APPENDIX 1

EARTHQUAKES AND SEISMIC RISK IN OHIO

GEOFACTS No. 3
OHIO DEPARTMENT OF NATURAL RESOURCES • DIVISION OF GEOLOGICAL SURVEY

Although most people do not think of Ohio as an earthquake-prone state, at least 120 earthquakes with epicenters in Ohio have been felt since 1776. In addition, a number of earthquakes with origins outside Ohio have been felt in the state. Most of these earthquakes have been felt only locally and have caused no damage or injuries.

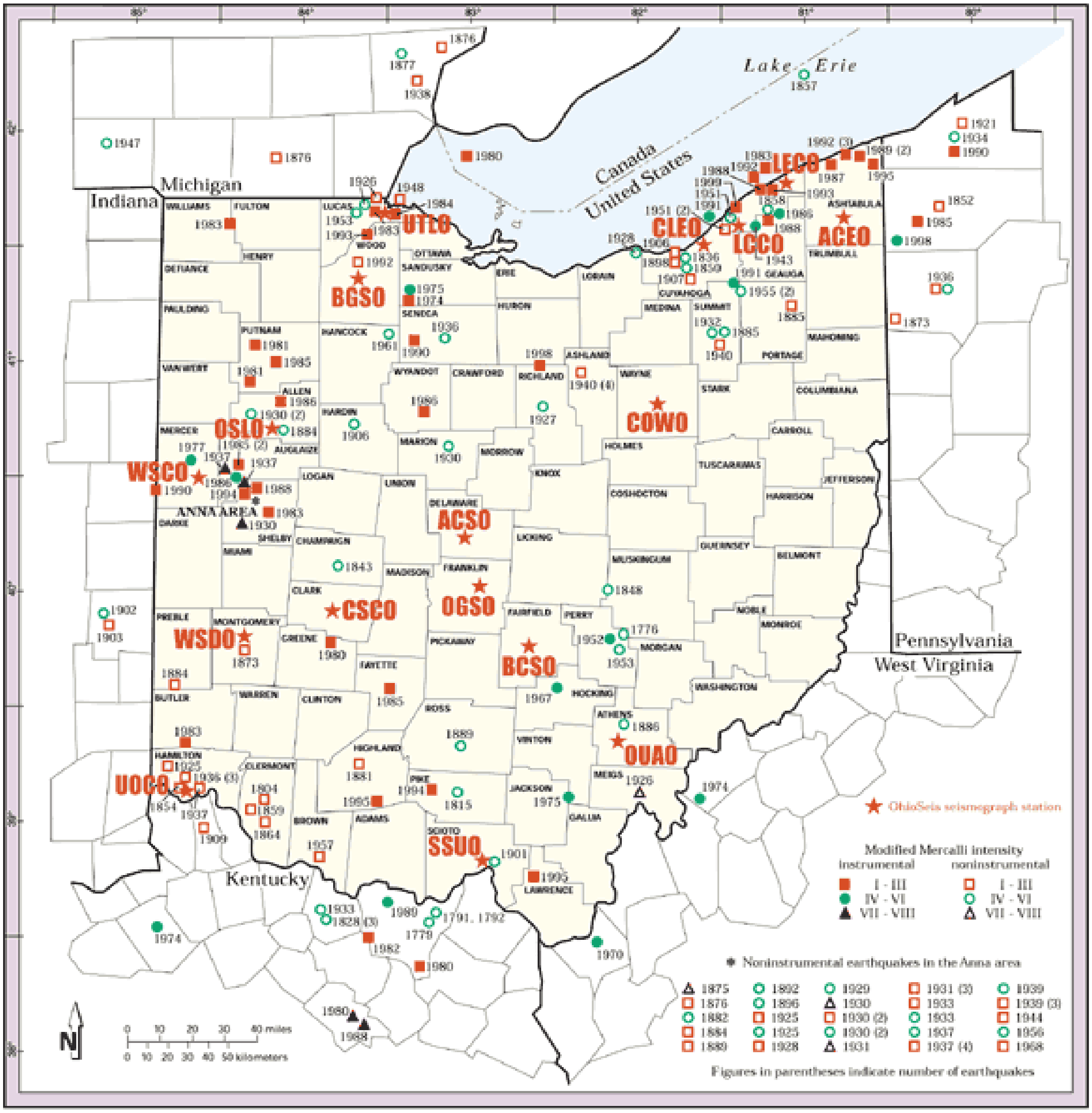
However, at least 14 moderate-size earthquakes have caused minor to moderate damage in Ohio. Fortunately, no deaths and only a few minor injuries have been recorded for these events.

Ohio is on the periphery of the New Madrid Seismic Zone, an area in Missouri and adjacent states that was the site of the largest earthquake sequence to occur in historical times in the continental United States. Four great earthquakes were part of a series at New Madrid in 1811 and 1812. These events were felt throughout the eastern United States and were of sufficient intensity to topple chimneys in Cincinnati. Some estimates suggest that these earthquakes were in the range of 8.0 on the Richter scale.

A major earthquake centered near Charleston, South Carolina, in 1886 was strongly felt in Ohio. More recently, an earthquake with a Richter magnitude of 5.3 centered at Sharpsburg, Kentucky, in 1980 was strongly felt throughout Ohio and caused minor to moderate damage in communities near the Ohio River in southwestern Ohio. In 1998 a 5.2-magnitude earthquake occurred in western Pennsylvania, just east of Ohio, and caused some damage in the epicentral area.

EARTHQUAKE REGIONS

Three areas of the state appear to be particularly susceptible to seismic activity (see map below). Shelby County and surrounding counties in western Ohio have experienced more earthquakes than any other area of the state. At least 40 felt earthquakes have occurred in this area since 1875. Although most of these events have caused little or no damage, earthquakes in 1875, 1930, 1931, and 1937 caused minor to moderate damage. Two earthquakes in 1937, on March 2 and March 9, caused significant damage in the Shelby County community of Anna. The damage included toppled chimneys, cracked plaster, broken windows, and structural damage to buildings. The community school, of brick construction, was razed because of structural damage.



ACSO Alum Creek (Ohio Earthquake Information Center)

OGSO Ohio Geological Survey
ACEO Ashtabula EMA
BCSO Bloom-Carroll Schools
BGSO Bowling Green State University
CSCO Clark State Community College
CLEO Cleveland Museum of Natural History
COWO College of Wooster
LECO Lake Erie College
LCCO Lakeland Community College
OSLO Ohio State University–Lima
OUAO Ohio University
SSUO Shawnee State University
UOCO University of Cincinnati
UTLO University of Toledo
WSCO Wright State–Celina
WSDO Wright State–Dayton (pending)

Northeastern Ohio has experienced at least 20 felt earthquakes since 1836. Most of these events were small and caused little or no damage. However, an earthquake on January 31, 1986, strongly shook Ohio and was felt in 10 other states and southern Canada. This event had a Richter magnitude of 5.0 and caused minor to moderate damage, including broken windows and cracked plaster, in the epicentral area of Lake and Geauga Counties.

Southeastern Ohio has been the site of at least 10 felt earthquakes with epicenters in the state since 1776. The 1776 event, recorded by a Moravian missionary, has a very uncertain location. Earthquakes in 1901 near Portsmouth (Scioto County), in 1926 near Pomeroy (Meigs County), and in 1952 near Crooksville (Perry County) caused minor to moderate damage.

CAUSES OF OHIO EARTHQUAKES

The origins of Ohio earthquakes, as with earthquakes throughout the eastern United States, are poorly understood at this time. Those in Ohio appear to be associated with ancient zones of weakness in the Earth's crust that formed during continental collision and mountain-building events about a billion years ago. These zones are characterized by deeply buried and poorly known faults, some of which serve as the sites for periodic release of strain that is constantly building up in the North American continental plate due to continuous movement of the tectonic plates that make up the Earth's crust.

SEISMIC RISK

Seismic risk in Ohio, and the eastern United States in general, is difficult to evaluate because earthquakes are generally infrequent in comparison to plate-margin areas such as California. Also, active faults do not reach the surface in Ohio and therefore cannot be mapped without the aid of expensive subsurface techniques.

A great difficulty in predicting large earthquakes in the eastern United States is that the recurrence interval--the time between large earthquakes--is commonly very long, on the order of hundreds or even thousands of years. As the historic record in most areas, including Ohio, is only on the order of about 200 years--an instant, geologically speaking--it is nearly impossible to estimate either the maximum magnitude or the frequency of earthquakes at any particular site.

Earthquake risk in the eastern United States is further compounded by the fact that seismic waves tend to travel for very long distances. The relatively brittle and flat-lying sedimentary rocks of this region tend to carry these waves throughout an area of thousands of square miles for even a moderate-size earthquake. Damaging ground motion would occur in an area about 10 times larger than for a California earthquake of comparable intensity.

An additional factor in earthquake risk is the nature of the geologic materials upon which a structure is built. Ground motion from seismic waves tends to be magnified by *unconsolidated* sediments such as thick deposits of clay or sand and gravel. Such deposits are extensive in Ohio. Buildings constructed on *bedrock* tend to experience much less ground motion, and therefore less damage. Geologic maps, such as those prepared by the Ohio Division of Geological Survey, delineate and characterize these deposits. Geologic mapping programs in the state geological surveys and the U.S. Geological Survey are therefore critical to public health and safety.

Modified Mercalli Scale		Magnitude Scale
I	Detected only by sensitive instruments	1.5
II	Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing	2
III	Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly, vibrations like passing truck	2.5
IV	Felt indoors by many, outdoors by few, at night some awaken; dishes, windows, doors disturbed; standing autos rock noticeably	3
V	Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects	3.5 4
VI	Felt by all, many frightened and run outdoors; falling plaster and chimneys, damage small	4.5
VII	Everybody runs outdoors; damage to buildings varies depending on quality of construction; noticed by drivers of autos	5
VIII	Panel walls thrown out of frames; walls, monuments, chimneys fall; sand and mud ejected; drivers of autos disturbed	5.5
IX	Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken	6 6.5
X	Most masonry and frame structures destroyed; ground cracked, rails bent, landslides	7
XI	Few structures remain standing; bridges destroyed, fissures in ground, pipes broken, landslides, rails bent	7.5
XII	Damage total; waves seen on ground surface, lines of sight and level distorted, objects thrown up into air	8

General relationship between epicentral Modified Mercalli intensities and magnitude. Intensities can be highly variable, depending on local geologic conditions (modified from D.W. Steeples, 1978, Earthquakes: Kansas Geological Survey pamphlet).

The brief historic record of Ohio earthquakes suggests a risk of moderately damaging earthquakes in the western, northeastern, and southeastern parts of the state. Whether these areas might produce larger, more damaging earthquakes is currently unknown, but detailed geologic mapping, subsurface investigations, and seismic monitoring will greatly help in assessing the risk.

Earthquake Preparedness

Large earthquakes are so infrequent in the eastern United States that most people do not perceive a risk and are therefore unprepared for a damaging event. Simple precautions such as bolting bookcases to the wall, strapping water heaters to the wall, putting latches or bolts on cabinet doors, and maintaining an emergency supply of canned food, drinking water, and other essentials can prevent both loss and hardship. Brochures on earthquake preparedness are available from disaster services agencies and the American Red Cross. Earthquake insurance is commonly available in Ohio for a nominal additional fee on most homeowner policies. Such a policy might be a consideration, particularly for individuals who live in areas of Ohio that have previously experienced damaging earthquakes.

The Ohio Seismic Network

In early 1999, the first statewide cooperative seismic network, OhioSeis, became operational. This network uses broadband seismometers to digitally record earthquakes in Ohio and from throughout the world. The network was established with the primary purpose of detecting, locating, and determining magnitude for earthquakes in the state. These data not only provide information to the public after an earthquake but, after a long period of

monitoring, will more clearly define zones of highest seismic risk in the state and help to identify deeply buried faults and other earthquake-generating structures. The OhioSeis network was funded in part by the Federal Emergency Management Agency (FEMA) through the Ohio Emergency Management Agency as part of the National Earthquake Hazards Reduction Program (NEHRP). The stations are operated independently by volunteers as part of a cooperative agreement.

For additional information concerning earthquakes, contact:

Ohio Department of Natural Resources
Division of Geological Survey
4383 Fountain Square Drive
Columbus, OH 43224-1362
Telephone: 614-265-6988

This GeoFacts compiled by Michael C. Hansen - January 2000

REFERENCES

Downloaded from http://www.dnr.state.oh.us/geosurvey/geo_fact/geo_f03.htm

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APPENDIX 2

LANDSLIDES IN OHIO

GEOFACTS No. 8

OHIO DEPARTMENT OF NATURAL RESOURCES • DIVISION OF GEOLOGICAL SURVEY

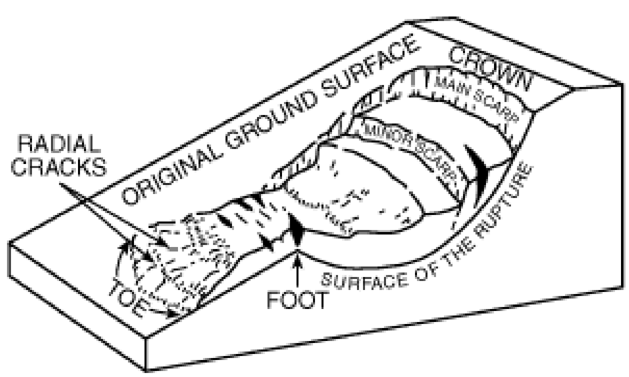
Landslides are a significant problem in several areas of Ohio. The Cincinnati area has one of the highest per-capita costs due to landslide damage of any city in the United States. Many landslides in Ohio damage or destroy homes, businesses, and highways, resulting in annual costs of millions of dollars. Upon occasion, they can be a serious threat to personal safety. On Christmas Eve 1986, an individual traveling in an automobile was killed by falling rock along U.S. Route 52 in Lawrence County in southern Ohio. Although this is Ohio's only recorded landslide fatality, there have been numerous near misses.

TYPES OF LANDSLIDES

The term landslide is a general term for a variety of downslope movements of earth materials. Some slides are rapid, occurring in seconds, whereas others may take hours, weeks, or even longer to develop.

Rotational Slump

A rotational slump is characterized by the movement of a mass of weak rock or sediment as a block unit along a curved slip plane. These slumps are the largest type of landslide in Ohio, commonly involving hundreds of thousands of cubic yards of material and extending for hundreds of feet.



Major Components of a Rotational Slump.

Rotational slumps have an easily recognized, characteristic form. The upper part (crown or head) consists of one or more transversely oriented zones of rupture (scarps) that form a stair-step pattern of displaced blocks. The upper surface of these blocks commonly is rotated backward (reverse slope), forming depressions along which water may accumulate to create small ponds or swampy areas. Trees on these rotated blocks may be inclined upslope, toward the top of the hill. The lower, downslope end (toe) of a rotational slump is a fan-shaped, bulging mass of material characterized by radial ridges and cracks. Trees on this portion of the landslide may be inclined at strange angles, giving rise to the descriptive terms "drunken" or "staggering" forest. Rotational slumps may develop comparatively slowly and commonly require several months or even years to reach stability; however, on occasion, they may move rapidly, achieving stability in only a few hours.

Earthflow

Earthflows are perhaps the most common form of downslope movement in Ohio; many of them are comparatively small in size. Characteristically, an earthflow involves a weathered mass of rock or sediment that flows downslope as a jumbled mass, forming a hummocky topography of ridges and swales. Trees may be inclined at odd angles throughout the length of an earthflow. Earthflows are most common in weathered surface materials and do not necessarily indicate weak rock. They are also common in *unconsolidated* glacial sediments. The rate of movement of an earthflow is generally quite slow.

Rockfall

A rockfall is an extremely rapid, and potentially dangerous, downslope movement of earth materials. Large blocks of massive *bedrock* may suddenly become detached from a cliff or steep hillside and travel downslope in free fall and/or a rolling, bounding, or sliding manner until a position of stability is achieved.

Most rockfalls in Ohio involve massive beds of sandstone or limestone. Surface water seeps into joints or cracks in the rock, increasing the weight of the rock and causing expansion of joints when it freezes, thus prying blocks of rock away from the main cliff. Weak and easily eroded clay or shale beneath the massive bed is an important contributing factor to a rockfall; undercutting in this layer removes basal support.

CAUSES OF LANDSLIDES

Landslides are not random, totally unpredictable phenomena. Certain inherent geologic conditions are a prerequisite to the occurrence of a landslide in a particular area. The presence of one or more of the following conditions can serve as an alert to potential landslide problems.

Steep slopes. All landslides move downslope under the influence of gravity. Therefore, steep slopes, cliffs, or bluffs are required for development of a landslide, especially in conjunction with one or more of the conditions listed below.

Jointed rocks. Vertical joints (fractures) in rocks allow surface moisture to penetrate the rock and weaken it. During periods of cold weather, this moisture freezes and causes the rock masses to be pried apart along the joint.

Fine-grained, permeable rock or sediment. These materials are particularly susceptible to landslides because large amounts of moisture can easily enter them, causing an increase in weight, reduction of the bonding strength of individual grains, and dissolution of grain-cementing materials.

Clay or shale units subject to lubrication. Ground water penetrating these materials can lead to loss of binding strength between individual mineral grains and subsequent failure. Excess ground water in the area of contact between susceptible units and underlying materials can lubricate this contact and thus promote failure.

Large amounts of water. Periods of heavy rainfall or excess snowmelt can saturate the zone above the normal water table and cause a landslide.

Although many areas of the state possess one or more of the above conditions, a landslide requires a triggering mechanism to initiate downslope movement. Events or circumstances that commonly trigger landslides in Ohio include:

Vibrations. Human-induced vibrations such as those from blasting, or even the passing of a heavy truck, in some circumstances, can trigger a landslide. Vibrations from earthquakes can trigger landslides, although no such occurrence has been documented in Ohio.

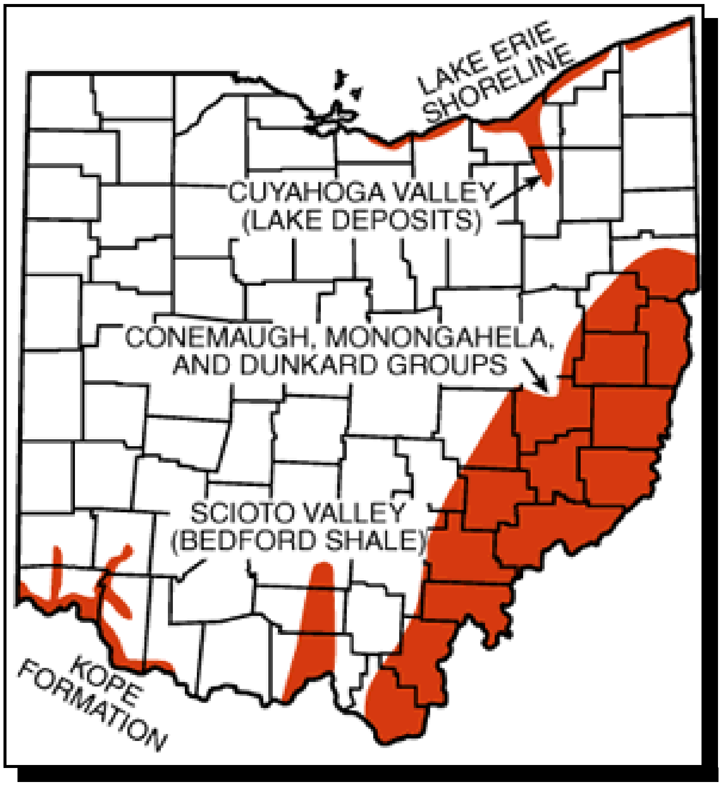
Oversteepened slope. Undercutting of a slope by stream or wave erosion or by human construction activities can disturb the equilibrium of a stable slope and cause it to fail. Addition of fill material to the upper portion of a slope can cause the angle of stability to be exceeded.

Increased weight on a slope. Addition of large amounts of fill, the construction of a building or other structure, or an unusual increase in precipitation, either from heavy rains or from artificial alteration of drainage patterns, can trigger a landslide.

Removal of vegetation. Cutting of trees and other vegetation on a landslide-prone slope can trigger failure. The roots tend to hold the rock or sediment in place and soak up excess moisture.

LANDSLIDE-PRONE AREAS OF OHIO

Landslides are rare or nonexistent throughout much of Ohio because of a lack of steep slopes and/or lack of geologic units prone to failure. Several areas of the state, however, experience frequent and costly landslides.



Areas of Ohio subject to severe slope failure.

Portions of eastern and southern Ohio are characterized by steep slopes and local relief of several hundred feet. In addition, *bedrock* of Mississippian, Pennsylvanian, and Permian ages, thick colluvium (deposits of broken and weathered *bedrock* fragments), and thick lake silts and outwash formed in association with Pleistocene glaciers make this area particularly prone to slope failures. The most slide-prone rocks in eastern Ohio are red mudstones ("red beds") of Pennsylvanian and Permian age. These rocks tend to lose strength when they become wet, forming rotational slumps or earthflows. About 85 percent of slope failures in this region are in red beds of the Pennsylvanian-age Conemaugh and Monongahela Groups.

Eastern Ohio also is subject to rockfalls. Thick, massive sandstones form steep cliffs in many areas of the region and, periodically, large blocks may suddenly fall or tumble downslope.

In the lower part of the Scioto River valley, thick colluvium developed on shales of Mississippian age, particularly the Bedford Shale, is prone to failure. Also prone to failure are lake clays and silts that accumulated in some valleys in this area when Pleistocene glaciers dammed the north-flowing preglacial Teays River system.

Portions of Cincinnati (Hamilton County) and surrounding counties where rocks of Ordovician age are exposed are prone to numerous and costly landslides in the form of rotational slumps and earthflows. The majority of *bedrock* slope failures are in the shale-dominated Kope Formation and to a lesser degree in the Miamitown Shale. Landslides tend to occur in the thick colluvium developed on these units when excessive hydrostatic pressure builds up in this zone.

The valley of the Cuyahoga River between Cleveland and Akron, in Cuyahoga and Summit Counties, is well known for rotational slumps in clays and silts deposited in lakes formed when glaciers of the Pleistocene Ice Age blocked various segments of the valley. The modern Cuyahoga River has cut through these deposits, leaving steep bluffs of unstable sediments along the valley walls. Many of these landslides tend to be concentrated on north-facing slopes where moisture retention is higher.

The eastern half of the Ohio portion of the Lake Erie shoreline, from Cleveland to Ashtabula, is characterized by *unconsolidated* glacial sediments such as till and lake clays and silts that are highly susceptible to wave erosion at the base of the bluff. Such erosion is accentuated during periods of high lake levels accompanied by large storms. The continual removal of slumped sediment by waves prevents natural achievement of stability of the slope. Many lakeshore homes, roads, and other structures have been destroyed in these areas, where bluff recession is as rapid as 7 feet per year.

How to Avoid Landslides

Site selection for a home or other structure in a landslide-prone area of the state should include a determination of the underlying geologic materials and their susceptibility to failure. Geologic maps are a key resource for this. The presence of hummocky topography, steplike scarps, unusually inclined trees or fence posts, and seeps of water are all signs that the slope has undergone failure at some time in the past.

Precautions against slope failure include avoiding the following practices: excavating at the base of the slope, placing large quantities of fill on the upper part of the slope, removing vegetation, disrupting natural drainage patterns, and allowing water from downspouts or septic tanks to discharge onto a slope. In questionable areas, the services of a consulting geologist familiar with the problems of slope failure may be well worth the expense.

Further Reading

Fisher, S. P., Fanaff, A. S., and Picking, L. W., 1968, Landslides of southeastern Ohio: Ohio Journal of Science, v. 68, p. 65-80.
Haneberg, W. C., Riestenberg, M. M., Pohana, R. E., and Diekmeyer, S. C., 1992, Cincinnati's geologic environment: a trip for secondary-school teachers: Ohio Division of Geological Survey Guidebook 9, 23 p.
Hansen, M. C., 1986, When the hills come tumbling down--landslides in Ohio: Ohio Division of Geological Survey, Ohio Geology, Spring, p. 1-7.

This GeoFacts compiled by Michael C. Hansen - September 1995

References

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APPENDIX 3

UNSTABLE SLOPES ADVISORY FOR SOLID WASTE LANDFILL FACILITIES

State of Ohio Environmental Protection Agency

STREET ADDRESS: MAILING ADDRESS:

Lazarus Government Center
122 S. Front St.
Columbus, Ohio 43215

TELE: (614) 644-3020 **FAX:** (614) 644-3184
www.epa.state.oh.us

P.O. Box 1049
Columbus, Ohio 43216-1049

DSIWM Guidance 0586

Unstable Slope Advisory for Solid Waste Landfill Facilities

May 29, 2004

APPLICABLE RULES

MSW:	OAC 3745-27-19(E)(1)(c)
ISW:	OAC 3745-29-19(E)(1)(c)
RSW:	OAC 3745-30-14(E)(1)(c)
Tires:	OAC 3745-27-75(E)(19)

C&DD: OAC 3745-400-11(E)(1)

Cross-References:
#0660 *Geotechnical and Stability Analyses for Ohio Waste Containment Facilities*

PURPOSE

This document outlines the operational and construction practices of material placement for maintaining stable waste slopes and the structural integrity of engineered components.

APPLICABILITY

This document applies to operating municipal (MSW), industrial (ISW) and residual (RSW) solid waste landfills, scrap tire monofills, and construction and demolition debris (C&DD) landfills.

BACKGROUND

Operational and construction practices have a profound impact upon the stability of waste slopes and in maintaining the integrity of the engineered components. Excavated and constructed slopes (including waste slopes) can fail if sound operating and construction practices are not followed.

Several incidents involving failure of slopes and damage to engineered components have occurred at solid waste landfills around the state. Each incident can, in part, be attributed to construction and operational errors, specifically over-steep waste slopes. The operators at the facilities where these failures occurred placed waste at a grade that exceeded the shear resistance of the affected material, or the shear forces induced by waste placement exceeded the shear resistance of one of the geosynthetic and/or soil interfaces. Additionally, each of these facility operators incurred significant cost to assess and repair damage to the engineered components of the facility.

Slope stability analyses on final, interim and internal slopes are a requirement in the solid waste rules. All the landfill rules also require the owner or operator to maintain the integrity of the engineered components of the landfill facility and repair any damage to or failure of the components.

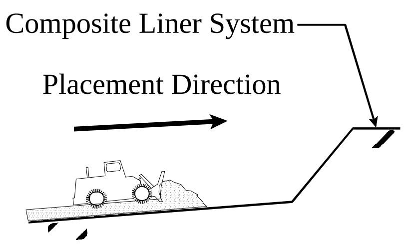
The following suggestions are not regulatory requirements but, adherence is highly recommended to help avoid slope failures, the resulting costly repairs to engineered components of the facility, violations for failing to maintain the integrity of the engineered components, and operational violations which could occur as a result of a failed engineered component.

PROCEDURE

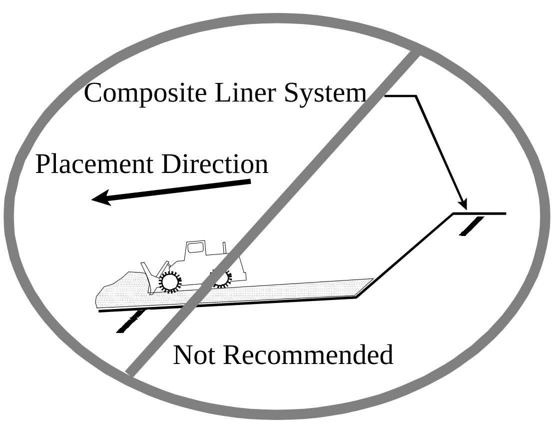
Construction

Drainage layer sand, frost protection material and the select waste layer should only be placed while advancing up slope relative to the bottom composite liner grade similar to that shown in Figure 1. This is especially true on perimeter containment berms. At Ohio facilities, placing drainage material from the top down or laterally across a containment berm has caused anchor trench pullout, ripped flexible membrane liners, and failure through the recompacted soil liner.

Figure 1



Recommended Placement Method



Waste Placement

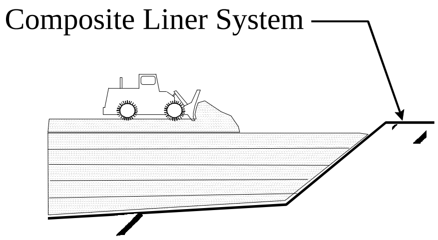
In cells where geosynthetics have not been installed (e.g. C&DD, RSW, scrap tire monfills) the maximum grade of waste placement should be determined from a slope stability analysis that incorporates appropriate shear strength values of the waste and the natural underlying materials. The shear strength of the natural materials should be obtained from testing site-specific natural material at site-specific normal stresses. For C&DD and RSW facilities, the maximum slope for the cap is 25%, DSIWM recommends waste placement does not exceed this slope.

In cells where geosynthetics have been installed, the geosynthetics are usually the weakest component (with the exception of some industrial wastes) and will dictate the maximum grade of waste placement. As with drainage layer sand, frost protection material and placement of the select waste layer, waste should initially be placed in thin nearly horizontal layers starting from the lowest area of the phase or cell and advanced up slope relative to the bottom composite liner grade (see Figure 1). Pushing waste in a direction that is down slope with the bottom liner grade can cause stresses in the geosynthetics or result in an interface failure that can compromise the composite liner system.

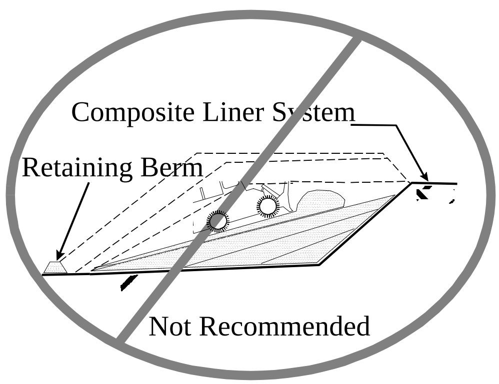
Waste should continue to be placed in thin nearly horizontal layers (see Figure 2) until sufficient normal stresses can be developed that will maintain the structural integrity of the liner system for waste placement at a steeper grade. This steeper slope can only be determined through a stability analysis which incorporates both the appropriate shear strength values of the waste and natural underlying materials as stated previously (for unlined cells), and the interface frictional values obtained from testing site-specific geosynthetics and soils at site-specific normal stresses. Waste placement at a steeper grade can also create failure planes through waste and where intermediate cover is placed.

The recommended placement method may require changes in phasing and construction of a haul road into the bottom of the cell, which in turn may require an alteration or modification to the PTI (or C&DD license), depending upon the extent of the changes. It should be pointed out that construction of a haul road into the bottom of a cell has its own attendant concerns for maintaining the integrity of engineered components, consequently its design and construction should be thoroughly evaluated.

Figure 2



Recommended Placement Method



Steep waste slopes have also been a cause of slope failure and destruction of composite bottom liner systems, resulting in significant remediation costs. The heterogeneous nature of MSW and the materials disposed in MSW landfills (such as ISW and RSW wastes), makes it very difficult to determine accurate and plausible shear strength values. ISW and RSW typically exhibit shear strength characteristics significantly less than that of MSW. One failure occurred in Ohio at a residual waste landfill with slopes of 5 horizontal to1 vertical (5:1) and resulted in waste material sliding into an adjacent uncertified cell. A slope of 3:1 is about the maximum feasible grade for MSW and about the maximum feasible final grade of a landfill given the limitations of the interface strengths with cap systems, equipment limitations, and difficulties with increased erosion and cover and cap maintenance. For detailed information on designing stable slopes see #0660 *Geotechnical and Stability Analyses for Ohio Waste Containment Facilities*.

<u>Saturation</u>

Saturation can dramatically affect shear strength. Failures have occurred through waste, intermediate covers on a steep slope, and in drainage layers on the side slope.

Slope stability analyses should evaluate saturated conditions. Selection of intermediate cover materials and placement should take into consideration the creation of failure planes. In another state, a slope failure occurred because a thick layer of wood chips was used as a cover material over a steep slope. The wood chips were eventually covered by subsequent layers of waste, but they had become saturated and eventually failed, resulting in a large waste slide. Granular drainage layer on the side slopes, left exposed during a long period of time, can become saturated and fail. The designer can account for the effects of exposure and saturation by designing the drainage layer to accommodate the maximum head predicted for the fifty year, one hour storm event. To mitigate saturation, the owner or operator can place the select waste layer (or a four foot thick lift of waste) up the exposed drainage layer on side slopes, if the slope stability analysis indicates waste placement will be stable.

<u>Summary:</u>

Operational and construction practices have significant impact on the stability of waste slopes and in maintaining the integrity of engineered components. Additionally, interim waste slopes are often the most critical slopes at landfills. Therefore, DSIWM recommends implementing the following practices at all landfills, as appropriate.

Drainage sand, frost protection material, select waste and initial lifts of waste should only be placed while advancing up slope relative to the grade of the bottom composite liner system.

In cells where geosynthetics have been installed, waste should be placed in thin nearly horizontal lifts (exclusive of the select waste layer).

The maximum grade of waste placement for interim and final slopes of waste should be determined from a stability analysis.

In general, waste slopes should not exceed 4:1 for C&DD and RSW, or 3:1 for MSW or ISW. However, given material limitations, the maximum allowable slope may need to be flatter.

Industrial and residual solid wastes should be evaluated on an individual basis to determine maximum waste placement grades for that particular waste and should not exceed 3:1.

The effects of saturation should be evaluated and measures taken to address the loss of shear strength that occurs.

Changes to the facility (e.g. a change in phasing or haul road construction) may require a permit alteration or modification or a license modification. Consult with the appropriate district office or license authority (for C&DD facilities) for additional information on modifications, alterations and license requirements.

POINT OF CONTACT

If you have questions regarding this document or would like additional information, please contact:

Central District Office DSIWM Supervisor
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(937) 285-6357
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(614) 644-2621

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