DISCUSSION

This map shows areas of relative landslide hazard for natural slopes under static (non-earthquake) conditions and indicates where further study is recommended prior to development (see table in map explanation). Areas of artificial fill, such as dam embankments and mine waste dumps, were not evaluated. The map is one of four sheets that cover the western Wasatch County study area (see "Location Map and Index to Sheets" at bottom of map).

Landslides, rock falls, and debris flows are downslope movements of rock or soil under the influence of gravity. Landsliding, characterized by rotational or translational movement along a buried slip surface, has been one of the most damaging geologic hazards in western Wasatch County. Some landslides are deep-seated and move slowly over long periods of time, whereas others are shallow and move rapidly in a single event. Landslides can damage buildings, transportation routes, and utilities both directly from ground displacement and indirectly from associated flooding. Avoidance is one prudent measure for landslide-hazard reduction, but engineering techniques are available to stabilize slopes and ensure that site grading and development do not destabilize slopes.

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Many of the landslides in western Wasatch County occurred during Pleistocene time (1.6 million to 10,000 years ago). The Pleistocene climate in Utah was wetter than the modern climate, and elevated pore-water pressures in the soil and rock contributed to landsliding. Although some of the slopes that failed during Pleistocene time may be relatively stable now, old landslides can be particularly susceptible to reactivation because of conditions such as increased permeability in the displaced soil or rock mass and established failure planes.

USE OF THIS MAP

The relative landslide hazard shown on this map consists of three categories: low, moderate, and high. The criteria used to define the relative landslide hazard were developed from analyzing failed geologic units, slope inclinations, and ages of existing landslides. A critical slope value was assigned for each geologic unit representing the inclination above which slope failure has typically occurred in the past. The more susceptible the geologic unit is to landsliding, the lower the critical slope value. The critical slope-inclination values used to derive the relative-hazard zones on this map range from 15 percent (9 degrees) to 50 percent (27 degrees). To incorporate existing landslides into the hazard rating, emphasis was placed on landslides estimated to have occurred during the past 5,000 years (late Holocene time) because these landslides represent slope failures under climatic conditions similar to the present. The map shows existing landslides identified in this study from geologic mapping, aerial-photograph interpretation, review of existing geological and geotechnical reports, and field reconnaissance. Existing landslides of late Holocene age (young) are designated on the map with a "Y." Existing landslides of pre-late Holocene age (old) are designated with an "O."

A low landslide hazard exists where slope inclination is less than the selected critical value and there is no evidence of previous landsliding (map unit L). Except in the case of essential facilities (for example, police and fire stations), site-specific geotechnical studies of landslide hazard will usually not be warranted prior to permitting development on sites within map unit L.

A moderate landslide hazard exists where slope inclination is greater than the selected critical value and there is no evidence of previous landsliding (map unit M), and where slope inclination is less than the selected critical value but there is evidence of previous landsliding (map units M_Y and M_O). Site-specific, reconnaissance-level geotechnical studies of landslide hazard are recommended prior to permitting development on sites within map units M, M_Y and M_O. Depending on the results of the reconnaissance-level study, some sites may require a detailed, quantitative slope-stability analysis to adequately evaluate the hazard and develop hazard-reduction measures.

A high landslide hazard exists where slope inclination is greater than the selected critical value and there is evidence of previous landsliding (map units H_Y and H_O). Site-specific, reconnaissance-level studies may in some cases be adequate to evaluate the hazard on sites within map units H_Y and H_O. However, detailed, quantitative slope-stability analyses will likely be necessary to evaluate the hazard and develop hazard-reduction measures prior to development within these high-hazard areas.

Existing landslides were mapped outside of the study-area boundary. These landslides are designated with either a "Y" or an "O" for reference, but do not include a relative-hazard designation as the hazard was not evaluated outside of the study area.

This map is intended to be used as a tool for planning new development. It will be most effective if used early in the planning process to identify the potential need for landslide-hazard studies on a development-wide scale. In existing residential developments within moderate- and high-hazard areas, site-specific hazard studies are recommended prior to new construction. Cooperatively funded studies of subdivisions or groups of lots may be the most cost-effective means of hazard evaluation in large areas of moderate or high hazard.

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EXPLANATION

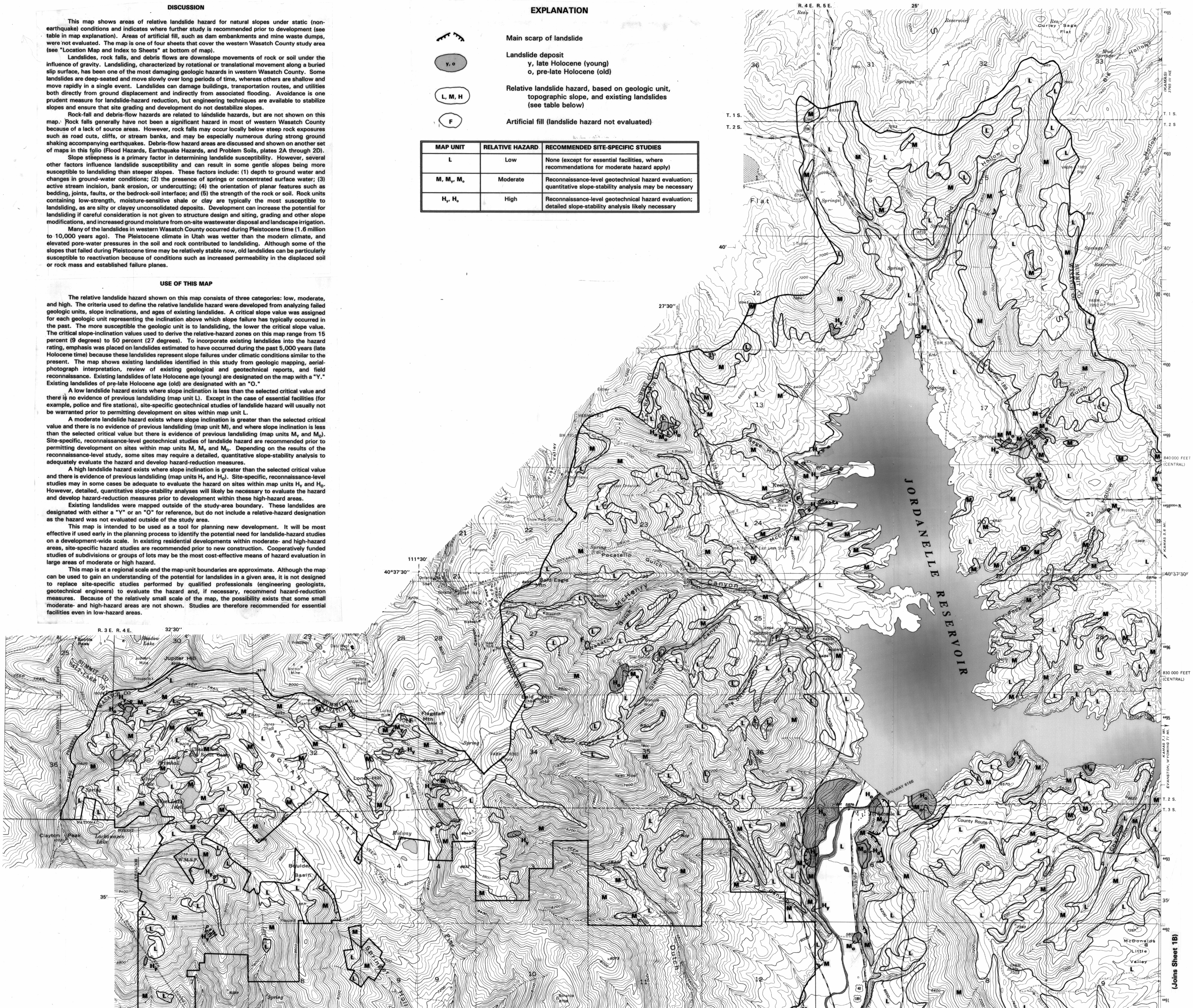
Main scarp of landslide

Landslide deposit
y, late Holocene (young)
o, pre-late Holocene (old)

Relative landslide hazard, based on geologic unit, topographic slope, and existing landslides (see table below)

Artificial fill (landslide hazard not evaluated)

MAP UNIT	RELATIVE HAZARD	RECOMMENDED SITE-SPECIFIC STUDIES
L	Low	None (except for essential facilities, where recommendations for moderate hazard apply)
M, M_y, M_o	Moderate	Reconnaissance-level geotechnical hazard evaluation; quantitative slope-stability analysis may be necessary
H_y, H_o	High	Reconnaissance-level geotechnical hazard evaluation; detailed slope-stability analysis likely necessary



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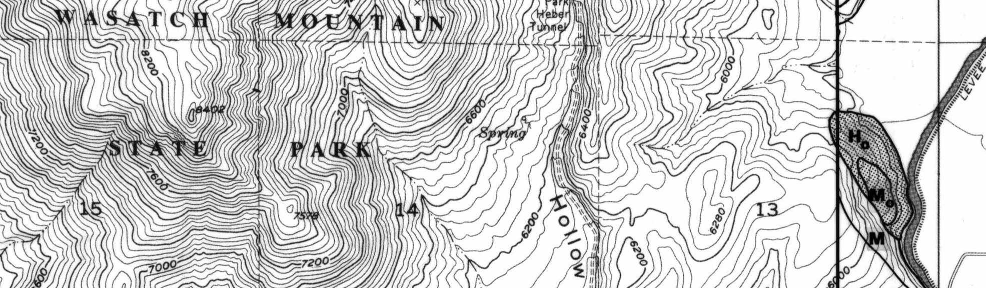

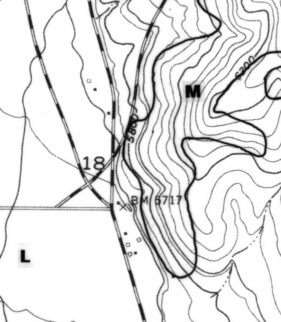

Location Map and Index to Sheets

Maps in this folio:

- Landslide Hazard (Plates 1A-1D)
- Flood Hazards, Earthquake Hazards, and Problem Soils (Plates 2A-2D)
- Suitability for Wastewater Disposal in Septic-Tank Soil-Absorption Systems (Plates 3A-3D)

PLATE 1A
LANDSLIDE HAZARD, WESTERN WASATCH COUNTY, UTAH

Michael D. Hylland and Mike Lowe
1995

Base from Brighton, Heber City, and Park City East, Utah, USGS 7.5-minute topographic quadrangle maps.
Drafted by Noah P. Snyder

DISCUSSION

This map shows areas of relative landslide hazard for natural slopes under static (non-earthquake) conditions and indicates where further study is recommended prior to development (see table in map explanation). Areas of artificial fill, such as dam embankments and mine waste dumps, were not evaluated. The map is one of four sheets that cover the western Wasatch County study area (see "Location Map and Index to Sheets" at bottom of map).

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USE OF THIS MAP

The relative landslide hazard shown on this map consists of three categories: low, moderate, and high. The criteria used to define the relative landslide hazard were developed from analyzing failed geologic units, slope inclinations, and ages of existing landslides. A critical slope value was assigned for each geologic unit representing the inclination above which slope failure has typically occurred in the past. The more susceptible the geologic unit is to landsliding, the lower the critical slope value. The critical slope-inclination values used to derive the relative-hazard zones on this map range from 15 percent (9 degrees) to 50 percent (27 degrees). To incorporate existing landslides into the hazard rating, emphasis was placed on landslides estimated to have occurred during the past 5,000 years (late Holocene time) because these landslides represent slope failures under climatic conditions similar to the present. The map shows existing landslides identified in this study from geologic mapping, aerial-photograph interpretation, review of existing geological and geotechnical reports, and field reconnaissance. Existing landslides of late Holocene age (young) are designated on the map with a "Y." Existing landslides of pre-late Holocene age (old) are designated with an "O."

A low landslide hazard exists where slope inclination is less than the selected critical value and there is no evidence of previous landsliding (map unit L). Except in the case of essential facilities (for example, police and fire stations), site-specific geotechnical studies of landslide hazard will usually not be warranted prior to permitting development on sites within map unit L.

A moderate landslide hazard exists where slope inclination is greater than the selected critical value and there is no evidence of previous landsliding (map unit M), and where slope inclination is less than the selected critical value but there is evidence of previous landsliding (map units M_Y and M_O). Site-specific, reconnaissance-level geotechnical studies of landslide hazard are recommended prior to permitting development on sites within map units M, M_Y and M_O. Depending on the results of the reconnaissance-level study, some sites may require a detailed, quantitative slope-stability analysis to adequately evaluate the hazard and develop hazard-reduction measures.

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EXPLANATION

Main scarp of landslide

y, o — Landslide deposit
y, late Holocene (young)
o, pre-late Holocene (old)

L, M, H — Relative landslide hazard, based on geologic unit, topographic slope, and existing landslides (see table below)

F — Artificial fill (landslide hazard not evaluated)

MAP UNIT	RELATIVE HAZARD	RECOMMENDED SITE-SPECIFIC STUDIES
L	Low	None (except for essential facilities, where recommendations for moderate hazard apply)
M, M_y, M_o	Moderate	Reconnaissance-level geotechnical hazard evaluation; quantitative slope-stability analysis may be necessary
H_y, H_o	High	Reconnaissance-level geotechnical hazard evaluation; detailed slope-stability analysis likely necessary

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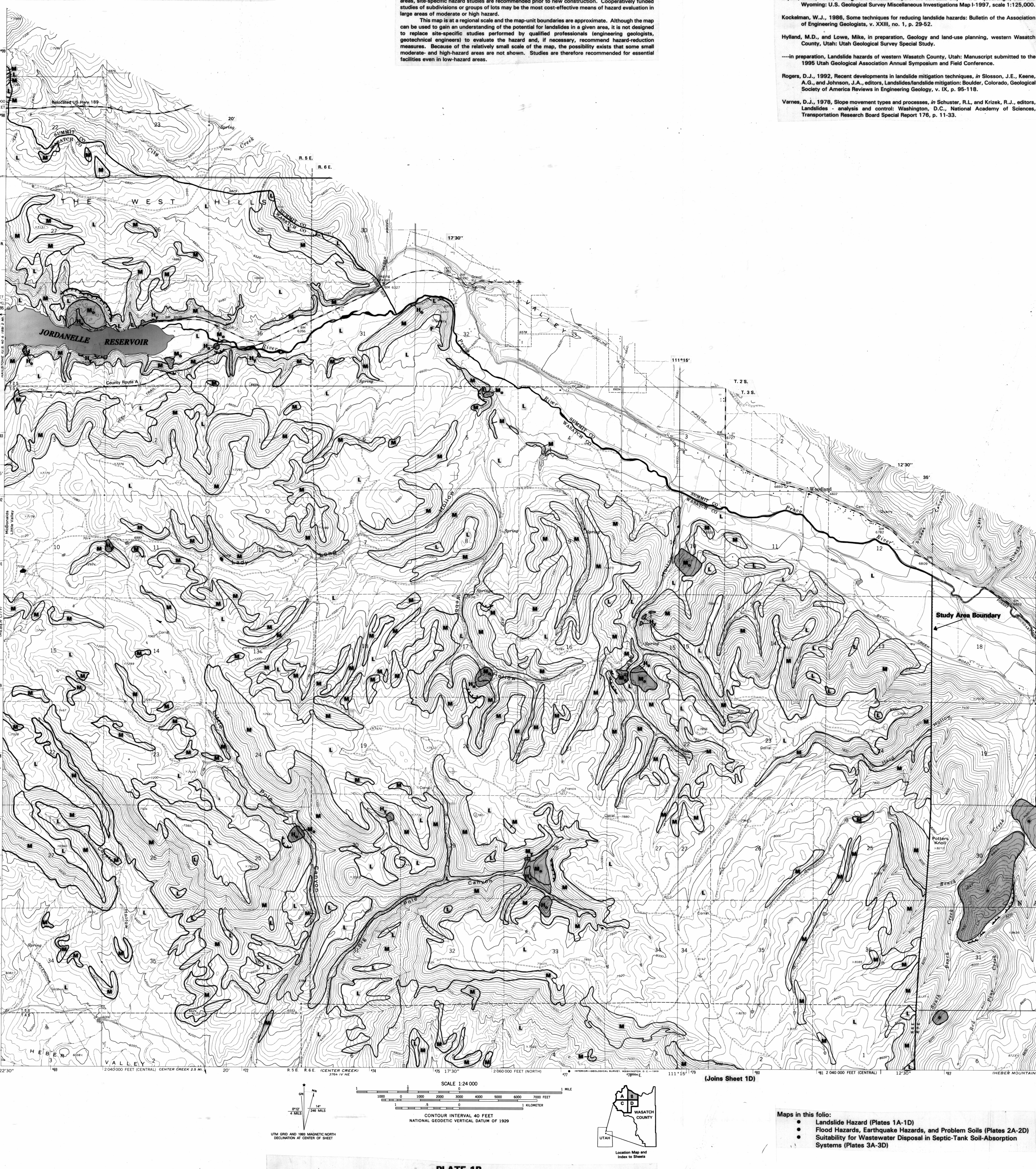

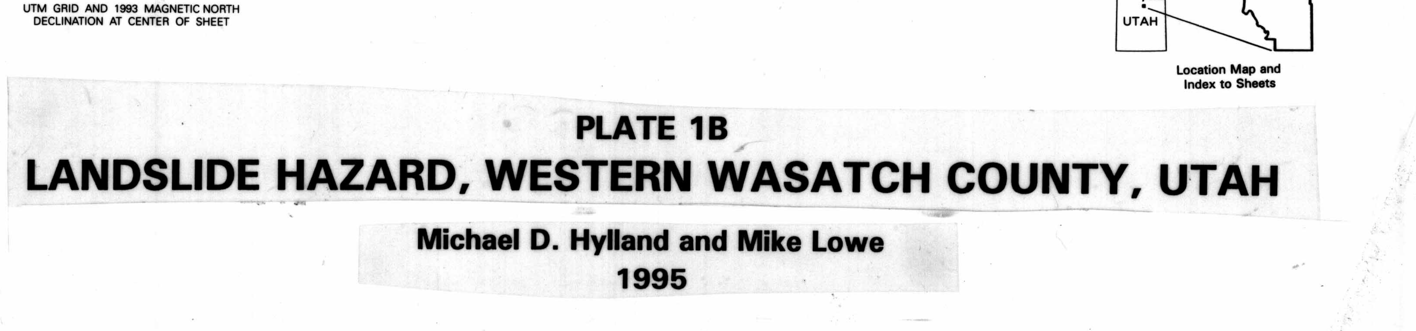

Maps in this folio:
- Landslide Hazard (Plates 1A-1D)
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Base from Kamas, Francis, and Woodland, Utah, USGS 7.5-minute topographic quadrangle maps.
Drafted by Noah P. Snyder

PLATE 1B
LANDSLIDE HAZARD, WESTERN WASATCH COUNTY, UTAH

Michael D. Hylland and Mike Lowe
1995

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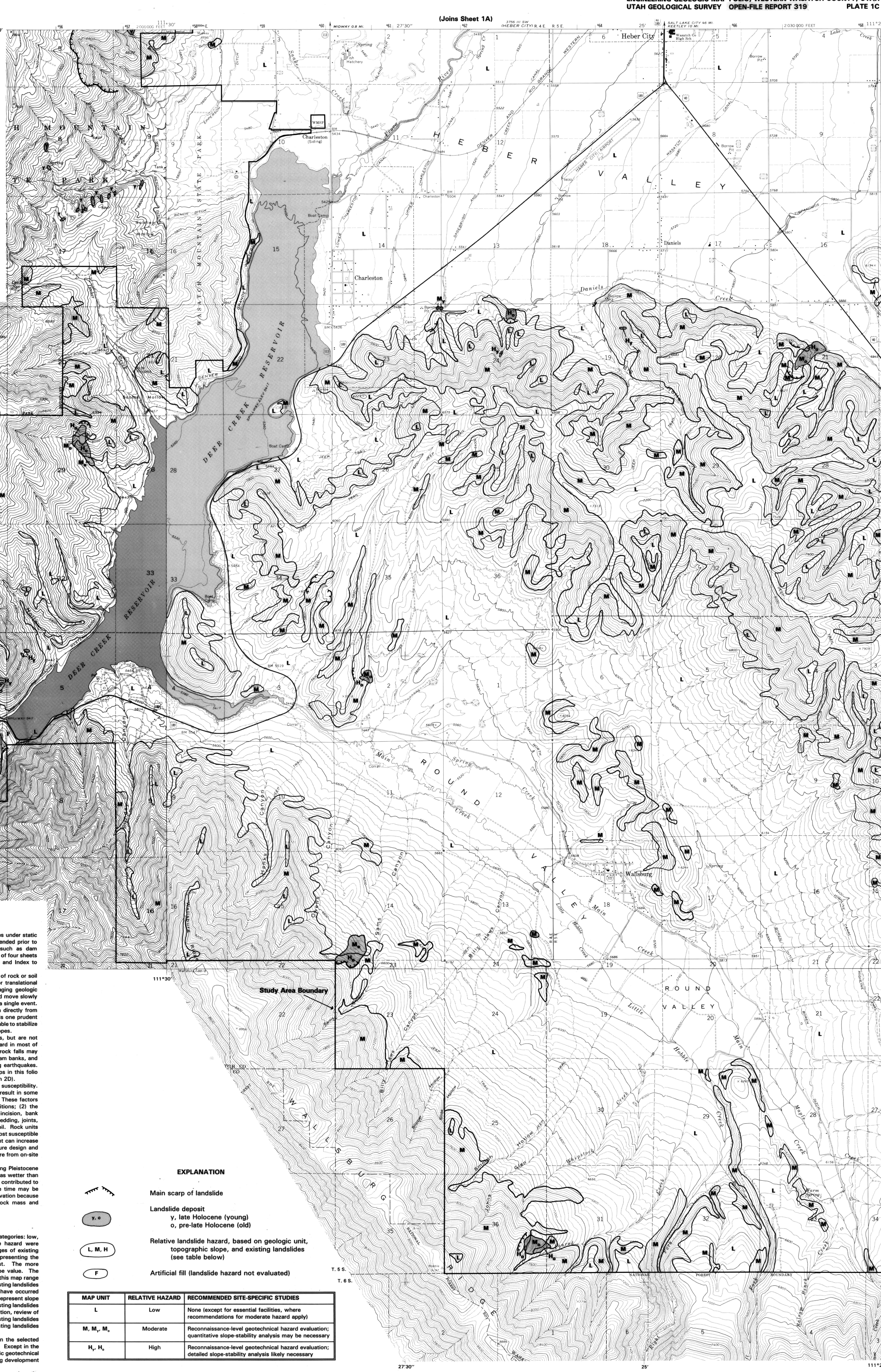

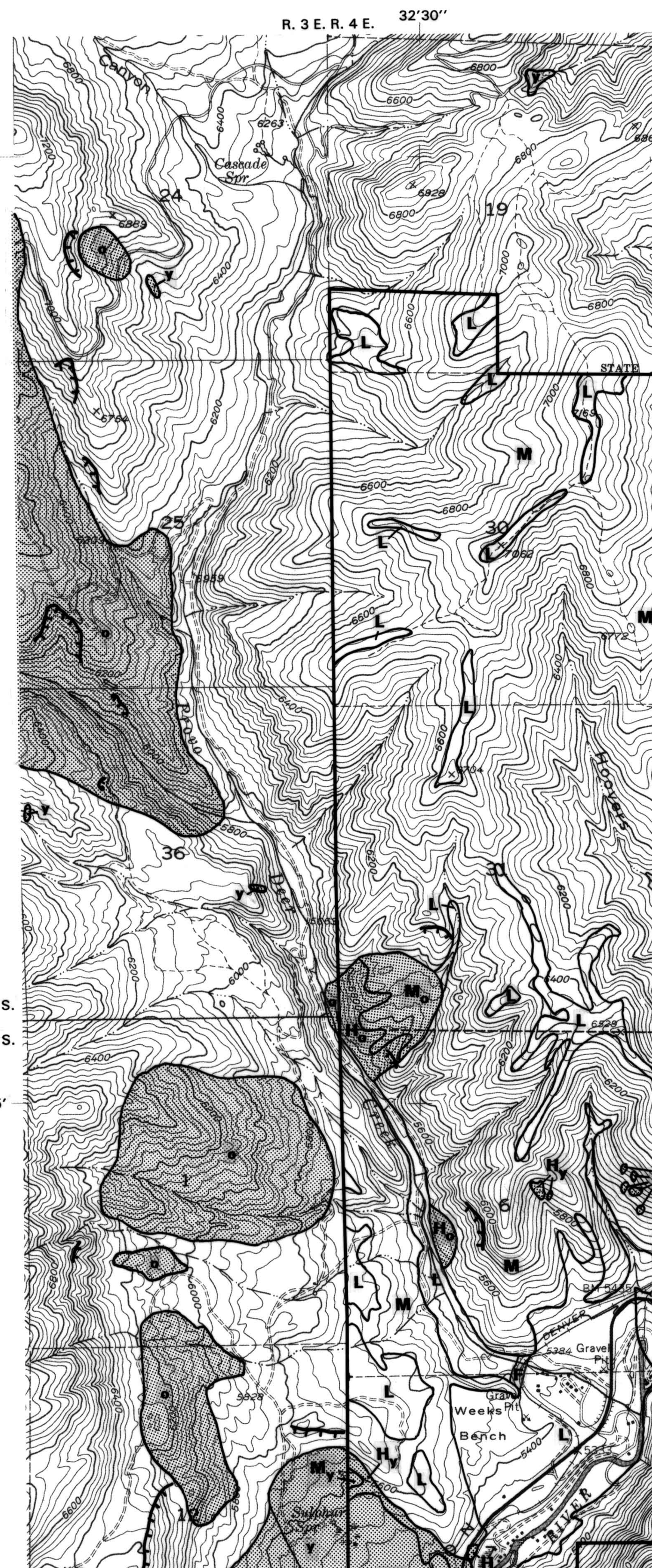

EXPLANATION

Main scarp of landslide

Landslide deposit
y, late Holocene (young)
o, pre-late Holocene (old)

Relative landslide hazard, based on geologic unit, topographic slope, and existing landslides (see table below)

Artificial fill (landslide hazard not evaluated)

MAP UNIT	RELATIVE HAZARD	RECOMMENDED SITE-SPECIFIC STUDIES
L	Low	None (except for essential facilities, where recommendations for moderate hazard apply)
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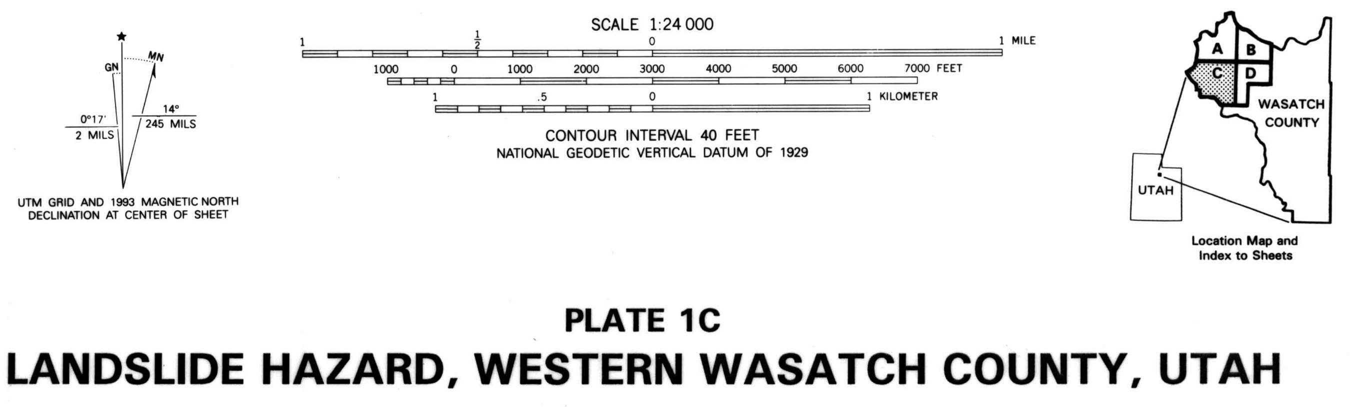

Location Map and Index to Sheets

PLATE 1C
LANDSLIDE HAZARD, WESTERN WASATCH COUNTY, UTAH

Michael D. Hylland and Mike Lowe
1995

Maps in this folio:
- Landslide Hazard (Plates 1A-1D)
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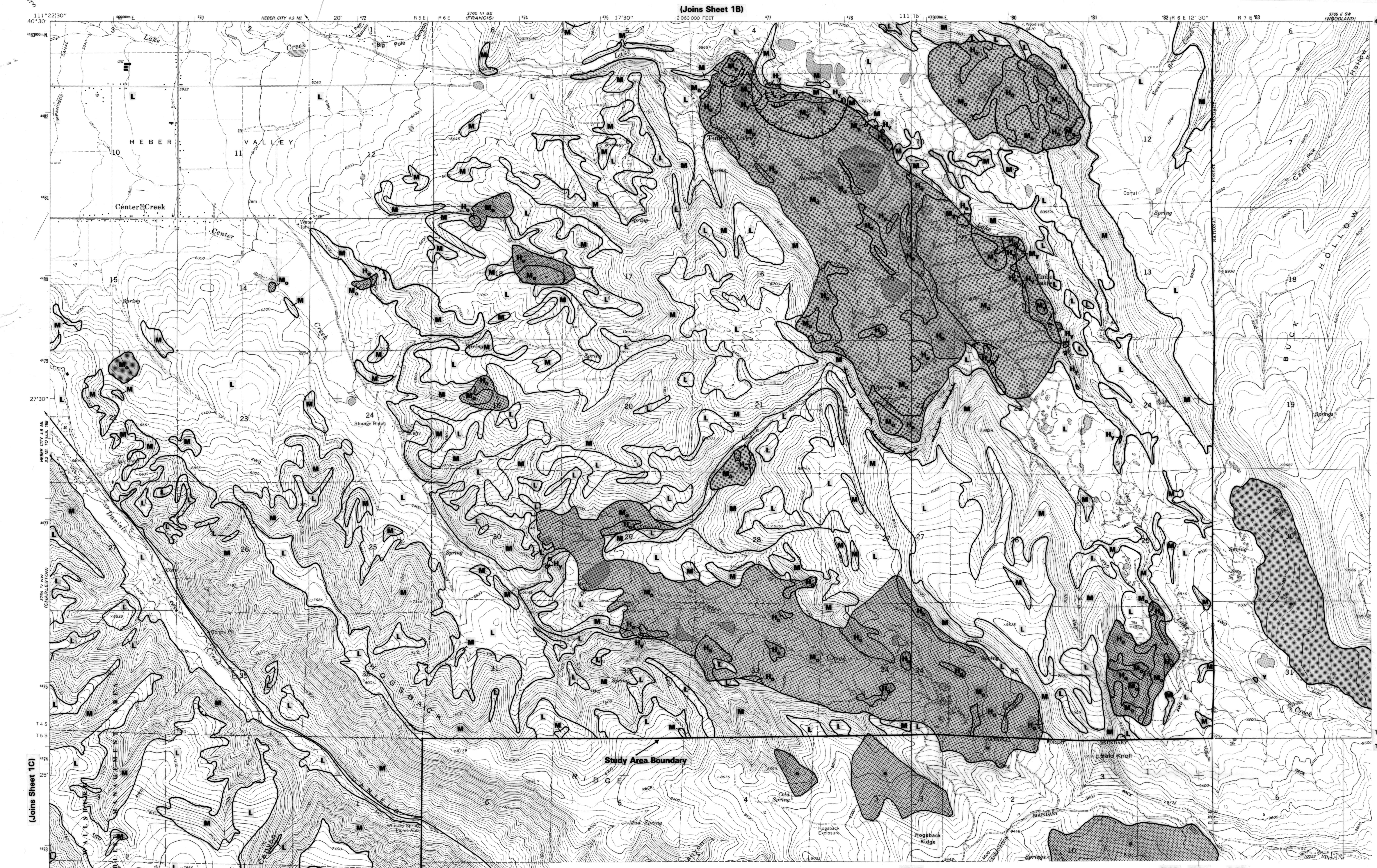
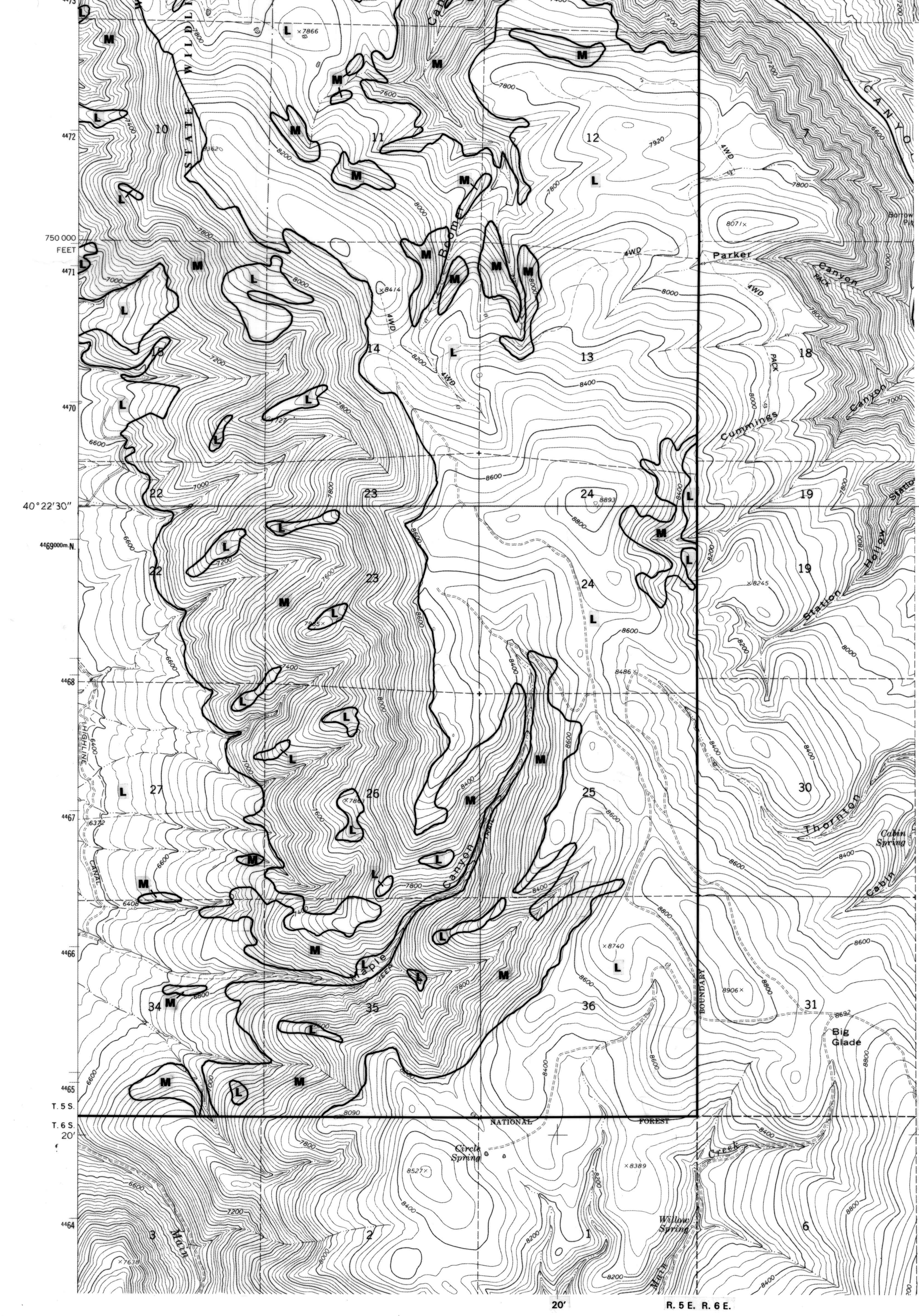
Base from Aspen Grove, Charleston, and Wallsburg Ridge, Utah, USGS 7.5-minute topographic quadrangle maps.
Drafted by Noah P. Snyder





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This map shows areas of relative landslide hazard for natural slopes under static (non-earthquake) conditions and indicates where further study is recommended prior to development (see table in map explanation). Areas of artificial fill, such as dam embankments and mine waste dumps, were not evaluated. The map is one of four sheets that cover the western Wasatch County study area (see "Location Map and Index to Sheets" at bottom of map).

Landslides, rock falls, and debris flows are downslope movements of rock or soil under the influence of gravity. Landsliding, characterized by rotational or translational movement along a buried slip surface, has been one of the most damaging geologic hazards in western Wasatch County. Some landslides are deep-seated and move slowly over long periods of time, whereas others are shallow and move rapidly in a single event. Landslides can damage buildings, transportation routes, and utilities both directly from ground displacement and indirectly from associated flooding. Avoidance is one prudent measure for landslide-hazard reduction, but engineering techniques are available to stabilize slopes and ensure that site grading and development do not destabilize slopes.

Rock-fall and debris-flow hazards are related to landslide hazards, but are not shown on this map. Rock falls generally have not been a significant hazard in most of western Wasatch County because of a lack of source areas. However, rock falls may occur locally below steep rock exposures such as road cuts, cliffs, or stream banks, and may be especially numerous during strong ground shaking accompanying earthquakes. Debris-flow hazard areas are discussed and shown on another set of maps in this folio (Flood Hazards, Earthquake Hazards, and Problem Soils, plates 2A through 2D).

Slope steepness is a primary factor in determining landslide susceptibility. However, several other factors influence landslide susceptibility and can result in some gentle slopes being more susceptible to landsliding than steeper slopes. These factors include: (1) depth to ground water and changes in ground-water conditions; (2) the presence of springs or concentrated surface water; (3) active stream incision, bank erosion, or undercutting; (4) the orientation of planar features such as bedding, joints, faults, or the bedrock-soil interface; and (5) the strength of the rock or soil. Rock units containing low-strength, moisture-sensitive shale or clay are typically the most susceptible to landsliding, as are silty or clayey unconsolidated deposits. Development can increase the potential for landsliding if careful consideration is not given to structure design and siting, grading and other slope modifications, and increased ground moisture from on-site wastewater disposal and landscape irrigation.

Many of the landslides in western Wasatch County occurred during Pleistocene time (1.6 million to 10,000 years ago). The Pleistocene climate in Utah was wetter than the modern climate, and elevated pore-water pressures in the soil and rock contributed to landsliding. Although some of the slopes that failed during Pleistocene time may be relatively stable now, old landslides can be particularly susceptible to reactivation because of conditions such as increased permeability in the displaced soil or rock mass and established failure planes.

USE OF THIS MAP

The relative landslide hazard shown on this map consists of three categories: low, moderate, and high. The criteria used to define the relative landslide hazard were developed from analyzing failed geologic units, slope inclinations, and ages of existing landslides. A critical slope value was assigned for each geologic unit representing the inclination above which slope failure has typically occurred in the past. The more susceptible the geologic unit is to landsliding, the lower the critical slope value. The critical slope-inclination values used to derive the relative-hazard zones on this map range from 15 percent (9 degrees) to 50 percent (27 degrees). To incorporate existing landslides into the hazard rating, emphasis was placed on landslides estimated to have occurred during the past 5,000 years (late Holocene time) because these landslides represent slope failures under climatic conditions similar to the present. The map shows existing landslides identified in this study from geologic mapping, aerial-photograph interpretation, review of existing geological and geotechnical reports, and field reconnaissance. Existing landslides of late Holocene age (young) are designated on the map with a "Y." Existing landslides of pre-late Holocene age (old) are designated with an "O."

A low landslide hazard exists where slope inclination is less than the selected critical value and there is no evidence of previous landsliding (map unit L). Except in the case of essential facilities (for example, police and fire stations), site-specific geotechnical studies of landslide hazard will usually not be warranted prior to permitting development on sites within map unit L.

A moderate landslide hazard exists where slope inclination is greater than the selected critical value and there is no evidence of previous landsliding (map unit M), and where slope inclination is less than the selected critical value but there is evidence of previous landsliding (map units M_Y and M_O). Site-specific, reconnaissance-level geotechnical studies of landslide hazard are recommended prior to permitting development on sites within map units M, M_Y and M_O. Depending on the results of the reconnaissance-level study, some sites may require a detailed, quantitative slope-stability analysis to adequately evaluate the hazard and develop hazard-reduction measures.

A high landslide hazard exists where slope inclination is greater than the selected critical value and there is evidence of previous landsliding (map units H_Y and H_O). Site-specific, reconnaissance-level studies may in some cases be adequate to evaluate the hazard on sites within map units H_Y and H_O. However, detailed, quantitative slope-stability analyses will likely be necessary to evaluate the hazard and develop hazard-reduction measures prior to development within these high-hazard areas.

Existing landslides were mapped outside of the study-area boundary. These landslides are designated with either a "Y" or an "O" for reference, but do not include a relative-hazard designation as the hazard was not evaluated outside of the study area.

This map is intended to be used as a tool for planning new development. It will be most effective if used early in the planning process to identify the potential need for landslide-hazard studies on a development-wide scale. In existing residential developments within moderate- and high-hazard areas, site-specific hazard studies are recommended prior to new construction. Cooperatively funded studies of subdivisions or groups of lots may be the most cost-effective means of hazard evaluation in large areas of moderate or high hazard.

This map is at a regional scale and the map-unit boundaries are approximate. Although the map can be used to gain an understanding of the potential for landslides in a given area, it is not designed to replace site-specific studies performed by qualified professionals (engineering geologists, geotechnical engineers) to evaluate the hazard and, if necessary, recommend hazard-reduction measures. Because of the relatively small scale of the map, the possibility exists that some small moderate- and high-hazard areas are not shown. Studies are therefore recommended for essential facilities even in low-hazard areas.

EXPLANATION

Main scarp of landslide

Landslide deposit (y, o)
y, late Holocene (young)
o, pre-late Holocene (old)

(L, M, H) Relative landslide hazard, based on geologic unit, topographic slope, and existing landslides (see table below)

(F) Artificial fill (landslide hazard not evaluated)

MAP UNIT	RELATIVE HAZARD	RECOMMENDED SITE-SPECIFIC STUDIES
L	Low	None (except for essential facilities, where recommendations for moderate hazard apply)
M, M_y, M_o	Moderate	Reconnaissance-level geotechnical hazard evaluation; quantitative slope-stability analysis may be necessary
H_y, H_o	High	Reconnaissance-level geotechnical hazard evaluation; detailed slope-stability analysis likely necessary

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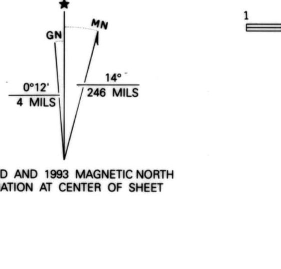

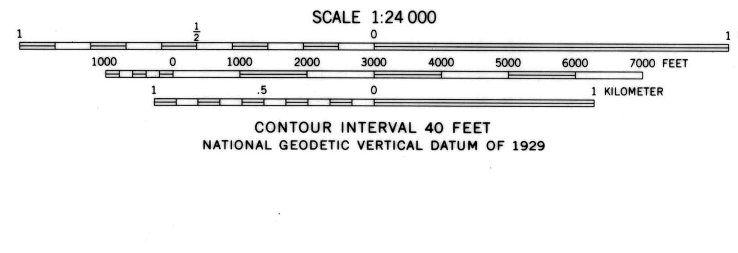

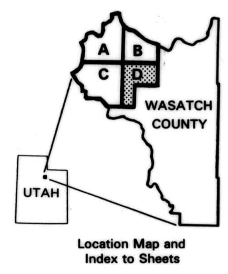

Location Map and Index to Sheets

Maps in this folio:

- Landslide Hazard (Plates 1A-1D)
- Flood Hazards, Earthquake Hazards, and Problem Soils (Plates 2A-2D)
- Suitability for Wastewater Disposal in Septic-Tank Soil-Absorption Systems (Plates 3A-3D)

PLATE 1D
LANDSLIDE HAZARD, WESTERN WASATCH COUNTY, UTAH

Michael D. Hylland and Mike Lowe

1995

Base from Center Creek, Twin Peaks, and Heber Mountain, Utah, USGS 7.5-minute topographic quadrangle maps.
Drafted by Noah P. Snyder

DISCUSSION

This map shows areas where flood hazards, earthquake hazards, and problem soils may exist, and indicates where further study is recommended prior to development (see table). The map is one of four sheets that cover the western Wasatch County study area (see "Location Map and Index to Sheets" at bottom of map).

Flood Hazards

Stream flooding, alluvial-fan flooding and debris flows, shallow ground-water flooding, and dam-failure inundation are potential hazards in certain areas of western Wasatch County. Stream flooding is typically associated with cloudburst rainstorms and seasonal snowmelt, and can accompany intentional releases from dams during periods of heavy runoff. Floodwaters are generally contained within stream channels in the mountains, but can affect broad areas in valley bottoms. Alluvial-fan flooding, characterized by little advance warning and unpredictable flow paths, is a hazard on Holocene alluvial fans. Floodwaters on alluvial fans commonly contain large amounts of sediment, including cobbles and boulders. Stream channels and Holocene-age (0-10,000 years old) alluvial fans can also be affected by debris flows, which occur when sediment and debris in the floodwaters create a muddy slurry much like wet concrete. Debris flows generally have not been a significant hazard in western Wasatch County in historical time. However, a potential hazard exists, especially if the vegetation in drainage basins is damaged by wildfire, grazing, or development. Hazards associated with these types of flooding include loss of life and property damage from drowning, high-velocity impact, erosion, or burial. Avoiding areas subject to these hazards is an effective means of hazard reduction. Where avoidance is not possible (for example, where development has been previously established on alluvial fans or flood plains), other hazard-reduction techniques can be used, including source-area stabilization, engineered protective structures, flood warnings, and floodproofing.

Shallow ground water can cause basement flooding in areas where the depth to ground water is 10 feet (3 m) or less. Shallow ground water can also damage underground utilities and septic-tank soil-absorption systems and can inundate landfills and waste dumps, contaminating aquifers and wells. The depth to ground water can fluctuate as the result of such factors as seasonal precipitation, irrigation, and long-term climate change. A rising water table can cause damage to previously unaffected facilities. Avoidance of potential shallow-ground-water areas is an effective method of reducing hazards, but other hazard-reduction techniques include the use of slab-on-grade foundations or basement sump pumps.

Dam-failure inundation is flooding associated with the catastrophic failure of a dam. The severity of flooding depends on the size of the reservoir and the type of failure. Relatively large dams such as Jordanelle and Deer Creek typically are less prone to failure than small dams because of more rigorous design, construction, and inspection practices. Proper land use on flood plains will help reduce damage from dam-failure inundation to some extent, but the principal means of hazard reduction is emergency response planning.

Earthquake Hazards

Potential earthquake hazards in western Wasatch County include ground shaking, landsliding, liquefaction, surface fault rupture, and tectonic subsidence. Ground shaking is generally the most widespread and frequent earthquake hazard, and is responsible for most earthquake-related damage. All of western Wasatch County is susceptible to ground shaking both from nearby earthquakes and from more distant earthquakes, such as those associated with the Wasatch fault zone along the western margin of the Wasatch Range. Ground shaking cannot be avoided, but resulting damage to structures can be reduced by meeting the seismic provisions of the Uniform Building Code (UBC). Western Wasatch County is in UBC seismic zone 3.

Earthquake-induced landsliding may be a significant hazard in western Wasatch County, particularly if an earthquake occurs in the springtime or during other wet periods. Earthquake-induced landslides will likely occur in moderate- and high-hazard areas as shown on the "Landslide Hazard" map of this folio (plates 1A through 1D). A general discussion of landslide hazard and hazard-reduction measures is included on the landslide-hazard map.

Liquefaction occurs when earthquake ground shaking causes soils to behave like a liquid. Such soils can lose their ability to support structures and in some cases move downslope. Liquefaction-potential maps have been prepared by others for the western Wasatch County area (see "Selected References"). The maps indicate that the liquefaction potential ranges from very low to moderate, with no areas of high potential. The area of moderate potential is restricted to the shallow ground-water zone along the Provo River. Various foundation designs and subgrade treatments are available to reduce liquefaction hazards.

During a large earthquake, fault rupture at depth may propagate upward and displace the ground surface, forming a main scarp and adjacent zone of deformation. The zone of deformation includes features such as ground cracks and tilted and downdropped blocks. Faults that show evidence of repeated surface displacement during late Quaternary, particulary Holocene, time represent a potential hazard to development. Although no faults in western Wasatch County show clear evidence of repeated Holocene displacement, four are believed to have moved during Quaternary time; the Bald Mountain fault northwest of Jordanelle Dam, and three faults bounding and within Round Valley. The U.S. Bureau of Reclamation has estimated that the most-recent movement on the Bald Mountain fault occurred more than 100,000 years ago. Information regarding the ages and recurrence intervals of movement on the Round Valley faults is lacking and detailed studies are needed. Surface-fault-rupture hazards are typically reduced by setting structures back a safe distance from the fault and zone of deformation.

Tectonic subsidence is the warping, lowering, or tilting of a valley floor that may accompany a large, surface-faulting earthquake. Subsidence can cause flooding, shallow ground-water ponding, and disruption of facilities that require horizontal floors or gentle gradients such as wastewater-treatment plants, irrigation canals, and sewer lines. Hazard-reduction measures include adequate design tolerances and incorporating safety features.

Problem Soils

Problem soils are surficial-geologic materials susceptible to volumetric change, collapse, subsidence, or dissolution that can cause engineering problems. Soils with a potential for collapse or shrink-swell are present in western Wasatch County and should be evaluated prior to development. Collapsible soils are subject to volume reductions that can damage structures. When wetted for the first time following deposition, the internal structure of the soil is destroyed resulting in subsidence or collapse of the ground surface. These soils are typically found in Holocene debris-flow deposits and alluvial fans. Expansive soils are clay-rich, and can shrink and swell with changes in moisture content. These soils can crack foundations and road surfaces, plug septic-tank soil-absorption systems, and promote landsliding. Avoidance, moisture control, and various engineering techniques are effective hazard-reduction measures.

USE OF THIS MAP

This map is intended to be used as a tool for land-use planning. It will be most effective if used early in the planning process to identify the potential need for hazard studies on a development-wide scale. The map is at a regional scale and, although it can be used to gain an understanding of the potential for flood hazards, earthquake hazards, and problem soils in a given area, it is not designed to replace site-specific studies performed by qualified professionals (engineering geologists, geotechnical engineers, hydrologists) to evaluate the hazard and, if necessary, recommend hazard-reduction measures. Because of the relatively small scale of the map, the possibility exists that some small hazard areas are not shown. Studies are therefore recommended for essential facilities even outside the delineated hazard areas (see table).

Flood Hazards

The map shows 100-year flood plains as delineated by the Federal Emergency Management Agency (FEMA), as well as minor drainages subject to flooding (and possibly debris flows) not delineated by FEMA. The potential flood hazard in minor drainages is indicated by geologically young alluvium deposited by floodwaters in the drainages. The Federal Insurance Administration's National Flood Insurance Program has established guidelines for development within the FEMA 100-year flood plains. Prior to development near minor drainages subject to flooding, studies should define the 100-year flood plain within which FEMA guidelines should be applied. Flooding may still occur in undesignated areas near drainages on the map during extreme rainstorms, but such events are infrequent.

The map shows boundaries of Holocene alluvial fans, which are areas where alluvial-fan flooding and debris flows may occur. Site-specific studies in these areas should address parts of the fan surface that would be subject to channelized flow versus sheet flow, the potential for debris flows based on slope and channel conditions above the fan, and the effect of existing upstream structures that might divert or contain floods or flows.

Where the map indicates shallow ground-water flooding is a potential hazard, site-specific investigations should be performed to characterize ground-water conditions prior to development. The studies should determine the shallowest expected water table as controlled by seasonal precipitation, irrigation, and long-term fluctuations.

The U.S. Bureau of Reclamation has prepared dam-failure inundation maps for Jordanelle and Deer Creek Dams (see "Selected References"), as well as emergency-action plans. The Utah Division of Water Rights, Dam Safety Section, maintains emergency-action-plan files for the smaller dams in the area. The information in these documents should be used for land-use and emergency-response planning.

Earthquake Hazards

Hazard zones associated with ground shaking, earthquake-induced landslides, and liquefaction are not shown on the map as noted in the "Discussion." Standard soil-foundation reports should provide data for UBC site coefficients used in seismic design. Recommendations for landslide-hazard investigations are included on the landslide-hazard map of this folio (plates 1A-1D). In the area of moderate liquefaction potential, site-specific studies should be performed for proposed essential facilities (for example, hospitals, police and fire stations) to evaluate the hazard and recommend hazard-reduction measures.

The map shows special-study zones associated with the Bald Mountain and Round Valley faults. The hazard associated with the Bald Mountain fault appears to be low and need only be considered if essential facilities are planned within the special-study zone. Because of the lack of information on activity of the Round Valley faults, site-specific studies to evaluate the earthquake history on these faults and characterize the zone of deformation are recommended prior to development within the associated special-study zones.

The extent and degree of tectonic-subsidence hazard is difficult to predict, and hazard areas have not been delineated on the map. The hazard is proportional to the potential for surface fault rupture, as well as the length and expected vertical displacment of the fault, and is therefore low in western Wasatch County. In general, the areas between the Bald Mountain fault and Jordanelle Reservoir and in Round Valley between the valley-bounding faults may experience tectonic subsidence during a surface-rupturing earthquake on one of these faults. Site-specific investigations (recommended for proposed essential and special-use facilities in these areas; see "Discussion") should address the likelihood of faulting and anticipated extent of tectonic-subsidence-related flooding and ground tilt.

Problem Soils

The map shows boundaries of Holocene alluvial fans where collapsible soils may be found. The location of expansive soils in western Wasatch County is more difficult to predict, and expansive-soil hazard areas are not shown on the map. U.S. Soil Conservation Service maps indicate that soils with a high shrink-swell potential may be widespread in western Wasatch County (see "Selected References"). The potential for collapse or shrink-swell, along with other soil-engineering properties, should be evaluated in a standard soil-foundation report prior to development.

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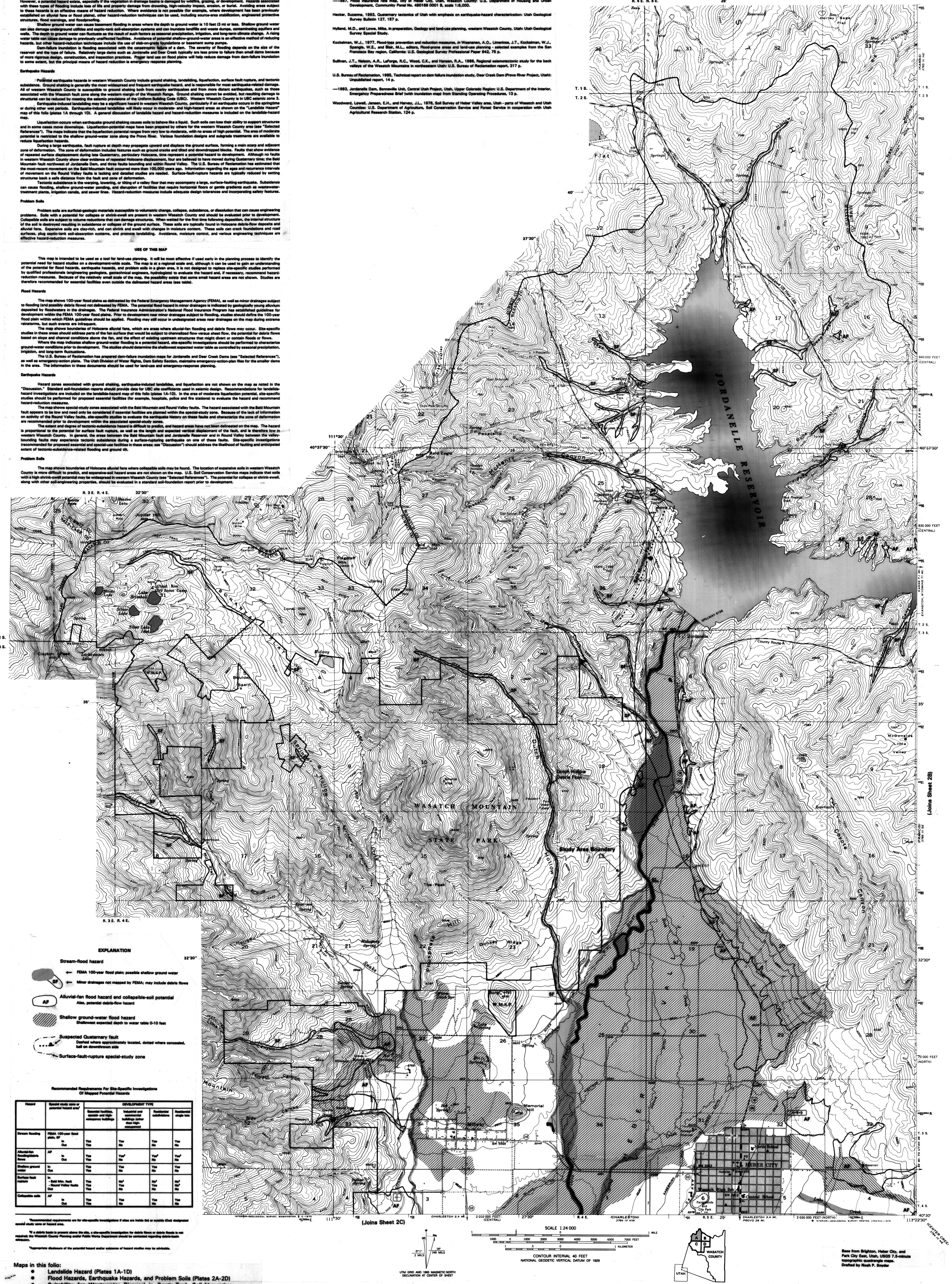


EXPLANATION

Stream-flood hazard

- FEMA 100-year flood plain; possible shallow ground water
- Minor drainages not mapped by FEMA; may include debris flows

Alluvial-fan flood hazard and collapsible-soil potential (AF)
Also, potential debris-flow hazard

Shallow ground-water flood hazard
Shallowest expected depth to water table 0-10 feet

Suspected Quaternary fault
Dashed where approximately located, dotted where concealed, ball on downthrown side

Surface-fault-rupture special-study zone

Recommended Requirements For Site-Specific Investigations Of Mapped Potential Hazards

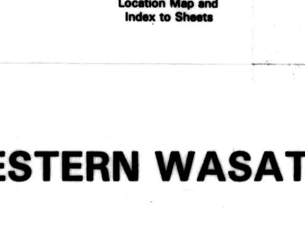
Hazard	Special study zone or potential hazard area[1]	DEVELOPMENT TYPE			
		Essential facilities, special- and high-occupancy buildings	Industrial and commercial buildings (other than high-occupancy)	Residential subdivisions	Residential single lots
Stream flooding	FEMA 100-year flood plain, SF				
	In	Yes	Yes	Yes	Yes
	Out	Yes	No	No	No
Alluvial-fan flooding/debris flows	AF				
	In	Yes	Yes[2]	Yes[2]	Yes[2]
	Out	Yes	No	No	No
Shallow ground water	In	Yes	Yes	Yes	Yes
	Out	Yes	No	No	No
Surface fault rupture	In				
	- Bald Mtn. fault	Yes	No[3]	No[3]	No[3]
	- Round Valley faults	Yes	Yes	Yes	No[3]
	Out	Yes	No	No	No
Collapsible soils	AF				
	In	Yes	Yes	Yes	Yes
	Out	Yes	No	No	No

[1]Recommended requirements are for site-specific investigations if sites are inside (In) or outside (Out) designated special study zone or hazard area.

[2]If a debris basin is present above the site, a site-specific investigation for debris flows or debris floods is not required; the Wasatch County Planning and/or Public Works Department should be contacted regarding debris-basin adequacy.

[3]Appropriate disclosure of the potential hazard and/or existence of hazard studies may be advisable.

Maps in this folio:
- Landslide Hazard (Plates 1A-1D)
- Flood Hazards, Earthquake Hazards, and Problem Soils (Plates 2A-2D)
- Suitability for Wastewater Disposal in Septic-Tank Soil-Absorption Systems (Plates 3A-3D)



Location Map and Index to Sheets

Base from Brighton, Heber City, and Park City East, Utah, USGS 7.5-minute topographic quadrangle maps.
Drafted by Noah P. Snyder

PLATE 2A
FLOOD HAZARDS, EARTHQUAKE HAZARDS, AND PROBLEM SOILS, WESTERN WASATCH COUNTY, UTAH

Michael D. Hylland and Charles E. Bishop

1995

DISCUSSION

This map shows areas where flood hazards, earthquake hazards, and problem soils may exist, and indicates where further study is recommended prior to development (see table). The map is one of four sheets that cover the western Wasatch County study area (see "Location Map and Index to Sheets" at bottom of map).

Flood Hazards

Stream flooding, alluvial-fan flooding and debris flows, shallow ground-water flooding, and dam-failure inundation are potential hazards in certain areas of western Wasatch County. Stream flooding is typically associated with cloudburst rainstorms and seasonal snowmelt, and can accompany intentional releases from dams during periods of heavy runoff. Floodwaters are generally contained within stream channels in the mountains, but can affect broad areas in valley bottoms. Alluvial-fan flooding, characterized by little advance warning and unpredictable flow paths, is a hazard on Holocene alluvial fans. Floodwaters on alluvial fans commonly contain large amounts of sediment, including cobbles and boulders. Stream channels and Holocene-age (0-10,000 years old) alluvial fans can also be affected by debris flows, which occur when sediment and debris in the floodwaters create a muddy slurry much like wet concrete. Debris flows generally have not been a significant hazard in western Wasatch County in historical time. However, a potential hazard exists, especially if the vegetation in drainage basins is damaged by wildfire, grazing, or development. Hazards associated with these types of flooding include loss of life and property damage from drowning, high-velocity impact, erosion, or burial. Avoiding areas subject to these hazards is an effective means of hazard reduction. Where avoidance is not possible (for example, where development has been previously established on alluvial fans or flood plains), other hazard-reduction techniques can be used, including source-area stabilization, engineered protective structures, flood warnings, and floodproofing.

Shallow ground water can cause basement flooding in areas where the depth to ground water is 10 feet (3 m) or less. Shallow ground water can also damage underground utilities and septic-tank soil-absorption systems and can inundate landfills and waste dumps, contaminating aquifers and wells. The depth to ground water can fluctuate as the result of such factors as seasonal precipitation, irrigation, and long-term climate change. A rising water table can cause damage to previously unaffected facilities. Avoidance of potential shallow-ground-water areas is an effective method of reducing hazards, but other hazard-reduction techniques include the use of slab-on-grade foundations or basement sump pumps.

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During a large earthquake, fault rupture at depth may propagate upward and displace the ground surface, forming a main scarp and adjacent zone of deformation. The zone of deformation includes features such as ground cracks and tilted and downdropped blocks. Faults that show evidence of repeated surface displacement during late Quaternary, particulary Holocene, time represent a potential hazard to development. Although no faults in western Wasatch County show clear evidence of repeated Holocene displacement, four are believed to have moved during Quaternary time; the Bald Mountain fault northwest of Jordanelle Dam, and three faults bounding and within Round Valley. The U.S. Bureau of Reclamation has estimated that the most-recent movement on the Bald Mountain fault occurred more than 100,000 years ago. Information regarding the ages and recurrence intervals of movement on the Round Valley faults is lacking and detailed studies are needed. Surface-fault-rupture hazards are typically reduced by setting structures back a safe distance from the fault and zone of deformation.

Tectonic subsidence is the warping, lowering, or tilting of a valley floor that may accompany a large, surface-faulting earthquake. Subsidence can cause flooding, shallow ground-water ponding, and disruption of facilities that require horizontal floors or gentle gradients such as wastewater-treatment plants, irrigation canals, and sewer lines. Hazard-reduction measures include adequate design tolerances and incorporating safety features.

Problem Soils

Problem soils are surficial-geologic materials susceptible to volumetric change, collapse, subsidence, or dissolution that can cause engineering problems. Soils with a potential for collapse or shrink-swell are present in western Wasatch County and should be evaluated prior to development. Collapsible soils are subject to volume reductions that can damage structures. When wetted for the first time following deposition, the internal structure of the soil is destroyed resulting in subsidence or collapse of the ground surface. These soils are typically found in Holocene debris-flow deposits and alluvial fans. Expansive soils are clay-rich, and can shrink and swell with changes in moisture content. These soils can crack foundations and road surfaces, plug septic-tank soil-absorption systems, and promote landsliding. Avoidance, moisture control, and various engineering techniques are effective hazard-reduction measures.

USE OF THIS MAP

This map is intended to be used as a tool for land-use planning. It will be most effective if used early in the planning process to identify the potential need for hazard studies on a development-wide scale. The map is at a regional scale and, although it can be used to gain an understanding of the potential for flood hazards, earthquake hazards, and problem soils in a given area, it is not designed to replace site-specific studies performed by qualified professionals (engineering geologists, geotechnical engineers, hydrologists) to evaluate the hazard and, if necessary, recommend hazard-reduction measures. Because of the relatively small scale of the map, the possibility exists that some small hazard areas are not shown. Studies are therefore recommended for essential facilities even outside the delineated hazard areas (see table).

Flood Hazards

The map shows 100-year flood plains as delineated by the Federal Emergency Management Agency (FEMA), as well as minor drainages subject to flooding (and possibly debris flows) not delineated by FEMA. The potential flood hazard in minor drainages is indicated by geologically young alluvium deposited by floodwaters in the drainages. The Federal Insurance Administration's National Flood Insurance Program has established guidelines for development within the FEMA 100-year flood plains. Prior to development near minor drainages subject to flooding, studies should define the 100-year flood plain within which FEMA guidelines should be applied. Flooding may still occur in undesignated areas near drainages on the map during extreme rainstorms, but such events are infrequent.

The map shows boundaries of Holocene alluvial fans, which are areas where alluvial-fan flooding and debris flows may occur. Site-specific studies in these areas should address parts of the fan surface that would be subject to channelized flow versus sheet flow, the potential for debris flows based on slope and channel conditions above the fan, and the effect of existing upstream structures that might divert or contain floods or flows.

Where the map indicates shallow ground-water flooding is a potential hazard, site-specific investigations should be performed to characterize ground-water conditions prior to development. The studies should determine the shallowest expected water table as controlled by seasonal precipitation, irrigation, and long-term fluctuations.

The U.S. Bureau of Reclamation has prepared dam-failure inundation maps for Jordanelle and Deer Creek Dams (see "Selected References"), as well as emergency-action plans. The Utah Division of Water Rights, Dam Safety Section, maintains emergency-action-plan files for the smaller dams in the area. The information in these documents should be used for land-use and emergency-response planning.

Earthquake Hazards

Hazard zones associated with ground shaking, earthquake-induced landslides, and liquefaction are not shown on the map as noted in the "Discussion." Standard soil-foundation reports should provide data for UBC site coefficients used in seismic design. Recommendations for landslide-hazard investigations are included on the landslide-hazard map of this folio (plates 1A-1D). In the area of moderate liquefaction potential, site-specific studies should be performed for proposed essential facilities (for example, hospitals, police and fire stations) to evaluate the hazard and recommend hazard-reduction measures.

The map shows special-study zones associated with the Bald Mountain and Round Valley faults. The hazard associated with the Bald Mountain fault appears to be low and need only be considered if essential facilities are planned within the special-study zone. Because of the lack of information on activity of the Round Valley faults, site-specific studies to evaluate the earthquake history on these faults and characterize the zone of deformation are recommended prior to development within the associated special-study zones.

The extent and degree of tectonic-subsidence hazard is difficult to predict, and hazard areas have not been delineated on the map. The hazard is proportional to the potential for surface fault rupture, as well as the length and expected vertical displacment of the fault, and is therefore low in western Wasatch County. In general, the areas between the Bald Mountain fault and Jordanelle Reservoir and in Round Valley between the valley-bounding faults may experience tectonic subsidence during a surface-rupturing earthquake on one of these faults. Site-specific investigations (recommended for proposed essential and special-use facilities in these areas; see "Discussion") should address the likelihood of faulting and anticipated extent of tectonic-subsidence-related flooding and ground tilt.

Problem Soils

The map shows boundaries of Holocene alluvial fans where collapsible soils may be found. The location of expansive soils in western Wasatch County is more difficult to predict, and expansive-soil hazard areas are not shown on the map. U.S. Soil Conservation Service maps indicate that soils with a high shrink-swell potential may be widespread in western Wasatch County (see "Selected References"). The potential for collapse or shrink-swell, along with other soil-engineering properties, should be evaluated in a standard soil-foundation report prior to development.

EXPLANATION

Stream-flood hazard

← FEMA 100-year flood plain; possible shallow ground water

SF ← Minor drainages not mapped by FEMA; may include debris flows

AF **Alluvial-fan flood hazard and collapsible-soil potential**
Also, potential debris-flow hazard

Shallow ground-water flood hazard
Shallowest expected depth to water table 0-10 feet

Suspected Quaternary fault
Dashed where approximately located, dotted where concealed, ball on downthrown side

← **Surface-fault-rupture special-study zone**

Recommended Requirements For Site-Specific Investigations Of Mapped Potential Hazards

Hazard	Special study zone or potential hazard area[1]	DEVELOPMENT TYPE: Essential facilities, special- and high-occupancy buildings	Industrial and commercial buildings (other than high-occupancy)	Residential subdivisions	Residential single lots
Stream flooding	FEMA 100-year flood plain, SF				
	In	Yes	Yes	Yes	Yes
	Out	Yes	No	No	No
Alluvial-fan flooding/debris flows	AF				
	In	Yes	Yes[2]	Yes[2]	Yes[2]
	Out	Yes	No	No	No
Shallow ground water	In	Yes	Yes	Yes	Yes
	Out	Yes	No	No	No
Surface fault rupture	In				
	- Bald Mtn. fault	Yes	No[3]	No[3]	No[3]
	- Round Valley faults	Yes	Yes	Yes	No[3]
	Out	Yes	No	No	No
Collapsible soils	AF				
	In	Yes	Yes	Yes	Yes
	Out	Yes	No	No	No

[1]Recommended requirements are for site-specific investigations if sites are inside (In) or outside (Out) designated special study zone or hazard area.

[2]If a debris basin is present above the site, a site-specific investigation for debris flows or debris floods is not required; the Wasatch County Planning and/or Public Works Department should be contacted regarding debris-basin adequacy.

[3]Appropriate disclosure of the potential hazard and/or existence of hazard studies may be advisable.

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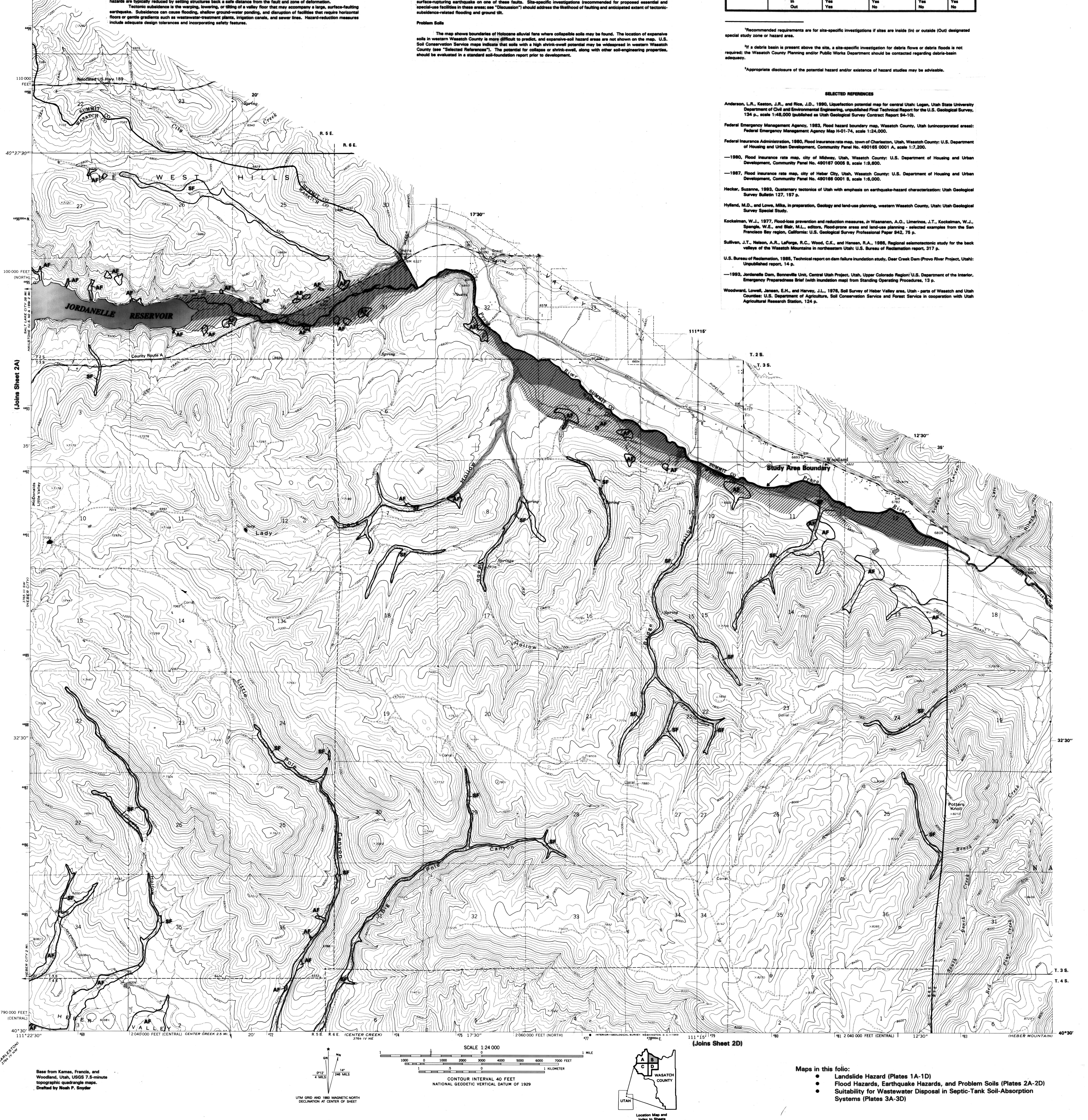
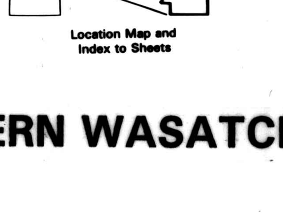


Base from Kamas, Francis, and Woodland, Utah, USGS 7.5-minute topographic quadrangle maps.
Drafted by Noah P. Snyder



Location Map and Index to Sheets

Maps in this folio:
- Landslide Hazard (Plates 1A-1D)
- Flood Hazards, Earthquake Hazards, and Problem Soils (Plates 2A-2D)
- Suitability for Wastewater Disposal in Septic-Tank Soil-Absorption Systems (Plates 3A-3D)

PLATE 2B

FLOOD HAZARDS, EARTHQUAKE HAZARDS, AND PROBLEM SOILS, WESTERN WASATCH COUNTY, UTAH

Michael D. Hylland and Charles E. Bishop

1995

EXPLANATION

Stream-flood hazard

← FEMA 100-year flood plain; possible shallow ground water

SF ← Minor drainages not mapped by FEMA; may include debris flows

AF **Alluvial-fan flood hazard and collapsible-soil potential**
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Shallow ground-water flood hazard
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Suspected Quaternary fault
Dashed where approximately located, dotted where concealed, ball on downthrown side

Surface-fault-rupture special-study zone

Recommended Requirements For Site-Specific Investigations Of Mapped Potential Hazards

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	- Bald Mtn. fault	Yes	No[3]	No[3]	No[3]
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Collapsible soils	AF				
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[1]Recommended requirements are for site-specific investigations if sites are inside (In) or outside (Out) designated special study zone or hazard area.

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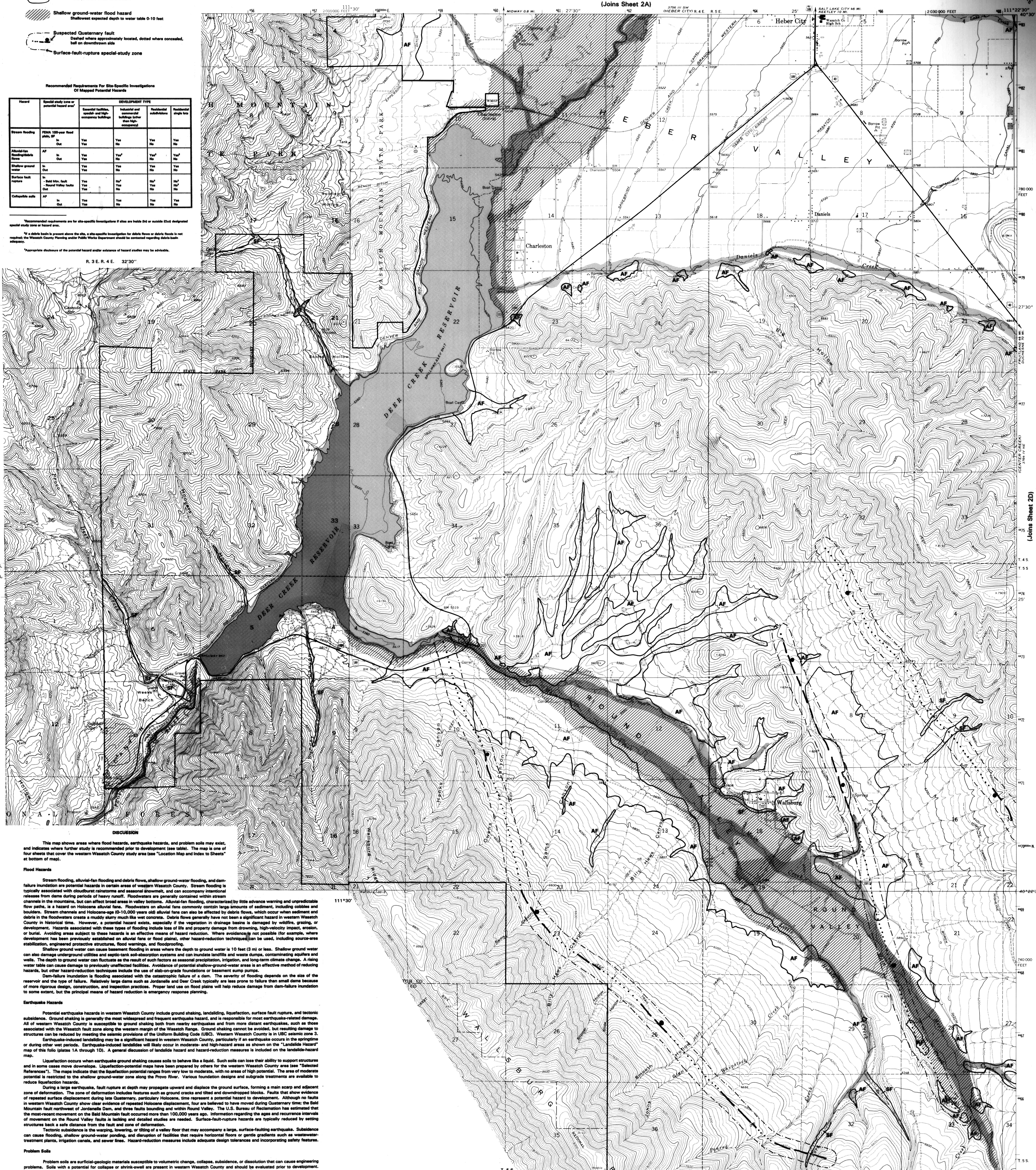

DISCUSSION

This map shows areas where flood hazards, earthquake hazards, and problem soils may exist, and indicates where further study is recommended prior to development (see table). The map is one of four sheets that cover the western Wasatch County study area (see "Location Map and Index to Sheets" at bottom of map).

Flood Hazards

Stream flooding, alluvial-fan flooding and debris flows, shallow ground-water flooding, and dam-failure inundation are potential hazards in certain areas of western Wasatch County. Stream flooding is typically associated with cloudburst rainstorms and seasonal snowmelt, and can accompany intentional releases from dams during periods of heavy runoff. Floodwaters are generally contained within stream channels in the mountains, but can affect broad areas in valley bottoms. Alluvial-fan flooding, characterized by little advance warning and unpredictable flow paths, is a hazard on Holocene alluvial fans. Floodwaters on alluvial fans commonly contain large amounts of sediment, including cobbles and boulders. Stream channels and Holocene-age (0-10,000 years old) alluvial fans can also be affected by debris flows, which occur when sediment and debris in the floodwaters create a muddy slurry much like wet concrete. Debris flows generally have not been a significant hazard in western Wasatch County in historical time. However, a potential hazard exists, especially if the vegetation in drainage basins is damaged by wildfire, grazing, or development. Hazards associated with these types of flooding include loss of life and property damage from drowning, high-velocity impact, erosion, or burial. Avoiding areas subject to these hazards is an effective means of hazard reduction. Where avoidance is not possible (for example, where development has been previously established on alluvial fans or flood plains), other hazard-reduction techniques can be used, including source-area stabilization, engineered protective structures, flood warnings, and floodproofing.

Shallow ground water can cause basement flooding in areas where the depth to ground water is 10 feet (3 m) or less. Shallow ground water can also damage underground utilities and septic-tank soil-absorption systems and can inundate landfills and waste dumps, contaminating aquifers and wells. The depth to ground water can fluctuate as the result of such factors as seasonal precipitation, irrigation, and long-term climate change. A rising water table can cause damage to previously unaffected facilities. Avoidance of potential shallow-ground-water areas is an effective method of reducing hazards, but other hazard-reduction techniques include the use of slab-on-grade foundations or basement sump pumps.

Dam-failure inundation is flooding associated with the catastrophic failure of a dam. The severity of flooding depends on the size of the reservoir and the type of failure. Relatively large dams such as Jordanelle and Deer Creek typically are less prone to failure than small dams because of more rigorous design, construction, and inspection practices. Proper land use on flood plains will help reduce damage from dam-failure inundation to some extent, but the principal means of hazard reduction is emergency response planning.

Earthquake Hazards

Potential earthquake hazards in western Wasatch County include ground shaking, landsliding, liquefaction, surface fault rupture, and tectonic subsidence. Ground shaking is generally the most widespread and frequent earthquake hazard, and is responsible for most earthquake-related damage. All of western Wasatch County is susceptible to ground shaking both from nearby earthquakes and from more distant earthquakes, such as those associated with the Wasatch fault zone along the western margin of the Wasatch Range. Ground shaking cannot be avoided, but resulting damage to structures can be reduced by meeting the seismic provisions of the Uniform Building Code (UBC). Western Wasatch County is in UBC seismic zone 3.

Earthquake-induced landsliding may be a significant hazard in western Wasatch County, particularly if an earthquake occurs in the springtime or during other wet periods. Earthquake-induced landslides will likely occur in moderate- and high-hazard areas as shown on the "Landslide Hazard" map of this folio (plates 1A through 1D). A general discussion of landslide hazard and hazard-reduction measures is included on the landslide-hazard map.

Liquefaction occurs when earthquake ground shaking causes soils to behave like a liquid. Such soils can lose their ability to support structures and in some cases move downslope. Liquefaction-potential maps have been prepared by others for the western Wasatch County area (see "Selected References"). The maps indicate that the liquefaction potential ranges from very low to moderate, with no areas of high potential. The area of moderate potential is restricted to the shallow ground-water zone along the Provo River. Various foundation designs and subgrade treatments are available to reduce liquefaction hazards.

During a large earthquake, fault rupture at depth may propagate upward and displace the ground surface, forming a main scarp and adjacent zone of deformation. The zone of deformation includes features such as ground cracks and tilted and downdropped blocks. Faults that show evidence of repeated surface displacement during late Quaternary, particulary Holocene, time represent a potential hazard to development. Although no faults in western Wasatch County show clear evidence of repeated Holocene displacement, four are believed to have moved during Quaternary time; the Bald Mountain fault northwest of Jordanelle Dam, and three faults bounding and within Round Valley. The U.S. Bureau of Reclamation has estimated that the most-recent movement on the Bald Mountain fault occurred more than 100,000 years ago. Information regarding the ages and recurrence intervals of movement on the Round Valley faults is lacking and detailed studies are needed. Surface-fault-rupture hazards are typically reduced by setting structures back a safe distance from the fault and zone of deformation.

Tectonic subsidence is the warping, lowering, or tilting of a valley floor that may accompany a large, surface-faulting earthquake. Subsidence can cause flooding, shallow ground-water ponding, and disruption of facilities that require horizontal floors or gentle gradients such as wastewater-treatment plants, irrigation canals, and sewer lines. Hazard-reduction measures include adequate design tolerances and incorporating safety features.

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Problem soils are surficial-geologic materials susceptible to volumetric change, collapse, subsidence, or dissolution that can cause engineering problems. Soils with a potential for collapse or shrink-swell are present in western Wasatch County and should be evaluated prior to development. Collapsible soils are subject to volume reductions that can damage structures. When wetted for the first time following deposition, the internal structure of the soil is destroyed resulting in subsidence or collapse of the ground surface. These soils are typically found in Holocene debris-flow deposits and alluvial fans. Expansive soils are clay-rich, and can shrink and swell with changes in moisture content. These soils can crack foundations and road surfaces, plug septic-tank soil-absorption systems, and promote landsliding. Avoidance, moisture control, and various engineering techniques are effective hazard-reduction measures.

USE OF THIS MAP

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The map shows 100-year flood plains as delineated by the Federal Emergency Management Agency (FEMA), as well as minor drainages subject to flooding (and possibly debris flows) not delineated by FEMA. The potential flood hazard in minor drainages is indicated by geologically young alluvium deposited by floodwaters in the drainages. The Federal Insurance Administration's National Flood Insurance Program has established guidelines for development within the FEMA 100-year flood plains. Prior to development near minor drainages subject to flooding, studies should define the 100-year flood plain within which FEMA guidelines should be applied. Flooding may still occur in undesignated areas near drainages on the map during extreme rainstorms, but such events are infrequent.

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The extent and degree of tectonic-subsidence hazard is difficult to predict, and hazard areas have not been delineated on the map. The hazard is proportional to the potential for surface fault rupture, as well as the length and expected vertical displacment of the fault, and is therefore low in western Wasatch County. In general, the areas between the Bald Mountain fault and Jordanelle Reservoir and in Round Valley between the valley-bounding faults may experience tectonic subsidence during a surface-rupturing earthquake on one of these faults. Site-specific investigations (recommended for proposed essential and special-use facilities in these areas; see "Discussion") should address the likelihood of faulting and anticipated extent of tectonic-subsidence-related flooding and ground tilt.

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PLATE 2C

FLOOD HAZARDS, EARTHQUAKE HAZARDS, AND PROBLEM SOILS, WESTERN WASATCH COUNTY, UTAH

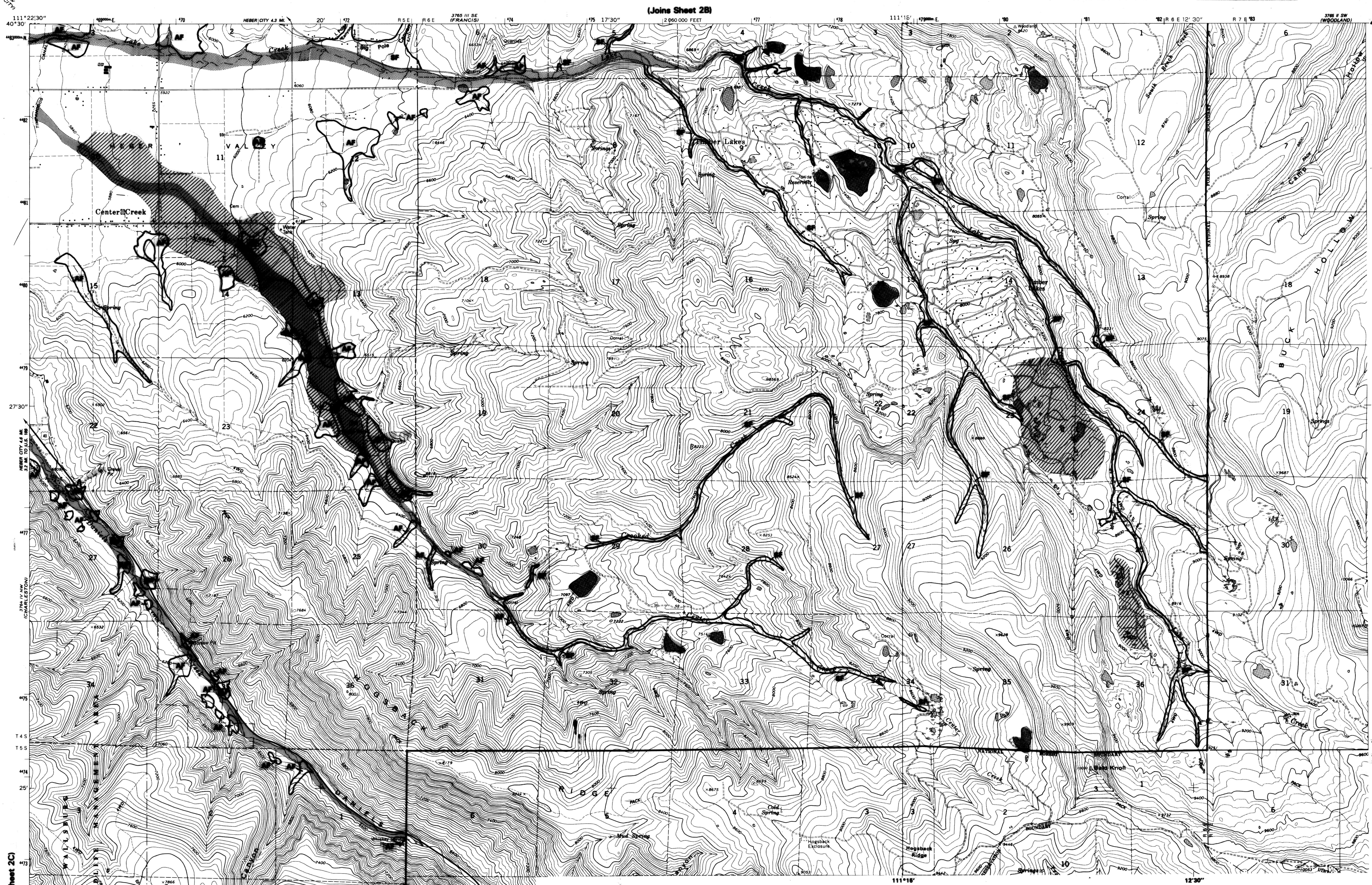
Michael D. Hylland and Charles E. Bishop

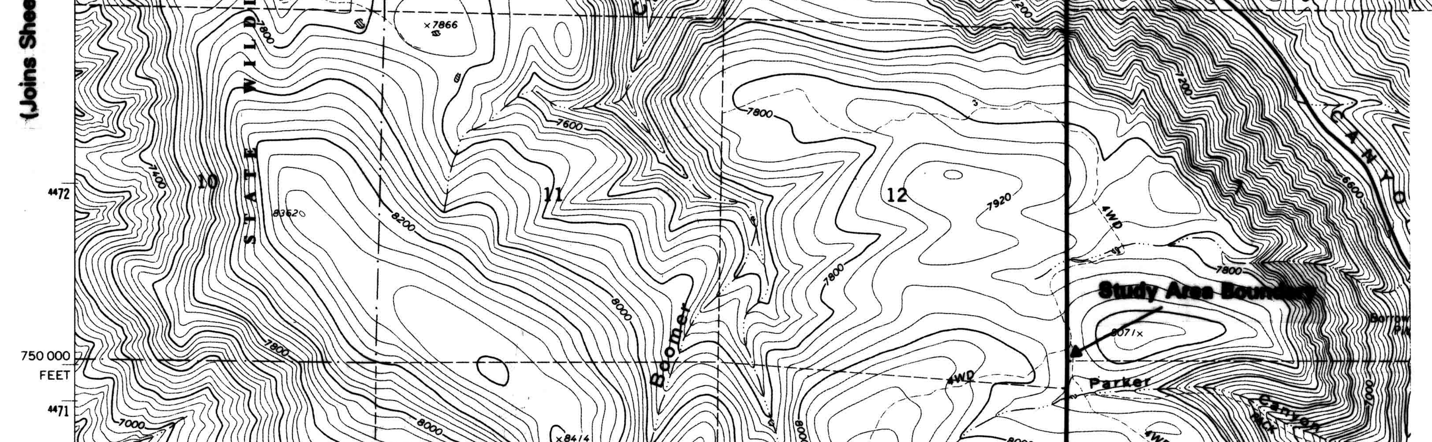
1995

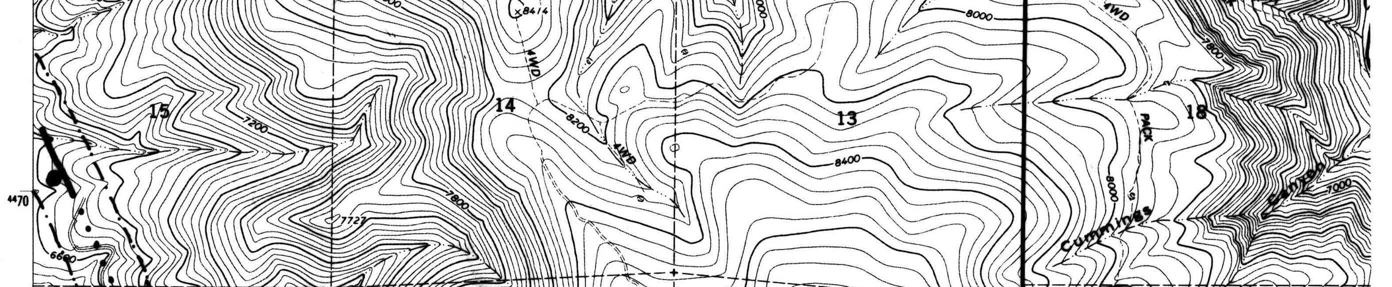
Maps in this folio:

- Landslide Hazard (Plates 1A-1D)
- Flood Hazards, Earthquake Hazards, and Problem Soils (Plates 2A-2D)
- Suitability for Wastewater Disposal in Septic-Tank Soil-Absorption Systems (Plates 3A-3D)

Base from Aspen Grove, Charleston, and Wallsburg Ridge, Utah, USGS 7.5-minute topographic quadrangle maps.
Drafted by Noah P. Snyder







EXPLANATION

Stream-flood hazard

- FEMA 100-year flood plain; possible shallow ground water
- SF — Minor drainages not mapped by FEMA; may include debris flows

AF — Alluvial-fan flood hazard and collapsible-soil potential
Also, potential debris-flow hazard

Shallow ground-water flood hazard
Shallowest expected depth to water table 0-10 feet

Suspected Quaternary fault
Dashed where approximately located, dotted where concealed, ball on downthrown side

Surface-fault-rupture special-study zone

Recommended Requirements For Site-Specific Investigations Of Mapped Potential Hazards

Hazard	Special study zone or potential hazard area[1]	DEVELOPMENT TYPE			
		Essential facilities, special- and high-occupancy buildings	Industrial and commercial buildings (other than high-occupancy)	Residential subdivisions	Residential single lots
Stream flooding	FEMA 100-year flood plain, SF In Out	 Yes Yes	 Yes No	 Yes No	 Yes No
Alluvial-fan flooding/debris flows	AF In Out	 Yes Yes	 Yes[2] No	 Yes[2] No	 Yes[2] No
Shallow ground water	In Out	Yes Yes	Yes No	Yes No	Yes No
Surface fault rupture	In - Bald Mtn. fault - Round Valley faults Out	 Yes Yes Yes	 No[3] Yes No	 No[3] Yes No	 No[3] No[3] No
Collapsible soils	AF In Out	 Yes Yes	 Yes No	 Yes No	 Yes No

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DISCUSSION

This map shows areas where flood hazards, earthquake hazards, and problem soils may exist, and indicates where further study is recommended prior to development (see table). The map is one of four sheets that cover the western Wasatch County study area (see "Location Map and Index to Sheets" at bottom of map).

Flood Hazards

Stream flooding, alluvial-fan flooding and debris flows, shallow ground-water flooding, and dam-failure inundation are potential hazards in certain areas of western Wasatch County. Stream flooding is typically associated with cloudburst rainstorms and seasonal snowmelt, and can accompany intentional releases from dams during periods of heavy runoff. Floodwaters are generally contained within stream channels in the mountains, but can affect broad areas in valley bottoms. Alluvial-fan flooding, characterized by little advance warning and unpredictable flow paths, is a hazard on Holocene alluvial fans. Floodwaters on alluvial fans commonly contain large amounts of sediment, including cobbles and boulders. Stream channels and Holocene-age (0-10,000 years old) alluvial fans can also be affected by debris flows, which occur when sediment and debris in the floodwaters create a muddy slurry much like wet concrete. Debris flows generally have not been a significant hazard in western Wasatch County in historical time. However, a potential hazard exists, especially if the vegetation in drainage basins is damaged by wildfire, grazing, or development. Hazards associated with these types of flooding include loss of life and property damage from drowning, high-velocity impact, erosion, or burial. Avoiding areas subject to these hazards is an effective means of hazard reduction. Where avoidance is not possible (for example, where development has been previously established on alluvial fans or flood plains), other hazard-reduction techniques can be used, including source-area stabilization, engineered protective structures, flood warnings, and floodproofing.

Shallow ground water can cause basement flooding in areas where the depth to ground water is 10 feet (3 m) or less. Shallow ground water can also damage underground utilities and septic-tank soil-absorption systems and can inundate landfills and waste dumps, contaminating aquifers and wells. The depth to ground water can fluctuate as the result of such factors as seasonal precipitation, irrigation, and long-term climate change. A rising water table can cause damage to previously unaffected facilities. Avoidance of potential shallow-ground-water areas is an effective method of reducing hazards, but other hazard-reduction techniques include the use of slab-on-grade foundations or basement sump pumps.

Dam-failure inundation is flooding associated with the catastrophic failure of a dam. The severity of flooding depends on the size of the reservoir and the type of failure. Relatively large dams such as Jordanelle and Deer Creek typically are less prone to failure than small dams because of more rigorous design, construction, and inspection practices. Proper land use on flood plains will help reduce damage from dam-failure inundation to some extent, but the principal means of hazard reduction is emergency response planning.

Earthquake Hazards

Potential earthquake hazards in western Wasatch County include ground shaking, landsliding, liquefaction, surface fault rupture, and tectonic subsidence. Ground shaking is generally the most widespread and frequent earthquake hazard, and is responsible for most earthquake-related damage. All of western Wasatch County is susceptible to ground shaking both from nearby earthquakes and from more distant earthquakes, such as those associated with the Wasatch fault zone along the western margin of the Wasatch Range. Ground shaking cannot be avoided, but resulting damage to structures can be reduced by meeting the seismic provisions of the Uniform Building Code (UBC). Western Wasatch County is in UBC seismic zone 3.

Earthquake-induced landsliding may be a significant hazard in western Wasatch County, particularly if an earthquake occurs in the springtime or during other wet periods. Earthquake-induced landslides will likely occur in moderate- and high-hazard areas as shown on the "Landslide Hazard" map of this folio (plates 1A through 1D). A general discussion of landslide hazard and hazard-reduction measures is included on the landslide-hazard map.

Liquefaction occurs when earthquake ground shaking causes soils to behave like a liquid. Such soils can lose their ability to support structures and in some cases move downslope. Liquefaction-potential maps have been prepared by others for the western Wasatch County area (see "Selected References"). The maps indicate that the liquefaction potential ranges from very low to moderate, with no areas of high potential. The area of moderate potential is restricted to the shallow ground-water zone along the Provo River. Various foundation designs and subgrade treatments are available to reduce liquefaction hazards.

During a large earthquake, fault rupture at depth may propagate upward and displace the ground surface, forming a main scarp and adjacent zone of deformation. The zone of deformation includes features such as ground cracks and tilted and downdropped blocks. Faults that show evidence of repeated surface displacement during late Quaternary, particulary Holocene, time represent a potential hazard to development. Although no faults in western Wasatch County show clear evidence of repeated Holocene displacement, four are believed to have moved during Quaternary time; the Bald Mountain fault northwest of Jordanelle Dam, and three faults bounding and within Round Valley. The U.S. Bureau of Reclamation has estimated that the most-recent movement on the Bald Mountain fault occurred more than 100,000 years ago. Information regarding the ages and recurrence intervals of movement on the Round Valley faults is lacking and detailed studies are needed. Surface-fault-rupture hazards are typically reduced by setting structures back a safe distance from the fault and zone of deformation.

Tectonic subsidence is the warping, lowering, or tilting of a valley floor that may accompany a large, surface-faulting earthquake. Subsidence can cause flooding, shallow ground-water ponding, and disruption of facilities that require horizontal floors or gentle gradients such as wastewater-treatment plants, irrigation canals, and sewer lines. Hazard-reduction measures include adequate design tolerances and incorporating safety features.

Problem Soils

Problem soils are surficial-geologic materials susceptible to volumetric change, collapse, subsidence, or dissolution that can cause engineering problems. Soils with a potential for collapse or shrink-swell are present in western Wasatch County and should be evaluated prior to development. Collapsible soils are subject to volume reductions that can damage structures. When wetted for the first time following deposition, the internal structure of the soil is destroyed resulting in subsidence or collapse of the ground surface. These soils are typically found in Holocene debris-flow deposits and alluvial fans. Expansive soils are clay-rich, and can shrink and swell with changes in moisture content. These soils can crack foundations and road surfaces, plug septic-tank soil-absorption systems, and promote landsliding. Avoidance, moisture control, and various engineering techniques are effective hazard-reduction measures.

USE OF THIS MAP

This map is intended to be used as a tool for land-use planning. It will be most effective if used early in the planning process to identify the potential need for hazard studies on a development-wide scale. The map is at a regional scale and, although it can be used to gain an understanding of the potential for flood hazards, earthquake hazards, and problem soils in a given area, it is not designed to replace site-specific studies performed by qualified professionals (engineering geologists, geotechnical engineers, hydrologists) to evaluate the hazard and, if necessary, recommend hazard-reduction measures. Because of the relatively small scale of the map, the possibility exists that some small hazard areas are not shown. Studies are therefore recommended for essential facilities even outside the delineated hazard areas (see table).

Flood Hazards

The map shows 100-year flood plains as delineated by the Federal Emergency Management Agency (FEMA), as well as minor drainages subject to flooding (and possibly debris flows) not delineated by FEMA. The potential flood hazard in minor drainages is indicated by geologically young alluvium deposited by floodwaters in the drainages. The Federal Insurance Administration's National Flood Insurance Program has established guidelines for development within the FEMA 100-year flood plains. Prior to development near minor drainages subject to flooding, studies should define the 100-year flood plain within which FEMA guidelines should be applied. Flooding may still occur in undesignated areas near drainages on the map during extreme rainstorms, but such events are infrequent.

The map shows boundaries of Holocene alluvial fans, which are areas where alluvial-fan flooding and debris flows may occur. Site-specific studies in these areas should address parts of the fan surface that would be subject to channelized flow versus sheet flow, the potential for debris flows based on slope and channel conditions above the fan, and the effect of existing upstream structures that might divert or contain floods or flows.

Where the map indicates shallow ground-water flooding is a potential hazard, site-specific investigations should be performed to characterize ground-water conditions prior to development. The studies should determine the shallowest expected water table as controlled by seasonal precipitation, irrigation, and long-term fluctuations.

The U.S. Bureau of Reclamation has prepared dam-failure inundation maps for Jordanelle and Deer Creek Dams (see "Selected References"), as well as emergency-action plans. The Utah Division of Water Rights, Dam Safety Section, maintains emergency-action-plan files for the smaller dams in the area. The information in these documents should be used for land-use and emergency-response planning.

Earthquake Hazards

Hazard zones associated with ground shaking, earthquake-induced landslides, and liquefaction are not shown on the map as noted in the "Discussion." Standard soil-foundation reports should provide data for UBC site coefficients used in seismic design. Recommendations for landslide-hazard investigations are included on the landslide-hazard map of this folio (plates 1A-1D). In the area of moderate liquefaction potential, site-specific studies should be performed for proposed essential facilities (for example, hospitals, police and fire stations) to evaluate the hazard and recommend hazard-reduction measures.

The map shows special-study zones associated with the Bald Mountain and Round Valley faults. The hazard associated with the Bald Mountain fault appears to be low and need only be considered if essential facilities are planned within the special-study zone. Because of the lack of information on activity of the Round Valley faults, site-specific studies to evaluate the earthquake history on these faults and characterize the zone of deformation are recommended prior to development within the associated special-study zones.

The extent and degree of tectonic-subsidence hazard is difficult to predict, and hazard areas have not been delineated on the map. The hazard is proportional to the potential for surface fault rupture, as well as the length and expected vertical displacment of the fault, and is therefore low in western Wasatch County. In general, the areas between the Bald Mountain fault and Jordanelle Reservoir and in Round Valley between the valley-bounding faults may experience tectonic subsidence during a surface-rupturing earthquake on one of these faults. Site-specific investigations (recommended for proposed essential and special-use facilities in these areas; see "Discussion") should address the likelihood of faulting and anticipated extent of tectonic-subsidence-related flooding and ground tilt.

Problem Soils

The map shows boundaries of Holocene alluvial fans where collapsible soils may be found. The location of expansive soils in western Wasatch County is more difficult to predict, and expansive-soil hazard areas are not shown on the map. U.S. Soil Conservation Service maps indicate that soils with a high shrink-swell potential may be widespread in western Wasatch County (see "Selected References"). The potential for collapse or shrink-swell, along with other soil-engineering properties, should be evaluated in a standard soil-foundation report prior to development.

Maps in this folio:

- Landslide Hazard (Plates 1A-1D)
- Flood Hazards, Earthquake Hazards, and Problem Soils (Plates 2A-2D)
- Suitability for Wastewater Disposal in Septic-Tank Soil-Absorption Systems (Plates 3A-3D)

PLATE 2D

FLOOD HAZARDS, EARTHQUAKE HAZARDS, AND PROBLEM SOILS, WESTERN WASATCH COUNTY, UTAH

Michael D. Hylland and Charles E. Bishop

1995

Base from Center Creek, Twin Peaks, and Heber Mountain, Utah, USGS 7.5-minute topographic quadrangle maps.
Drafted by Noah P. Snyder

DISCUSSION

This map shows areas of relative suitability for wastewater disposal in properly designed, constructed, and maintained septic-tank soil-absorption (STSA) systems. The map is one of four sheets that cover the western Wasatch County study area (see "Location Map and Index to Sheets" at bottom of map).

Site characteristics critical to the proper functioning of a conventional STSA system include soil type, depth to ground water, depth to bedrock, slope steepness and stability, and flood hazard. The permeability and filtering capacity of a soil depends on its texture (grain-size distribution) and structure (arrangement of particles). Soils with a high clay content seldom possess sufficient permeability to function properly in a STSA system, particularly if the clay minerals are expansive. Such soils may perform satisfactorily for a short time, but insufficient permeability eventually causes system failure as the soil becomes saturated and swells. If soils are too coarse grained and lack fine particles, permeabilities may be too high and filtering capability too low to effectively filter contaminants from the effluent. Under such conditions ground-water contamination is a concern. In areas where ground water is shallow, the potential for ground-water contamination is increased, as is the possibility of system saturation and failure. STSA systems installed in or just above bedrock may lead to the pollution of ground water in rock aquifers with high fracture permeability and low filtering capability, or to system failure in rock with low permeability.

Surface seepage may result when STSA systems are installed on steep slopes, especially where impermeable soil horizons or caliche layers restrict the downward movement of the effluent and force it to migrate laterally to a slope face. STSA systems on potentially unstable slopes can destabilize the slopes by increasing soil moisture. In addition to destroying the STSA system, the resultant slope failure can damage other structures and property. Flooding presents a hazard to STSA systems because associated erosion can damage the system. Also, floodwaters infiltrating the ground may flood the system and cause failure and/or carry fine sand and silt into distribution lines, causing them to plug.

Geologic, hydrologic, and soil conditions in western Wasatch County are variable, and as a result, the suitability for STSA systems varies widely. Large portions of the area are characterized by shallow or exposed bedrock, shallow ground water, and/or slow soil permeability. Other areas are generally suitable for STSA systems or have limiting conditions that are either localized or can be accommodated in system design.

USE OF THIS MAP

The relative STSA suitability consists of four categories: (I) generally suitable, (II) generally suitable but locally unsuitable, (III) generally unsuitable but locally suitable, and (IV) generally unsuitable. The mapped boundaries of the relative-suitability areas should be considered gradational, representing zones of transition rather than distinct boundaries.

The criteria used to define the relative-suitability categories are based on Wasatch City-County Health Department requirements. Site conditions critical in establishing the suitability categories are denoted on the map by qualifiers (a through e) and geologic-hazards designations (F and L) (see map Explanation). These conditions and sources of data include:

- soil percolation rates from U.S. Soil Conservation Service information,
- seasonal ground-water depth from water wells, Wasatch City-County Health Department, and Natural Resources Conservation Service,
- depth to bedrock from Utah Geological Survey (UGS) surficial-geologic maps,
- slope inclination from slope maps generated by the Wasatch County Geographical Information Systems Department,
- flood-hazard areas determined from Federal Emergency Management Agency and Federal Insurance Administration maps and UGS surficial-geologic maps, and
- landslide-hazard areas from UGS surficial-geologic maps.

In general, a suitability designation of "I" indicates that site conditions are favorable for proper functioning of a STSA system, and the risk of system failure due to geologic or hydrologic factors is low. Areas designated as "II," "III," and "IV," respectively, have certain limiting conditions of progressively greater extent. For example, a map area designated as "IIa" indicates that site conditions should be favorable over most of the area, but slow percolation rates should be expected locally. In contrast, a map area designated as "IIIa" indicates that slow percolation rates should be expected over most of the area, and favorable conditions should exist only locally. Extensive investigation may be required to locate acceptable STSA-system sites within areas of suitability category "III." Within areas of suitability category "IV," unfavorable site conditions should be expected over the entire area, and alternative methods of wastewater disposal, such as sewers, will likely be necessary.

This map is intended to be used as a tool for highlighting possible geologic and hydrologic conditions that might affect the performance of proposed STSA systems. It will be most effective if used to guide planning decisions regarding the suitability of particular areas for conventional STSA systems or alternative methods of wastewater disposal, such as mound systems, pressure-distribution systems, or sewers. The relative suitability for conventional STSA systems is based on geologic conditions expected in an area, and does not reflect considerations such as aquifer recharge areas, proximity to lake shores or streams, and STSA-system density.

The map is at a regional scale and, although it can be used to gain an understanding of the general suitability for STSA systems in a given area, it is not intended to provide information for design of on-site wastewater-disposal systems. Site-specific suitability evaluations performed by qualified professionals (engineering geologists, geotechnical engineers, health department officials) including percolation tests and determination of depth to ground water, depth to bedrock, and topographic slope, are necessary prior to installation of any new STSA system. Additionally, flood and landslide hazards should be evaluated in areas where those hazards are indicated on the map. Plates 1A through 1D (Landslide Hazard) and 2A through 2D (Flood Hazards, Earthquake Hazards, and Problem Soils) of this map folio include discussions of these hazards and recommendations for hazard-evaluation studies. STSA systems may be feasible within some of these hazard areas with proper hazard-reduction measures or site modification.

EXPLANATION

Suitability:

I	Generally suitable
II	Generally suitable but locally unsuitable
III	Generally unsuitable but locally suitable
IV	Generally unsuitable

Qualifiers:

a	Slow percolation rate (greater than 60 minutes per inch)
b	Fast percolation rate (less than 4 minutes per inch)
c	Depth to shallowest expected water table 0-5 feet
d	Depth to bedrock (including tufa in Midway area) 0-5 feet
e	Slope steeper than 25 percent

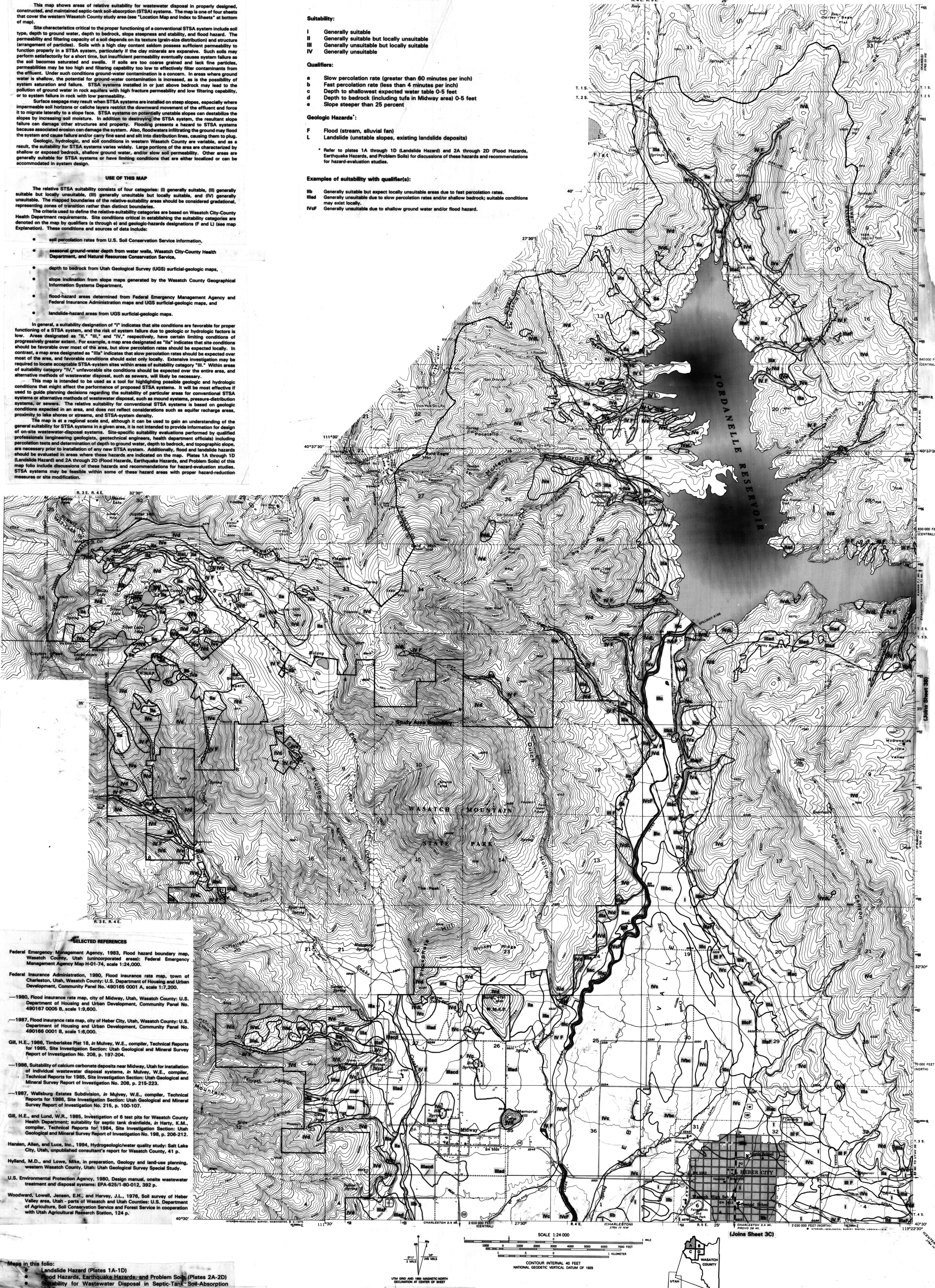
Geologic Hazards*:

F	Flood (stream, alluvial fan)
L	Landslide (unstable slopes, existing landslide deposits)

* Refer to plates 1A through 1D (Landslide Hazard) and 2A through 2D (Flood Hazards, Earthquake Hazards, and Problem Soils) for discussions of these hazards and recommendations for hazard-evaluation studies.

Examples of suitability with qualifier(s):

IIb	Generally suitable but expect locally unsuitable areas due to fast percolation rates.
IIIad	Generally unsuitable due to slow percolation rates and/or shallow bedrock; suitable conditions may exist locally.
IVcF	Generally unsuitable due to shallow ground water and/or flood hazard.



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I Generally suitable
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III Generally unsuitable but locally suitable
IV Generally unsuitable

Qualifiers:

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b Fast percolation rate (less than 4 minutes per inch)
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d Depth to bedrock (including tufa in Midway area) 0-5 feet
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L Landslide (unstable slopes, existing landslide deposits)

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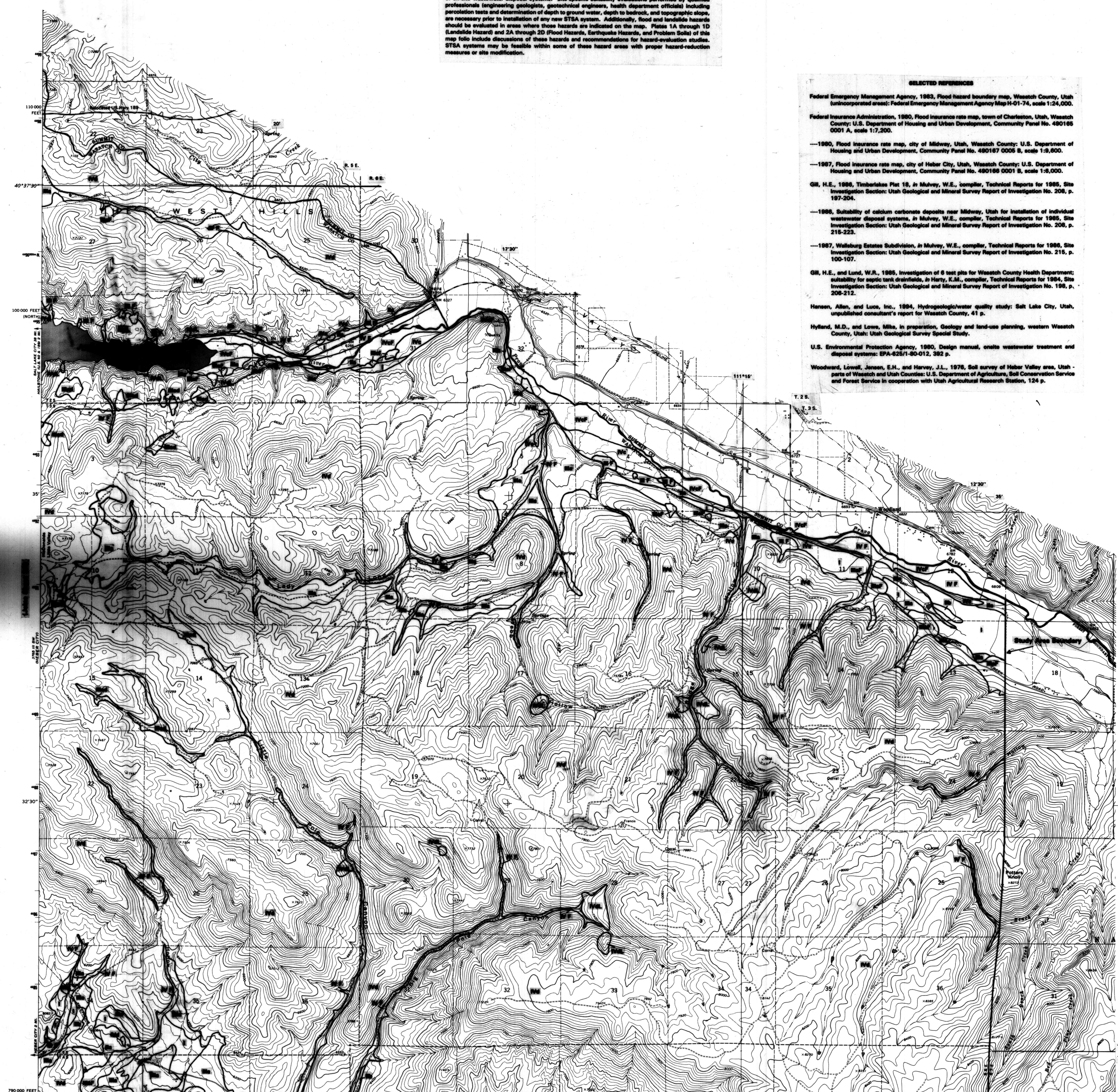
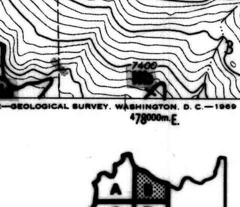


SCALE 1:24 000

CONTOUR INTERVAL 40 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

UTM GRID AND 1983 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET



Location Map and Index to Sheets

Maps in this folio:
- Landslide Hazard (Plates 1A-1D)
- Flood Hazards, Earthquake Hazards, and Problem Soils (Plates 2A-2D)
- Suitability for Wastewater Disposal in Septic-Tank Soil-Absorption Systems (Plates 3A-3D)

PLATE 3B

SUITABILITY FOR WASTEWATER DISPOSAL IN SEPTIC-TANK SOIL-ABSORPTION SYSTEMS, WESTERN WASATCH COUNTY, UTAH

Michael D. Hylland

1995

EXPLANATION

Suitability:

- **I** Generally suitable
- **II** Generally suitable but locally unsuitable
- **III** Generally unsuitable but locally suitable
- **IV** Generally unsuitable

Qualifiers:

- **a** Slow percolation rate (greater than 60 minutes per inch)
- **b** Fast percolation rate (less than 4 minutes per inch)
- **c** Depth to shallowest expected water table 0-5 feet
- **d** Depth to bedrock (including tufa in Midway area) 0-5 feet
- **e** Slope steeper than 25 percent

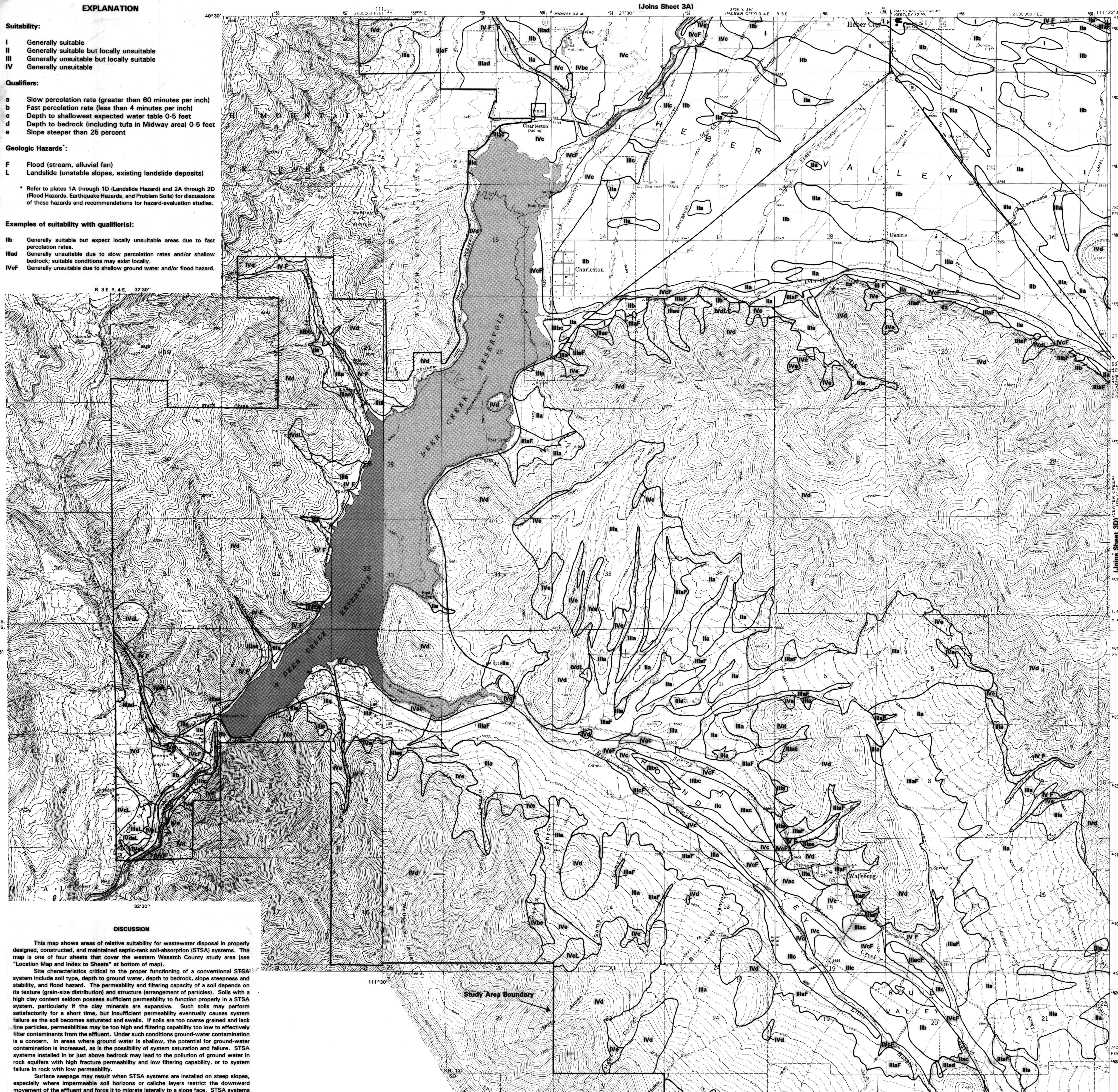
Geologic Hazards*:

- **F** Flood (stream, alluvial fan)
- **L** Landslide (unstable slopes, existing landslide deposits)

* Refer to plates 1A through 1D (Landslide Hazard) and 2A through 2D (Flood Hazards, Earthquake Hazards, and Problem Soils) for discussions of these hazards and recommendations for hazard-evaluation studies.

Examples of suitability with qualifier(s):

- **IIb** Generally suitable but expect locally unsuitable areas due to fast percolation rates.
- **IIIad** Generally unsuitable due to slow percolation rates and/or shallow bedrock; suitable conditions may exist locally.
- **IVcF** Generally unsuitable due to shallow ground water and/or flood hazard.



DISCUSSION

This map shows areas of relative suitability for wastewater disposal in properly designed, constructed, and maintained septic-tank soil-absorption (STSA) systems. The map is one of four sheets that cover the western Wasatch County study area (see "Location Map and Index to Sheets" at bottom of map).

Site characteristics critical to the proper functioning of a conventional STSA system include soil type, depth to ground water, depth to bedrock, slope steepness and stability, and flood hazard. The permeability and filtering capacity of a soil depends on its texture (grain-size distribution) and structure (arrangement of particles). Soils with a high clay content seldom possess sufficient permeability to function properly in a STSA system, particularly if the clay minerals are expansive. Such soils may perform satisfactorily for a short time, but insufficient permeability eventually causes system failure as the soil becomes saturated and swells. If soils are too coarse grained and lack fine particles, permeabilities may be too high and filtering capability too low to effectively filter contaminants from the effluent. Under such conditions ground-water contamination is a concern. In areas where ground water is shallow, the potential for ground-water contamination is increased, as is the possibility of system saturation and failure. STSA systems installed in or just above bedrock may lead to the pollution of ground water in rock aquifers with high fracture permeability and low filtering capability, or to system failure in rock with low permeability.

Surface seepage may result when STSA systems are installed on steep slopes, especially where impermeable soil horizons or caliche layers restrict the downward movement of the effluent and force it to migrate laterally to a slope face. STSA systems on potentially unstable slopes can destabilize the slopes by increasing soil moisture. In addition to destroying the STSA system, the resultant slope failure can damage other structures and property. Flooding presents a hazard to STSA systems because associated erosion can damage the system. Also, floodwaters infiltrating the ground may flood the system and cause failure and/or carry fine sand and silt into distribution lines, causing them to plug.

Geologic, hydrologic, and soil conditions in western Wasatch County are variable, and as a result, the suitability for STSA systems varies widely. Large portions of the area are characterized by shallow or exposed bedrock, shallow ground water, and/or slow soil permeability. Other areas are generally suitable for STSA systems or have limiting conditions that are either localized or can be accommodated in system design.

USE OF THIS MAP

The relative STSA suitability consists of four categories: (I) generally suitable, (II) generally suitable but locally unsuitable, (III) generally unsuitable but locally suitable, and (IV) generally unsuitable. The mapped boundaries of the relative-suitability areas should be considered gradational, representing zones of transition rather than distinct boundaries.

The criteria used to define the relative-suitability categories are based on Wasatch City-County Health Department requirements. Site conditions critical in establishing the suitability categories are denoted on the map by qualifiers (a through e) and geologic-hazards designations (F and L) (see map Explanation). These conditions and sources of data include:

- soil percolation rates from U.S. Soil Conservation Service information,
- seasonal ground-water depth from water wells, Wasatch City-County Health Department, and Natural Resources Conservation Service,
- depth to bedrock from Utah Geological Survey (UGS) surficial-geologic maps,
- slope inclination from slope maps generated by the Wasatch County Geographical Information Systems Department,
- flood-hazard areas determined from Federal Emergency Management Agency and Federal Insurance Administration maps and UGS surficial-geologic maps, and
- landslide-hazard areas from UGS surficial-geologic maps.

In general, a suitability designation of "I" indicates that site conditions are favorable for proper functioning of a STSA system, and the risk of system failure due to geologic or hydrologic factors is low. Areas designated as "II," "III," and "IV," respectively, have certain limiting conditions of progressively greater extent. For example, a map area designated as "IIa" indicates that site conditions should be favorable over most of the area, but slow percolation rates should be expected locally. In contrast, a map area designated as "IIIa" indicates that slow percolation rates should be expected over most of the area, and favorable conditions should exist only locally. Extensive investigation may be required to locate acceptable STSA-system sites within areas of suitability category "III." Within areas of suitability category "IV," unfavorable site conditions should be expected over the entire area, and alternative methods of wastewater disposal, such as sewers, will likely be necessary.

This map is intended to be used as a tool for highlighting possible geologic and hydrologic conditions that might affect the performance of proposed STSA systems. It will be most effective if used to guide planning decisions regarding the suitability of particular areas for conventional STSA systems or alternative methods of wastewater disposal, such as mound systems, pressure-distribution systems, or sewers. The relative suitability for conventional STSA systems is based on geologic conditions expected in an area, and does not reflect considerations such as aquifer recharge areas, proximity to lake shores or streams, and STSA-system density.

The map is at a regional scale and, although it can be used to gain an understanding of the general suitability for STSA systems in a given area, it is not intended to provide information for design of on-site wastewater-disposal systems. Site-specific suitability evaluations performed by qualified professionals (engineering geologists, geotechnical engineers, health department officials) including percolation tests and determination of depth to ground water, depth to bedrock, and topographic slope, are necessary prior to installation of any new STSA system. Additionally, flood and landslide hazards should be evaluated in areas where those hazards are indicated on the map. Plates 1A through 1D (Landslide Hazard) and 2A through 2D (Flood Hazards, Earthquake Hazards, and Problem Soils) of this map folio include discussions of these hazards and recommendations for hazard-evaluation studies. STSA systems may be feasible within some of these hazard areas with proper hazard-reduction measures or site modification.

SELECTED REFERENCES

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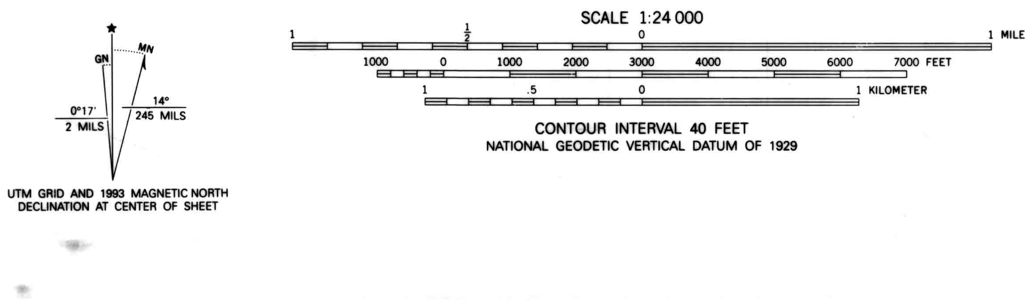

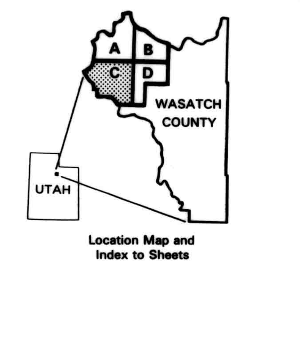

Location Map and Index to Sheets

PLATE 3C

SUITABILITY FOR WASTEWATER DISPOSAL IN SEPTIC-TANK SOIL-ABSORPTION SYSTEMS, WESTERN WASATCH COUNTY, UTAH

Michael D. Hylland
1995

Maps in this folio:

- Landslide Hazard (Plates 1A-1D)
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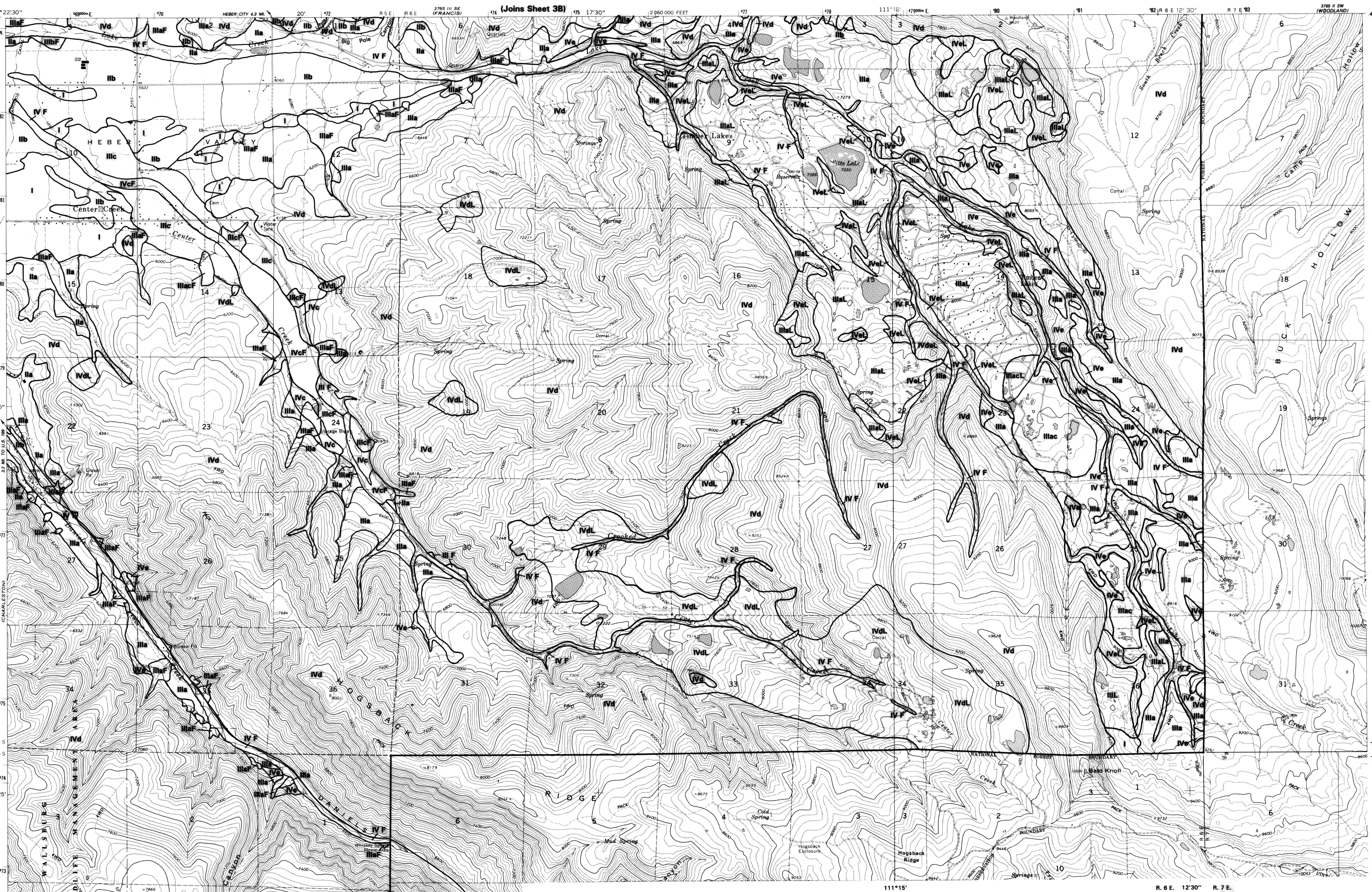
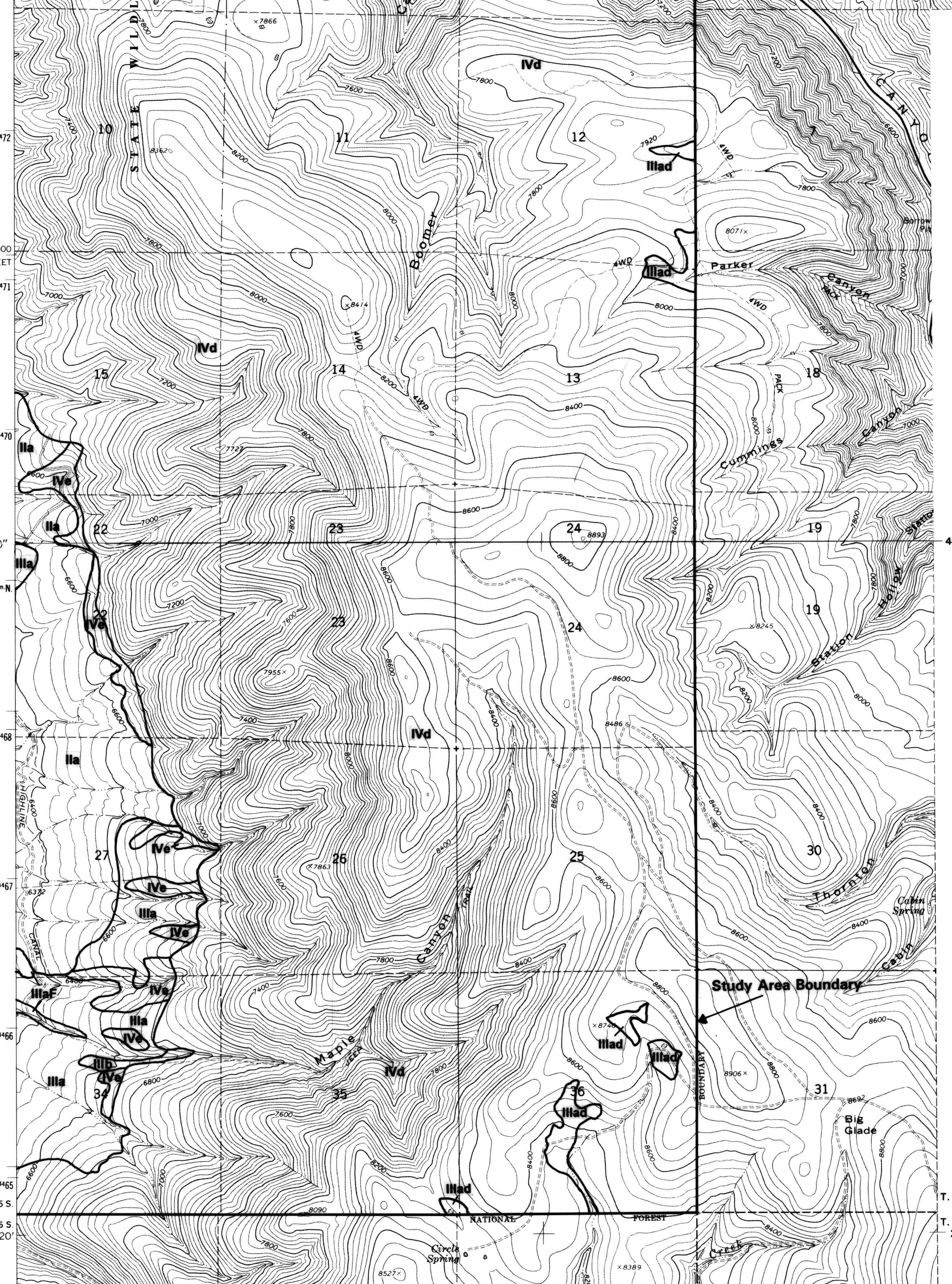
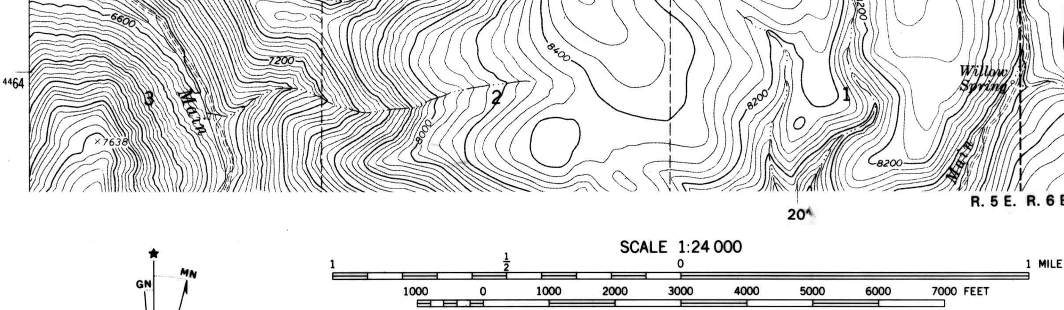
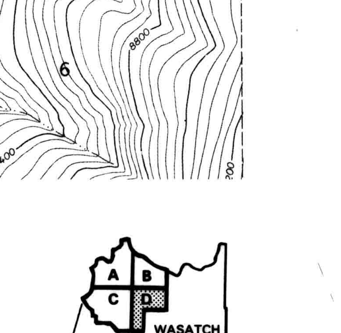
- Suitability for Wastewater Disposal in Septic-Tank Soil-Absorption Systems (Plates 3A-3D)

Base from Aspen Grove, Charleston, and Wallsburg Ridge, Utah, USGS 7.5-minute topographic quadrangle maps.
Drafted by Noah P. Snyder









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EXPLANATION

Suitability:

I Generally suitable
II Generally suitable but locally unsuitable
III Generally unsuitable but locally suitable
IV Generally unsuitable

Qualifiers:

a Slow percolation rate (greater than 60 minutes per inch)
b Fast percolation rate (less than 4 minutes per inch)
c Depth to shallowest expected water table 0-5 feet
d Depth to bedrock (including tufa in Midway area) 0-5 feet
e Slope steeper than 25 percent

Geologic Hazards*:

F Flood (stream, alluvial fan)
L Landslide (unstable slopes, existing landslide deposits)

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PLATE 3D

SUITABILITY FOR WASTEWATER DISPOSAL IN SEPTIC-TANK SOIL-ABSORPTION SYSTEMS, WESTERN WASATCH COUNTY, UTAH

Michael D. Hylland

1995

Base from Center Creek, Twin Peaks, and Heber Mountain, Utah, USGS 7.5-minute topographic quadrangle maps.
Drafted by Noah P. Snyder

Maps in this folio:

- Landslide Hazard (Plates 1A-1D)
- Flood Hazards, Earthquake Hazards, and Problem Soils (Plates 2A-2D)
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