

**SOLID WASTE MANAGEMENT DIVISION
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
AGENCY OF NATURAL RESOURCES
STATE OF VERMONT**

**PROCEDURE FOR INCORPORATING SEISMIC EVENT CONSIDERATIONS INTO
MUNICIPAL SOLID WASTE LANDFILL SITING AND DESIGN IN VERMONT**

February 10, 1994

ADOPTED:

<u>Signature</u>	<u>2/16/94</u>
Chuck Clarke, Secretary	Date
Agency of Natural Resources	

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I. INTRODUCTION

On October 9, 1993 the new RCRA Subtitle D regulations, 40 CFR Part 258, Solid Waste Disposal Criteria, went into effect. Section '258.14 prohibits locating new municipal solid waste landfill ("MSWLF") units or lateral expansions in seismic impact zones, except in an approved State. Owners or operators in an approved State shall demonstrate that the structural components of new MSWLF units and lateral expansions in a seismic impact zone are designed to resist the maximum horizontal acceleration in lithified earth material at the site. The language of '258.14 is attached and should be referred to as necessary. Section §258.2 of 40 CFR Part 258 should be referred to for the definitions of *new MSWLF unit* and *lateral expansion*.

The current Vermont Solid Waste Management Rules do not specifically prohibit new MSWLF units or lateral expansions from being sited in a seismic impact zone. However, Subchapter 5 - Siting, addresses location standards in a more general sense. Section 6-503(a), General Performance Standard, requires that "facilities shall be located such that an emission or discharge from the facility will not unduly harm the public health and will have the least possible reasonable impact on the environment, regardless of the technology used to minimize an emission or discharge". Section 6-606(a) of Subchapter 6 - Design has a similar general performance standard. In addition, Section 6-503(a)(5) requires that the facility is not located in areas that have serious development limitations, such as highly erodible soils, steep slopes, or do not have the physical capability to support the facility.

This procedure is intended to address siting and design considerations and requirements for any new MSWLF units or lateral expansions located in seismic impact zones which initiated disposal of municipal solid waste after October 9, 1993. It is based on information currently available and may be revised as additional technical information is obtained. Section II below provides some technical guidance that should be considered in the preparation of certification applications. Section III provides technical site analysis and design requirements that shall be incorporated into certification applications in order to demonstrate compliance with the Vermont Solid Waste Management Rules and the Federal Part 258 Rules.

Appropriate use of professional expertise, such as geotechnical engineers, geologists, and those experienced in seismic analysis and design, shall be utilized as necessary.

II. SITING AND DESIGN CONSIDERATIONS

A seismic impact zone is identified as an area with a ten percent or greater probability that the maximum horizontal acceleration in lithified earth material, expressed as a percentage of the earth's gravitational pull (g) will exceed 0.10g in 250 years. Maximum horizontal acceleration in lithified earth material means the maximum expected horizontal acceleration depicted on a seismic hazard map, with a 90 percent or greater probability that the acceleration will not be exceeded in 250 years, or the maximum expected horizontal acceleration based on a site-specific seismic risk assessment. Lithified earth material means all

rock, including all naturally occurring and naturally formed aggregates of masses of minerals or small particles of older rock that formed by crystallization of magma or by induration of loose sediments. This term does not include man-made materials, such as fill, concrete, and asphalt, or unconsolidated earth materials, soil, or regolith lying at or near the earth surface.

For the purposes of this procedure, seismic impact zones are delineated on the most current version of the United States Geological Survey Map MF 2120, entitled *Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico* (Algermissen et al., 1991). A reduced copy of this map is attached. **As the attached map shows, most of Vermont except the extreme northeast corner is currently considered a seismic impact zone.**

Siting characteristics with respect to non-lithified (unconsolidated) earth materials need to be considered. These include liquefaction potential of site materials and other stability concerns.

Well-sorted sandy or silty soils that are saturated and loosely compacted, and sensitive cohesive soils when natural moisture exceeds the soil's liquid limit, are subject to liquefaction. Geologic deposits which may be susceptible to liquefaction during seismic events within Vermont could include deltaic, floodplain, and lacustrine deposits. However, most of these deposits may consist of the relatively impermeable unconsolidated material that is desirable when considering potential contaminant attenuation and protection to bedrock aquifers. The pros and cons, including design considerations, should be weighed for sites when evaluating hydrogeologic benefits versus structural considerations.

Other site characteristics vulnerable to earthquake shocks that should be considered include very steep slopes of weak, fractured and brittle rocks which are vulnerable to transient shocks caused by tensional faulting. Dry cohesionless materials on a slope at an angle of repose will respond to seismic shock by shallow sloughing and slight flattening of the slope. Deposits of loose granular soils may be compacted by the ground vibrations induced by an earthquake.

Siting considerations for new MSWLF units or lateral expansions in seismic impact zones could include increased isolation distances to sensitive environmental areas, potential contaminant receptors, and social/public areas of concern. More specific siting considerations could include a more optimum hydrogeologic setting such as greater separation distances to ground water, surface water, and bedrock.

In addition to the siting considerations discussed above, a siting requirement is that new MSWLF units and lateral expansions shall not be located within 200 feet of a fault that has had displacement in Holocene time. For the definition of fault, displacement, and Holocene, see the language of '258.13 of the Federal Rules, which is attached to this procedure. It shall be assumed that no fault within the State of Vermont has had displacement in Holocene time unless the standard site investigation indicates potential displacement (through displaced sediments, etc.). The 1961 Centennial Geologic Map of Vermont (bedrock), University of Vermont Library, and Vermont State Geologist's Office shall be utilized as necessary for determining locations and characteristics of known faults. Documentation of fault characteristics shall be supplemented by field information during the standard site investigation as necessary. Subsequent fault investigation may be necessary on a case by case basis if the standard site investigation indicates potential fault displacement during Holocene time.

General design considerations within seismic impact zones include shallower excavated or constructed

sideslopes, use of materials with higher friction angles (textured synthetic membranes, etc.), use of composite liners, use of materials with better strength characteristics, and minimizing the complexity of the landfill design in general (shape, amount of liner seams, etc.). Specific design considerations for leachate collection, removal, and storage system includes more flexible pipes and liner penetrations, more permeable and transmissive materials to transmit leachate, large diameter and/or backup side slope riser pipes, minimizing the piping outside of the liner system, and underdrain systems to collect leachate in case of liner failure.

III. SITE ANALYSIS AND DESIGN REQUIREMENTS

The following requirements pertain to the site structural and stability analysis. Items A and B shall be performed for all new MSWLF units or lateral expansions. Items A, B, and C shall be performed for all new MSWLF units or lateral expansions located in seismic impact zones. These items shall be incorporated into certification applications.

- A. The design of new MSWLF units or lateral expansions shall incorporate a static (non-seismic) analysis of the structural integrity and overall stability of the landfill site. This not only includes the subbase, but each component of the liner system, the leachate collection & removal system, and the final cover. The landfill design, as constructed, shall achieve the following minimum factors of safety under static conditions, unless otherwise approved by the Department:
- 1) 1.50 for the bearing capacity and settlement of the landfill's subbase under full load conditions.
 - 2) 1.25 for the structural design of the landfill liner system, and leachate collection, removal, and storage system under full load conditions.
 - 3) 1.50 for the final cover.
- B. Site analysis and design submittals shall include the following:
- 1) Data and procedures which are consistent with current practice and which are based on identified procedure(s) and/or publication(s).
 - 2) Identification of the method and/or model used to calculate the factors of safety as well as a brief summary of the pertinent method and/or model.
 - 3) A description of the various assumptions and rationale used in the analysis.
 - 4) Documentation based upon the standard site investigation and/or known information, as necessary, which confirms the new MSWLF unit or lateral expansion is not located within 200 feet of a fault that has had displacement in Holocene time.
- C. Any new MSWLF units or lateral expansion of existing MSWLF units located in a seismic impact zone shall also resist the maximum horizontal acceleration in lithified earth materials at the site. As part of this demonstration, the owner/operator shall:

- 1) Determine the expected maximum horizontal ground acceleration in lithified earth materials at the site as delineated on the most current version of the United States Geological Survey Map MF 2120, entitled *Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico* (Algermissen et al., 1991).
- 2) Determine the site-specific seismic hazards such as ground motion, soil settlement, liquefaction of soils, or slope failure on the foundation soils.
- 3) Design the facility to withstand the impacts from the expected maximum horizontal ground acceleration. The design shall incorporate structural considerations associated with all materials, as constructed, overlying the lithified earth material.
- 4) Demonstrate that the landfill's long-term containment structures, including liner systems, leachate collection, removal, and storage systems, and surface water control systems are designed to retain a minimum factor of safety of 1.0.

Pertinent Section of 40 CFR Part 258

§258.13 Fault areas.

(a) New MSWLF units and lateral expansions shall not be located within 200 feet (60 meters) of a fault that has had displacement in Holocene time unless the owner or operator demonstrates to the Director of an approved State that an alternative setback distance of less than 200 feet (60 meters) will prevent damage to the structural integrity of the MSWLF unit and will be protective of human health and the environment.

(b) For the purpose of this section:

(1) *Fault* means a fracture or a zone of fractures in any material along which strata on one side have been displaced with respect to that on the other side.

(2) *Displacement* means the relative movement of any two sides of a fault measured in any direction.

(3) *Holocene* means the most recent epoch of the Quaternary period, extending from the end of the Pleistocene Epoch to the present.

§258.14 Seismic Impact zones.

(a) New MSWLF units and lateral expansions shall not be located in seismic impact zones, unless the owner or operator demonstrates to the Director of an approved State/Tribe that all containment structures, including liners, leachate collection systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for the site. The owner or operator must place the demonstration in the operating record and notify the State Director that it has been placed in the operating record.

(b) For the purposes of this section:

(1) *Seismic impact zone* means an area with a ten percent or greater probability that the maximum horizontal acceleration in lithified earth material, expressed as a percentage of the earth's gravitational pull paragraph (g) of this section, will exceed 0.10g in 250 years.

(2) *Maximum horizontal acceleration in lithified earth material* means the maximum expected horizontal acceleration depicted on a seismic hazard map, with a 90 percent or greater probability that the acceleration will not be exceeded in 250 years, or the maximum expected horizontal acceleration based on a site-specific seismic risk assessment.

(3) *Lithified earth material* means all rock, including all naturally occurring and naturally formed aggregates of masses of minerals or small particles of older rock that formed by crystallization of magma or by induration of loose sediments. This term does not include man-made materials, such as fill, concrete, and asphalt, or unconsolidated earth materials, soil, or regolith lying at or near the earth surface.

REFERENCES

Information from the following references was used in the preparation of this procedure.

U.S. EPA, "Solid Waste Disposal Facility Criteria, Technical Manual"; EPA530-R-93-017, order number PB94-100-450; USEPA; Solid Waste and Emergency Response; Washington, D.C. 20460, 1993.

Inyang, H.I., "Aspects of Landfill Design for Stability in Seismic Zones"; J. Environmental Systems, Vol.21(3) 223-235, 1991-92.

Inyang, H.I., "Hazardous Waste Facilities in Seismic Zones", AAAS/EPA Environmental Science and Engineering Fellowship Report, American Association for the Advancement of Science, Washington, D.C., 1991.

Bonaparte, R. and Seed, R.B., "Seismic Analysis and Design of Lined Waste Fills: Current Practice", in Proceedings of a Specialty Conference sponsored by the Geotechnical Engineering Division of the American Society of Civil Engineers, Geotechnical Special Publication No. 31, 1992.

Vermont Solid Waste Management Rules; Solid Waste Management Division, Department of Environmental Conservation, effective date February 1, 1989.

6 NYCRR Part 360, Solid Waste Management Facilities, Revisions/Enhancements to New York State's Solid Waste Management Facilities; Division of Solid Waste, Department of Environmental Conservation, effective October 9, 1993.

40 CFR Parts 257 and 258, Solid Waste Disposal Facility Criteria, Final Rule; Federal Register, Part II, Environmental Protection Agency, October 9, 1991.

California Code of Regulations, Title 23. Waters, Division 3. State Water Resources Control Board, Chapter 15. Discharges of Waste to Land; includes July, 1991 Amendments.

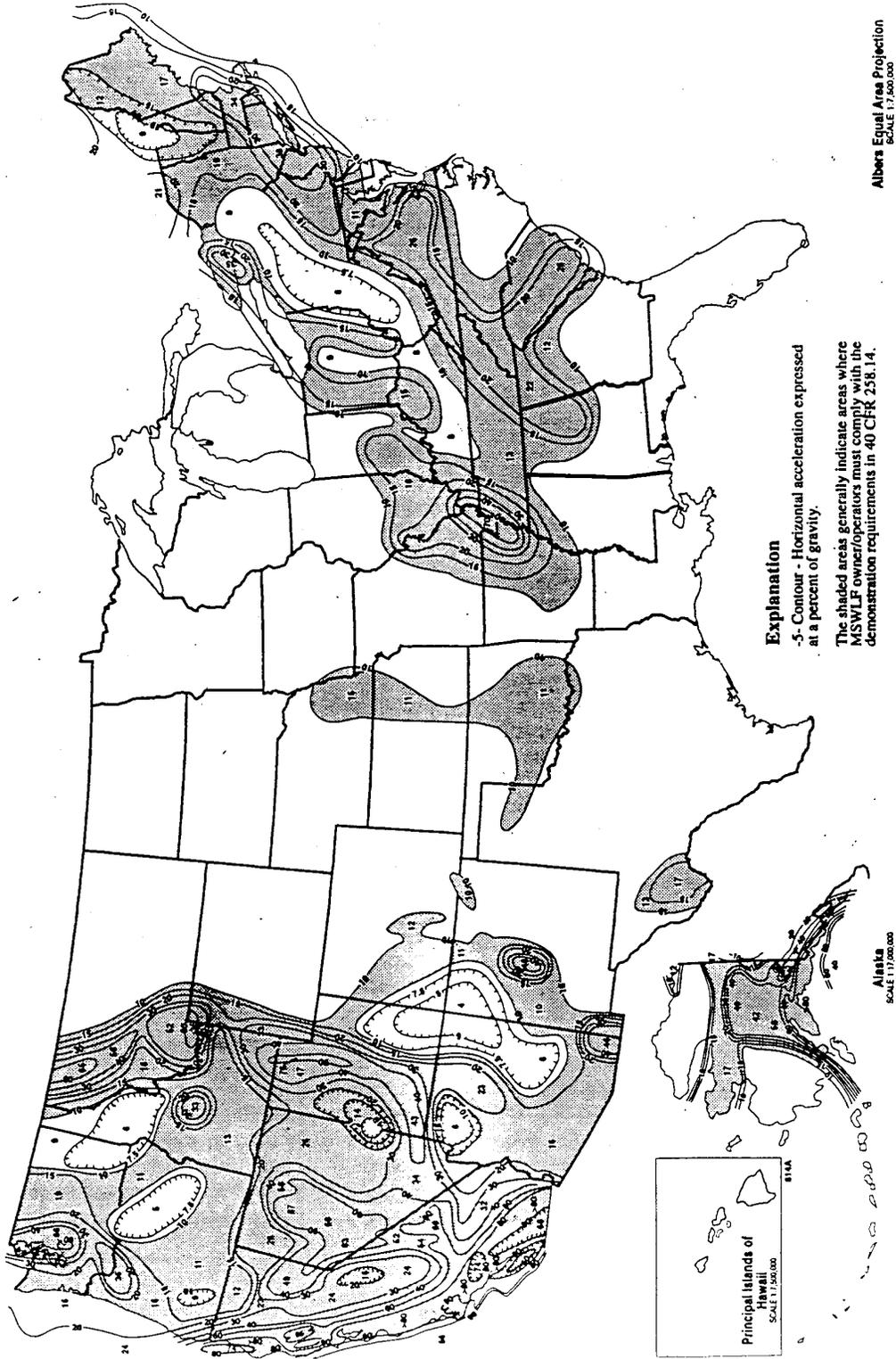


Figure 2-6. Seismic Impact Zones
(Areas with a 10% or greater probability that the maximum horizontal acceleration will exceed .10g in 250 years)

