1-1-1982

Shallow land burial area screening study

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November 4, 1982

Members of the Low-Level
Waste Siting Commission

Dear Commission Member:

Pursuant to Public Law Chapter 439, I hereby submit to the Low-Level Waste Siting Commission a geological report entitled "A shallow land burial screening study for Maine". The issue of low-level radioactive waste isolation is herein partially addressed by the application of the appropriate geologic parameters cited in 10 CFR, Part 61 of the Nuclear Regulatory Commission.

The attached report represents a regional geological characterization at a scale commensurate with the available geologic information by utilizing the rapidly developing data base of the Maine Geological Survey. In addition to the information generated by the MGS, the data base has been rapidly enlarged by the voluntary contribution of physical resource information from other state, federal, academic, and private industry sources. This data base is currently programmed for computer processing and as more geologic information is gathered, the MGS will have the capability of addressing more detailed geologic characterizations. The geological parameters and criteria utilized in this study also apply to the issues of hazardous waste and landfills in the State. In addition, the report presents a methodology which can be adapted and applied to a wide variety of environmental or economic issues.

The MGS compilers for this report are Dr. Marc C. Loiselle, Senior Geologist and Ms. E. Melanie Lanctot, Water Resources Analyst. Dr. Loiselle is a geochemist and his training and research was carried out at the University of California at Riverside, the Massachusetts Institute of Technology, and the Virginia Polytechnical Institute. Ms. Lanctot is a graduate of Elmira College, New York with an M.S. at SUNY at Stony Brook. She is presently involved in an investigation of radon in groundwater in Maine as well as a study of the quantity and quality of water in significant aquifers. Mr. Robert Johnston of the MGS is responsible for the cartographic and drafting preparation of this report.

Very truly yours,

Walter A. Anderson
State Geologist
Commission Member

Shallow Land Burial Area Screening Study

Prepared for the

Low-Level Waste Siting Commission
State of Maine

Principal Investigator: Marc C. Loiselle
Compilation Assistance: E. Melanie Lanctot
Cartographic Assistance: Robert A. Johnston

Maine Geological Survey
DEPARTMENT OF CONSERVATION

Walter A. Anderson
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1982

"Not in my back yard, you don't!!"
Anonymous

Abstract

In response to Federal legislation the Maine Legislature passed Public Law Chapter 439, An Act Assuring Legislative Participation in Nuclear Waste Repository Research and Development Activity Within the State. A section of this law directed the State Geologist to report on the suitability of areas within the state for a low-level radioactive waste disposal facility. This report presents the results of a geologic screening study designed to eliminate areas not favorable for a waste disposal site and identify areas suitable for a more detailed study. This study considered only geologic screening factors, and as such is only one-half of a comprehensive screening study which must also consider demographic, socio-economic, and environmental factors when determining the overall suitability of an area for a waste disposal facility.

The technical criteria for site selection outlined in the NRC Licensing Requirements for Land Disposal of Radioactive Waste (Proposed), 10 CFR 61, were used in selecting geologic screening factors for the study. Four screening factors are used to eliminate areas considered not favorable for the location of a shallow land burial waste disposal facility:

- location of the 100-year flood plain
- insufficient thickness of overburden (less than 50 feet (15 meters))
- location of high yield bedrock aquifers
- location of sand and gravel aquifers

Maps at a uniform scale of 1:250,000 (1 inch = 4 miles) were prepared from available information, and used to construct a composite map of these negative screening factors (the blue overlay in the series of county maps). This overlay may be used to eliminate areas not suitable for a low-level waste disposal facility.

A consideration of the technical criteria in 10 CFR 61 indicated two surficial materials in Maine possess the characteristics of low porosity and permeability and long ground water travel times desirable in a host material for a waste disposal facility. These are deposits of glacial marine silt and clay and deposits of basal or lodgement till. A lack of detailed surficial geologic mapping does not allow more detailed consideration of basal till at this time. A map of deposits of marine silt and clay (the Presumpscot Formation) was also prepared at a scale of

1:250,000 (the orange overlay in the series of maps). Areas of Presumpscot Formation that are not screened out by one or more of the geologic factors listed above are considered geologically favorable for a waste disposal site at this level of screening, and should be considered for more detailed study when and if it becomes necessary.

The limitations of scale and the nature of the available data used in this screening study must be kept in mind when considering the results presented in the screening maps. However, it is clear that from a geologic standpoint a number of areas appear suitable for a waste disposal facility and would warrant more detailed study if necessary.

Introduction

In December, 1980, the U. S. Congress passed the National Low-level Radioactive Waste Policy Act (Public Law 96-573). Under this law each state is responsible for providing the capacity for disposal of low-level radioactive waste generated within its borders (except for waste generated as a result of defense or federal research and development activities). It was allowed that the necessary disposal capacity may be developed within the state, or the states may enter into compacts to establish and operate regional disposal facilities. In addition, the law provided that after January 1, 1986, any such compact may restrict the use of regional disposal facilities to the waste generated within the region. As a result, it is anticipated that effective January 1, 1986, the disposal facilities currently used by waste generators in Maine will no longer be available.

In response, in 1981 the Maine Legislature passed Public Law Chapter 439, An Act Assuring Legislative Participation in Nuclear Waste Repository Research and Devlopment Activity within the State. The Legislature accepted the responsibility for providing the capacity for disposal of low-level waste generated within the state; provided for generators within the state to report annually on volumes and radioactivity of waste generated; empowered the Governor to negotiate with other states on the establishment and operation of a regional facility; established the Low-level Waste Siting Commission to study the overall problem of low-level radioactive waste; and directed the State Geologist to report to the Governor and the Legislature on the suitability of areas within the state for low-level waste disposal. This section further specified that the State Geologist consider proposed and final rules for facility siting under 10 Code of Federal Regulations, Part 61, in preparing his report.

During 1981 and 1982 the Maine Geological Survey made several presentations to the Low-level Waste Siting Commission on the surficial geology, hydrogeology, and seismicity of the state. They also applied to the Commission for funds to carry out a broad-scale geologic screening study to eliminate areas not suitable for a disposal facility, and indicate areas suitable for more detailed investigation.

This report is the result of that screening study. It consists of a discussion of the technical criteria, methodology, and individual geologic screening factors used in the study, a discussion of surficial materials within the state suitable for a disposal facility, and a series of county-based maps at a scale of 1:250,000 (1 inch = 4 miles) showing the individual geologic screening factors, the distribution of marine silt and clay deposits in the state, and a composite of the geologic screening factors that mark areas not suitable for waste disposal in a shallow land burial facility. These last two maps may be combined to show areas suitable for more detailed investigation.

10 CFR, Part 61, lists technical criteria dealing with both the geology/hydrogeology of a potential site and socio-economic and environmental factors. This report is a geologic screening study, and as such is only one-half of a comprehensive initial screening study. It must be emphasized that only geologic factors were considered in this study, and potentially favorable areas are outlined without regard to factors such as population density, etc. It is anticipated that this report will serve as a guide for subsequent complimentary screening studies.

Technical Criteria and Geologic Screening Factors

Minimum technical criteria that a site must meet are described in the Nuclear Regulatory Commission's (NRC) Proposed Liscensing Requirements for Land Disposal of Radioactive Waste, 10 CFR, Part 61 (published in the Federal Register, v. 46, no. 142, p. 38081-38100). In particular, the following are listed:

10 CFR 61.50 a(2) The disposal site shall be capable of being characterized, modelled, analyzed, and monitored.

____________ a(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 of (these propsed rules).

____________ a(4) Areas must be avoided having economically significant natural resources which, if exploited, would result in a failure to meet the performance objectives of (these proposed rules).

____________ a(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 floodplain, coastal high hazard area, or wetland.

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

____________ a(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 (NRC) 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 of (these proposed rules) being met.

____________ a(8) Any groundwater discharge to the surface within the disposal site must not originate within the hydrogeologic unit used for disposal.

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

____________ a(10) Areas must be avoided where surface geologic processes such 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 of (these propsed rules) or may preclude defensible modelling and prediction of long term impacts.

____________ a(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 of (these proposed rules) or significantly mask the environmental monitoring program.

10 CFR 61.51 a(6) The disposal site must be designed to eliminate the contact of water with the waste during storage, the contact of standing water with the waste during disposal, and the contact of percolating or standing water with the waste after disposal.

10 CFR 61.52 a(3) Wastes deposited as Class C intruder....must be disposed of so that the top of the waste is a minimum of 5 meters (16 feet) below the surface of the cover or must be disposed of with natural or engineered barriers that are designed to protect against inadvertant intrusion for at least 500 years.

These criteria were selected to provide maximum assurance of isolation of the waste from the biosphere. Disregarding intentional or unintentional human intrusion, the primary pathway for radionuclide release to the environment is ground water. As a result, many of the technical criteria above deal with the hydrogeology of any potential site. This was kept in mind when selecting the geologic screening factors discussed below.

In addition to 10 CFR 61, a number of additional reports and studies were used as supporting material in selecting screening factors that would reflect the minimum technical criteria listed above. A list of these additional sources is given in Appendix A. These sources also stress the hydrogeology of any potential site as a primary geologic concern.

From a list of possible geologic screening factors, four were selected which satisfied the following constraints:

A) The screening factor could be used to make a yes or no decision as to the suitability of an area.

B) The screening factor could be presented on a scale appropriate for an initial screening of areas (in this case a scale of 1:250,000, or 1 inch = 4 miles).

C) The data for the screening factor was readily available for compilation.

These three constaints are discussed in more detail in the section describing the methodology of the study. The geologic screening factors selected are:

- Location of the 100-year flood plain
- Thickness of overburden
- Location of high yield bedrock aquifers
- Location of sand and gravel aquifers

A high risk of tectonic or seismic activity is not treated as a geologic screening factor because of insufficient data to satisfy the first constraint above, but neotectonic activity and seismicity in Maine are discussed in a separate section of the report.

Characteristics of host materials for a waste disposal facility are not explicitly discussed in 10 CFR 61, but the hydrogeologic charcteristics may be inferred from 10 CFR 61.50 a(7) and 10 CFR 61.51 a(6) above. Isolation of the waste from percolating water after disposal and the restriction of potential radionuclide transport to predominantly diffusion both imply a host material with low permeability and long ground water travel times. Two surficial materials in Maine satisfy these criteria: glacial marine clay and basal or lodgement till. The properties and distribution of these materials are discussed below; because of the lack of detailed information on the distribution of lodgement till in the state, deposits of marine silt and clay were used in identifying areas suitable for more detailed study. This is discussed in more detail in the section on surficial materials.

Methodology

The process of selecting a site for a low-level waste disposal facility consists of a series of screening and selection studies progressing from a statewide or regional assessment to site-specific investigations. This study is the first, or coarsest, screening of suitable areas. As a result, the objective of the study is to eliminate broad areas which are clearly unacceptable and identify areas suitable for more detailed screening studies. This report does not rank areas suitable for more detailed study; identification of areas as "more favorable" or "less favorable" would require more detailed information than can be presented at this scale, and should not be done without consideration of socio-economic and environmental factors not considered here. For this reason the geologic screening factors were selected with the constraint that they could be used to make a yes or no decision on the suitablility of an area.

The scale used for the maps in the report is 1:250,000, or 1 inch equals 4 miles. Any larger scale such as 1:125,000 (1 inch = 2 miles) or 1:62,500 (1 inch = 1 mile) would have required a corresponding increase in the number of maps required and the cost of the report. Also, for some areas the quality of the available data would not justify treatment at a larger scale.

In order to be useful, however, the screening maps must be at a scale that will allow accurate location of suitably sized areas. An area of 200 acres was selected as the minimum area required for a facility; this area is considered necessary for a regional facility, however, and a smaller area may be sufficient for a facility designed for waste generated solely in state. At a scale of 1:250,000 an area of 200 acres corresponds to a square 1/8 inch on a side (or the equivalent). A smaller scale (such as 1:500,000) would make it difficult or impossible to accurately locate areas this small.

A major constraint in selecting geologic screening factors was to use readily available data that reflected the NRC minimum technical criteria. As a result, only information already in map form that could then be compiled at a scale of 1:250,000 was used. It was not possible to construct detailed slope maps, compile additional well inventory data (except in special instances), or make use of well logs, test pits, and geophysical information to evaluate complex regional stratigraphy of surficial materials. It is assumed that this information can be more efficiently considered in later, more restricted screening studies when and if they become necessary.

With consideration of scale and availability of data in mind the geologic screening factors selected are:

- 100-year flood plain and drainage
- Thickness of overburden (not allowed if less than 50 feet (15 meters)
- High yield bedrock aquifers
- Sand and gravel aquifers

Maps of each of these factors are available at various scales and the information was recompiled at a scale of 1:250,000. With the constraint that a minimum thickness of 50 feet (15 meters) of surficial materials is necessary for an area to be suitable, the presence of any of the above factors is considered sufficient to make a location unsuitable.

Maps of individual screening factors for each county or set of counties are included in the report. In addition, a composite of all four screening factors is provided as a blue transparent overlay. This overlay shows all areas considered unsuitable for a shallow land burial facility because of the presence of one or more of the individual screening factors.

When this overlay of the composite of negative screening factors is combined with the orange transparent overlay of deposits of marine silt and clay (Presumpscot Formation), the two together can be used to identify areas of Presumpscot Formation which have none of the unfavorable characteristics considered in this report. These areas are considered suitable for more detailed studies.

Surficial Materials

Two common surficial materials in Maine satisfy the requirements of low porosity and permeability discussed above: deposits of glacial marine silt and clay (the Presumpscot Formation (Bloom, 1960)), and deposits of basal or lodgement till. Both of these materials were deposited as a result of the Wisconsinan episode of continental glaciation that affected Maine between 20,000 and 10,000 years ago. This section contains a description of the origin, distribution, and properties of these materials, with a particular emphasis on marine silt and clay deposits. Much of this section was taken from the Surficial Geology Handbook for Coastal Maine (Thompson, 1979).

"Till" is a general term for a heterogeneous mixture of sand, silt, clay, and stones deposited directly from glacial ice. Two major genetic types of till occur in Maine: ablation till, deposited by the settling out of particles from melting glacial ice, and basal or lodgement till, which was deposited at the base of an active glacier. Ablation till is generally loose and sandy, with moderate to high porosity and permeability; as a result it is unsatisfactory as a host material and will not be discussed further.

Basal till is generally more fine-grained and compact than ablation till due to the grinding effects and weight of the overriding glacial ice. It also contains a higher percentage of silt and clay than ablation till. This type of till is frequently difficult to excavate and is often called "hardpan". Accretion of basal till to thicknesses of over 100 feet (30 meters) has occurred in drumlins and other areas of heavy till deposition. Basal till deposition may be widespread, but these "early" glacial deposits are frequently covered by later ablation tills, marine deposits, glacio-fluvial deposits, or modern stream deposits. A complex stratigraphy similar to figure 1 is typical in southern portions of the state. Lack of detailed surficial geologic mapping will not allow accurate maps of the distribution of basal tills in Maine to be prepared. In addition, while basal till is finer-grained and more compact than other tills, the wide range in particle size and heterogeneous nature of the deposits contrasts with the more uniform marine deposits. As a result characterization and hydrologic modelling would be more difficult in basal till. Basal tills remain a possible host material for a waste disposal facility, but lack of detailed information on their distribution combined with the availability of information on extensive deposits of marine silt and clay led to looking at the Presumpscot Formation when considering areas suitable for more detailed study.

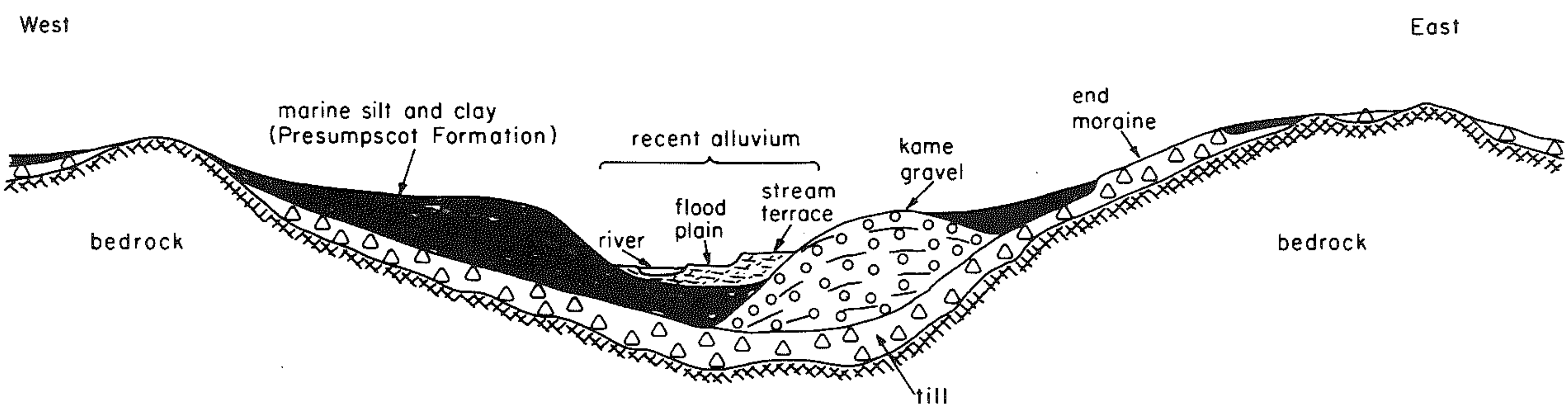
West
East
marine silt and clay
(Presumpscot Formation)
recent alluvium
river
flood plain
stream terrace
kame gravel
end moraine
bedrock
bedrock
till

Figure 1

The Presumpscot Formation was deposited very shortly after warming of the climate caused the last glacier to withdraw from coastal Maine between 13,300 and 12,700 years ago. The weight of the Late Wisconsinan glacial ice depressed the earth's crust in Maine by about 240 meters (780 feet) (Stuiver and Borns, 1975). Even though sea level was lower in late-glacial time than the present (because more water existed as glacial ice), this depression caused a marine invasion of the coastal region. The sea flooded southern Maine to present-day elevations of up to 123 meters (400 feet) or more. During this marine invasion the sediments of the Presumpscot Formation were deposited. Crustal rebound due to unloading of the glacial ice rapidly raised coastal Maine to a point where sea level was approximately 65 meters (210 feet) below the present level between 9,000 and 10,000 years ago (Milliman and Emery, 1968; Schnitker, 1974), with a slow approach to present-day conditions since then.

Two types of glacial marine deposits are shown on reconnaissance surficial geologic maps published by the Maine Geological Survey. The dominant facies is composed of silt and clay, with low porosity and permeability. A second facies is composed mostly of fine sand, but may be underlain by the silt- and clay-rich facies. Both types of Presumpscot Formation are included in the maps compiled for this report.

Detailed information on the sedimentology, stratigraphy, and hydrogeology of the Presumpscot Formation is generally lacking. Exceptions include studies by Goldthwait (1949, 1951, 1953) and Caldwell (1959). Appendix B is a bibliography of papers dealing directly or indirectly with the marine deposits of coastal Maine.

Goldthwait (1953) and Caldwell (1959) both found that samples of the Presumpscot Formation contain an average of 40% clay-sized particles, 50% silt-sized particles, and 10% fine sand-sized material. The formation may be massive or well stratified, and thin layers of fine sand are commonly interbedded with the silt and clay. Minor amounts of gravel are locally interbedded with the formation. Pebbles and larger stones that are actually mixed with the silt and clay were introduced by submarine slumps or by falling from icebergs. Generalized stratigraphic relations between the Presumpscot Formation, earlier glacial deposits, and recent alluvial deposits are shown in figure 1. The Presumpscot may lie on bedrock or earlier till deposits, and may be overlain by later glacio-fluvial deposits or alluvial deposits. The poor drainage characteristic of the Presumpscot leads to the development of wetland and swamp deposits where the topography leads to ponding.

The fact that the marine deposits may overlie earlier till deposits presents one problem of interpretation of the area screening maps: while a 50 foot minimum thickness of surficial material was selected as necessary for an area to be potentially suitable for a waste disposal facility, with the available data it is impossible to know the actual thickness of clay in any given area. This screening study can only point out areas where 50 feet of impermeable clay may exist; additional work, including obtaining test borings and well logs, is necessary to verify the actual section in any area.

The deposits of marine clay do have a recognized economic potential. In 1975, the clay production in Maine was 125,000 short tons. Most of the clay excavated was used for making bricks and cement, with the remainder used for pottery and as a liner for other waste sites. Several studies have investigated the use of Maine clays in making a lightweight aggregate (Trefethen, 1955; Caldwell, 1959; Doyle, 1962). In order to make lightweight aggregate the clay must be heated very rapidly to the point where it simultaneously degasses and partially melts, trapping bubbles of gas in the viscous melt. The melt is then cooled to form a lightweight, slag-like material. At present no lightweight aggregate is produced from Maine clays, and given the extensive deposits in coastal Maine no potential resource conflict is forseen.

In summary, southern Maine contains extensive deposits of late-glacial marine sediments composed dominantly of silt and clay. These sediments appear to have the low permeability desirable for the host material for a waste disposal facility. Very little detailed information on the sedimentology, stratigraphy, and, in particular, the hydrogeology of the Presumpscot Formation is available. The screening study can point out areas where marine clay is exposed at the surface and which lack any of the unfavorable geologic screening factors discussed above (and below), but considerable characterization work would be required to establish the suitability of any given potential site.

Geologic Screening Factors: Descriptions and Sources of Data

100-Year Flood Plain and Drainage

10 CFR 61.50 a(5) states that a disposal site must be generally well drained and free from areas of flooding or frequent ponding, and that it should not be located in a 100-year flood plain, coastal high-hazard zone, or wetland. The location of the 100-year flood plain (an area with 1 chance in 100 of being inundated in any given year), obtained from maps prepared by the U. S. Geological Survey at scales of 1:24,000 and 1:62,500, is used as one of the geologic screening factors. These maps also indicate coastal areas with 1 chance in 100 of being flooded in any given year, and provide an approximation to wetland areas in the state.

The U.S.G.S. maps were prepared using regional flood stage - frequency relations determined by hydrologists at the Augusta, Maine, Water Resources Division office. They estimated a 10-foot rise over the mapped stream elevation and a 5-foot rise over lake or pond level as the limit of the 100-year flood (U.S.G.S., personal communication). Coverage was not available for the entire study area, so the Maine Geological Survey prepared equivalent maps for areas lacking U.S.G.S. coverage using comparable methods. Maps were not prepared for areas lacking deposits of marine silt and clay, and are labelled "NOT MAPPED" on the individual screening factor maps.

These maps may also be used to visually estimate the upstream drainage area affecting a potentially suitable area. Quantitative estimates of upstream drainage area affecting a given areas should be determined from larger scale maps (1:62,500 or 1:24,000) in subsequent detailed studies.

Sources:

U. S. Geological Survey, Water Resources Division. Maps of Flood-Prone Areas; Prepared by the Water Resources Division, Augusta Office, 1972, 1973, 1974, 1975, 1976, 1979.

Equivalent maps prepared by the Maine Geological Survey using comparable methods, 1982.

Thickness of Overburden

A sufficient thickness of material with low porosity and permeability is required to provide maximum assurance that the waste will be isolated from the biosphere. Specifically, 10 CFR 61.52 a(5) states that Class C intruder waste must be disposed of so that the top of the waste is a minimum of 5 meters (16 feet) below the surface or otherwise disposed of with barriers to protect against inadvertant intrusion for at least 500 years. Similarly, there must be a minimum thickness of impermeable material separating the waste from what may be relatively more permeable bedrock or underlying surficial materials. A report prepared by Environmental Resources Management, Inc. of Pennsylvania for the New Jersey Department of Environmental Protection recommended a thickness of 3 meters (10 feet) between the bottom of the trench and bedrock; the NRC makes no recommendation. Assuming a disposal trench depth of approximately 7 meters (24 feet), the total thickness of surficial material required in a suitable area is approximately 15 meters (50 feet). Areas with a thickness of overburden less than 50 feet were considered unsuitable for a shallow land burial facility. (This estimate of 50 feet was also selected because available maps of depth to bedrock were contoured at 10, 20, and 50 foot intervals; i.e., areas with less than 50 feet of overburden were readily available from the maps).

The source of information for these maps consists of the Maine Geological Survey Ground Water Resource Map series. In three instances additional unpublished data was plotted and contoured to extend the published information into northern Kennebec County, into southern Franklin County, and into southern Somerset and Piscataquis Counties.

The ultimate source of the data is information on bedrock wells drilled for public and private water supplies, obtained from well inventory surveys, private drillers, and the Water Well Drillers Association. As a result, the density of data points is not even throughout the study area, and in some areas there was insufficient data to allow contours of depth to bedrock to be drawn. These are labelled "INSUFFICIENT DATA" on the individual screening factor map and the overlay composite of negative factors. The MGS Ground Water Resource Maps should be consulted to determine the density of data points used to contour depth to bedrock.

Sources:

Caswell, W. Bradford, and Lanctot, E. M., 1975, Ground Water Resource Maps of Waldo County; Maine Geological Survey

_____ and _____, 1975, Ground Water Resource Maps of York County; Maine Geological Survey

_____ and _____, 1975 (Revised 1977), Ground Water Resource Maps of Southern Hancock County; Maine Geological Survey

_____ and _____, 1975 (Revised 1977), Ground Water Resource Maps of Lincoln and Sagadahoc Counties; Maine Geological Survey

_____ and _____, 1976, Ground Water Resource Maps of Southern Washington County; Maine Geological Survey

_____ and _____, 1976 (Revised 1978), Ground Water Resource Maps of Cumberland County; Maine Geological Survey

_____ and _____, 1976 (Revised 1978), Ground Water Resource Maps of Southern Penobscot County; Maine Geological Survey

_____ and _____, 1977, Ground Water Resource Maps of Southern Kennebec County; Maine Geological Survey

_____ and _____, 1977 (Revised 1978), Ground Water Resource Maps of Knox County; Maine Geological Survey

_____ and _____, 1978, Ground Water Resource Maps of Androscoggin County; Maine Geological Survey

Maine Geological Survey, Unpublished well inventory information, northern Kennebec, southern Franknlin, southern Somerset, and southern Piscataquis Counties

High Yield Bedrock Aquifers

There are several reasons for not allowing a low-level waste disposal facility on or near a high-yield bedrock aquifer. Ground water must be considered an economically important natural resource, and its development and exploitation could significantly impair the performance of a disposal facility. Also, the presence of high yield wells in bedrock implies a zone of relatively high permeability and rapid ground water travel times. For maximum assurance of waste containment, disposal facilities should not be sited on or adjacent to pathways with a potential for rapid dispersal of radionuclides.

The source of information for these maps is the same as for the thickness of overburden maps. High yield zones are defined as areas where three or more wells with yields of 10 gallons per minute or more were contained in an area of 1 square mile or less. In addition, the contours were drawn to contain no wells with yields less than 10 gallons per minute. Areas with insufficient data on the thickness of overburden maps apply to the high yield bedrock aquifer maps as well, as does the comment that the original Ground Water Resource Maps should be consulted to estimate the density of data used for contouring.

The zones of high yield bedrock wells shown on the screening factor maps may belong to more continuous, linear features related to shear zones or fractures in bedrock. Otherwise suitable areas that lie within or on extensions of these inferred linear zones of high bedrock yield should be considered with this potential in mind.

Sources:

Same as for thickness of overburden maps.

Sand and Gravel Aquifers

If the desired physical properties of the host material for a disposal site include low porosity and permeability, the converse that materials with high porosity and good permeability should be avoided is implied. Also, the same factors of ground water resource potential and rapid radionuclide dispersal applied to bedrock aquifers apply to these deposits as well. Areas of sand and gravel aquifers as shown on maps prepared by the Maine Geological Survey in cooperation with the U. S. Geological Survey are therefore considered not suitable for a waste disposal facility. These areas include both deposits of sand and gravel exposed at the surface and buried aquifers.

Aquifer boundaries on the maps used as sources were determined from geologic field investigations combined with aerial photograph interpretation. Boundaries of buried aquifers and potential yield were interpreted from available geologic and hydrologic data. Aquifers with yields of 10 gallons per minute or more were compiled on the 1:250,000 screening factor maps.

Sources:

Caswell, W. Bradford (compiler), 1979, Sand and Gravel Aquifer Maps 1,2, 4-13, 17-19; Maine Geological Survey

Tolman, Andrews L., and Lanctot, E. M. (compilers), 1980, 1981, Sand andGravel Aquifer Maps 14-16, 39-42, 45, 46, 49-51; Maine Geologial Survey

_____ and _____ (compilers), 1982, Ground Water Resources of Surficial Aquifers, Maps 1-4, 12; Maine Geological Survey

Neotectonics and Seismicity

10 CFR 61.50 a(9) states that areas must be avoided where tectonic processes such as faulting, folding, etc., occur with such frequency as to significantly affect the ability of the disposal site to meet the performance objectives of the proposed rules. Potential seismic or other tectonic activity was not selected as a geologic screening factor due to insufficient data for use on screening maps, but recent investigations by the Maine Geological Survey, the Institute for Quaternary Research at the University of Maine, Orono, and the Weston Geophysical Observatory of Boston College have greatly increased available information on seismicity and neotectonic activity in Maine.

Research done in connection with the Nuclear Regulatory Commission's New England Seismotectonic Study has produced evidence of significant crustal subsidence along portions of the Maine coast, particularly in eastern Washington County (see Reports of Activities of the Maine Geological Survey for fiscal years 1979, 1980, and 1981 for specific papers). Rates of subsidence of up to 9 mm/year are indicated by leveling studies. It is clear that waste disposal facilities should not be located in areas where crustal subsidence, acting over periods of up to 500 years, could cause submergence and inundation of the waste disposal site. The high rates of subsidence are localized in coastal areas; areas which are probably unsuitable for a waste disposal facility for other reasons, but the possibility of prolonged and significant vertical crustal motion must be considered when characterizing a potential disposal site.

The effects of possible seismic activity cannot be addressed with only magnitude-frequency relations, but must be in part addressed at the site design stage. The compilation of Lepage and Johnston (1982) can be used to visually estimate the frequency and magnitude of earthquake activity in the state, and more sophisticated treatments (cf. Chiburis, 1981) can be used to quantitatively estimate areas of high seismic activity. Much of the seismic activity in the state of Maine occurs at magnitudes of less than 3.0 on the Richter scale, and usually has no visible effect on structures, so these treatments of magnitude-frequency relations can be deceiving. Instead, estimates of the maximum expected horizontal and vertical accelerations (important factors in the design of critical facilities) must be determined. Because of the relatively recent establishment of a seismic network to monitor earthquake activity in the northeast region, contour maps showing the maximum expected horizontal acceleration are very crude and of no use in a regional screening study (Algermissen and Perkins, 1976).

The effects of tectonic and seismic activity in Maine must be considered when siting a facility such as a low-level waste disposal facility, but at this time we feel it should be addressed at later stages in the site selection process (if necessary), and possibly in the design stage.

Summary and Conclusions

This study represents an initial screening of areas in Maine geologically suitable for a shallow land burial low-level radioactive waste disposal facility. Areas that have been indicated as "favorable" for a waste disposal facility on the area screening maps have deposits of marine silt and clay exposed at the surface and none of the negative geologic sceening factors discussed in the report.

A number a factors must be kept in mind when considering the results of this study:

- the study has used only geologic screening factors to determine the suitability of areas. No demographic, socio-economic, or environmental factors have been considered.

- limitations of scale must be considered. At this scale more detailed information such as slope information, logs of wells and test pits, etc., have not been considered. Subsequent more detailed screening (if necessary) may show that areas considered suitable at this level of screening possess geologic or hydrologic characteristics unsuitable for waste disposal facility.

- this study in no way represents or even approaches a site characterization study. Only readily available information was used in this initial screening effort. Descriptions of site characterization studies may be found in the NRC Draft Environmental Impact Statement for 10 CFR 61 (see Appendix A)

However, even given the limitations of scale and nature of the available data used in this screening study, it is clear that from a geologic standpoint a number of areas appear suitable for a waste disposal facility and would warrant more detailed study if necessary.

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(Note: References to additional reports used in selecting the geologic screening factors are in Appendix A; references to the Presumpscot Formation are in Appendix B.)

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