ENGINEERING GEOLOGIC CASE STUDIES IN UTAH
1986

Edited by William R. Lund

UTAH GEOLOGICAL AND MINERAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
SPECIAL STUDIES 68 **1986**

STATE OF UTAH
Norman H. Bangerter, Governor

DEPARTMENT OF NATURAL RESOURCES
Dee C. Hansen, Executive Director

UTAH GEOLOGICAL AND MINERAL SURVEY
Genevieve Atwood, Director

UGMS Editorial and Illustrations Staff

J. Stringfellow .... Editor
Leigh M. MacManus, Carolyn M. Olsen .... Editorial Staff
Kent D. Brown, James W. Parker, Patricia H. Speranza .... Cartographers

ENGINEERING GEOLOGIC CASE STUDIES IN UTAH
1986

Edited by William R. Lund

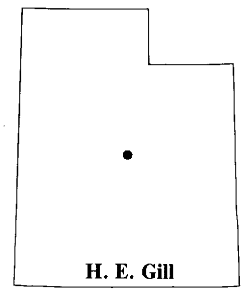
UTAH GEOLOGICAL AND MINERAL SURVEY
a division of
UTAH DEPARTMENT OF NATURAL RESOURCES
SPECIAL STUDIES 68 1986

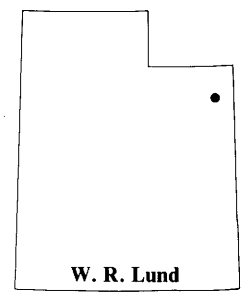
FORWARD
by
William R. Lund

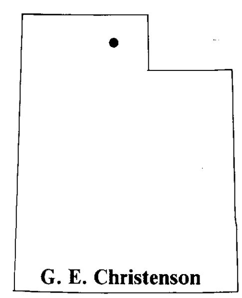
The Utah Geological and Mineral Survey (UGMS) maintains an active program of engineering geologic research and investigation throughout the state. An important part of that program, as mandated by the state legislature, is providing assistance to tax-supported entities on matters where geology is of concern. As a result, the Site Investigation Section within the UGMS's Applied Geology program undertakes a wide variety of projects in response to requests from cities, towns, counties, special service districts, and other state agencies. The projects can be of either short or long duration and vary from the simple to the complex. Information dissemination is a major goal of the UGMS, and the results of Site Investigation projects are published in a vareity of formats. Because the majority of studies are special-purpose projects that address specific problems of interest to a limited audience, they are usually released as technical memoranda. However, the number produced is still comparatively small and, in general, figures and tables are not drafted to the standards used for more formal UGMS publications. Special Studies are reserved for projects of enduring interest, are subject to an intensive review and editorial process, and are available for sale at the UGMS. Reports of Investigation may be obtained for the cost of reproduction at the UGMS sales desk.

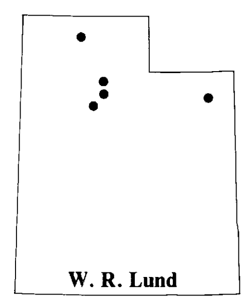
This Special Studies is unique in that it consists of a compilation of five Reports of Investigation done over a period of four years by various geologists within the Site Investigation Section. Taken together, they represent a body of work that is both typical of UGMS applied geology projects, and demonstrative of techniques and methodologies with broad application to the field of engineering geology. However, because the reports were previously issued in response to requests for geologic assistance, and in some instances were used as decision documents by the requesting entity, they have not been substantially altered, and in general do not conform to current UGMS editorial standards.

The paper by Gill discusses problems associated with development in a mountain watershed that also supplies culinary water to a nearby community. It should be of interest to planners and public health officials. Christenson and Klauk consider the application of engineering geology to land-use planning: Christenson for a rapidly growing, but essentially rural community, and Klauk for a multi-acre research facility in a major urban area. The two papers by Lund deal with different aspects of waste disposal. The first is a semi-regional evaluation of suitability for wastewater disposal utilizing septic tank and soil absorption systems, and the other is a preliminary geologic evaluation and ranking of five sites being considered for hazardous waste disposal facilities. Each of the five studies demonstrates the application of geologic principles to the solving of a specific problem. Moreover, they show the utility of such investigations both as a planning tool and for recognizing and mitigating geologic hazards.









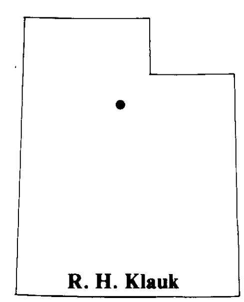


TABLE OF CONTENTS

Geologic and Hydrologic Evaluation of Mt. Pleasant Watershed Sanpete County, Utah, by H.E. Gill 1

Abstract 1
Introduction 1
Purpose and Scope 2
Setting 2
Basic data and interpretive maps 2
General geology 2
Soils 3
Surface hydrology 4
Culinary water supply 4
Geologic hazards 4
  Flooding and erosion potential 4
  Slope stability 5
  Earthquake potential 7
Watershed contamination 8
Conclusions and recommendations 8
References 8

ILLUSTRATIONS

Figure 1. General location map, Mt. Pleasant watershed, Sanpete County, Utah 1
2. North-facing cirque at head of Straight Fork of Pleasant Creek 4
3. Map of springs supplying culinary water to Mt. Pleasant City 5
4. Forest Service-terraced land to retard erosion until protective vegetation cover becomes established 5
5. Rock fall hazard due to road cut in Straight Fork of Pleasant Creek 7
6. Slope failure due to road cut near North Fork Creek 7
7. Major landslides and erosion, probably because of weakened slope due to high-angle fault 7
8. Slump-earth flow at head of Blue Slide Fork of Pleasant Creek 8

TABLES

Table 1. Generalized geologic section and water-bearing properties of the principal formations exposed in the Mt. Pleasant Watershed, from Robinson, 1971 3
2. Abstract accounts of significant cloudburst floods in Mt. Pleasant, Utah 6

PLATES

Plate 1. Geology 11
2. Soils 13
3. Surface hydrology 15
4. Slope stability 17
5. Suitability for septic tank absorption fields 19

Geologic Evaluation of Septic Tank and Soil Absorption System Suitability, Dry Fork Canyon, Uintah County, Utah, by W.R. Lund 21

Abstract 21
Introduction 21
Purpose and Scope 21
Setting 22
General geology 22
Hydrology 23

TABLE OF CONTENTS

Septic tank and soil absorption systems 23
  Survey of existing domestic wastewater disposal problems 24
  Site evaluation criteria 25
  Site suitability evaluation 26
Summary 27
Glossary 27
References 28

ILLUSTRATIONS

Figure 1. Location map 22

TABLES

Table 1. Results of water quality analyses from selected wells and surface water sites in Dry Fork Canyon, Utah 24

PLATES

Plate 1. Geology 31
2. Estimated depth to the seasonal high stand of the shallow water table 33
3. Suitability for wastewater disposal in soil absorption systems 35

Engineering Geology for Land-Use Planning, Smithfield, Utah, by G.E. Christenson 37

Abstract 37
Introduction 37
Purpose and scope 38
Setting 38
Geology 38
Soils 39
Ground water 39
  Occurrence 39
  Quality 40
    Wells 41
    Springs 41
Suitability for wastewater disposal in soil absorption systems 42
Geologic hazards 43
  Flooding and debris flow 43
  Slope stability 43
  Adverse foundation conditions 44
  Seismicity and earthquake potential 44
Conclusions and recommendations 46
References 46

ILLUSTRATIONS

Figure 1. Location map 37
2. Schematic block diagram showing relation of confined, unconfined, and perched ground water in the Smithfield area 40
3. Location of earthquake epicenters of Richter magnitude 2.0 or greater in the Cache Valley area, 1850 through September 1983 45

TABLES

Table 1. Discharge data for springs 3 and 4 (pl. 3) during 1983 42
2. Nitrate concentration in springs 2 and 4 (pl. 3) 42

TABLE OF CONTENTS

PLATES

Plate 1. Geology 49
2. Soils 51
3. Ground water 53
4. Suitability for wastewater disposal in soil absorption systems 55
5. Geologic hazards 57

Preliminary Geologic Evaluation of Five Proposed Hazard Waste Facility Sites in Utah, by W.R. Lund 59

Abstract 59
Introduction 59
Purpose and scope 60
Regional setting 60
Site characterization 60
Site 1: Hansel Valley 60
Site 2: Rush Valley 61
Site 3: Salt Lake Valley 62
Site 4: Cedar Valley 63
Site 5: Ashley Valley 64
Prelimary site evaluation and ranking 65
Conclusions and recommendations 66
General References 66
Guidelines for the conduct of site-suitability investigations and preparation of geologic reports for hazardous waste facilities 69
General comments on geologic mapping and report preparation 69
General information 70
Specific geotechnical information 70
General geology descriptions 70
Analysis of relationship of geologic factors and hazardous waste disposal 71
References 72

ILLUSTRATIONS

Figure 1. Location map showing proposed hazardous waste sites 60
2. Hansel Valley site; T. 12 N., R. 8 W., sec. 23, SLB&M 61
3. Rush Valley site; T. 7 S., R. 5 W., sec. 9, SLB&M 62
4. Salt Lake Valley site; T. 3 S., R. 2 W., SLB&M 63
5. Cedar Valley site; T. 6 S., R. 2 W., sec. 22, SLB&M 64
6. Ashley Valley site; T. 4 S., R. 22 E., sec. 9, SLB&M 65

TABLES

Table 1. Preliminary ranking of sites according to geologic suitability for hazardous waste facilities 65

Engineering Geology for Land-Use Planning for Research Park, University of Utah, Salt Lake City, Utah, by R.H. Klauk 73

Abstract 73
Introduction 73
Background and Purpose 73
Scope of Work 74
Setting 74

TABLE OF CONTENTS

Geology 74
Soils 76
Ground water 77
Geologic hazards 77
  Flooding 77
  Slope instability 78
  Adverse foundation conditions 78
  Seismicity 79
Conclusions and recommendations 81
References 81

ILLUSTRATIONS

Figure 1. Location map of Research Park, Salt Lake City, Utah 74
2. Photograph showing alluvial-fan deposits overlying lacustrine sediments in an area previously mapped as Lake Bonneville deposits 75
3. Faults and areas of deformed sediments in the vicinity of Research Park, Salt Lake City, Utah 76
4. Ground water under unconfined, artesian, and perched conditions in Salt Lake County, Utah 77
5. Location of earthquake epicenters in the Salt Lake City area, 1850 through September, 1984 80

TABLES

Table 1. Earthquakes greater than Richter magnitude 4.0 within 15 miles of Research Park, Salt Lake City, Utah, 1850 to September 1984 79

PLATES

Plate 1. Geology 83
2. Soils 85
3. Geologic hazards 87

APPENDICES

Appendix 1. Well- and spring-numbering systems used in Utah 90
2. Intensified design review and field inspection in Utah Seismic Safety Advisory Council Zone U-4 91
3. Modified Mercalli intensity scale of 1931 92
4. Unified soil classification system 93
5. Geologic time and formations 94

REPORT OF INVESTIGATION NO. 169
GEOLOGIC AND HYDROLOGIC EVALUATION OF MT. PLEASANT WATERSHED SANPETE COUNTY

by
Harold E. Gill

ABSTRACT

The city of Mt. Pleasant obtains its culinary water from springs located in a mountain watershed east of the town. Increased recreational activity and development of summer homes in that area pose a potential threat to the city's water supply. Information on the geology of the watershed is required to adequately plan for future growth and to insure a continued supply of high-quality water.

The Mt. Pleasant watershed lies on the west slope of the Wasatch Plateau, a zone of structural transition between the Colorado Plateau and Basin and Range physiographic provinces. Bedrock in the study area includes the Cretaceous Blackhawk, Price River and North Horn Formations, and the Tertiary Flagstaff Limestone. Glacial deposits of Quaternary age are found at higher elevations. Recent unconsolidated sediments are of two types: alluvium along the mountain front and in stream channels, and colluvium on mountain slopes. Bedrock in the plateau is warped into a series of broad, gentle flexures except at the western edge, where dips steepen abruptly to form the Wasatch monocline. Several high-angle, north-south-trending normal faults cross the watershed and produce large displacements in the monocline down to the west. The faults do not show evidence of geologically recent activity, and no earthquakes of Richter magnitude 5 or greater have been recorded within 20 miles of the study area.

The greatest hazard to the watershed is from contamination of culinary water supplies by failure of septic tank and soil absorption systems. Approximately 90 percent of the study area is unsuitable for soil absorption systems because of shallow bedrock, steep and locally unstable slopes, flood hazard, and/or moderate- to low-permeability soils. Future development in the watershed should be permitted only in areas mapped as suitable for soil absorption systems. In addition, soil and foundation investigations are recommended prior to development due to the widespread occurrence of shrink-swell-susceptible soils and large number of landslides in the North Horn Formation.

INTRODUCTION

The Mt. Pleasant watershed (approximate area 26 square miles) is about 2.5 miles east of Mt. Pleasant City on the west slope of the Wasatch Plateau in Sanpete County, Utah (figure 1). The watershed is primarily used for recreation activities such as camping, skiing, hunting, and trail riding, both on motorcycles and 4-wheel drive vehicles. Three springs comprising Mt. Pleasant's culinary water supply are located in the southern portion of the study area. With continued growth, a need may arise for additional water sources within the watershed. Several cabins with individual wastewater disposal systems have already been built in the

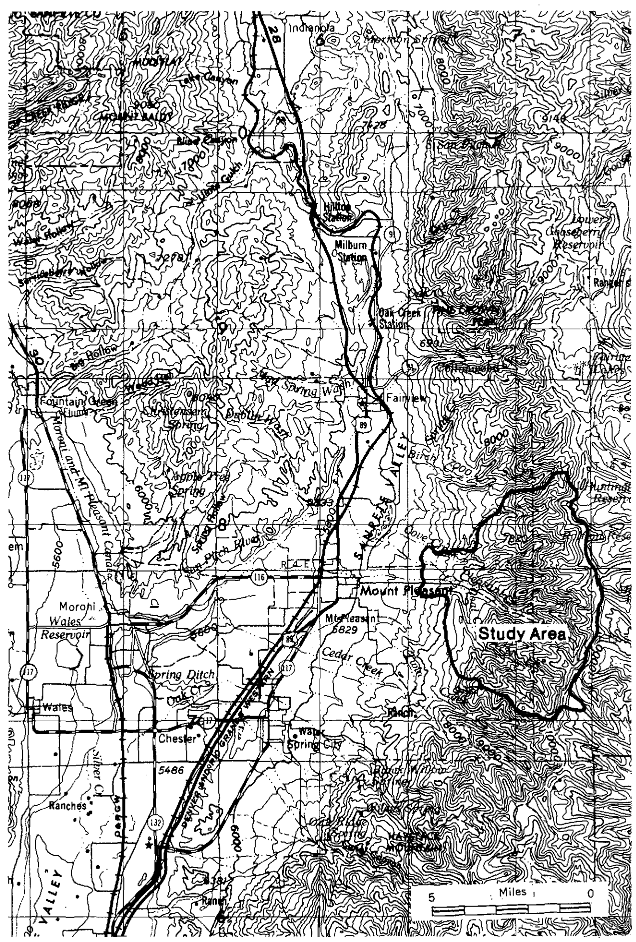


Figure 1. General location map, Mt. Pleasant watershed, Sanpete County, Utah.

northwest portion of the study area and others are planned. In view of this, and the likelihood of continued recreational use, this study was requested by Mt. Pleasant City to provide a geologic and hydrologic evaluation of the watershed. Of major concern during the investigation was an analysis of the potential for ground-water contamination, particularly of the city's existing culinary water supply.

PURPOSE AND SCOPE

The intent of this report is to provide geologic, hydrologic, and soils information on the Mt. Pleasant watershed which will allow city planners and others to evaluate development proposals by recognizing geologic hazards and identifying land-use conflicts. To accomplish this, a series of basic data and interpretive maps were prepared for the watershed. Basic data maps include Geology, Soils, and Surface Hydrology. The interpretative maps are Slope Stability and Suitability for Septic Tank Absorption Fields. An explanation is included on each interpretive map that allows it to be used independently of this text. To complete the study, the following scope of work was undertaken:

1. Review of available published and unpublished reports, well logs, and maps pertaining to the geology, hydrology, and soils of the study area;

2. Geologic mapping from aerial photographs, followed by three days of field reconnaissance to check mapping and verify data gathered during the literature search;

3. Preparation of basic data maps, interpretive maps, and accompanying text.

SETTING

The Mt. Pleasant watershed lies on the west slope of the Wasatch Plateau in central Utah. The climate in the region is semi-arid with less than 20 inches of rainfall per year. Winter and spring are the two wettest seasons. The western slope of the plateau is drained by a large number of perennial streams tributary to the San Pitch River in Sanpete Valley. The San Pitch River flows south and joins the Sevier River west of Gunnison. The streams in the Mt. Pleasant watershed have cut deep V-shaped canyons into the west face of the plateau. The profiles of the canyon walls reflect the underlying rock type, with more resistant rock units (sandstone and limestone) forming cliffs while less resistant rock units (shale) weather to gentle slopes.

The summit of the Wasatch Plateau forms the eastern boundary of the study area and is the drainage divide between the Colorado River Basin to the east and the Great Basin to the west.

BASIC DATA AND INTERPRETIVE MAPS

Basic data maps prepared for this study include Geology, Soils, and Surface Hydrology (Plates 1, 2 and 3). These maps present basic geologic, soild, and hydrologic information required to make interpretations pertaining to waste disposal and slope stability. A discussion of the data presented on the basic data maps, as well as information pertaining to other geologic considerations is presented in this report. Two interpretive maps, Slope Stability and Suitability for Septic Tank Absorption Fields (Plates 4 and 5), were prepared for use by city planners. An explanation is included on each interpretive map that allows it to be used independently of this text.

GENERAL GEOLOGY

The Wasatch Plateau occupies a zone of structural transition between the Colorado Plateau to the east and the Great Basin to the west. Regionally, the rocks of the plateau are warped into broad gentle folds but, considered over a limited area, the bedding is essentially horizontal. The west slope of the Wasatch Plateau is formed by the Wasatch monocline. As a result, rock units in the study area dip steeply to the west toward the Sanpete and Sevier Valleys. Equivalent beds across the monocline show an elevation difference of 6,000 to 7,000 feet. The strike of the monocline is approximately N. 20°-30° E. and the dip of the steepest beds between Mt. Pleasant and Fairview averages between 25°-33° W. (Pashley, 1956).

Bedrock exposed in the study area ranges in age from middle Cretaceous to early Tertiary (100 my to 30 my B.P.) and includes, from oldest to youngest, the Blackhawk, Price River, North Horn, and Flagstaff Formations (table 1).

A prominent north-trending normal fault approximately 7.5 miles east of Mt. Pleasant has displaced the Wasatch monocline (plate 1). Nearly vertical cliffs of the more resistant beds in the Blackhawk, Price River, and North Horn Formations are found on the upthrown eastern side of the fault. Gentle west-dipping beds of the North Horn and Flagstaff Formations are present at the base of the plateau west of the fault.

Several high-angle faults traverse the watershed from north to south. Spieker (1946) believes that the faulting occurred concurrently with the formation of the Wasatch monocline, between the Miocene and the Eocene Epochs (11 to 60 my B.P.) of the Tertiary Period. The youngest faults near the study area are approximately 4 miles east-southeast of the eastern watershed boundary. The approximate date of the last movement of these faults is late Pleistocene, approximately 10,000 to 500,000 years B.P. (Anderson and Miller, 1979).

Evidence of glaciation was recognized at higher elevations of the Wasatch Plateau by Spieker and Billings (1940). They found cirques, U-shaped valleys, and moraines typical of alpine glaciation. They also saw several east-facing cirques along the crest of the plateau just east of the study area. A north-facing cirque was recognized at the head of Coal Fork of Mt. Pleasant Creek. Pashley (1956) mapped two small, well-developed, north-facing cirques, one at the head of Straight Fork of Pleasant Creek (figure 2) and the other at the head of South Fork of Cove Creek. These cirques are the only evidence of glaciation in the study area. They were formed by small mountain glaciers that did not develop moraines or extend far enough down the canyons to alter their V-shaped profiles.

Table 1. Generalized geologic section and water-bearing properties of the principal formations exposed in the Mt. Pleasant Watershed, from Robinson, 1971.

System	Series	Stratigraphic Unit	Maximum thickness (feet)	Area of exposure	Description of rocks	Water-bearing properties
Quaternary	Pleistocene and Holocene	Valley fill	500 +	Forms the valley floors in Sanpete and Arapien Valleys and is exposed along several of the major streams entering the valleys from the Wasatch Plateau.	Consists mostly of coalescing alluvial fans, floodplain deposits of the San Pitch River, and possible lacustrine deposits at depth beneath the valley floors; mostly boulders, cobbles, gravel, sand, silt, and clay.	Principal aquifer in the San Pitch River drainage basin; low to high permeability; yields small to very large quantities of water to wells and springs.
Tertiary	Upper Paleocene and lower Eocene (?)	Flagstaff Limestone	1,500	Exposed on Wasatch Plateau in northern part of area and as principal formation in southern part of area; also exposed on the central and southern San Pitch Mountains and as patches on Cedar Hills.	Tan and gray to blue freshwater limestone predominating, with interbedded gray shale and sandstone, contains algal limestone; lacustrine origin.	Probably low primary permeability but locally very high permeability in solution channels along fractures and joints; yields small to large quantities of water to numerous springs on the Wasatch Plateau, the largest of which are used for municipal supplies.
Cretaceous	Paleocene and Upper Cretaceous	Local unconformity North Horn Formation	2,400	Exposed on Wasatch Plateau from Ephraim to north of Milburn; exposed in central part and along western base of San Pitch Mountains.	Buff to gray sandstone, variegated shale, limestone, and conglomerate, origin probably both fluviatile and lacustrine.	Permeabililty probably low to moderate in sandstone beds, but probably high secondary permeability in the calcareous sandstone and limestone sections along fractures and joints; yields small to large quantities of water to numerous springs on the Wasatch Plateau and San Pitch Mountains, the largest of which are used for public supply.
	Upper Cretaceous	Price River Formation (includes Castlegate Sandstone Member)	2,000	Exposed in the Wasatch Plateau in several canyons between Spring City and Fairview and in Twelvemile Canyon; also exposed in Maple Canyon near Freedom and along the east base of the San Pitch Mountains.	Gray to red sandstone and massive conglomerate, with some shale; largely continental origin.	Moderate permeability in sandstone and conglomeate, particularlyalong bedding planes, high permeability where fractured; yields large quantity of water to Coal Fork Spring.
		Blackhawk Formation	1,800	Exposed only in the Wasatch Plateau in several canyons between Spring City and Fairview and in Twelvemile Canyon.	Sandstone, shale, and coal; chief coal-producing formation in the Wasatch Plateau; marine origin.	Water-bearing properties unknown; not significant as a source of ground water.

SOILS

The soils in the watershed are of two general types and are normally found in two separate areas. Alluvial sediments occur along stream channels and at the base of the mountain front where they were deposited by running water. Colluvial and residual soils are located on mountain slopes throughout the study area (Plate 1).

The alluvial sediments have been grouped on plate 2 by grain size and engineering characteristics according to the Unified Soils Classification System (Appendix). Sand and gravel deposits are found in and around all stream beds. Thicknesses vary but are generally less than 20 feet. The majority of the alluvial sediments are found at the base of the mountain front where they range in thickness from 5 feet to greater than 35 feet.

Most of the soils found in the study area consist of colluvium or residual materials. Colluvium is comprised of gravity-transported debris that usually accumulates at the

Figure 2. North-facing cirque at head of Straight Fork of Pleasant Creek.

base of a slope or cliff. Residual soils develop by *in situ* weathering of bedrock and have not been transported. Residual soils are found at higher elevations in the watershed. The colluvial and residual soils are generally shallow (less then 20 feet) and consist of clay, silt, and sand. Their composition depends on the lithology of the underlying bedrock (for example, shales yield silty and clayey soils). These soils have been grouped on plate 2 according to plasticity and shrink-swell characteristics. Soil data for the area west of the Manti-LaSal National Forest boundary was obtained from an unpublished U.S. Soil Conservation Service soil map of Sanpete County. For the portion of the study area east of the forest boundary, mapping was completed using a generalized land-type association map obtained from the Manti-LaSal National Forest, supplemented with field data.

SURFACE HYDROLOGY

The Mt. Pleasant watershed includes three major streams: Pleasant Creek, North Creek, and Cove Creek. Pleasant Creek is the largest perennial stream in the study area, draining approximately 18.5 square miles (Robinson, 1971). It forms at the confluence of three smaller streams which originate in a small basin above 6,800 feet elevation. The Pleasant Creek drainage encompasses approximately three-fourths of the Mt. Pleasant watershed. The remaining northern portion of the watershed is drained by North and Cove Creeks. They are fed by three streams: Quaking Hollow Creek, and North and South Forks of North Creek. Numerous springs and seeps were observed throughout the study area (plate 3). Total flow of the three main streams and their tributaries, as well as the springs and seeps within the watershed, was estimated in August 1981 to be approximately 13 second-feet.

CULINARY WATER SUPPLY

The Mt. Pleasant water supply consists of three springs and one well. The well, housed in a concrete block building approximately one mile east of Mt. Pleasant, produces about 800 gallons per minute (gpm) but is operated only during periods of peak water demand. The remainder of the year, the city relies on the springs for culinary water. Coal Fork, Sneak, and City Springs are located in Coal Fork Canyon in the southern half of the study area (plate 3). The largest of the three, Coal Fork Spring, is at the head of the system and, depending on the time of year, discharges as much as 210 gpm. Sneak Spring and City Spring produce 80 and 90 gpm respectively.

Coal Fork and City Springs are collected in relatively new concrete boxes. Both were constructed with covers approximately 3 feet above the ground surface. This design reduces the possibility of contamination by flooding at these locations. The two springs have fenced protection zones around the collection boxes. City Spring has recently been redeveloped and has two separate fenced areas, one 300 feet by 100 feet and the other 40 feet by 30 feet. Coal Fork Spring has a 100-foot by 50-foot fenced area, but the fence is in disrepair and does little to control access to the spring.

At the time of the field reconnaissance, Sneak Spring was not contributing to the culinary system. The collection area could not be accurately located, but is believed to be in the channel of Coal Fork Creek. For this reason, the spring was judged unsuitable by the State Health Department and taken out of service. When in use, the flow from Sneak Spring joins with the discharge from Coal Fork Spring at a junction box near a service road (figure 3). Sneak Spring is located where flooding is a hazard. A flood in 1946 deposited boulders and debris in the bottom of Coal Fork Creek, and it was probably then that the original spring location was lost.

No evidence of slope stability problems endangering the springs was observed. However, due to caving along the east side of the service road approximately 100 feet south of the Coal Fork Spring/Sneak Spring junction box, a 50-foot section of cast-iron water line has been replaced with plastic PVC pipe. Additional caving at this location could present a hazard to the buried water line located along the west edge of the service road.

Water from all three springs is carried to Mt. Pleasant through a new 4-inch cast-iron water line buried 6 to 10 feet below the service road (plate 3). With the exception of the caving noted near the junction box south of Sneak Spring, no evidence of slope instability was observed along the pipeline right-of-way.

GEOLOGIC HAZARDS

Flooding and Erosion Potential

Summers in the study area are typified by cloudburst storms that last an hour or two and are often accompanied by hail. When these storms concentrate near the crest of the plateau, they may cause flash floods which carry mud and boulders to the Sanpete Valley . Such flash floods have been costly to the residents of Mt. Pleasant (table 2). Flooding is now largely controlled by stone barrier walls that form a debris basin a short distance west of the mouth of Pleasant Creek Canyon.

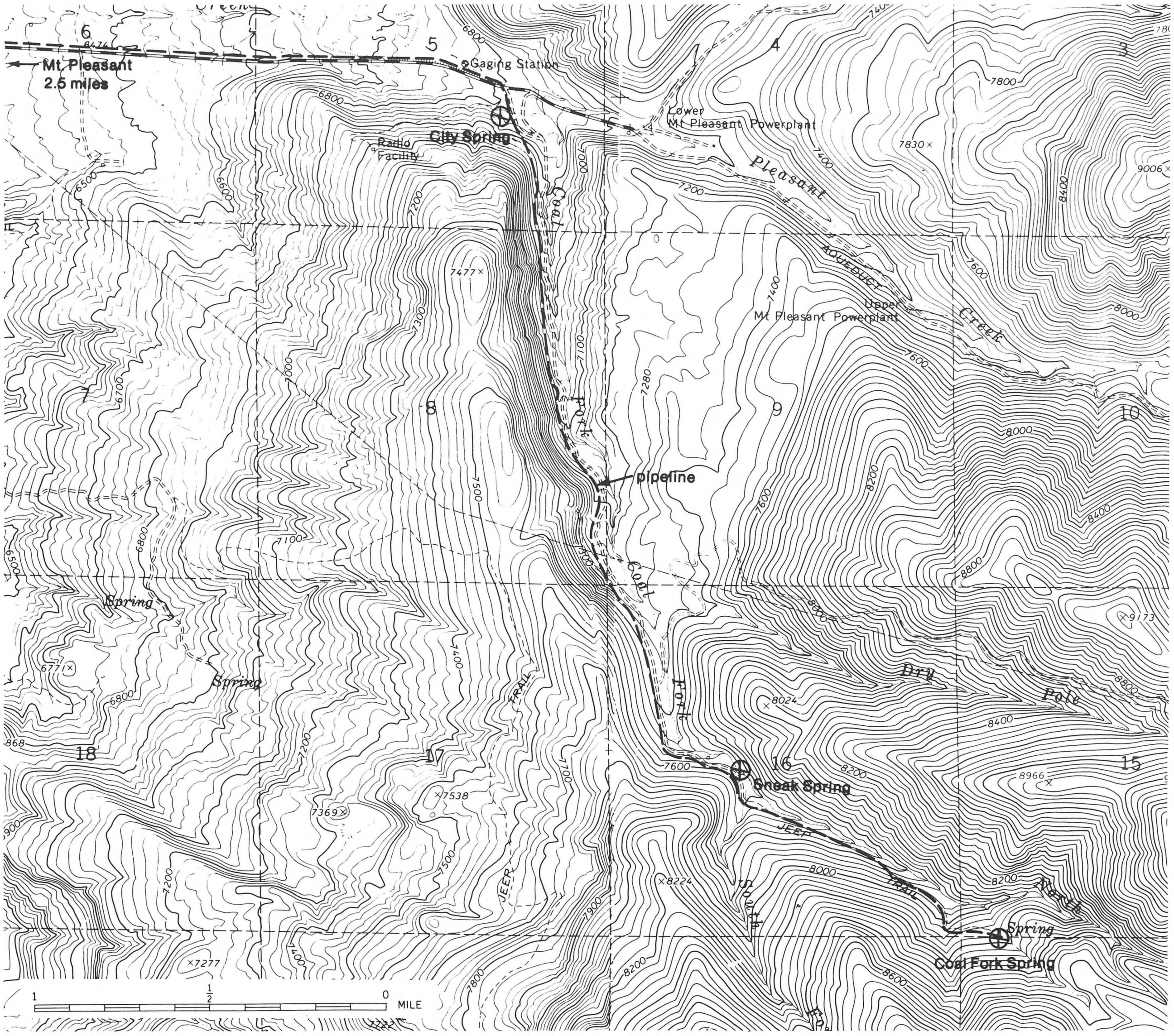


Figure 3. Map of springs supplying culinary water to Mt. Plesasant City.

Erosion is confined immediately adjacent to stream channels, except where vegetation has been removed by forest fires, landslides, or road construction. In 1954 and 1955 the National Forest Service terraced and revegetated with grass slopes that had been stripped of vegetation by over grazing and/or forest fires (figure 4). The intent was to retard runoff and prevent erosion and flooding until a natural protective vegetative cover could be re-established. The project appears to have been largely successful.

Slope Stability

Slope failures are caused by a number of factors related to the physical properties of the slope material and the subsequent history of erosion and weathering. Conditions observed in the study area that have created or may lead to slope instability are listed below.

Figure 4. Forest Service-terraced land to retard erosion until protective vegetation cover becomes established.

Table 2. Abstract accounts of significant cloudburst floods in Mt Pleasant, Utah.

Stream Course Date	Remarks
Cedar & Pleasant Creeks July 29,1901 August 2, 1901	Two floods reported but little damage was done.
Coal Creek August 21, 1907	A heavy downpour did considerable damage, especially to the second crop of hay in the process of being cut.
Coal Creek August 21, 1909	'Torrents of water rushed down the hillsides and into town, carrying everything before it.' Huge boulders and logs were brought down. Much damage to reservoirs, irrigation ditches and highways. Streets flooded, cellars filled, and gardens and orchards washed out.
Pleasant Creek July 19,1918	Cloudburst. One farmer drowned and property damage amounted to $100,000. Streets covered with mud, boulders, and debris. One house swept away and many smaller buildings destroyed. Fences torn down. Machinery, wagons, automobiles and other implements scattered. Cellars flooded. Mud and debris spread over a large area of farmland. Fields and gardens ruined.
Pleasant Creek July 9, 1918	Second flood in three weeks due to cloudburst. City power plant out of commission since June 20 flood was again damaged. Mud, boulders, etc. strewn over the town and fields. Ground floor of hotel flooded. Homes flooded. Several blocks of railroad tracks covered with mud and debris.
Pleasant & Twin Creeks July 21, 1934	Two floods 'roared into town' flooding streets and lots.
Pleasant & Twin Creeks July 30, 1936	City water mains washed out. Dividing dams in irrigation ditches destroyed. Haystacks and crops damaged. Roads near Scipio, Sigurd, and Glenwood closed by storm.
Pleasant Creek July 25, 1941	Heavy rain caused flood of 600 to 700 cfs in Pleasant Creek. Boulders up to 3 feet in diameter were moved by the flood. At Fifth West Street debris at bridge caused the river to overflow and flood railroad yard and adjacent property.
Pleasant Creek July 24, 1946	As a result of heavy rainfall, Pleasant Creek overflowed in numerous places causing widespread damage. At State Street bridge, mud and boulders leaped 10 to 12 feet into the air; floodwater was diverted into Main Street where tremendous damage was done to many businesses. Damage estimated to far exceed half a million dollars.
Birch & North Creeks August 7, 1952	A cloudburst on top of the divide caused floods in Birch Creek and North Creek which damaged irrigation systems in both streams. Mud, rocks, and debris were deposited on farmlands east and north of Mount Pleasant. Damage to irrigation systems and farmlands estimated at $10,000.
Birch & North Creeks August 16, 1955	A cloudburst on east mountains resulted in floods in North and Blue Slide Forks of Pleasant Creek. Mud flowed in some sections as heavy as concrete mix. The flood stayed in the channel through Mt. Pleasant but flooded grain fields east of town and came down 1st South Street and flooded yards from 8th East to 4th East. At the same time a flood from Birch Creek damaged cropland in the Round Hills area. Round Hills road impassable for short time.
Pleasant Creek July 29, 30, 1956	Storms on July 29 and 30 caused a flood down South Fork of Pleasant Creek on afternoon of July 30. The flood from South Fork was estimated at 157 cps. Gages at lower powerplant recorded 0.97 inch for the 29th storm. No record of the July 30 storm.
South Coal Fork August 25, 1961	Rain of high intensity in isolated areas caused flooding on South Coal Fork near Mount Pleasant. The peak discharge of 3,310 cfs from 1.2 square miles is believed to be greater than the 50-year flood. In lower Coal Creek the Soil Conservation Service reported 0.50 inch of rain in 10 minutes. Considerable overland and channel erosion occurred and large deposits of rock and debris left in Coal Fork channel below mouth of South Coal Fork.
Twin, North & Pleasant Creeks July 19, 1965	Heavy rains in mountains east of Mount Pleasant caused flash floods in Twin, North, and Pleasant Creeks. North Creek flood brought down great deal of debris. Twin Creek overflowed banks east and north of cemetary and flowed over U.S. Highway 89 and scattered debris along 7th and other streets in south end of Mount Pleasant.
Pleasant & Twin Creeks July 31, 1965	Heavy storm sent tons of rock and debris down Pleasant Creek. Debris basin three miles east of town saved Mount Pleasant from being flooded. Floods at Wales and Spring City caused damage to roads and culinary water systems, and there were some turkeys lost. Reported $10,000 damage to Wales Canyon road.

1. Removal of lateral and/or underlying support by erosion, by previous slope failure, or by man. Examples of all three processes were observed in the study area (plate 4). Numerous road cuts have created unstable slopes resulting in rockfalls and debris flows (figures 5, and 6). Several examples of slope instability were observed where streams cut laterally into their banks. Erosion and previous sliding has created a large unstable slope at the head of Blue Slide Fork (figure 7).

2. Loading. Forms of natural slope loading include precipitation, soil saturation near seeps and springs, and accumulation of talus on unstable ground. A slump-earth flow at the head of Blue Slide Fork is a possible example of slope failure due to saturation loading (figure 8).

3. Inherently weak material. Organic material and some clay and shale found in the watershed are in this group. Soils with shrink-swell potential ranging from low to high occur over most of the study area but are found predominantly at higher elevations to the east. Saturation of these soils on a steep slope could produce slope failures.

4. Shallow bedrock combined with steep slopes. Steeply dipping bedrock with shallow soil cover is found throughout the study area. Creep, the slow downslope movement of soil and rock debris, was recognized in several road cuts (plate 4). The introduction of excess moisture to these materials can create saturated conditions that lead to mud or debris flows.

The rock unit exhibiting the greatest number of slope failures in the Wasatch Plateau is the North Horn Formation. All the landslides in the study area, excluding those caused by stream or road cuts, have occurred in this formation. It is comprised primarily of lacustrine shale with limestone and fluvial sand interbeds. Shale has a lower shear strength than most rock types and in many cases cannot support its own weight on steep slopes when saturated. Slope failures are common in areas underlain by shale bedrock, especially when steep slopes are present. All the landslides that have occurred in the North Horn Formation are found on slopes of 30 percent or greater.

Earthquake Potential

The study area is in seismic zone 3 of the Uniform Building Code and Utah Seismic Safety Advisory Council seismic zonation maps of Utah. This is a zone of active seismicity and high potential for earthquakes. Several small earthquakes (Richter magnitude 2 or less) have occurred in the site vicinity since 1962. In 1961, a Richter magnitude 5 earthquake was recorded near Ephraim, 20 miles to the southwest. The largest earthquake recorded in the area was in 1901 at Richfield, approximately 60 miles to the south. That event registered an estimated Richter magnitude 6.5 (Arabasz and others, 1979).

Some potential for ground rupture along north-south-trending faults in the study area does exist in the event of a medium to large earthquake. However, the potential for strong ground shaking is considered to be much higher. The greatest danger in this case would be

Figure 5. Rock fall hazard due to road cut in Straight Fork of Pleasant Creek.

Figure 6. Slope failure due to road cut near North Fork Creek.

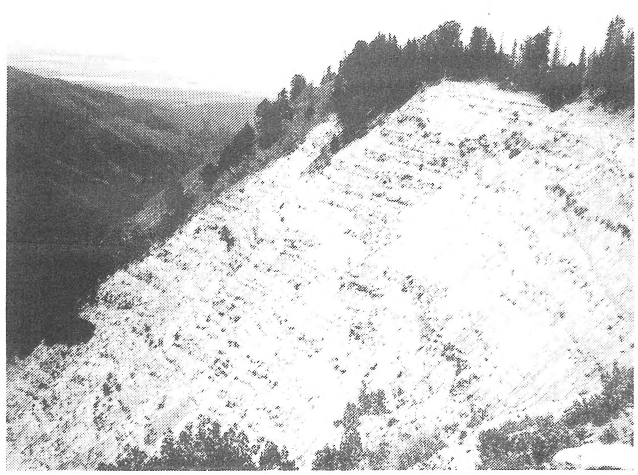


Figure 7. Major landslide and erosion, probably because of weakened slope due to a high-angle fault.

Figure 8. Slump-earth flow at head of Blue Slide Fork of Pleasant Creek.

earthquake-induced slope failure, particularly along road cuts and stream banks, and where slopes exceed 30 percent in the North Horn Formation. A major earthquake could also alter spring flow and water levels in wells.

WATERSHED CONTAMINATION

The potential for watershed contamination will increase with new development in and around the study area. The greatest hazard is from failure of septic tank soil absorption systems leading to introduction of untreated sewage effluent into culinary water sources. Approximately 90 percent of the study area is unsuitable for soil absorption fields (plate 5). Large areas are characterized by shallow bedrock, steep slopes, and/or soils with moderate to low permeability. Aspen Hills Subdivision, the major development in the study area, is located in the northwest corner of the watershed (plate 5). Shallow rock, moderate to slow soil permeability, and steep slopes are all common at this location. Richard Anderson, former Chief Environmental Health Specialist for the Central Utah Health District, stated that he observed a low- permeability layer of silty clay/clay (CL/CH) approximately 4 feet below the ground surface in the subdivision. Mr. Anderson said that to his knowledge there had been no absorption field failures in the past but this was probably due to the infrequent, weekend-only use of the cabins. He was of the opinion that if the number of cabins or the length of residency increased, severe contamination problems could result.

According to the State Division of Environmental Health, the land bordering Mt. Pleasant's three springs is privately owned and no protection agreement exists with the owners. Therefore, it is possible for development to occur immediately upslope from the springs. This would create a potential contamination problem for the town's culinary water supply. The property bordering the springs is unsuitable for septic tank absorption fields due either to low permeability soils, steep slopes, or shallow bedrock (plate 5). The only location within the study area that contains suitable conditions for individual wastewater disposal systems is at the mouth of Pleasant Creek. There, slopes are moderate to gentle, soils are suitable for absorption fields and bedrock is deeper than 10 feet.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this investigation the following conclusions and recommendations are presented.

- The greatest hazard to the watershed is contamination of culinary water supplies due to failure of septic tank absorption fields. The presence of shallow bedrock, steep slopes, and soils with moderate to low permeability greatly increase the potential for failure. Few areas within the watershed are suitable for soil absorption systems. However, the maps presented are for general planning purposes only and all proposed developments should be evaluated on a site-by-site basis due to the variability of soil types and conditions at any given location.

- The greatest number of landslides in this portion of the Wasatch Plateau and all the slope failures observed in the study area, with the exception of those caused by stream and road cuts, have occurred in the North Horn Formation. The potential for slope failure within this formation increases when slopes exceed 30 percent. A detailed slope stability analysis is recommended prior to development in those areas of the watershed where the North Horn Formation is present beneath slopes greater than 15 percent.

- Silty and clayey soils are common over most of the watershed. The moderate to high shrink/swell capacity of these soils may cause foundation problems in some areas. They are not highly susceptible to erosion, but a problem may develop in areas where vegetation is stripped from steep slopes and along improperly graded roads. A thorough soils/foundation investigation including an evaluation of erosion hazard is recommended for all proposed development.

REFERENCES

Anderson, L. W., and Miller, D. G., 1979, Quaternary fault map of Utah: Fugro Inc., Consulting Engineers and Geologists, Long Beach, California, 35 p.

Arabasz, W. J., Smith, R. B., and Richins, W. D., 1979, Earthquake studies in Utah: University of Utah Seismograph Station, Department of Geology and Geophysics, University of Utah, 552 p.

Butler, Elmer, and Marsell, R. E., 1972, Developing a state water plan—cloudburst floods in Utah 1939-69: U.S. Geological Survey and Utah Division of Water Resources Cooperative Investigations Report No. 11, 103 p.

Doelling, H. H., 1972, Central Utah coal fields; Sevier-Sanpete, Wasatch Plateau, Rock Cliffs, and Emery: Utah Geological and Mineral Survey Monograph Series No. 3, 571 p.

McCauley, M. L., and Gamble, James, 1976, Geologic hazards and their relation to planning, location, and design of transportation facilities: State of California Department of Transportation, Division of Construction and Office of Transportation Laboratory, p. III-1 to III-41.

Pashley, E. F., Jr., 1956, The geology of the western slope of the Wasatch Plateau between Spring City and Fairview, Utah: Ohio State University master's thesis, 117 p.

Robinson, G. B., Jr., 1968, Selected hydrologic data San Pitch River drainage basin, Utah: U.S. Geological Survey, Utah Basic-Data Release No. 14, 44 p.

———1971, Ground-water hydrology of the San Pitch River drainage basin, Sanpete County, Utah: U.S. Geological Survey Water-Supply Paper 1896, 80 p.

Shroder, J. F., Jr., 1967, Landslides of Utah: University of Utah Ph.D. dissertation, 201 p.

Spieker, E. M., 1946, Late Mesozoic and early Cenozoic history of central Utah: U.S. Geological Survey Professional Paper 205-D, p. 117-161.

Spieker, E. M., and Billings, M. P., 1940, Glaciation in the Wasatch Plateau, Utah: Geological Society of America Bulletin, v. 51, no. 8, p. 1173-1198.

State of Utah Department of Health, 1979, State of Utah Public Drinking Water Regulations: Division of Environmental Health, Bureau of Public Water Supplies, p. 2.0 - 2.9.

Wooley, R. R., 1946, Cloudburst floods in Utah 1850-1938: U.S. Geological Survey Water-Supply Paper 994, 128 p.

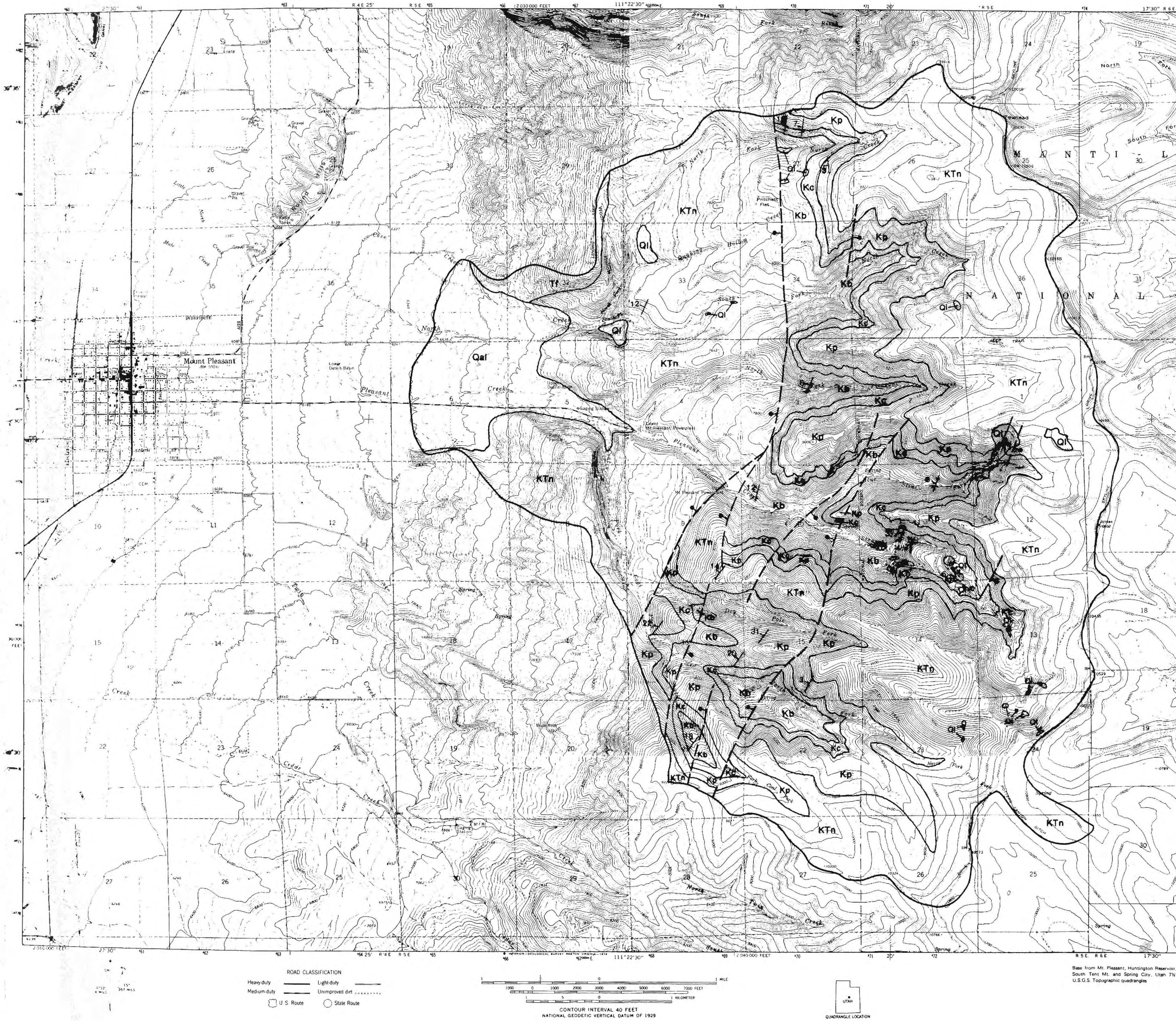


PLATE 1
GEOLOGY
Report of Investigation No. 169
Mt. Pleasant, Utah
January 1982

EXPLANATION

- Strike and dip of bedding (16)
- Horizontal strata
- Geologic unit contact dashed where location is approximate
- Fault dashed where inferred (bar and ball on downthrown side)

QUATERNARY

Qal — ALLUVIUM
clay, silt, sand, gravel and some unsorted flood deposits.

Ql — LANDSLIDE DEPOSITS
Mixed rubble and blocks of material slumped from formations at higher elevations.

CRETACEOUS

Tf — FLAGSTAFF LIMESTONE
Limestone, dark grey to tan, light grey and white, of varied lithology; shale, some sandstone, silicic ash, and gypsum; local oil shale (unit 50-1, 500 feet thick).

KTn — NORTH HORN FORMATION
Shale, variegated red, grey, green; sandstone, buff to red; conglomerate; limestone; coal and lignite beds (unit 500-3000 + feet thick).

TERTIARY

Kp — PRICE RIVER FORMATION
Sandstone, medium- to coarse-grained, interbeds of grey to brown shale, some carbonaceous material, friable and massive bedding creates step-like outcrops (unit 600-1000 feet thick).

Kc — CASTLEGATE SANDSTONE MEMBER
Conglomerate; sandstone, medium- to coarse-grained; lower part forms massive cliff. Occasional sandy shale and even thin lenses of coal (unit 150-500 feet thick).

ANGULAR UNCONFORMITY

Kb — BLACKHAWK FORMATION
Sandstone, yellow grey to brown, irregularly bedded; shale, grey to black, carboniferous; coal beds (unit 800-1,800 feet thick).

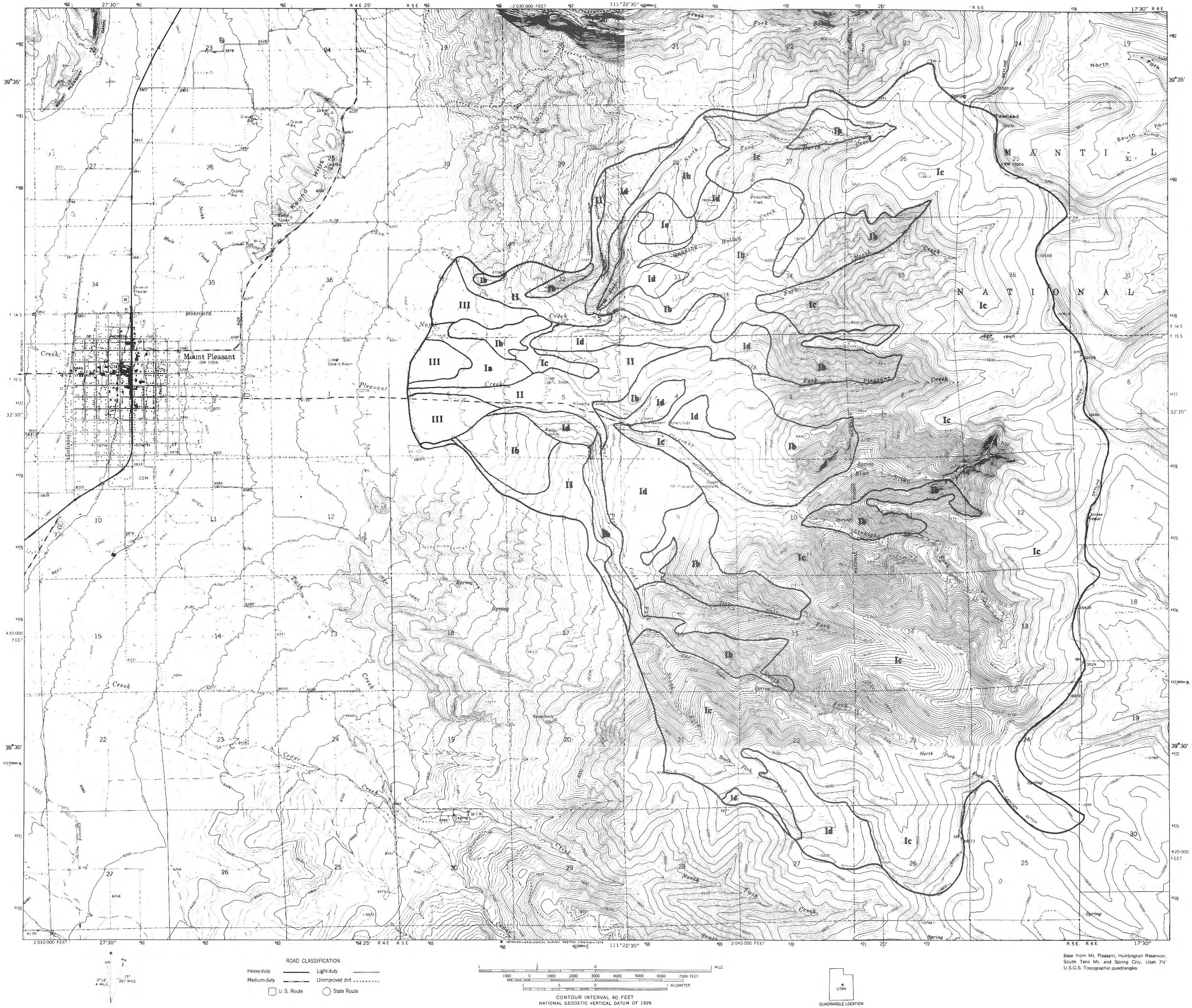


PLATE 2

SOILS

Report of Investigation No. 169
Mt. Pleasant, Utah
January 1982

Explanation

The soils information shown on this map west of the Manti-La Sal National Forest boundary has been adapted from an unpublished U.S. Soil Conservation Service soils report on Sanpete Valley, Utah. The portion of the soils map east of the National Forest boundary is based on a generalized land-type association map received from the Manti-La Sal National Forest as well as soil observations made in the field. The different soil types identified within the watershed have been grouped according to the Unified Soil Classification system on the basis of their characteristics as engineering materials. Because the soil units are principally those of the U.S. Soil Conservation Service, the same cautions concerning the accuracy for the soil contact locations and included soil units made for their maps apply here.

I	Silty clay, clay, silt, silty sand, clayey sand, clayey gravel, silty gravel; (CL, CH, ML, SM, SC, GC, GM), low to high plasticity, very slow to slow permeability, low to high shrink-swell potential.
Ia	Low plasticity and low shrink-swell potential.
Ib	Low plasticity and moderate shrink-swell potential.
Ic	Medium plasticity and moderate shrink-swell potential.
Id	Medium plasticity and high shrink-swell potential.
Ie	High plasticity and high shrink-swell potential.
II	Silty gravel, clayey gravel, silty sand, clayey sand; (GM, GC, SM, SC), low to medium plasticity, moderate to rapid permeability, low shrink-swell potential.
III	Silty sand, clayey sand; (SM, SC), low plasticity, low permeability, low shrink-swell potential.

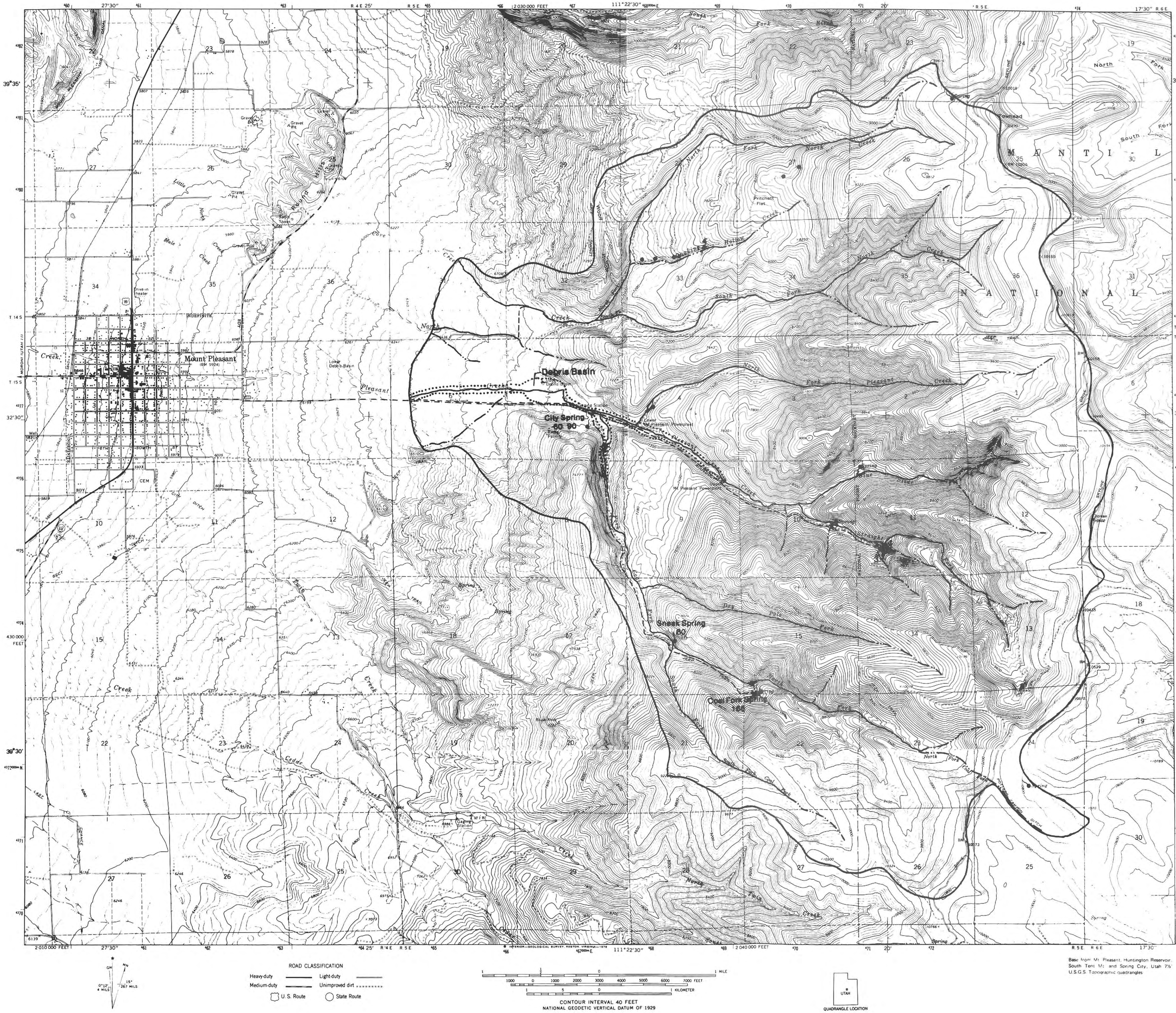


PLATE 3

SURFACE HYDROLOGY
Report of Investigation No. 169
Mt. Pleasant, Utah
January 1982

Explanation

This map is a compilation of surface hydrologic information collected during a field reconnaissance conducted the week of August 18, 1981. The drilling of monitoring wells to define shallow ground water conditions was beyond the scope of this study.

Perennial stream, dashed where intermittent.

Sneak Spring 80 — Spring, with estimated flow in gallons per minute during August 1981. Named springs comprise Mt. Pleasant's culinary water supply.

Seep

Flood-prone area*

Buried pipeline or aqueduct

*Data from U.S. Geological Survey 1973, Map of Flood-Prone Area, Mt. Pleasant, Utah.

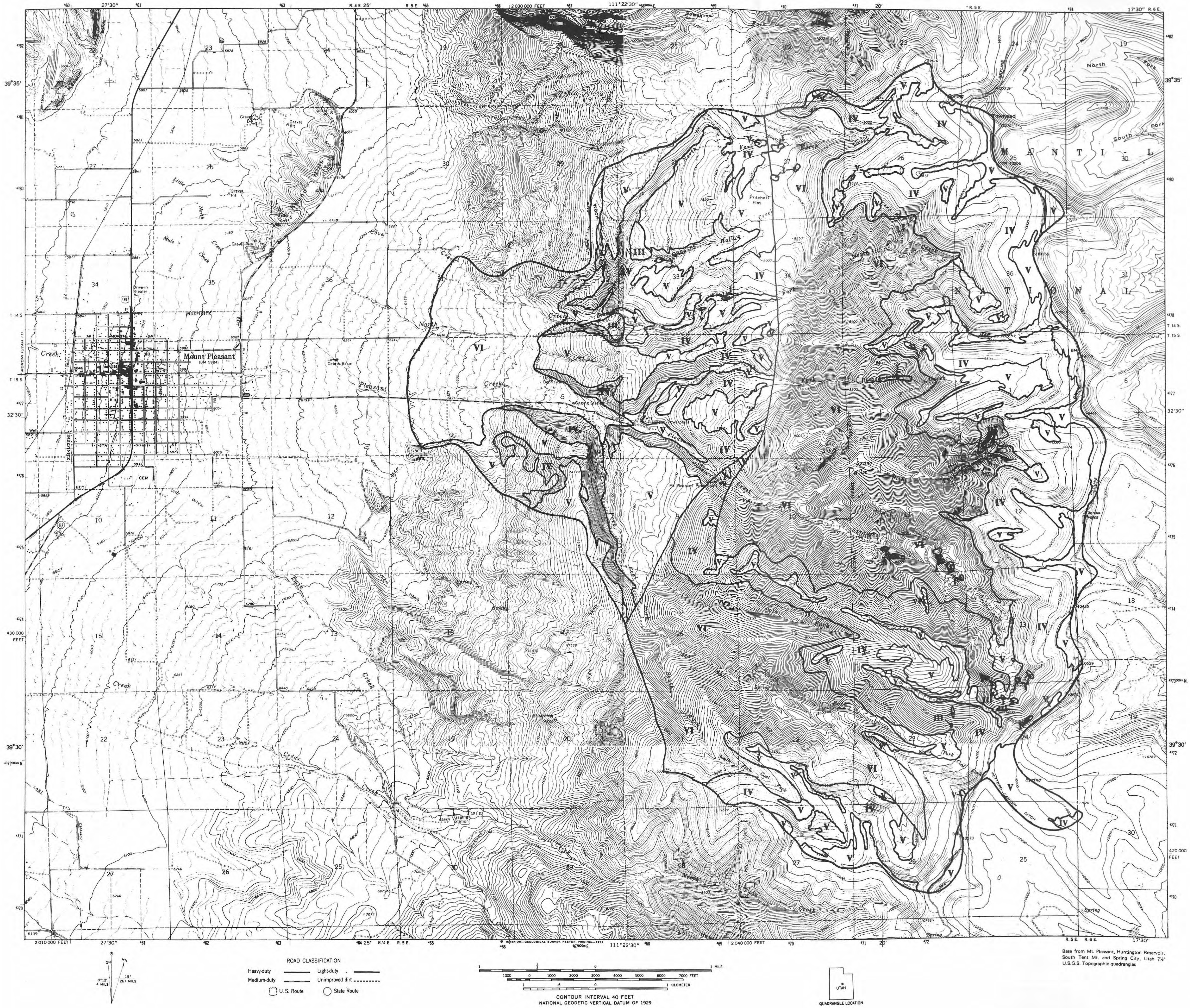


PLATE 4

SLOPE STABILITY
Report of Investigation No. 169
Mt. Pleasant, Utah
January 1982

EXPLANATION

Existing rockfalls, debris slides, and slump features, as well as areas of potential rockfall hazard are identified on this map (Map Units I-IV). The geologic rock unit with the greatest number of landslides in the Wasatch Plateau is the North Horn Formation. All the slope failures within the study area, excluding those caused by stream or road cuts, are in the North Horn Formation in areas with slopes greater than 30 percent. Therefore, all areas in the North Horn Formation with slopes greater than 30 percent have the highest landslide potential (Map Unit IV). Slopes in the North Horn Formation of less than 30 percent are generally less stable than equivalent slopes in other formations and the potential for failure is moderate to low (Map Unit V). Landslide potential on natural slopes in the remainder of the area is considered low, although slopes can be destabilized locally by road cuts or other disturbance (Map Unit VI).

Although presently considered stable, extensive uncontrolled lot grading or road building on mountain slopes could reactivate old landslides or generate new ones. A complete stability analysis including an evaluation of the effects of seismic loading is recommended for construction of roads or structures in those areas of the study area where the North Horn Formation is present beneath slopes greater than 15 percent.

I	Slope failures caused by the removal of basal support in road or stream cuts.
II	Areas of rockfall hazard created by the removal of basal support in road cuts.
III	Rock falls, debris slides, and slump features within the North Horn Formation.
IV	Areas within the North Horn Formation with slopes greater than 30 percent where landslide potential is greatest.
V	Areas within the North Horn Formation with slopes less than 30 percent where landslide potential is moderate to low.
VI	Areas of low landslide potential, but slope failures have occurred in road cuts.

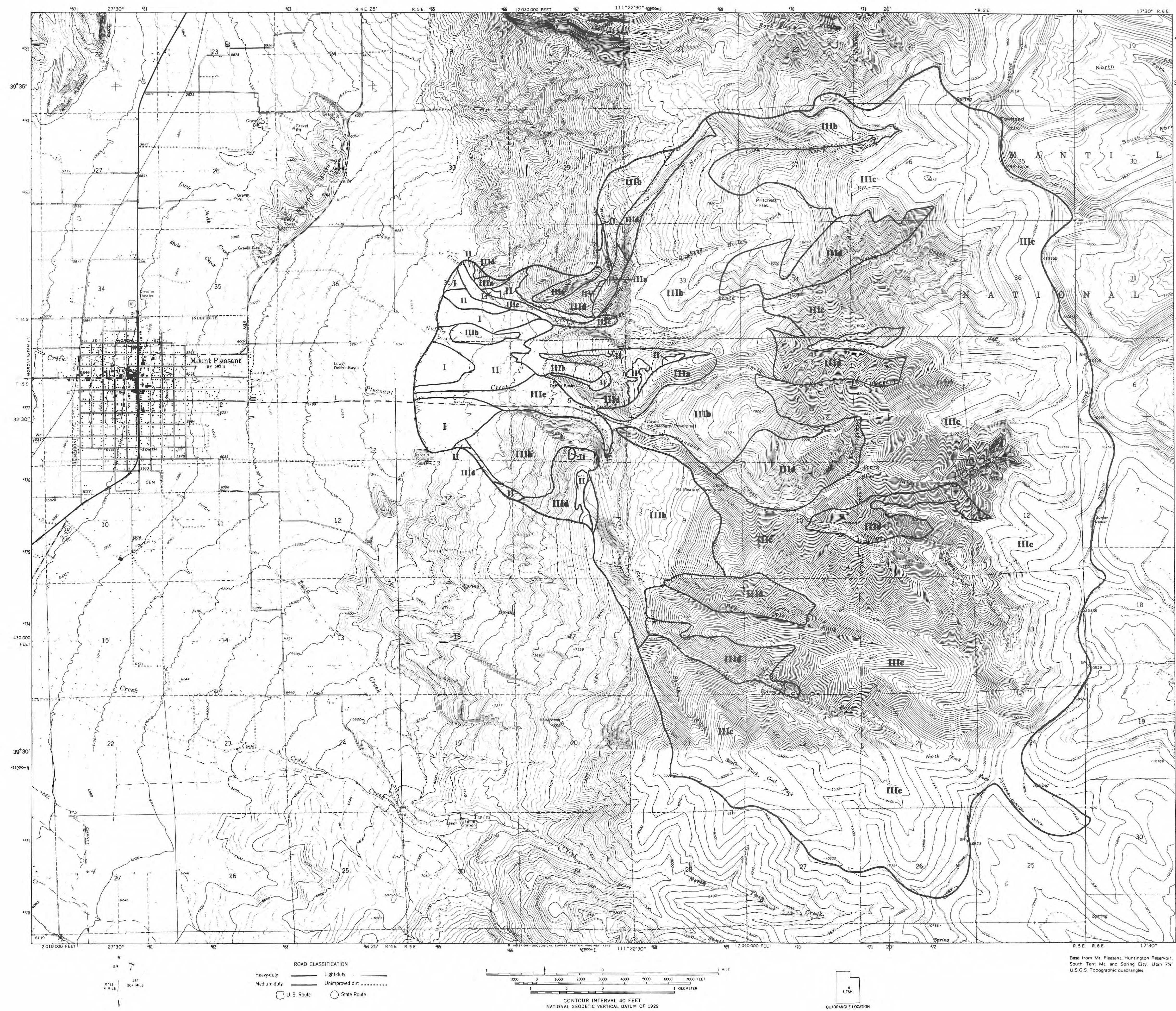


PLATE 5

SUITABILITY FOR SEPTIC TANK ABSORPTION FIELDS

Report of Investigation No. 169

Mt. Pleasant, Utah

January 1982

EXPLANATION

From a geologic standpoint, the suitability of an area for soil absorption fields is dependent upon soil type, depth to ground water, and depth to bedrock. Permeability and filtering capacity of a soil is dependent upon soil type (grain size). In general, soils with a high clay content, particularly if the clays are expansive, lack sufficient permeability to perform satisfactorily. Saturation occurs rapidly and surface seepage results. Coarse-grained or gravelly soils have permeabilities that are too high, and filtering capacities that are too low to properly treat effluent and a possible ground-water contamination problem results. If systems are placed on steep slopes, surface seepage of unfiltered or partially filtered effluent may result. Shallow bedrock causes problems due to: 1) increased excavation costs, 2) possible ground-water contamination of water supplies in rock aquifers, and 3) saturation of system due to low permeabilities in unfractured rock. For best results in an absorption field, bedrock depth should be greater than five feet below the bottom of the system, slopes should be less than eight percent, and soil types should have moderate to rapid permeability (silty sand, sandy silt).

There are few areas within the Mt. Pleasant watershed which are well suited for soil absorption systems. Conditions vary locally and a site evaluation should be performed before declaring any specific site as suitable.

I	Generally Suitable: Silty sand, clayey sand (SM or SC), moderate permeability; low shrink-swell potential, bedrock depth greater than five feet, slopes gentle, flood hazard low.
II	Moderately Suitable: Silty sand, clayey sand, silty clay, silt (SM, SC, CL, ML), moderate permeability, low to moderate shrink-swell potential; bedrock depth greater than five feet, slopes between 8 and 15 percent, flood hazard low.
III	Unsuitable: Silty clay, silt, clay, clayey gravel (CL, ML, CH, GC).
IIIa	Unsuitable due to shallow rock.
IIIb	Unsuitable due to moderate to slow permeability.
IIIc	Unsuitable due to slow permeability and steep slopes.
IIId	Unsuitable due to steep slopes.
IIIe	Streambed and flood-plain deposits: Unsuitable due to very rapid permeability and flood hazard.

Geology modified from H.H. Doelling, 1972

REPORT OF INVESTIGATION NO. 176 GEOLOGIC EVALUATION OF SEPTIC TANK AND SOIL ABSORPTION SYSTEM SUITABILITY, DRY FORK CANYON, UINTAH COUNTY, UTAH

by
William R. Lund

ABSTRACT

Dry Fork Canyon is on the south slope of the Uinta Mountains about 7 miles northwest of Vernal, Utah. The population of the canyon has grown steadily for a number of years, but development has been confined to single-family dwellings on large lots. Renewed interest in the energy resources of the Uinta Basin has produced increased demand for housing and several large subdivisions are proposed for the canyon. Dry Fork Canyon is neither sewered nor served by a public water system. Culinary water is obtained from individual domestic wells and sewage is disposed of using conventional septic tank and soil absorption systems. Concern that increased development would result in contamination of ground-water supplies prompted an investigation of geologic and hydrologic conditions in the canyon related to waste disposal.

Bedrock formations exposed in the narrow, steep-walled canyon range in age from Pennsylvanian to Jurassic, and include from youngest to oldest the Navajo Sandstone, Chinle Formation, Shinarump Conglomerate, Moenkopi Formation, Park City Formation, and Weber Sandstone. Unconsolidated deposits are of variable thickness and consist of colluvium and residual soils on slopes, and of alluvium in flood-plain, alluvial-fan, and stream terrace deposits. Aquifers in the study area may be unconfined, confined, or perched and grade into each other in complex ways. Recharge is chiefly from precipitation in the Uinta Mountains and infiltration from Dry Fork Creek. A shallow, unconfined aquifer exists in the flood-plain alluvium along Dry Fork Creek. It is the source of water to many of the culinary wells in the canyon.

A survey of existing wastewater disposal practices in the canyon showed that septic tank and soil absorption systems are the primary means of disposal. Only one failing system was identified (surfacing sewage effluent) but several others were found in areas of shallow ground water and highly permeable soils. A water-quality testing program utilizing 14 representative wells distributed throughout the canyon showed no evidence of a canyon-wide, ground-water contamination problem. However, two isolated cases of bacteria-contaminated well water had been previously identified by the local health department.

Criteria selected to map suitability for septic tank and soil absorption systems included: soil type and characteristics, depth to ground water, depth to bedrock, slope, and flood hazard. Results of the mapping showed that much of the canyon is suitable for installation of septic tank and soil absorption systems, but that marginally suitable and unsuitable areas are also present. Factors presenting the greatest constraints to soil absorption system installation are shallow ground water and bedrock.

INTRODUCTION

Dry Fork Canyon is situated on the south slope of the Uinta Mountains about 7 miles northwest of the town of Vernal in Uintah County, Utah (figure 1). The population in the canyon has grown steadily for the last several years and until recently (1982) the growth has been confined to individual homes built on large lots to take advantage of the area's rural setting. However, renewed interest in synthetic fuel and related energy development has produced an influx of population to the Vernal area and created an increased demand for housing. To help meet that demand, several subdivisions have been proposed for Dry Fork Canyon. The canyon is not sewered, nor is it served by a public water system. Water is obtained from domestic wells and sewage is disposed of in septic tank and soil absorption (STSA) systems. Concern by canyon residents that increased development would result in contamination of ground-water supplies prompted the Uintah County Board of Commissioners to request that the Utah Geological and Mineral Survey evaluate the geologic and hydrologic conditions in the canyon as they relate to wastewater disposal in soil absorption systems.

PURPOSE AND SCOPE

The intent of this study is to provide the county commissioners, public health officials, and planners with the necessary geologic, hydrologic, topographic, and soils information to make decisions for the regulation of STSA systems in Dry Fork Canyon. Three maps were prepared which present basic geologic and soils information, estimated depth to the seasonal high stand of the shallow water table, and suitability for wastewater disposal in soil absorption sys-

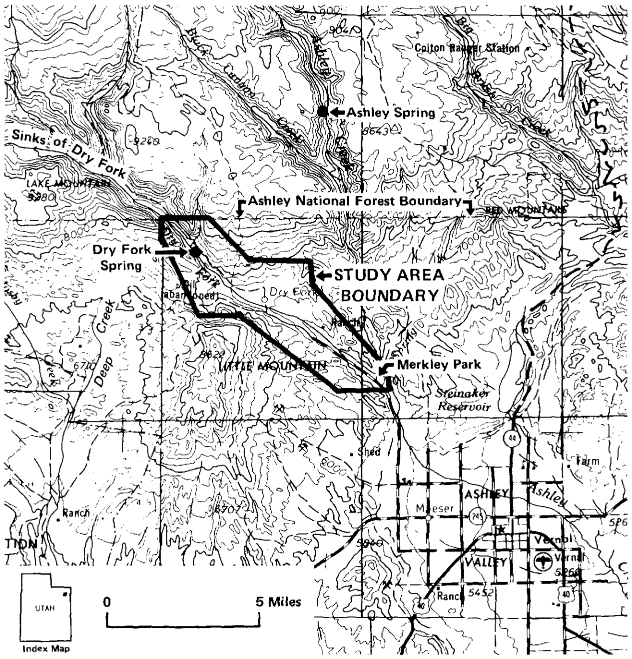


Figure 1. Location map.

tems. This text provides additional detailed information on the geologic and hydrologic setting of the canyon, and a discussion of STSA system suitability. Activities conducted as part of this investigation included:

1. Consultation with the Uintah County Board of Commissioners, the Uintah Basin District Health Department, and the Vernal City - Uintah County Planning Office to determine information needs and the scope of the study.

2. Review of available literature, including unpublished USDA Soil Conservation Service soil mapping and test data.

3. Collection of water well logs available for Dry Fork Canyon from the Utah State Division of Water Rights.

4. Geologic mapping on 1:24,000 scale color and 1:20,000 scale black and white aerial photography with field checking.

5. Laboratory analysis of water samples from 14 wells, limited field analysis of surface water from three stream sites and a number of domestic wells, and depth to water measurements from domestic wells throughout the canyon.

6. Discussions with canyon residents concerning water supply and wastewater disposal practices and problems.

7. Preparation of maps and text.

SETTING

Dry Fork Canyon lies on the south slope of the Uinta Mountains at their juncture with the Uinta Basin. The canyon extends northwestward from Merkley Park, 7 miles northwest of Vernal, for a distance of approximately 22 miles. Only the first 8.5 miles of the canyon from its mouth to the Ashley National Forest boundary (figure 1) are included in the study area. About 1/4 mile wide in its lower reaches, the canyon widens to over a mile in the vicinity of the unincorporated community of Dry Fork, and then narrows again to less than 600 feet before reaching the forest boundary. Dry Fork Creek is an intermittent stream bordered by a well-developed flood plain in the wider sections of the canyon. The canyon walls are precipitous and afford many scenic panoramas.

Access to the canyon is by a paved county road extending to the community of Dry Fork. At that point the road splits, one fork going west over a divide into the Deep Creek drainage, and the other continuing up Dry Fork Canyon into the Uinta Mountains. Traditionally a rural area with low population, small ranches and orchards are typical of the canyon. An influx during the last 10 years of residents who commute to jobs outside the canyon has added approximately 20 homes. The homes are scattered, and with the exception of a few houses and outbuildings at the community of Dry Fork, there is no clustering of residents in the canyon.

The climate is semiarid with a mean annual rainfall of between 12 and 20 inches. From the first of November through March, most precipitation is in the form of snow. Both rainfall and snowfall tend to increase with altitude (Kinney, 1955).

GENERAL GEOLOGY

Dry Fork Canyon is located on the south flank of the Uinta arch, a flat-topped, east-west-trending, asymmetrical anticlinal fold (Untermann and Untermann, 1964). Bedrock formations exposed in the canyon dip to the south at low to moderate angles (8 to 15 degrees) toward the Uinta Basin. The dip of the rock is steeper than the gradient of Dry Fork Creek, so progressively older formations are exposed upstream from the mouth of the canyon (plate 1). The bedrock that crops out in the study area ranges in age from Pennsylvanian (320 to 280 million years before present) - my B.P.) to Jurassic (195 to 136 my B.P.) and include from youngest to oldest the Navajo Sandstone, Chinle Formation, Shinarump Conglomerate, Moenkopi Formation, Park City Formation, and Weber Sandstone. Detailed descriptions for each rock unit are presented in the explanation for plate 1.

Glaciated in its upper reaches during the Pleistocene Epoch (1.6 my to 10,000 yr B.P.), Dry Fork Canyon was strongly eroded in the study area by glacial melt waters (Maxwell and others, 1971). The canyon has since been partially filled by unconsolidated alluvial and colluvial deposits (plate 1). Tertiary (65 to 1.6 my B.P.) terrace deposits, some exhibiting strongly-developed caliche horizons, are found high above the present canyon floor. The thickness of the unconsolidated deposits is variable but exceeds 125 feet in several places. A strong correlation exists between some surface soils (0.5 feet) and underlying bedrock formations. Sandy soils are associated with the Weber and Navajo Sandstones and the Shinarump Conglomerate, while silt and clay soils are found with the Chinle and Moenkopi Formations. A table presenting various soils properties of the unconsolidated deposits in the study area is found on plate 1.

Dry Fork Canyon is located at the northeast edge of the Deep Creek fault zone (Kinney, 1955; Maxwell and others, 1971). The faults mapped in the study area (plate 1) are northwest-southeast-trending normal faults, the majority of which are downdropped to the southwest. Kinney (1955) believes the principal movement along the fault zone was right lateral strike slip, and that tilted grabens and horst blocks developed to adjust for the horizontal displacement. Maxwell and others (1971) cite physiographic evidence to indicate that rock fracturing associated with faulting caused Dry Fork Creek to follow a course to the southeast rather than flowing south into the Deep Creek drainage. The degree of rock fracturing observed in outcrops decreases to the southeast away from the exposed fault traces. It is not known how far the faults extend to the southeast beneath the valley fill.

HYDROLOGY

Ground water in the study area occurs in both bedrock and unconsolidated valley-fill aquifers. The aquifers may be unconfined, confined, or perched and those conditions may grade into each other in complex ways (Hood and Fields, 1978). Recharge to bedrock aquifers is principally from precipitation falling in the Uinta Mountains. In outcrop (recharge) areas, ground water is generally unconfined, but becomes confined as it moves down dip to the south and southeast toward the Uinta Basin (Maxwell and others, 1971; Hood and Fields, 1978). Confined conditions in bedrock aquifers are confirmed in the study area by the presence of several deep, flowing wells. Hood and Fields (1978) identified six bedrock formations in the northern Uinta Basin as major hydrologic units on the basis of their large areal extent or thickness, large yield to wells or springs, or function as a recharge media. Two of those rock units, the Navajo and Weber Sandstones, crop out in the study area (plate 1), and a third, undifferentiated Mississippian (345 to 320 m y B.P.) limestone, is exposed further up Dry Fork Canyon. The upper sandstone member of the Chinle Formation may also be locally significant as a bedrock aquifer. An examination of water well driller's logs indicates that at least some water is being obtained from each of the bedrock formations in the canyon. However, the quality of many of the logs is poor, and it is not always possible to identify the rock units penetrated or the formations producing water.

Unconsolidated valley-fill and glacial outwash deposits yield water to shallow wells throughout the Uinta Basin. The permeability of these deposits ranges from low to very high, and the presence of clay or "hardpan" below the water table often creates confined or leaky confined conditions (Hood and Fields, 1978). Many water well logs in Dry Fork Canyon record clay horizons in the unconsolidated valley-fill sequence. Recomputation of data from a USDA Soil Conservation Service pump test conducted in the canyon indicates that a change from confined to unconfined conditions occurred during pumping due to a clay layer and that vertical leakage between aquifers took place (Hood, 1976). The presence of locally confined conditions in the unconsolidated valley-fill sequence was confirmed in discussions with owners of shallow wells in the canyon. Many well owners indicated that the water levels in their wells now stand at a higher elevation than where water was first encountered during drilling. This was verified by numerous depth to water measurements which were compared with the water levels reported for the wells on drillers' logs.

A shallow unconfined water table exists beneath the flood plain of Dry Fork Creek (plate 2). The depth to water depends upon the season of the year, level of flow in Dry Fork Creek, location relative to the stream, and precipitation. Fluctuations of several feet in the water table can be expected between spring and fall, and wet or dry years. Estimated depths to the seasonal high stand of the shallow water table shown on plate 2 are based on water-level records from selected wells, field observations, and topography. Drilling and monitoring of observation wells was beyond the scope of the project.

Surface water sinks exist along Dry Fork Creek above the study area (figure 1). The sinks are located where the stream crosses glacial moraine deposits underlain by jointed and solution-channeled limestone. The stream flow disappears into the cobbles and gravel of the streambed and into sink holes developed in and adjacent to the channel. Annually 25,000 to 30,000 acre-feet of water disappears into the sinks. Only when surface flows exceed 40 cubic feet per second does water continue down the channel past the sinks (Maxwell and others, 1971). Dye tracer tests conducted jointly by the USDA Soil Conservation Service and the U.S. Bureau of Reclamation (Maxwell and others, 1971) established a connection between the sinks and Ashley Spring, located in Ashley Creek Gorge several miles east of the study area (figure 1). A connection was also shown to exist with Dry Fork Spring which rises along Dry Fork Creek about 2 miles above the community of Dry Fork (plate 2). Dry Fork Spring is intermittent, discharging only during the spring and summer when the flow in Dry Fork Creek exceeds 40 cubic feet per second. Monitoring of observation wells and small springs located downstream from Dry Fork Spring during the dye tests showed no evidence of a connection between the sinks and the valley-fill aquifers in the study area (Maxwell and others, 1971). The many small springs that surface in the alluvium along Dry Fork Creek (plate 2) are recharged by leakage from the stream. Other springs located elsewhere in the canyon receive recharge from unlined irrigation ditches (Searle, 1967) and seepage from bedrock aquifers (Maxwell and others, 1971).

SEPTIC TANK AND SOIL ABSORPTION SYSTEMS

To function safely and effectively, STSA systems require adequate site conditions, proper construction, and regular maintenance. Insufficient attention to any of these factors can result in system failure. This report presents information regarding site conditions in Dry Fork Canyon relevant to STSA systems. However, it must be remembered that even when installed under the best possible site conditions, STSA systems will fail if improperly constructed or maintained.

Survey of Existing Domestic Wastewater Disposal Problems

The primary concerns with the use of STSA systems are surfacing of sewage effluent and contamination of ground water. Only one failing STSA system was encountered during this investigation where sewage effluent was observed coming to the ground surface in an unpaved driveway. Conditions at this site are such that an STSA system should function satisfactorily, and it is suspected that the system is either improperly constructed or has been damaged by vehicles passing over it.

Ground-water contamination is of particular concern in Dry Fork Canyon because of the shallow depth to ground water in many areas (plate 2) and the residents' reliance on individual domestic wells. A total of 72 water well logs were on file (August 1982) with the Utah State Division of Water Rights for the study area. A number of older wells also exist for which only partial or no information is available. The wells are unevenly distributed in the canyon, range in depth from 21 to 1444 feet, and tap both unconsolidated valley-fill and bedrock aquifers. To determine the extent of ground-water contamination in the canyon, 14 wells (plate 2) were selected for water quality testing. Seven of the wells obtain water from bedrock aquifers, the other seven from unconsolidated valley-fill aquifers. The wells were chosen on the basis of location in the canyon, quality of the driller's log and details of construction. Well construction was considered particularly important because wells were required that would allow the aquifer of interest to be sampled without interference from other water-bearing horizons above or below. Samples were collected from an outside water tap at the home served by the well. To ensure that water was being obtained from the well and not a holding tank, the taps were allowed to run for 10 to 15 minutes before the samples were collected. The samples were taken in containers provided by the Utah State Health Laboratory and delivered to the laboratory within 24 hours for analysis. The following parameters, considered indicative of ground-water contamination by sewage, were measured: total organic carbon, total coliform (membrane filter), fecal coliform (membrane filter), chloride, nitrate, sulfate, and total phosphorous. In addition, hydrogen ion concentration (pH), specific electrical conductance, and salinity were determined in the field for each of the samples and for three surface water sites along Dry Fork Creek (plate 2). The results of the water analyses are presented in table 1.

Although recognized as a limited data base from which to make conclusions regarding water quality, the test results in table 1 do provide useful insight into hydrologic conditions in Dry Fork Canyon. The results give no indication of an existing canyon-wide, ground-water contamination problem. With the exception of total coliforms in four wells

Table 1. Results of water quality analyses from selected wells and surface water sites in Dry Fork Canyon, Utah

Sample	Total Organic Carbon mg/l	Total Califorms /100 ml	Fecal Califorms /100 ml	Chloride mg/l	Nitrate as N mg/l	Sulfate mg/l	Total Phosphorus mg/l	pH	Electrical Conductivity in MHOS	Salinity %	Water Level ft/m	Total Depth ft/m
Public Drinking Water Standards[1]	--	1	1	250[2]	10.00	1000	--	6.5-9.5[2]	--	--	--	--
BR-1[3]	11.8	0	0	13	2.65	390	0.05	7.1	1230	0.8	51/15.6	280/85.4
BR-2	12.1	11	0	50	1.80	505	0.05	7.2	1150	0.9	50/15.3	310/94.6
BR-3	17.0	1	0	4	0.05	94	4.25	7.2	440	0.3	44/13/4	200/61.0
BR-4	22.9	0	0	4	0.05	50	0.05	7.6	410	0.2	11/3.4	150/45.8
BR-5	13.5	0	0	14	0.05	210	0.05	7.5	780	0.3	15/4.6	150/45.8
BR-6	38.5	0	0	6	0.05	70	0.05	7.3	460	0.3	?	263/81/7
BR-7	39.6	0	0	2	0.05	42	0.05	8.4	445	0.1	flowing artesian	300/91.5
A-1[4]	4.1	27	0	1	0.05	14	0.15	7.9	310	0.2	35/10/7	80/24.4
A-2	24.2	3	0	1	0.75	57	0.15	7.2	510	0.3	10/3.1	51/15.6
A-3	10.6	0	0	1	0.65	21	0.10	7.3	340	0.5	8/2.4	60/18.3
A-4	10.3	0	0	1	0.05	10	0.05	7.7	235	0.1	31/9.5	105/32.0
A-5	39.8	0	0	1	0.40	38	0.05	7.5	425	0.1	11/3.4	38/11.6
A-6	21.1	0	0	2	1.15	232	0.05	7.5	710	0.5	10/3.1	120/36.6
A-7	9.1	0	0	2	0.25	72	0.05	7.3	590	0.2	14/4.3	58/17.7
SS-1[5]	--	--	--	--	--	--	--	8.6	550	0.3	--	--
SS-2	--	--	--	--	--	--	--	8.3	650	0.4	--	--
SS-3	--	--	--	--	--	--	--	8.2	510	0.5	--	--

1. State of Utah Public Drinking Water Regulations
2. Secondary drinking water standard
3. BR = bedrock well
4. A = unconsolidated valley-fill well
5. SS = surface water site

(BR-2, BR-3, A-1, A-2), all the test results are within standards established by the State of Utah Public Drinking Water Regulations.

The total coliform counts are not considered indicative of a sewage contamination problem in the absence of fecal coliform bacteria. High sulfide values in wells BR-1, BR-2, and BR-3 likely reflect the presence of gypsum and anhydrite in the Moenkopi Formation (plate 1). Both minerals contain sulfate and are readily soluble in water (Hem, 1970). The high sulfate value in well A-6 may indicate that the well penetrates the Moenkopi Formation even though the driller's log reports completion in conglomerate. The Phosphoria Member of the Park City Formation contains economically significant quantities of phosphorus in the Vernal area (Kinney, 1955; Untermann and Untermann, 1964). The elevated total phosphorus value in well BR-3, which penetrates the Park City Formation, is considered attributable to the presence of phosphate-rich shale in the well. The associated low concentration of nitrate, a far more common and mobile constituent of sewage effluent, is further evidence that the high phosphorus value in BR-3 is naturally occurring.

Two cases of bacteria-contaminated well water in the canyon have been reported to health authorities (oral commun., Uintah Basin District Health Department personnel, 1982). The exact source of the contamination has not been determined; however, both occurrences are believed to represent isolated problems related to site-specific conditions. One well is located in the open next to a shed, the only protection provided being a roof shingle placed over the top of the open casing. The second well is in a field where livestock are sometimes pastured. Estimated depth to the seasonal high stand of the shallow water table at the second well is less than 5 feet. Other undetected or unreported site-specific ground-water contamination problems related to STSA systems may exist in the canyon. However, in the absence of test data showing a wide-spread, ground-water contamination problem, their occurrence would be considered an indication of local construction, maintenance, or siting inadequacies.

Site Evaluation Criteria

The criteria used in this study to evaluate site suitability or STSA systems are: soil type and characteristics, depth to ground water, depth to bedrock, slope, and flood hazard. Soils with excessively high or low permeability, less than 1 minute per inch or greater than 60 minutes per inch are considered unsuitable for soil absorption systems (U.S. Public Health Service, 1957; Warshall, 1979). The permeability and filtering capacity of a soil depends on its texture (grain size and distribution) and structure (the manner in which individual and groups of soil particles are arranged). Coarse-grained, mixed gravel and cobble soils lacking interstitial fines possess limited effluent filtering capacity and may be too permeable to function in a soil absorption system. Clay soils, particularly if the clay minerals are expansive, generally lack adequate permeability and may swell when wet (Parker and others, 1978). Soil textures lying between the very coarse and the very fine grained are best for use in soil absorption systems. When classified according to the Unified Soil Classification System (appendix), suitable soils generally fall into the soil groups GM, SM, and ML; suitable to marginal soils in GC, SW, SP, and SC; marginal to unsuitable soil in GP, GW, MH, and CL, and unsuitable soils in CH, OL, OH, and PT. The Unified Soil Classification System group symbols corresponding to the unconsolidated deposits in Dry Fork Canyon are shown on plate 1 along with other soil characteristics of importance to STSA systems. Percolation test data were used to refine the assessment of soil suitability where available.

STSA systems installed in areas of shallow ground water increase the potential for ground-water contamination and the possibility of system saturation and failure (Otis, 1978; Parker and others, 1978; Christenson, 1981). Numerous studies have shown that percolation through 2 to 4 feet of unsaturated soil is sufficient to remove bacteria, viruses, and heavy metals to acceptable levels and nearly all phosphorus from sewage effluent (Seabloom, 1976; Tyler and others, 1978; U.S. Environmental Protection Agency, 1980). On that basis, 4 feet of unsaturated soil was established as the minimum acceptable separation between the bottom of a soil absorption system and the water table. Removal of nitrogen by the soil is less complete, and instances of nitrate-contaminated ground water have been reported from densely populated areas relying on STSA systems (Twichell and Davis, 1978; Tyler and others, 1978; DeWalle, Schaff, and Hatlen, 1980). The degree of nitrogen removal provided by a soil depends on soil type, loading rate, and the presence of aerobic or anerobic soil conditions. Dilution is the main mechanism available to reduce nitrate concentrations to safe levels in ground water (Tyler and others, 1978).

Shallow bedrock may effect STSA systems by either halting the downward percolation of effluent to cause ponding and saturated soil conditions or, if fractured, by allowing the sewage easy access to rock aquifers. To ensure proper effluent renovation, 4 feet of unsaturated soil was established as the minimum acceptable separation between the bottom of a soil absorption system and bedrock.

Slope angle affects runoff, infiltration, movement of effluent in soil, and limits the use of mechanical equipment to install STSA systems (Parker and others, 1978). The steeper the slope, the deeper a soil absorption system must be to provide sufficient horizontal separation and filtration of effluent before reaching the ground surface (Utah State Division of Health, 1967). The steepness of the slope on which an STSA system can be successfully installed depends on other site factors such as soil type, depth to bedrock, slope configuration, hillside stability, and climate. For this study, slope angle alone was not considered sufficient criteria to rank a site as unsuitable. However, it is acknowledged that a 25 percent (12 degree) slope represents a practical upper limit for STSA system installation and function (Troyan and Norris, 1977; Parker and others, 1978). Areas in Dry Fork Canyon with slopes in excess of 25 percent are considered marginal for STSA systems and in most instances other site factors, e.g., shallow bedrock, combine to make them unsuitable.

Flooding represents a hazard to STSA systems both because associated erosion can uncover and destroy the system and because flood waters infiltrating into the ground may plug distribution lines with fine sand and silt. Flood hazards in the study area are of two types, overbank flooding associated with spring runoff along Dry Fork Creek, and flash floods along ephemeral drainages during the summer months. A high probability of flooding (based on topography and evidence of past flooding) was considered sufficient to rank a site as unsuitable. A lesser probability, particularly of flash flooding, in areas with adequate space for system setbacks or diversion structures were evaluated individually and resulted in sites being ranked from suitable to marginal.

Site Suitability Evaluation

The evaluation of site suitability for STSA systems in Dry Fork Canyon was based on the premise that a properly sited, constructed, and maintained soil absorption system is a safe and effective method of disposing of home sewage (Warshall, 1979; Machmeier, 1980; U.S. Environmental Protection Agency, 1980). Studies have shown that the average life expectancy of an STSA system operated under reasonable conditions is 18 to 26.7 years (Hill and Frink, 1974; Clayton, 1975; Twichell and Davis, 1978), a time span which compares favorably with the design life of many integrated sewage collection and treatment facilities. A considerable effort was made during the literature review portion of this study to identify references that correlate site conditions with a recommended lot size. That effort proved largely fruitless; the consensus being that properly functioning STSA systems will not create a pollution problem provided that their density of installation is not too great. Building lots need to be large enough to allow installation of a correctly-sized STSA system with sufficient additional space for a backup system should the first fail. Where conditions are suitable over a considerable area, lot sizes of 1/2 to 1 acre have been recommended (Nery, 1968; Holzer, 1975; Utah State Department of Health, 1982). Such spacing is generally thought sufficient to insure proper dilution of any nitrate leached to the water table (Holzer, 1975). Under less suitable conditions a larger lot size may be required. In Wilson vs. Sherborn, 1975 Mass. App. Ct. Dav. Sh 645, the court validated two-acre zoning upon a showing that a placement of septic tanks and wells on smaller lots could lead to pollution of water supply (Jackman, 1974). In marginal areas where site conditions change rapidly over short distances, two approaches to lot size are possible: 1) restrict development to large lots to ensure inclusion of sufficient suitable area for an STSA system, or 2) require detailed predevelopment site studies to locate acceptable disposal sites and limit construction to those areas. The first approach may result in the platting of some lots, no matter how large, which do not include sufficient suitable area for an STSA system. The second, while more efficient, is more costly and may lead to the abandonment of properties where the number of prospective lots make development uneconomical.

The evaluation of site suitability for soil absorption systems presented on plate 3 is based on an analysis of the site suitability criteria discussed in the previous section. The map was prepared at a scale of 1:24,000 (1 inch = 2000 feet) and is intended for general planning purposes and preliminary site reviews. Use of the map does not preclude the need for a site-specific investigation prior to installation of STSA systems. Four site suitability categories were established for Dry Fork Canyon:

1. Generally suitable; site conditions favorable, danger of system failure due to geologic or hydrologic factors is low. Site-specific investigations still necessary.

2. Generally suitable but locally unsuitable; site conditions favorable over most of the area but unfavorable conditions exist locally. Site-specific investigations necessary, special construction techniques may be required.

3. Generally unsuitable but locally suitable; site conditions unfavorable over most of the area but favorable conditions exist locally. Extensive investigation may be required to locate acceptable STSA sites, special construction techniques may be required.

4. Generally unsuitable; site condition unfavorable, alternative methods of sewage disposal normally required.

The four suitability categories are identified on plate 3 by Roman numerals I through IV respectively. Subscripts to the numerals (a through i) denote site conditions critical in establishing the category classifications. A detailed explanation of the classification system is presented on plate 3.

One site factor of importance when evaluating the ground-water contamination potential of STSA systems which did not lend itself to analysis on plate 3 is the location of water wells. Numerous investigators have proposed safe separation distances between STSA systems and culinary wells (U.S. Public Health Service, 1957; Parker and others, 1978; U.S. Environmental Protection Agency, 1980). Existing Utah Health Code (Part IV) regulations require a separation distance of 100 feet between deep wells and STSA systems. Proposed revisions to the regulations governing STSA systems would establish a 100-foot minimum separation from deep wells used for public water supply, and a mandatory 200-foot) but recommended 1500-foot separation from shallow wells. STSA systems serving individual residences would be required to have a 100-foot separation from deep wells and a 200-foot distance from shallow wells. Adequate separation distances are particularly important for private wells due to their wide variation in construction standards. Few of the wells examined during this study showed evidence of an adequate surface seal and many of those described on drillers' logs did not meet current construction standards (State of Utah Division of Water Rights, 1980). Wells were observed within 12 feet of STSA systems, in low areas where surface runoff collects, and adjacent to animal pens and barns. It can be expected that such conditions will eventually lead to contamination problems.

SUMMARY

The principal questions to be answered by this study were: 1) are natural conditions in Dry Fork Canyon such that STSA systems can be used to safely dispose of domestic wastewater, and 2) will a substantial increase in the number of systems in the canyon result in a ground-water contamination problem. In answer to the first question, a review of the geology, hydrology, and soils in the study area (plates 1 and 2) indicates that natural conditions are variable and that suitability for STSA systems ranges from good to unfavorable depending upon location (plate 3). A considerable area exists in the canyon where STSA systems can, on the basis of site conditions, be expected to function satisfactorily. Many marginal areas will accept systems only on a limited basis, their location controlled by the availability of suitable site conditions. Development in areas identified as unsuitable will require alternative methods of sewage disposal approved by appropriate health authorities. The second question, regarding the possibility of ground-water contamination resulting from an increase in the number of STSA systems in the canyon, depends on a more complex set of factors, and therefore is more difficult to answer. With the possible exception of nitrates, properly sited, constructed, and maintained STSA systems do not present a hazard to ground-water supplies. Nitrate contamination can be controlled within acceptable limits (10 mg/l, Utah Safe Drinking Water Standards) by avoiding high-density developments (lot sizes less than 1 acre). From the standpoint of site conditions, a potential ground-water contamination problem exists in areas identified as unsuitable for STSA systems on the basis of shallow depth to ground water or fractured bedrock (plate 3). Both conditions may allow sewage effluent access to the water table. Problems may also arise in areas classified as "generally suitable but locally unsuitable" or "generally unsuitable but locally suitable" (plate 3) unless detailed preinstallation site evaluations are performed (Zulauf, 1976; Parker and others, 1978; U.S. Environmental Protection Agency, 1980; Struchtemeyer and Black, 1982). Unfortunately, the contamination potential of STSA systems depends on more than just suitability of natural site conditions. Ground-water contamination can occur under the best site conditions if system construction and maintenance are inadequate. The location of water wells in relation to STSA systems and the construction of the wells are also important considerations. These factors are independent of site conditions and are often difficult to control from a regulatory standpoint. The results of this study indicate that geologically it should be possible, within the limits stated, to utilize STSA systems for sewage disposal in Dry Fork Canyon without endangering ground-water quality. However, it will be necessary to gain control over those non-site condition factors influencing the contamination potential of STSA systems before satisfactory ground-water quality can be assured.

Other than a one-acre minimum to prevent possible nitrate contamination, a correlation between lot size and site conditions does not exist for STSA systems. Conditions conducive to the proper functioning of an STSA system must be present on a lot, no matter what its size, before the system can be installed. Five failing systems spread over 25 acres on 5-acre lots provide no advantage over 5 properly functioning systems on adjacent 1-acre lots. Installation of STSA systems should be based solely on the ability of site conditions to satisfactorily accommodate the system as determined by a site- specific investigation. If no suitable sites are available on a 5-acre lot, increasing the lot's size to 10 acres will be of no benefit if the additional 5 acres does not include a suitable site. It is recommended that for developments in the canyon proposed for areas identified on plate 3 as "generally suitable but locally unsuitable" and "generally unsuitable but locally suitable" preconstruction waste disposal investigations be required. The number of lots in a subdivision and their layout could then be established on the availability of disposal sites, rather than relying on a predetermined minimum lot size that may or may not bear a relationship to existing site conditions.

GLOSSARY

Alluvial fan: A low, outspread, relatively flat to gently sloping mass of loose rock material, shaped like an open fan or a segment of a cone made by a stream where it runs out onto a level plain or meets a slower stream.

Alluvium: Sedimentary deposits resulting from the action of running water.

Aquifer: Stratum or zone below the surface of the earth capable of producing water as to a well.

Caliche: Secondary accumulation of calcium carbonate developed in soils at or near the ground surface.

Colluvium: A general term applied to loose and incoherent deposits usually at the foot of a slope or cliff and brought there chiefly by gravity.

Confined ground water Ground water under pressure significantly greater than that of the atmosphere and whose upper surface is the bottom of an impermeable bed; i.e. artesian ground water.

Graben: An elongate, relatively depressed crustal unit or block that is bounded by faults along its sides.

Horst: An elongate, relatively uplifted crustal unit or block that is bounded by faults along its sides.

Perched ground water: Unconfined ground water separated from an underlying main body of ground water by an unsaturated zone.

Quartzose: A term applied to sands, sandstones, and grits essentially composed of quartz.

Terrace: A relatively flat, horizontal, or gently inclined surface, sometimes long and narrow which is bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side.

Unconfined ground water: Ground water that has a free water table, i.e., water not confined under pressure beneath a relatively impermeable stratum.

REFERENCES

Baumann, R.E., Jones, E.E., Jakubowski, W.M., and Nottingham, M.C., 1978, Septic tanks *in* Home Sewage Treatment Symposium, 2nd, 1977, Proceedings: American Society of Agricultural Engineers, p. 38-53

Bowman, J.O., 1981, A study of septic tank absorption systems *in* McClelland, N.I., and Evans, J.L., eds, Individual On-Site Wastewater Systems Conference, 7th, Ann Arbor, 1980, Proceedings: National Sanitation Foundation, p. 115-128.

Brown, K.W., Slowey, J.F., and Wolf, H.W., 1978, The movement of salts, nutrients, fecal coliform and virus below septic leach fields in three soils, *in* Home Sewage Treatment Symposium, 2nd, 1977, Proceedings: American Society of Agricultural Engineers, p. 208-217.

Carrara, P.E., 1980, Surficial geologic map of Vernal 1° x 2° Quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I-1204, scale 1:250,000.

Christenson, G.E., 1981, Engineering geology for land-use planning, Ballard, Utah: Utah Geological and Mineral Survey Report of Investigation No. 167, 13 p.

Clayton, J.W., 1975, An analysis of septic tank survival data from 1952 to 1972 in Fairfax County, Virginia *in* Jewell, W.J., and Swan, R., eds., Water Pollution Control in Low Density Areas Conference, Hanover, 1975, Proceedings: University Press of New England, p. 75-88.

Clyde, G.C., Oaks, R.Q., Kolesar, P.T., and Fisk, E.P., 1981, The potential for ground-water contamination along basin margins in the arid west: alluvial fans and lake features: Utah Water Research Laboratory, Utah State University, Hydraulics and Hydrology Series UWRL/H-81/05, 82 p.

Costa, J.E., and Baker, V.R., 1981, Surficial geology building with the earth: New York, John Wiley and Sons, p. 397-423.

DeWalle, F.B., 1978, Failure analysis of septic tank systems *in* Plews, Gary, Seabloom, Robert, and Strong, D., eds., Northwest On-Site Wastewater Disposal Short Course, 2nd, Seattle, 1978, Proceedings: University of Washington Departments of Civil Engineering and Environmental Health, p. 206-222.

DeWalle, F.B., Schaff, R.M., and Hatlen, J.B., 1980, Well water quality deterioration central Pierce County, Washington: American Water Works Association Journal, September 1980, p. 533-536.

Fisk, E.P., and Clyde, C.G., 1981, A survey and evaluation of shallow ground-water contamination hazards in the State of Utah: Utah Water Research Laboratory, Utah State University, Hydraulics and Hydrology Series UWRL/N-81/04, 45 p.

Fritton, D.D., Stahl, J.H., and Aron, G., 1982, A site evaluation model for effluent disposal *in* On-Site Sewage Treatment Symposium, 3rd, 1981, Proceedings: American Society of Agricultural Engineers, p. 32-41.

Gill, H.E., 1982, Geologic and hydrologic evaluation of Mt. Pleasant watershed, Sanpete County, Utah: Utah Geological and Mineral Survey Report of Investigation No. 169, 18 p.

Hansen, W.R., 1969, The geologic story of the Uinta Mountains: U.S. Geological Survey Bulletin 1291, 144 p.

Hantzsche, N.N., Neikirk, W.T., and Wishom, T.V., 1982, Soil textural analysis for on-site sewage disposal evaluation *in* On-Site Sewage Treatment Symposium, 3rd, 1981, Proceedings: American Society of Agricultural Engineers, p. 51-60.

Harkin, J.M., 1976, Use of soil as a treatment and disposal media for wastewater *in* Northwest On-Site Wastewater Disposal Short Course, 1st, Seattle, 1976, Proceedings: University of Washington Department of Civil Engineering and Environmental Health, p. 9-19.

Hatlen, J.B., 1976, Public health considerations for on-site sewage disposal *in* Northwest On-Site Wastewater Disposal Short Course, 1st, Seattle, 1976, Proceedings: University of Washington Department of Civil Engineering and Environmental Health, p. 27-32.

Hem, J.D., 1970, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 1473, 363 p.

Hill, D.E., and Frink, C.R., 1974, Longevity of septic systems in Connecticut soils: Connecticut Agricultural Experiment Station, Bulletin 747.

Holzer, T.L., 1975, Limits to growth and septic tanks *in* Water Pollution Control in Low Density Areas Conference, Hanover, 1975, Proceedings: University Press of New England, p. 65-75.

Hood, J.W., 1976, Characteristics of aquifers in the northern Uinta Basin area, Utah and Colorado: State of Utah Department of Natural Resources Technical Publication No. 53, 71 p.

———1977, Hydrologic evaluation of Ashley Valley, northern Uinta Basin area, Utah: State of Utah Department of Natural Resources Technical Publication No. 54, 25 p.

Hood, J.W., and Fields, F.K., 1978, Water resources of the northern Uinta Basin area, Utah and Colorado, with special emphasis on ground water supply: State of Utah Department of Natural Resources Technical Publication No. 62, 75 p.

Jackman, R.D, 1974, The septic tanks role in land use *in* Conference on Land and Water Use in Oregon: Water Resources Research Institute, Oregon State University, p. 69-75.

Johnson Division, Universal Oil Products Company, 1972, Ground water and wells: St. Paul, Minnesota, p. 65-80.

Kinney, D.M., 1955, Geology of the Uinta River - Brush Creek area Duchesne and Uintah Counties, Utah: U.S. Geological Survey Bulletin 1007, 185 p.

Lund, W.R., 1981, Engineering geology for land-use planning Perry, Utah: Utah Geological and Mineral Survey Report of Investigation No. 165, 12 p.

Lustig, K.W., 1978, Effects of wastewater on ground water: an Idaho experience *in* Plews, Gary, Seabloom, Robert, and Strong, D., eds., Northwest On-Site Wastewater Disposal Short Course, 2nd, Seattle, 1978, Proceedings: University of Washington Departments of Civil Engineering and Environmental Health, p. 223-230.

MacGregor, A.S., and Johnson, G.M., 1978, Management districts - a key to implementing an on lot disposal alternative *in* McClelland, N.I., ed., Individual On-Site Wastewater Systems Conference, 4th, Ann Arbor, 1977, Proceedings: National Sanitation Foundation, p. 41-52.

Machmeier, R.E., 1980, Town and country sewage treatment: Agricultural Extension Service, University of Minnesota Extension Bulletin 304 - revised 1980, 66 p.

Maxwell, J.D., Bridges, B.L., Barker, D.A., and Moore, L.G., 1971, Hydrogeology of the eastern portion of the south slopes of the Uinta Mountains, Utah: State of Utah Department of Natural Resources Information Bulletin No. 21, 54 p.

Metcalf and Eddy Inc., 1979, Wastewater engineering, treatment/disposal/refuse: New York, McGraw-Hill, 920 p.

Miller, D.W., ed., 1980, Waste disposal effects on ground water: Berkeley, Premier Press, 512 p.

Mountainland Association of Governments, 1981, Impact of septic tank systems on ground and surface water in the Mountainland area, final version: Provo, Utah, 67 p.

Nelson, J.D., and Ward, R.C., 1982, Ground-water monitoring strategies for on-site sewage disposal systems *in* On-Site Sewage Treatment Symposium, 3rd, 1981, Proceedings: American Society of Agricultural Engineers, p. 301-308.

Nery, R.J., 1968, Planning for private water and sewer systems *in* Better Water and Sewer Services for Small Communities in North Carolina Symposium, Chapel Hill, 1968, Proceedings: Institute of Government and Water Resources Research Institute, University of North Carolina.

Otis, R.J., 1978, Site evaluation for absorption systems *in* Plews, Gary, Seabloom, Robert, and Strong, D., eds., Northwest On-Site Wastewater Disposal Short Course, 2nd, Seattle, 1978, Proceedings: University of Washington Departments of Civil Engineering and Environmental Health, p. 38-59.

Parker, D.E., Lehr, J.H., Roseler, R.C., and Paeth, R.C., 1978, Site evaluation for soil absorption systems *in* Home Sewage Treatment Symposium, 2nd, 1977, Proceedings: American Society of Agricultural Engineers, p. 3-15.

Patterson, J.W., Minear, R.A., and Nedved, T.K., 1971, Septic tanks and the environment: PB-204 519 National Technical Information Service, U.S. Department of Commerce, 98 p.

Peavy, H.S., and Groves, K.S., 1978, The influence of septic tank drainfields on ground water *in* Home Sewage Treatment Symposium, 2nd, 1977, Proceedings: American Society of Agricultural Engineers, p. 218-225.

Rowley, R.D, Tweto, Ogden, Hansen, W.R., and Carrara, P.E., 1979, Geologic map of the Vernal 1° x 2° Quadrangle, Colorado, Utah and Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-1163, scale 1:250,000.

Scalf, M.R., Dunlap, W.J., and Kreissl, J.F., 1977, Environmental effects of septic tank systems: EPA-600/3-77-096, 35 p.

Seabloom, R.W., 1976, Soil capabilities in wastewater renovation *in* Northwest On-Site Wastewater Disposal Short Course, 1st, Seattle, 1976, Proceedings: University of Washington Departments of Civil Engineering and Environmental Health, p. 20-26.

Searle, L.B., 1967, untitled paper on irrigation canal leakage in Ashley Valley and Dry Fork Canyon: U.S. Soil Conservation Service, unpublished, 8 p.

Sowers, G.B., and Sowers, G.F., 1970, Introductory soil mechanics and foundations: London, McMillan Company, 554 p.

State of Utah Department of Health, 1980, State of Utah public drinking water regulations, part I - administrative rules and part II - design and construction standards: Division of Environmental Health, Salt Lake City, Utah.

Stewart, L.W., and Reneau, R.B., Jr., 1982, Movement of fecal coliform bacteria from septic tank effluent through coastal plain soils with high seasonal fluctuating water tables *in* On-Site Sewage Treatment Symposium, 3rd, 1981, Proceedings: American Society of Agricultural Engineers, p. 319-327.

Struchtemeyer, R.A., and Black, R.W., 1982, Experiences with using on-site investigations to size and design septic tank drain fields *in* On-Site Sewage Treatment Symposium, 3rd, 1981, Proceedings: American Society of Agricultural Engineers, p. 42-50.

The Asphalt Institute, 1978, Soils manual for the design of asphalt pavement structures: Manual Series No. 10 (MS-10), p. 1-71.

Troyan, J.J., and Norris, D.P., 1977, Cost-effectiveness analysis of alternatives for small wastewater treatment systems: prepared for EPA Technology Transfer Municipal Design Seminar on Small Wastewater Treatment Systems, Seattle, 1977.

Twichell, J.H., and Davis, H.C., 1978, The effects of the use and regulation of septic tank systems upon land use in Massachusetts: Water Resources Research Center, University of Massachusetts, Project No. A-103, 90 p.

Tyler, E.J., Laak, R., McCoy, E., and Sandhu, S.S., 1978, The soil as a treatment system *in* Home Sewage Treatment Symposium, 2nd, 1977, Proceedings: American Society of Agricultural Engineers, p. 22- 37.

Untermann, G.E., and Untermann, B.R., 1964, Geology of Uintah County: Utah Geological and Mineral Survey Bulletin 72, 112 p.

U.S. Environmental Protection Agency, 1980, Design manual, on-site wastewater treatment and disposal systems: Office of Research and Development Municipal Environmental Research Laboratory, Cincinnati, Ohio, 391 p.

U.S. Geological Survey, 1980, Land use and land cover, 1975-77 Vernal, Utah; Colorado; Wyoming: Land Use Series Map I-142, scale 1:250,000.

U.S. Public Health Service, 1957, Manual of septic-tank practice: U.S. Department of Health, Education, and Welfare, Rockville, Maryland, 92 p.

Utah State Department of Health, 1982, Wastewater disposal regulations, part IV, individual wastewater disposal systems: Utah Water Pollution Control Committee, unpublished, 82 p.

Utah State Division of Health, 1967, Code of waste disposal regulations, part IV, individual wastewater disposal systems: Utah Water Pollution Control Board, 17 p.

Warkentin, B.P., and Harward, M.E., 1978, Potential of soil as a treatment medium *in* Plews, Gary, Seabloom, Robert, and Strong, D., eds., Northwest On-Site Wastewater Disposal Short Course, 2nd, Seattle, 1978, Proceedings: University of Washington Departments of Civil Engineering and Environmental Health, p. 60-70.

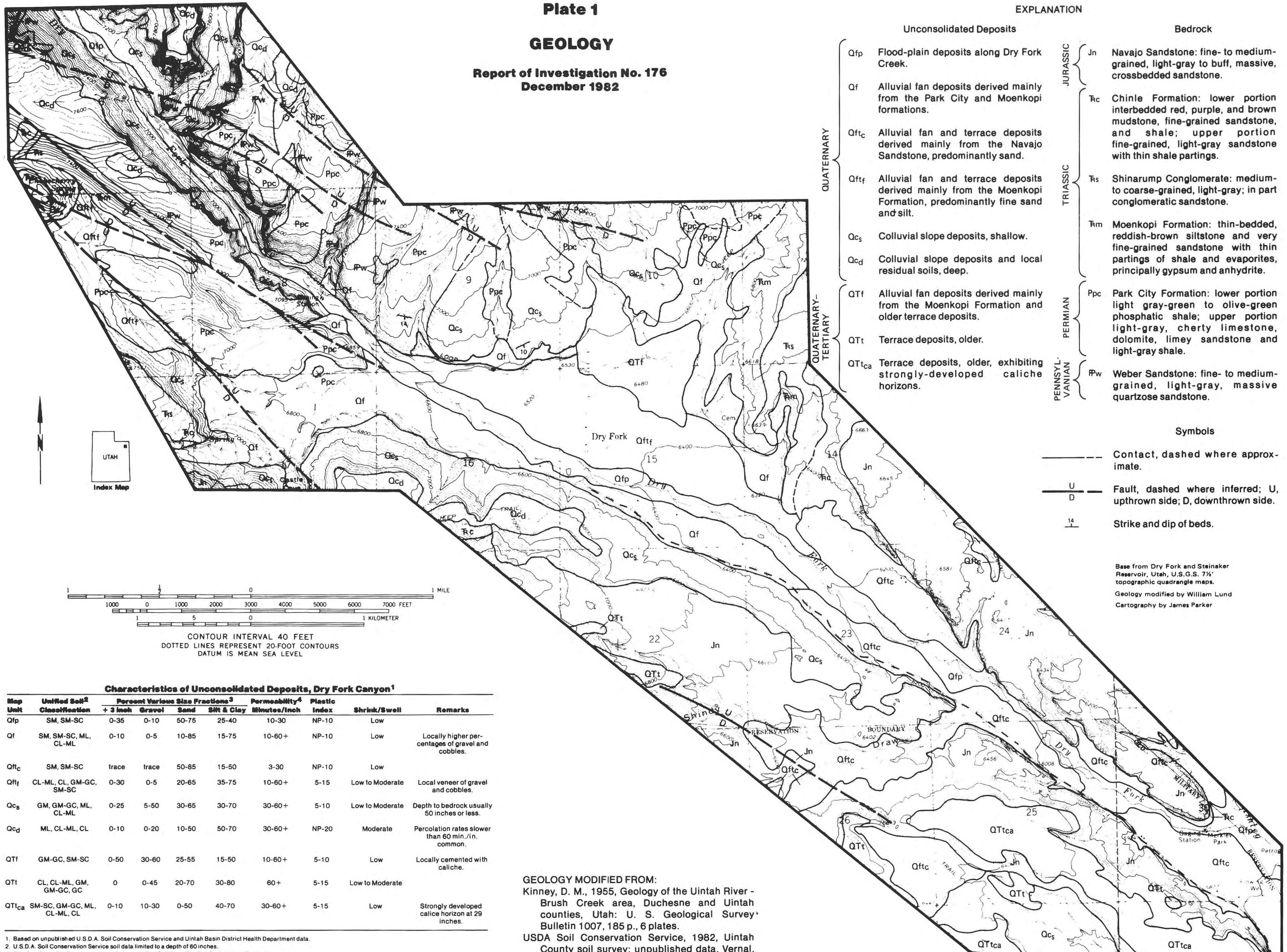
Warshall, P., 1979, Septic tank practices: Garden City, Anchor Books, 177 p.

Zulauf, A., 1976, Soils-characteristics, surveys and maps *in* Northwest On-Site Wastewater Disposal Short Course, 1st, Seattle, 1976, Proceedings: University of Washington Departments of Civil Engineering and Environmental Health, p. 38-48.

Plate 1

GEOLOGY

Report of Investigation No. 176
December 1982



EXPLANATION

Unconsolidated Deposits

QUATERNARY

- **Qfp** Flood-plain deposits along Dry Fork Creek.
- **Qf** Alluvial fan deposits derived mainly from the Park City and Moenkopi formations.
- **Qft_c** Alluvial fan and terrace deposits derived mainly from the Navajo Sandstone, predominantly sand.
- **Qft_f** Alluvial fan and terrace deposits derived mainly from the Moenkopi Formation, predominantly fine sand and silt.
- **Qc_s** Colluvial slope deposits, shallow.
- **Qc_d** Colluvial slope deposits and local residual soils, deep.

QUATERNARY-TERTIARY

- **QTf** Alluvial fan deposits derived mainly from the Moenkopi Formation and older terrace deposits.
- **QTt** Terrace deposits, older.
- **QTt_{ca}** Terrace deposits, older, exhibiting strongly-developed caliche horizons.

Bedrock

JURASSIC

- **Jn** Navajo Sandstone: fine- to medium-grained, light-gray to buff, massive, crossbedded sandstone.

TRIASSIC

- **₮c** Chinle Formation: lower portion interbedded red, purple, and brown mudstone, fine-grained sandstone, and shale; upper portion fine-grained, light-gray sandstone with thin shale partings.
- **₮s** Shinarump Conglomerate: medium- to coarse-grained, light-gray; in part conglomeratic sandstone.
- **₮m** Moenkopi Formation: thin-bedded, reddish-brown siltstone and very fine-grained sandstone with thin partings of shale and evaporites, principally gypsum and anhydrite.

PERMIAN

- **Ppc** Park City Formation: lower portion light gray-green to olive-green phosphatic shale; upper portion light-gray, cherty limestone, dolomite, limey sandstone and light-gray shale.

PENNSYLVANIAN

- **PPw** Weber Sandstone: fine- to medium-grained, light-gray, massive quartzose sandstone.

Symbols

- Contact, dashed where approximate.
- Fault, dashed where inferred; U, upthrown side; D, downthrown side.
- 14 Strike and dip of beds.

Base from Dry Fork and Steinaker Reservoir, Utah, U.S.G.S. 7½' topographic quadrangle maps.
Geology modified by William Lund
Cartography by James Parker

Characteristics of Unconsolidated Deposits, Dry Fork Canyon[1]

Map Unit	Unified Soil[2] Classification	Percent Various Size Fractions[3] + 3 inch	Gravel	Sand	Silt & Clay	Permeability[4] Minutes/Inch	Plastic Index	Shrink/Swell	Remarks
Qfp	SM, SM-SC	0-35	0-10	50-75	25-40	10-30	NP-10	Low	
Qf	SM, SM-SC, ML, CL-ML	0-10	0-5	10-85	15-75	10-60+	NP-10	Low	Locally higher percentages of gravel and cobbles.
Qft_c	SM, SM-SC	trace	trace	50-85	15-50	3-30	NP-10	Low	
Qft_f	CL-ML, CL, GM-GC, SM-SC	0-30	0-5	20-65	35-75	10-60+	5-15	Low to Moderate	Local veneer of gravel and cobbles.
Qc_s	GM, GM-GC, ML, CL-ML	0-25	5-50	30-65	30-70	30-60+	5-10	Low to Moderate	Depth to bedrock usually 50 inches or less.
Qc_d	ML, CL-ML, CL	0-10	0-20	10-50	50-70	30-60+	NP-20	Moderate	Percolation rates slower than 60 min./in. common.
QTf	GM-GC, SM-SC	0-50	30-60	25-55	15-50	10-60+	5-10	Low	Locally cemented with caliche.
QTt	CL, CL-ML, GM, GM-GC, GC	0	0-45	20-70	30-80	60+	5-15	Low to Moderate	
QTt_{ca}	SM-SC, GM-GC, ML, CL-ML, CL	0-10	10-30	0-50	40-70	30-60+	5-15	Low	Strongly developed calice horizon at 29 inches.

1. Based on unpublished U.S.D.A. Soil Conservation Service and Uintah Basin District Health Department data.
2. U.S.D.A. Soil Conservation Service soil data limited to a depth of 60 inches.
3. Size fractions of soil components conform to Unified Soil Classification System specifications.
4. Permeability rates shown represent an average range for the soils in the map unit.

GEOLOGY MODIFIED FROM:

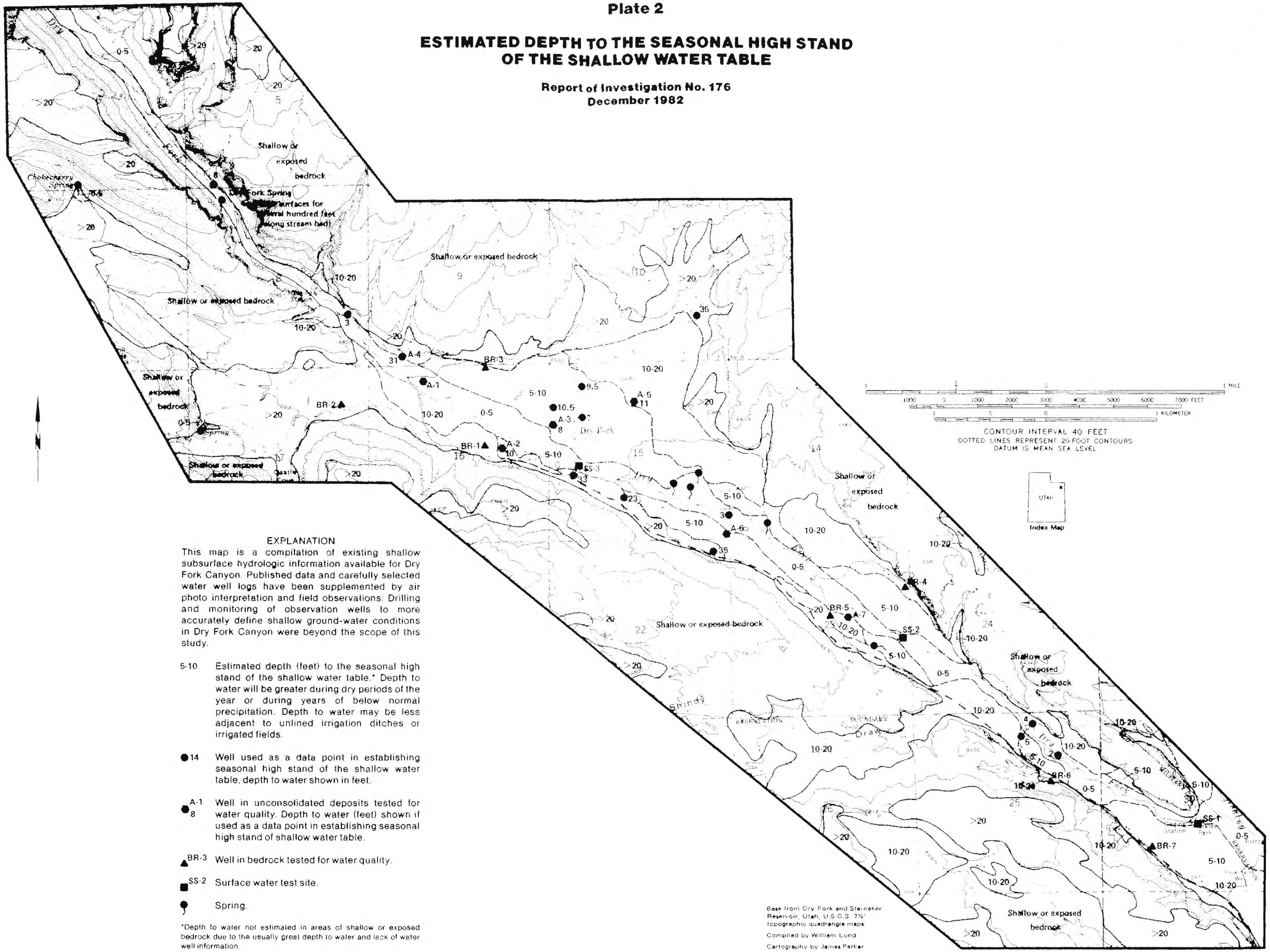
Kinney, D. M., 1955, Geology of the Uintah River - Brush Creek area, Duchesne and Uintah counties, Utah: U. S. Geological Survey Bulletin 1007, 185 p., 6 plates.

USDA Soil Conservation Service, 1982, Uintah County soil survey; unpublished data, Vernal, Utah.

Plate 2

ESTIMATED DEPTH TO THE SEASONAL HIGH STAND OF THE SHALLOW WATER TABLE

Report of Investigation No. 176
December 1982



EXPLANATION

This map is a compilation of existing shallow subsurface hydrologic information available for Dry Fork Canyon. Published data and carefully selected water well logs have been supplemented by air photo interpretation and field observations. Drilling and monitoring of observation wells to more accurately define shallow ground-water conditions in Dry Fork Canyon were beyond the scope of this study.

5-10 Estimated depth (feet) to the seasonal high stand of the shallow water table.* Depth to water will be greater during dry periods of the year or during years of below normal precipitation. Depth to water may be less adjacent to unlined irrigation ditches or irrigated fields.

●14 Well used as a data point in establishing seasonal high stand of the shallow water table, depth to water shown in feet.

●A-1 8 Well in unconsolidated deposits tested for water quality. Depth to water (feet) shown if used as a data point in establishing seasonal high stand of shallow water table.

▲BR-3 Well in bedrock tested for water quality.

■SS-2 Surface water test site.

Spring.

*Depth to water not estimated in areas of shallow or exposed bedrock due to the usually great depth to water and lack of water well information.

Base from Dry Fork and Steinaker Reservoir, Utah, U.S.G.S. 7½' topographic quadrangle maps.

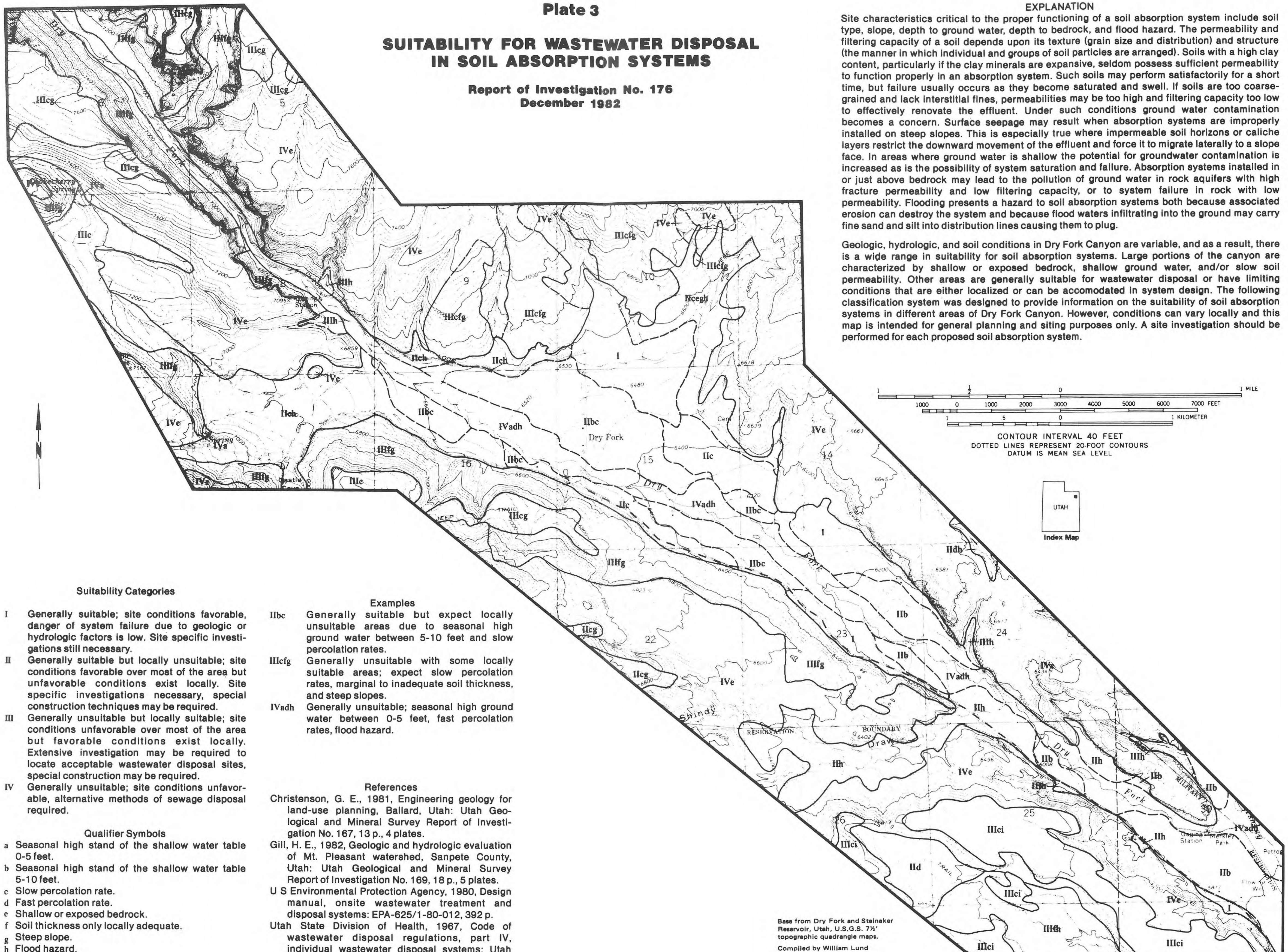
Compiled by William Lund

Cartography by James Parker

Plate 3

SUITABILITY FOR WASTEWATER DISPOSAL IN SOIL ABSORPTION SYSTEMS

Report of Investigation No. 176
December 1982



Base from Dry Fork and Steinaker Reservoir, Utah, U.S.G.S. 7½′ topographic quadrangle maps.
Compiled by William Lund
Cartography by James Parker

EXPLANATION

Site characteristics critical to the proper functioning of a soil absorption system include soil type, slope, depth to ground water, depth to bedrock, and flood hazard. The permeability and filtering capacity of a soil depends upon its texture (grain size and distribution) and structure (the manner in which individual and groups of soil particles are arranged). Soils with a high clay content, particularly if the clay minerals are expansive, seldom possess sufficient permeability to function properly in an absorption system. Such soils may perform satisfactorily for a short time, but failure usually occurs as they become saturated and swell. If soils are too coarse-grained and lack interstitial fines, permeabilities may be too high and filtering capacity too low to effectively renovate the effluent. Under such conditions ground water contamination becomes a concern. Surface seepage may result when absorption systems are improperly installed on steep slopes. This is especially true where impermeable soil horizons or caliche layers restrict the downward movement of the effluent and force it to migrate laterally to a slope face. In areas where ground water is shallow the potential for groundwater contamination is increased as is the possibility of system saturation and failure. Absorption 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 capacity, or to system failure in rock with low permeability. Flooding presents a hazard to soil absorption systems both because associated erosion can destroy the system and because flood waters infiltrating into the ground may carry fine sand and silt into distribution lines causing them to plug.

Geologic, hydrologic, and soil conditions in Dry Fork Canyon are variable, and as a result, there is a wide range in suitability for soil absorption systems. Large portions of the canyon are characterized by shallow or exposed bedrock, shallow ground water, and/or slow soil permeability. Other areas are generally suitable for wastewater disposal or have limiting conditions that are either localized or can be accomodated in system design. The following classification system was designed to provide information on the suitability of soil absorption systems in different areas of Dry Fork Canyon. However, conditions can vary locally and this map is intended for general planning and siting purposes only. A site investigation should be performed for each proposed soil absorption system.

Suitability Categories

- I Generally suitable; site conditions favorable, danger of system failure due to geologic or hydrologic factors is low. Site specific investigations still necessary.
- II Generally suitable but locally unsuitable; site conditions favorable over most of the area but unfavorable conditions exist locally. Site specific investigations necessary, special construction techniques may be required.
- III Generally unsuitable but locally suitable; site conditions unfavorable over most of the area but favorable conditions exist locally. Extensive investigation may be required to locate acceptable wastewater disposal sites, special construction may be required.
- IV Generally unsuitable; site conditions unfavorable, alternative methods of sewage disposal required.

Qualifier Symbols

- a Seasonal high stand of the shallow water table 0-5 feet.
- b Seasonal high stand of the shallow water table 5-10 feet.
- c Slow percolation rate.
- d Fast percolation rate.
- e Shallow or exposed bedrock.
- f Soil thickness only locally adequate.
- g Steep slope.
- h Flood hazard.
- i Caliche.

Examples

- IIbc Generally suitable but expect locally unsuitable areas due to seasonal high ground water between 5-10 feet and slow percolation rates.
- IIIcfg Generally unsuitable with some locally suitable areas; expect slow percolation rates, marginal to inadequate soil thickness, and steep slopes.
- IVadh Generally unsuitable; seasonal high ground water between 0-5 feet, fast percolation rates, flood hazard.

References

Christenson, G. E., 1981, Engineering geology for land-use planning, Ballard, Utah: Utah Geological and Mineral Survey Report of Investigation No. 167, 13 p., 4 plates.

Gill, H. E., 1982, Geologic and hydrologic evaluation of Mt. Pleasant watershed, Sanpete County, Utah: Utah Geological and Mineral Survey Report of Investigation No. 169, 18 p., 5 plates.

U S Environmental Protection Agency, 1980, Design manual, onsite wastewater treatment and disposal systems: EPA-625/1-80-012, 392 p.

Utah State Division of Health, 1967, Code of wastewater disposal regulations, part IV, individual wastewater disposal systems: Utah Water Pollution Control Board, 17 p.

REPORT OF INVESTIGATION NO. 181
ENGINEERING GEOLOGY FOR LAND-USE PLANNING
SMITHFIELD, UTAH

by
Gary E. Christenson

ABSTRACT

Smithfield is in the Cache Valley of northern Utah approximately 5 miles north of Logan. It is the largest city in Utah that depends entirely on septic tank and soil absorption systems for domestic wastewater disposal. Information regarding soil absorption field suitability and ground-water contamination are a major concern in planning for the city's future growth. Much of the city is underlain by Quaternary-age alluvial-fan deposits and Lake Bonneville deltaic and lake-bottom sediments. Rocks of the Tertiary-age Salt Lake Formation are found in the foothills east of town. The potentially active East Cache fault zone traverses the base of the foothills, but conclusive evidence for post-Bonneville movement on the fault is lacking. Ground water occurs in shallow unconfined, perched, and confined aquifers with greatest depths to water and principal recharge occurring in the east.

Water in the principal aquifer is under artesian pressure and is of good quality with slightly elevated nitrate concentrations in and near the city. Nitrate levels in perched and shallow unconfined aquifers are locally higher. The principle sources of nitrates in all aquifers are septic tank effluent and leaching of surface contaminants by infiltrating precipitation and irrigation water. Conditions for septic tank soil absorption systems are good in much of the developed area of Smithfield but are poor in the remaining undeveloped area.

Geologic hazards in Smithfield include flooding, particularly along Summit Creek, and flash flooding and debris flows on alluvial fans at the mountain front. Bedrock slopes are generally stable, but steep slopes in unconsolidated deposits along Summit Creek are potentially unstable if disturbed. Shallow ground water and expansive soils are found in the northwest and southwest. Strong ground shaking accompanying earthquakes may affect the area, although the potential for surface fault rupture is low. Site-specific studies addressing hazards delineated in this report should be completed prior to development in hazard-susceptible areas.

INTRODUCTION

Smithfield is approximately five miles north of Logan in the Cache Valley of northern Utah (figure 1). It is at the mouth of Smithfield Canyon and covers about 3.5 square miles of valley floor and bench area. The city has a population of 4993 (1980), nearly double that of 2512 in 1960, with expansion of the incorporated area being principally to

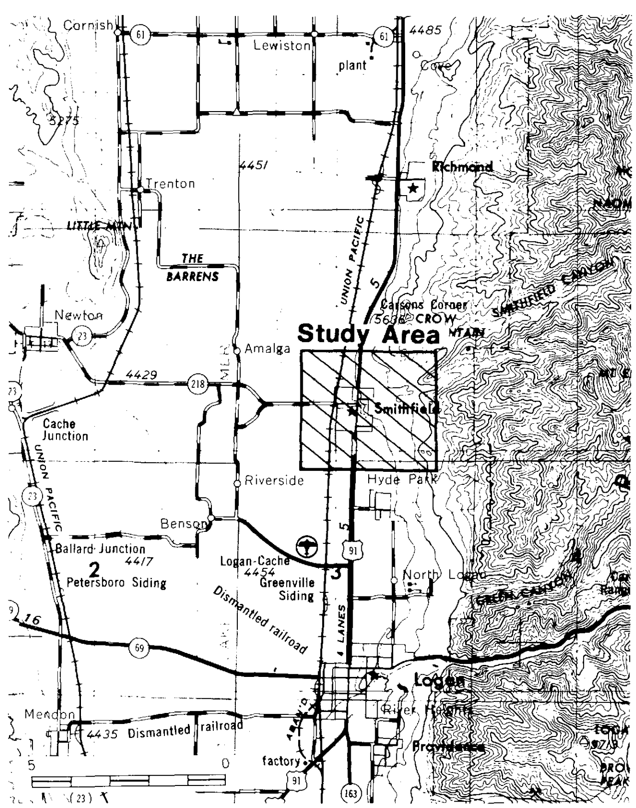


Figure 1. Location map.

the north and east.

Smithfield is the largest city in Utah that depends on septic tank and soil absorption systems for domestic wastewater disposal (Valley Engineering, Inc., 1980). In 1976, Valley Engineering, Inc. was retained to prepare a water and sewer master plan by the cities of Smithfield, Hyde Park, and North Logan. Because of the high number and increasing rate of septic tank system failures in Smithfield, that report recommended construction of a sewer system for Smithfield. The city completed step I of the work required by the EPA to qualify for partial federal funding in 1980. This consisted of preparation of a wastewater facility plan to define the problem, investigate alternative solutions, and recommend a preferred course of action (Valley Engineering, Inc., 1980). However, Smithfield residents rejected a bonding proposal to provide funding for the recommended sewer system in 1980. At present, various sewer system and funding alternatives are again under consideration. In the interim, concern over the effects of present wastewater disposal practices on culinary ground-water supplies and possible future effects of continuing these practices prompted the city to request the Utah Geological and Mineral Survey to undertake this study.

PURPOSE AND SCOPE

The purpose of this study is to compile and evaluate data relating to geologic, soil, and hydrologic conditions in the Smithfield area to provide the city with information useful in planning with particular emphasis on concerns relating to wastewater disposal. Proper planning for wastewater disposal is of major importance, both in the siting of new soil absorption systems and in the design of possible alternative systems to minimize impact on ground-water quality. The scope of work included:

1. Review of all available literature on geology, soils, and hydrology of the area.

2. Compilation of water well data held by the Utah Division of Water Rights.

3. Sampling of ground water from wells and springs and analysis for nitrates, phosphates, chlorides, sulfates, and coliform bacteria.

4. Drilling of eight test holes to evaluate soil conditions at depths from 5-25 feet.

5. Logging of existing test pits and compilation of available test pit and percolation rate data.

6. Discussions with city, state, and federal officials regarding existing problems in the city.

7. Analysis of the available data and preparation of this report.

The study area boundary includes the existing incorporated city and parts of the surrounding area into which Smithfield may expand. The study area extends at least 1/4 mile north, south, and west and 1/2 mile east of the present city limits.

SETTING

Smithfield is on the east side of the Cache Valley at the base of the Bear River Range. The principal drainage in Cache Valley is the Bear River which flows about one mile west of the Smithfield city limit. Summit Creek, a tributary to the Bear River, flows through Smithfield, draining a portion of the western Bear River Range that includes Smithfield and Birch Canyons. Elevations in the city range from 4930 feet in the east bench area to 4500 feet in western Smithfield on the gently west-sloping valley floor. Average annual precipitation varies from about 16 inches in west Smithfield to 18 inches on the east bench.

GEOLOGY

The general geology in the study area is shown in plate 1. Geologic materials exposed at the surface in the Smithfield area include both bedrock and unconsolidated basin-fill deposits. Bedrock consists of calcite-cemented conglomerate containing rounded limestone, dolomite, and chert pebbles. The unit is an upper member of the Tertiary Salt Lake Formation (Williams, 1962; Galloway, 1970), and is exposed in the northeastern corner of the map area and in Long Hill.

Most of Smithfield is underlain by unconsolidated deposits of Quaternary age. Surficial materials are chiefly alluvial (stream) and lacustrine (lake) deposits less than about 20,000 years old. The most significant influence on the nature and distribution of surficial materials was the presence of Lake Bonneville, an ice-age lake which inundated the Smithfield area and much of northern Utah from about 10,000 to 20,000 years ago. The oldest Quaternary deposits exposed are those between elevation 4780 feet and 5150 feet along foothills of the Bear River Range east of Smithfield (Qlb, plate 1). These materials were deposited from about 16,000 to 14,500 years ago as shoreline and nearshore deposits as Lake Bonneville transgressed and stabilized at its highest stage, termed the Bonneville level (5150 feet; Currey, 1982). The lake level dropped rapidly from 5150 feet about 14,300 years ago as the overflow channel or lake outlet to the north rapidly eroded down to a level of 4780 feet (Currey, 1982; Currey and others, 1983). The lake remained at this level, termed the Provo level, from 14,300 to about 13,500 years ago. During this time, gravels of the east bench (Summit Park - Smithfield Golf Course area) were deposited in a delta built of detritus from Smithfield and Birch Creeks where they entered the lake (Qlpd, plate 1). Further offshore, in what is presently western Smithfield, the water depth was around 300 feet and the finer-grained materials washed from the mountains and across the delta were deposited as silt and clay beds on the lake bottom.

The lake had receded from the Provo level by about 13,500-12,000 years ago (Currey and others, 1983). Major streams such as Summit and Birch Creeks cut through the delta gravels and redeposited them with additional materials from the mountains in an alluvial fan on the old lake bottom at the base of the delta. Lake-bottom silt and clay is still exposed north and southeast of Smithfield (Qlp), but most of the city is underlain by the alluvial-fan gravels (Qal). Similar alluvial-fan deposits from Dry Canyon and various small, unnamed canyons east of the study area now cover older lake deposits in the east bench area (Qal). Deposition of alluvium continues to the present.

In addition to geologic materials, plate 1 shows several lineaments in the northeast corner of the map area which have been identified on aerial photographs. These are considered by Woodward-Lundgren and Associates (1974) to be possible segments of the East Cache fault zone which trends along the east side of Cache Valley at the base of the Bear River Range. The fault zone is very prominent elsewhere along the mountain front, displacing Quaternary-age deposits, and a branch trends east of Smithfield about two miles east of the study area boundary. However, the features identified at the mountain front in plate 1 do not show strong evidence of movement since Lake Bonneville receded from its highest level 14,300 years ago. These photo lineaments traverse Bonneville-level deposits and generally consist of drainages which are not necessarily fault related. A spring and landslide occur in the vicinity of the lineaments, but these may also have other causes and are not conclusive evidence for faulting. Natural exposures are poor, and the existence of faults here can not be confirmed without subsurface investigation. Other workers in the area have inferred older, buried faults in the east bench area but report no evidence to indicate that faults are active (Williams, 1962; Galloway, 1970).

SOILS

Soils in the Smithfield area range from clean, poorly-graded gravels to thinly laminated clays. Gravelly and sandy soils are widespread in the eastern and central parts of the map area, while silty and clayey soils occur chiefly in the western and southern areas (plate 2). Most of the east bench north of Dry Creek is underlain by poorly-graded deltaic sand and gravel. Along Dry Creek, soils are of alluvial origin and consist of very coarse-grained (cobbly and bouldery) deposits near the mountain front grading westward into interbedded gravel, sand, and silt and ultimately to very uniform silt and clay in the vicinity of Sky View High School (see log of test boring 4, plate 2). West of the high school and throughout much of the city, gravelly soils of the Summit Creek alluvial fan are found. These gravels are similar to those of the east bench but generally contain more fine-grained material. North of Smithfield, clays of the old lake bottom are exposed. West and south of Smithfield, these clays are found locally but are partially buried beneath silty and clayey deposits in the distal segments of the Summit Creek alluvial fan.

Plate 2 depicts the distribution of various soil types in the upper five feet as modified from the USDA Soil Conservation Service soil survey of Cache County (Erickson and Mortensen, 1974). The forty soil series mapped in that report in the study area have been combined into the five soil units shown in plate 2 based on engineering interpretations and soil type (Unified Soil Classification System, appendix). Some soil boundaries have been modified based on geologic mapping, test borings, and air photo interpretation. Contacts between soil units are generally irregular and gradational and represent zones of transition rather than distinct contacts. Soil descriptions in the map explanation are also modified from Erickson and Mortensen (1974). Percolation rate data in the soil survey report have been supplemented with information from tests for septic tank system approval in subdivisions in north and east Smithfield.

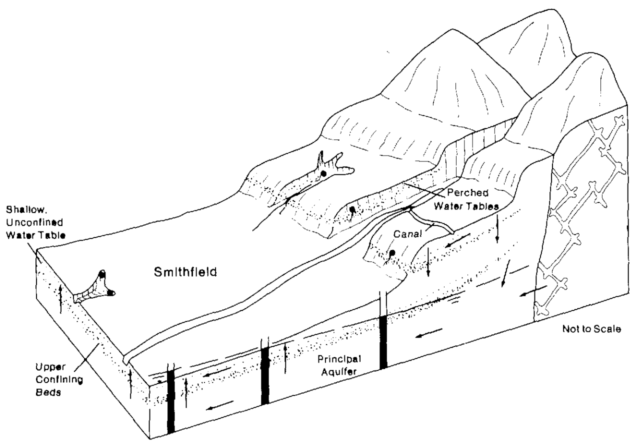
Eight test borings were drilled to evaluate soils at depths from 5-25 feet. Logs of test borings shown in plate 2 and numerous soil exploration trenches for septic tank systems indicate that soils are highly variable vertically as well as laterally. Because of this variability, plate 2 is generalized and soils shown on the map should be confirmed by test pits at each site. Verification is particularly important where soil investigations are required for approval of septic tank systems or for foundation design.

GROUND WATER

Occurrence

Ground water in the Smithfield area occurs in the unconsolidated basin-fill deposits underlying the city as shown in figure 2. The numerous sand and gravel layers in the basin fill are collectively termed the principal aquifer, and all irrigation and culinary wells in Smithfield tap this aquifer (Bjorklund and McGreevy, 1971). Water in these layers is generally under artesian pressure because it is confined beneath less permeable fine-grained (silt and clay) layers termed the upper confining beds. These beds are not completely impermeable, however, and some upward leakage occurs where artesian conditions exist. Unconfined water-table conditions are present in the principal aquifer in recharge areas along the mountain front where confining layers are thin or absent and sand and gravel layers are not saturated through their entire thickness. Plate 3 shows depth to water contours on the potentiometric surface of the principal aquifer, i.e., contours either indicate the level to which water will rise in a well intersecting confined sand and gravel aquifers where artesian conditions exist or indicate the depth to the water table where unconfined conditions exist. The location of wells used to construct the map and data pertaining to these wells are also shown in plate 3. Well data and most depth to water measurements are taken from drillers' logs on file at the Utah Division of Water Rights. Where multiple depth to water measurements are given for a single well, later measurements were taken from McGreevy and Bjorklund (1970) and deVries (1982).

Flow of ground water in the principal aquifer is from east to west. Recharge occurs from the downward infiltration of water from precipitation, streams, canals, irrigated fields, and subsurface inflow from bedrock aquifers, principally along the valley margin where permeable sand and gravel extend to great depths and interbedded clay layers are thin or absent (Bjorklund and McGreevy, 1971). Discharge from the principal aquifer occurs west of Smithfield where flow is upward through leaky confining layers. Between the



EXPLANATION

Zone of clay or silt having low permeability (confining layer or aquiclude)

Potentiometric surface or principal aquifer beneath upper confining beds showing level to which water will rise in wells

Spring

Direction of ground water movement

Figure 2. Schematic block diagram showing relation of confined, unconfined, and perched ground water in the Smithfield area (adapted by Bjorklund and McGrevy, 1971).

major recharge and discharge areas of the principal aquifer, infiltrating water from the surface recharges shallow unconfined and perched aquifers and infiltrates into the principal aquifer only where upper confining layers are permeable and artesian conditions do not exist.

Depth to water contours shown in plate 3 are generalized. An insufficient number of wells could be measured to provide a 1983 depth to water data base, so measurements made at the time of drilling were used. Annual fluctuations of up to 10 feet have been recorded for some wells, with highest levels in August and lowest levels in March and April. This indicates a significant component of recharge to the principal aquifer from irrigation. Maximum long-term fluctuations from year to year for a given month are on the order of 10-15 feet (McGreevy and Bjorklund, 1970). However, no apparent trends for ground-water levels other than a direct response to precipitation are indicated by the long-term measurements. Water levels in Cache Valley are stable and natural recharge-discharge relationships have not been changed by withdrawal from wells (Bjorklund and McGreevy, 1971).

Well yields in the principal aquifer are very high. Well 6 (plate 3) has a reported yield of 3600 gallons per minute (gpm), and most other large wells report yields exceeding 1000 gpm (Bjorklund and McGreevy, 1971). A test to determine aquifer characteristics was performed at well 6 (plate 3) in 1969 by the U.S. Geological Survey. The well was pumped continuously at 3600 gpm for 12 days with a drawdown of 10 feet. Water level recovery data were taken for four hours after pumping was halted and the data indicate a transmissivity of 330,000 ft^3/day/ft and a hydraulic conductivity of 1400 ft^3/day/ft^2 (Bjorklund and McGreevy, 1971). These values are very high, even when compared to other wells nearby, but serve to indicate the extremely high permeability and water transmitting capacity of these sand and gravel aquifers.

As shown in plate 3, the springs west of Smithfield are natural discharge points for ground water leaking upward from the principal aquifer and for ground water in a postulated shallow unconfined aquifer above the upper confining beds (Bjorklund and McGreevy, 1971). The existence of this shallow unconfined aquifer is based on the presence of such aquifers under similar conditions elsewhere in the Cache Valley. Logs of several wells indicate water encountered above the upper clay layers, but most do not. Water was encountered above the upper clay beds in soil test boring 1 (plate 2), but the saturated thickness was only about one foot. The extent and importance of this aquifer is not known. Other springs in the Smithfield area flow from perched water tables in the east bench area south of Summit Creek. It is probable that a similar perched zone occurs in the bench north of Summit Creek as well. Shallow water is also present in the flood plains of Summit and Birch Creeks as indicated by basement flooding in at least one home along Summit Creek east of Mack Park.

Quality

Ground water is used for a variety of purposes in Smithfield, including public and private drinking water supplies. To evaluate the effect of wastewater disposal in soil absorption systems on the quality of ground water, samples were taken from selected wells and springs for analysis. Sample locations and a tabulation of both well construction data and water quality analyses done for this study and compiled from other sources are presented in plate 3. For this study, samples from springs were taken as near the source as possible, but in several cases samples could not be obtained at the discharge point. Samples from wells were taken from outside taps at private wells and from sampling points on discharge pipes at irrigation wells.

To approximate natural background quality of ground water in Smithfield, analyses from various recharge sources were used. Water in Summit Creek and in the Logan, Hyde Park, and Smithfield Canal is considered representative of the general quality of infiltrating surface water. Water from springs used for public supply 1.5 miles and more east of Smithfield in Smithfield Canyon is probably similar in quality to that recharging the deep aquifer system through bedrock underflow. Analyses of water quality from these sources are shown at the bottom of the table in plate 3, along with public drinking water standards set by the Utah Health Department for comparison.

When found in concentrations above background levels, certain water-quality parameters are considered indicative of septic tank effluent contamination. From a survey of the literature, the Mountainland Association of Governments (1981) determined these parameters to include nitrates, chlorides, sulfates, sodium, coliform bacteria, potassium, and total dissolved solids. Detailed work by the State of Washington has identified viruses, bacteria, nitrates, phosphates, and detergents as primary indicators, and chlorides, nitrites, and hardness as secondary indicators. Of these, Seabloom (1976) considers high concentrations of nitrogen and phosphorus compounds and high fecal coliform counts to be the most common and most diagnostic indicators.

Samples taken for this study were analyzed for total and fecal coliform (membrane filter method), nitrate, total phosphorus, chloride, and sulfate. Of these, nitrates are probably the least effectively treated by soils, particularly under aerobic (unsaturated) conditions, and can remain in ground water for great distances (Seabloom, 1976). Coliform bacteria and phosphorus compounds are removed quite rapidly by fine-grained soils, but are less effectively treated by gravelly soils and, if present, are reliable indicators of contamination (Spahr, 1973). High concentrations of soluble salts, particularly chlorides, are also common in effluent (DeWalle and others, 1980; DeWalle and Schaff, 1980).

While these parameters may indicate contamination by septic tank effluent, none are found exclusively in effluent and all have other sources. Certain coliform bacteria (nonfecal) occur naturally in soil. Fecal coliforms are found in wastes from all warm-blooded animals and may get into surface and ground water from leaching of wastes from feed lots in Smithfield Canyon (Meyers and others, 1972) or from dairies and animal grazing areas. Nitrogen and phosphorus compounds may be leached into the ground water from fertilizers and decaying plant remains by infiltrating precipitation or irrigation water. Soluble salts such as chlorides and sulfates may have natural sources in basin-fill material. Water quality analyses are thus somewhat ambiguous with regard to source, and identification of sources must be based on local environmental conditions as well as the presence of contaminants.

Wells

All wells selected for water quality analysis in this study tapped the principal aquifer, i.e., only wells with a total depth exceeding 100 feet with casings either not perforated or perforated below 100 feet were sampled (see table, plate 3). Logs of wells indicate clayey layers above aquifer zones with water under artesian pressure in most wells. All water from wells tested satisfied public drinking water standards for the parameters used in this study. Nitrate concentrations showed the most significant trends and are listed on the map in plate 3 at each well sampled. Nitrate concentrations typical of recharge waters are 0.04 mg/l for the Logan, Hyde Park, and Smithfield Canal; 0.1 - 0.8 mg/l for the Smithfield culinary springs; and 0.08 - 0.28 mg/l for Summit Creek. Water in wells west of Smithfield shows concentrations similar to this, but wells in and near the city show concentrations from 1.14 - 3.72 mg/l. This indicates that a source of nitrate contamination exists somewhere between the principal recharge and discharge areas, and that the nitrates are essentially removed in transit between the source and the wells west of town. Although it is thought that these nitrate concentrations are representative of the principal aquifer, contaminant levels may be in part attributable to leakage along well casings from contaminated shallow aquifers above upper confining layers. Sufficiently detailed records of well construction are not available to evaluate this possibility. In any case, wells with high nitrate levels occur in areas surrounded by irrigated farmland with no nearby septic tank systems, and in urban areas with many septic tank systems. Thus, both septic tank effluent and leaching from irrigated farmland appear to be contributing to nitrate levels in ground water.

Coliform bacteria, sulfate, chloride, and phosphorus levels show no significant trends. Coliform bacteria were absent from all wells. Except in isolated cases, chloride, sulfate, and phosphorus concentrations were within or slightly above background levels and do not indicate a groundwater contamination problem with respect to these anions.

Springs

Several springs were sampled to determine water quality in the perched gravel aquifer in the east bench (springs 2, 3, and 4; plate 3) and in the unconfined aquifer beneath Smithfield (springs 1, 5, and 6; plate 3). No wells draw water from these zones, so they could only be tested in springs. Spring water generally showed higher total coliform counts and higher nitrate levels than well water. High total coliform counts are common in surface water (see table, plate 3) and shallow ground water in gravelly materials. Coliform bacteria commonly occur in soils and, in the absence of fecal coliforms, do not indicate contamination by effluent. Chloride, sulfate, and phosphorus concentrations are low in spring waters and not significantly above background levels.

Nitrate levels in springs west of Smithfield indicate a possible contribution to spring flow from a shallow aquifer beneath Smithfield. While much of the water discharged in these springs may be leakage upward from the principal aquifer, nitrate levels are generally higher than those in adjacent wells. This is probably due to a contribution from the shallow unconfined aquifer which derives nitrates from downward-percolating irrigation water and/or effluent. Because most of these springs are a mile or more from concentrated sources of effluent and are surrounded by cultivated fields and in some cases drain from beneath fields, it is believed that irrigation water is the principal nitrate source. Clyde and others (1981) performed studies to the north in Richmond with respect to nitrate levels in spring and well water before and after installation of a sewer system in 1972. It was found that nitrate levels decreased markedly following installation of the sewer, but that final levels were from 1.04 - 9.29 mg/l and still above expected background. These continued high nitrate levels (generally higher that those in Smithfield) were attributed to effects of the agriculture and dairy industries (Clyde and others, 1981).

Perched ground water in the east bench area exhibits considerable variation in nitrate concentration. This is probably due to the variety of sources for both nitrates and water. The nitrate concentration in spring 3 (Taylor spring) is very low while that in springs 2 (golf course spring) and 4 (Berg spring) are just below or exceed, respectively, the primary standard set for safe drinking water (plate 3). It is believed that much of the water in spring 3 infiltrates from the Logan, Hyde Park and Smithfield Canal. Correlation between changes in flow in the canal and in discharge at the spring (table 1), as well as low nitrate concentration in both. The spring and the canal water indicate a direct connection with a relatively short travel distance. Spring 3 was the only locality where fecal coliforms were found. However, it is also the locality with the longest overland flow distance before sampling, and it is possible that the coliforms were picked up during flow at the surface. This is the most probable source because no septic tanks are used in this area and no fecal coliforms occur in the canal water.

High nitrate and phosphate concentrations in spring 2 (golf course spring) are probably from leaching of fertilizer and decaying plant material by irrigation water applied to the golf course and cultivated fields in the area. No septic tanks are found in the recharge area. High nitrate concentrations in spring 4 (Berg spring) may be both from leaching by irrigation water and from effluent because several houses are present in the spring recharge area. The more consistent base flow of this spring (table 1) indicates a partial year-round source other than irrigation inflow. Water quality analyses were performed on water from springs 2 and 4 twice in 1979 and again for this study. Nitrate concentrations have shown a progressive increase over this period, indicating a trend which will probably continue (table 2).

Table 1. Discharge data for springs 3 and 4 (pl. 3) during 1983

Date	Spring 3 (Taylor)	Spring 4 (Berg)	Remarks
5/24	2.4	2.2	Flow turned into Logan, Hyde Park, and Smithfield Canal.
6/10	3.3	2.2	
6/16	5.0	2.4	
7/1	6.7	3.8	
7/7	6.7	4.6	
7/29	6.7	5.0	
8/22	—	—	Irrigation on golf course reduced to twice weekly.
9/22	4.3	4.6	
9/27	4.0	4.6	
10/3-5	—	—	Irrigation halted on golf course and flow turned out of Logan, Hyde Park, and Smithfield Canal.
10/7	3.2	4.3	
10/13	3.2	4.3	
10/25	3.0	3.5	
10/28	2.7	3.2	
11/15	2.9	3.3	
12/2	2.6	—	

Table 2. Nitrate concentrations in springs 2 and 4 (pl. 3).

Spring	Date	Nitrates (mg/l)
2	3/20/79	0.754
	9/12/79	3.36
	8/5/83	9.45
4	3/20/79	2.32
	9/12/79	3.0
	6/14/83	11.30

SUITABILITY FOR WASTEWATER DISPOSAL IN SOIL ABSORPTION FIELDS

Site suitability for septic tank soil absorption systems depends on soil type, slope, depth to rock and ground water, and flooding potential (Christenson, 1981; U.S. Environmental Protection Agency, 1981; Lund, 1983). Grain size is the principal factor in determining soil permeability (percolation rate) and capacity to treat effluent. Fine-grained soils (chiefly clay) or coarse-grained soils with high percentages of clay (some clayey sands and gravels) may lack sufficient permeability to allow effluent to percolate away from drainlines at a satisfactory rate. Where clays with high shrink-swell potential are present, permeability will decrease progressively with time as clays saturate and swell. Conversely, coarse-grained soils lacking fines (clean sands and gravels) have little filtering or exchange capacity and effluent may enter the ground water relatively untreated. This is particularly critical in areas of shallow ground water or in areas of recharge to deeper aquifers where coarse-grained soils exist to great depths with no intervening fine-grained layers.

Slopes exceeding 25 percent are considered prohibitive and slopes from 10-25 percent marginal for soil absorption systems because effluent migrating laterally may surface on the slope before sufficient travel distance through soils can occur to allow for proper treatment. Introduction of water (effluent) into a steep slope may also induce ground instability and damage or expose drainlines. In areas of shallow rock, contamination of rock aquifers may occur as effluent percolates into fractures and enters the ground water relatively untreated. If the rock is unfractured and impermeable, problems similar to those in clayey soils may result as effluent is unable to percolate outward and comes to the surface above drainlines or backs up the system. Shallow ground water may adversely affect soil absorption systems through flooding of drainlines. Surface flooding by streams will have a similar affect although only temporary and may also threaten the system with erosion and/or plugging of drainlines with material (fine sand, silt, and clay) carried by infiltrating water.

The general suitability for septic tank soil absorption systems from the standpoint of geology, soils, and hydrology is shown in plate 4. This map was constructed from data of many types and from many sources. The principal source of soil data was the U.S. Department of Agriculture·Soil Conservation Service soil survey of the Cache Valley area (Erickson and Mortensen, 1974). Modifications made to the soil survey map for compilation of plate 2 were carried over for use in plate 4, with the addition of slope categories from the soil survey map. Geology and ground-water information were taken from plates 1 and 3, respectively. Finally, information from Smithfield City, the Bear River Health Department, and Valley Engineering, Inc. (1980) regarding soil percolation rates and existing soil absorption field and seepage pit failures was incorporated. Not all failures can be explained by natural site conditions, and it is probable that some were caused by poor system design, construction, and/or maintenance.

A survey of Smithfield residents by Valley Engineering, Inc. (1980) documented the extent of septic tank failure problems in the city. Failures have increased from 25-30 occurrences for the period May 1975 - May 1976 to over 80 for the period May 1977 - May 1978. Problems are spread throughout the city, including existing systems which have operated properly for many years in areas shown on plate 4 to be suitable for drainfields. The most probable explanation is that long-term soil clogging resulting from build-up of an organic mat around drainlines is occurring in these otherwise suitable areas. However, new systems are also failing in north and east Smithfield in areas shown in plate 4 to be marginal to unsuitable for drainfields. Much of the remaining undeveloped area in and around Smithfield also falls into these categories.

GEOLOGIC HAZARDS

The principal geologic hazards affecting Smithfield which should be considered in planning are shown and discussed in Plate 5. Many of the hazardous areas are outside the present city limits but affect areas of potential future development.

Flooding and Debris Flows

Floods occur in response to summer cloudburst storms or rapid spring snowmelt and runoff with the most serious flooding usually occurring along Summit Creek. Perhaps the largest cloudburst-generated flood along Summit Creek occurred June 6 and 7, 1964, when over 2 inches of rain in 24 hours was recorded at Logan (Butler and Marsell, 1972). Other significant cloudburst floods in the Cache Valley were reported on July 24, 1923; May 10, 1947; September 15-16, 1963; and August 3, 1969 (Butler and Marsell, 1972; Wooley, 1946). Storm-related floods also occurred in 1980 and 1981 (Utah Division of Comprehensive Emergency Management, 1981). Details of flood damage from these events are lacking.

Seasonal flooding related to spring snowmelt also effects local streams, although these floods have not been systematically documented as have cloudburst events. Snowmelt flooding was experienced during the spring of 1983 with destruction of several bridges across Summit Creek and general scour and undercutting of embankments, culverts, bridges, and roads.

The generalized zone of flooding (Unit I, plate 5) represents the extent of the 100-year flood as defined by the Federal Insurance Administration (1975, 1981). The map does not necessarily reflect the influence of culverts, bridges, and flood-control structures. Three principal zones of flooding are delineated: (1) Summit Creek, (2) Birch Creek, and (3) an unnamed, abandoned channel in northwest Smithfield. While mapped as a flood hazard zone, it is believed that the degree of hazard along the channel in northwest Smithfield is much less than that along Summit and Birch Creeks. Flood hazard is considered less because the channel drains a very small area and is essentially dammed in its headwaters by railroad and road embankments. Variances have been granted by the Department of Public Safety for building in this channel.

In addition to overbank flooding by major streams, debris flows and flash flooding from smaller streams along the foothills east of Smithfield present local hazards. Heavy spring runoff and cloudburst floods have transported debris onto the east bench. The extent of this debris (delineated Qal in plate 1) roughly marks the probable maximum extent of debris-flow activity (Unit II, plate 5) since Lake Bonneville retreated from the area about 14,300 years ago. In some cases, incision by modern streams and construction of retention structures and canals have made it unlikely that a similar extent could be achieved during modern times. These factors were considered in delineating the zones of normal flooding shown within Unit II (plate 5). Debris-laden floods from Dry Creek in the spring of 1983 reached the Logan, Hyde Park, and Smithfield Canal (south of 300 South street), although most of the coarser debris was dropped before entering the canal. As shown in plate 5, this canal should provide an adequate barrier for most floods, although it could conceivably be breached during large events. An incised drainage south of Long Hill poses a particular threat to the canal and area downslope. This stream emerges from its incised channel just upslope from the canal and could fill and breach the canal during heavy runoff.

Slope Stability

For purposes of stability assessment, slopes in the Smithfield area have been grouped into two categories according to whether underlying geologic materials are bedrock or unconsolidated deposits. Bedrock slopes are generally very steep (greater than 40 percent) but do not show evidence of instability. Lower bedrock slopes are generally buried under a variable thickness of colluvium, indicating that rockfall has occurred. However, no fresh rockfall scars or coarse debris are present. Rock outcroppings are few, even on upper slopes, and rockfall hazard is thus generally low. A possible slump in bedrock materials has been mapped east of the study area at the mouth of a small canyon by Woodward-Lundgren and Associates (1974). If this feature represents a rock slump, it is stabilized and predates Lake Bonneville. Bedrock slopes in the study area appear stable under present conditions.

Slopes in unconsolidated deposits are generally not as steep but are less stable than bedrock slopes. The unconsolidated deposits range from clean, poorly-graded gravel to clay. Coarser-grained deposits in steep slopes are subject to debris slides as the loose material sloughs away to achieve a more stable slope angle. Such rapid debris slide-type failures may occur if slopes become devegetated and/or saturated. Finer-grained materials are more subject to rotational earth slumps. One such slump is present in the northeast corner of the study area on the north side of Summit Creek (Unit IVa, plate 5). This slump is in fine-grained Lake Bonneville deposits. Hummocky topography typical of such failures remains but in subdued form, and drainage has been reestablished around the slump indicating that it is not recent. The slump involves Bonneville-level deposits of Lake Bonneville so it is younger than 14,300 years. Possible alluvial deposits related to the Provo level of Lake Bonneville (13,500 - 14,300 years ago; Currey and others, 1983) appear at the toe of the slide in an undeformed terrace indicating that the slump may have occurred prior to the retreat from the Provo level 13,500 years ago. A more recent and much smaller failure occurred around 1970 (Kaliser, 1975) on the bench slope south of Summit Creek near its confluence with Birch Creek (plate 5). This failure occurred in colluvium and fine-grained deposits on the slope, taking out part of a hillside irrigation canal and leaving a spoon-shaped scar in the hillside. Similarly, shallow active failures are present in road and waterline cuts along the south side of Smithfield Canyon where materials are chiefly clayey sands.

While no significant slope failures are presently active or appear to be eminent, a change in conditions could destabilize slopes, particularly in unconsolidated materials. Slope failure may be induced by disruption of vegetation, grading or cutting into slopes, wetting, or ground shaking. Development plans in any of the hillside areas (Units III and IV, plate 5) should be carefully considered with respect to slope stability.

Adverse Foundation Conditions

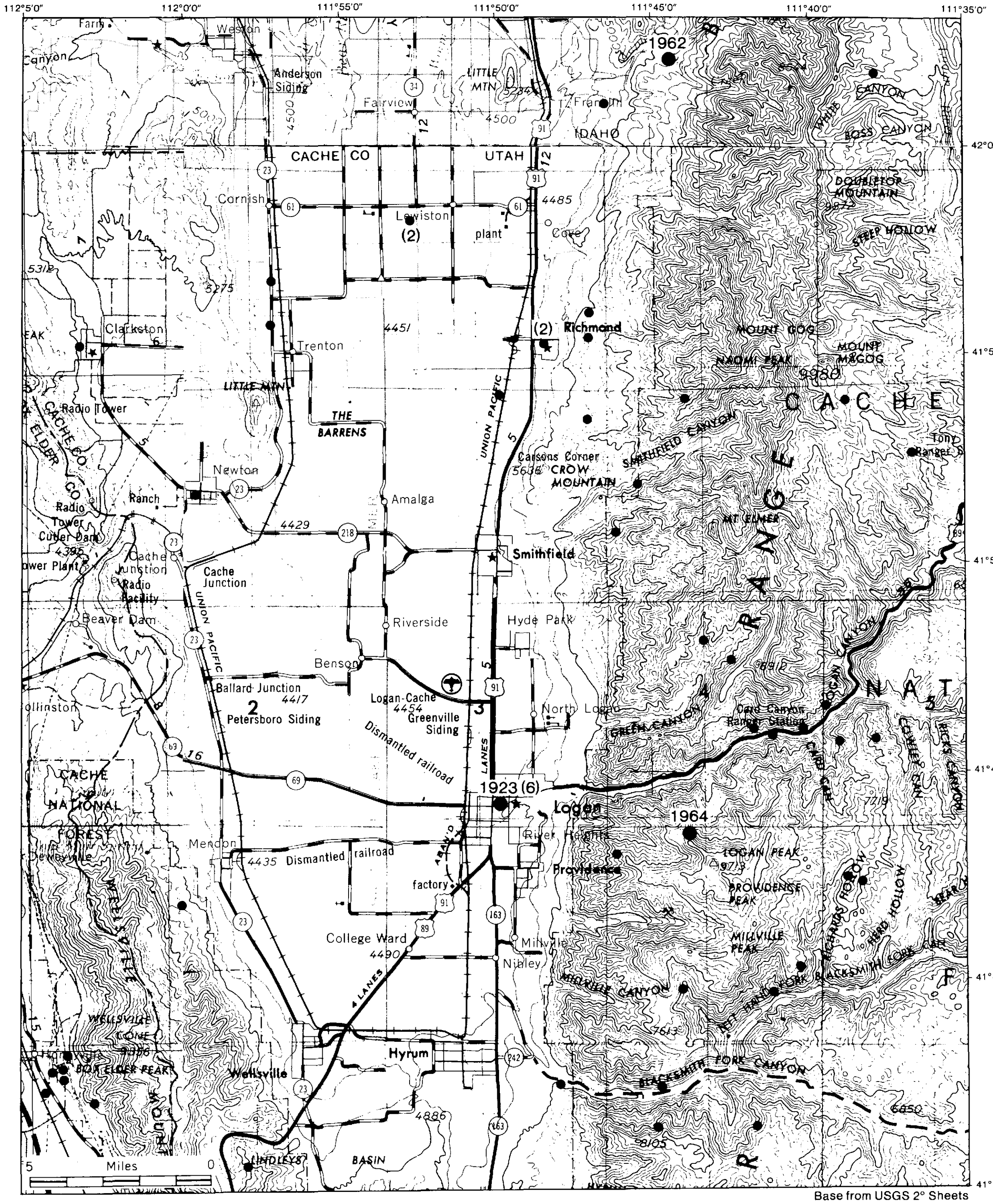
Two important conditions potentially hazardous to building foundations are present in the Smithfield area and are shown in plate 5. These are soils with high shrink-swell potential (expansive clays) and areas of possible shallow ground water. Expansive clays occur to some degree in most fine-grained soils. Soils with moderate shrink-swell potential are found in soil units III and IV (plate 2), but are not shown in plate 5. Only the soils exhibiting high shrink-swell potential (Soil Unit V, plate 2) are shown. Clays in these soils are subject to large changes in volume in response to changes in water content. This may lead to subsidence and/or heave beneath a foundation. Most adverse soil conditions are outside the present city limits except in the north. No severe soil-related foundation problems have been reported in Smithfield to date (George Walker, Jr., oral commun., April 1983).

Shallow ground water is present west of Smithfield (plate 5). It is generally absent in the city except locally along Summit and Birch Creeks. Transient shallow ground-water conditions may also occur locally in summer and fall in response to excessive irrigation, but the principal zone of shallow ground water is in the vicinity of springs and flowing wells to the west. In addition to flooding basements and below-ground structures, shallow ground water reduces bearing strengths of soils because of increased hydrostatic pressure. Certain soil types, principally clean sands, may also react adversely to seismic ground shaking if saturated. An instantaneous increase in hydrostatic pressure and loss of grain-to-grain contact accompanying shaking may lead to a complete loss of shear strength in the soil. This phenomenon is termed liquefaction and is an important consideration anywhere shallow ground water is present in a seismically active area.

Seismicity and Earthquake Potential

A plot of earthquake epicenters (Richter magnitude 2.0 or greater) in the Cache Valley - Bear River Range area from 1850 to September 30, 1983 is shown in figure 3. Data for this map are from the University of Utah Seismograph Stations catalog of earthquakes in Utah. Three earthquakes of Richter magnitude 4.0 or greater have occurred in the area, the largest on August 30, 1962. The epicenter was in the Bear River Range northeast of Richmond in southern Idaho (figure 3). Because of its magnitude and proximity to populated areas, this earthquake was the most damaging in Utah's history. The maximum modified Mercalli intensity was VII (appendix), and it produced damage in three-fourths of the houses in Richmond (Rogers and others, 1976). Major structural damage was incurred in Logan and presumably also in Smithfield. Other earthquakes of magnitude 4.0 or greater occurred on June 7, 1923, with the epicenter at Logan, and on October 18, 1964, with the epicenter 5-6 miles east of Logan (figure 3). The earthquake with its epicenter nearest Smithfield occurred on September 9, 1962, about 3.5 miles to the east in the upper Birch Canyon area. Other events of magnitude 2.0 - 4.0 are clustered in the Bear River Range east of the Cache Valley.

As shown in figure 3, Smithfield is in a seismically active area. Although few epicenters are centered along mapped traces of the East Cache fault zone, geologic evidence indicates that this zone is capable of generating earthquakes much larger than any that have occurred during historic time. For these reasons, the area is in Uniform Building Code seismic zone 3 in which earthquakes of modified Mercalli intensity VIII and higher may occur causing major damage. While most damage would result from severe ground shaking, surface fault rupture may also occur. The most likely areas of surface fault rupture are along zones of previous (prehistoric) fault rupture. Woodward-Lundgren and Associates (1974) have mapped lineaments from aerial photographs in the area which may be indicative of zones of



EXPLANATION

(2) ● Richter magnitude 2.0 - 4.0 with number of events shown at locations where more than one event has occurred.

1923 ● Richter magnitude greater than 4.0 with year event occurred.

Figure 3. Location of earthquake epicenters of Richter magnitude 2.0 or greater in the Cache Valley area, 1850 through September 1983.

past fault rupture (plate 5). Field investigation indicates that definitive evidence for rupture since the retreat of Lake Bonneville about 14,300 years ago is lacking and that the portion of the East Cache fault zone at the mountain front east of Smithfield has probably been inactive during at least Holocene time (0-10,000 years) and possibly longer.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations drawn from data presented in this report are listed below. They represent the major geologic and hydrologic factors to be considered in future planning for Smithfield. With regard to present ground-water quality and effects of existing wastewater disposal practices, the following is concluded:

- Water from wells in the principal aquifer is of good quality and within public drinking water standards for parameters tested for this study. However, nitrate concentrations in the principal aquifer are generally higher in and near the city than in outlying areas or in recharge waters. Where monitored, nitrate concentrations are increasing with time, indicating a potential, although not yet critical, contamination problem.

- Nitrate concentrations in spring water indicate contamination of shallow unconfined and perched ground water. Concentrations have increased significantly over the past four years in the east bench perched ground-water zone where nitrate levels are approaching or exceeding primary drinking water standards.

- The source of nitrates in aquifers varies locally, but chiefly includes septic tank effluent and leaching of surface contaminants (animal wastes, fertilizer, decaying plant matter) by infiltrating precipitation and irrigation water. The extent of the contribution of septic tank effluent is not known.

- Water quality parameters tested in this study other than nitrates (chlorides, sulfates, total phosphorus, coliform bacteria) show no consistent trends that would indicate contamination by septic tank effluent.

- Much of the remaining undeveloped area in and around Smithfield is marginal to unsuitable for conventional septic tank soil absorption systems. Limited subsurface data indicate that in areas where soil type is the limiting factor, deeper soils may be more suitable.

Based on these conclusions and data presented on other aspects of development in Smithfield, the following recommendations for use in general planning with regard to geologic, hydrologic, and soils conditions are made:

- Future plans for development in areas subject to geologic hazards shown in plate 5 should include detailed studies which address the potential for the particular hazard(s) at the site and, where necessary, list mitigating measures to be taken. These may include flooding and debris-flow hazard assessments, slope stability analyses, soil/foundation investigations, and faulting/seismic hazards analyses. Such studies should be performed and reviewed by experienced and competent professional geologists and engineers.

- All future construction should conform to Unified Building Code standards for seismic zone 3 with monitoring by regulatory agencies as recommended by the Utah Seismic Safety Advisory Council (1979) for their seismic zone U-4 (appendix).

- Soil/foundation investigations should be performed for all proposed large buildings and subdivisions even if located outside hazardous zones shown in plate 5. The investigations should include consideration of liquefaction potential and suitability of soils for soil absorption systems as appropriate.

- Nitrate concentrations in water in the principal aquifer beneath and down-gradient from Smithfield indicate that it is not fully protected from downward percolation of contaminated water by the upper confining layers or by upward seepage from artesian zones. Continued use of existing soil absorption systems and addition of new systems will probably contribute to a long-term increase in nitrate levels. However, the existing levels are low in view of the number and long history of use of soil absorption systems in Smithfield. Therefore, critical nitrate levels in the principal aquifer may not be reached for many years. However, the probable contribution of septic tank effluent to the contamination of the shallow ground water, as well as the increasing failure rate of existing soil absorption systems and poor conditions in undeveloped areas for new systems, indicate that serious consideration should be given to alternate methods of waste disposal.

REFERENCES

Beer, L. B., 1967, Ground-water hydrology of southern Cache Valley, Utah: Utah State Engineer Information Bulletin no. 19, 119 p.

Bjorklund, L. J., and McGreevy, L. J., 1971, Ground-water resources of Cache Valley, Utah and Idaho: Utah Department of Natural Resources Technical Publication 36, 72 p.

Butler, Elmer, and Marsell, R. E., 1972, Developing a state water plan - cloudburst floods in Utah, 1939-1969: U.S. Geological Survey and Utah Division of Water Resources Cooperative Investigations Report no. 11, 103 p.

Christenson, G. E., 1981, Engineering geology for land-use planning, Ballard, Utah: Utah Geological and Mineral Survey Report of Investigation 167, 13 p.

Clyde, C. G., Oaks, R. Q., Kolesar, P. T., and Fisk, E. P., 1981, The potential for ground-water contamination along basin margins in the arid west; alluvial fans and lake features: Utah Water Research Laboratory Hydraulics and Hydrology Series, UWRL/H-81/05, 82 p.

Currey, D. R., 1982, Lake Bonneville: selected features of relevance to neotectonic analysis: U.S. Geological Survey Open-File Report 82-1070, 30 p.

Currey, D. R., Oviatt, C. G., and Plyler, G. B., 1983, Stansbury shoreline and Bonneville lacustral cycle: Geological Society of America Abstracts with Programs, v. 15, no. 5, p. 301.

deVries, J. L., 1982, Evaluation of low-temperature geothermal potential in Cache Valley, Utah: Utah Geological and Mineral Survey Report of Investigation no. 174, 96 p.

DeWalle, F. B., and Schaff, R. M., 1980, Ground-water pollution by septic tank drainfields: Journal of the Environmental Engineering Division, American Society of Civil Engineers, v. 106, p. 631-646.

DeWalle, F. B., Schaff, R. M., and Hatlen, J. B., 1980, Well water quality deterioration, central Pierce County, Washington: American Water Works Association Journal, p. 533-536.

Erickson, A. J., and Mortensen, V. L., 1974, Soil survey of Cache Valley area, Utah: USDA Soil Conservation Service and Forest Service and Utah Agricultural Experiment Station, 192 p.

Federal Insurance Administration, 1975, Flood hazard boundary map, City of Smithfield, Utah (Cache County): Map H-01, community number 490020A.

Federal Insurance Administration, 1981, Flood hazard boundary map, Cache County, Utah, unincorporated area: National Flood Insurance Program, community-panel numbers 490012 0005 A and 490012 0006 A.

Fisk, E.P., and Clyde, C.G., 1981, A survey and evaluation of shallow ground-water contamination hazards in the State of Utah: Utah Water Research Laboratory Hydraulics and Hydrology Series UWRL/H-81/04, 45 p.

Galloway, C. L., 1970, Structural geology of eastern part of the Smithfield Quadrangle, Utah: unpublished University of Utah Masters thesis, 115 p.

Gill, H. E., 1982, Geologic and hydrologic evaluation of Mt. Pleasant watershed, Sanpete County, Utah: Utah Geological and Mineral Survey Report of Investigation 169, 18 p.

Intermountain Association of Petroleum Geologists, 1953, Guide to the geology of northern Utah and southeastern Idaho: Fourth Annual Field Conference, 143 p.

Kaliser, B. N., 1975, Preliminary geologic reconnaissance of the Summit Park Subdivision: Utah Geological and Mineral Survey Report of Investigation 104, 4 p.

Lund, W. R., 1983, Geologic evaluation of septic tank and soil absorption system suitability, Dry Fork Canyon, Uintah County, Utah: Utah Geological and Mineral Survey Report of Investigation 176, 31 p.

McGreevy, L. J., and Bjorklund, L. J., 1970, Selected hydrologic data, Cache Valley, Utah and Idaho: Utah Basic-Data Release no. 21, 51 p.

Meyers, D. W., Middlebrooks, E. J., and Porcella, D. B., 1972, Effects of land use on water quality: Summit Creek, Smithfield, Utah: Utah Water Research Laboratory report PRWR 17-1, 43 p.

Rogers, A. M., and others, 1976, A study of earthquake losses in the Salt Lake City, Utah area: U.S. Geological Survey Open-File Report 76-89, 357 p.

Seabloom R. W., 1976, Soil capabilities in wastewater renovation *in* Northwest On-site Wastewater Disposal Short Course, 1st, Seattle, 1976, Proceedings: University of Washington Department of Civil Engineering on Environmental Health, p. 20-26.

Smith, N., 1953, Tertiary stratigraphy of northern Utah and southeastern Idaho *in* Guide to the Geology of Northern Utah and Southeastern Idaho: Intermountain Association of Petroleum Geologists, Fourth Annual Field Conference, p. 73-77.

Spahr, M. D., 1973, Water quality survey in the west valley area, Yakima County: Washington Department of Social Services, Water Supply and Waste Section, 10 p.

U.S. Environmental Protection Agency, 1980, Design manual, on-site wastewater treatment and disposal systems: EPA-625/1-80-012, 392 p.

Utah Division of Comprehensive Emergency Management, 1981, History of Utah floods, 1847-1981: Flood-Plain Management Status Report.

Utah Seismic Safety Advisory Council, 1979, Seismic zones for construction in Utah: Delbert Ward, Executive Director, 13 p.

Utah State Division of Health, 1967, Code of wastewater disposal regulations, part IV, individual wastewater disposal systems: Utah Water Pollution Control Board, 17 p.

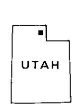
Valley Engineering, Inc., 1980, Smithfield-Hyde Park wastewater facilities plan: consulting report for Smithfield City.

Williams, J. S., 1958, Geologic atlas of Utah, Cache County: Utah Geological and Mineral Survey Bulletin 64, 104 p.

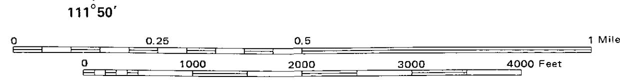
———1962, Lake Bonneville: Geology of southern Cache Valley, Utah: U.S. Geological Survey Professional Paper 257-C, 152 p.

Woodward-Lundgren and Associates, 1974, Investigation and evaluation of the northern Wasatch and Cache Valley faults: consulting report to the Utah Geological and Mineral Survey, 147 p.

Wooley, R. R., 1946, Cloudburst floods in Utah, 1850-1938: U.S. Geological Survey Water-Supply Paper 994, 128 p.



Location Map



CONTOUR INTERVAL 40 FEET
Dotted Lines Represent 10-Foot Contours
Datum Is Mean Sea Level

Base map from Smithfield, Utah, 1964
U.S.G.S. 7.5' topographic quadrangle.
Cultural update from G. Walker and R. McGee
map of Smithfield City, 1981.

Plate 1

GEOLOGY

Report of Investigation No. 181
December 1983

EXPLANATION

QUATERNARY

Unconsolidated Material

Qal	Stream alluvium and alluvial fan deposits, includes thin covering of slopewash where deposits border slopes. Chiefly gravel but includes sand, silt, and clay.
Qlp Qlyd Qlpd	Provo level (4780 feet) and younger deposits of Lake Bonneville. Qlp - chiefly deep-lake deposits (silt and clay), locally covered with slopewash near the east bench area. Qlyd - deltaic deposits younger than those at the Provo level. Qlpd - chiefly deltaic deposits at the Provo level (sand and gravel), includes alluvium of Summit and Birch Creeks graded to that level.
Qls	Landslide deposits; chiefly fine-grained (silt and clay) Lake Bonneville deposits in a rotational slump in Smithfield Canyon.
Qlb	Bonneville level (5150 feet) and older (transgressive) deposits of Lake Bonneville, interbedded clay, silt, sand, and gravel.

TERTIARY

Rock

Tsl	Salt Lake Formation; rounded limestone pebble conglomerate, includes colluvial and residual soils of variable thickness.

Symbols

———	Contact, dashed where approximate or gradational.
— — —	Photo lineaments, possible faults with Quaternary displacement.

REFERENCES

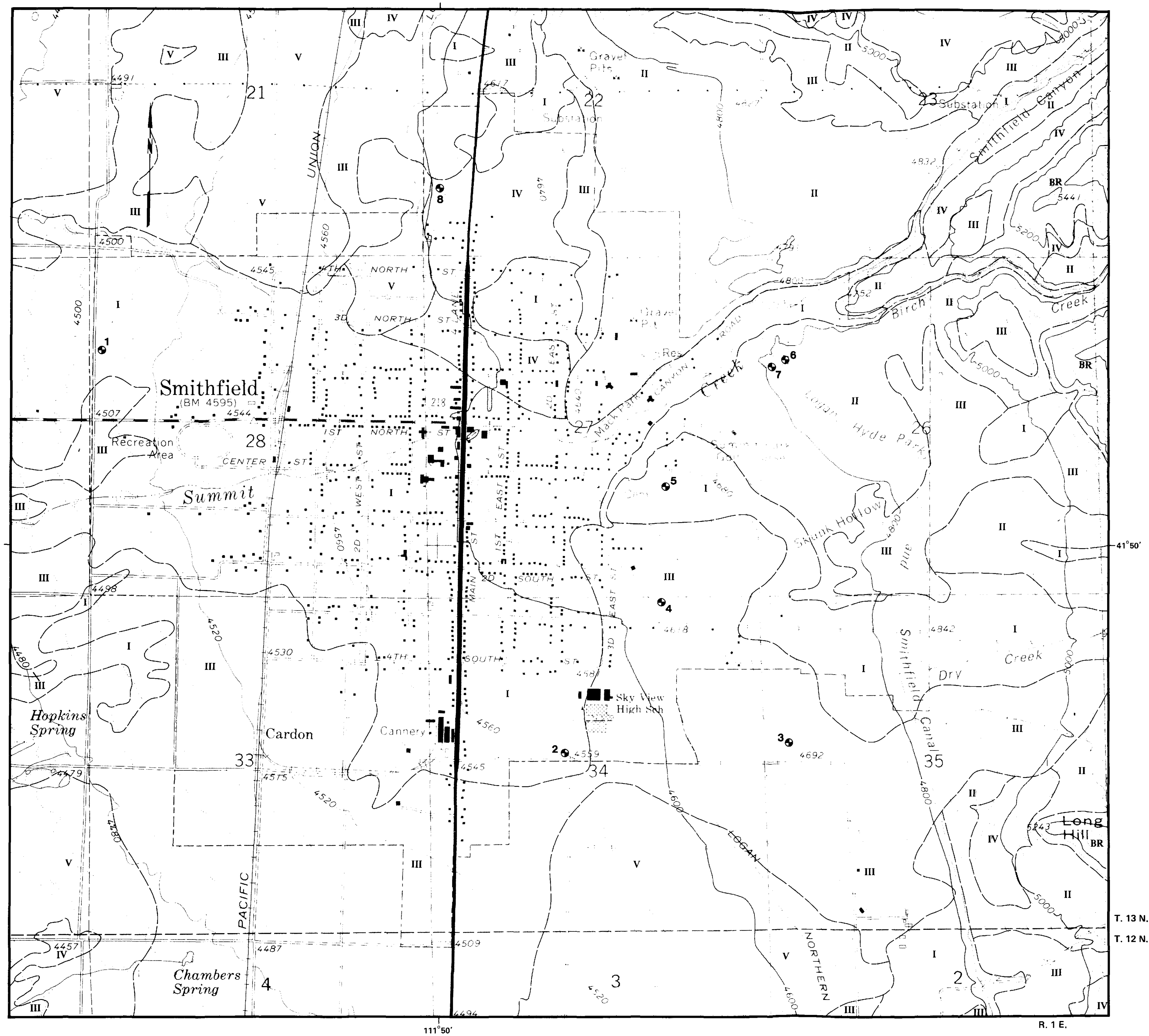
Currey, D.R., Oviatt, C.G., and Plyler, G.B., 1983, Stansbury shoreline and Bonneville lacustral cycle: Geological Society of America Abstracts with Programs, v. 15, p. 301.

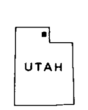
Galloway, C. L., 1970, Structural geology of eastern part of the Smithfield Quadrangle, Utah: Unpublished Master's thesis, University of Utah, 115 p.

Williams, J. S., 1958, Geologic atlas of Utah, Cache County: Utah Geological and Mineral Survey Bulletin 64, 104 p.

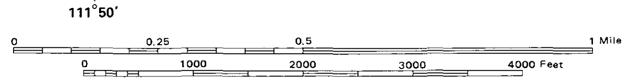
________, 1962, Lake Bonneville: Geology of southern Cache Valley, Utah: U.S. Geological Survey Professional Paper 257-C, 152 p.

Woodward-Lundgren and Associates, 1974, Investigation and evaluation of the northern Wasatch and Cache Valley faults: Consulting report to the Utah Geological and Mineral Survey, 147 p.





Location Map



CONTOUR INTERVAL 40 FEET
Dotted Lines Represent 10-Foot Contours
Datum Is Mean Sea Level

Base map from Smithfield, Utah, 1964
U.S.G.S. 7.5' topographic quadrangle.
Cultural update from G. Walker and R. McGee
map of Smithfield City, 1981.

Plate 2

SOILS

Report of Investigation No. 181
December 1983

EXPLANATION

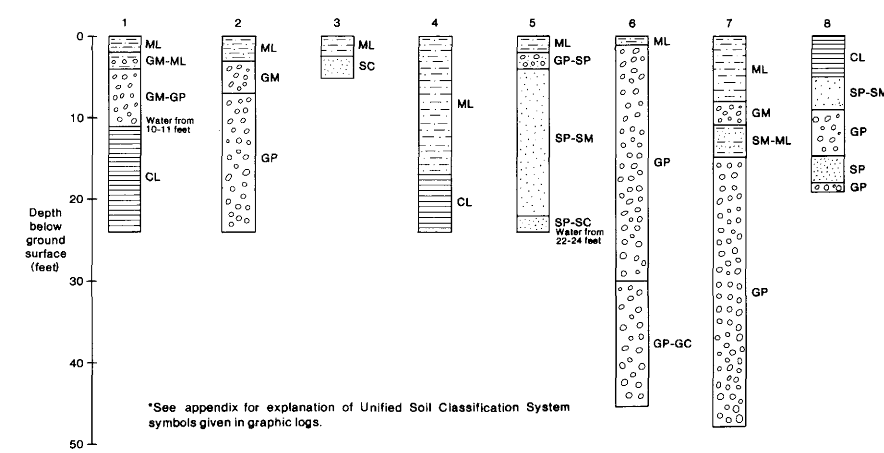
Soil Unit	Predominant Soil Type	USCS Symbol	Estimated Percolation Rate*	Shrink-Swell Potential	Description
I	Silty gravel	GM	Rapid (0-30 min/inch)	low	Overlain by silty topsoil, contains boulders and cobbles near mountain front; chiefly alluvium.
II	Silty gravel, poorly-graded gravel	GM, GP-GM	Rapid (0-30 min/inch)	low	Overlain by silty topsoil, lacks boulders and large cobbles, sandy; chiefly poorly-graded deltaic material.
III	Silt	ML	Slow to moderate (30-60+ min/inch)	low to moderate	Locally contains gravel layers; mixed alluvial and lacustrine deposits.
IV	Silt, clay	ML, CL	Slow to moderate (30-60+ min/inch)	moderate	Chiefly lacustrine deposits.
V	Clay	CL, CH	Slow (60+ min/inch)	high	Chiefly lacustrine deposits.
BR	Bedrock	—	—	—	Exposed bedrock and shallow residual and colluvial soils.

*Estimated from percolation test results (Smithfield City, Bear River Health Department, engineering consultants) and data in Erickson and Mortenson (1974).

Symbol

2 ⊕ Test boring (see logs below)

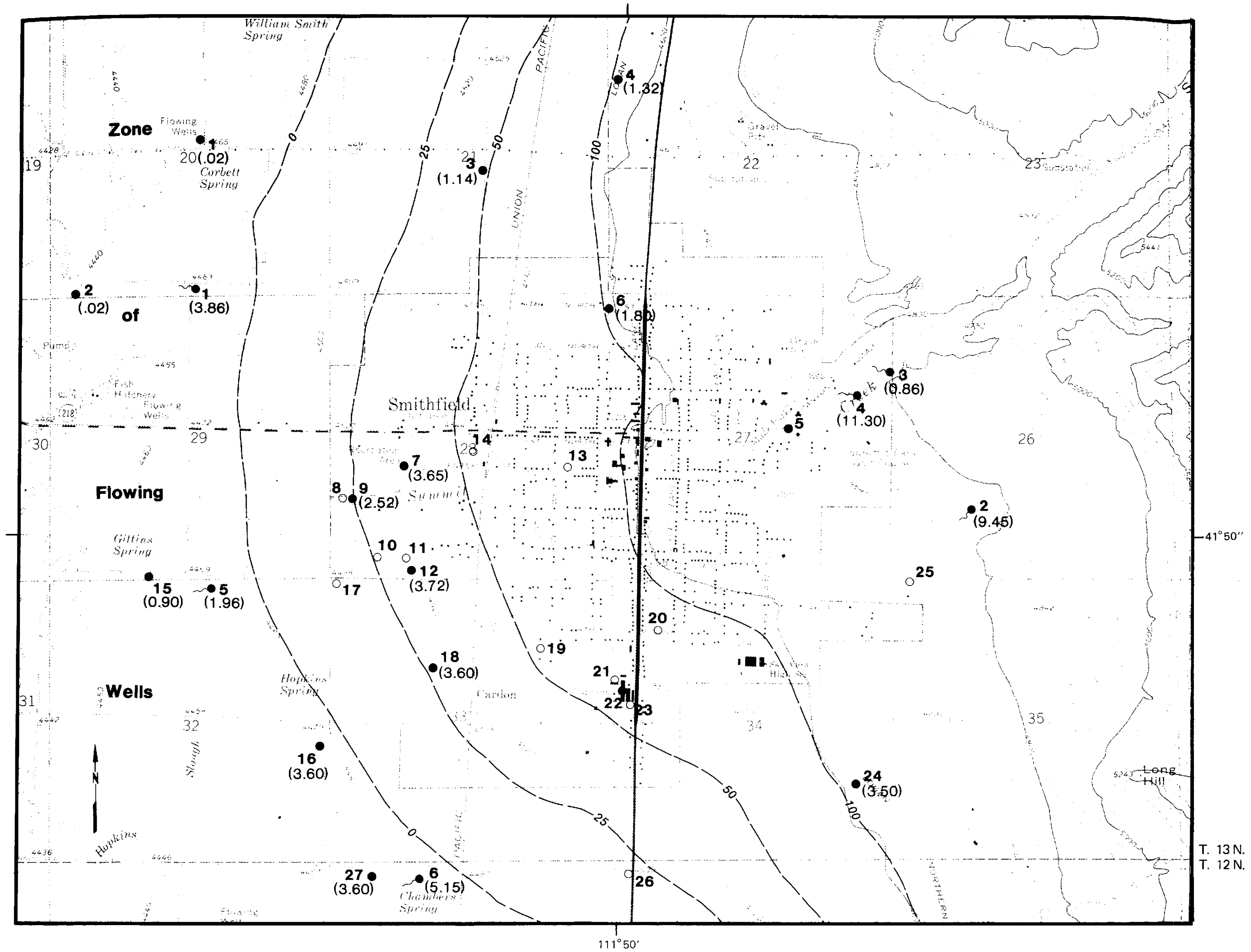
Logs of Test Borings*

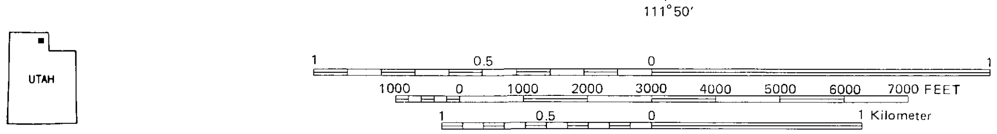


*See appendix for explanation of Unified Soil Classification System symbols given in graphic logs.

REFERENCE

Erickson, A. J., and Mortenson, V. L., 1974, Soil survey of Cache Valley area, Utah: USDA Soil Conservation Service and Forest Service and Utah Agricultural Experiment Station, 192 p.





Base map from Smithfield, Utah, 1964 U.S.G.S. 7.5′ topographic quadrangle. Cultural update from G. Walker and R. McGee map of Smithfield City, 1981.

EXPLANATION

● 1 (2.65) Well, analyzed for water quality (see table) with nitrate concentration shown in parentheses (mg/l) where available.

○ 2 Well, no water quality data available.

1 (3.80) Spring, analyzed for water quality (see table) with nitrate concentration shown in parentheses (mg/l).

50 Approximate depth (feet) to water in wells in the principal aquifer (contours correspond to the level to which water will rise in wells where confined conditions exist and to the water table where unconfined conditions exist).

REFERENCES

Beer, L. B., 1967, Ground water hydrology of southern Cache Valley, Utah: Utah State Engineer Information Bulletin, no. 19, 119 p.

Bjorklund, L. J., and McGreevy, L. J., 1971, Ground-water resources of Cache Valley, Utah and Idaho: Utah Department of Natural Resources Technical Publication 36, 72 p.

deVries, J. L., 1982, Evaluation of low-temperature geothermal potential in Cache Valley, Utah: Utah Geological and Mineral Survey Report of Investigation no. 174, 96 p.

McGreevy, L. J., and Bjorklund, L. J., 1970, Selected hydrologic data, Cache Valley, Utah and Idaho: Utah Basic-Data Release no. 21, 51 p.

Meyers, D. W., Middlebrooks, E. J., and Porcella, D. B., 1972, Effects of land use on water quality, Summit Creek, Smithfield, Utah: Utah Water Research Laboratory PRWR 17-1, 43 p.

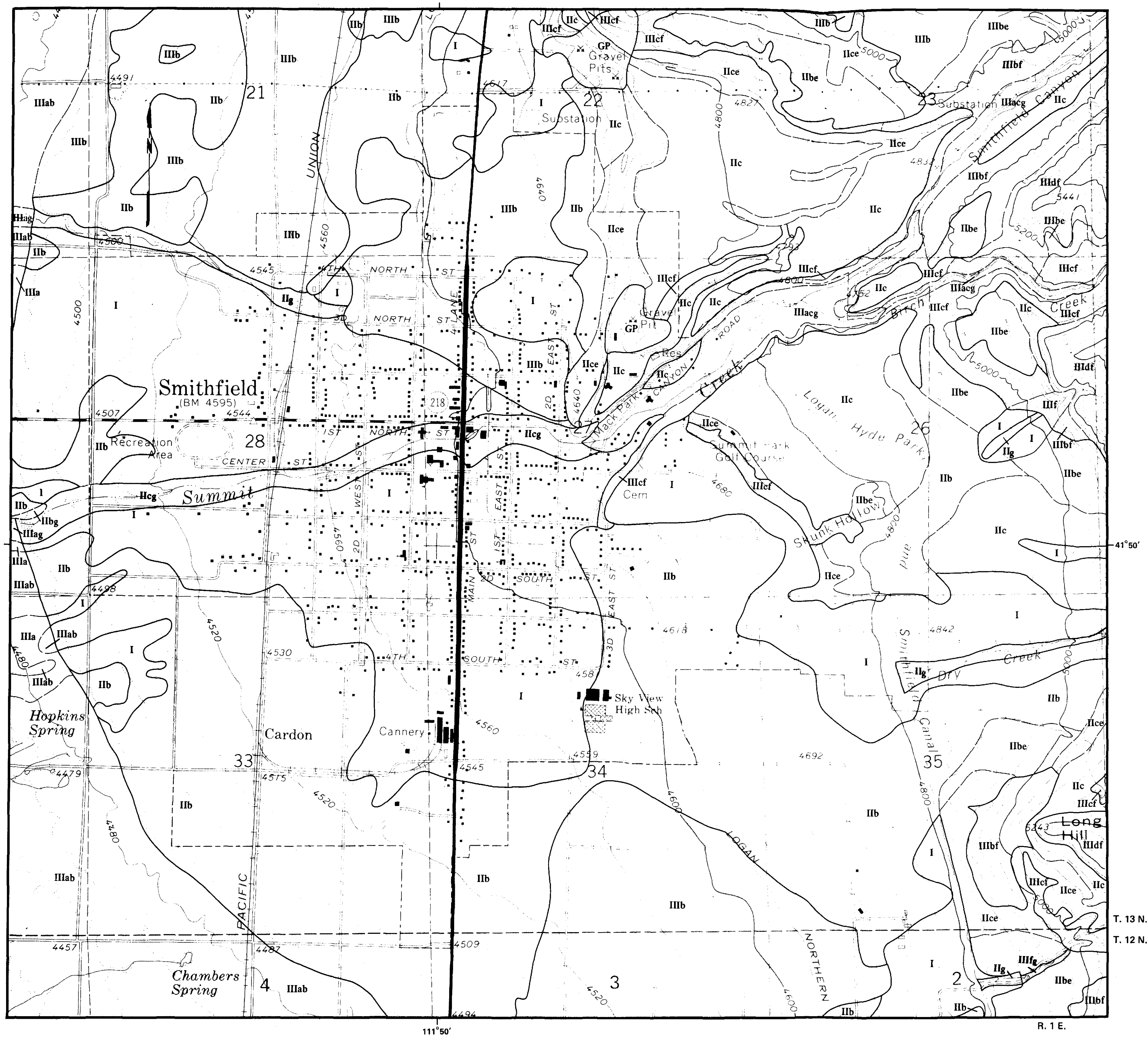
Plate 3

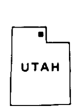
GROUND WATER

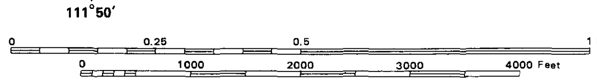
Report of Investigation No. 181
December 1983

			Well Data					Water Quality Data							
	No. (see map)	Location (see appendix)	Depth to water (feet)	Date measured	Total depth (feet)	Date drilled	Perforated Interval (feet)	Sample date	mg/l Nitrate	Chloride	Sulfate	Total Phosphorus	Total Coliform per 100 ml	Fecal Coliform per 100 ml	Source*
Wells	1	(A-13-1) 20 acc	F	5-25-62	107	5-25-62	None	6-14-83	.02	6	22	.02	0	0	This study
	2**	20 ccc	F	8-21-80	125	8-21-80	None	6-14-83	.02	10	18	.20	0	0	This study
	3	21 dbb	52	2-15-77	158	2-15-77	100-158	6-14-83	1.14	7	10	<.02	0	0	This study
	4	22 bbc	104	7- 1-80	302	6-30-80	120-130	6-14-83	1.32	7	11	.02	0	0	This study
	5	27 acd	170	11- 1-66	268	11- 1-66	150-246	9- 1-81	—	8	5	—	—	—	deVries (1982)
			161	3- -68											
	6	28 aaa	103	9-20-62	477	9-20-62	181-474	8- 5-83	1.80	5	11	<.02	0	0	This study
			110	3- -67											
	7	28 cab	30	9-18-68	210	9-18-68	122-158	7-19-82	3.65	9	12	—	—	—	Utah Health Dept.
							190-210								
	8	28 cbc	57	7- 3-78	147	7- 3-78	None								
	9	28 cbc	31	6-13-80	139	6-13-80	None	6-14-83	2.52	6	10	<.02	0	0	This study
	10	28 ccd	18	9-11-67	133	9-11-67	None								
			12	10- -68											
	11	28 cdc	30	7- -79	137	7- -79	None								
	12	28 cdc	42	4- -79	140	4- -79	None	6-14-83	3.72	7	12	<.02	0	0	This study
	13	28 dab	80	6- 1-54	235	6- 1-54	105-?								
			91	3- -68											
	14	28 dbb	55	7-14-61	315	7-14-61	?								
			61	3- -68											
	15	29 cdc	F	6- 6-61	160	6- 6-61	150-155	6-14-83	0.90	17	11	<.02	0	0	This study
	16	32 daa	F	5-17-53	131	5-17-53	101-111	6-14-83	3.60	7	12	.02	0	0	This study
	17	33 bbb	20	8-10-77	148	8-10-77	137-147								
	18	33 bdb	45	3-25-81	158	3-25-81	None	6-14-83	3.60	7	27	<.02	0	0	This study
	19	33 bdd	53	7-12-53	333	7-12-53	165-333								
			60	3- -67											
	20	34 bbd	82	6-17-59	337	6-17-59	80-337								
			87	3- -67											
	21	34 bcb	55	8-10-53	315	8-10-53	135-?								
			67	3- -67											
	22	34 bcc	50	6-27-69	322	6-27-69	All gravels	9-1-81	—	9	7	—	—	—	deVries (1982)
							169-318								
	23	34 bcc	65	3- -67	76	1918	?								
	24	34 dac	95	8-27-75	160	8-27-75	None	8-5-83	3.50	6	13	<.02	0	0	This study
	25	35 bbb	227	11- -60	290	1960	?								
	26	(A-12-1) 3 bbb	7	9- -67	166	1934	?								
	27	4 bba	F	5-27-69	145	5-27-69	None	6-14-83	3.60	8	13	.02	0	0	This study
			Description												
Springs	1	(A-13-1) 20 dcc	Culvert draining from beneath field					8- 5-83	3.85	10	16	<.02	3000	0	This study
	2	26 cac	Flow in wooden collection box (golf course spring)					8- 5-83	9.45	7	20	.12	1200	0	This study
	3	27 ada	Flow in hillside canal behind Taylor home					6-14-83	.86	4	16	.06	160	4	This study
	4	27 ada	Inflow to artificial pond behind Berg home					6-14-83	11.30	8	13	<.02	20	0	This study
	5	32 abb	Flow at head of spring southeast of Gittin's Spring					8- 5-83	1.96	5	12	<.02	300	0	This study
	6	(A-12-1) 4 bab	Culvert entering pond at Chamber's Spring					8- 5-83	5.15	30	23	<.02	600	0	This study
Misc.	Range for city culinary springs, Smithfield Canyon							9-79 — 10-79	0.1-0.8	2-6	4-16	—	—	—	Utah Health Dept.
	Summit Creek 0.5 miles east of Birch Creek confluence							Mean 1971	0.277	2.3	—	.084	1817.1	—	Meyers and others (1972)
	Logan, Hyde Park, and Smithfield Canal							8- 5-83	0.04	1	11	<.02	1500	0	This study
	Utah drinking water primary standard							—	10	—	500-1000	—			
	Utah drinking water secondary standard							—	45	250	250	—			

*All analyses for this study done at Utah State Health Lab, Salt Lake City
**Log data are those of well closest to this location. Many wells in area, but none match location closely.
F = flowing







CONTOUR INTERVAL 40 FEET
Dotted Lines Represent 10-Foot Contours
Datum Is Mean Sea Level

Base map from Smithfield, Utah, 1964 U.S.G.S. 7.5' topographic quadrangle. Cultural update from G. Walker and R. McGee map of Smithfield City, 1981.

Plate 4

SUITABILITY FOR WASTEWATER DISPOSAL IN SOIL ABSORPTION SYSTEMS

Report of Investigation No. 181
December 1983

Suitability assessments for wastewater disposal in soil absorption systems shown on this map are for standard buried trench or bed systems in the upper five feet of soil. Three suitability categories designated I through III have been defined. In cases where marginal (Unit II) to unsuitable (Unit III) conditions may exist, qualifiers (designated a through g) have been attached to the category designations to indicate why conditions are not considered favorable. Map unit boundaries and suitability assessment are modified from the USDA Soil Conservation Service soil survey for Cache County (Erickson and Mortensen, 1974). Test drilling at several sites indicated that, in areas where slow percolation rate is the limiting factor (qualifier symbol b) in the upper 5 feet, more permeable soils may exist at depth and deep systems may be feasible. Because of the variable soil types and the possibility of alternate system designs, it is emphasized that this map is for general planning purposes only. No specific areas should be accepted or prohibited for soil absorption systems based on this map. Site investigations should still be performed for each system in all areas.

EXPLANATION

Suitability Categories

- I Generally suitable
- II Marginally suitable, locally unsuitable
- III Generally unsuitable

Qualifiers

- a Possible shallow ground water (water table locally less than 5 feet)
- b Slow percolation rate in upper 5 feet (faster percolation rates may be found in soils from 5-25 feet)
- c Rapid percolation rate, local potential for contamination of streams and ground water
- d Exposed or shallow bedrock
- e Moderate slope (10-30%)
- f Steep slope (greater than 20%)
- g Flood hazard

Symbols

- Contact between suitability categories (I, II, III)
- Contact within suitability-categories between areas with different qualifiers (a, b, c, d, e, f, g)
- GP Gravel pit

REFERENCES

Christenson, G. E., 1981, Engineering geology for land-use planning, Ballard, Utah: Utah Geological and Mineral Survey Report of Investigation 167, 13 p.

Erickson, A. J., and Mortensen, V. L., 1974, Soil survey of Cache Valley area, Utah: USDA Soil Conservation Service and Forest Service and Utah Agricultural Experiment Station, 192 p.

Lund, W. R., 1983, Geologic evaluation of septic tank and soil absorption system suitability, Dry Fork Canyon, Uintah County, Utah: Utah Geological and Mineral Survey Report of Investigation 176, 31 p.

Smithfield City Corporation, 1983, Regulations for individual wastewater disposal systems: Ordinance No. 83-3, 84 p.

U. S. Environmental Protection Agency, 1980, Design manual, on-site wastewater treatment and disposal systems: EPA-625/1-80-012, 392 p.

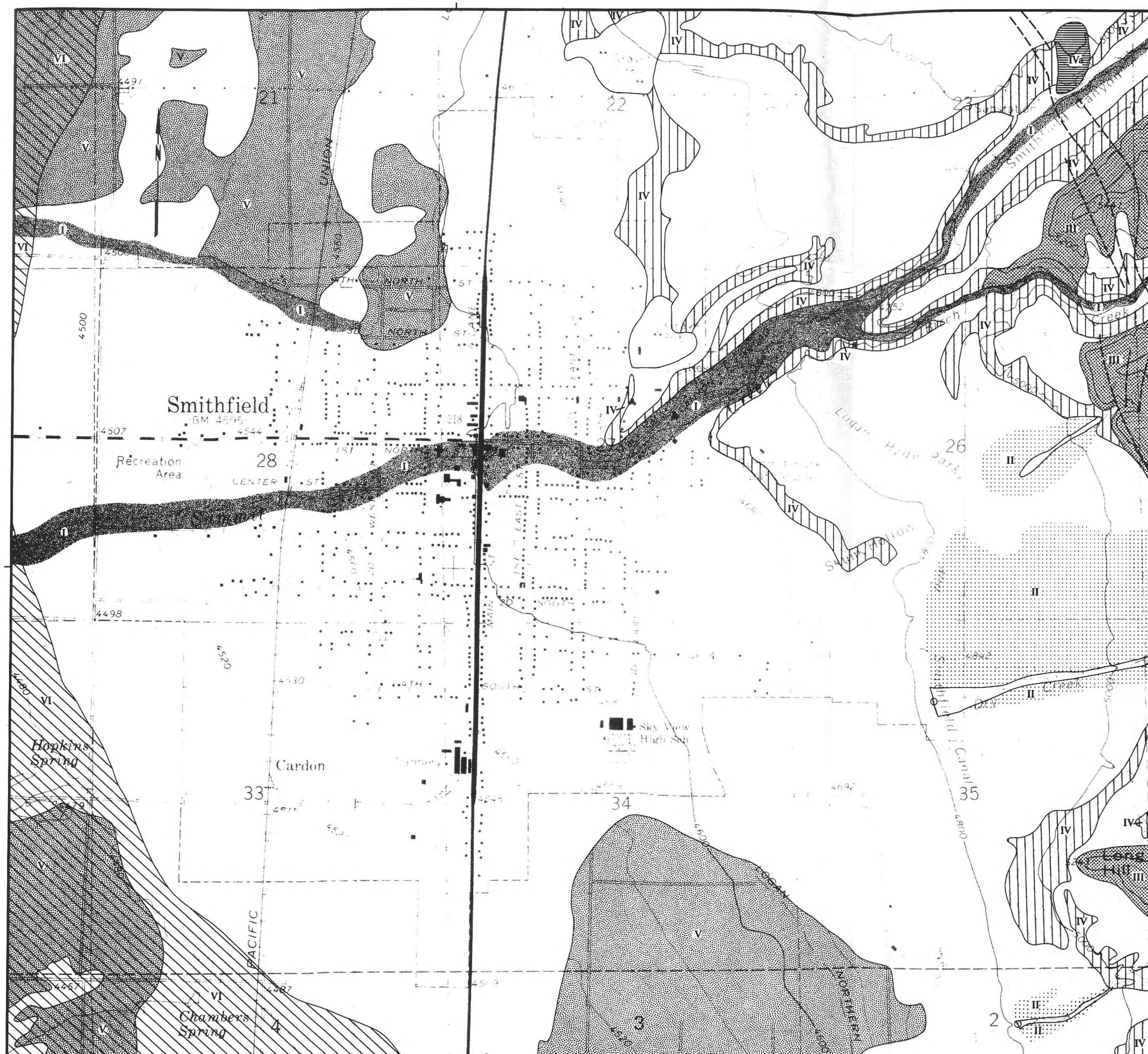
Utah State Division of Health, 1967, Code of wastewater disposal regulations, part IV, individual wastewater disposal systems: Utah Water Pollution Control Board, 17 p.

Plate 5

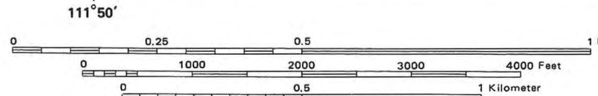
GEOLOGIC HAZARDS

Report of Investigation No. 181

December 1983



Location Map



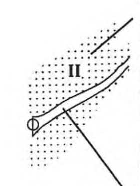
CONTOUR INTERVAL 40 FEET
Dotted Lines Represent 10-Foot Contours
Datum Is Mean Sea Level

Base map from Smithfield, Utah, 1964 U.S.G.S. 7.5′ topographic quadrangle. Cultural update from G. Walker and R. McGee map of Smithfield City, 1981.

Geologic hazards are natural geologic processes which adversely affect man and his works. Hazards affecting Smithfield include flooding, debris flows, slope failure, highly expansive soils, high ground water, and earthquake ground rupture. Those hazards which affect specific areas and for which at least approximate limits can be defined are shown in this map and are described below. A hazard not depicted on the map because it affects the entire area is earthquake ground shaking. Smithfield is in Uniform Building Code seismic zone 3 and Utah Seismic Safety Advisory Council (1979) seismic zone U-4. These are the zones of highest risk in the state in both zonation schemes and equate to maximum Modified Mercalli intensities of VIII and greater (major damage, appendix). Because of this, all structures in Smithfield should be designed and constructed according to UBC standards for seismic zone 3 with close inspection and monitoring as recommended by the Seismic Safety Advisory Council (1979) for its seismic zone U-4 (see appendix).

EXPLANATION

Generalized zone of flooding along major streams with a one percent probability of occurrence annually (100-year flood) (Federal Insurance Administration, 1975, 1981). Flooding may be accompanied by a rise of the water table in this zone. Plans for development should be accompanied by an assessment of flooding potential and, if warrented, a listing of mitigating measures to be taken. Local topographic and hydrologic conditions exist within the zone which reduce the flood hazard and may exclude certain areas from the zone.



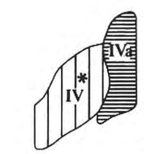
Zone of debris flow, debris flood, and flash flood hazard from small mountain drainages.

Maximum extent of post-Lake Bonneville alluvial fan deposits and thus probable maximum extent of modern debris flow-flood activity. The basinward boundary is taken at the Logan, Hyde Park, and Smithfield Canal since this acts as a barrier to modern downslope flow.

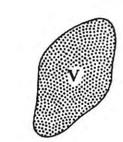
Extent of most recent deposits indicating probable limit of normal flooding from these canyons. Circle represents likely breach point or point of maximum sedimentation in the Logan, Hyde Park, and Smithfield Canal during very heavy flooding.

It is recommended that plans for development in these areas include an analysis of the debris flow-flood hazard and, if warrented, a listing of mitigating measures to be taken.

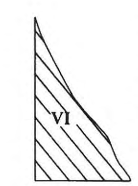
Slopes (generally 40 to 80%) underlain by bedrock (Salt Lake Formation) and colluvium. Rockfall hazard minimal and localized to areas downslope from outcrops. No evidence of instability under modern conditions, but undercutting, loading (either dynamic as associated with seismic shaking or static as with placement of fill or structures) and/or wetting of slopes could induce failure. Slope stability analyses should accompany any plans for development of these areas.



Slopes (generally 20 to 80%) underlain by unconsolidated deposits ranging from gravel to silt and clay. Stability varies with soil type, but prehistoric (IVa) and historic (✱) slope failures have occurred along Summit Creek and in man-made cuts. Failures are chiefly earth slumps and debris slides. Undercutting, loading (dynamic or static), and/or wetting of slopes could induce instability. Slope stability analyses should accompany any plans for development in these areas.



Area underlain by soils with high shrink-swell potential. Such soils are hazardous to building foundations if subjected to changes in moisture content. Soil/foundation investigations including an assessment of the shrink-swell potential of soils should accompany any plans for development in these areas.



Zone of springs and shallow ground water (less than 5 feet). Spring flow and depth to water fluctuates seasonally and annually with precipitation amounts, irrigation practices, and extent of pumping. Saturation can reduce soil bearing strength, particularly during earthquake ground shaking, as well as cause flooding of subsurface facilities (buried utilities, soil absorption fields, basements). Soil/foundation investigations with an assessment of liquefaction potential and the highest stand of the water table should accompany any plans for development in the area.

Lineaments identified on aerial photography as indicative of a probable active fault or rupture, or fault apparently with lack of recent activity (Woodward-Lundgren and Associates, 1974). Surface geologic reconnaissance yielded no strong evidence that these lineaments represent faults with movement during Holocene time (last 10,000 years). It is recommended that plans for proposed development within this zone include subsurface exploration (trenching) of these lineaments to determine if they are fault-related and, if so, the probable age of most recent faulting.

REFERENCES

Federal Insurance Administration, 1975, Flood hazard boundary map, City of Smithfield, Utah (Cache County): Map H-01, community number 490029A.

Federal Insurance Administration, 1981, Flood hazard boundary map, Cache County, Utah, unincorporated area: National Flood Insurance Program, community-panel numbers 490012 000 5 A and 490012 000 6 A.

Utah Seismic Safety Advisory Council, 1979, Seismic zones for construction in Utah: Delbert Ward, Executive Director, 13 p.

Woodward-Lundgren and Associates, 1974, Investigation and evaluation of the northern Wasatch and Cache Valley faults: Consulting report to the Utah Geological and Mineral Survey, 147 p.

REPORT OF INVESTIGATION NO. 182
PRELIMINARY GEOLOGIC EVALUATION OF FIVE PROPOSED HAZARDOUS WASTE FACILITY SITES IN UTAH

by
William R. Lund

ABSTRACT

Five sites are being considered by the Utah Division of Environmental Health for possible construction of hazardous waste storage, treatment, and disposal facilities. The sites were selected based on projections of the amount and location of future hazardous waste production in Utah. Baseline geologic and hydrologic data are required to make a preliminary suitability ranking of the sites and to identify needs for further study.

Sites 1 through 4 are in northern Utah in the Great Basin portion of the Basin and Range physiographic province. Site 5 is in eastern Utah in the Uinta Basin, a subdivision of the Colorado Plateau physiographic province. Site 1 is at the south end of Hansel Valley near the Great Salt Lake. Lake Bonneville shoreline and deep water deposits are exposed at the surface and depth to ground water varies from 1 to more than 100 feet. Soils are generally porous, and a recently active fault passes within a mile of the property. Site 2 is in Rush Valley about eight miles north of Vernon. Lake Bonneville deposits cover the site below an elevation of 5250 feet. The remainder of the property is underlain by a pre-Bonneville alluvial fan. Ground water ranges from about 15 to greater than 90 feet beneath the ground surface. Flash flooding is possible along intermittent drainages, and Quaternary-age faults are located within 3 miles of the site. Site 3 is on the west side of Salt Lake Valley near the town of Herriman. Lake Bonneville deposits consisting of clay, silt, sand, and a gravel cover the site. Depth to ground water increases from west to east across the property and is everywhere greater than 100 feet beneath the surface. Flooding along intermittent drainages is a hazard and the Wasatch fault is about 10 miles to the west. The area in which the site is located is a recharge zone for deep aquifers in the Salt Lake Valley. Site 4 is in Cedar Valley about 2 miles northeast of Fairfield. Thin eolian and alluvial deposits cover the property and overlie Lake Bonneville sediments of unknown thickness. Artesian conditions, probably in a multiple aquifer system, likely exist at the site. The site is nearly flat and, because Cedar Valley is a closed basin, flooding and ponding of water is a problem. Site 5 is five miles east of Vernal on a pediment cut into the Cretaceous Mancos Shale. Thickness of the shale is unknown but probably exceeds 1000 feet. Depth to ground water is also unknown but typically is absent or several hundred feet deep and of poor quality in the Mancos Shale. Flooding is a hazard along intermittent streams. The site is in Utah's lowest seismic hazard zone.

Based on available geologic and hydrologic information, the sites were preliminarily ranked in decreasing order of suitability as follows: site 5, 4, 2, 3, and 1. Site 5 is considered the most suitable because of the thick section of low permeability shale present, the likely absence of ground water within several hundred feet of the surface, and low seismic risk. Site 1 is the least suitable due to high seismic hazard, porous soil, shallow ground water, and proximity to the Great Salt Lake. Site 4 may have potential for long-term disposal of hazardous waste, but sites 2 and 3 should be used only for temporary storage or treatment facilities. All five sites would require additional site-specific investigations prior to actual construction of a hazardous waste facility.

INTRODUCTION

The Utah Division of Environmental Health, Bureau of Solid and Hazardous Waste, has been given the responsibility by the State Legislature (Senate Bill 258, 1981 General Session) of developing a Statewide Hazardous Waste Facility Siting Plan. Part of that plan includes identifying areas in the State where the construction and operation of hazardous waste storage, treatment, and disposal facilities appears environmentally feasible (D. Parker, written commun., 1983). Hazardous waste as defined by the State Health Department, and as used in this report, includes any "solid waste or combination of solid wastes which, because of its quantity, concentration, or physical, chemical, or infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness or may pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed." This definition specifically excludes radioactive wastes which are regulated under other criteria.

Five prospective sites have been selected and are under investigation by the Bureau staff. The Utah Geological and Mineral Survey was asked to review the geologic and hydrologic information available for the sites and to make a preliminary evaluation of their geologic suitability for hazardous waste facilities. This report presents the results of that review and recommends guidelines for future site-suitability investigations and the preparation of detailed geologic reports for hazardous waste facilities.

PURPOSE AND SCOPE

The purpose of this investigation was to evaluate the geologic and hydrologic information available for the five sites with regard to the siting of hazardous waste facilities. A reconnaissance was made of each location but no other field activities were performed. The results of the investigation provide baseline data which can be used to make a preliminary ranking of the sites and to identify needs for further study. It is emphasized that this report represents a compilation of existing information only and does not provide the detailed data necessary for actual site selection. Additional geologic and hydrologic investigations are required before a final determination can be made on the location of any hazardous waste facility.

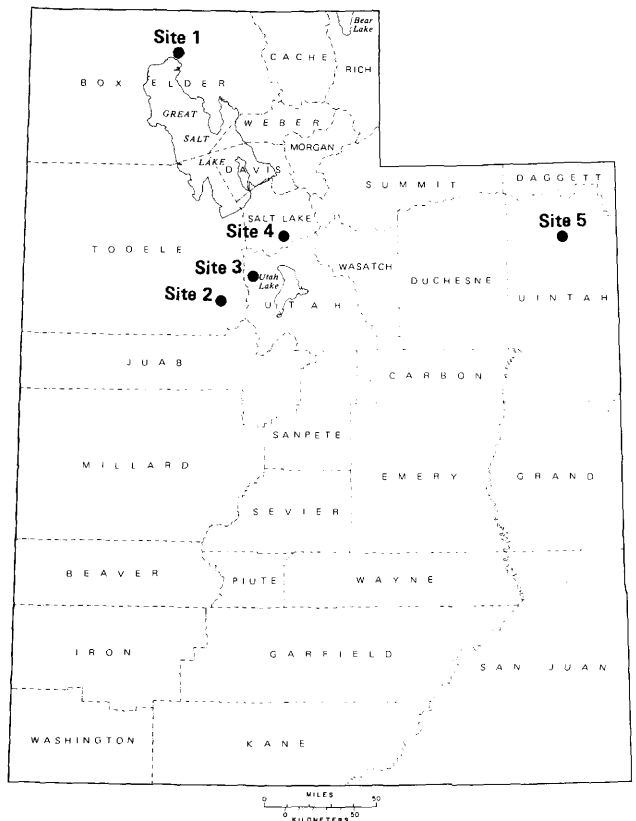


Figure 1. Location map showing proposed hazardous waste sites.

REGIONAL SETTING

The five sites being considered by the Bureau of Solid and Hazardous Waste are in northern and eastern Utah (figure 1). Their selection was based on a projection of future hazardous waste production in Utah and an estimate of where facilities would be needed to treat or dispose of the waste (K. Montague, oral commun., 1983). Four of the sites (1 through 4, fig. 1) lie in the Great Basin portion of the Basin and Range physiographic province, an area characterized by narrow, north-south-trending mountain ranges and intermontane valleys. Surface drainage is closed within the Great Basin as a whole, and many of the valleys form closed basins where surface runoff accumulates in playa lakes or seasonally wet marsh areas. The geology in the mountain ranges is complex, consisting of folded and faulted rocks of Precambrian to Tertiary age. Bedrock geology beneath the valleys is largely unknown due to the accumulation of valley-fill deposits which may reach thicknesses of more than 1000 feet in some basins. These unconsolidated and semiconsolidated deposits of clay, silt, sand, and gravel make excellent aquifers and commonly contain multiple saturated layers. Ground water occurs under both artesian (confined) and water table (unconfined) conditions, and perched ground water is found locally. While adjacent valleys may be closed to surface drainage, most are hydraulically connected in the subsurface with ground water moving along fractures and solution channels in bedrock from higher to lower basins. In many basins, water recharging the ground-water system along basin edges discharges in springs near valley bottoms.

The fifth site is in the Uinta Basin, a subdivision of the Colorado Plateau physiographic province. Rocks in the Uinta Basin are generally flat lying; dips of less than 10 degrees are common and large areas are underlain by a single geologic formation. Soil cover is thin, ranging from none to a maximum of a few tens of feet in larger stream drainages. Shallow ground water occurs in the unconsolidated deposits along perennial streams, but the principal aquifers are limestone and sandstone formations lying hundreds and sometimes thousands of feet beneath the surface.

SITE CHARACTERIZATION

The five sites are each one square mile (640 acres) in size. Their locations relative to each other and to population centers are shown on figure 1. Existing geologic and hydrologic information pertaining to the sites is summarized below. Sources are cited in the text as appropriate and are grouped together by site in the "Selected References" section of the report.

Site 1 Hansel Valley

Location: T. 12 N., R. 8 W., sec. 23, SLB&M; Salt Wells, Utah 7.5 minute topographic quadrangle; Box Elder

County approximately 23 miles southwest of Snowville, Utah.

Site Description: The site lies near the south end of Hansel Valley immediately north of Salt Wells Flat (mud flats) and the Great Salt Lake (figure 2). It is on the west side of the valley adjacent to the Hansel Mountains. Slopes are gentle on the north, east, and south, but moderate to steep on the west. Drainage is poorly developed, sheet wash predominates. Hansel Valley is not a closed basin, surface drainage flows south toward the mud flats. Maximum and minimum site elevations are 4340 and 4225 feet respectively (estimated from topographic maps). Vegetative cover is sparse, consisting chiefly of range grass, sagebrush, and greasewood. Present land use is open range, access is by graded dirt road from Snowville or Golden Spike National Historic Site.

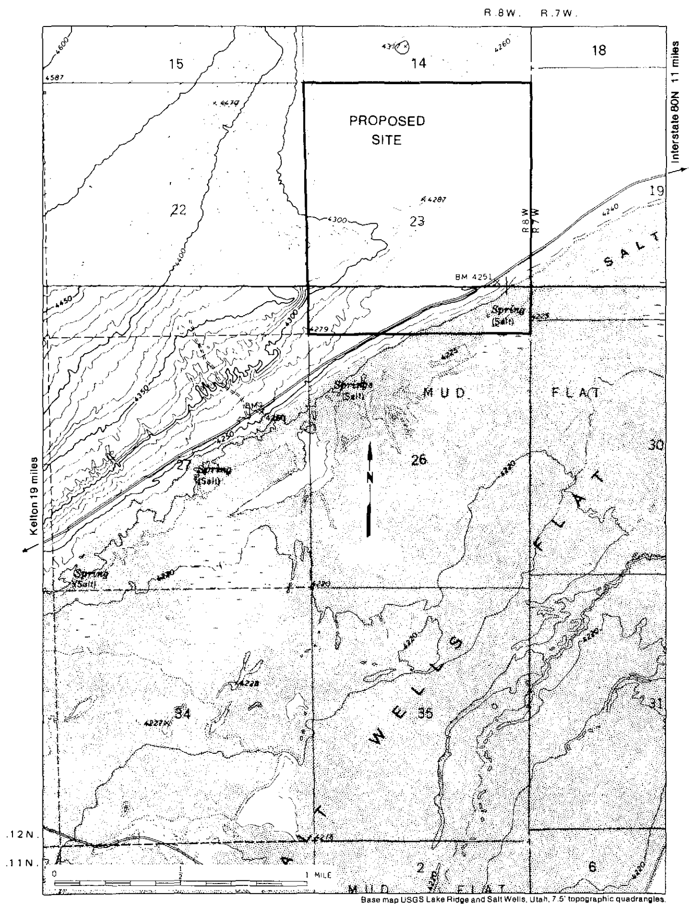


Figure 2. Hansel Valley site; T. 12 N., R. 8 W., sec. 23, SLB&M

Climate: Semiarid; normal annual precipitation 8-10 inches (Utah Division of Water Resources, no date), average monthly temperature (1899-1966 at Snowville) January 22°F/August 69°F, estimated annual potential evapotranspiration 41 inches (Hood, 1971).

Geology: Lake Bonneville deposits cover all but the southeast corner of the site which extends into Salt Wells Flat (Doelling and others, 1980). Silt and clay predominate on the east, sand and gravel on the west. Thickness of lacustrine deposits and depth to bedrock are unknown. Location of range-bounding faults mapped by Adams (1962) and Doelling and others (1980) north of the site are unknown in the site vicinity. Recent (1934) fault scarps in basin-fill deposits one to two miles west of the site (Adams, 1938) are now largely obscured (R. Smith, oral commun., 1983).

Soil: USDA Soil Conservation Service mapping (Chadwick and others, 1975) shows that silt and sandy silt soils predominate on the site with limited areas of silty sand and gravel in the southeast and southwest portions of the section. Clay and clayey silt are found at the surface in the northwest but overlie sand and gravel at depths of 4 feet or less. Soil permeability ranges from slow to moderately rapid (Chadwick and others, 1975).

Ground Water: Depth to ground water varies with surface elevation across the site (Hood, 1971). It is shallowest near Salt Wells Flat (0-5 feet) and deepest at the higher elevations to the west (95-105 feet). Water quality is poor (saline) and the direction of flow is toward Salt Wells Flat and the Great Salt Lake (Hood, 1971). Springs at the south end of the site discharge ground water directly to Salt Wells Flat (figure 1). There are no known wells on site.

Hazards: Hansel Valley is an active seismic area; the 1934 Hansel Valley earthquake (estimated Richter magnitude 6.6) produced Utah's only historic instance of seismically induced ground displacement (20 inches) (Arabasz and others, 1979). The earthquake damaged buildings and railroads, caused landslides and liquefaction, altered discharge from springs, and caused one death when an excavation collapsed. The Utah Seismic Safety Advisory Council seismic zone map of Utah (Ward, 1979) places the site in zone U-3; major damage, corresponds to intensity VIII and higher of the modified Mercalli scale (appendix).

Possible ground subsidence is suggested by a comparison of railroad surveys made in 1850 and 1934 which show a general subsidence of 4 feet over several square miles at the south end of Hansel Valley (Adams, 1938). Adams (1938) attributes 1.2 feet of the subsidence to the 1934 earthquake and the remainder to other causes. Later workers feel that much of the apparent subsidence may be due to errors in survey data (D. Mabey, oral commun., 1984)

Summary: Porous soils and a shallow water table combine to create a potential for ground-water contamination with a direct connection to the Great Salt Lake. The site is in an area of high seismic hazard and would be subject to severe ground shaking and possible ground rupture in the event of another moderate to large earthquake. The site may also be subject to long-term ground subsidence related to tectonic activity in the area.

Site 2 Rush Valley

Location: T. 7 S., R. 5 W., sec. 9, SLB&M; Faust, Utah 7.5 minute topographic quadrangle; Tooele County approximately 8 miles north of Vernon, Utah.

Site Description: The site is on an alluvial fan on the east side of the Onaqui Mountains in central Rush Valley (figure 3). The alluvial surface has a gentle to moderate slope to the east, entrenched (8-10 feet) stream channels create locally steep slopes. Drainage is well developed, three large intermittent tributaries to Faust Creek cross the site from west to east. Rush Valley is a closed basin, surface runoff accumulates in Rush Lake on the south side of the Stockton bar. Maximum and minimum site elevations are 5210 and 5100 feet respectively (estimated from topographic maps). Vegetative cover is moderate and consists chiefly of range grass and sagebrush. Present land use is open range; State Route 36 crosses the site from north to south.

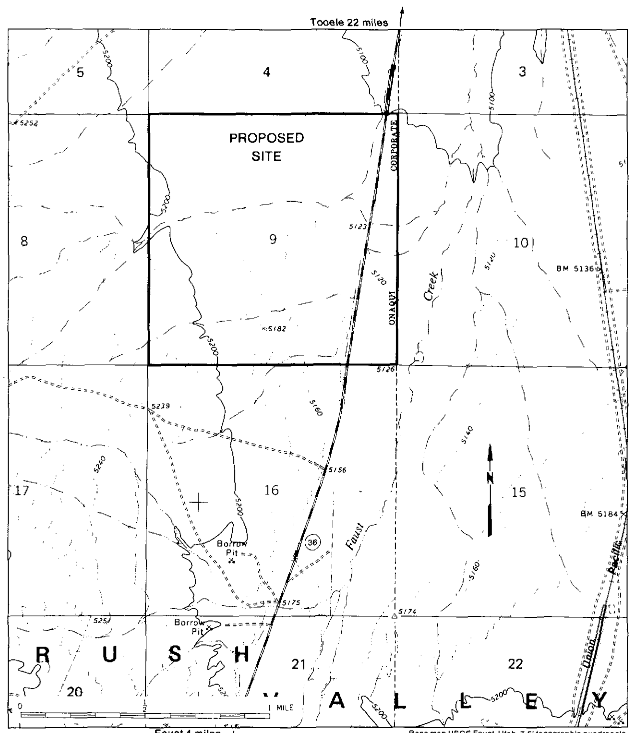


Figure 3. Rush Valley site; T. 7 S., R. 5 W., sec. 9, SLB&M

Climate: Semiarid; normal annual precipitation 8-10 inches (Utah Division of Water Resources, no date), average annual air temperature estimated to be 47-50°F, average annual evaporation estimated to be 50 inches (Hood and others, 1969).

Geology: The Bonneville shoreline (marking the highest stand of Lake Bonneville, 5200-5250 feet) crosses the southwest quadrant of the site in a southeast to northwest direction. Lacustrine deposits of silt and clay extend from the shoreline eastward to State Route 36. East of the highway, the lake deposits are covered by younger alluvial silt and sand laid down by Faust Creek. Beneath the Lake Bonneville sediments and exposed west of the shoreline are older alluvial deposits of silt, sand, and gravel. Thicknesses estimated by Everitt and Kaliser (1980) for the unconsolidated deposits in Rush Valley are: old alluvium, 500 feet plus; Lake Bonneville deposits, 0 to 100 feet; and younger alluvium, 0 to 15 feet. Quaternary (potentially active) faults are mapped 3 miles to the southwest and photo lineaments of possible tectonic origin have been identified one mile to the west (Everitt and Kaliser, 1980).

Soil: USDA Soil Conservation Service mapping (unpublished) identified three general soil types on the site. The soils and approximate percentage of each are: clay and clayey silt, 25 percent; silty or clayey sand and gravel, 60 percent; and silt and clay over shallow (3 to 4 feet) sand and gravel, 15 percent. Permeability of the clay and clayey silt soil is moderately low to moderate while that of the sand and gravel is moderate to moderately rapid (unpublished USDA Soil Conservation Service data).

Ground Water: Depth to ground water varies with surface elevation across the site. It is shallowest near Faust Creek (15 to 35 feet) where it fluctuates with the seasons, and deepest at higher elevations near the southwest section corner (70 to 90 feet) (Hood and others, 1969). Water quality is "fresh" ranging from 250 to 1000 mg/l total dissolved solids (Price, 1981). The direction of ground-water flow is to the northeast toward the valley. An estimated 5000 acre-feet of ground water is discharged annually along the eastern edge of Rush Valley into structurally distorted rocks of the Oquirrh Mountains (Hood and others, 1969). There are no known wells on site.

Hazards: Everitt and Kaliser (1980) state that Tooele and Rush Valleys contain Quaternary faults that have been active in post-Bonneville time (less than 14,500 years B.P.) and that "The entire area therefore may be considered to be seismically active, with no part of the valleys more than 10 miles from a potentially active fault." Quaternary faults are located within 3 miles of the proposed site. The Utah Seismic Safety Advisory Council seismic zone map of Utah (Ward, 1979) places the site in zone U-3; major damage, corresponds to intensity VIII and higher of the modified Mercalli scale.

Minor to moderate flooding may occur along intermittent streams crossing the site during the spring snowmelt or periods of heavy precipitation (Hood and others, 1969).

Summary: A potential for ground-water contamination exists, particularly on the east side of the site where depth to ground water may be less than 30 feet. Subsurface outflow of ground water through the Oquirrh Mountains could carry contaminants to adjoining basins. Seismic activity may subject the site to ground shaking and possible ground rupture in the event of a moderate to large earthquake.

Site 3 Salt Lake Valley

Location: T. 3 S., R. 2 W., sec. 27, SLB&M; Lark, Utah 7.5 minute topographic quadrangle; Salt Lake County one-half mile northwest of Herriman, Utah.

Site Description: The site is located on the west side of Salt Lake Valley at the base of the Oquirrh Mountains between Copper and Keystone Gulches (figure 4). The ground surface slopes gently to moderately to the east. Drainage is well developed; Copper and Midas Creeks, both intermittent streams with incised channels, cross the site from west to east. Maximum and minimum site elevations are 5160 and 4975 respectively feet (estimated from topographic maps). Portions of the property are cultivated and mine tailings extend onto the site from the west. Access is provided by 118th South Street which forms the north site boundary.

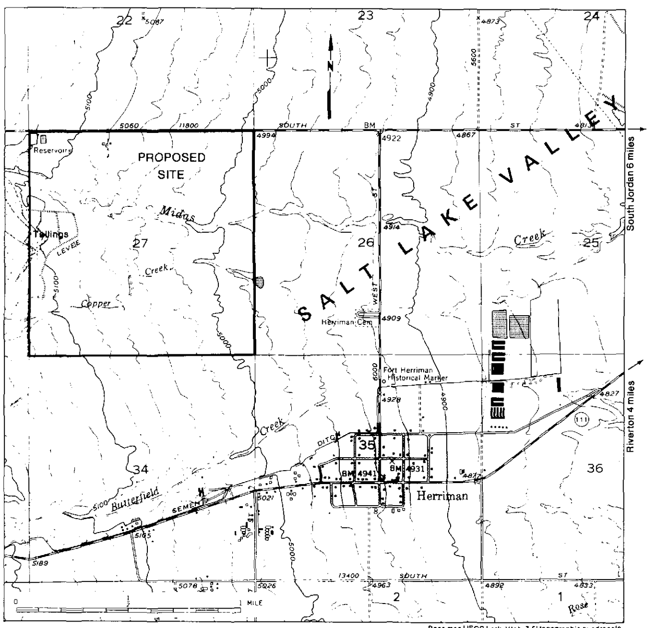


Figure 4. Salt Lake Valley site; T. 3 S., R. 2 W., sec. 27, SLB&M

Climate: Continental; normal annual precipitation 14-16 inches (Hely and others, 1971), average annual temperature 50-55°F (Woodward and others, 1974), annual pan evaporation in Jordan Valley (1956-1968) 66.5 inches (Hely and others, 1971).

Geology: Lake Bonneville deposits consisting of clay, silt, sand, and gravel cover the site (Miller, 1980). Sand and gravel are found on the northern one-third of the site, silt and clay on the southern two-thirds. Fluvial sand, gravel, and cobbles have been deposited in stream channels and on low terrace surfaces adjacent to drainages. Thickness of the lake deposits is unknown but is probably less than 100 feet. Quaternary faults have not been identified on the west side of the Salt Lake Valley. Faults of unknown age have been found in basin-fill sediments near the center of the valley at about 4700 South and 2700 West (Gorden and Vandell, 1979), and the Wasatch fault lies 12 miles to the east.

Soil: USDA Soil Conservation Service mapping (Woodward and others, 1974) shows sand, gravel, and sandy silt along streams and on adjacent terrace and alluvial outwash surfaces. Silt and clay cover the remainder of the site except where obscured by mine tailings. Permeability of the coarse-grained soil ranges from moderately low to moderately rapid while that of the fine-grained soil is very slow to moderate.

Ground Water: Depth to ground water increases rapidly across the site from west to east (Hely and others, 1971). The water table is approximately 145 feet deep on the west side of the site (exclusive of areas covered by mine tailings) and about 250 feet deep on the east side. The direction of ground-water flow is east toward the valley. Hely and others (1971) identify the site as lying within the principal recharge area of the deep aquifers in Salt Lake Valley. Water quality data are unavailable; the effect on water quality of mining and mineral processing activities west of the site are unknown. Wells were observed on site, but their logs are not on file with the State Division of Water Rights.

Hazards: The Utah Seismic Safety Advisory Council seismic zone map for Utah (Ward, 1979) places the site in zone U-4; major damage, corresponds to intensity VIII or greater on the modified Mercalli scale. Midas and Copper Creeks both show evidence of flood activity associated with the spring snowmelt and periods of heavy precipitation. The possible effect on ground-water gradients and the potential for subsidence related to the proposed development of a municipal well field approximately 2 miles southeast of the site are unknown.

Summary: The site is located in the principal recharge area of the deep aquifers in Salt Lake Valley and would represent a potential ground-water contamination hazard. A possible existing ground-water contamination problem related to nearby mining activity may make it difficult to monitor for pollution resulting from waste leaks at the site. Seismic activity would subject the site to ground shaking.

Site 4 Cedar Valley

Location: T. 6 S., R. 2 W., sec. 22, SLB&M; Cedar Fort, Utah 7.5 minute topographic quadrangle; Utah County approximately 2 miles northeast of Fairfield, Utah.

Site Description: The site lies on the gently sloping floor of Cedar Valley (figure 5). Cedar Valley is a closed basin, surface runoff collects south of Fairfield. Site drainage is poorly developed, sheet wash predominates and water ponds locally. Maximum and minimum site elevations are 4858 and 4844 feet. Present land use is open range. Vegetative cover is moderate to heavy and consists of grass and sagebrush. Access is provided by a graded dirt road from State Route 73.

Climate: Semiarid; normal annual precipitation 10-12 inches (Utah Division of Water Resources, no date), average monthly temperatures January 22.6°F/July 70.9°F, estimated June 1 to September 15 average evaporation rate 36 inches (Larson, 1960).

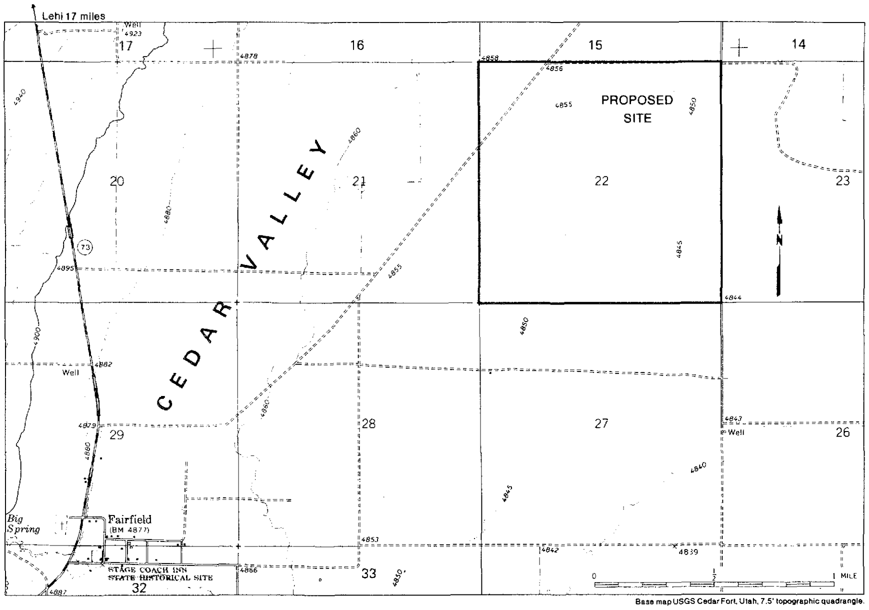


Figure 5. Cedar Valley site; T. 6 S., R. 2 W., sec. 22, SLB&M

Geology: Alluvial and eolian deposits of silt and fine sand cover the site. Exposures in a shallow borrow pit on site show these materials are thin (1 to 3 feet) and overlie Lake Bonneville deposits of silt, clay, and some sand. Thickness of the lacustrine deposits is unknown but is believed to be a few tens of feet. Fine-grained (70 percent silt and clay) pre-Lake Bonneville Quaternary and Tertiary (?) sediments, locally more than 1000 feet thick, are reported to underlie the lake deposits (Larson, 1960). No Quaternary faults have been recognized in Cedar Valley (Larson, 1960; Bucknam, 1977; Anderson and Miller, 1979).

Soil: USDA Soil Conservation Service mapping (unpublished) shows that the soil on site consists of clay and some silt exhibiting low to moderate plasticity. Permeabilities are reported as slow to moderate low (unpublished USDA Soil Conservation Service data).

Ground Water: Artesian conditions, probably in a multiple aquifer system, are believed to exist at the site. Feltis (1967) reported the depth to the piezometric surface as 30 feet near the northwest corner of the site and 40 feet near the southwest corner. There are no wells on site, but several large irrigation wells have been drilled a short distance to the north. The effect of well pumping on the piezometric surface since 1967 is not known. The site is located on the east flank of a ground-water high; subsurface inflow from nearby Manning Canyon supplies the major source of recharge (Feltis, 1967). The direction of ground-water flow is from west to east. Water leaves Cedar Valley through the Lake Mountains along fractures and solution channels in bedrock. The water may discharge in springs and seeps on the east side of the Lake Mountains, in the bottom of Utah Lake, or to the alluvium northeast of the Lake Mountains on the west side of northern Utah Valley (Feltis, 1967). Water from most wells in northern Cedar Valley contains less than 500 ppm dissolved solids.

Hazards: The Utah Seismic Safety Advisory Council seismic zone map for Utah (Ward, 1979) places the site in zone U-3; major damage, corresponds to intensity VIII or greater on the modified Mercalli scale. The low ground surface gradient and the resulting poorly developed drainage system could make surface flooding a problem during the spring snowmelt and periods of heavy rainfall.

Summary: Additional information is required concerning the ability of site soils to isolate waste from the water table. A potential ground-water contamination problem exists if the soils are permeable. Seismic activity may subject the site to ground shaking.

Site 5 Ashley Valley

Location: T. 4 S., R. 22 E., sec. 9, SLB&M; Naples, Utah 7.5 minute topographic quadrangle; Uintah County approximately 5 miles northeast of Vernal, Utah.

Site Description: The site is on a pediment surface on the east side of Ashley Valley between the Buckskin Hills and the flood plain of Ashley Creek (figure 6). The ground surface has a moderate slope to the south with locally steep slopes along incised stream channels. Drainage is well developed, several intermittent tributaries to Ashley Creek cross the site from north to south. Maximum and minimum site elevations are 5545 and 5295 feet respectively (estimated from topographic maps). Vegetative cover is moderate and consists of grass, sagebrush, and juniper. Present land use is open range, a pipeline crosses the northeast quadrant of the site. Access is by a combination of paved and graded dirt roads from Vernal.

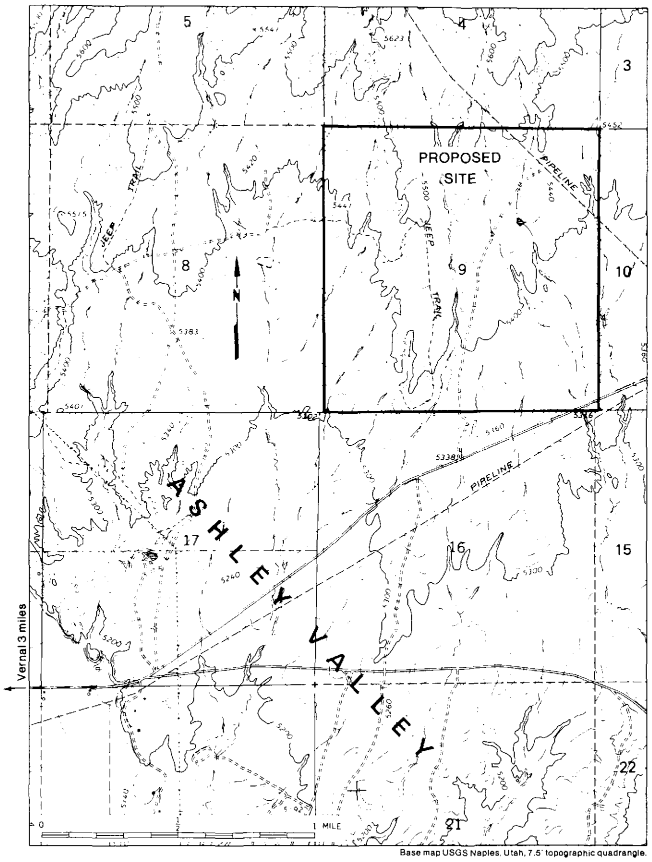


Figure 6. Ashley Valley site; T. 4 S., R. 22 E., sec. 9, SLB&M

Climate: Semiarid; average annual precipitation 12-14 inches, average annual air temperature 45°F; estimated average annual pan evaporation rate at Vernal 55.8 inches (Utah State Climatologist, oral commun., 1983).

Geology: The pediment surface on which the site is located is cut on Cretaceous-age Mancos Shale. The Mancos Shale consists of soft, dark-gray to greenish-gray, fissile shale that includes beds of siltstone, bentonitic clay, and thin layers of fine-grained sandstone (Rowley and others, 1979). Except where fractured by faulting or folding, the shale normally possesses low permeability. Thickness of the shale at the site is unknown but probably exceeds 1000 feet. The shale is covered in most places by a residual clay soil or alluvial sand and gravel deposited as the pediment developed. The residual soil is usually thin (4 to 6 feet) and the alluvial deposits probably do not exceed 20 feet in most places. Recent fluvial deposits of clay, sand, gravel, and cobbles are found along stream channels. The shale is nearly flat lying and there are no faults or folds in the site vicinity (Kinney, 1955; Untermann and Untermann, 1964; Rowley and others, 1979).

Soil: USDA Soil Conservation Service mapping (unpublished) shows three general soil types on site. The soils and approximate percentage of each are: sand and gravel with some silt and clay, 30 percent; clay and clay silt over shallow bedrock, 50 percent; and clay and clay silt, 20 percent. The coarse-grained soils are found on remnants of the original pediment surface between incised stream channels. Their permeabilities range from moderate to rapid. The clay and clayey silt soils over shallow bedrock are found in upland areas between drainages where erosion has removed the pediment gravels. The deeper (greater than 60 inches) clay and clayey silt soils are alluvial and colluvial materials deposited along stream channels as the Mancos Shale is eroded. Permeability of the clay soils is slow to moderate (unpublished USDA Soil Conservation Service data).

Ground Water

Data are not available on ground water beneath the site. The Mancos Shale makes a poor aquifer because of its low permeability and often does not contain ground water. No wells have been drilled on or near the site but, in other areas of the state where wells have been developed in the Mancos Shale, either no water was encountered or the water present was of poor quality (saline) and limited quantity.

Hazards: Flooding may occur along intermittent stream channels during the spring snowmelt and periods of heavy precipitation. The Utah Seismic Safety Advisory Council seismic zone map for Utah (Ward, 1979) places the site in zone U-1; minor damage, corresponds to intensity V and VI of the modified Mercalli scale.

Summary: Locating a hazardous waste facility at this site would require modification of existing stream channels to prevent flooding. Other geologic and hydrologic factors appear favorable.

PRELIMINARY SITE EVALUATION AND RANKING

The level of geologic and hydrologic information available varies considerably between the five sites. Therefore, it was difficult to make a comparative evaluation of them and the suitability ranking presented (table 1) is considered preliminary and subject to verification by future site-specific investigations.

Despite data deficiencies, the best and the worst sites are readily identifiable. Site 5 in Ashley Valley has characteristics that make it well suited for a hazardous waste facility.

Table 1. Preliminary ranking of sites according to geologic suitability for hazardous waste facilities.

Site No.	Location	Suitability Rank (1-most suitable 5-least suitable)
1	Hansel Valley	5
2	Rush Valley	3
3	Salt Lake Valley	4
4	Cedar Valley	2
5	Ashley Valley	1

Bedrock consists of a thick (greater than 1000 feet) section of low permeability shale with little or no potential as an aquifer. Most site soils are derived from the shale and share its low permeability. Shallow ground water is not known to exist at the site and average annual evaporation is more than three times average annual precipitation. There are no Quaternary faults in the site vicinity and the Uinta Basin is in Utah Seismic Safety Advisory Council seismic zone U-1, the lowest earthquake hazard zone in the state. Conversely, site 1 in Hansel Valley is the least suited for a hazardous waste facility. High seismic risk from both ground rupture and ground shaking, tectonically induced ground subsidence, and a potential ground-water contamination problem that could reach the Great Salt Lake make this site a poor choice for any type of hazardous waste facility.

Site 4 in Cedar Valley is ranked second because the soils are low- permeability silt and clay and there are no known Quaternary faults in the site vicinity. A ground-water high beneath the site and a potential for seismically induced ground shaking are unfavorable features associated with the location. Site 2 in Rush Valley is considered third because of its more porous soils, high ground water in some areas, and the presence of Quaternary faults within 3 miles of the site boundary. Site 3 is fourth because it is located in the principal recharge area of the deep aquifers supplying culinary and irrigation water to the Salt Lake Valley. Site 3 is also in Utah Seismic Safety Advisory Council seismic zone U-4, the zone of highest earthquake hazard in the State.

CONCLUSIONS AND RECOMMENDATIONS

Hazardous wastes include a wide variety of substances that differ greatly in the degree of hazard they present and the length of time they remain hazardous. When combined with the many options available for storage, treatment, and disposal of such substances, it is difficult at this preliminary investigation stage to make specific inferences concerning the five sites. However, based on this investigation, the following conclusions and recommendations are made:

- Site 5 and possibly site 4 appear to possess geologic and hydrologic characteristics necessary for the safe, long-term (1000 years plus) storage of hazardous waste. For that reason, those sites are recommended for further investigation as permanent waste disposal facilities.
- Geologic and hydrologic conditions at site 1 are not adequate to ensure the isolation of hazardous waste from the environment. Therefore, it is recommended that the site be removed from further consideration for hazardous waste facilities.
- Sites 2 and 3 may prove suitable for the temporary storage or treatment of hazardous waste. Site 2 has some potential as a disposal site, but the location of site 3 in the principal recharge area of the deep aquifers in Salt Lake Valley makes it poorly suited for permanent waste disposal.
- Final selection of a site for a hazardous waste facility requires detailed information about the geology, hydrology, soils, climate, and topography of the area under consideration. This information can only be obtained from regional and site-specific investigations designed expressly to answer siting questions related to hazardous waste disposal.

Suggested guidelines for the conduct of site-suitability investigations and the preparation of detailed geologic reports for hazardous waste facilities are presented following references.

REFERENCES

General References

Anderson, L.W., and Miller, D.G., 1979, Quaternary fault map of Utah: Long Beach, California, Fugro Inc., 35 p., scale 1:500,000.

Arabasz, W.J., Smith, R.B., and Richins, W.D., eds., 1979, Earthquake studies in Utah 1850 to 1978: University of Utah Seismograph Stations, Department of Geology and Geophysics, University of Utah, 552 p.

Arnow, Ted, and Clebsch, Alfred, Jr., 1982, Water resources data Utah, water year 1981: U.S. Geological Survey Water-Data Report UT-81-1, 708 p.

Brown, H.S., and LeGrand, H.E., 1981, Perspective on management and disposal of hazardous wastes: Association of Engineering Geologists Bulletin, v. XVIII, no. 3, p. 231-236.

Butler, Elmer, and Marsell, R.E., 1972, Developing a state water plan, cloudburst floods in Utah, 1939-69: U.S. Geological Survey and Utah Department of Natural Resources Division of Water Rights Cooperative-Investigation Report Number 11, 103 p.

California Division of Mines and Geology, 1975, Recommended guidelines for preparing engineering geologic reports: CDMG Note Number 44, 2 p.

Campbell, Alice, 1978, Geological investigation of disposal sites for hazardous waste: California Geology, v. 31, no. 10, p. 229-233.

Cartwright, Keros, and others, 1981, Hydrologic considerations in hazardous waste disposal in Illinois: Illinois Geological Survey Environmental Geology Notes 94, 20 p.

Clark-McGlennon Associates, Inc., 1980a, Criteria for evaluating sites for hazardous waste management: New England Regional Commission, Boston, Mass., 49 p.

———1980b, An introduction to facilities for hazardous waste management: New England Regional Commission, Boston, Massachusetts, 57 p.

Craig, R.W., and Lash, T.R., eds., 1980, Siting non-radioactive hazardous waste management facilities, an overview; final report of the first Keystone workshop on managing non-radioactive hazardous wastes: Keystone Center, Keystone, Colorado, 31 p.

Division of Comprehensive Emergency Management, 1981, Utah's history of floods 1847 to 1981: State of Utah Department of Public Safety, 45 p.

Fields, Timothy, Jr., and Lindsey, A.W., 1975, Landfill disposal of hazardous wastes: a review of literature and known approaches: U.S. Environmental Protection Agency Report EPA/530/SW-165, 36 p.

Glover, E.W., 1981, Role of the geotechnical consultant in siting suitable areas for hazardous waste disposal: Association of Engineering Geologists Bulletin, v. XVIII, no. 3, p. 227-230.

Hazardous Waste Dialogue Group, 1983, Siting hazardous waste management facilities: The Conservation Foundation, Chemical Manufacturers Association, and National Audubon Society, 71 p.

Huges, G.M., 1972, Hydrogeologic considerations in the siting and design of landfills: Illinois State Geological Survey Environmental Geology Notes Number 51, 22 p.

Hynes, J.L., and Sutton, C.J., 1980, Hazardous wastes in Colorado, a preliminary evaluation of generation and geologic criteria for disposal: Colorado Department of Health and Colorado Geological Survey Information Series 14, 100 p.

Johnson, K.S., Luza, K.V., and Roberts, J.F., 1980, Disposal of industrial wastes in Oklahoma: Oklahoma Geological Survey Circular 80, 82 p.

Lindorff, D.E., and Cartwright, Keros, 1977, Ground-water contamination: problems and remedial actions: Illinois State Geological Survey Environmental Geology Notes Number 81, 58 p.

Longmire, P.A., Gallaher, B.M., and Hawley, J.W., 1981, Geological, geochemical, and hydrological criteria for disposal of hazardous waste in New Mexico *in* Wells, S.G., Lambert, Wayne, and Callender, J.F., eds., Environmental Geology and Hydrology in New Mexico: New Mexico Geological Society Special Publication No. 10, p. 93-102.

Miller, D.G., Jr., and Alexander, W.J., 1981, Geologic aspects of waste disposal site evaluations: Association of Engineering Geologists Bulletin, v. XVIII, no. 3, p. 245-252.

Miller, D.W., ed., 1980, Waste disposal effects on ground water: Berkeley, Premier Press, 512 p.

Schlotthauer, W.E., Nance, B.W., and Olds, J.D., 1981, Identification and characteristics of aquifers in Utah: Utah Division of Water Rights, 238 p.

Stokes, W.L., 1977, Physiographic subdivisions of Utah: Utah Geological and Mineral Survey Map 43, scale 1:3,168,000.

Utah State University - Utah Division of Water Rights, no date, Developing a state water plan, hydrologic atlas of Utah, 306 p.

Ward, D.B., 1979, Seismic zones for construction in Utah: Seismic Safety Advisory Council, State of Utah, 13 p.

Wooley, R.R., 1946, Cloudburst floods in Utah 1850-1938, with a section on Physiographic features by R.E. Marsell: U.S. Geological Survey Water-Supply Paper 994, 128 p.

Site 1 Hansel Valley

Adams, O.C., 1962, Geology of the Summer Ranch and Promontory Mountains, Utah: Utah State University, unpublished master's thesis.

Adams, T.C., 1938, Land subsidence north of Great Salt Lake, Utah: Seismological Society of America Bulletin, v. 28, no. 2, p. 65-70.

Chadwick, R.S., and others, 1975, Soil survey of Box Elder County, Utah, eastern part: USDA Soil Conservation Service, U.S. Fish and Wildlife Service and Bureau of Land Management, in cooperation with Utah Agricultural Experiment Station, 223 p.

Cook, K.L., 1971, Earthquakes along the Wasatch Front, Utah *in* Environmental Geology of the Wasatch Front: Utah Geological Association Publication No. 1, p. H1-H29.

Doelling, H.H., and others, 1980, Geology and mineral resources of Box Elder County, Utah: Utah Geological and Mineral Survey Bulletin 115, 251 p.

Hood, J.W., 1971, Hydrologic reconnaissance of Hansel Valley and northern Rozel Flat, Box Elder County, Utah: Utah Department of Natural Resources Division of Water Rights Technical Publication No. 33, 41 p.

Site 2 Rush Valley

Armin, R.A., and Moore, W.J., 1981, Geology of the southeastern Stansbury Mountains and southern Onaqui Mountains, Tooele County, Utah: U.S. Geological Survey Open-File Report 81-247, 28 p.

Bissell, H.J., and others, 1959, Geology of the southern Oquirrh Mountains and Fivemile Pass - northern Boulter Mountain area, Tooele and Utah Counties, Utah: Utah Geological Society Guidebook to the Geology of Utah Number 14, 262 p.

Bucknam, R.C., 1977, Map of suspected fault scarps in unconsolidated deposits, Tooele 2° Sheet, Utah: U.S. Geological Survey Open-File Report 77-495, scale 1:250,000.

Everitt, B.L., and Kaliser, B.N., 1980, Geology for assessment of seismic risk in the Tooele and Rush Valleys, Tooele County, Utah: Utah Geological and Mineral Survey Special Studies 51, 33 p.

Hood, J.W., Price, Don, and Waddell, K.M., 1969, Hydrologic reconnaissance of Rush Valley, Tooele County, Utah: Utah Department of Natural Resources Division of Water Rights Technical Publication No. 23, 63 p.

Moore, W.J., and Sorensen, M.L., 1979, Geologic map of the Tooele 1° X 2° Quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I-1132, scale 1:250,000.

Price, Don, 1981, Surface-water resources in the Tooele 2° Quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I-1245, scale 1:250,000.

USDA Soil Conservation Service, 1983, Soil mapping and descriptions from selected areas in Rush Valley: unpublished, Tooele, Utah.

Site 3 Salt Lake Valley

Arnow, Ted, 1971a, Geologic framework *in* Environmental geology of the Wasatch Front: Utah Geological Association Publication 1, p. B1-B6.

———1971b, Hydrologic framework *in* Environmental geology of the Wasatch Front: Utah Geological Association Publication 1, p. C1-C7.

Cook, K.L., 1971, Earthquakes along the Wasatch Front, Utah *in* Environmental Geology of the Wasatch Front: Utah Geological Association Publication Number 1, p. H1-H29.

Crawford, A.L., ed., 1964, Geology of Salt Lake County: Utah Geological and Mineral Survey Bulletin 69, 190 p.

Davis, F.D., compiler, 1983, Geologic map of the central Wasatch Front, Utah: Utah Geological and Mineral Survey Map 54-A, scale 1:100,000, 2 sheets.

Gordon, W.J., and Vandell, T.D., 1979, Report of fault study UDOT/UDPS complex north of 4700 South Street on 2700 West Street, Salt Lake County, Utah, for the Utah State Building Board: Dames and Moore Job No. 04000-037-06, 9 p.

Hely, A.G., Mower, R.W., and Harr, A.C., 1971, Water resources of Salt Lake County, Utah, with a section on Geologic setting by Ted Arnow: Utah Department of Natural Resources Division of Water Rights Technical Publication No. 31, 239 p.

Miller, R.D., 1980, Surficial geologic map along part of the Wasatch Front, Salt Lake Valley, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-1198, scale 1:100,000.

Morisawa, Marie, 1971, The Wasatch fault zone - general aspects *in* Environmental Geology of the Wasatch Front: Utah Geological Association Publication 1, p. D1-D17.

Van Horn, Richard, 1971, Faults - criteria for their recognition in the Salt Lake City area, Utah *in* Environmental geology of the Wasatch Front: Utah Geological Association Publication Number 1, p. E1-E5.

Woodward, Lowell, and others, 1974, Soil survey of Salt Lake area, Utah: USDA Soil Conservation Service and Utah Agricultural Experiment Station, 132 p.

Site 4 Cedar Valley

Bissell, H.J., and others, 1959, Geology of the southern Oquirrh Mountains and Fivemile Pass - northern Boulter Mountain area, Tooele and Utah Counties, Utah: Utah Geological Society Guidebook to the Geology of Utah Number 14, 262 p.

Bucknam, R.C., 1977, Map of suspected fault scarps in unconsolidated deposits, Tooele 2° Sheet, Utah: U.S. Geological Survey Open-File Report 77-495, scale 1:250,000.

Feltis, R.D., 1967, Ground-water conditions in Cedar Valley, Utah County, Utah: Utah Department of Natural Resources Division of Water Rights Technical Publication No. 16, 31 p.

Larsen, N.W., 1960, Geology and ground-water resources in northern Cedar Valley, Utah County, Utah: Brigham Young University Research Studies Geology Series, v. 7, no. 1, 42 p.

Lund, W.R., and Kaliser, B.N., 1979, Preliminary geotechnical reconnaissance of a proposed new townsite in Cedar Valley, Utah County, Utah: Utah Geological and Mineral Survey Report of Investigation No. 131, 22 p.

Moore, W.J., and Sorensen, M.L., 1979, Geologic map of the Tooele 1° X 2° Quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I-1132, scale 1:250,000.

Price, Don, 1981, Surface-water resources in the Tooele 2° Quadrangle, Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I-1245, scale 1:250,000.

USDA Soil Conservation Service, 1983, Soil mapping and descriptions from selected areas in Cedar Valley: unpublished, Salt Lake City, Utah.

Site 5 Ashley Valley

Carrara, P.E., 1980, Surficial geologic map of the Vernal 1° X 2° Quadrangle, Colorado and Utah: U.S. Geological Survey Miscellaneous Investigation Series Map I-1204, scale 1:250,000.

Hood, J.W., 1977, Hydrologic evaluation of Ashley Valley, northern Uinta Basin area, Utah: Utah Department of Natural Resources Division of Water Rights Technical Publication No. 54, 25 p.

Hood, J.W., and Fields, F.K., 1978, Water resources of the northern Uinta Basin area Utah and Colorado, with special emphasis on ground-water supply: Utah Department of Natural Resources Division of Water Rights Technical Publication No. 62, 75 p.

Kinney, D.M., 1955, Geology of the Uinta River - Brush Creek area Duchesne and Uintah Counties, Utah: U.S. Geological Survey Bulletin 1007, 185 p.

Lindskov, K. L., and Kimball, B.A., 1984, Water resources and potential hydrologic effects of oil-shale development in the southeastern Uinta Basin, Utah and Colorado: U.S. Geological Survey Professional Paper 1307, 32 p.

Rowley, P.D., and others, 1979, Geologic map of the Vernal 1° X 2° Quadrangle, Colorado, Utah and Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF-1163, scale 1:250,000.

Untermann, G.E., and Untermann, B.R., 1964, Geology of Uintah County: Utah Geological and Mineral Survey Bulletin 72, 98 p.

USDA Soil Conservation Service, 1983, Soil mapping and descriptions from selected areas in Ashley Valley: unpublished, Vernal, Utah.

GUIDELINES FOR THE CONDUCT OF SITE-SUITABILITY INVESTIGATIONS AND PREPARATION OF GEOLOGIC REPORTS FOR HAZARDOUS WASTE FACILITIES

This section provides information on the conduct of detailed site-suitability investigations and preparation of geologic reports for hazardous waste facilities. The guidelines are necessarily generic in character and apply to investigations and reports required for the permanent disposal of hazardous waste. Similar but less intensive investigations are needed for treatment or temporary storage facilities. The information provided here is extracted, with minor modification, from Information Series 14 "Hazardous Wastes in Colorado; A Preliminary Evaluation of General and Geologic Criteria for Disposal" prepared jointly by the Colorado Geological Survey and Colorado Department of Health (Hynes and Sutton, 1980). An additional source of information regarding siting of hazardous waste facilities in an environment similar to Utah's is "Geological, Geochemical, and Hydrological Criteria for Disposal of Hazardous Wastes in New Mexico" by Longmire, Gallaher, and Hawley contained in "Environmental Geology and Hydrology in New Mexico," New Mexico Geological Society Publication No. 14 (1981).

A geotechnical report for hazardous waste facilities must provide all necessary information relating to the engineering, geology, and environmental protection of the proposed disposal site. This information enables the applicant and reviewing agencies to make decisions relating to this activity with the full benefit of all relevant data and interpretations. In addition to normal parameters for any engineering-geologic investigation, the evaluation of site suitability for disposal of hazardous waste requires attention to certain special factors. These include the need for long-term containment of the hazardous waste of concern, and continuing reconnaissance of the site after closure due to the serious nature of the health and environmental hazards associated with the leakage of the wastes to the environment. Investigation of these factors should conform to the relevant definitions, and to the criteria and regulations of the U.S. Environmental Protection Agency and Utah Department of Health.

Determination of geologic, hydrologic, and geotechnical parameters and the interrelations of these to the proposed activities constitute the principal contribution of the required report(s). These topics are usually presented as a separate section supported by specific geological data and explanation text. Relationships discussed should include (1) effects of the geological conditions on the proposed operation, and (2) effects of the proposed activity upon future geological processes and conditions in the area. These relationships are the key to determining the long-term safety of the project with regard to potential geologic hazards and constraints and the evaluation of pertinent parameters required for adequate containment of the hazardous wastes and their derived products.

To this end the following outline is presented as a general guide for preparation of engineering geologic reports. This outline describes and recommends many specific investigations and studies. Some items may require particular emphasis because of the nature of the hazardous waste. Additional items not presented in this outline may be necessary for a particular site, or other specific situations may render parts of the outline inapplicable. Judgements must be made by the professional geologist preparing the reports as to the geologic conditions that should be emphasized in the report. However, completeness of geotechnical reports and analyses are essential if delays in the review process are to be minimized. General guidelines not specifically related to hazardous wastes were adapted from Shelton and Prouty (1979) and Shelton and Junge (1979).

Reports should be prepared in accordance with the highest current standards of the profession, realizing that omissions of pertinent data are as serious an error as giving misinformation. The report must be prepared by a qualified engineering geologist.

GENERAL COMMENTS ON GEOLOGIC MAPPING AND REPORT PREPARATION

A. Each report must be the product of independent geologic study and mapping of the subject area at an appropriate scale and level of investigation to yield the required detail and kinds of relevant data. It will be necessary for the geologist to extend his mapping into adjacent areas to assure the ultimate suitability of the site.

B. All mapping should be done on a detailed topographic base map with satisfactory horizontal and vertical control. The base map should be the same scale as that used for the project plans so that the two can be easily compared.

C. Mapping by the geologist should reflect careful attention to the physical characteristics, lithology, structural elements, and three-dimensional distribution of the earth materials exposed or inferred within the area. In most areas these materials will include both bedrock and surficial deposits. Exploratory drill holes and test pits will be necessary in all cases to provide data and/or check interpretations.

D. Where three-dimensional relationships are significant but cannot be described satisfactorily by words alone, the report should be accompanied by appropriately positioned cross sections.

E. Locations and descriptions of test holes and other specific sources of subsurface information should be included in the report, on the geologic map, and on the cross sections.

GENERAL INFORMATION

A. Project Description

1. Present zoning, land use and status of the proposed site and surrounding area.
2. Indicate size and type of operation and relationship to adjoining areas.

B. Location

1. Specify site location in terms of section, township, range, and county.
2. Depict site location on an index map of appropriate scale, usually U.S. Geological Survey 7.5' topographic quadrangle map at 1:24,000 or county maps at 1:50,000.

C. Scope

1. Make reference to any previous geologic investigations used in preparation of the report.
2. Indicate the commissioning person or organization.
3. Nature and source of information used, including geologic environmental and health impacts.
4. List all methods of investigation as well as professional firm(s) and individual(s) who participated.
5. If the level of investigation varies within the subject areas, describe in the text and show on the maps areas of concentration or exclusion.

D. Regional Setting

1. Describe the general physiographic setting of the site and its relationship to local topographic features.
2. Describe the general geologic setting of the site and indicate any lithologic, tectonic, geomorphic or soils problems specific to the area.
3. Describe general surface and ground-water conditions and their relationship to the site.
4. Describe the known or probable mineral resources in the area.
5. Describe the climate in the area.

SPECIFIC GEOTECHNICAL INFORMATION

The report should contain specific descriptions of the hydrology and geology of the site and of the geotechnical aspects as they apply to hazardous waste disposal. The following section will be divided into these two categories. Where interpretations are involved, the basis for such interpretations should be clearly stated. References should be given for all information submitted which is not a direct result of the specific investigations conducted for the particular site-suitability study.

GENERAL GEOLOGY DESCRIPTIONS

The following checklist should be used as a general guide but may not be a complete list of all relevant geologic parameters.

A. Bedrock Units

1. Rock type.
2. Age of and correlation with recognized formations.
3. Dimensional characteristics such as thickness and extent.
4. Distribution and surface expression of bedrock units.
5. Physical and chemical characteristics.
6. Distribution and extent of the weathered zone.
7. Response of bedrock materials to natural processes.
8. Regional and local geohydrology of the bedrock units.

B. Surficial Deposits

1. Regional and local structural setting. Location and distribution of structure(s).
2. Identification of material types.
3. Dimension characteristics such as thickness and extent.
4. Surface expression and relationships with present topography.
5. Physical and chemical characteristics.
6. Distribution and extent of altered zones.
7. Response of surficial materials to natural processes.
8. Geohydrology of the surficial units.

C. Structural Features

1. Occurrence and distribution.
2. Dimensional characteristics.
3. Orientation and changes in orientation.
4. Special effects on the bedrock.
5. General seismo-tectonic environment.
6. Fault capability (e.g., location, magnitude, and association with faults or fault systems).

D. Surface Drainage

1. Distribution and occurrence.
2. Relations to topography (drainage density and patterns).
3. Relations to geologic features.
4. Source and permanence.
5. Variations in amounts of flow.
6. Evidence of earlier occurrence of water at localities now dry.
7. Estimated peak flows and physiographic flood plain or drainages (including flash flood and debris flood areas). Use probable maximum flood or 100-year flood, depending on land use and need for protection.
8. Water quality.
9. Use of surface waters.

E. Ground Water

1. Distribution and occurrence (confined and unconfined).

2. Hydraulic gradients.
3. Recharge areas for aquifers.
4. Relations to topography.
5. Relations to geologic features.
6. Seasonal variations.
7. Water quality.
8. Use of ground water.

F. Other Features of Special Significance (Rogers and others, 1974).

1. Accelerated erosion and/or deposition.
2. Lateral spreading failures.
3. Subsidence or settlement (including hydrocompaction and piping).
4. Soil creep.
5. Slump and slide masses in bedrock and/or surficial deposits.
6. Deposits related to geologically recent flooding.
7. Rockfall areas.
8. Subsidence over underground mines or naturally created voids.
9. Seismic hazards (Kirkham and Rogers, 1978).
10. Expansive soil and rock.
11. Snow-avalanche areas.
12. Geomorphic processes.
13. Potential mineral resources (e.g., possible conflicts with mineral resources).

ANALYSIS OF RELATIONSHIP OF GEOLOGIC FACTORS AND HAZARDOUS WASTE DISPOSAL

This analysis is usually presented as a separate section supported by the above-mentioned geologic descriptions and normally constitutes the principal findings of the report. The analysis should evaluate (1) the effects of geologic conditions upon the proposed construction and operation of the site and (2) the effects of these proposed modifications upon forseeable future geologic processes and conditions in the area. This evaluation ultimately should address site suitability, project feasibility, and evaluate whether or not it is reasonable to develop the subject property as planned. Special attention should be given to standards set by the State of Utah and the U.S. Environmental Protection Agency.

The following checklist includes the items that ordinarily should be considered in preparing this section of the geologic report:

A. Climatology

1. A thorough examination of wind patterns with emphasis on severity of winds and proximity of population centers.
2. Precipitation and evaporation data and trends should be documented or ascertained.
3. Theoretical 24-hr, 50-yr, and maximum-anticipated storms should be calculated and their effects analyzed.
4. Deflation potential should be evaluated with respect to long-term breach of containment due to loss of protective cover.

B. Surface Hydrology

1. Investigation of the potential for contamination of streams by overflow or spillage.
2. Potential for sheet erosion.
3. Location of all perennial and ephemeral streams with respect to potential loss of containment.
4. Proposed flood protection.
5. A complete investigation of flood potential in the area and its impact on the site should be performed.

C. Ground Water

1. Describe ground-water quality.
2. Complete three-dimensional representation of aquifers, surficial and bedrock, within 500 ft of the surface and their relationship to the site.
3. Describe hypothetical flow patterns from the waste site substantiated by on-site investigations.
4. Map and describe all aquifer-recharge areas.
5. Describe present flow patterns, depth to water table, and rate of ground-water movement.
6. Document all wells and exploratory borings within one mile of the site.

D. Lithology

1. Describe the lithology, including subsurface data, of the bedrock and surficial deposits in the area.
2. Describe subsurface relationship of permeable and impermeable units to the proposed site.
3. Determine in situ permeability of host rock.
4. Provide well logs and cross sections of the site to a depth of at least 500 ft below the bedrock-soil interface.

E. Structure

1. Location, spacing, and proximity of faults, joints, and fractures.
2. Seismic history.
3. Description of folding.

F. Geomorphology

1. Describe landforms in the area.
2. Avoid areas of high relief, such as buttes and mesas, which are relatively sensitive to changes in the regional baseline of nearby streams.
3. Describe the type(s) of surface and its potential for erosion.

4. Avoid physiographic flood plains.
5. Determine slope stability.

G. Geochemistry Recommendations

1. Perform detailed mineralogical, physical, and chemical studies of selected clay mineral(s) in order to determine their exact suitability or compatibility with various types of pollutants (organic and/or inorganic).
2. Determine the chemical-physical relationships between the clay mineral(s) and the specific wastes to be disposed of by conducting laboratory studies coupled with in situ "in the field" observations. Various physical and chemical parameters to consider include: pH, Eh, ion exchange capacities, and precipitation products of the clay mineral and the type(s) of pollutant.
3. Frequent field inspections, such as soil sampling, should take place in order to assure that a closed system between the waste-disposal site and the surrounding media is constantly maintained and to verify or modify the assumptions and interpretations utilized in the original suitability studies.

H. Special Recommendations

1. Describe any possible geologic barriers to the surface and subsurface movement of waste material.
2. Possible mitigation of any of the aforementioned problems.
3. Description and availability of linear materials for prevention of fluid migration.
4. Describe the nature and availability of the cover material proposed for site.
5. Describe the ongoing monitoring procedures and design conditions to be employed during operation of the site and after final closure.

REFERENCES

Kirkham, W. R., and Rogers, W. P., 1978, Earthquake potential in Colorado, a preliminary evaluation: Colorado Geological Survey Open-File Report 78-3, 196 p., 3 plates.

Office of Nuclear Waste Management, and U.S. Geological Survey, 1979, Earth science technical plan for mined geologic disposal of radioactive waste: U.S. Department of Energy draft TID-29018, 151 p.

Rogers, W. P., Ladwig, L. R., Hornbaker, A. L., Schwochow, S. D., Hart, S. S., Shelton, D. C., Scroggs, D. L., and Soule, J. M., 1974, Guidelines and criteria for identification and land-use controls of geologic hazard mineral resource areas: Colorado Geological Survey Special Publication 6, 146 p.

Shelton, D. C., and Prouty, Dick, 1979, Nature's building codes, geology and construction in Colorado: Colorado Geological Survey Special Publication 12, 72 p.

Shelton, D. C., and Junge, W. R., 1979, Recommended outlines for preparing engineering geologic reports for uranium-mill siting, radioactive-tailing storage and associated land-use changes: Colorado Geological Survey unpublished report, 6 p.

REPORT OF INVESTIGATION NO. 204
ENGINEERING GEOLOGY FOR LAND-USE PLANNING FOR RESEARCH PARK, UNIVERSITY OF UTAH SALT LAKE CITY, UTAH

by
Robert H. Klauk

ABSTRACT

Research Park is owned and operated by the University of Utah as a center for scientific research, advancement of education, and economic development. It is located on the east side of Salt Lake City at the base of and including portions of the Wasatch Range. Damaging floods and debris flows in 1983 and 1984 made apparent the need to consider geologic hazards when planning new developments along the Wasatch Front. Information on the geology of the park and its surroundings provide the data base required by planners and others to make informed decisions for a future growth.

Both bedrock and unconsolidated basin-fill deposits are present in Research Park. Bedrock includes the Triassic Ankareh Formation, the Upper Triassic/Lower Jurassic Nugget Sandstone, and the Jurassic Twin Creek Limestone. These formations consist chiefly of sandstone, mudstone, shale, and limestone. Unconsolidated deposits cover most of the park and are of late Pleistocene and Holocene age. They are principally of lacustrine and alluvial origin. The lacustrine sediments were deposited in Lake Bonneville and include shoreline deposits of sand, silt and gravel and offshore deposits of massive to thinly bedded sand, silty clay, and clayey silt. Alluvium includes stream-terrace, flood-plain, and alluvial-fan deposits. The alluvium ranges in size from boulders to clay with the large material closer to the mountains. Presently, active depositional areas include the flood plain of Red Butte Creek and alluvial fans at the mouths of Georges and Soldiers Hollows. These fans may be subject to flooding during high-intensity, localized rainstorms. Several faults showing evidence of Quaternary movement are located in the vicinity of Research Park.

Geologic hazards that may affect development of the park include flooding, slope failure, adverse foundation conditions, and seismicity. The short, steep canyons that drain the west-facing slope of the Wasatch Range are especially vulnerable to cloudburst floods. Research Park includes the lower reaches of three such canyons. Natural slopes underlying bedrock and unconsolidated deposits show no evidence of instability. However, cuts in rock and unconsolidated materials made at steep angles may be unstable. Conditions that may adversely affect foundations include expansive soils, collapsible soils, shallow ground water, excavation difficulty, and localized areas of unengineered fill. Earthquake hazard is high due to Research Park's location near the active Wasatch fault zone.

Plans for development in areas subject to geologic hazards identified in this report should be based on detailed siting studies that address the hazard and recommend mitigation measures.

INTRODUCTION

Background and Purpose

Research Park, owned and administered by the University of Utah, was founded in 1968 to promote the social welfare of the State of Utah through the advancement of education, science, research, economic development, and related purposes. The park is located adjacent to the University of Utah on the east side of Salt Lake City at the base of the Wasatch Range (figure 1). The master plan for Research Park calls for the eventual development of most of the park. Damaging floods and debris floods/flows along the Wasatch Front in 1983 and 1984 made apparent the need to consider geologic hazards when planning new developments. Charles A. Evans, Assistant Director of Research Park, requested the Utah Geological and Mineral Survey (UGMS) to evaluate geologic hazards for the park.

The purpose of this report is to provide geologic, hydrologic, and soils information in a format useful to planners and others responsible for development in the park. Hazards considered include flooding and associated debris floods and debris flows, slope instability, seismicity, and adverse foundation conditions. This report and accompanying maps identify areas that may be affected by geologic hazards. However, the report is for general planning purposes only and does not preclude the need for site-specific investigations.

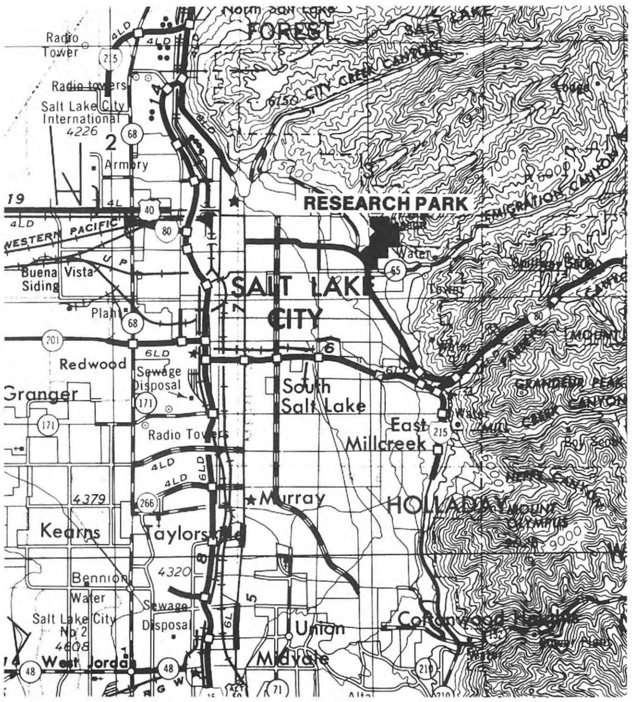


Figure 1. Location map of Research Park, Salt Lake City, Utah.

Scope of Work

The scope of work for this investigation included:

1. Review of published and available unpublished literature and other information including reports, maps and well logs pertinent to the geology, hydrology, and soils of Research Park.

2. Examination of aerial photography for the years, 1937, 1946, 1953, 1980, and 1981.

3. Field work (approximately 5 days in the summer of 1984) to verify existing data and to obtain additional field information.

4. Report writing and the preparation of geologic, soils, and hazard maps.

The scope of work did not include test borings, installation of ground-water monitoring wells, trenching faults, or laboratory testing.

SETTING

Research Park is on the east side of Salt Lake City on the border between the Wasatch Range to the east and the Salt Lake Valley to the west. Elevations in the park range from 4700 feet in the valley to 5773 feet in the mountains. Red Butte Creek drains Red Butte Canyon and flows southwest through the park in an incised channel that, in places, is more than 40 feet deep. Annual precipitation for the park ranges from 20 to 30 inches. The University of Utah and Fort Douglas are immediately north of the park and Pioneer State Park and the U. S. Bureau of Mines Research Center are to the south. A number of research, development, and consulting firms as well as the UGMS are located in the park at this time.

GEOLOGY

Research Park is located in both the Basin and Range and Middle Rocky Mountain physiographic provinces (Stokes, 1977). Geologic units exposed in the park include bedrock and unconsolidated deposits. With the exception of one small outcrop, bedrock is found only in that part of the park located in the Wasatch Range. Bedrock includes the Triassic Ankareh Formation, the Nugget Sandstone of Upper Triassic and Lower Jurassic age, and the Jurassic Twin Creek Limestone (plate 1 and appendix). The Ankareh Formation consists of the Mahogany, Gartra Grit, and Upper Members. The Mahogany and Upper Members are mudstone, shale, and sandstone, whereas the Gartra Grit Member is quartzite. The Nugget Sandstone is composed of crossbedded sandstone, and the Twin Creek Limestone is primarily limestone and limy shale (Van Horn, 1969). All bedrock units dip steeply to the southeast.

The valley portion of Research Park is covered by late Pleistocene and Recent unconsolidated deposits of lacustrine or alluvial origin (plate 1). The lacustrine sediments were deposited in ancient Lake Bonneville which occupied part of the Basin and Range physiograpic province during late Pleistocene time (Scott and others, 1983). Previous investigators (Van Horn, 1969; Miller, 1980; and Davis, 1983) show deposits from two lake cycles (Bonneville and Alpine) in Research Park. Scott and others (1983), however, have reinterpreted Lake Bonneville stratigraphy and conclude that lacustrine deposits formerly considered Alpine, a penultimate lake cycle, are part of a single lake cycle (Bonneville) and are less than 20,000 years old.

The oldest Quaternary deposits exposed in Research Park are between elevations 4786 and 5203 feet (Currey, 1982). These materials were deposited from 20,000 to 14,000 years ago as Lake Bonneville transgressed and stabilized for approximately 1,000 years at its highest stand, termed the Bonneville level (5203 feet; Scott and others, 1983). Shoreline deposits consist of medium to fine sand with silt and local accumulations of coarse sand and gravel. Offshore deposits are massive to thinly bedded, sandy, clayey silt and sandy and silty clay. Scott and others (1983) determined that approximately 15,000 years ago the lake rapidly dropped (possibly in one year's time) to the Provo level (4786 feet) as its outlet to the north was eroded. Sediment deposited at the Provo level includes sand and gravel. The lake dropped below the Provo level by 13,000 B.P. All of Research Park is located at or above the Provo level.

Alluvium in Research Park includes terrace, flood-plain, and alluvial-fan deposits. A terrace formed on the south side of Red Butte Creek after Lake Bonneville receded to the Provo level. The terrace grades to the Provo shoreline and consists of cobbly sand and gravel with some boulders near the mountains. The recession of Lake Bonneville below the Provo shoreline lowered the base level of Red Butte Creek allowing it to incise its channel through the lacustrine deposits. Flood-plain alluvium is presently being deposited in this channel and consists of cobbley, silty, sand and gravel with boulders near the mouth of the canyon. Alluvial fans at the mouths of Georges Hollow and Soldiers Hollow also formed after the lake receded. These fans consist of bouldery to silty gravel and sand at their apexes with grain size decreasing downslope. Fan deposition may be continuing today, but only in response to infrequent, high intensity, localized rain storms.

During this investigation it was determined that alluvial-fan deposits cover areas between the Provo and Bonneville shorelines within Research Park previously mapped as Lake Bonneville lacustrine deposits (figure 2). The extent of these deposits can only be determined by an extensive program of test borings and test pits that is beyond the scope of this study. Therefore, a map unit combining undifferentiated alluvial-fan and lacustrine deposits is shown on plate 1.

Several Quaternary faults less than 20,000 years old have been mapped in the vicinity of Research Park. The main trace of the East Bench fault, a segment of the Wasatch fault, is one mile northwest of the park (figure 3). This fault has a pronounced scarp that is 164 feet high at some locations (Scott and Shroba, 1985). How much of the scarp is due to late-Quaternary faulting (post-Lake Bonneville) and

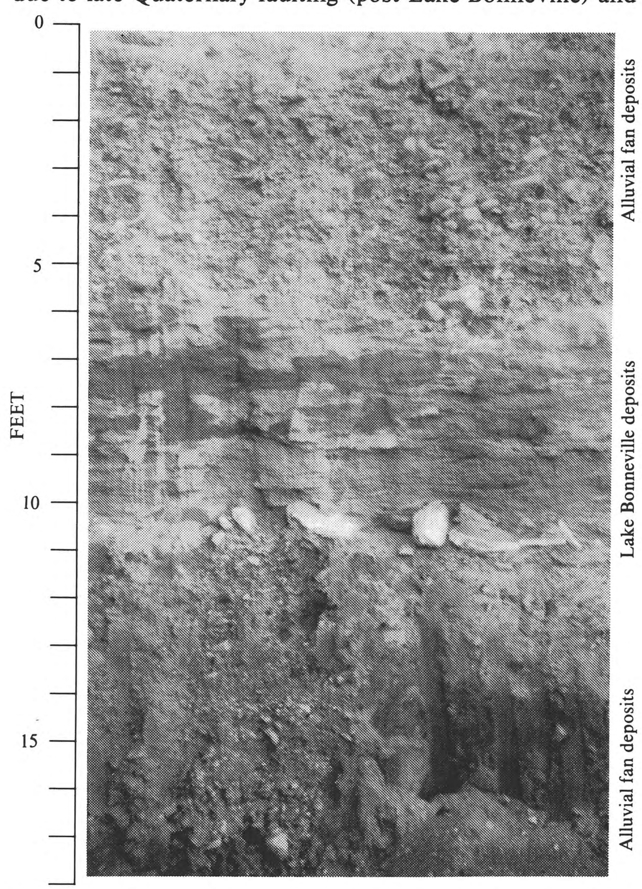
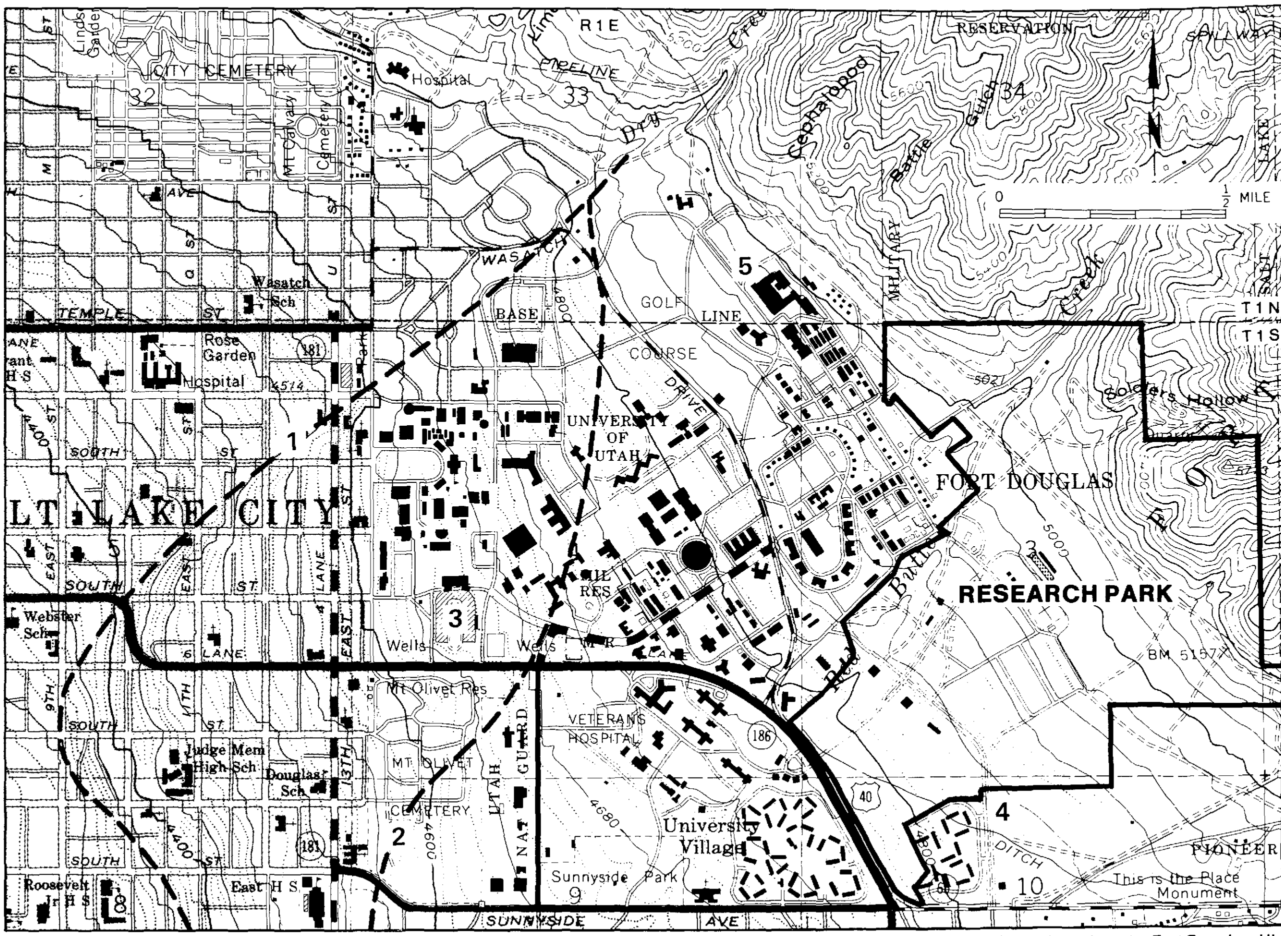


Figure 2. Photograph showing alluvial-fan deposits overlying lacustrine sediments in an area previously mapped as Lake Bonneville deposits.

how much represents older faulting is not known (Scott and Shroba, 1985). The age and recurrence intervals of the seismic events that created the East Bench fault are also unknown. Swan and others (1981) have investigated the Wasatch fault near the mouth of Little Cottonwood Canyon, approximately 12.5 miles south of Research Park, and report that the graben at that site was produced by a minimum of two or three surface rupture events with an average vertical tectonic displacement of between 1.3 and 9.8 feet per event. Their preferred average value is 6.6 feet. The recurrence interval for each event was estimated to be from 450 to 3300 years with a preferred interval of approximately 2200 years. Schwartz and Coppersmith (1984) have reinterpreted this recurrence interval to be between 2400 and 3000 years with a similar displacement per event. Van Horn (1969 and 1972) estimates movement on the East Bench fault has occurred within the past 5000 years. Van Horn (1969 and 1972) also mapped a second fault branching from the East Bench fault and trending in a northwesterly direction through the University of Utah campus within 0.75 miles of Research Park (figure 3). Christenson and Gill (1982) located faults in an excavation for Robert L. Rice stadium, also on campus, that may be associated with this fault. Everitt (1980) noted deformed sediments in an excavation on U.S. Bureau of Mines property immediately south of Research Park (figure 3). He was unable to determine how the deformation was induced but did identify the deposits as Lake Bonneville in origin, indicating the deformation is less than 20,000 years old. Everitt (1980) identified faults displacing pre-Lake Bonneville alluvial-fan deposits in an excavation for an addition to the University of Utah Medical Center, located less than 0.4 miles north of Research Park (figure 3).

A fault has also been mapped in Research Park by Van Horn (1969) (plate 1). This fault trends to the north-northwest with the downdropped block to the southwest and appears to displace Lake Bonneville sediments. A series of ground-water seeps occur along this fault. The scarp is largely obscured by erosion and vegetation and appears to be buried to the north and south by alluvial fans at the mouths of Soldiers and Georges Hollows, respectively. This indicates the fault has not displaced post-Lake Bonneville alluvial deposits, thus dating the faulting event between 14,000 and 10,000 years ago. Van Horn (1969) shows the fault joining with a bedrock fault on the north side of Red Butte Canyon. No evidence of the bedrock fault (breccia, slickensides, offset beds) was observed in the field during this study. Furthermore, the left-lateral fault displacement indicated by Van Horn (1969) between the Thaynes and Ankareh Formations is inconsistent with normal faulting characteristic of the Wasatch fault. If the bedrock fault does exist, it is not a continuation of the Quaternary fault in Research Park. Scott and Shroba (1985) do not show this Quaternary fault on their map. Scott (personal commun., 1985) indicated this scarp may not have resulted from post-Lake Bonneville faulting but may be some pre-lake feature overlain by lacustrine (Lake Bonneville) sediments.



Base from USGS 7.5′ quadrangle; Fort Douglas, Utah

Explanation

1 East Bench Fault
2 Fault mapped by Van Horn (1969 and 1972)
3 Robert L. Rice Stadium site (Christiansen and Gill, 1982)
4 Deformed bedding at U.S. Bureau of Mines site (Everitt, 1980)
5 University of Utah hospital site (Everitt, 1980)

Figure 3. Faults and areas of deformed sediments in the vicinity of Research Park, Salt Lake City, Utah.

SOILS

Soils in Research Park are residual and transported. Residual soils result from *in situ* weathering of bedrock and are found primarily on mountain slopes. Transported soils are colluvial, alluvial, and lacustrine and occur in other areas of the park.

Plate 2 shows the distribution of soil types in Research Park as modified from the U.S. Soil Conservation Service (SCS) soil survey of the Salt Lake City area (Woodward and others, 1974). The nine pedological soil units mapped by the SCS have been combined to form the five engineering geologic soil units shown on plate 2 (Unified Soil Classification System, appendix). The modification was based on geologic mapping, excavation inspections, soil borings, air photo interpretation, and the need to present soil information in a format useful to those concerned with development in Research Park. Contacts between soil units are irregular and gradational, and represent zones of transition. Soil descriptions in the map explanation are modified from Woodward and others (1974).

Residual soils are thin, unevenly distributed, and not differentiated from bedrock in this report. The composition of residual soils formed on bedrock is clay, silt, and sand. Their character depends on the nature of the parent rock; quartzites and sandstones yield sandy soils whereas shales, mudstones, and siltstones produce silty and clayey soils. Transported soils range from coarse- to fine-grained.

Coarse-grained soils consist of gravel with sand, sand with gravel (GP, SP), and clayey or silty sand with gravel or gravel with sand (SC, SM, GC, GM). Fine-grained soils are made up of sandy lean clay, lean clay, silt, and sandy silt (CL, ML).

GROUND WATER

Research Park is underlain by a deep, unconfined aquifer that grades laterally into and provides recharge for the deep, confined aquifer beneath the central part of the Salt Lake Valley (Hely and others, 1971; figure 4). Depth to the unconfined aquifer is not known, but based on a water well approximately 1500 feet south of Research Park it is estimated to be about 150 feet below the ground surface at the Provo shoreline (elevation 4,786 feet). No water wells have been drilled in Research Park.

Although perched water has not been reported in the literature for this part of the Salt Lake Valley, a spring is present near the mouth of Georges Hollow and seeps emanate along the scarp mapped by Van Horn (1969) (plate 3). The spring discharges from a circular depression in the alluvial fan at the mouth of the hollow. The spring is perennial, and is recharged from either the Twin Creek Limestone or Nugget Sandstone which crop out 250 feet and 650 feet to the east and northeast, respectively (plates 1 and 3). Flow rates are unknown but discharge is significant and saturates an extensive area downslope. A temperature of 57° F was measured for this spring and is similar to temperatures measured for three water wells completed in the unconfined aquifer in the vicinity of Research Park (Klauk, 1984). This indicates the spring has not been thermally influenced. Seeps saturate an area immediately downslope and extending 100 to 150 feet from the scarp. The seep area is recharged from the east and may result from ground water emanating from the fault zone or bedrock near to the surface. The extent of shallow ground water in these two areas is not known but is believed to be limited.

GEOLOGIC HAZARDS

Geologic hazards that may affect development in Research Park include flooding and associated debris floods and debris flows, slope instability, seismicity, and adverse foundation conditions. These hazards can adversely affect a structure during its design life and must be taken into account when planning for individual developments.

Flooding

Floods occur in response to spring and summer cloudburst storms or rapid spring snowmelt. The short, steep canyons and larger ravines and hollows that drain the west-facing slopes of the Wasatch Range are especially vulnerable to cloudburst floods (Marsell, 1971). A cloudburst that occurred in the vicinity of Salt Lake City on August 19, 1945 produced 0.54 inches of rain in 15 minutes and caused a major debris flow that devastated a cemetery and homes in the Perrys Hollow area approximately 2 miles northwest of Research Park (Butler and Marsell, 1972). Perrys Hollow and two adjoining unnamed tributaries drain about one square mile of grass and brush covered foot-hills. Georges Hollow is of similar size and vegetative cover. Scott and Shroba (1985) indicate the alluvial fan at the mouth of this hollow has not been active since early Holocene time. However, the drainage incised within this fan is evidence for active downcutting due to flow since that time. A road crossing the mouth of Georges Hollow blocks this drainage and will disperse flood water over a wider area at the fan apex in the event of a large cloudburst storm. The total area that could be inundated by a cloudburst flood is unknown;

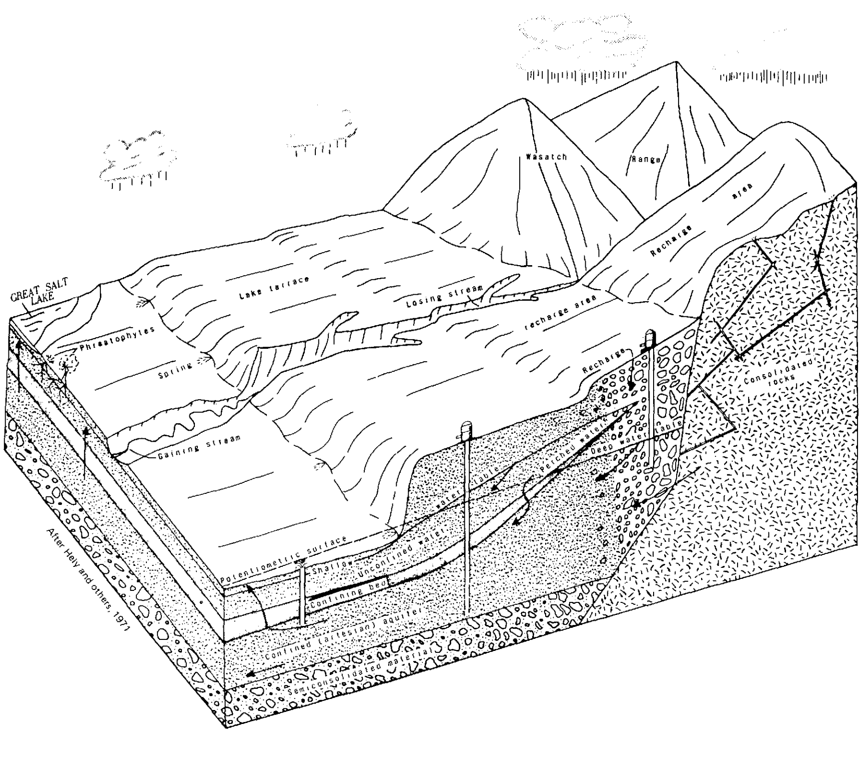


Figure 4. Ground water under unconfined, artesian, and perched conditions in Salt Lake County, Utah.

the minimum area considered to be affected is delineated on plate 3. Flooding could also occur from Soldiers Hollow, but its smaller drainage area significantly reduces the magnitude of this hazard. Plate 3 identifies areas that could be flooded from cloudburst storms. The path flood waters take and the distance they travel depend on the volume of runoff and cannot be accurately mapped. The areas identified in plate 3, however, are considered reasonable for most storms. Red Butte Creek does not present a cloudburst flood hazard. Although the drainage area is large (7.25 square miles), the incised channel of Red Butte Creek is sufficient to accommodate flooding.

A second type of flooding that commonly occurs along the Wasatch Front results from rapid snowmelt. Conditions that may contribute to this type of event are: (1) a heavy winter snowpack, (2) saturated soil conditions prior to winter due to heavy, late-autumn rains, (3) abnormally low temperatures during late winter and early spring, which retain a deep snow cover at lower elevations, (4) sustained high temperatures once melting commences, and (5) additional precipitation during melting (Marsell, 1971). In 1983, these conditions occurred and resulted in significant flooding along the Wasatch Front. However, there was no flooding in Research Park even though Red Butte Creek flowed at 105 ft^3/sec. which is greater than the maximum calculated 100 year recurrence interval flow (Lindskov, 1984). Flood waters were contained within the creek channel in the park. No flooding was reported from either Georges or Soldiers Hollows. A repeat of these conditions in 1984 also resulted in no flooding in Research Park.

Other hazards related to cloudburst storms and rapid snowmelt are debris flows and debris floods that result when saturated soil conditions produce failures on steep hillslopes high in mountain drainages. The landslides then move rapidly into canyon bottoms, where they combine with snow melt to create viscous debris flows or less viscous debris floods. In late May and June of 1983, rapid snowmelt in the Wasatch Range induced numerous debris floods and debris flows between Salt Lake City and Willard, Utah. Similar conditions in 1984 produced additional flows and floods. A reconnaissance of Red Butte Canyon, Soldiers Hollow, and Georges Hollow was conducted as part of this study to identify flows or floods that occurred in these drainages and to identify any partly detached landslides with the potential to create similar events in the future. In Red Butte Canyon a debris flow was located in an unnamed tributary of Knowltons Fork approximately 4.75 miles above the canyon mouth. The flow did not reach the channel of Red Butte Creek and no other significant flows or detached slides were observed in the canyon. No evidence of debris floods, debris flows, or detached landslides occurring since 1982 were found in either Georges or Soldiers Hollows. This was probably due to the type of bedrock, lack of soil cover, and less steep slopes in these drainages.

Case (1984) prepared a dam failure-inundation map for Salt Lake County. He concluded that failure of the Red Butte reservoir dam would not result in flooding in Research Park.

Slope Instability

Slopes in Research Park can be grouped into those underlain by bedrock and those underlain by unconsolidated deposits. Natural bedrock slopes are steep (greater than 30 percent) but show no evidence of instability. However, potential for failures in rock cuts for construction excavations does exist. The steeply dipping Mahogany and Upper Members of the Ankareh Formation contain relatively soft (less resistant) shale and mudstone interbedded with more resistant sandstone. The shale and mudstone beds have low shear strength and could allow planes of weakness to develop. Undercutting, loading (either dynamic seismic shaking or static placement of fill or structures) and/or wetting could induce failure.

Slopes in unconsolidated deposits in Research Park are generally less than 10 percent and stable. No existing slope failures were identified on natural slopes, but unconsolidated materials at steep angles in excavations may be unstable. Van Horn (1969) reported failures in cut slopes in Research Park in different soil types.

Adverse Foundation Conditions

Conditions which may adversely affect foundations in Research Park include: (1) expansive soils, (2) collapsible soils, (3) shallow ground water, (4) excavation difficulty, and (5) disturbed soils. The Mahogany and Upper Members of the Ankareh Formation contain shale and mudstone interbedded with more resistant sandstone. These shale and mudstone beds and residual soils derived from them are potentially moisture sensitive and may swell upon wetting to produce fractures in foundations.

Collapsible soils are sometimes associated with alluvial fans in the desert regions of Utah. Collapsible soils are hard and dry with a low density that allows them to compact when wetted. Curtin (1973) reports collapsible soils range from silty sand to clay, but generally are poorly graded and fine grained with more than 50 percent silt and clay. A fine sandy silt with a trace of clay (ML) sample taken from a depth of 24.5 feet in a foundation test boring in Research Park showed 3 percent collapse after wetting during a laboratory consolidation test (Gordon, 1978). This is the only known occurrence of a collapsible soil in Research Park.

Shallow ground water in Research Park appears to be localized to the spring and seep areas. The extent of shallow ground water in these two areas is not known but is believed to be limited. It is important that development in the vicinity of the springs and seeps consider high ground water because, in addition to flooding below-ground structures, saturated fine sand deposits subjected to earthquake shaking can liquefy (Anderson and others, 1982). Anderson and others (1982) report that three types of failure are commonly associated with liquefaction. These are: (1) flow landslides, (2) lateral spread landslides, and (3) bearing capacity failures. Conditions in Research Park are such that lateral spread landslides and bearing capacity failures could occur in soils subjected to seismic ground shaking.

Bedrock either crops out or is near the surface above an elevation of 5000 feet in Research Park. The primary foundation problem associated with bedrock aside from slope instability is difficulty of excavation. Even the Mahogany Member of the Ankareh Formation which was classified as soft by Gordon and Beck (1985) is equivalent to a very strong incompressible soil. Much of the coarse-grained unconsolidated material in Research Park, especially near the apexes of the alluvial fans, contains large boulders which may cause problems for smaller excavation equipment.

Research Park was formerly part of Fort Douglas and the U.S. Army used the area for a variety of purposes (rifle range, artillery range, tank exercises). At various times, military-related construction resulted in disturbed soils in portions of the park. The artillery impact area noted on plate 3 is one such area. Identification of all disturbed soil areas was beyond the scope of this investigation.

Seismicity

Research Park is located in the Intermountain Seismic Belt, a zone of high seismic activity extending from northern Arizona to northwestern Montana (Smith and Sbar, 1974). A plot of Richter magnitude 2.0 or greater earthquakes in the Salt Lake City area from 1850 to 1984 is presented in figure 5. Data for this map are from the University of Utah Seismograph Station catalog of earthquakes in Utah. Although no ground ruptures have been reported in the Salt Lake City area during this period, four earthquakes of Richter magnitude 5.0 or greater and Mercalli intensities VI to VIII (table 1; figure 5; and appendix) have produced damage in the form of cracked walls, fallen plaster, toppled chimneys, and broken windows (Rogers and others, 1976). Based on the short historical record, the Salt Lake City area has experienced a magnitude 5.0 or larger earthquake with an intensity VI or greater on the average of once every 34 years. The University of Utah seismograph station recorded a magnitude 1.8 earthquake with the epicenter located approximately 1 mile west of Research Park on April 25, 1985. Although no damage occurred, the event was felt in the UGMS building located in the park (Genevieve Atwood, oral commun., 1985).

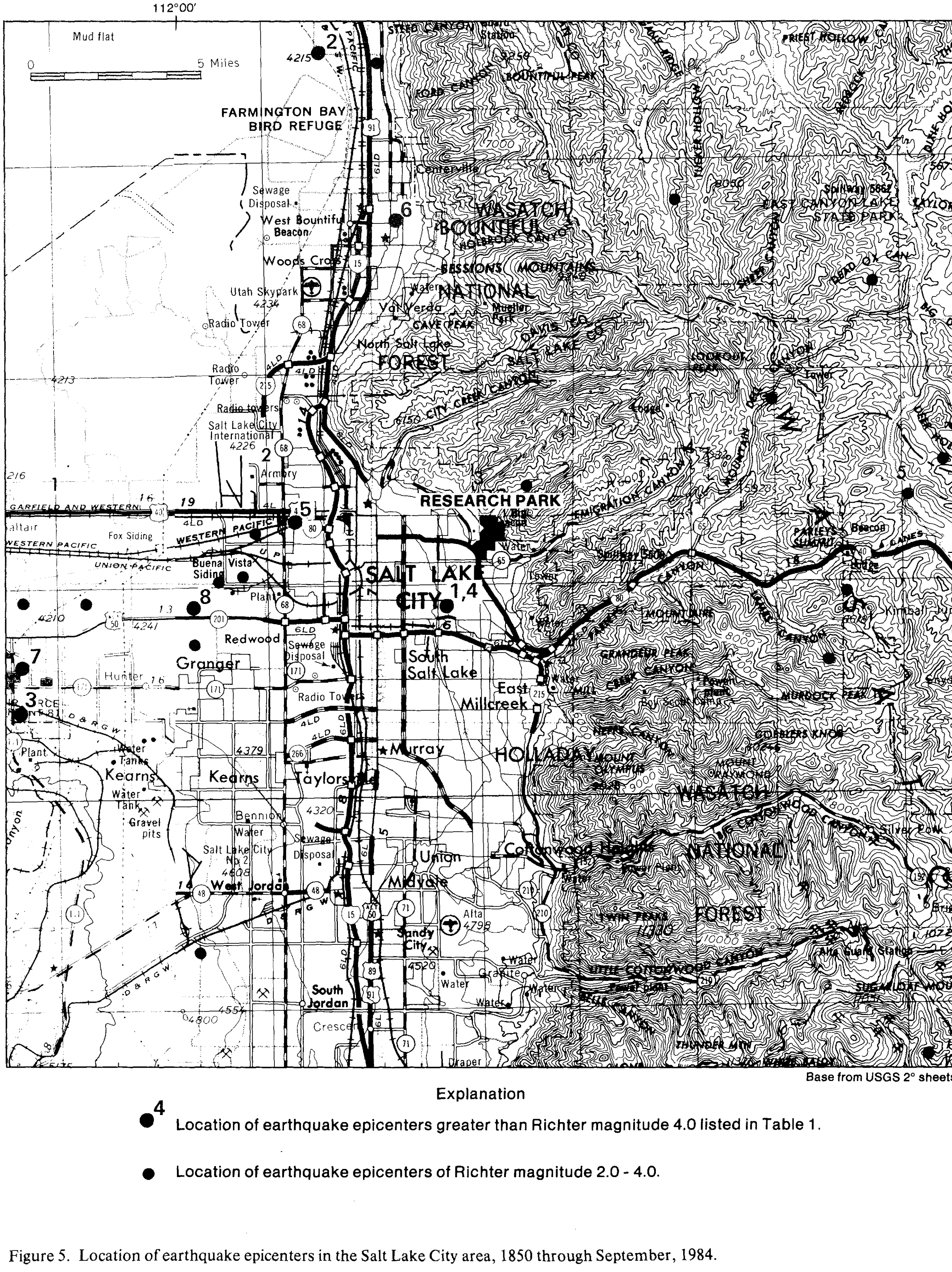
Few epicenters are located along mapped traces of the Wasatch fault. The fault is believed to dip to the west, however, and the epicenters associated with movement of the fault would be several miles west of the surface trace. Geologic evidence indicates this fault is capable of earthquakes much larger than those occurring in historic time. A shock of Richter magnitude 7.1 or greater would be required to produce the fault scarps present at the mouth of Little Cottonwood Canyon (Gordon, 1978). Ground rupture may have occurred in Research Park prior to deposition of the alluvial fan at the mouth of Georges Hollow which began forming immediately after the recession of Lake Bonneville from the Bonneville level 14,000 to 15,000 years ago. Ground rupture occurred at the University Hospital site prior to 18,000 years ago (Scott and Shroba, 1985). Schwartz and Coppersmith (1984) have estimated a return interval for surface faulting at the Little Cottonwood site of between 2400 and 3000 years. This suggests the recurrence interval for surface faulting in Research Park is much greater than for the main segments of the Wasatch fault. Further study is needed to verify that the scarp mapped by Van Horn (1969) is related to Quaternary faulting. Trencnmg the scarp could possibly accomplish this, as well as identify the width of the zone of deformation, provide data to help date the last event, and determine recurrence intervals. Although the return interval of surface rupture in Research Park may be great, considerable damage in the form of partial collapse of ordinary substantial buildings could result from severe ground shaking associated with earthquakes

Table 1. Earthquakes greater than Richter magnitude 4.0 within 15 miles of Research Park, Salt Lake City, Utah, 1850 to September 1984.

Index to Numbers in Figure 5	Date	Magnitude	Maximum Intensity	Epicenter Location Latitude(N)	Epicenter Location Longitude(W)
1	1910	5.7	VII	40° 44.94′	111° 50.95′
2	1914	4.3	V	40° 59.00′	111° 55.00′
3	1943	5.0	VI	40° 42.00′	112° 04.80′
4	1949	5.0	VI	40° 44.94′	111° 50.95′
5	1955	4.3	V	40° 47.00′	111° 56.00′
6	1955	4.3	V	40° 54.82′	111° 52.64′
7	1962	5.2	VI	44° 42.92′	112° 5.33′
8	1983	4.3	V	40° 44.88′	111° 59.56′

Source: University of Utah Seismograph Station (1984).

Note: Pre-1950 earthquake catalogue relies heavily on non-instrumental intensity data. From 1950 through June 30, 1962, numerous instrumental locations were determined by the U.S. Coast and Geodetic Survey. From July 1, 1962 through September 30, 1974, locations were determined by a skeletal state network and regional stations operated by other agencies. Locations from October 1, 1974 to present were determined from a dense high-gain network of telemetered stations.



Base from USGS 2° sheets

Explanation

● 4 Location of earthquake epicenters greater than Richter magnitude 4.0 listed in Table 1.

● Location of earthquake epicenters of Richter magnitude 2.0 - 4.0.

Figure 5. Location of earthquake epicenters in the Salt Lake City area, 1850 through September, 1984.

on the main trace of the Wasatch fault. Adherence to the Utah Seismic Safety Advisory Council guidelines outlined in appendix would help reduce this damage.

CONCLUSIONS AND RECOMMENDATIONS

The following hazard conditions have been identified in Research Park and should be addressed during planning for future development.

1. Flooding within the incised drainage of Red Butte Creek.
2. Flooding with possible associated debris floods and debris flows from Georges and Soldiers Hollows from high intensity rainstorms.
3. Slope instability in rock excavations in the Ankareh Formation and in excavations in unconsolidated material.
4. Springs, seeps and associated high ground water.
5. Seismic ground shaking and possible surface fault rupture.
6. Adverse soil conditions.

Based on these hazards, the following recommendations for general planning in Research Park are made:

1. Plans for development in areas subject to geologic hazards shown on plate 3 should include detailed studies which address the particular hazard(s) at the site and, where necessary, list mitigation measures. These studies should be conducted and reviewed by experienced professional geologists and engineers.
2. All future construction should conform to Unified Building Code standards for seismic zone 3 with monitoring by regulatory agencies as recommended by the Utah Seismic Safety Advisory Council (1979) for seismic zone U-4 (appendix).
3. Soil/foundation investigations should be performed for all proposed buildings, even if located outside the hazard zones shown on plate 3. The investigations should include depth to shallow ground water and consideration of liquefaction potential.

REFERENCES

Anderson, L. R., and others, 1982, Liquefaction potential map for Davis County, Utah: Utah State University, Logan Utah and Dames and Moore Consulting Engineers, Salt Lake City, 49 p.

Butler, Elmer, and Marsell, R.E., 1972, Developing a state water plan cloudburst floods in Utah, 1939-69: Utah Department of Natural Resources Cooperative-Investigations Report No. 11, 103 p.

Case, W.F., 1984, Dam failures in Salt Lake County due to a local earthquake—a worst-case scenario: Utah Geological and Mineral Survey unpublished map, scale 1:62,500.

Christenson, G.E., and Gill, H.E., 1982, Excavation at Rice Stadium, University of Utah: unpublished Utah Geolo. and Mineral Survey memorandum and log, 2 p.

Currey, D.R., 1982, Lake Bonneville-selected features of relevance to neotectonic analysis: U.S. Geological Survey Open-File Report 82-1070, 30 p.

Curtin, George, 1973, Collapsing soil and subsidence, *in* Moran, D.E., and others, eds., Geology, seismicity and environmental impact: Association of Engineering Geologists Special Publication, October 1973, p. 89-100.

Davis, F.D., compiler, 1983, Geologic map of the central Wasatch Front, Utah: Utah Geological and Mineral Survey Map 54-A, scale 1:100,000.

Everitt, B.L., 1980, Geology of some foundation excavations in northeastern Salt Lake City: Utah Geolog. and Mineral Survey Report of Investigation No. 149, 24 p.

Gordon, W.J., 1978, Soils and foundation investigation proposed office building and associated parking structure complex south of Red Butte Creek within the northern portion of the University of Utah Research Park Salt Lake City, Utah for Northwest Pipeline Corporation: Dames and Moore, Salt Lake City, Utah, 23 p.

Gordon, W.J., and Beck, D.G., 1985, Engineering and geology geotechnical investigation proposed 1.5 million gallon water tank located on the south facing slope near the mouth of Red Butte Canyon Salt Lake City, Utah: Dames and Moore, Salt Lake City, Utah, 23 p.

Hely, A.G., Mower, R.W., and Harr, C.A., 1971, Water resources of Salt Lake County, Utah: Utah Department of Natural Resources Tech. Publication No. 31, 244 p.

Klauk, R.H., 1984, Low-temperature geothermal assessment of the Jordan Valley Salt Lake County, Utah: Utah Geological and Mineral Survey Report of Investigation No. 185, 160 p.

Lindskov, K.L., 1984, Floods of May to June, 1983 along the northern Wasatch Front, Salt Lake City to North Ogden, Utah: Utah Geological and Mineral Survey Water Resources Bulletin 24, p. 8.

Marsell, R.E., 1971, Cloudburst and snowmelt floods, *in* Environmental studies of the Wasatch Front, 1971: Utah Geological Association Publication 1, p. N1-N18.

Miller, R.D., 1980, compiler, Surficial geologic map along part of the Wasatch Front, Salt Lake Valley, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-1198, scale 1:100,000.

Rogers, A.M., and others, 1976, A study of earthquake losses in the Salt Lake City, Utah area: U.S. Geological Survey Open-File Report 76-89, 357 p.

Schwartz, D.P., and Coppersmith, K.J., 1984, Fault behavior and characteristic earthquakes-examples from the Wasatch and San Andreas fault zones: Journal of Geophysical Research, v. 89, no. B7, p. 5681-5698.

Scott, W.E., and others, 1983, Reinterpretation of the exposed record of the last two lake cycles of Lake Bonneville, western United States: Quaternary Research, v. 20, p. 261-285.

Scott, W. E., and Shroba, R. R., 1985, Surficial geologic map along the Wasatch fault zone in the Salt Lake Valley, Utah: U.S. Geological Survey Open-File Report 85-448, scale 1;24,000, 18 p.

Smith, R.B., and Sbar, M.L., 1974, Contemporary tectonics and seismicity of the western United States with emphasis on the Intermountain Seismic Belt: Geological Society of America Bulletin 85, p. 1205-1218.

Stokes, W.L., 1977, Physiographic subdivisions of Utah: Utah Geological and Mineral Survey Map 43, scale approximately 1:2,500,000.

Swan, F.H., and others, 1981, Study of earthquake recurrence intervals of the Wasatch fault, Utah, Little Cottonwood Canyon site: U.S. Geological Survey Open-File Report 81-450, 30 p.

Utah Seismic Safety Council, 1979, Seismic zones for construction in Utah: Delbert Ward, Exec. Director, 13 p.

Van Horn, Richard, 1969, Preliminary geologic map of the southern half of the Fort Douglas Quadrangle, Salt Lake County, Utah: U.S. Geological Survey Open-File Map 69-308, scale 1:24,000.

———1972, Map showing relative ages of faults in the Sugar House Quadrangle, Salt Lake County, Utah: U.S. Geological Survey Map I-766-B, scale 1:24,000.

Woodward, Lowell, and others, 1974, Soil survey of Salt Lake area, Utah: U.S. Department of Agriculture, Soil Conservation Service, 132 p.

EXPLANATION

UNCONSOLIDATED MATERIAL

Quaternary

- **Qal** — Alluvium: sand with cobbles, gravel, silt, and clay; boulders near mountain front; includes thin covering of slopewash
- **Qat** — Terrace alluvium: gravel and sand; cobbles and boulders near mountain front
- **Qaf** — Alluvial-fan deposits: poorly sorted cobbles, gravel, sand, silt and clay, boulders near the mountain front
- **Qlg_1** — Lacustrine gravel and sand: shore-zone deposits of Lake Bonneville (Provo level)
- **Qlg_2** — Lacustrine gravel and sand; locally cobbly; shore zone deposits of Lake Bonneville (Bonneville level)
- **Qla** — Lacustrine and alluvial-fan deposits: undifferentiated

BEDROCK

Jurassic

- **Jtc** — Twin Creek Limestone: gray silty limestone and shale

Triassic(?) and Jurassic(?)

- **JTRn** — Nugget Sandstone: tan fine- to medium-grained, crossbedded sandstone

Triassic

- **TRau** — Upper member Ankareh Formation. Brown to purple shale, mudstone, and fine-grained sandstone
- **TRag** — Gartra Grit Member Ankareh Formation. Light gray to pale purple massive to crossbedded quartzite
- **TRam** — Mahogany Member Ankareh Formation. Brown to reddish purple shale, mudstone, and fine-grained sandstone

SYMBOLS

Contact, dashed where approximate or gradational

U / D — Fault, dashed where inferred, dotted where concealed. U on upthrown side, D on downthrown side

REFERENCES

Davis, F. D. (Compiler), 1983, Geologic map of the central Wasatch Front, Utah: Utah Geological and Mineral Survey Map 54-A, scale 1:1,000,000.

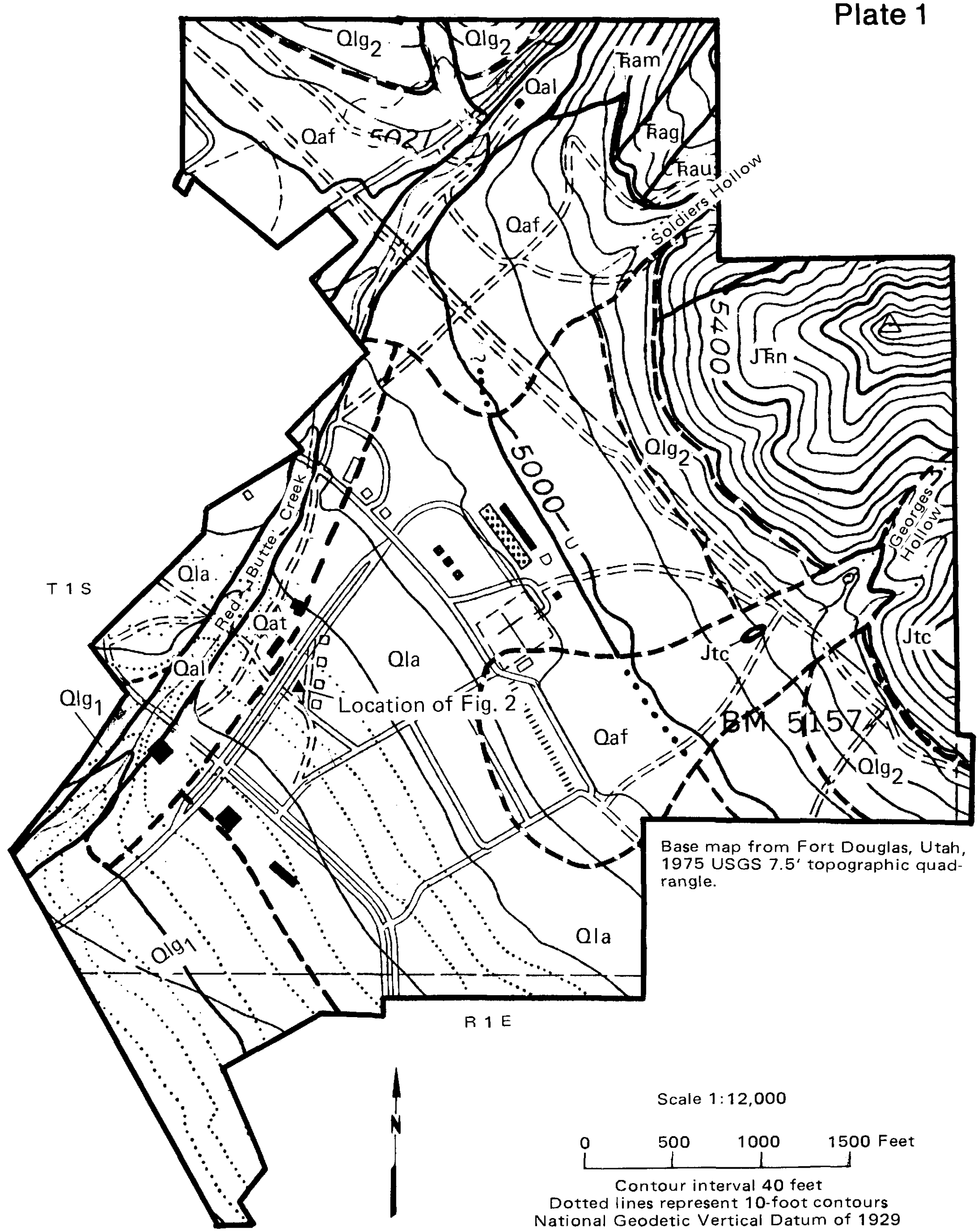
Everitt, B. L., 1980, Geology of some foundation excavations in northeastern Salt Lake City: Utah Geological and Mineral Survey Report of Investigation No. 149, 24 p.

Miller, R. D. (Compiler), 1980, Surficial geologic map along part of the Wasatch Front, Salt Lake Valley, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-1198, scale 1:1,000,000.

Scott, W. E., and Shroba, R. R., 1985, Surficial geologic map along the Wasatch fault zone in Salt Lake City, Utah: U.S. Geological Survey Open-File Report 85-448, 18 p.

Van Horn, Richard, 1969, Preliminary Geologic Map of the southern half of the Fort Douglas quadrangle, Salt Lake County, Utah: U.S. Geological Survey Open-File Map 69-308, scale 1:24,000.

Plate 1



Base map from Fort Douglas, Utah, 1975 USGS 7.5′ topographic quadrangle.

Scale 1:12,000

0 500 1000 1500 Feet

Contour interval 40 feet
Dotted lines represent 10-foot contours
National Geodetic Vertical Datum of 1929

GEOLOGIC MAP OF RESEARCH PARK, SALT LAKE CITY, UTAH

EXPLANATION

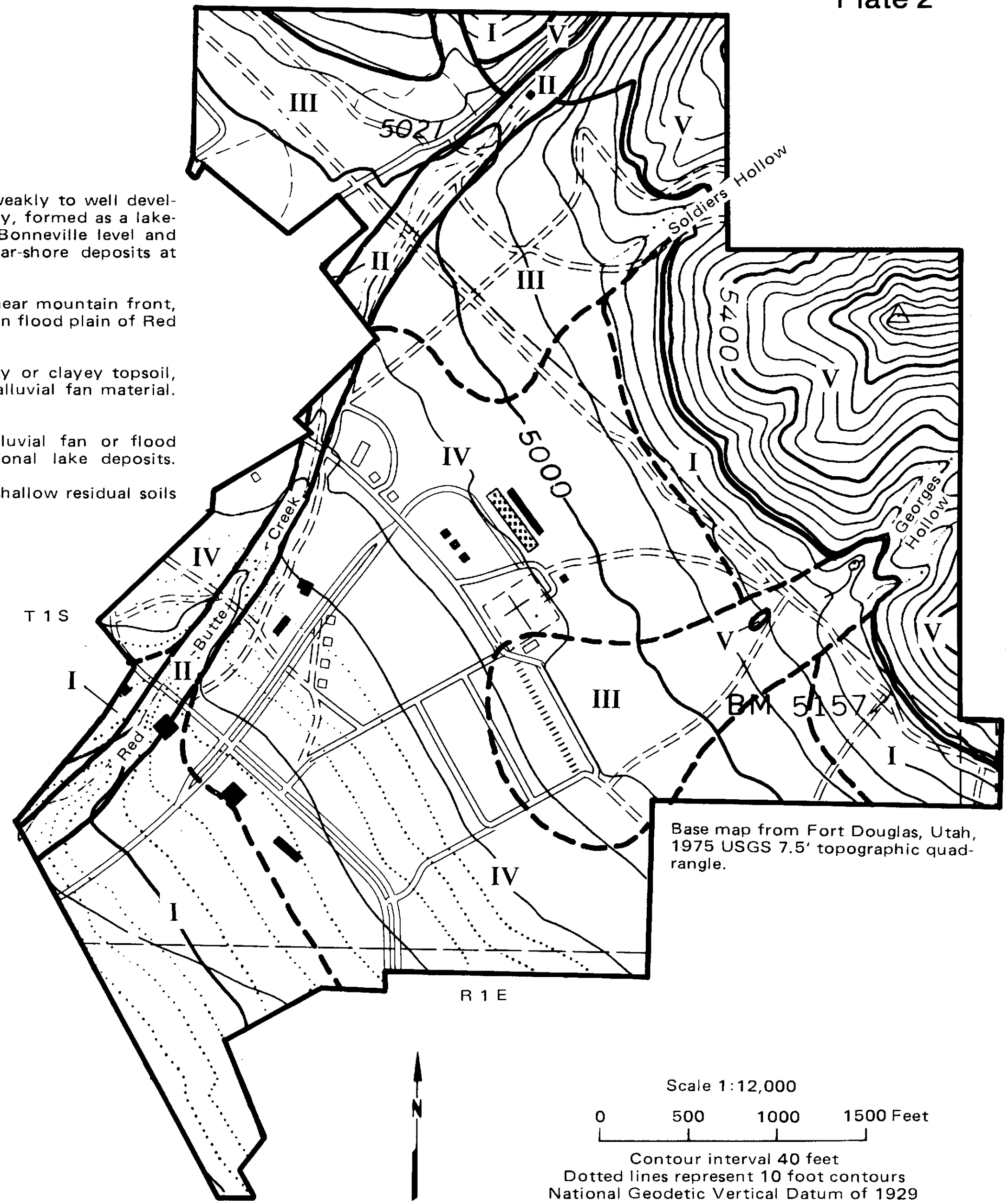
CHARACTERISTICS

Soil unit	Predominant soil type	USCS symbol	Shrink-swell potential	Description
I	Sandy gravel-gravelly sand	GP-SP	low	Locally overlain by a weakly to well developed soil, locally cobbly, formed as a lake-shore embankment at Bonneville level and as deltas and other near-shore deposits at Provo level.
II	Sandy gravel-gravelly sand	GP-GM SP-SM	low	Cobbles and boulders near mountain front, locally silty, deposited in flood plain of Red Butte Creek.
III	Clayey sand and gravel, silty sand and gravel	GC-SC GM-SM	low	Locally overlain by silty or clayey topsoil, cobbles and boulders, alluvial fan material.
IV	Silty clay-clayey silt Sandy silt and clay	CL-ML	low to moderate	Locally overlain by alluvial fan or flood plain deposits, transitional lake deposits.
V	Bedrock	----	----	Exposed bedrock and shallow residual soils and colluvial deposits.

The soils information shown on this map has been adapted from the USDA Soil Conservation Service soil survey of the Salt Lake City area (Woodward and others, 1974). The soil units identified by Woodward and others (1974) have been modified based on geologic mapping, excavation inspections, soil borings, and air photo interpretation. Contacts between soil units are generally irregular and gradational, and represent zones of transition rather than distinct contacts. This map is intended for general planning purposes and does not preclude the need for site-specific investigations.

SYMBOLS

Contact, dashed where approximate or gradational



Base map from Fort Douglas, Utah, 1975 USGS 7.5' topographic quadrangle.

Contour interval 40 feet
Dotted lines represent 10 foot contours
National Geodetic Vertical Datum of 1929

REFERENCES

Bressler, D. E., 1980, Soil and foundation investigation office building Research Park, Salt Lake City, Utah: Chen and Associates, Inc., Salt Lake City, Utah, 7p.

Everitt, B. L., 1980, Geology of some foundation excavations in northeastern Salt Lake City: Utah Geological and Mineral Survey Report of Investigation No. 149, 24 p.

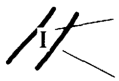
Gill, H. E., 1985, Report of excavation inspection logs for field work conducted in 1981 and 1982: Utah Geological and Mineral Survey unpublished data, 2 p.

Gordon, W. J., 1978, Soils and foundation investigation proposed office building and associated parking structure complex south of Red Butte Creek within the northern portion of the University of Utah Research Park Salt Lake City, Utah for Northwest Pipeline Corporation: Dames and Moore, Salt Lake City, Utah, 23 p.

Woodward, Lowell, and others, 1974, Soil survey of Salt Lake area, Utah: U. S. Department of Agriculture, Soil Conservation Service, 132 p.

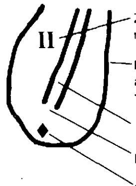
SOIL MAP OF RESEARCH PARK, SALT LAKE CITY, UTAH

EXPLANATION



Generalized zone of flooding along Red Butte Creek with one percent probability of occurrence annually (100 year flood). (Federal Emergency Management Agency, 1983).

Zone that receives bank storage from Red Butte Creek during periods of high runoff that could adversely affect deep excavations.



Zone of debris flow, debris flood, and flash flood hazard from mountain drainages due to high intensity rain storms.

Maximum extent of post-Lake Bonneville alluvial-fan deposits and thus probable maximum extent of modern debris flow activity.

Incised drainages which channelize flood water.

Point at which flood water is no longer channelized.

Point where road blocks the drainage, allowing dispersion of flood water over other parts of the alluvial fan.

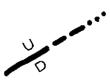
It is recommended that plans for development in these zones include analyses of flood hazard and, if warranted, a listing of mitigating measures to be taken.

IIIa Slopes (generally 30-80%) underlain by bedrock (Twin Creek Limestone, Nugget Sandstone, and Garta Grit Member of the Ankareh Formation), insitu soils, and colluvium. Rockfall hazard is minimal. No evidence of instability under present conditions.

IIIb Slopes (generally 50-80%) underlain by bedrock (Mahogany and Upper Members of the Ankareh Formation), insitu soils, and colluvium. Bedrock is soft and exhibits close fractures (Gordon and Beck, 1985). Undercutting, loading (either dynamic as associated with seismic shaking or static as with placement of fill or structures) and/or wetting of slopes could induce failure.

Slope stability analyses should accompany plans for development in these areas.

IV Zone of springs and spring runoff. Spring flow fluctuates seasonally and annually with precipitation. Saturation can reduce soil bearing strength, particularly during earthquake ground shaking, as well as cause flooding of subsurface facilities. Soil/foundation investigations with assessments of liquefaction potential should accompany plans for development in this zone.



Fault, dashed where inferred, dotted where concealed. U on upthrown side, D on downthrown side. It is recommended that development in the vicinity of this fault include trenching to determine magnitude of event(s), age of most recent event, and width of the zone of deformation.

NOTE: Alluvial-fan zones may have collapsible soils. Gordon (1980) reports a sample collected from a depth of 24.5 feet in an alluvial fan area exhibited 3% collapse. Soil/foundation investigations with an assessment of collapsible soils should accompany plans for development in these zones.

Non-geologic hazard.

V Former artillery impact area for Fort Douglas. Soils are disturbed. Soil/foundation investigations including the depth of the disturbed soils should accompany plans for development in this area.

REFERENCES

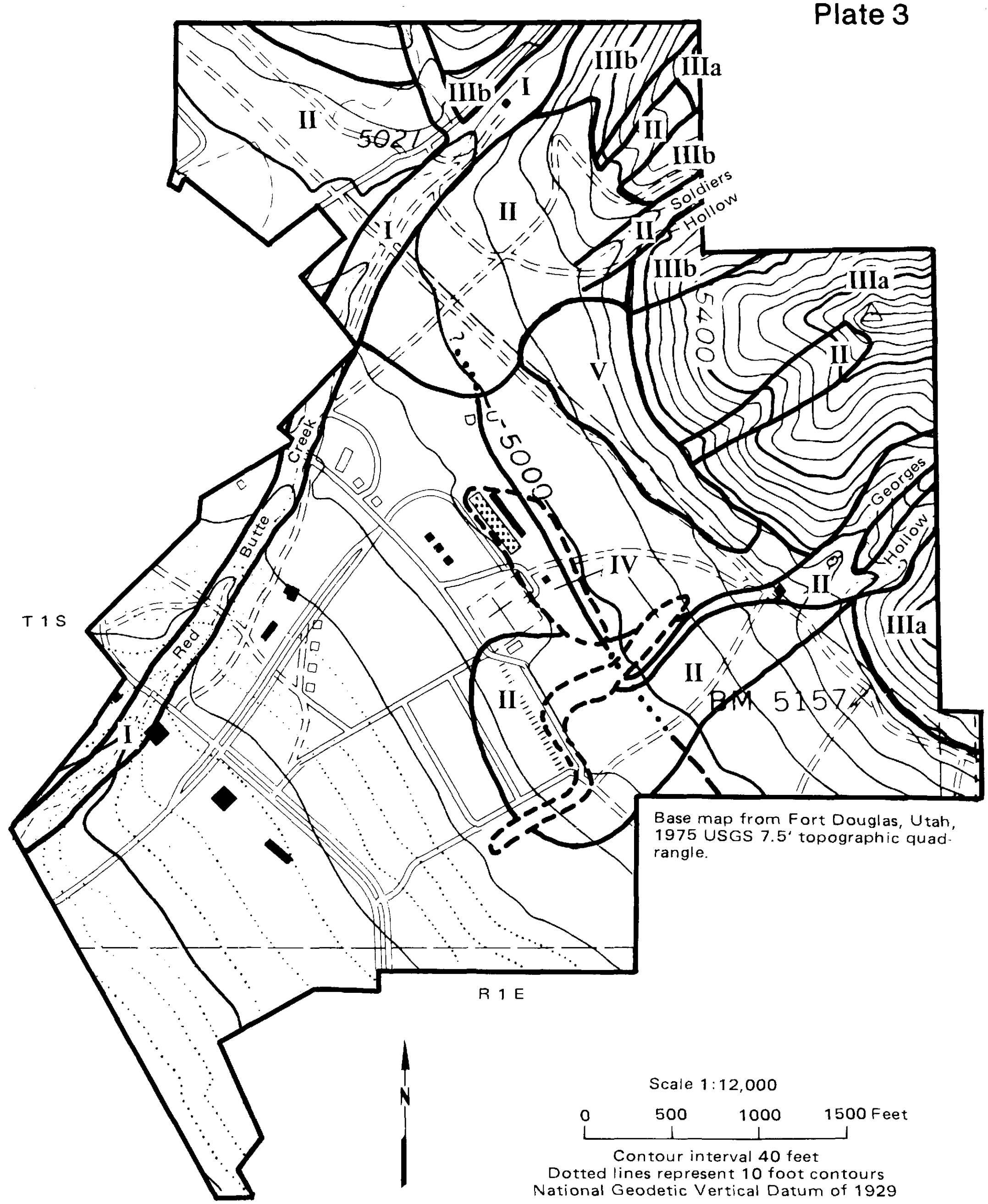
Federal Emergency Management Agency, 1983, Flood insurance rate map, City of Salt Lake City, Utah: National Flood Insurance Program, Community-Panel Number 490105 0032 A, Panel No. 32.

Gordon, W. J., 1978, Soils and foundation investigation proposed office building and associated parking structure complex south of Red Butte Creek within the northern portion of the University of Utah Research Park Salt Lake City, Utah for Northwest Pipeline Corporation: Dames and Moore, Salt Lake City, Utah, 23 p.

Gordon, W. J., and Beck, D. G., 1985, Engineering and geology geotechnical investigation proposed 1.5 million gallon water tank located on the south facing slope near the mouth of Red Butte Canyon Salt Lake City, Utah: Dames and Moore, Salt Lake City, Utah, 23 p.

Utah Seismic Safety Council, 1979, Seismic zones for construction in Utah: Delbert Ward, Executive Director, 13 p.

Plate 3



Base map from Fort Douglas, Utah, 1975 USGS 7.5' topographic quadrangle.

N

Scale 1:12,000

0 500 1000 1500 Feet

Contour interval 40 feet
Dotted lines represent 10 foot contours
National Geodetic Vertical Datum of 1929

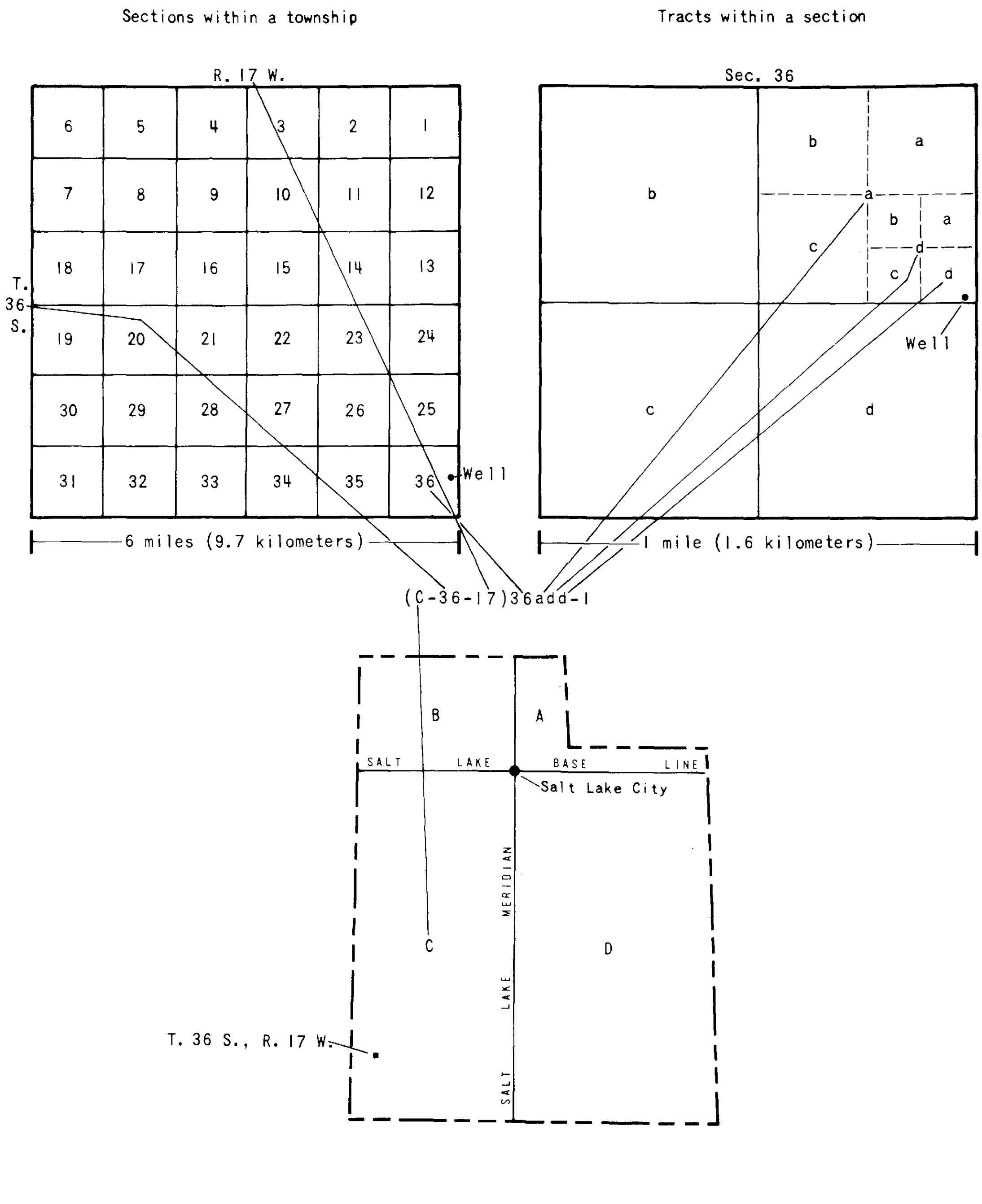
GEOLOGIC HAZARDS MAP OF RESEARCH PARK, SALT LAKE CITY, UTAH

APPENDICES

APPENDIX 1

Well- and Spring-Numbering Systems Used in Utah

The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U.S. Government. The number identifies the well or spring and locates its position to the nearest 10-acre tract in the land net. By this system, the State is divided into four quadrants by the Salt Lake base line and meridian, and these quadrants are designated by the uppercase letters A, B, C, and D, thus: A, for the northeast quadrant; B, for the northwest; C, for the southwest; and D, for the southeast quadrant. Numbers designating the township and range, respectively, follow the quadrant letter, and the three are enclosed in parentheses. The number after the parentheses designates the section, and the letters following the section number give the location within the section. The first letter indicates the quarter section, which is generally a tract of 160 acres; the second letter indicates the 40-acre tract, and the third letter indicates the 10-acre tract. The numbers that follow the letters indicate the serial number of the well or spring within the 10-acre tract.

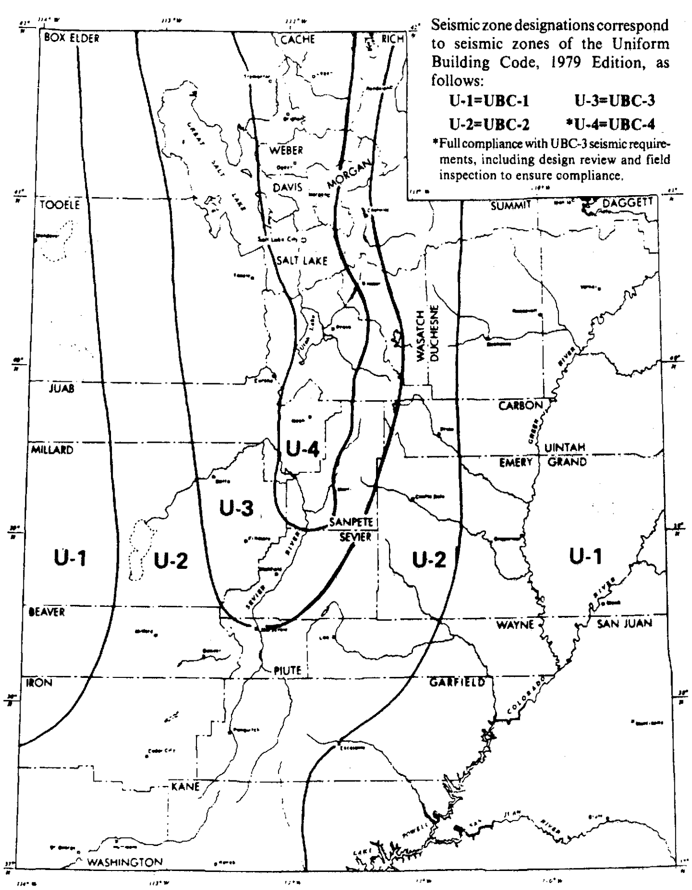


APPENDIX 2

Intensified Design Review and Field Inspection in Utah Seismic Safety Advisory Council Zone U-4

Seismic zone U-4 in the recommended seismic zone map represents a region in which ground accelerations due to seismicity may be slightly greater than the ground accelerations in zone U-3. However, the ground accelerations in zone U-4 are not expected to be of the same magnitude as those to which the UBC zone 4 design standards apply. We have been unable to justify application of UBC zone 4 design criteria to Utah's zone U-4, yet the seismic risk in zone U-4 is greater than in zone U-3. In order to accommodate this potential increased seismic risk in zone U-4, the recommendation is made that the seimic design standards for UBC zone 3 also be applied to zone U-4, but that more rigorous design review and inspection be done for construction in zone U-4 in order to assure complete compliance with the UBC criteria. Design professionals and the construction trades have definite responsibility in fulfilling this recommendation, though ultimate enforcement responsibility lies with the building department which reviews the plans, and the inspector who oversees the construction. Thus, the recommended seismic zone map for the State considers the expected greater seismicity in zone U-4, yet conformance with the current standards contained in the UBC is retained.

Better understanding of seimicity conditions in Utah in future years may result in a modification of the UBC's seismic design criteria at some future time. In the meantime, the recommended substitute zone map accommodates seismicity conditions in the State as they presently are understood, while at the same time it retains the standards of practice which currently are in use.



Excerpted from: Utah Seismic Advisory Council, 1979, Seismic zones for construction in Utah: Delbert Ward, Exectuve Director, p. 6.

APPENDIX 3

MODIFIED MERCALLI INTENSITY SCALE OF 1931
(Abridged)

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

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

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

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

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

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

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

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

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

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

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

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

Source: Earthquake Information Bulletin: 6(5), 1974, p.28.

APPENDIX 4

UNIFIED SOIL CLASSIFICATION SYSTEM

Major Divisions			Group Symbols		Typical Names
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines
			GP		Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with fines (Appreciable amount of fines)	GM*	d	Silty gravels, gravel-sand-silt mixtures
				u	
			GC		Clayey gravels, gravel-sand-clay mixtures
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines
			SP		Poorly graded sands, gravelly sands, little or no fines
		Sands with fines (Appreciable amount of fines)	SM*	d	Silty sands, sand-silt mixtures
				u	
			SC		Clayey sands, sand-clay mixtures
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silt and clays (Liquid limit less than 50)		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
			OL		Organic silts and organic silty clays of low plasticity
	Silts and clays (Liquid limit less than 50)		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
			CH		Inorganic clays of high plasticity, fat clays
			OH		Organic clays of medium to high plasticity, organic silts
	Highly organic soils		Pt		Peat and other highly organic soils

*Division of GM and SM groups into subdivisions of d and u for roads and airfields only. Subdivision is based on Atterburg limits; suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u used when L.L. is greater than 28.

Source: PCA Soil Primer, Portland Cement Association, Chicago, 1962, p. 26.

APPENDIX 5

GEOLOGIC TIME AND FORMATIONS

NORTH AMERICA				
eras	periods and systems		epochs and series	principal mountain-making episodes
Cenozoic	Quaternary		Holocene (Recent) Pleistocene (Glacial)	Cascadian
	Tertiary		Pliocene Miocene Oligocene Eocene Paleocene	Laramide (Rocky mts.)
Mesozoic	Cretaceous (Upper Cretaceous)		Laramie Montana Colorado Dakota	
	Comanchean (Lower Cretaceous)		Washita Fredericksburg Trinity Arundel Patuxent	Nevadan
	Jurassic		Upper Middle Lower	
	Triassic		Upper Middle Lower	
Paleozoic	Permian		Ochoan Guadalupian Leonardian Wolfcamp	Appalachian
	Pennsylvanian		Virgilian Missourian Desmoinesian Atokan Morrowan	
	Mississippian		Chesterian Meramec Osagian Kinderhook	Acadian
	Devonian		Chautauquan Senecan Erian Ulsterian	
	Silurian		Cayugan Niagaran Medinan	Taconic
	Ordovician		Cincinnatian Champlainian Canadian	
	Cambrian		Croixan Albertan Waucobian	Killarney
Proterozoic	not divided into periods	Keweenawan Huronian	Beltian Grand Canyon	Algoman
Archeozoic		Timiskaming Keewatin	Vishnu	Laurentian

UTAH GEOLOGICAL AND MINERAL SURVEY

606 Black Hawk Way
Salt Lake City, Utah 84108-1280

THE UTAH GEOLOGICAL AND MINERAL SURVEY is one of eight divisions in the Utah Department of Natural Resources. The UGMS inventories the geologic resources of Utah (including metallic, nonmetallic, energy, and ground-water sources); identifies the state's geologic and topographic hazards (including seismic, landslide, mudflow, lake level fluctuations, rockfalls, adverse soil conditions, high groundwater); maps geology and studies the rock formations and their structural habitat; and provides information to decisionmakers at local, state, and federal levels.

THE UGMS is organized into five programs. Administration provides support to the programs. The Economic Geology Program undertakes studies to map mining districts, to monitor the brines of the Great Salt Lake, to identify coal, geothermal, uranium, petroleum and industrial minerals resources, and to develop computerized resource data bases. The Applied Geology Program reponds to requests from local and state governmental entities for site investigations of critical facilities, documents, responds to and seeks to understand geologic hazards, and compiles geologic hazards information. The Geologic Mapping Program maps the bedrock and surficial geology of the state at a regional scale by county and at a more detailed scale by quadrangle.

THE INFORMATION PROGRAM distributes publications, and answers inquiries from the public and manages the UGMS Library. The UGMS Library is open to the public and contains many reference works on Utah geology and many unpublished documents about Utah geology by UGMS staff and others. The UGMS has begun several computer data bases with information on mineral and energy resources, geologic hazards, and bibliographic references. Most files are not available by direct access but can be obtained through the library.

THE UGMS PUBLISHES the results of its investigations in the form of maps, reports, and compilations of data that are accessible to the public. For future information on UGMS publications, contact the UGMS sales office, 606 Black Hawk Way, Salt Lake City, Utah 84108-1280