed and operating.

After listening to some of the talks I gather that there needs to be some more specific requirements in the rule in order to get it past a hearing. I wonder if a new site can be licensed before the current closed and still leaking waste disposal sites are either remedied or decommissioned in some way.

R.D. Smith: We've heard a lot of discussion on how to instill public confidence. I don't think you have to be too perceptive to realize that as long as there are facilities that are viewed as inadequate, where there are questions about their acceptability, you won't be able to instill a great deal of confidence.

The parallel in high-level waste disposal is that for forty years we've been telling people that we know how to take care of high-level waste, and yet the first high-level waste has yet to go into the ground.

With low-level waste it's a little bit different. We tell people we know what to do, and yet there are several examples where we have done it less than perfectly.

I am inclined to agree that people's confidence in us would be greatly enhanced by tackling the existing facilities and showing that they're really not as bad as perceived, and that in spite of problems in the past, those problems are correctable and we should move on with it.

J. Blakeslee: There are a number of items that have come up in the meeting that sound similar to other items at other meetings that I have attended. We need to look a little further in addressing them.

Site suitability is predicated on the expected performance of the site to contain the waste that's been buried. There's been a considerable amount of discussion about modeling to determine what that long term performance might be, and then some arguments over whether you can validate these models.

It seems to me that one of the parameters of interest would be the waste form itself. This has been pretty much ignored at this meeting in the last couple of days. Mr. Robertson spoke on the subject some this morning and I heard Mr. Bradley discuss a total system approach yesterday. Does 10 CFR 61 adequately address the waste form composition and define low-level waste that is acceptable for shallow land burial?

I recently attended a low-level waste compact meeting in Colorado. The public was concerned that there is no definition of low-level waste and they wanted to know what are you planning to bury in their state. They don't really care about the suitability of the site, but in order to establish a test of reasonableness for whether that site is suitable or not, they want to know what you are going to emplace there, its chemical form, and the interactions between the waste form, its package and environment.

This morning Mr. Robertson alluded to the fact that most of the problems with the West Valley and Maxey Flats sites are related to the waste form and not necessarily to the design and construction of the burial ground.

Therefore, I would like to see some discussion of dialogue today, and then in a future meeting, on the waste form.

J. Robertson: The waste form is one of the factors responsible for bathtubbing, the deterioration of the trench cap, and the increase in the trench cap permeability. It's not the only factor. There certainly are other considerations too. But the waste form has been a big factor in compaction and settling of the trench cap.

L. Mezga: The Department of Energy is looking at a systems approach considering waste form, engineered barriers, and geologic materials for both greater confinement and shallow land burial. The program is attempting to develop optimum disposal systems for any particular waste-environment combination.

The program is currently funding waste form related work at Brookhaven National Laboratory and Savannah River Laboratory, where researchers are studying the effects of waste form on leaching and leach rates with lysimeter tests. The new concepts developed will possibly be demonstrated in demonstrations of greater confinement and improved shallow land burial concepts.

R.D. Smith: At this symposium we are discussing site suitability -- the site itself -- and yet the site is only one of several important factors to the system. It's difficult to talk about any one of those factors. There will be a symposium on site design and operations, and people will be saying yes, but what about the waste form or the site itself. They are so closely interrelated that it's very difficult to talk about one without considering the other.

Waste form plays a very important part. We've put considerable emphasis in 10 CFR Part 61 on a requirement of stability for the higher activity waste. Stability of the waste contributes to not only the long term stability of the site so that it doesn't require lots of care and maintenance, and it also contributes to prevention of water intrusion and subsequent migration, which is one of the things that was just pointed out. It also plays an important role on the intruder scenarios. Intrusion into stabilized and solidified waste gives you a different kind of exposure than if you encounter waste that is deteriorated or looks like dirt. So it is important.

There's a legal definition of low-level waste that you find in at least one piece of legislation, maybe two. It's the conventional, traditional definition that says that low-level waste is everything other than a couple of other kinds of waste that we haven't defined either. It's not a very satisfying definition. What we've attempted to do in 10 CFR Part 61 is to take that part of this almost infinite spectrum of waste and identify by isotope, concentration, physical form, site, operations, and institutional control what is acceptable for disposal under the combination of factors that are represented in 10 CFR Part 61. We have not defined low-level waste. You won't find low-level waste defined in 10 CFR Part 61 except where we talk about radioactive waste that is used herein, which refers to material called low-level waste which somebody else tried to define. I don't know what the definition for low-level waste is. We've attempted to identify certain categories of waste, certain classes of waste which have radiological and physical properties, as being acceptable for disposal under the conditions of 10 CFR Part 61.

J. Blakeslee: Do you feel that the definition in the regulation is adequate? My personal belief is it is not, but I'd like to know what NRC feels.

R.D. Smith: What's wrong with the definition or lack of definition that is in 10 CFR Part 61? What would you like to see and what does this population in Jefferson County want to see in the way of a definition of low-level waste to make them feel better?

J. Blakeslee: I think what they want to see is a list of items that excludes certain categories of material which will decompose with time, and also will not impact the environment with hazardous materials which are nonradioactive, the toxic things that are contained within low-level waste that might fall into the Class A group. It won't do very much good to contain the radionuclies within the burial ground if 20 miles away you have an outcrop of a toxic material that makes all the wheat fields die at Rocky Mountain Arsenal.

I think what the people would like to see is materials that are not organic, incinerated so that they have been reduced or oxidized to the form that nature would convert them after they had been in the burial ground for a period of time. We bury things and then we are very disappointed because Mother Nature converts them to something else. Let's do that conversion process up front. Then when we put it in the ground let's put it in the ground in such a manner that there are no interstices to fill between the packages and let all the bad things happen that Mr. Robertson told us about this morning.

R.D. Smith: If you look at the Class A waste, we have segregated those wastes. We are not particularly concerned about biodegradation because of the low amount of radicactivity that is present. We are telling people to put into a stable form those things where degradation of the waste form would be a problem. They should pretreat it if necessary to make a stable waste form. Then degradation won't occur over the period of time that we're concerned with the radiosiotopes.

As far as chemical toxicity and chemical hazards are concerned, this is an area of concern to us as well. To the extent that we can, we require that pathogenic, carcinogenic, hazardous chemicals be pretreated and taken care of before being disposed. Now that's not an absolute guarantee that everything that goes in there is a non-hazardous waste from the standpoint of chemical toxicity.

E. Watson: My comment is related to the question of the previous speaker, but it really stems from the discussion we had this morning. You can have the best documented and most realistic and well validated environmental transport model in the world, be it atmospheric, surface water, or ground water and you really can't solve the problem if you're asking for consequences without an adequate source term. The source term is very much related to the form of waste, to the site design, and to a number of other factors.

I have been in this business for a number of years, and am far less concerned about validating environmental transport models than I am the source term, particularly when we're being asked to evaluate consequences from low-level waste sites and other kinds of facilities for 100, 500 and 1000 years from now. Believe it or not, some people even want you to project 10,000 years from now.

The source term and all of its ramifications is a very important consideration that has not really been addressed in these two days.

R. Murray: What happens if the utilities concentrate their wastes and raise the category from a low-level to a higher category, from, say, A to B to C? Is it possible that they would pay a serious economic penalty in terms of cost of storage or cost of disposal which would thus cause them to back off and fail to concentrate, which we generally agree is a desirable practice?

R.D. Smith: When you look at Table 1 in 10 CFR Part 61 you can perhaps see a disincentive for volume reduction because it may move you from Class A to Class B or to Class C. I'm not so sure it is that simple.

We've done some analyses in the environmental impact statement where we considered a spectra of volume reduction and waste processing, and tried to estimate the impacts of treatment costs, radiation exposures and disposal costs. What a utility would have to judge is whether the cost of processing and disposing of one cubic foot of Class B waste is cheaper and better than the disposal of ten cubic feet of Class A waste.

There's a processing cost involved in volume-reduction and there might be a difference in disposal costs between the A and B, but on the other hand you're getting rid of less.

The concern, as I see it, is as you get closer and closer to the right-hand side of that table you get closer and closer to generating something that's not acceptable for near-surface disposal and would require a different method of disposal which may not be available to you at the present time. Carried to extremes, volume reduction gives you high-level waste, and how far toward that do you want to go? There are economic considerations, and I think it's part of the cost-benefit balance that a waste generator should take into account in deciding whether to put in equipment and facilities which in themselves are fairly capital-intensive. Is it really worth it from that standpoint?

P. Skinnar: The people in the audience have focused on some of the basic issues facing decisions in the future to establish a site. New York, like Kentucky, has a bad problem on its hands, one that has caused the local people and statewide and regional concerned citizens to cause significant difficulties in the establishment of any new low-level waste facility in the State of New York and in the region as a whole. Curing the problem at West Valley, Maxey Flats and Sheffield should have priority.

As a group that has already been spending a great deal of money regulating it, and after 1981 or 1982 may end up spending a great deal of money to cure that problem, we re only too happy to hear that it is correctable. We hope that after we spend the money that it will be reimbursed by the federal government. But I think we have to face up to some basic difficulties with 10 CFR Part 61 that you're going to have trouble selling to the public.

There are three basic classes of wastes in Table 1 of 10 CFR Part 61: Classes A, B and C. Class A controls essentially are business-as-usual. The controls over these degradable, compressible wastes bear no resemblance to Class B, which require stabilization and a great deal of care. What is going to happen to this regional compact facility that sets up this fabulous system for segregated wastes only to find that the Class A section is collapsing, filling up with water, and leaking out non-toxic water into the local streams? What is the local environmental group going to do?

It's quite clear that they will say that the radioactive waste site at Place X has developed a tremendous leak, and it is going to cost millions of dollars to fix it. No amount of careful press releases from regulatory agencies that the leakage is non-radioactive and non-hazardous is going to improve the public's perception of the performance of that facility.

Based on that we come to the conclusion that if we're really going to meet the problem of low-level waste management that Class A wastes represents, which I understand make up about 60 percent of the waste to be managed at these sites, they have to receive special treatment to assure that that facility will not experience the same problems that have occurred at Sheffield, Maxey Flats and West Valley.

The point brought up by many that studies are ongoing, give me, an engineer, a great deal of concern. There's talks of refining mathematical models and carefully considering input data. I might point out that there's some very basic things going wrong with these facilities. The roofs are caving in. I was at a meeting yesterday where they were discussing nearly losing one of our state regulatory persons through the roof at one of the newer trenches at West Valley. He was pulled out from crotch-level through the stuff.

We can validate and verify and check every mathematical model to the end of the earth, but if you're going to give us a mathematical model to guide the generation of performance qualities of a facility you'd better give us one that provides for desiccation cracks that go all the way to the waist and with settlement holes three to four feet in diameter which occur without predictable bases. And that's for Class A wastes.

Now for Class B and Class C wastes, let's hope we're on the right track. But we've still got a big problem in Class A wastes.

Lastly, I went through all of Appendix D in this gigantic five-volume NUREG-0782, and I couldn't figure out how many cubic feet of Class A, Class B and Class C wastes are being produced now and projected to be produced in the future. We've got to answer those questions if we're going to tell the public how well 10 CFR Part 61 is going to perform.

D. Jacobs: It is very obvious to most of us that you don't judge the performance of a site on the basis of a predictive model. You do some monitoring and you measure what's going on.

Making a prediction 500 years in the future requires you to have some basis for making the prediction, because most of us aren't going to be around to judge how adequate the performance really was. That's a problem we face in waste management that we don't ordinarily face in the operation of other types of nuclear facilities.

R. Wood: These are my personal views, not those of Niagara Mohawk, but they represent something about operating plant perspective.

I am concerned about comments that imply that all combustible waste ought to be incinerated. Although I certainly agree that environmentally it would be desirable to reduce the volume, I don't know of a single incinerator processing light water reactor trash anywhere in the world that has operated for a substantial period of time and is fully satisfactory to its operators.

They are a pain in the neck, notwithstanding the fact that people are selling them. If we ever get to the point where there is adequate disposal capability available, I seriously question whether utilities are going to interest themselves in the capital cost or in the operational headaches of running incinerators if they can dispose of the trash as is, or compacted in drums, because the costs are substantial and the operational headaches are even worse.

I would also like to point out that there is substantial public sensitivity to incinerators that process radioactive materials. Our company was involved for a time in a plan to demonstrate an incinerator at our operating nuclear station, although this particular incinerator was also a calciner. It wasn't the fact that it was a calciner that really bothered the public, it was just the idea of an incinerator that had radioactive feed, regardless of the quantity of radioactivity that was going in. It's a major question in the actual licensing arena, where there is public access and can very well be public hearings, whether these incinerators are going to be successfully licensed in the foreseeable future or whether very many utilities are even going to want to attempt it, understanding the difficulties that they are going to have in the public arena.

As regards volume reduction other than incinerating trash, I think that we're seeing this coming in the industry together with improved solidified waste forms. I think that we're going to continue to see judgment exercised in the extent of volume reduction that's practiced on the higher level material, things like letdown resins and cleanup resins for BWRs because of the high activity. You can expect the operators to use their judgments. They don't want to have to handle this very highly radioactive waste product.

Another illustration of where excessive and unnecessary regulation of the waste form could potentially give us a headache is in the area of packaging. There has been considerable sentiment expressed, for example, that rectangular containers are much superior from the disposal viewpoint, and I don't doubt that they are. But there are a lot of people who feel that in-drum mixing, which can't be done very practically today with anything but a 55-gallon drum, is a much more operable and readily maintainable kind of solidification process than things that involve large casks or liners. There is even a substantial body of opinion that in-drum mixing, where you don't have to worry about having your solidification agent ruin your waste processing gear, is much more consistent with ALARA, which is another regulatory concern as well as a real genuine concern for the industry.

I say these things only to point out that there are a lot of interrelationships and to caution against unduly trying to constrain the waste form if it can be avoided.

D. Jacobs: I guess the ultimate that I've seen along those lines is in Russia. They incinerate much of their institutional waste and reduce it to a small volume, place the materials into drums, mix it with bituminous material and then store the conditioned waste in a concrete monolith above the surface of the ground. In my mind this is quite an overkill for that type of waste.

J.C. Brantley: We've heard a lot from people who are responsible for siting and from people who are apparently going to spend a lot of time doing studies of radioactive waste and siting. I represent the people who are trying to get sites established and people who are using the material and need the sites established.

So far I have ended up the day with a sinking feeling at the pit of my stomach.

If I had been running this meeting I would put a date up there right over the top of everybody: January 1, 1986. That's four years from about three weeks from now. The companies that are making radioactive materials and the doctors who are using the radioactive materials must have some place to put their waste by January 1, 1986, by act of Congress.

Yesterday we heard that there were no technical problems with siting, that it is a political problem. We were warned about co-option, political problems and public education, all of which are extremely difficult problems. But we received no suggestions for solutions, only that they were problems.

So far today we have been listening to a group of people who have been telling us what we have to do. So far we've heard about ecological mapping, surface hydrology, underground hydrology, wind studies, precipitation studies and geotechnical evaluations.

If I put this all together there is a multiple process that is going to result in a site to bury low-level waste. It starts with the reconnaissance or screening program, site characterization, design, licensing, construction and operation. When is this all going to get done? The best estimate is four to six years for the process. And we've got four years.

Is this going to get done in four years?

B. Fish: We have a curious mixture of problems.

In Kentucky we produce practically no low-level radioactive waste compared with nearly every other state. One good size reactor facility can produce about ten times the amount of waste we produce in Kentucky. All of our waste is institutional.

Because of the restrictions on the Barnwell waste disposal, we ship all of our waste to Richland. In 1980 South Carolina shipped to Richland waste that they could not accept on their own site, ten times as much as we produced in Kentucky.

So Kentucky doesn't produce a high volume of waste. On the other hand we have a site on our hands. Both of these present problems. We have been trying to decide what do we do with our small quantity of low-level radioactive waste. At the same time we're trying to decide what to do with our old site. To a certain extent these problems may be mutually soluble. We hope so.

We are considering entering into a compact with other states. We have talked about a compact with three different regional groups of states. We have dropped from one, but we're in active discussion with the two others.

We may decide to go it alone, and we can. As a matter of fact, in terms of public opinion we have the support of our local citizens to reopen Maxey Flats for our own disposal site. We're not really sure we want to do that because there's some other implications for the future. We may be shortchanging commercial development in our state if we do. We want to look at all of the aspects.

But there is the problem of 1986. At every compact meeting I've attended there is consensus that there is absolutely no way, unless you already have a site in your region, to have a site by January 1986.

What does that mean? Does that mean you stop producing waste? Even with our 3000 cubic feet per year, and with a de minimis level it's about 1500 cubic feet per year, we can't stop because the waste is from medical treatment and research at our medical schools. I assume that our power reactors can't stop producing waste either, despite the fact that the law says the waste disposal sites can shut down.

That tells me either one of two things must happen: Either we have to shorten the licensing process so that we can meet 1986 -- and I doubt that that can be done -- or the date has to be changed.

What if the date were changed to something more realistic right now? The nearest realistic date would be January 1989 or 1990, if you're very optimistic, and no real problems arise in licensing, environmental studies and the like.

But if we got realistic and Congress moved the deadline from 1986 to 1989, we probably wouldn't be entering into compacts now; it would be 1988 before we'd start talking about it.

So with blind faith that we aren't going to paint ourselves into that corner in 1986, we're going ahead with our compacting plans. The Midwest group that both Illinois and Kentucky are dealing with are trying to have a draft compact for consideration by this coming session of all of our state legislatures, probably mid-February. If it passes we're still talking about 1989 before we can have a site operational. We will have to contend with between 30 and 35 senators that can drag heels. None of the compacts become official, no matter what the deadline is, until the Congress approves them.

Another possibility is to amend the standing act to change the date once the states have shown their good faith in compacting together. We're trying to meet these deadlines and not wait until 1989 to do it.

The next step appears to be in Congress. There's not much that we can do to shorten the date. But it's extremely important to take a look at the effect of 10 CFR Part 61 on selecting sites, and almost equally important, rejecting sites.

One of the problems that constantly confronts us when many states get together is: We don't want you to do it in our state; we know it has to be done, but not here. There's nothing wrong with that feeling. There is the feeling that if another state is benefiting from it, why should they deposit material in our state. There are two answers: One of them is strictly political.

Your state can be chosen to be the host state for the regional site with a two-thirds majority vote. That's pretty raw politics. It takes a lot of back-slapping to make sure that you don't get to be a host state. It's much better if you can adduce some reason, such as NRC and 10 CFR Part 61. If we have objective criteria for selecting or rejecting portions of the region as candidate sites -- and there are some objective bases, such as to minimize the transport of radioactivity throughout the region - this may require more than one site. Economics probably require only one site. Several things have to be considered: economics, minimizing transport (because this is an environmental impact), and other criteria which would be involved in 10 CFR Part 61. Also it's extremely important that very soon, between now and February, we have something we can refer to and tell the legislature how the site will be chosen. If we say we're going to use 10 CFR Part 61, we will be asked: What in 10 CFR Part 61 tells you where to put that site?

Right now that is the importance of 10 CFR Part 61 to the states. It is especially important in Kentucky because we're looking at 10 CFR Part 61 from the rear. We don't have a choice of waste form or container or other factors because the waste is already there. The question is what can we do in terms of remedial action that will bring our waste form more in compliance to what it would have been if it had been suitable to start with.

This is a test of 10 CFR Part 61. We're going to apply 10 CFR Part 61 principles in remedying our site to make it a better, more suitable site from a geohydrological standpoint.

J.C. Brantley: Let me tell you a little bit about another political region in the northeast. We have not been sleeping. We're working hard to get a site operational in the region. I am chairman of an organization called NELRAD, which is made up of all of the generators of radioactive waste in New England.

We've been extremely active in trying to get a bill through the legislature and trying to get a siting process established. The criticism that we've uniformly received from the environmental organizations, is that there is no 10 CFR Part 61. They say that until 10 CFR Part 61 is finalized they are not going to approve any kind of siting process for New England or Massachusetts.

My frustration has come from the fact that I hear talk about another meeting in September of 1982 on 10 CFR Part 61. In New England we're working on our Council of Northeastern Governors (CONEG). They have established a policy group on low-level waste siting. They are working on some policy matters, bills, and a compact with the idea that it will be brought before the legislators of New England by 1983.

I'm encouraged by the fact that you who have a site feel that there is a possibility that Congress can be persuaded to change that date.

My company is a $100 million business. We make and produce radioactive material; probably more than 50 percent of the radioactive materials used in this country for medical research are made by my company alone. The people who own my company do not want to be told that the legislature might change the rule in 1986. They want to know what we are doing and why we do not have a solution in our region.

The important thing is to get a site operational rather than to talk about studies to determine if we know how to select a site. If we need studies to improve site operations to eliminate the problems you're talking about, let's identify them as such, not things that need to be done for siting. When you talk to public groups, which I do on the subject of waste management, the fact that you talk about the money you spend on studies is interpreted to mean that it's not safe yet to put in a site. So please identify the studies as development of methods to improve the operation of the site or correcting specific problems at sites.

Mr. Fish made a statement yesterday that I wanted to correct, "nobody publicly recommended they do anything about Maxey Flats." The conservation foundation has been running our organization the last two years. Their number one recommendation to DOE is that the problems at Maxey Flats, Sheffield and West Valley, should be solved before we go any farther.

D. Jacobs: Lance Mezga, representing the DOE, Low-Level Waste Management Program, is faced with the 1986 date quite frequently, and I'd like for him to make some comments on how DOE and its programs are proceeding toward trying to meet this date, and what some of their recent actions are.

L. Mezga: The schedule for completion of the various handbooks documenting low-level waste management technology were discussed yesterday. The handbooks include separate volumes on shallow land burial technology, environmental monitoring, corrective measures, and waste generation reduction. The drafts of these handbooks will be distributed to external peer review groups as soon as possible, hopefully within the fiscal year.

I cannot comment on the length of time required to complete the licensing process as prescribed by 10 CFR 61 but the DOE LLWMP is providing assistance to the states and various compacting regions. For example, the program is assisting the State of Tennessee in its preliminary site screening process.

DOE is considering new sites for defense wastes at its facilities. One of those is at Oak Ridge. The program is cognizant of the schedule and is trying to provide the technical information to the potential users as soon as possible.

DOE currently supports a number of technology projects which some people interpret as evidence that low-level waste is not being properly managed at this time. The activities and studies funded by the DOE LLWMP are designed to improve our ability to predict site performance by better defining inputs to the various models.

I'm surprised that no one has raised the issue of the quality of information used to input the models. We have discussed models and their limitations a great deal, however we have not talked about the confidence one has in the inputs to those models at all. No matter how good the model is, one's confidence in the results is a function of his confidence in the inputs. Many of the technology development tasks funded by the program, such as the borehole geophysics work, are aimed at improving our confidence in the input parameters to those models so that we are more confident with the outputs of the models.

S. Salomon: I happen to notice in the newsletter distributed yesterday, "the Radioactive Exchange," that the Hittman Corporation came up with a new kind of a concept which apparently gets around a lot of these problems that you're talking about.

For those of you who haven't read it, it says: "The Hittman design is different in several respects. Instead of relying on trenches, Hittman proposed to construct a mausoleum-like structure to house the waste slightly above the surface of the ground. Waste would be contained in coffin-like receptacles housed in the facility which would be sealed to prevent infiltration or migration. The concept allows for a retrievability option currently not practicable in standard burial design."

It goes further to say that at least in hostile environments in the country that they believe that it will be cost-competitive with the trench design discussed yesterday and today.

Has Hittman approached the NRC on this concept? What does NRC think of this concept? Does it have real potential, like Hittman seems to believe that it does?

R.D. Smith: We have not been approached by Hittman on this concept other than receiving a brochure in the mail that showed four pages of conceptual illustrations. The concept is not inconsistent with those things that we've characterized as engineered structures, and they certainly are an alternative to near-surface disposal.

In preparing 10 CFR Part 61 we concentrated on criteria that would be suitable for shallow land burial because that's the current mode of operation. It is also to expand 10 CFR Part 61 to include criteria for such things as engineered structures.

E. Hawkins: What kind of information is available, similar to that in the ecological maps for the coastal states, for sites in the interior part of the United States? These people will be wanting to know what they have to find out and where they can find the information for areas in the middle of the country. The Draft Branch Technical Position paper given out this morning strongly implies on-site meteorological measurements. From what Mr. Van der Hoven said that that may not be necessary. I would like some feedback on whether it is necessary.

A. Sherk: It is difficult to assemble a map series as extensive as coastwide. We thought that the Atlantic coast would probably be the most difficult area to map simply because there are 15 coastal states with limited intercommunications. Even though they were given the opportunity to develop coastal zone management plans we felt this would be an excellent opportunity to display types of coastwide ecology because species don't recognize political boundaries.

It is less difficult in an area like Rhode Island. Those people have to be concerned about what Massachusetts and Connecticut are doing because just about anything those two states do impacts on Rhode Island. As it turned out, the New England states work very well with one another. They all don't work well with one another, but their nearest neighbors are given a great deal of consideration.

Selected or priority areas in the interior would have to be considered on a case-by-case basis.

Within the Department of the Interior we have been seriously discussing with the Bureau of Mines and the Bureau of Land Management the areas they have in mind for priority actions according to their own authorities, such as the oil shale, coal, tar sands problems in the Colorado, Wyoming, Utah areas. The Bureau of Mines is particularly interested in on-shore disposal of manganese nodule waste mined on the high seas, and gaining our perspective on the ecological information they would need for their decision making process. They need just about the same kind of information that the Fish and Wildlife Service needs; it's just that we use it differently. If NRC has priority areas that it would like to have considered, the Fish and Wildlife Service would be more than happy to focus our mapping effort on those in-land areas.

The Bureau of Land Management has expressed a need for information on everything west of 103 degrees, that's everything west of the eastern boundary of Colorado.

A display would probably be made up of something on the order of 125 map sheets. It is certainly possible to prepare 200 sheets a year, but it might tie up all of the cartographic capability in the United States to get it done. However, we have a base map series that's complete for the whole United States, and we can provide a regional perspective at a consistent scale using a classification of ecological information that would be of maximum use in planning processes for siting considerations.

It does take some time. There are a number of entities that have to be involved in the production of a series, including the state governments.

We produced a prepublication prototype of the Toledo area on the western end of Lake Erie to try to bring in as many as possible of the entities involved in managing and regulating activities in the Great Lakes.

We have worked out a mechanism for involving the various concerned entities in the production of this map set that can be as large as you like, both from the standpoint of the initial design, for checking the accuracy of the information and then carrying it through to the actual publication of the series and the distribution.

There were a lot of comments made yesterday about the involvement of non-federal people in federal activities. Probably the biggest difficulty we've had is working with the other federal agencies rather than with the state people or the local representatives.

I'm very optimistic about our ability to meet the needs of the Nuclear Regulatory Commission. If they have priority areas we'll definitely try to respond to those needs.

E. Hawkins: I don't want anyone to get the implication that we have to wait on the ecological maps before we can begin looking at applications. The ecological information is important; the map would be a very good way to get it. But the maps are not required by NRC before they can look at applications. We are ready to go.

R. Wood: I would like to suggest one very concrete proposal for your consideration and for the record: I propose that the Nuclear Regulatory Commission issue a letter to each state governor, and further that the letter be signed by the chairman of the Nuclear Regulatory Commission, the Secretary of Energy, and the Administrator of the Environmental Protection Agency, and that letter should say that there is no impediment to the siting, start-up and safe operation of low-level waste sites, and, further, recognizing the work that has not yet been completed in support of the regulatory process, the staffs of the EPA, DOE, and most particularly NRC commit themselves to working with the states to expeditiously license and otherwise provide technical assistance in the selection and licensing of sites.

B. Browning: As I mentioned in my welcoming speech, in 1979 the then-chairman of the Nuclear Regulatory Commission, Dr. Hendrie, sent just exactly such a telegram to the governors of all of the states. We may want to do it again. In 1979 we said we were ready to process any application. Now we're trying to help that process by getting the regulation formalized. But there's nothing holding up processing an application. That message and that telegram still stand.

D. Jacobs: Several of the papers this morning addressed sources of information and types of information that would be useful to regulators in dealing with license applications and with the regulation of the operation of facilities under their jurisdiction. They were not necessarily required to be a part of 10 CFR Part 61, and that the timely procession of actions required to finalize 10 CFR Part 61 does not necessarily depend upon amplification to include all of these factors.

In summing up today's discussion, my impression is that NRC has done a very credible job in coming up with minimum site suitability requirements. Development of site selection criteria is difficult because the usual approach is to look for an ideal site. You soon find that no site meets any set of ideal requirements, and you can quickly eliminate every possible site in the universe.

The approach made by NRC assumes that there are a large number of sites that can be operated successfully and within the performance objectives they have used as a premise for the development of site suitability requirements.

Although this meeting was to be devoted to site suitability requirements, site suitability requirements cannot be divorced from the other aspects of 10 CFR Part 61. A systems approach is required. There is interaction between the suitability of the site, the operating procedures and processes, and the design of the site.

There is a tradeoff between the degree of the containment and stability you put into the waste form and how much is to be provided host medium into which you place the material. The balance for low-level waste, Categories A, B and C may be different for each with respect to treatment because certainly at some level we need not worry about the radioactive content of the materials.

It's very difficult to establish a de minimis level. But certainly we don't want to entrap ourselves into treating every piece of radioactive waste as though it were a high-level package.

ATTENDEE LIST

Melvin R. Adams
Rockwell Hanford Operations
P.O. Box 800
Richland, WA 99352

James F. Albaugh
Rockwell Hanford Operations
P.O. Box 800
Richland, WA 99352

Howard W. Althouse
U.S. Ecology
9200 Shelbyville Rd.
Louisville, KY 40222

Don Anderson
NYS, ERDA
Agency Bldg. 2
Empire State Plaza
Albany, NY 12223

Don C. Banks
USAE Waterway Exp. Station
P.O. Box 631
Vicksburg, MS 39180

Michael J. Barainca
Low-Level Waste Management
U.S. DOE
Idaho Falls, ID 83401

Claud Barraud
Dept. of the Environment
Nuclear Programs Division
Ottawa, Ontario, Canada K1A1C8

Maurice F. Bender
NUS Corporation
9950 West Lawrence, Suite 401
Schiller Park, IL 60176

J. D. Bernardy
New England Nuclear Corp.
549 Albany St.
Boston, MA 02118

George Birchard
Office of Research
USNRC
Washington, DC 20555

J. Blakeslee
Rockwell International
P.O. Box 464
Building 750
Golden, CO 80401

Robert Blumberg
Oak Ridge National Laboratory
P.O. Box X
MS D-33, Bldg. 4500-N
Oak Ridge, TN 37830

Hall Bohlinger
Louisiana Dept. of Nautral Resources
P.O. Box 14690
Baton Rouge, LA 70898

Glenn Bradley
Chem-Nuclear Systems, Inc.
7979 Old Georgetown Rd
Bethesda, MD 20014

J. Calvin Brantley
New England Nuclear Corp.
549 Albany St.
Boston, MA 02118

B. Brindel
Aerojet Energy Conv. Co.
1425 Ct. Ave., NW
Suite 1107
Washington, DC 20036

Robert E. Browning
Division of Waste Management
USNRC
Washington, DC 20555

Phillip L. Buckingham
ERM, Inc.
P.O. Box 357
West Chester, PA 19380

Texas Chee
Dept. of Energy
NE 320 (DWD), Germantown
Washington, DC 20545

Rowena O. Chester
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

James R. Clark
Nuclear Fuel Services, Inc.
6000 Executive Blvd.
Rockville, MD 20152

Jim W. Colby
Radioactive Exchange
P.O. Box 9528
Washington, DC 20002

J. Cole
Consultant
5917 River Drive
Lorton, VA 22079

Rick Cothern
USEPA
WH-550, Office of Drinking Water
401 M Street, SW
Washington, DC 2046-

J. C. Dempsey
New York State
Energy Research & Development
Authority
Agency Building No. II
Rockefeller Plaza
Albany, NY 12223

Dale H. Denham
Battelle Northwest
P.O. Box 999
Richland, WA 99352

J. Dieckhoner
USDOE
Defense Waste
Washington, DC 20545

Richard C. Diehl
Aerojet Energy Conversion Co.
P.O. Box 13222
Sacramento, CA 95813

K. Dinan
Resource Dev. Assoc.
2550 M. St., NW
Suite 275
Washington, DC 20037

J. DiNunno
NUS
4 Research Place
Rockville, MD 20850

Anthony J. DiRocco
Nuclear Energy Services
NES Division
Shelter Rock Rd
Danbury, CT 06810

J. Donoghue
ACRS
H-1016
1717 H. St., NW
Washington, DC 20555

K. Dragonette
Division of Waste Management
USNRC
Washington, DC 20555

A. Louise Dressen
Chem-Nuclear Systems, Inc.
P.O. Box 1866
Bellevue, WA 98009

Maxine M. Dunkelman
Division of Waste Management
USNRC
Washington, DC 20555

R. Eaton
Atomic Energy Cont. Board, Canada
Ottawa, Canada K1P539

Koneta L. Eldridge
ERM, Inc.
P.O. Box 357
West Chester, PA 19380

J. Eng
New Jersey Dept. of Environmental
Protection
380 Scotch Rd.
Trenton, NJ 08628

Raymond Eng
Ebasco Services, Inc.
Two World Trade Center
15th Floor
New York, NY 10048

Les Ettlinger
MITRE
W. 805 MITRE Corp.
1820 Dolly Madison Blvd.
McLean, VA 22102

Birney R. Fish
Manager Low-Level Radwaste Program
Kentucky Dept. of Natural Resources
& Environmental Protection
4th Floor
Capitol Plaza Tower
Frankfort, KY 40601

James Reese Fowler
Science Applications, Inc.
800 Oak Ridge Turnpike
Oak Ridge, TN 37830

A. J. Francis
Brookhaven National Laboratory
Building 318
Upton, NY 11973

Floyd Lee Galpin USEPA
Office of Radiation Programs
(ANR-460)
401 M St., SW
Washington, DC 20460

R. Ronald Geoffrion
Los Alamos National Laboratory
Box 1663 MS 755
Los Alamos, NM 87545

Michael S. Giuffre
TASC
1 Jacob Wab
Reading, MA 01867

Paul Goldberg
Office of Policy Evaluation
USNRC
Washington, DC 20555

Debra A. Gomer
Nuclear Metals, Inc.
2229 Main St.
Concord, MA 01742

Mick Greeson
Carolina Power & Light Co.
P.O. Box 1551
Raleigh, NC 27609

Samuel B. Gregorio
Dept. of Natural Resources &
Environmental Protection
Plaza Tower
Frankfort, KY 40601

Philip F. Gustafson
Dept. of Nuclear Safety
Springfield, IL 62704

James E. Hammelman
Science Applications, Inc.
1710 Goodridge Drive
McLean, VA 22102

J. A. Hanny
Am. Enr. Cont.
575 Shoup Ave.
Idaho Falls, ID 83402

Kathleen F. Harer
U.S. Dept. of Energy
Technical Services Division
Oak Ridge Operations Office
P.O. Box E
Oak Ridge, TN 37830

Edward F. Hawkins
Division of Waste Management
USNRC
Washington, DC 20555

Edward L. Helminski
The Radioactive Exchange
P.O. Box 9528
Washington, DC 20016

Richard J. Heystee
Ontario Hydro
H15 026
700 University Ave.
Toronto, Ontario, CANADA M5G1X6

G. R. Hill
Southern State Energy Board
2300 Peachford Rd.
Suite 1230
Atlanta, GA 30338

Water M. Hipsher
U.S. Ecology
9200 Shelbyville Rd.
Louisville, KY 40222

Gale Holladay
Lawrence Livermore National Laboratory
P.O. Box 5504, L-156
Livermore, CA 94550

R. Hooker
Savannah River Laboratory
Building 773-A, Rm. E114
Aiken, SC 29808

D. Huff
Oak Ridge National Laboratory
Environmental Sciences Division
P.O. Box X
Oak Ridge, TN 37830

Preston H. Hunter
Ford, Bacon & Davis Utah
P.O. Box 8009
375 Chipeta Way
Salt Lake City, UT 84108

Donald G. Jacobs
Evaluation Research Corporation
800 Oak Ridge Turnpike
Suite 501
Oak Ridge, TN 37830

Dale T. Jessop
Assoc. Tech. Inc.
222 S. Church St.
Charlotte, NC 28202

Elizabeth Jordan
U.S. Dept. of Energy
Germantown
Washington, DC 20545

Clyde P. Jupiter
Office of Research
USNRC
Washington, DC 20555

Louis S. Karably
Law Engineering Testing Co.
2749 Delk Rd., SE
Marietta, GA 30067

Felix M. Killar
Middle South Services
P.O. Box 61000
New Orleans, LA 70161

Robert E. Kratzke
Office of Nuclear Material Safety & Safeguards
USNRC
Washington, DC 20555

Charles O. Kunz
New York State Health Dept.
Division of Labs & Research
Albany, NY 12201

Robert E. Lampton
Bechtel National Inc.
P.O. Box 350
Oak Ridge, TN 37830

Ronald B. Lantz
Intera
11999 Katy Freeway
Houston, TX 77079

William L. Lappenbusch
U.S. Environmental Protection Agency
Office of Drinking Water (WH-550)
401 M. St., SW
Washington, DC 20460

Dewey E. Large
U.S. Department of Energy
Oak Ridge Operations
P.O. Box E
Oak Ridge, TN 37830

Peter T. Lassovszky
Environmental Protection Agency
Office of Drinking Water (WH-550)
401 M St., SW
Washington, DC 20460

Vibeke Libby
Stone & Webster Eng. Corp.
245 Summer St.
Boston, MA 02107

Craig A. Little
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

Paul Lohaus
USNRC
Washington, DC 20555

A. L. Lotts
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

Albert J. Machiels
University of Illinois
Nuclear Engineering Program
214 Nuclear Engineering Laboratory
Urbana, IL 61801

R. Carroll Maninger
Lawrence Livermore National Laboratory
P.O. Box 5511, L-644
Livermore, CA 94550

Timothy J. McCartin
Office of Research
USNRC
Washington, DC 20555

James G. McCray
Dept. of Nuclear Energy Engineering
University of Arizona
Tucson, AZ 85721

David McGoff
U.S. Department of Energy
NE 320 (DWD)
233-3031
Germantown, MD 20545

John R. Mernagh
Ontario Hydro
700 University Ave.
Toronto, Ontario CANADA M561X6

G. Lewis Meyer
U.S. Environmental Protection Agency
9520 Beach Mill Rd.
Great Falls, VA 22066

Lance J, Mezga
Oak Ridge National Laboratory
Environmental Sciences Division
P.O. Box X
Oak Ridge, TN 37830

Jack C. Newell
Roy F. Weston, Inc.
Weston Way
West Chester, PA 19380

Raymond L. Murray
North Carolina State University
P.O. Box 5596
Raleigh, NC 27650

Eric Nelson
Stone & Webster Engineering Corp.
P.O. Box 2325
Boston, MA 02107

Iral C. Nelson
Battelle-Northwest
P.O. Box 999
Richland, WA 99352

Thomas Nicholson
Office of Research
USNRC
Washington, DC 20555

Edward O'Donnell
Office of Research
USNRC
Washington, DC 20555

Larry R. Olden
Ontario Hydro
700 University Ave.
Toronto, Ontario, CANADA

Oktay R. Oztunali
Dames and Moore
20 Haarlem Ave.
White Plains, NY 10603

R. Pennifill
USNRC
Washington, DC 20555

J. Wynn Phillips
Hittman Corp.
9190 Red Branch Rd.
Columbia, MD 21045

Paul Piciulo
Brookhaven National Laboratory
Building 830
Uton, NY 11973

William R. Rhyne
H&R Technical Associates, Inc.
977 Oak Ridge Turnpike
Oak Ridge, TN 37830

Craig I. Roberts
NUS Corporation
7601 Warbler Lane
Derwood, MD 20855

J. B. Robertson
USGS
Reston, VA 22092

Karen E. Leslie-Ross
International Energy Assoc. Lt.
600 New Hampshire Ave., NW
Suite 600
Washington, DC 20037

F. Dean Rowsell
American Energy Control
454 Shoup Ave.
Idaho Falls, ID 83402

S. Saari
MITRE Corp.
W. 805
1820 Dolley Madison Blvd.
McLean, VA 22102

Ronald Sanacore
American Nuclear Insurors
270 Farmington Ave.
Farmington, CT 06032

David L. Schrieber
Schrieber Consultants, Inc.
303 Park Drive
P.O. Box 1087
Coeur d'Alene, ID 83814

Jacob Sedlet
Argonne National Laboratory
9700 South Cass Ave.
Argonne, IL 60516

L. T. Skoblar
Ebasco Services Inc.
Two World Trade Center
New York, NY 10048

Jacob Shapiro
Harvard University Health Services
75 Mt. Auburn St.
Cambridge, MA 02138

L. Sheely
Min. Rad. Material Users
4344 IDS Center
Minneapolis, MN 55402

Albert Sherk
Office of Biological Services
U.S. Fish and Wildlife Service
U.S. Dept. of the Interior
Washington, DC 20240

Ed Shum
Division of Fuel Cycle and
Material Safety
USNRC
Mailston 35-396
Washington, DC 20555

David Siefken
Division of Waste Management
USNRC
Washington, DC 20555

Terry C. Silverberg
Northern States Power
414 Nicollette Mall
Minneapolis, MN 55401

Peter N. Skinnar
New York State Attorney General
Justice Building
The Capitol
Albany, NY 12224

R. Dale Smith
Division of Waste Management
USNRC
Washington, DC 20555

T. Smith
American Planning Assoc.
1313 E 60th St.
Chicago, IL 60637

Stephen N. Salomon
Office of State Programs
USNRC
Washington, DC 20555

Russell E. L. Stanford
Edison Electric Institute
1111 19th St., NW
Washington, DC 20036

William P. Staub
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

Janis D. Stelluto
NELRAD
21 Brier Rd.
Gloucester, MA 01930

R. John Starmer
Division of Waste Management
USNRC
Washington, DC 20555

F. Sturz
Division of Fuel Cycle and
Material Safety
USNRC
Washington, DC 20555

Arthur A. Sutherland
Rogers and Associates
515 E. 4500 S., Suite G-100
Salt Lake City, UT 84107

Edmund C. Tarnuzzer
Yankee Atomic Electric Co.
1671 Worcester Rd.
Framington, MA 01701

Warren T. Thompson
Oak Ridge National Laboratory
Building 1000, MS 141-C
P.O. Box X
Oak Ridge, TN 37830

Joseph F. Tinney
Science Applications, Inc.
1710 Goodridge Rd.
McLean, VA 22102

S. J. Tranchina
Stone & Webster Engineering Corp.
P.O. Box 2703
New York, NY 10116

Isaac Van der Hoven
NOAA
Washington, DC

Emil Veakis
Brookhaven National Laboratory
Building 830
Upton, NY 11973

Joseph L. Wallach
Atomic Energy Control Board
P.O. Box 1046
Ottawa, Ontario, CANADA KIP 5S9

Edwin C. Watson
Battelle-Northwest
P.O. Box 999-Sigma 3
Richland, WA 99352

James E. Watson, Jr.
University of North Carolina
Dept. of Env. Sc. and Engineering
Chapel Hill, NC 27514

A. E. Wegele
Detroit Edison Co.
2000 Second Ave.
Detroit, MI 48226

Allen J. Weiss
Brookhaven National Laboratory
Building 701
Dept. of Nuclear Energy
Upton, NY 11973

Joseph H. White III
Environmental Coalition on Nuclear Power
11 South Merion Ave.
Bryn Mawr, PA 19010

Lawrence A. White
Golder Associates
1810 Parsonage Rd.
Parkton, MD 21120

E. F. Wilson
Arkansas Dept. of Health
4815 West Markham St.
Little Rock, AR 72201

Derek Widmayer
USNRC
Washington, DC 20555

Donald E. Wood
Rockwell Hanford Operations
P.O. Box 800
Richland, WA 99352

Richard M. Wood
Niagara Mohawk Power Corp.
300 Erie Blvd., West-R&D Building C-3
Syracuse, NY 13202

M. Güven Yalcintas
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

Georgia Yuan
Washington State University
SE 435 Gladstone St.
Pullman, WA 99163

H. E. Zittel
Oak Ridge National Laboratory
P.O. Box X
Oak Ridge, TN 37830

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Compiled by M.G. Yalcintas, Oak Ridge National Laboratory
D.G. Jacobs, Evaluation Research Corporation

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Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, TN 37830

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U.S. Nuclear Regulatory Commission
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This document is a compilation of the papers presented at the Low-Level Waste Symposium on Site Suitability Requirements, the questions and answer periods following individual papers, and the panel discussions at the end of each day.

The goal of the symposium was to provide a forum for experts in a variety of fields representing a variety of organizations. These experts were given the opportunity to comment on the reasonableness and appropriateness of those portions of the proposed 10 CFR Part 61 that deal with site suitability. The following questions were to be addressed by the speakers and considered during discussion periods:

(1) Can sites be found that meet the proposed criteria? (2) Would such sites be safe and effective sites? (3) Do the criteria eliminate safe and effective sites? (4) Can it be shown that a given site meets the proposed criteria? (5) Should the proposed criteria be revised? (6) Should other criteria on site suitability be added?

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