Project:			Requesting Agency:
Preliminary geologic hazards inventory for the Bear River Range Planning Unit, Cache and Rich Counties, Utah			Utah Division of State Lands and Forestry
By: Kimm M. Harty	Date: 9-29-87	County: Cache and Rich	Job No.: 87-012
USGS Quadrangle: Naomi Peak, Tony Grove Peak, Garden City, Boulder Mtn., Hardware Ranch, Logan, Logan Peak, Red Spur Mtn., Curtis Ridge, Temple Peak, Meadowville.			

PURPOSE AND SCOPE

In response to a request from Paul E. Pratt of the Division of State Lands and Forestry, an inventory of geologic hazards for state lands in the Bear River Range Planning Unit in Cache and Rich Counties was compiled by the Utah Geological and Mineral Survey. The information is needed by the Division for use in development of a general management plan for the Franklin Basin and Scattered Trust Lands Management Areas (fig. 1). All information compiled in this inventory is taken from published and unpublished sources, and topographic maps. No field work or air photo analysis was performed. The inventory consists of a table of data (table 1) with accompanying explanatory text. The table represents a Township/Range, section by section compilation of possible hazards, and is keyed to sections shown in figures 1 and 2. The text contains a more detailed description of possible geologic hazards. Some hazards are present in nearly all land parcels and are discussed in the text rather than compiled in the table. The hazards noted for each section may be present based on the results of this review, but all data are subject to revision based on site-specific investigations. Therefore, this inventory is preliminary and is intended to be used for general planning purposes only.

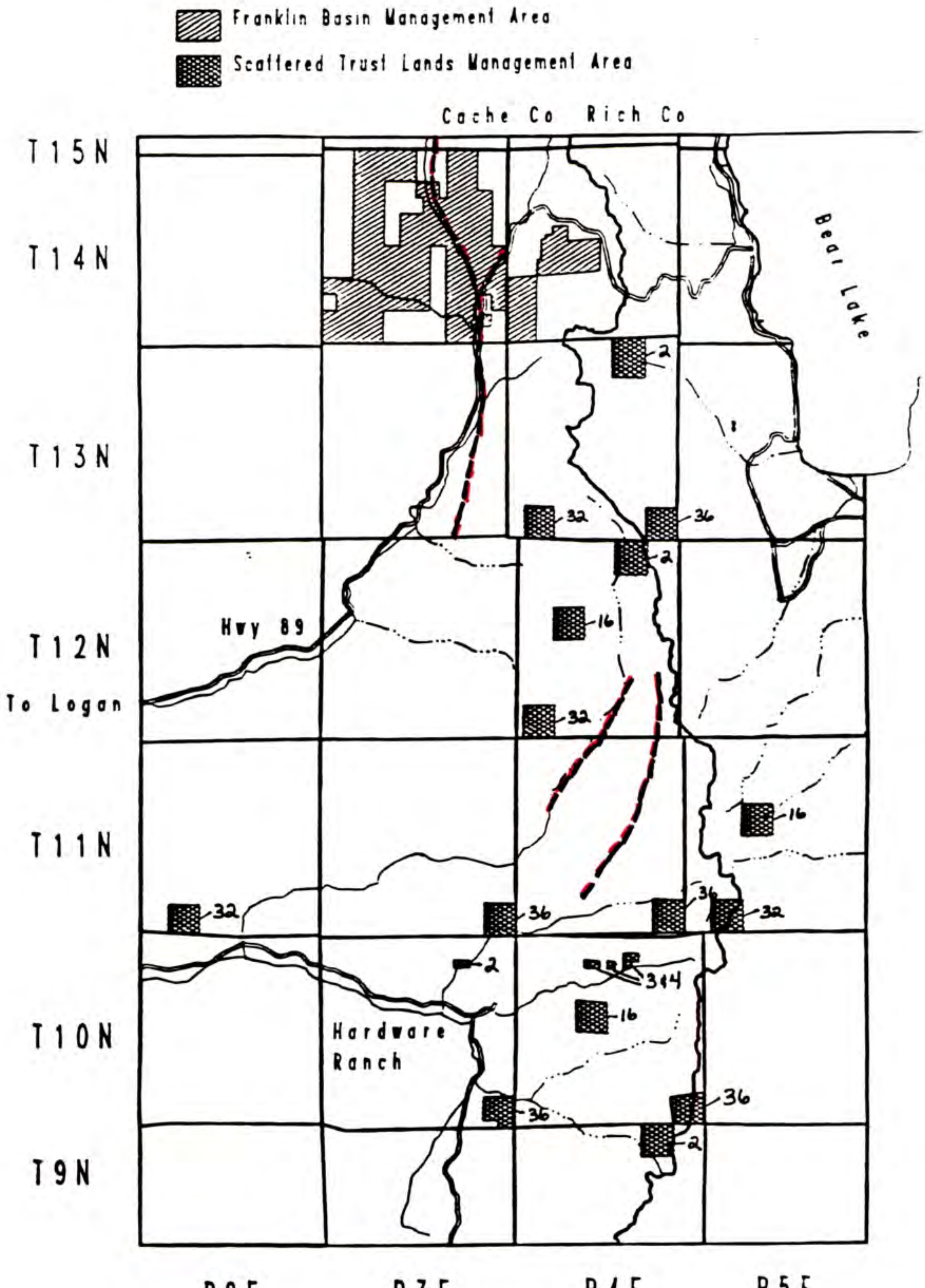
GEOLOGIC HAZARDS

The principal geologic hazards considered in this inventory include slope stability (mainly rockfall), flooding, seismic activity (surface fault rupture, ground shaking), and ground subsidence. Other hazards, such as ground failure accompanying seismic shaking and poor foundation conditions are discussed, but not included in a site-by-site hazard assessment because they require site-specific information to predict. However, they should be considered in any detailed hazards assessment of the parcels.

Slope Failure

Slope failures are a potential hazard in the study area, and include chiefly rockfalls, rock slides, and shallow debris slides and slips. Several landslides have occurred within sandstone and conglomerate rocks of the Wasatch Formation, and in the Brigham Formation (formerly known as Brigham Quartzite) along the eastern foothills of the Bear River Range (Kaliser, 1972). Numerous large landslides, mostly debris slips, have been mapped in these geologic units in the Bear River Range by DeGraff (1976). Rockfalls and rock topples were not included in the study. The mapped area includes the western half of the Bear River Range Planning Unit, with the easternmost mapped boundary extending north-south through the center of Range 4 E. Landslides occur primarily along the western mountain front of the Bear River Range, and on steep slopes along major

Figure 1. Bear River Range Planning Unit



Suspected late Quaternary faults (Sullivan and others, 1986).

Table 1. Geologic hazards inventory for state lands in the Bear River Range Planning Unit.

Land Parcel			Geologic Hazards[1]			
Township	Range	Section[2]	Surface fault rupture[3]	Slope failure[4]	Flooding	Subsidence[5]
Franklin Basin Management Area						
T 14 N	R 3 E	2		X		X
		4		X		X
		5		X		X*
		8		X		X*
		10	X	X	X	X
		11		X		
		12		X		
		13		X		X
		14	X	X	X	X
		15	X	X	X	X
		16		X		X
		17		X		X
		20		X		X*
		21		X		X*
		22		X		X
		23	X	X	X	X
		24		X	X	X
		25		X	X	X
		26	X	X		
		27		X	X	X
		28		X	X	X*
		29		X	X	X*
		30		X	X	X
		31		X		X*
		32		X		X
		35		X	X	
		36		X		
T 14 N	R 4 E	17		X		
		20		X		X*
		21		X		X*
		30		X		X
		31		X		
				X		
Scattered Trust Lands Management Area						
T 13 N	R 4 E	2		X		X*
		32		X		
		36		X		
T 12 N	R 4 E	2		X		
		16		X		X
		32		X		
T 11 N	R 5 E	16		X		
		32		X		
T 11 N	R 4 E	36		X		X
T 11 N	R 3 E	36		X	X	
T 11 N	R 2 E	32		X		X
T 10 N	R 4 E	3		X		
		4		X		
		16		X		
		36		X		
T 10 N	R 3 E	2		X	X	X
		36		X	X	X
T 9 N	R 4 E	2		X		

1 The hazards indicated may exist based on topography and existing geology data, but have not been confirmed through field investigation. This inventory is preliminary, subject to revision, and is intended for general planning purposes only.

2 The assessment applies to the entire section for the Scattered Trust lands, but applies only to those portions of sections contained within the Franklin Basin.

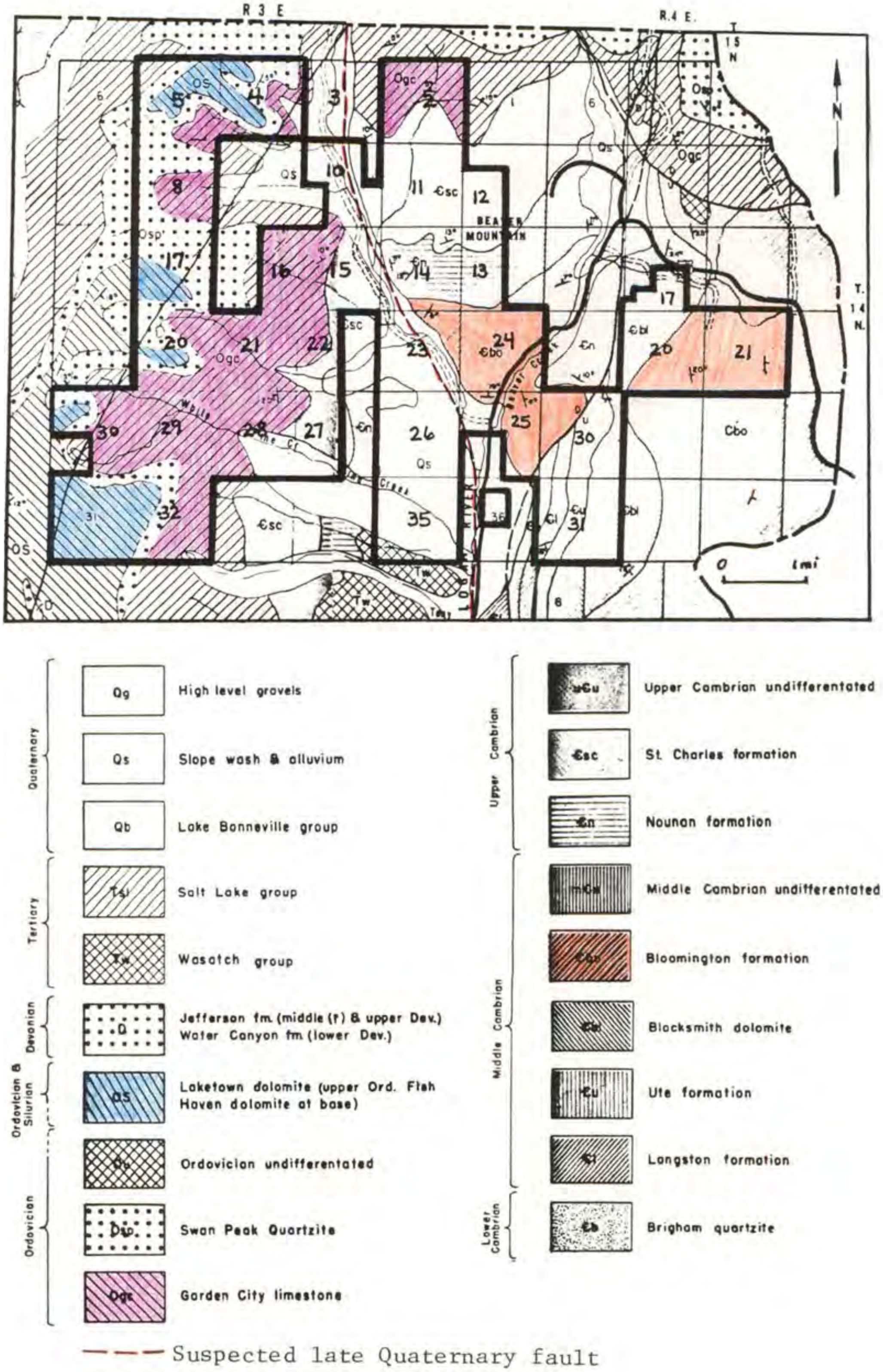
3 Hazards due to surface fault rupture are considered present only in parcels traversed by active faults. However, severe ground shaking accompanying earthquakes may occur at all parcels.

4 Slope failure hazards are primarily rockfalls, rock slides, and debris slides.

5 Parcels contain outcrops of either Bloomington Formation, Garden City Limestone, or Laketown Dolomite, which are prone to subsidence due to solution and sinkhole development.

*Denotes parcels containing subsidence features as determined from topographic maps.

Figure 2. General geologic map of the Franklin Basin Management Area (Williams, 1958).



canyons, including Logan Canyon, East Canyon, and Blacksmith Fork Canyon and its tributaries Left Hand Fork and Sheep Creek (DeGraff, 1976). None of the mapped landslides occurs within parcels of the Franklin Basin or Scattered Trust Lands Management Areas. However, the scale of aerial photography used to map landslides prohibited identification of slides less than one acre in size. In addition, most of the slides were mapped using 1968 aerial photography, and thus landslides that have occurred within the last 19 years are not shown. Due to the predominance of generally competent rocks and steep slopes in the management areas, the most probable slope failure hazard is from rock or debris falls and slides, and the potential for these hazards occurring is marked in every parcel on the geologic hazards inventory (table 1).

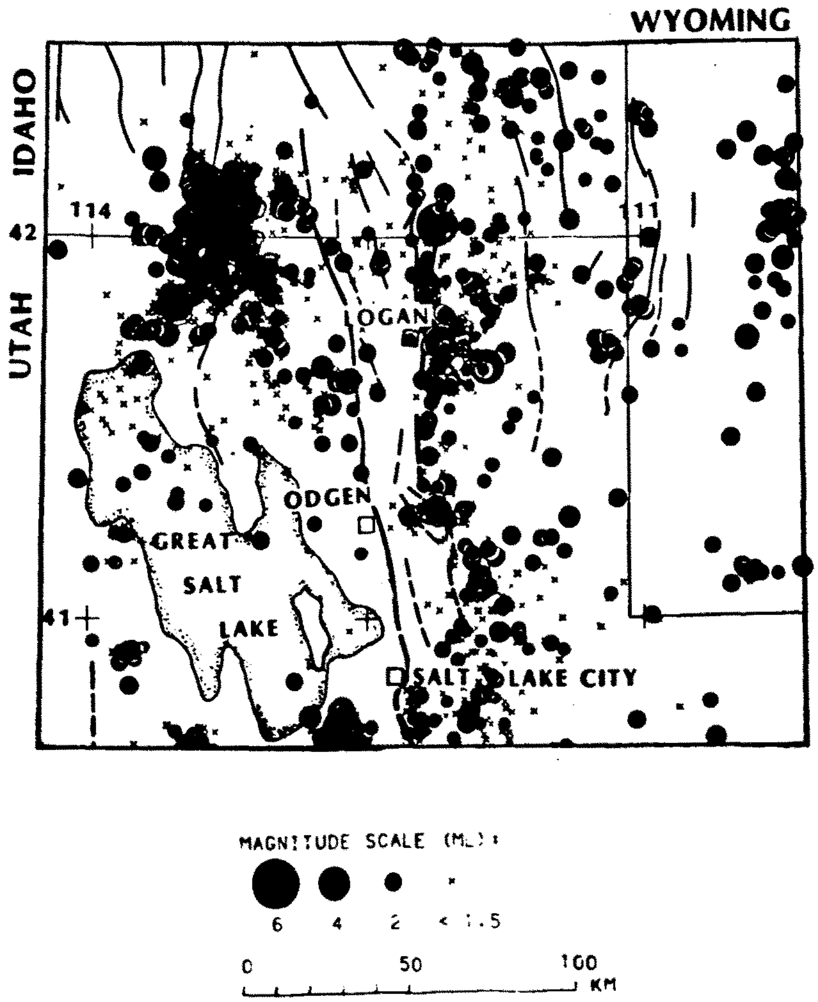
Due to adequate precipitation, steep slopes, and accumulations of hillslope talus, the possibility for initiation of debris flows in the planning unit is considered good. However, the greatest hazard posed by this type of slope failure is mainly in downstream runout areas near canyon mouths, where water-mobilized debris is generally deposited. None of the parcels lie in these most hazardous areas. Debris flows may be initiated along any steep canyon in the planning unit, but this hazard is not assessed on a site-specific basis nor considered separately from the rockfall hazards marked on the inventory compilation (table 1). Snow avalanches may be a hazard on and below steep slopes in the study units and information on this hazard may be obtained from the Utah Avalanche Forecast Center.

Seismic Hazards

Most earthquakes in Utah occur within the Intermountain Seismic Belt (ISB), which trends roughly north-south through the center of the state. The Bear River Range Planning Unit lies in the ISB, and has been seismically active during historical time (fig. 3). The most widespread hazard associated with earthquakes is ground shaking. The Uniform Building Code places the Bear River Range Planning Unit in seismic zone 3, indicating the potential for major damage and a maximum Modified Mercalli (MM) intensity of VIII (see MM intensity scale, appendix). The Utah Seismic Safety Advisory Council (1979) places the study region in seismic zones 3 and 4, with zone 4 including most of the Franklin Basin Management Area and approximately one half of the Scattered Trust Lands. Since 1850, five earthquakes of magnitudes 4.0 or greater have occurred within the vicinity of the Bear River Range Planning Unit (Arabasz and Smith, 1979). The two largest of these, the Bear Lake Valley and Richmond earthquakes, occurred within 12 and 8 miles respectively of parcels in the planning unit. The 1884 Bear Lake Valley earthquake had an estimated magnitude of 6.0 and maximum MM intensity of VIII. The 1962 Richmond earthquake registered a magnitude of 5.7 and had an estimated MM intensity of VII (Arabasz and Smith, 1979). In 1966, a 4.6 magnitude earthquake occurred within the Bear River Range Planning Unit, with the epicenter located approximately one half mile north-northwest of the Scattered Trust Lands parcel in T. 11 N., R. 3 E., section 36 (Arabasz and others, 1979). The Bear River Range Planning Unit is subject to ground shaking from earthquakes occurring outside as well as within the Bear River Range.

In the Bear River Range Planning Unit, ground shaking associated with large earthquakes may cause other hazards, such as slope failures and soil liquefaction. Of particular concern is the potential for rockfall and rock slide initiation. Keefer (1984) determined the minimum Richter magnitude

Figure 3. Earthquake epicenter map for the northern Utah vicinity for period 1962-June 1978 (Smith and others, 1979).



needed to initiate these types of slope failures is a 4.0. Rockfalls and rock slides were reported during the 1962 Richmond earthquake. Rock slumps and rock block slides can occur during a 5.0 magnitude earthquake, and a 6.0 magnitude shock is needed to initiate rock avalanches (Keefer, 1984). Soil liquefaction occurs when earthquake ground shaking causes certain types of soils (especially saturated sands and silty sands) to lose strength and liquefy due to increased pore-water pressures. Conditions necessary to induce liquefaction include earthquakes of magnitudes 5.0 or larger (Kuribayashi and Tatsuoka, 1975; Youd, 1977), and ground water within about 30 feet of the ground surface (Youd and others, 1978). In the planning unit, the necessary shallow ground water and soil conditions likely exist mainly along flood plains of larger rivers and streams. This hazard was not assessed in the parcel inventory because it requires site-specific investigation. The ground shaking hazard is considered present in all parcels, although the intensity of the shaking is dependent on soil and rock conditions and proximity to the earthquake epicenter.

Another hazard related to seismic activity is surface fault rupture. During large earthquakes, the ground surface tends to rupture along established planes of weakness, or faults. To the west of the Bear River Range Planning Unit, the Wasatch and East Cache Valley fault zones are believed capable of generating earthquakes of Richter magnitude 7.0 or larger (Cluff and others, 1974; Algermissen and others, 1983) that may cause severe ground shaking in the Bear River Range. Geologic evidence suggests that the closest of these faults, the East Cache Valley fault, has experienced at least two surface faulting events since Lake Bonneville time (15,000 to 14,000 yr B.P. [before present]) (Cluff and others, 1974; Swan and others, 1983; McCalpin, 1987), with the most recent event probably occurring prior to 6,000 to 8,000 yr B.P. (Swan and others, 1983).

To the east of the Bear River Range Planning Unit, the Bear Lake fault zone traverses north-south along the east side of Bear Lake, and exhibits geologic and geomorphic evidence of recent faulting (Kaliser, 1972; Anderson and Miller, 1979; Hecker, 1987). Based on a preliminary field reconnaissance, the age of last movement on this fault is estimated to be between late Pleistocene and early Holocene time (approximately 150,000 to 8,000 yr B.P.) (A.J. Crone, U.S. Geological Survey, oral commun., March 1987).

There are three, down-to-the-west normal faults in the vicinity of the Bear River Range Planning Unit that are suspected of having experienced surface rupture within late Quaternary time (approximately < 500,000 yr B.P.) (Sullivan and others, 1986; J.T. Sullivan, U.S. Bureau of Reclamation, oral commun., September 1987). One of these traverses generally north-south through the Franklin Basin Management Area (figs. 1 and 2), and the others trend northeast-southwest between parcels of the Scattered Trust Lands (fig. 1). The "Franklin Basin" fault is the only one of the three faults that has been previously identified on geologic maps (Williams, 1958; Stokes and Madsen, 1961), but all have only recently been identified by Sullivan and others (1986) as being possibly active. Using air photo analysis, Sullivan and others (1986) have preliminarily identified fault escarpments juxtaposing Quaternary-age materials against older rocks, and fault scarps cutting Quaternary deposits (J.T. Sullivan, oral commun., September 1987). However, additional investigation and field checking are needed to support these observations. For the geologic hazards inventory, surface fault rupture hazard is designated within parcels crossed by the fault traversing the Franklin Basin Management Area (table 1, fig. 2).

Flooding

A number of land parcels may be subject to overbank flooding from rainstorms and seasonal snowmelt, or flash-flooding during severe rainstorms. For the inventory, the potential for flood hazard was noted only in parcels containing a large perennial river or perennial tributary to a major river (table 1). For the Franklin Basin Management Area, these include the Logan River, Beaver Creek, and White Pine Creek. For the Scattered Trust Lands Management Area, these include Rock Creek and Sheep Creek. These rivers and creeks may also serve as conduits for debris flows initiated along canyon walls of these or tributary channels. Flash flooding may also occur in the numerous intermittent creeks contained in the parcels, but this should be evaluated on a site-specific basis.

Subsidence

Subsidence of the ground surface is a potential geologic hazard in many areas of the Bear River Range Planning Unit, particularly in the Franklin Basin Management Area. Limestones of the Garden City geologic unit are especially prone to development of karst features, including sinkholes and closed depressions, due to the dissolution of calcium carbonate by infiltrating precipitation and ground water. The formation of underground drainage channels and caves, and subsequent collapse of these features is also a possibility, but this has not been documented to date. Limestone units of the Bloomington Formation are also susceptible to the formation of subsidence features; the well-known "Peter Sinks" and associated large sinkholes are located along the eastern and southeastern margins of Franklin Basin parcels in T. 14 N., R. 4 E. Numerous sinkholes are located in the portion of Laketown Dolomite that crops out along the southwestern border of the Franklin Basin Management Area (fig. 2). Within the management area, sinkholes are found in this formation only in T. 14 N., R. 3 E., section 31. For the inventory, all parcels containing outcrops of Garden City Limestone, Bloomington Formation, or Laketown Dolomite are considered prone to subsidence hazards, and outcrops of these rocks are highlighted on the Franklin Basin Management Area geologic map (fig. 2). Also noted on the inventory (table 1) are parcels in which subsidence-related features exist. These include sinkholes, closed depressions, and lakes believed to have formed by solution and collapse. Many of the Cambrian-age rock formations in the planning unit contain soluble limestone and dolomite, but these are not marked on the inventory due to a lack of surficial subsidence features on topographic maps.

FOUNDATION CONDITIONS

Building foundation conditions are generally considered poor in the Bear River Range Planning Unit, due to steep slopes and shallow bedrock. Excavation difficulty is likely, due to shallow or outcropping bedrock, and coarse clasts on the surface or near surface. In addition, there is a moderate to severe limitation for constructing septic tanks and sewage lagoons, due mainly to slope conditions and depths to bedrock (Erickson and Mortensen, 1974). Septic tank contamination of ground water is a possibility due to the abundant limestone and dolomite rock formations in the management areas. For the purpose of this inventory, foundation conditions are considered poor, but soil investigations should be conducted to determine specific site suitabilities.

CONCLUSIONS

The available published information permits only a limited geologic hazards evaluation. Geologic hazards mapping has generally not been completed in the Bear River Range, and the analysis is based on interpretations from 7 1/2 minute topographic quadrangles, a 1:126,720 geologic map of Cache County (Williams, 1958), and a geologic map of northern Rich County (Richardson, 1941). Other sources either covering small areas or of limited applicability are available and some are included in the list of references. This inventory lists the possible existence of the major hazards common in Utah, but does not included all possible hazards and does not insure that those listed occur. A site-specific field investigation is recommended to determine which, if any, of the possible geologic hazards is actually present.

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APPENDIX

MODIFIED MERCALLI INTENSITY SCALE OF 1931
(Abridged)

I. Not felt except by a very few under especially favorable circumstances.

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made cracking sound. Sensation like heavy truck striking building; standing motor cars rocked noticeably.

V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.

VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.

IX. Damage considerable in specially designed structures; well designed frame structures thrown out of plume; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

XI. Few, if any structures (masonry) remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.