README: LIQUEFACTION SUSCEPTIBILITY MAP OF TETON COUNTY, IDAHO

William M. Phillips
Digital Database 6

Idaho Geological Survey
PO Box 443014
University of Idaho
Moscow, ID 83844-3014
www.idahogeology.org
phillips@uidaho.edu

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WHAT IS LIQUEFACTION?

Liquefaction occurs during strong earthquake ground shaking when saturated, cohesionless earth materials lose strength due to high excess pore-water pressure. The consequences of liquefaction can be catastrophic, including destruction of roads, railways, bridge abutments, canals, sewer and water lines, and building foundations. Liquefaction susceptibility is highest in artificial fills and loose, sandy deposits that are saturated with water.

HOW THIS MAP WAS PRODUCED

This map was produced using a combination of: 1) a standard methodology (ATE Classification) that relates deposit age, texture (grain size and sorting), and environment of deposition to liquefaction susceptibility; and 2) depth to the local water table. This analysis was performed at a scale of 1:50,000 in an area containing the majority of county population and infrastructure, including the towns of Tetonia, Driggs, and Victor (outlined in red on the map and provided in the GIS dataset). Outside of this area liquefaction susceptibility was not analyzed but is probably very low because of generally deep water tables and thin surficial deposits overlying sedimentary and volcanic bedrock.

Age-Texture-Environment (ATE) Classification

Liquefaction susceptibility is related to deposit age, texture, and environment of deposition (Federal Emergency Management Administration, 2009, Table 4-10, p. 4-22; Youd and Perkins, 1978). A classification process similar to that employed in Washington State (Palmer and others, 2004) was used to relate these factors to deposits. Earth materials within about 30 m (100 ft) of the surface were classified using geologic maps of the area (Mitchell and Bennett, 1979; Scott, 1982) and soil maps (Soil Survey Staff, 2011), augmented with shallow water well logs (IDWR, 2011).

For each geologic or soil map unit, a score between 0-5 was assigned for each classifying factor based upon unit descriptions (Table 1). Equal weighting was given to age, texture, and environment. The scores were summed to give an age-texture-environment (ATE) score (Table 2). Liquefaction cannot occur in bedrock, so these units were given a score of zero although they were classified as to age, texture, and environment.

Depth to Local Water Table

Because liquefaction occurs only in saturated earth materials, it is essential to determine areas subject to high water tables. The best source for this information in Teton County are soil maps that show the distribution of hydric soils (Table 3; Soil Survey Staff, 2011). Hydric soils and high water tables are concentrated adjacent to the Teton River on river terraces, marshes, and on the flood plains of secondary streams.

Domestic water wells are a second source of information. Static water level data from wells in Teton County were obtained from the Idaho Department of Water Resources (IDWR, 2011). After removing mislocated records or those with missing data, 2244 wells were used with ESRI ArcMap to construct a model of average water-table depths. Water tables in Teton County experience large seasonal fluctuations. For this reason, high water tables are defined conservatively as static water levels of <12 m (<40 ft) below the ground surface. Irrigation practices, multi-year droughts or wet cycles, and local pumping may also influence water-table levels. These factors make it difficult to precisely estimate water-table depths. Therefore, areas identified as subject to high water tables should be viewed as guidelines to focus further investigation of liquefaction susceptibility rather than definitive measures of the depth-to-water.

EXPLANATION OF LIQUEFACTION SUSCEPTIBILITY CLASSES

Class 3: High liquefaction susceptibility based on potential for saturation and presence of cohesionless sediments. Subject to at least annual saturation because of high water tables. Underlain by hydric soils and Holocene sedimentary deposits that are likely to contain cohesionless sediments.

Class 3 areas contain hydric soils and shallow unconsolidated sedimentary deposits of Holocene age. Hydric soils are subject to flooding, ponding, or seasonal saturation by shallow (<30 cm, <1 ft) water tables. Areas underlain by hydric soils (Table 3) were identified from the report "Hydric Soils List – Map Units with Hydric Components." This report is included in the soil mapping database for the Teton County area (Soil Survey Staff, 2011). Shallow sedimentary deposits in these areas are estimated to be Holocene in age because they are, in general, active sites of sediment deposition. These deposits are described as peat and organic matter, and stratified clay, silt, gravel, and sand (IDWR, 2011; Scott, 1982; Soil Survey Staff, 2011). They have high ATE scores of 13 (Table 2).

Class 2: Lower Liquefaction Susceptibility. Average water table within 12 m (40 ft) of surface. Annual saturation possible in some areas. Underlain by Holocene to late Pleistocene sedimentary deposits that may contain cohesionless sediments.

Class 2 areas have water-table depths of <12 m (<40 ft) and are underlain by shallow sedimentary deposits of Holocene to late Pleistocene age. Saturation of near-surface deposits is possible, particularly during spring melt and summer irrigation seasons. Depth to water was estimated from 2244 water well logs (IDWR, 2011). Hydric soils are not present in Class 2 areas. Shallow sedimentary deposits consist of alluvial fans, stream terraces, alluvium along flood plains of secondary streams, and loess-covered hills on west side of Teton River (Mitchell and Bennett, 1979; Scott, 1982). The alluvial-fan deposits are composed of gravel and sand interbedded with silt and clay. Many alluvial-fan deposits are too compacted or too coarse grained to liquefact even when saturated, but lenses of cohesionless sands may be locally present. They have an ATE score of 9. Alluvium in terraces and along flood plains of secondary streams are finer grained (sand, silt, and clay) and are more susceptible to liquefaction. They have an ATE score of 13. Loess-covered hills west of Teton River are composed of interbedded clay, gravel, and sand (IDWR, 2011). These features appear to be mixed lake and alluvial deposits. Relatively low shear velocities (<300 m/s) were measured in some of these hills, suggesting that areas of low cohesion may be present. They have an ATE score of 6.

Class 1: Low liquefaction susceptibility based on potential for saturation and presence of cohesionless sediments. Average water table greater than 12 m (40 ft). Not subject to saturation under ordinary conditions. Underlain by earth materials that are unlikely to contain cohesionless sediments.

Class 1 areas have water-table depths of >12 m (40 ft) and are not subject to saturation under normal conditions. They are mostly underlain by alluvial fans east of the Teton River or shallow loess overlying volcanic bedrock in the northern portion of the map. These deposits have ATE scores of 9 and 6. These deposits are unlikely to liquefact even when saturated.

Class 0: Liquefaction Susceptibility Not Evaluated in Detail

Class 0 areas consist largely of the Big Hole Mountains and adjacent loess-covered volcanic uplands. Liquefaction susceptibility was not evaluated in detail in these lightly populated areas. However, it is clear that liquefaction susceptibility is generally very low in these areas. The Big Hole Mountains are largely underlain by well-drained, shallow soils on steep slopes that overlie sedimentary and volcanic bedrock. The volcanic uplands consist of well-drained loess over rhyolitic or basaltic bedrock. Water tables are generally >12 m (40 ft) below the land surface. Liquefaction will not occur in these environments except where perched water tables or springs are present together with sandy deposits.

LIMITATIONS ON THE USE OF THESE MAPS

This map is a general guide to outlining areas with the potential for liquefaction. Because this map is based on regional geological and hydrological data, detailed geotechnical investigations are required to determine actual ground conditions for specific building sites. This map is intended to be used at a scale of 1:50,000. As with all maps, users should not apply this map, either digitally or on paper, at more detailed scales.

REFERENCES

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ACKNOWLEDGMENTS

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TABLES

Table 1. Age-Texture-Environment (ATE) symbols for the Teton County study area.

Symbol	Age	Description	Score
H	11-0 ka	Holocene (end of last glacial period to present day)	5
yP	25-11 ka	Younger Pleistocene (last glacial period-Pinedale)	3
oP	160 – 25 ka	Older Pleistocene (older glacial periods – Bull Lake)	2
P	2.6 Ma – 11 ka	Pleistocene, undivided	1
T	65.5-2.6 Ma	Tertiary (mostly Pliocene-Miocene)	0
pT	>65.5 Ma	PreTertiary (Mesozoic-Paleozoic)	0
Texture (Grain Size) Classes and Symbols			
Symbol		Description	Score
c		coarse, predominantly gravel and sand	3
s		sandy, predominantly sand and silt	5
f		fine, predominantly silt and clay	2
u		unknown or texturally diverse	2
b		bedrock	0
Environment Classes and Symbols			
Symbol	Environment	Description	Score
afg	Alluvial	Alluvial fan, glacial outwash	3
af	Alluvial	Alluvial fan, nonglacial source	4
am	Alluvial	Main stream, meandering	5
el	Eolian	Loess	2
la	Lake/Alluvial	Mixed deposits of lakes and streams	4

s	Sedimentary	Sedimentary rocks	0
v	Volcanic	Basalt lava flows, rhyolite tuffs and flows	0

Table 2. Age-Texture-Environment Scores for geologic units of Teton County detailed study area.

Unit	Name	Age	Texture	Environment	A	T	E	Total	Class
Qa	Alluvium of Teton River	H	u	am	5	3	5	13	High
Qas	Alluvium of sidestreams	H	u	am	5	3	5	13	High
Qfg	Alluvial fan gravel, nonglacial source	yP	c	af	3	3	0	6	Medium
Qalo	Alluvial fan gravel, glacial outwash	yP	c	afg	3	3	3	9	High
Qyh	Huckleberry Ridge Tuff/Quaternary Basalt	oP	b	v	2	0	0	0	Null
Ql?	Mixed lake/alluvium with loess cover	P	u	la	2	3	4	9	High
Qel	Loess	yP	f	el	3	1	2	6	Medium

Table 3. Hydric Soils in the Teton Area, Idaho and Wyoming (Soil Survey Staff, 2011).

Soil Name	Map Symbol*	Landform
Cedron silty clay loam	Ce	Flood plains and swales
Foxcreek gravelly loam	Fr	Valley floors
Foxcreek loam	Fs	Valley floors
Foxcreek loam, shallow variant	Ft	Valley floors
Foxcreek gravelly loam, shallow variant	Fu	Valley floors
Foxcreek silty clay loam, heavy subsoil variant	Fv	Valley floors
Furniss mucky silty clay loam	Fw	Valley floors
Furniss silty clay loam	Fx	Valley floors
Marsh	Ma	Marshes
Tepete mucky peat	Ta	Valley floors
Tepete mucky peat, shallow	Te	Valley floors
Zohner silty clay loam	Zc	Valley floors
Zohner silty clay loam, moderately deep variant	Zd	Valley floors

*Map symbol used on Teton County area soil maps (Soil Survey Staff, 2011).

DIGITAL MAP, DOCUMENTATION, AND GIS FILES*

Liquefaction_Susceptibility_Map_Teton_County_Idaho.PDF
README_Documentation_Liquefaction_Susceptibility_Map_Teton_County_Idaho.PDF

GIS Files with Base Name of:
Liquefaction_Susceptibility_Map_Teton_County_Idaho
Teton_County_Detailed_Study_Area

Metadata file
Liquefaction_Susceptibility_Map_Teton_County_Idaho.htm

ASCII Grid Representation of Liquefaction Susceptibility Map of Teton County, Idaho
Liquefaction_Susceptibility_Map_Teton_County_Idaho_Grid.txt

*Available for free download at www.idahogeology.org