

# Liquefaction Susceptibility Map for the Wood River Valley, Blaine County, Idaho

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## WHAT IS LIQUEFACTION?

During strong earthquake shaking, saturated cohesionless earth materials may experience a sudden loss of strength and stiffness due to excess pore-water pressure. This phenomenon is called liquefaction. The consequences of liquefaction can be catastrophic, including destruction of roads, 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.

## PURPOSE AND LIMITATIONS OF THIS MAP

This map provides an assessment of the potential for liquefaction in the Wood River Valley using standard screening techniques (Richardson and others, 1995). The assessment was performed at a scale of 1:50,000 and is based on regional geological and hydrological data, and on geophysical measurements at 51 sites. Detailed geotechnical investigations are required to determine actual ground conditions for specific building sites.

## 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; 2) depth to the top of the regional unconfined aquifer as measured in water wells; 3) depth to the local water table from seismic P wave velocities at 51 sites; and 4) soil maps showing saturated (hydic) soils. This analysis was performed in the portion of the Wood River Valley containing the majority of population and infrastructure including the towns of Sun Valley, Ketchum, Hailey, and Bellevue. This area is shown outlined in red on the map. Outside of this area, liquefaction susceptibility was not analyzed in detail. Here, the landscape consists mostly of steep hillslopes with thin soils over bedrock, and liquefaction susceptibility is likely low.

## Age-Texture-Environment (ATE) Classification

Liquefaction susceptibility is related to the age, texture, and environment of deposition of earth materials (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 the deposits of the Wood River Valley. Surface earth materials were classified using a surficial geologic map of the area (Breckenridge and Ohberg, 2006). For each geologic map unit, a numerical score between 0 and 6 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 for each unit (Table 2).

## Depths to Local Water Tables

Because liquefaction occurs only in saturated earth materials, it is essential to determine areas subject to high water tables. The depth to water varies widely in the study area both spatially and temporally. The Wood River Valley contains two aquifers: an upper unconfined aquifer that extends over the entire valley; and a deeper confined aquifer present only in the southern valley (Bartolino and Adkins, 2012). Only the upper unconfined aquifer is relevant to this work; the depth to its top generally corresponds with the local water table. Water tables in the Wood River Valley may experience large seasonal fluctuations. For this reason, high water tables are defined conservatively as <6 m (<20 ft) below the ground surface. Irrigation practices, multi-year droughts or wet cycles, and local pumping or discharges 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. Areas of shallow (<6 m; <20 ft) water table were delineated from a water table map of the unconfined aquifer constructed from water well measurements made in October 2006 (Skinner and others, 2007). This data was augmented by local measurements of water table depth at 51 sites were made in April 2013 using P wave velocities (Fugro Consultants, 2013) and soil maps of Blaine County showing regions underlain by hydric soils that are saturated or seasonally saturated. In general, the three sources of data were in good agreement.

## EXPLANATION OF LIQUEFACTION SUSCEPTIBILITY CLASSES

**Class 3: High Liquefaction Susceptibility**  
Average water table within 6 m (20 ft) of surface. Underlain by deposits with ATE scores >12. Near-surface saturation of Class 3 deposits is possible, particularly during spring melt and summer irrigation seasons. The deposits are dominantly mainstem and sidestream alluvium that may contain lenses of cohesionless sediment.

**Class 2: Medium Liquefaction Susceptibility**  
Average water table within 6 m (20 ft) of surface. Underlain by deposits with ATE scores between 8 and 11. Near-surface saturation of Class 2 deposits is possible, particularly during spring melt and summer irrigation seasons. These deposits consist of gravel-rich terrace deposits along the Wood River and side streams.

**Class 1: Low Liquefaction Susceptibility**  
Average water table greater than 6 m (20 ft). Underlain by deposits with ATE scores less than 8. Not subject to saturation under ordinary conditions. Class 1 deposits are unlikely to liquefact.

**Class 0: Liquefaction Susceptibility Not Evaluated in Detail**  
Class 0 areas consist of uplands outside of the Wood River Valley. Liquefaction susceptibility was not evaluated in these lightly populated areas. Liquefaction susceptibility is probably low because loose, young deposits over bedrock are very thin and water tables deep. Liquefaction will not occur in these environments except where perched water tables or springs are present together with loose sandy deposits.

Table 1. Age-Texture-Environment (ATE) symbols and scores.

AGE			
Symbol	Age	Description	Score
H	11.5-0 ka	Holocene	6
HfP	25-0 ka	Younger Pleistocene to Holocene	4
Yf	25-11 ka	Younger Pleistocene	3
oP	160-25 ka	Older Pleistocene	2
HP	0-2.6 Ma	Holocene-Pleistocene	2
P	2.6 Ma-11 ka	Pleistocene, undivided	1
PPI	0.0 Ma-11.5 ka	Pleistocene-Pliocene	0

TEXTURE			
Symbol	Description	Score	
t	fine, predominantly silt and clay	2	
u	texturally diverse	3	
s	coarse, predominantly sand and gravel	4	
b	bedrock	0	

ENVIRONMENT			
Symbol	Environment	Description	Score
af	Alluvial	Alluvial fan	4
am	Alluvial	Main stream, meandering	5
ab	Alluvial	Main stream, braided	3
as	Alluvial	Side stream, meandering	5
ac	Alluvial-Colluvial	Gravel deposits in colluvium	2
c	Colluvial	Colluvium, granitic and dioritic	2
g	Glacial	Till with lesser outwash	2
m	Made Ground	Fill, landscaping mounds, mine tailings	6
ml	Mass Wasting	Landslide and talus deposits	4

Table 2. Age-Texture-Environment classification of Wood River area geology units.

Unit	Name	Age	Texture	Env	Env	Total	Class	
m	Fill (mine tailings, landscaping mounds, etc.)	H	u	m	6	2	14	High
Qac	Alluvium and colluvium	H	u	ac	6	2	11	Medium
Qad	Alluvial fan and debris flow deposits	H	u	af	6	2	12	High
Qag1	Gravel terrace deposits of Big Wood River	HP	c	ab	4	4	8	Low
Qag2	Gravel terrace deposits of Big Wood River	Yf	c	ab	3	4	7	Low
Qag3	Gravel terrace deposits of Big Wood River	oP	c	ab	2	4	6	Low
Qag4	Gravel terrace deposits of Big Wood River	PPI	c	ab	0	4	4	Low
Qagc	Gravel deposits in colluvium	PPi	c	ab	0	4	4	Low
Qagc1	Gravel deposits in sidestreams	HP	c	ab	2	2	4	Low
Qagc2	Gravel deposits in sidestreams	YfP	c	ab	4	4	8	Medium
Qagc3	Gravel deposits in sidestreams	oP	c	ab	2	2	4	Low
Qagc4	Gravel deposits of unglaciated streams	HP	c	ab	2	2	4	Low
Qam	Alluvium of Big Wood River	H	c	am	6	4	10	Medium
Qas	Alluvium of sidestreams	H	c	am	6	4	10	Medium
Qcd	Colluvium from Cretaceous(?) diorite rocks	HP	u	co	2	2	4	Low
Qcg	Colluvium from Cretaceous granitic rocks	HP	c	ab	2	2	4	Low
Qcm	Colluvium from metasedimentary rocks	HP	u	co	2	2	4	Low
Qcv	Colluvium from Eocene volcanics	HP	u	co	2	2	4	Low
Qcwb	Colluvium from volcanic breccias, tuffs, sedimentary interbeds	HP	u	co	2	2	4	Low
Qcw	Colluvium from sedimentary rocks	HP	c	ab	2	2	4	Low
Qdf	Debris-flow deposits	H	u	af	6	2	8	Medium
Lgt	Glacial deposits, undivided	P	u	g	1	2	3	Low
Qg1	Neoglacial deposits, undivided	H	u	g	6	2	8	Medium
Qg2	Till of late Pleistocene glaciation	Yf	u	g	3	2	5	Low
Qg3	Till of pre-late Pleistocene glaciation	oP	u	g	2	2	4	Low
Qls	Landslide deposits	HP	u	mw	2	2	4	Low
Qld	Landslide deposits Area of Deposition	HP	u	mw	2	2	4	Low
Qsh	Landslide deposits Headwall area	HP	u	mw	2	2	4	Low
Qtl	Talus	H	c	mw	6	4	10	Medium
Qaf	Alluvial fan deposits	HP	c	af	2	4	6	Low

Table 3. Wood River area Vs5, Vs30 and depth to water table data.

Line ID	Site Name	Latitude	Longitude	Vs5 (m/s)	Vs30 (m/s)	Depth to water table (m)
BL-1	BLM land on Big Wood River, Bellevue	43.405906	-114.266381	323.6	434.6	21.25
BL-2	Wisher Sand and Gravel, Bellevue	43.405232	-114.258978	240.3	426.8	23.50
BL-3	Blaine County Rd & Bridge, Bellevue	43.438229	-114.273271	12.0	302.9	no data
BL-4	Swift Sure Ranch, Bellevue	43.429833	-114.255215	207.2	389.1	6.00
BL-5	Swift Sure Ranch, Bellevue	43.430335	-114.252895	212.1	370.3	15.50
BL-6	Howard Preserve, Bellevue	43.455620	-114.263427	213.5	318.1	4.25
BL-7	Memorial Park, Bellevue	43.460118	-114.252824	315.2	403.9	12.25
BL-8	BLM land on Muldoon Rd, Bellevue	43.466136	-114.240200	237.2	384.9	32.00
BL-9	O'Donnell Park, Bellevue	43.467472	-114.250661	244.3	383.2	no data
BL-10	90 Tendency Street, Bellevue	43.470676	-114.269937	215.7	418.7	5.00
BL-11	Woodside Elementary School, Hailey	43.492244	-114.276479	212.5	363.8	12.75
BL-12	McKeecher Park, Hailey	43.514271	-114.305625	231.8	333.0	13.25
BL-13	Park on War Eagle Drive, Hailey	43.507211	-114.313564	199.9	416.2	5.25
BL-14	Croy Creek, Hailey	43.514494	-114.324694	217.2	335.3	15.25
BL-15	Wood River High School (south field), Hailey	43.512337	-114.291739	207.5	319.9	13.50
BL-16	Hailey Elementary School, Hailey	43.514566	-114.308918	270.6	465.4	11.50
BL-17	Lions Park, Hailey	43.514522	-114.320448	194.8	433.3	7.75
BL-18	Hop Porter Park, Hailey	43.518634	-114.319755	195.4	312.6	5.50
BL-19	Wood River High School (north field), Hailey	43.519395	-114.295908	294.2	364.9	23.00
BL-20	City Park in Deerfield Subdivision, Hailey	43.518625	-114.303345	221.5	343.1	11.75
BL-21	Old Cutters Subdivision Park, Hailey	43.530868	-114.307615	224.2	346.4	21.00
BL-22	Wood River Middle School, Hailey	43.530164	-114.316873	193.9	305.5	8.50
BL-23	Open space for Old Cutters Subdivision, Hailey	43.531281	-114.300705	262.1	446.4	23.50
BL-24	Calvary Bible Church, Hailey	43.544577	-114.327034	227.1	391.5	6.50
BL-25	Deer Creek Ranch, northwest of Hailey	43.558087	-114.357448	188.2	303.4	10.75
BL-26	Deer Creek Ranch, northwest of Hailey	43.558981	-114.356747	181.1	298.5	6.00
BL-27	Idaho Department of Lands, east of Hwy 75	43.559603	-114.325227	259.3	341.5	14.00
BL-28	Deer Creek Ranch, northwest of Hailey	43.561026	-114.350136	172.5	253.3	10.25
BL-29	Deer Creek Ranch, northwest of Hailey	43.564098	-114.359419	367.7	621.0	6.50
BL-30	Indian Creek Ranch, northeast of Hailey	43.563071	-114.305652	274.4	434.9	12.25
BL-31	Headlands Subdivision, north of Hailey	43.587216	-114.339608	225.2	386.5	15.75
BL-32	Ohio Gulch	43.589133	-114.317800	343.5	473.3	21.25
BL-33	Intersection of Hwy 75 and East Fork Rd	43.604041	-114.347542	238.7	485.2	7.00
BL-34	West side of Hwy 75, north of East Fork Rd	43.616257	-114.354074	223.6	426.5	14.75
BL-35	St. Luke's Wood River Medical Center, Ketchum	43.656888	-114.349208	291.0	434.2	4.25
BL-36	Big Wood River, South of Ketchum	43.654265	-114.346340	222.2	403.9	5.25
BL-37	Sun Valley Water and Sewer District, Ketchum	43.657874	-114.351415	195.7	392.6	5.75
BL-38	Independence Gulch, Elkhorn	43.671434	-114.360605	144.3	279.2	3.75
BL-39	Sun Valley Resort Ski Area Parking, Ketchum	43.673706	-114.355216	208.0	483.9	17.00
BL-40	Ernest Hemingway Elementary School, Ketchum	43.683728	-114.371336	208.0	397.4	5.00
BL-41	Sun Valley Resorts property on Sun Valley Rd	43.685844	-114.338925	351.5	587.8	9.25
BL-42	City of Sun Valley property on Sun Valley Rd	43.686228	-114.359487	265.7	440.5	21.00
BL-43	Forest Service land on Warm Springs Rd	43.688886	-114.413403	225.8	517.5	4.25
BL-44	Sun Valley Resorts property on Sun Valley Rd	43.690978	-114.355646	291.0	451.9	22.00
BL-45	Sun Valley Resorts property on Sun Valley Rd	43.692304	-114.358465	616.6	1018.5	4.00
BL-46	Sun Valley Resorts property on Sun Valley Rd	43.705162	-114.351648	210.5	385.9	6.00
BL-47	Parking area along Sun Valley Rd (NF-51)	43.709964	-114.342381	234.4	438.7	22.00
BL-48	BLM land on Hulen Meadows Rd	43.718511	-114.300772	248.2	418.5	6.00
BL-49	BLM land on Hulen Meadows Rd	43.719529	-114.301089	215.2	430.6	4.25
BL-50	Forest Service land on Lake Creek Rd	43.734173	-114.368911	222.2	391.2	13.50
BL-1	Minnie Moore Mine Tailings, Bellevue	43.487747	-114.281750	209.9	291.2	16.25

## Explanation

- Seismic P wave velocities (depth to water table) measurement sites
- Class 3: High liquefaction susceptibility
- Class 2: Medium liquefaction susceptibility
- Class 1: Low liquefaction susceptibility
- Class 0: Area unevaluated
- Boundary of evaluated area

## REFERENCES CITED

Bartolino, J.R., and C.B. Adkins, 2012. Hydrogeologic framework of the Wood River Valley aquifer system, south central Idaho. U.S. Geological Survey Scientific Investigations Report 2012-5053, 46 p., 1 plate.

Breckenridge, R.M., and K.L. Ohberg, 2006. Surficial geologic map of the Wood River Valley area, Blaine County, Idaho: Idaho Geological Survey Digital Web Map 54, scale 1:50,000.

Federal Emergency Management Agency, 2009. Multi-Hazard Loss Estimation Methodology Earthquake Model, HAZUS-MH MR4, Technical Manual. Available at <http://www.fema.gov/library/viewRecord.do?id=3731>.

Fugro Consultants, Inc., 2013. Blaine County, Idaho IMASW Seismic Survey Data Report: Fugro Consultants, Inc., Lakewood, Colorado, 11 p. Available at [www.idahogeology.org](http://www.idahogeology.org).

Palmer, S.P., S.L. Magrino, E.L. Bilderback, J.L. Poelstra, D.S. Folger, and R.A. Niggemann, 2004. Liquefaction susceptibility and site class maps of Washington State by county. Washington Department of Natural Resources, Division of Geology and Earth Resources Open File Report 2004-20. Available online at <ftp://198.187.344.geology.wa.gov/ofr04-20/>.

Richardson, G.N., E. Kavazanjian, Jr., and N. Matsui, 1995. RCRA subtitle D (258) seismic design guidance for municipal solid waste landfill facilities: U.S. Environmental Protection Agency EPA/600/R-95/051, 143 p.

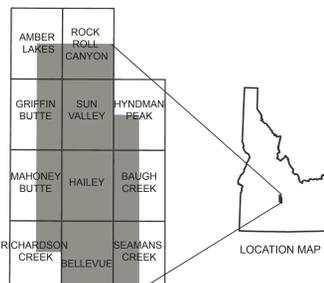
Skinner, K.D., J.R. Bartolino, and A.W. Trammer, 2007. Water-resource trends and comparisons between partial development and October 2006 hydrologic conditions, Wood River Valley, south-central Idaho: U.S. Geological Survey Scientific Investigations Report 2007-5258, 31 p., 4 plates, 1 appendix. (Also available at <http://pubs.er.usgs.gov/usgspubs/sir/sir20075258>.)

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture, 2013. Soil Survey Geographic (SSURGO) Database for Blaine County, Idaho. Available online at <http://soildatamart.nrcs.usda.gov>. Accessed 06/2013.

Youd, T.L., and M. Perkins, 1978. Mapping liquefaction-induced ground failure potential. Journal of the Geotechnical Engineering Division ASCE, v. 104 no. 4, p. 433-446.

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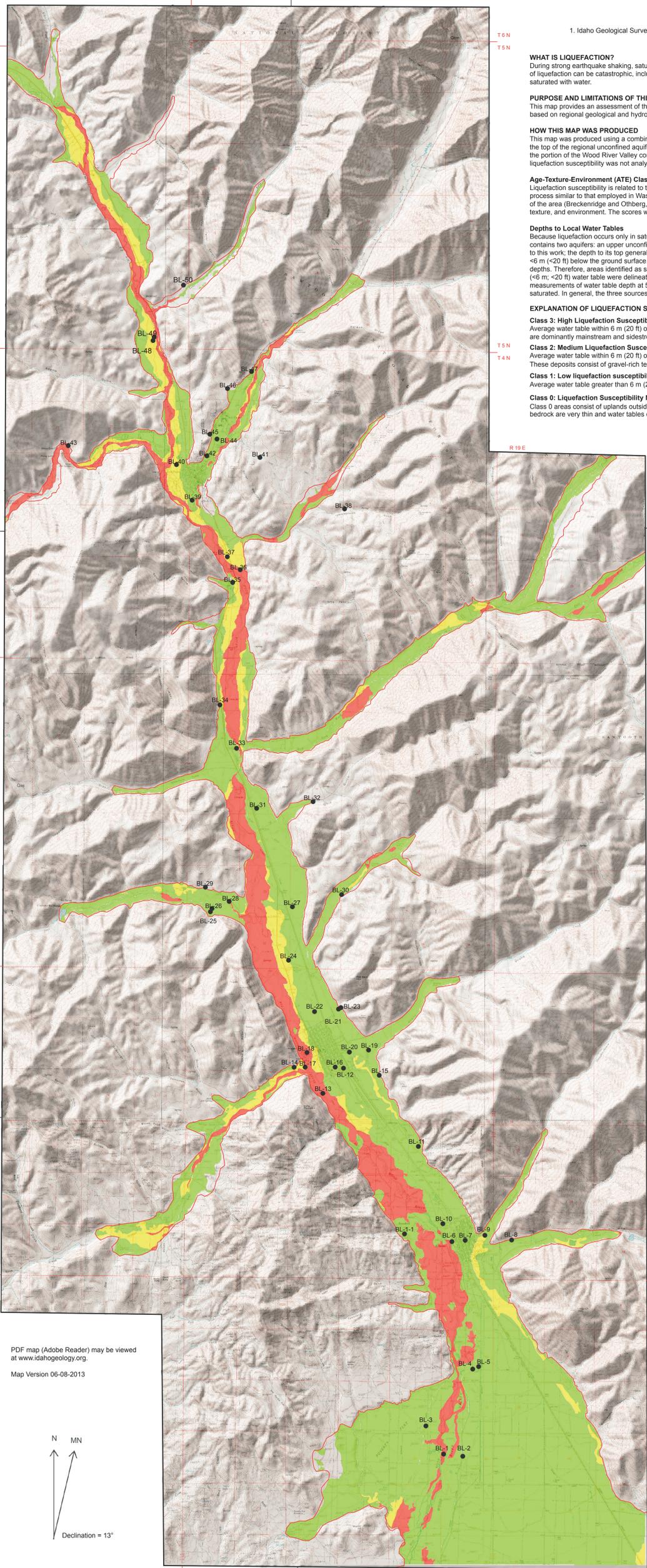
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IDAHO  
GEOLOGICAL SURVEY

Base built from U.S. Geological Survey 1:24,000-scale Digital Raster Graphs for the following quadrangles: Amber Lakes, Baugh Creek SW, Bellevue, Griffin Butte, Hailey, Hyndman Peak, Mahoney Butte, Richardson Summit, Rock Roll Canyon, Seamans Creek, and Sun Valley.

Projection: Idaho State Plane Coordinate System, central zone, 1927 North American Datum.



PDF map (Adobe Reader) may be viewed at [www.idahogeology.org](http://www.idahogeology.org).  
Map Version 06-08-2013

Contour intervals for Amber Lake Quad, Hailey Quad, Baugh Creek Quad and Bellevue Quad = 40 feet.  
Contour intervals for Griffin Butte Quad, Mahoney Butte Quad, Richardson Summit Quad, Rock Roll Canyon Quad and Seamans Creek Quad = 20 feet.