UTAH GEOLOGICAL AND MINERAL SURVEY
REPORT OF INVESTIGATION

TECHNICAL REPORTS FOR 1987
SITE INVESTIGATION SECTION

Report of Investigation 216

Compiled by
Bill D. Black

1988

UTAH GEOLOGICAL AND MINERAL SURVEY
a division of
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Illustration

PREFACE

The Site Investigation Section is a part of the Utah Geological and Mineral Survey Applied Geology Program. The section is responsible for providing assistance to tax-supported entities (i.e. cities, towns, counties, state agencies, and school districts) on matters where geologic factors are of concern. Therefore, the Site Investigation Section undertakes a broad spectrum of projects that vary in length and complexity. Emphasis is placed on site evaluations of critical public facilities such as police and fire stations, hospitals, water treatment plants, and schools. The section also conducts investigations to answer specific geologic or hydrologic questions from state and local government agencies, such as evaluations of protection zones required for culinary springs and investigations of slope stability or soil problems in developing areas for county planning departments. Such projects are usually of short duration (a month or less) and are performed at no cost to the requesting agency, although services in kind are usually provided. The Site Investigation Section also conducts studies of a longer and more detailed nature. These studies are also intended to meet specific needs, and are performed on a cost-sharing basis with the entity requesting the study. In addition to these projects, the Site Investigation Section reviews and comments on technical reports submitted to state and local government agencies by consultants.

Information dissemination is a major goal of the UGMS. Site Investigation Section studies considered of general interest to the public are published in one of three UGMS formats: Reports of Investigation, Special Studies, and Bulletins. These publications allow for wide distribution and long-term availability of information and are included in the UGMS publications list. Special Studies and Bulletins can be purchased from the UGMS and can also be found in many libraries throughout the state. Reports of Investigation can be obtained for the cost of reproduction at the UGMS publications sales desk. However, many Site Investigation Section projects address specific problems of interest to a limited audience. These studies are commonly presented in a technical report or letter and are distributed on a need-to-know basis. Copies of the reports are maintained in the Site Investigation Section files and are available for inspection upon request.

The purpose of this Report of Investigation is to present, in a single document, the 17 technical reports and letters generated by the Site Investigation Section in 1987 (fig. 1) which received limited distribution. The reports are grouped by topic, and the author(s) and requesting agency are indicated on each report. Minor editing has been performed for clarity and conformity, but no attempt has been made to upgrade the original graphics, most of which were produced on a copying machine. This report represents the fifth annual compilation of Site Investigation Section studies, and is intended to make the results of the Site Investigation Section projects available to the general public.

Bill D. Black

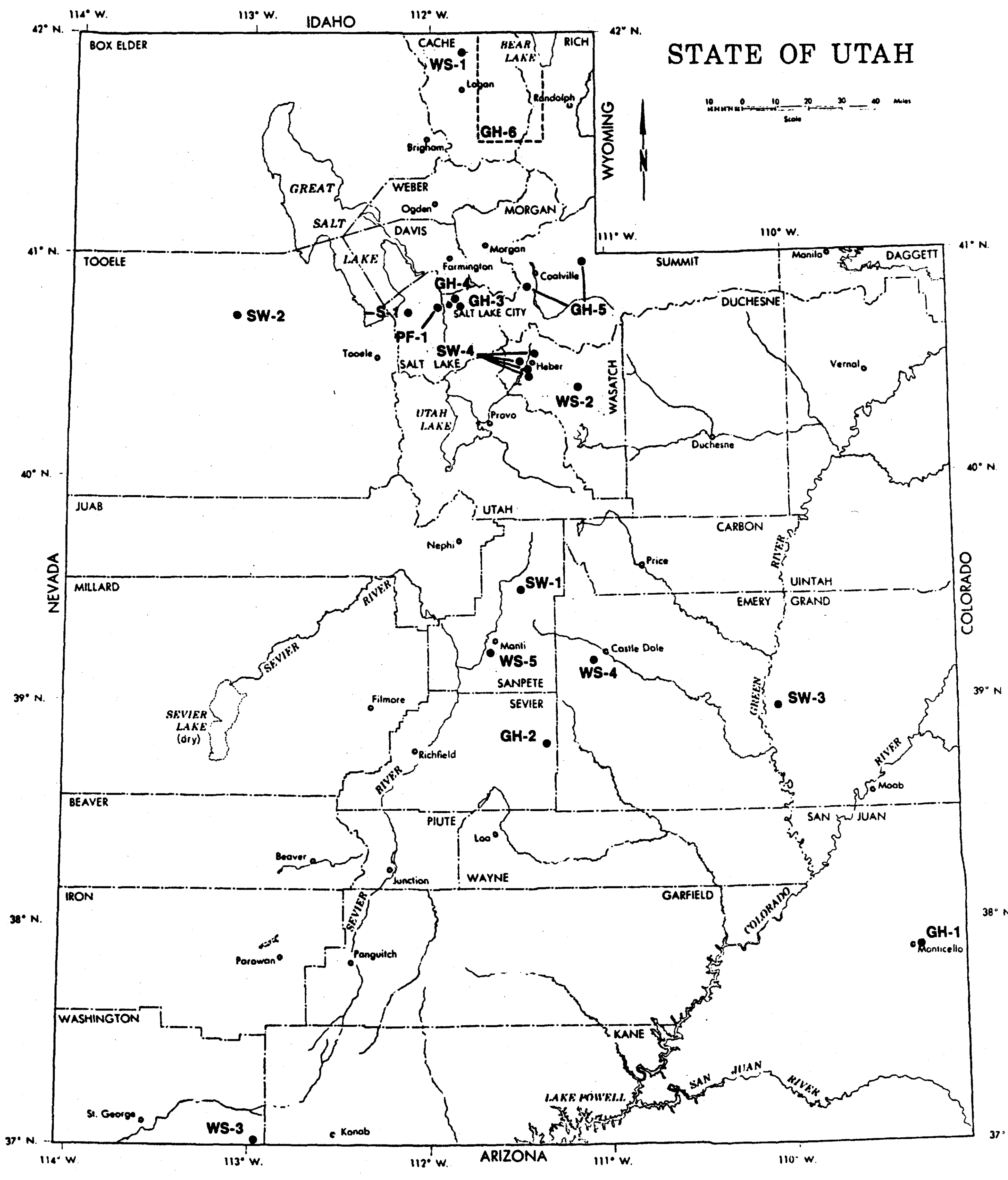

Figure 1. Location Map.

Public Facilities

Project: Geologic hazards investigation, proposed Department of Natural Resources building site, Salt Lake County, Utah.			Requesting Agency: Department of Natural Resources
By: William F Case	Date: 1987	County: Salt Lake County	Job No.: 87-009 (PF-1)
USGS Quadrangle: Salt Lake City North (1254)			

PURPOSE AND SCOPE

The purpose of this report is to provide geologic hazard information concerning the building site for a proposed Department of Natural Resources (DNR) Building (Attachment 1). The Wildlife Building will be razed to construct the building which will house five divisions, one division per floor, plus a basement if feasible. The scope of the investigation involved a review of soils and foundation reports of the following, nearby buildings (Attachment 1): the present Department of Natural Resources Building, Agriculture Building, proposed Energy Office, and Cannon Health Building; collection of nearby water well logs from the Division of Water Rights library; review of appropriate literature; and interviews with Dee C. Hansen, Director of Department of Natural Resources; Larry L. Naccarato, structural engineer, and Einer Johnson, architect, in the Division of Facilities Construction and Management; Ralph Christensen, maintenance superintendent of the Redwood Road Complex of buildings; and Harry Corci of the architectural firm of Seigfried A. Weiss, the firm that designed the present Department of Natural Resources Building. The soils and foundation report of the Wildlife Building could not be located; the architectural firm is no longer in existence and the Division of Facilities Construction and Management did not have a copy.

REGIONAL GEOLOGY

Salt Lake Valley is a part of the Basin and Range physiographic province which encompasses most of the interior western United States. The province is characterized by north-trending, mountain ranges separated by deep valleys filled with thick sedimentary sequences. The valleys consist of blocks of bedrock that have been downdropped relative to mountain blocks along bounding earthquake faults. Blocks in the Basin and Range province are composed of consolidated rock up to 2500 million years old (Hintze, 1973). Unconsolidated to semiconsolidated sedimentary deposits of wind, lakes, rivers, and debris flows; and consolidated volcanic rocks have provided valley fill for the last 80 million years (Hintze, 1973).

The Salt Lake Valley floor consists of a various bedrock blocks approximately 600 to 5000 feet below the surface (Arnow and Mattick, 1968). Lakes have existed in the Salt Lake Valley for the last 15 million years (Currey and others, 1984). Great Salt Lake is a remnant of Ice Age Lake Bonneville which covered a large percentage of western Utah from 25,000 to 10,000 years before present. Lake Bonneville left sand and gravel beaches at elevations from 5090 ft. to 4250 ft. (Currey and others, 1984) on the valley sides, and fine-grained lake bottom deposits on the valley floor. Great Salt Lake levels range from a postulated low of 4180 feet in A.D. 1200 (Currey and others, 1984) to western Utah desert threshold elevations between 4212 and 4216 feet above which water spills into a very large shallow area which includes the Bonneville Salt Flats. Water flowed over the thresholds at least twice in the last 3000 years, the most recent, may have been around A. D. 1700 (Currey and others, 1984). Glaciers flowed into Lake Bonneville from Little Cottonwood Canyon and occupied upper Big Cottonwood Canyon during the Ice Age and contributed sediment to the extensive deltas in front of the Cottonwood Canyons. During times of rapid snowmelt or high precipitation debris flows issued from Wasatch and Oquirrh mountain canyons depositing alluvial fans at their mouths. All sedimentary deposits in the valley are eventually reworked and redeposited by the Jordan River and its tributary network on their way to the Jordan River delta on the shore of the Great Salt Lake.

SITE GEOLOGY

The DNR building site is located on the thickest sedimentary unit in Salt Lake Valley. According to Arnow and others (1970) and Mattick (1970) the total thickness of valley fill near the study area is approximately 4000 feet including mostly unconsolidated sediments in the upper 2200 feet. The DNR test well is the nearest deep well to the proposed site. It was drilled at the Cannon Health Building site to a depth of 1063 feet. Bedrock was not encountered in the well, or in any of the 25 nearby water wells which have lithology logs on file with the Utah Division of Water Rights (Attachment 2). The surface sediments at the site are Jordan River deposits mostly derived from the drainage basins of the two Cottonwood Creeks, especially from Little Cottonwood Creek (Miller, 1980, Marine and Price, 1964). Utah Geological and Mineral Survey (UGMS) logged four trenches at the present DNR building site in July, 1978. The sediment section in the trenches consisted of 2 to 3.5 feet of landfill overlying 1.8 feet of silt which was deposited on fine to medium sand to a depth of 8 feet, the bottom of the trenches (Puri, 1978a). In addition to sediments ranging in size from clays to gravels, logs of borings completed at building sites near the study area indicate the presence of methane, organic debris, and fluid (hydraulic) sand (Attachment 3). The Jordan River sediments at the site are probably several hundred feet thick because the first lake bottom clays were encountered at a depth of 675 feet in the DNR test well.

GEOLOGIC HAZARDS INVESTIGATION

Geologic hazards in the Salt Lake Valley fall under four overlapping categories; earthquake initiated hazards, surface and ground water hazards, slope failures, and hazards due to the physical or chemical properties of sediments. Surface rupture, liquefaction, and ground shaking hazards cause most of the property damage during an earthquake. Flooding and high ground water affect structures located near rivers or on lowlands in the valley and cloudburst precipitation events or rapid snowmelt causes debris flows below canyon mouths. Except for lateral spreading on gentle slopes, most slope failures such as slumps or rock falls, occur on steep slopes. The bearing strength of some fine-grained, saturated, lake bottom sediments decreases when a structural load is applied to them. Sensitive clays in the bottom sediments in some parts of the valley lose bearing strength during ground shaking. Methane occurs in some areas of the valley but is not considered much of a hazard.

Earthquake Hazards:

Utah Geological and Mineral Survey is participating in the United States Geological Survey (USGS) program Regional Earthquake Hazards Assessments. The USGS picked the Wasatch Front because researchers believe that the Wasatch fault zone is due for a major damaging earthquake. UGMS trenching to characterize fault segments in the Wasatch fault zone supports conclusions of Schwartz and Coppersmith (1984), i.e. 7.0-7.5 magnitude earthquakes are characteristic in the Wasatch fault zone and have a recurrence interval around 450 years. The Wasatch Front is in seismic zone U-4, buildings constructed in seismic zone U-4 should satisfy Uniform Building Code 3 seismic requirements according to Ward (1979). Doser (1984) claims the magnitude 7.3 Borah Peak Idaho earthquake is a good analogy of the type of earthquake expected along the Wasatch Front. Mabey (1985), the UGMS Deputy Director, cautions making simple comparisons with Borah Peak because ground shaking in Wasatch Front valleys may be greater due to thicker valley fill and large lakes could alter the hydrologic response. The typical major earthquake event to occur in the Wasatch fault zone would have the following characteristics: 1) magnitude approximately 7.0-7.5, 2) around 6 ft maximum vertical displacement and approximately 15 mi maximum horizontal surface rupture, possibly along an exposed scarp, 3) the zone of deformation may extend over a mile from the fault scarp (Keaton, 1987), and 4) the epicenter (and zone of maximum ground shaking) may be up to 15 mi valleyward of the surface expression of the fault.

Because of the distance from known faults (Attachment 1) and the fact that no faults were discovered in the trenches that UGMS logged in 1978, the DNR site will not experience surface rupture but may subside as much as 5 feet because it is in a fault deformation zone (Keaton,1987). The site ground response during an earthquake constitutes a definite hazard because of site amplification of surface seismic waves and liquefaction. The spectral oscillation of the deep soil may amplify ground motions (Puri, 1978b) at the resonance period of the structure. Hays and King (1984) predict that ground motion on the valley floor may be 10 greater than on bedrock for 3 to 7 story structures. Liquefaction and resultant loss of bearing strength of sediments during an earthquake constitutes a serious hazard to any structure of importance, particularly a multistory building. Subsurface investigations of nearby building sites indicate that the bearing strength of the soils at the new DNR building site will probably decrease due to liquefaction during an earthquake. According to Puri (1978a), the longest trench at the DNR site had a sand dike which intruded into the overlying sediments. Sand dikes are caused by liquefaction and flowage of saturated sand due to ground shaking during an earthquake. Low density, compressible soils were noted at various depths down to 48 feet during the boring of all holes at the present DNR site (Attachment 3), in fact, Boring #3 was abandoned because of fluid sand (Pittsburgh Testing Laboratory, 1978). Puri (1978a) remarked that trench walls collapsed soon after opening because the fine to medium sand unit liquefied. Puri (1978b) suggested that if ground accelerations reached 20 percent of the acceleration of gravity "...there is a strong possibility that some of the substrata would liquefy...". According to Algermissen and Perkins (1976) the Salt Lake Valley is in a seismic zone where horizontal accelerations could reach 0.2 g. The new DNR building site is in a high liquefaction potential zone, that is, the critical acceleration needed to induce liquefaction is less than 0.13 g, which has a greater than 50 percent probability of being exceeded within 100 years (Anderson and others, 1986). Liquefaction can also occur without ground shaking, a static load will induce liquefaction. There have been no studies of the clay mineralogy at the site to determine if they are sensitive, i.e. if they will release water and lose bearing strength during ground shaking.

Surface and Ground Water:

Water-related hazards in the Salt Lake Valley include a shallow water table, Jordan River flooding, and flooding by the Great Salt Lake due to high water levels, standing wave oscillations caused by wind or landsliding below the lake surface, or a possible surge of lake water because of an earthquake.

Ground water near the surface increases the probability that sediments will liquefy during an earthquake, causes construction problems, and floods structures build below the ground surface. The water table in the study area ranges from 5 to 10 feet below the surface (Attachment 3). Recharge is from surface precipitation and upward leakage from aquifers 100 to 300 feet below the surface (Seiler and Waddell, 1984). Artesian pressure from aquifers provides most of the shallow water in the area, twenty-three of the twenty-five nearby water wells are artesian. Ralph Christensen reported no major maintenance problems caused by the water table except when sump pumps at the Wildlife Building fail (personal commun., 26 May, 1987). Mr. Christensen believes that most of the water problems are because of irrigation of the grounds around the building.

Elevation of the site is approximately 4220 feet according to the United States Geological Survey 7 1/2 minute Quadrangle: Salt Lake City North. A special 100-year flood hazard area (HUD, 1974) as delineated along the Jordan River is within 700 feet of the DNR site (Attachment 4). Water from the Great Salt Lake is not likely to reach the proposed DNR site without meteoric or tectonic intervention. Levels have reached the western Utah desert after flowing over a broad topographic sill with three thresholds ranging from 4212 to 4217 feet, twice in the last 3000 years (Currey and others, 1984). Shoreline development should be above the elevation of 4217 ft., "...an elevation at which a consensus of hazard mitigation personnel, policymakers, and lake experts has recommended the establishment of a "Beneficial Development Area" (BDA), whereby further development on land below this elevation should be restricted..." (Harty and Christenson, 1987). Harty and Christenson (1987) report that communications with lake researchers have indicated that the 4221-4222 elevation is the highest level attained in the last 10,000 years and that it is unlikely that the lake will reach this level without dramatic climate change. If lake levels approach the site elevation because of increased inflow or subsiding ground surface, waves or water surges may affect the building. Standing wave oscillations (seiche) caused by wind surges or earthquakes can temporarily raise water levels a few feet. UGMS Deputy Director Don R. Mabey reported on a wind surge which produced an 8-cycle seiche with a maximum amplitude of 1.5 ft. above static level and a period of 6 hours (Mabey, 1986). Mabey (1985) recounted a newspaper article in which a lake surge caused by a 1909 earthquake washed water over the rails on the Lucin Cutoff and over the bath house pier at Saltair. According to earthquake-caused tectonic subsidence models developed by Keaton (1987), the deformation zone in which the site is located may permanently drop approximately 5 feet; this would put the DNR building site very close to the present Great Salt Lake shoreline (Attachment 5). The drop in ground surface would produce a lake surge which conceivability would have an amplitude of several feet in the deformation zone and would produce a Great Salt Lake seiche with a peak of a few feet above static level. A UGMS map of inundation areas, assuming all major dams in Salt Lake County fail due to an earthquake, indicates that the proposed site will be under shallow surface water (Case, 1984).

Slope Failures:

Slope failures will not likely be a problem although Jordan River bluffs may slump because of natural erosion. Lateral flows were not noticed in the trenches. There are no steep slopes or canyon mouths near the site.

Methane:

Methane at the site evidently is more of a nuisance during construction than a geologic hazard. Ralph Christensen, maintenance superintendent of the Redwood Road Complex of buildings, reported no building maintenance problems or personnel complaints because of methane in the soil (personal commun., 26 May, 1987). The presence of methane was recorded by drillers in four of the five borings at the Agriculture Building site and in boring #1 at the site of the present DNR Building. The Cannon Health Building and Energy Office sites did not have methane in the borings. Methane was measured by UGMS in four auger holes at the DNR site on 31 August, 1978 and 10 May, 1979 (Klauk, 1979). Klauk (1979) recorded methane amounts greater than 1000 ppm in the four holes in August. By May of the next year methane in one of the holes had decreased to 160 ppm, two holes were unreadable because of the physical condition of the casing, and the methane amount in the remaining hole was unchanged. Geologists at the Utah Geological and Mineral Survey concluded that the methane is natural because it occurs at depths greater than 30 feet, far below the 3.5 feet thick landfill deposit, and that the gas can be easily vented and should cause no problems.

CONCLUSIONS

The major geologic hazards which have to be considered during design of the new DNR building are: the decrease of bearing strength due to liquefaction of low-density soils, and ground response of the site and structure. The 1978 Pittsburgh Testing Laboratory report on the foundation characteristics of the soils beneath the present DNR building stated: "This site is a relatively poor site on which to build a major structure." There is much evidence of liquefaction in the borings and trenches. Measures should be taken to densify the soil or emplace footings below the liquefaction zone, greater than 30 feet deep according to Les Youd, Brigham Young University Civil Engineering Department (personal commun., 14 April, 1987). Artesian pressure could cause piping in foundation materials if fissures develop to the depth of the aquifers. Possible amplification of ground motion at the spectral period of a 5-story building is important enough to consider during the design stage. Because of the thickness of the sedimentary units below the site, the site may experience more surface seismic wave amplification than any other part of the valley. The spectral response of the site should be determined using broad-band seismographs during nuclear or mine blasts before building design. Strong motion accelerometers should be installed in the building. Because of the elevation of the site, flooding by the Great Salt Lake is not likely to be a problem, seiche and surge are low probability events. Subsidence and deformation during an earthquake may permanently lower the site to a point where shallow ground water and surface water will cause flooding. The site is not expected to react well during a major earthquake, any multi-storeyed structure on the site should be designed understanding the geologic problems.

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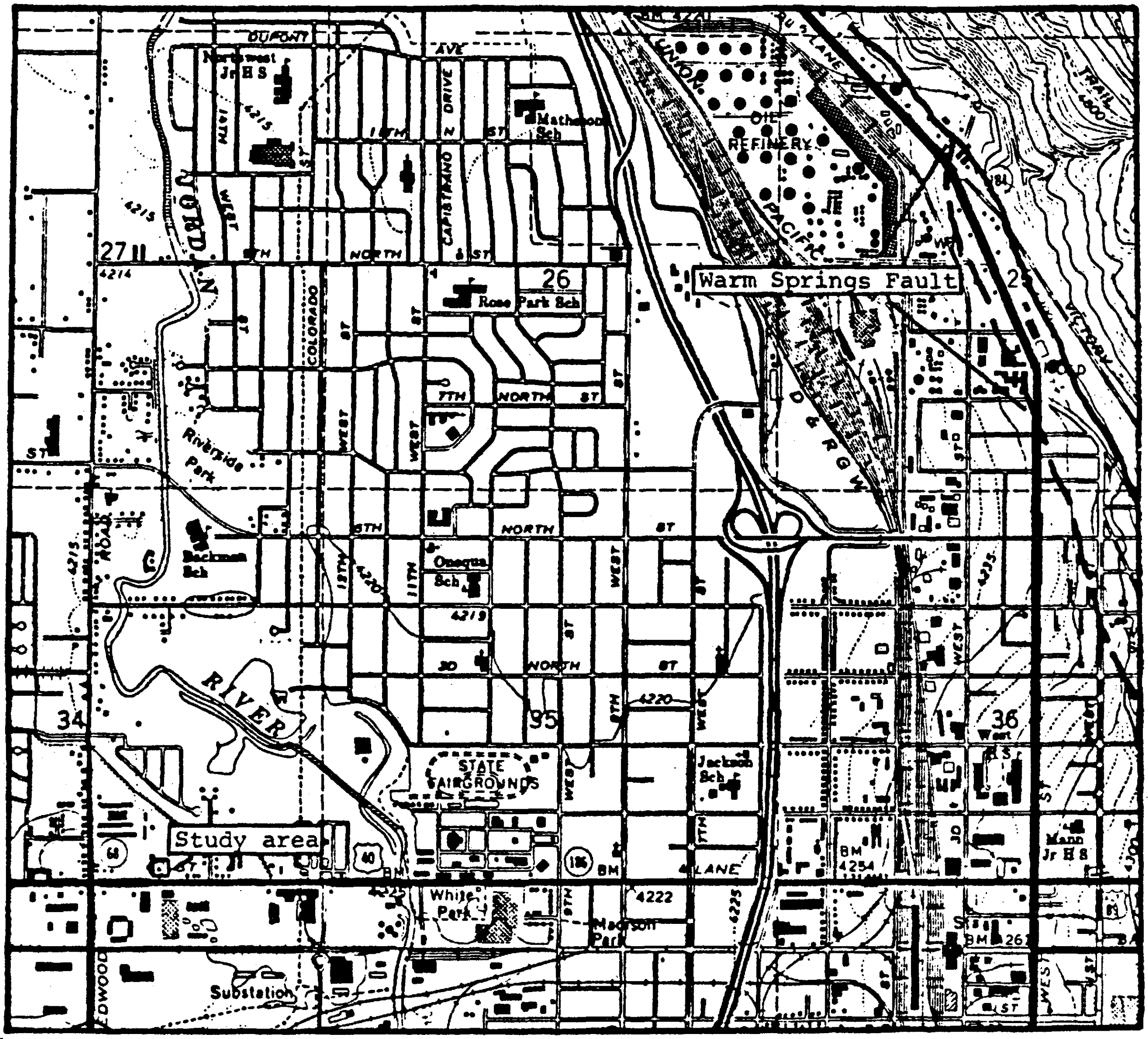
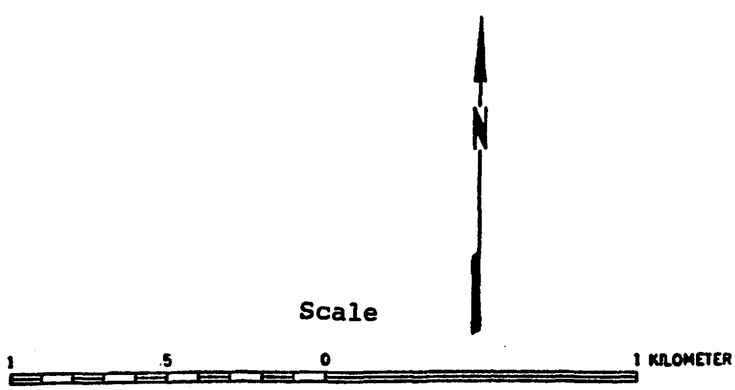
Base map from: USGS topographic quadrangle Salt Lake City North, Utah.

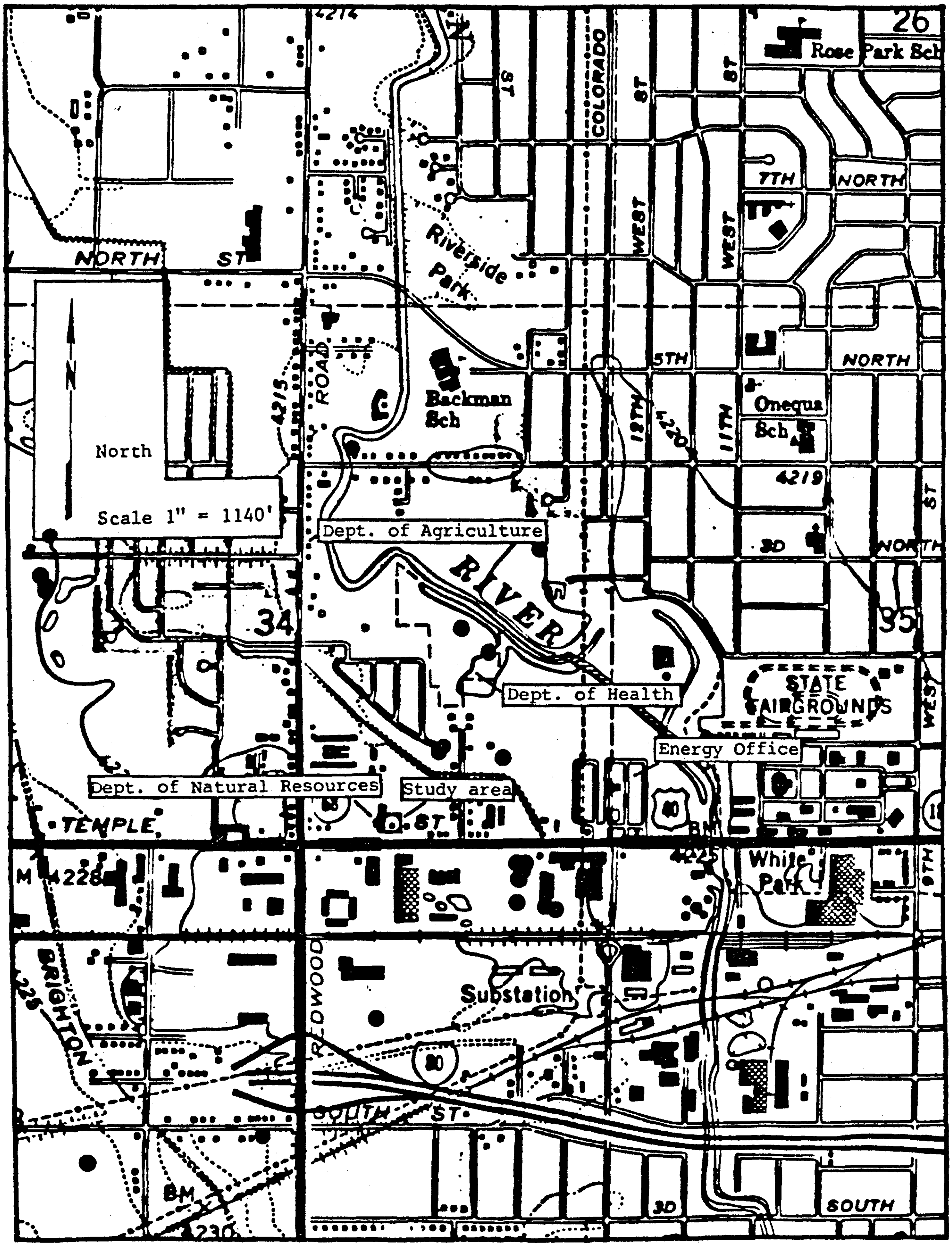


Index map showing study area and location of fault scarps.

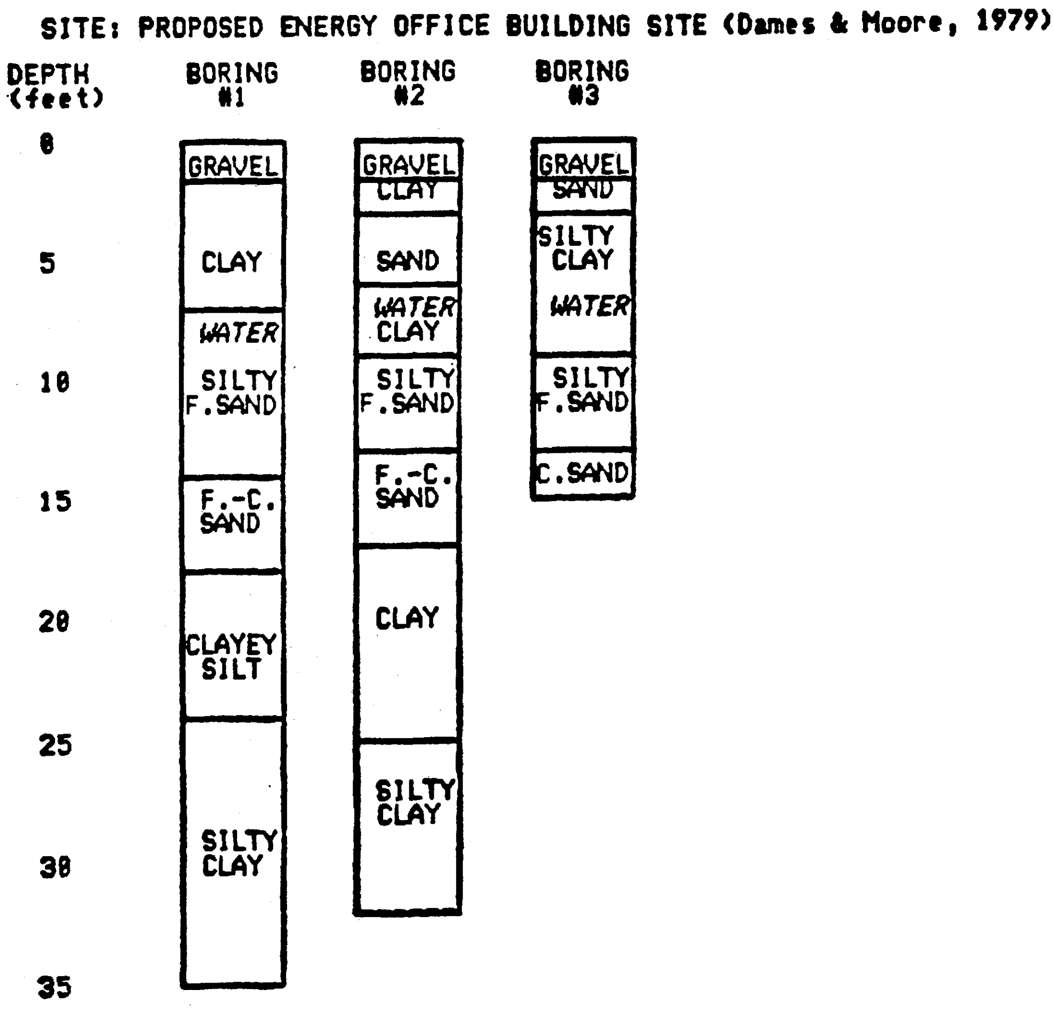


Utah Geological and Mineral Survey

Site Investigation Section

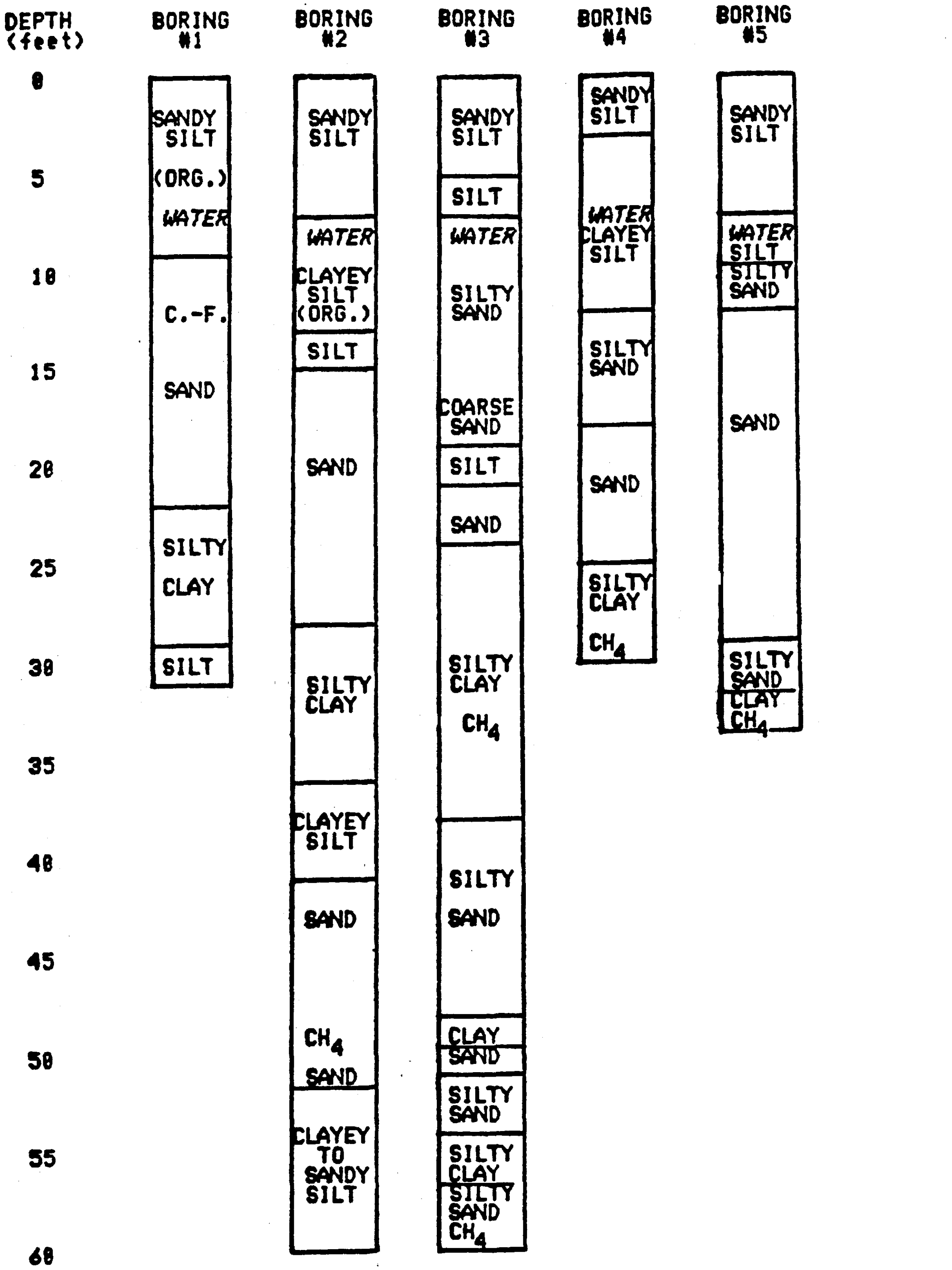


Map showing location of water wells●, Redwood Road Complex buildings and study area.

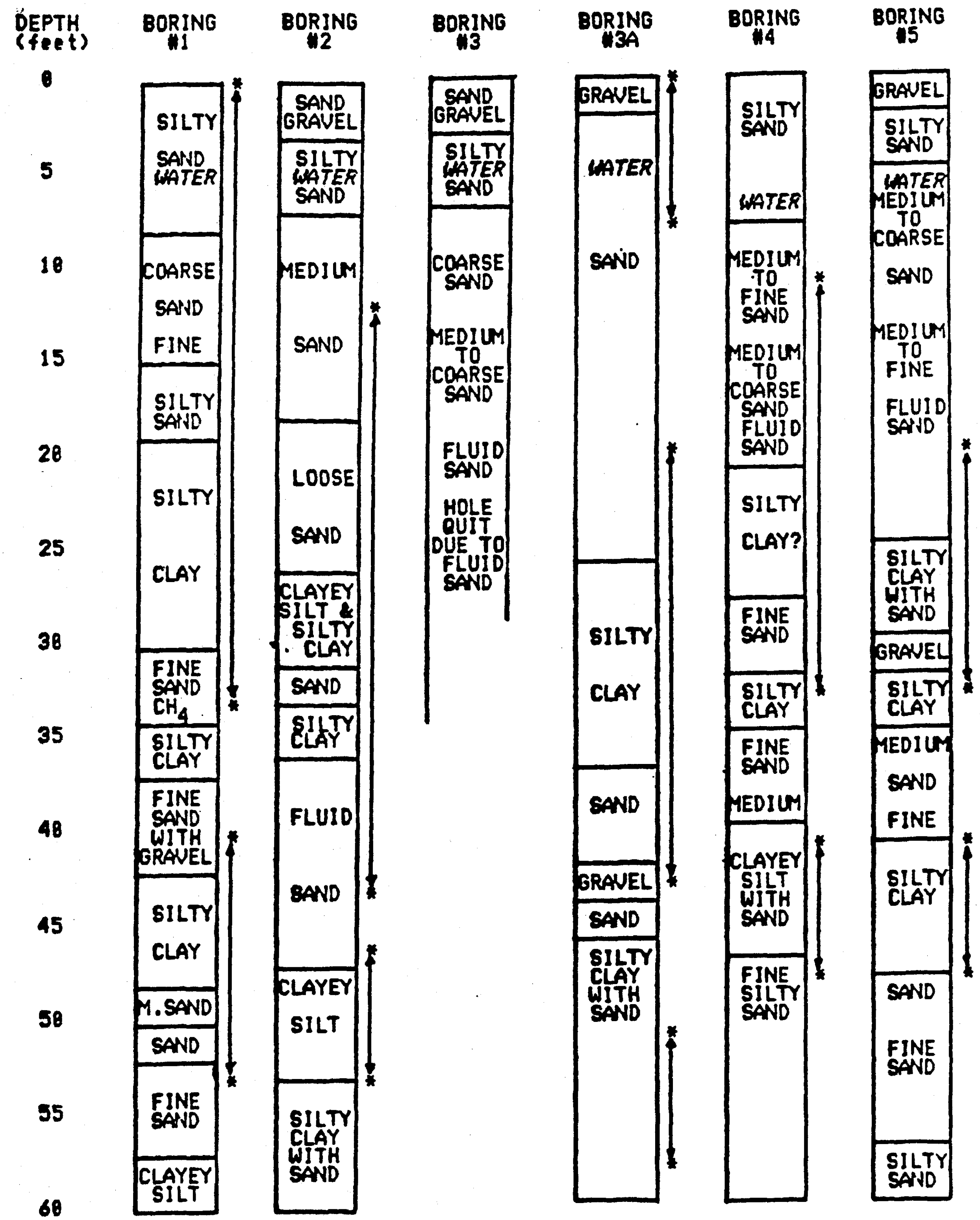


Lithology Logs of borings of buildings near the proposed Department of Natural Resources Building site.

SITE: DEPARTMENT OF AGRICULTURE BUILDING (Pittsburgh Testing Lab., 1979)

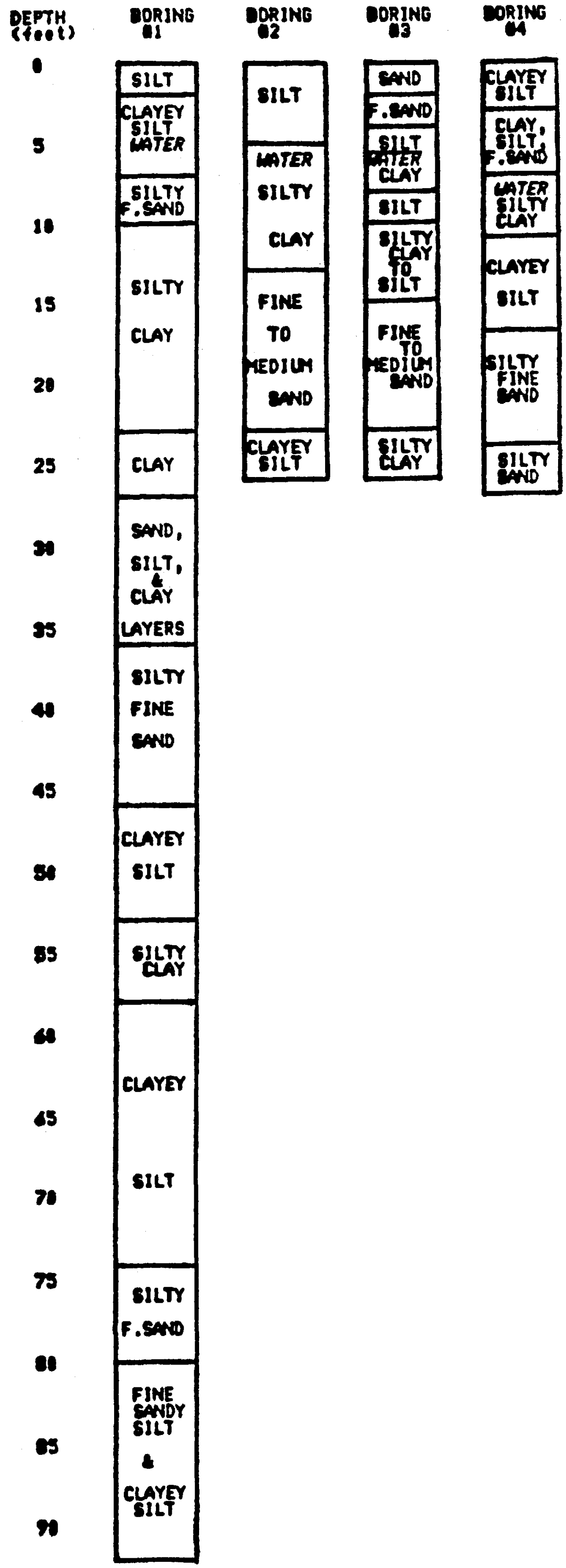


SITE: PRESENT DEPARTMENT OF NATURAL RESOURCES BUILDING (Pittsburgh Testing Laboratory, 1978)



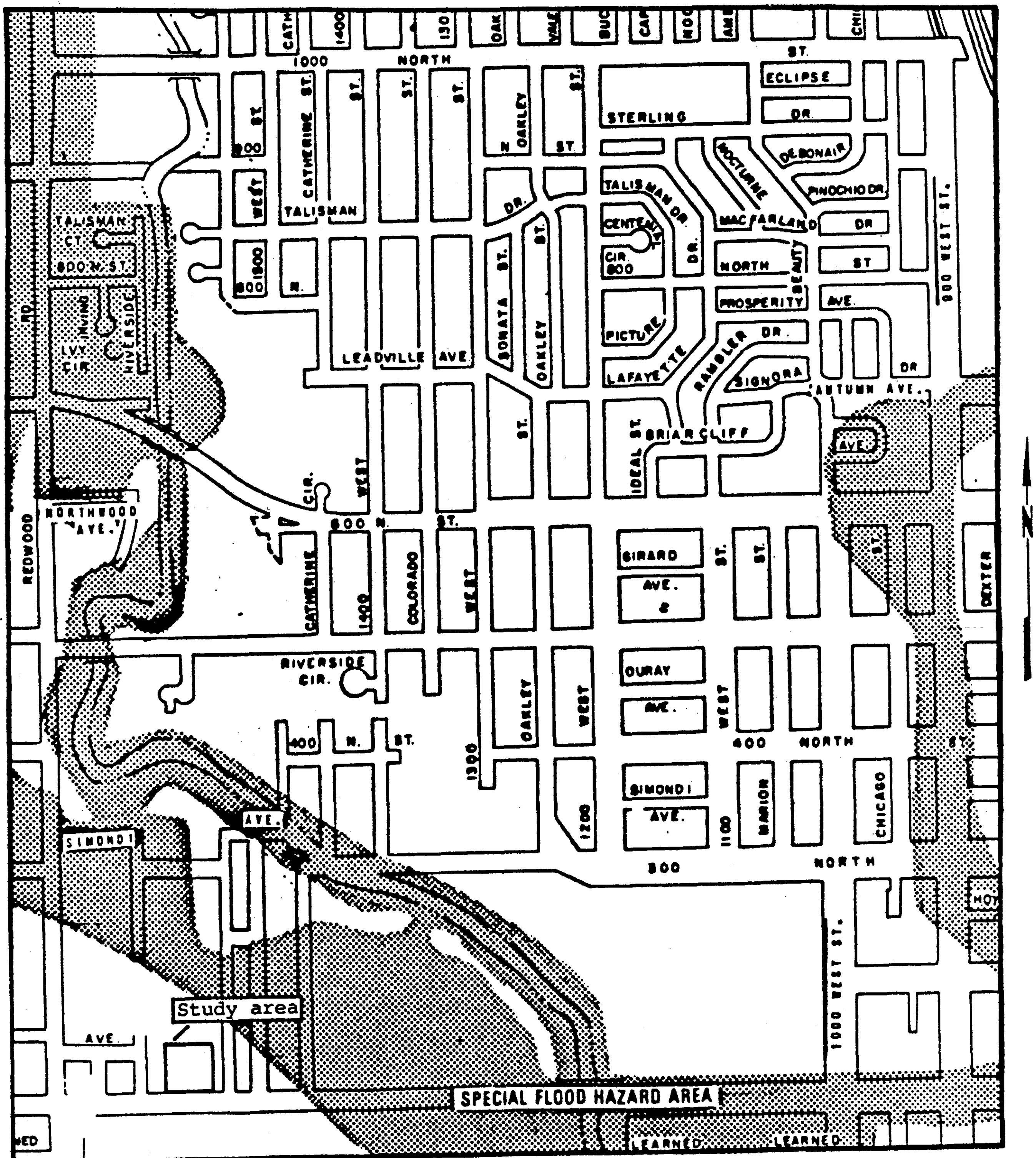
(Note: *←——→* indicates interval of low-density, weak soil)

SITE: CANNON HEALTH BUILDING SITE (Dames & Moore, 1984)

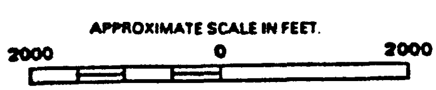


Attachment 4, Job No.   Job No. 87-009 (PF-1)

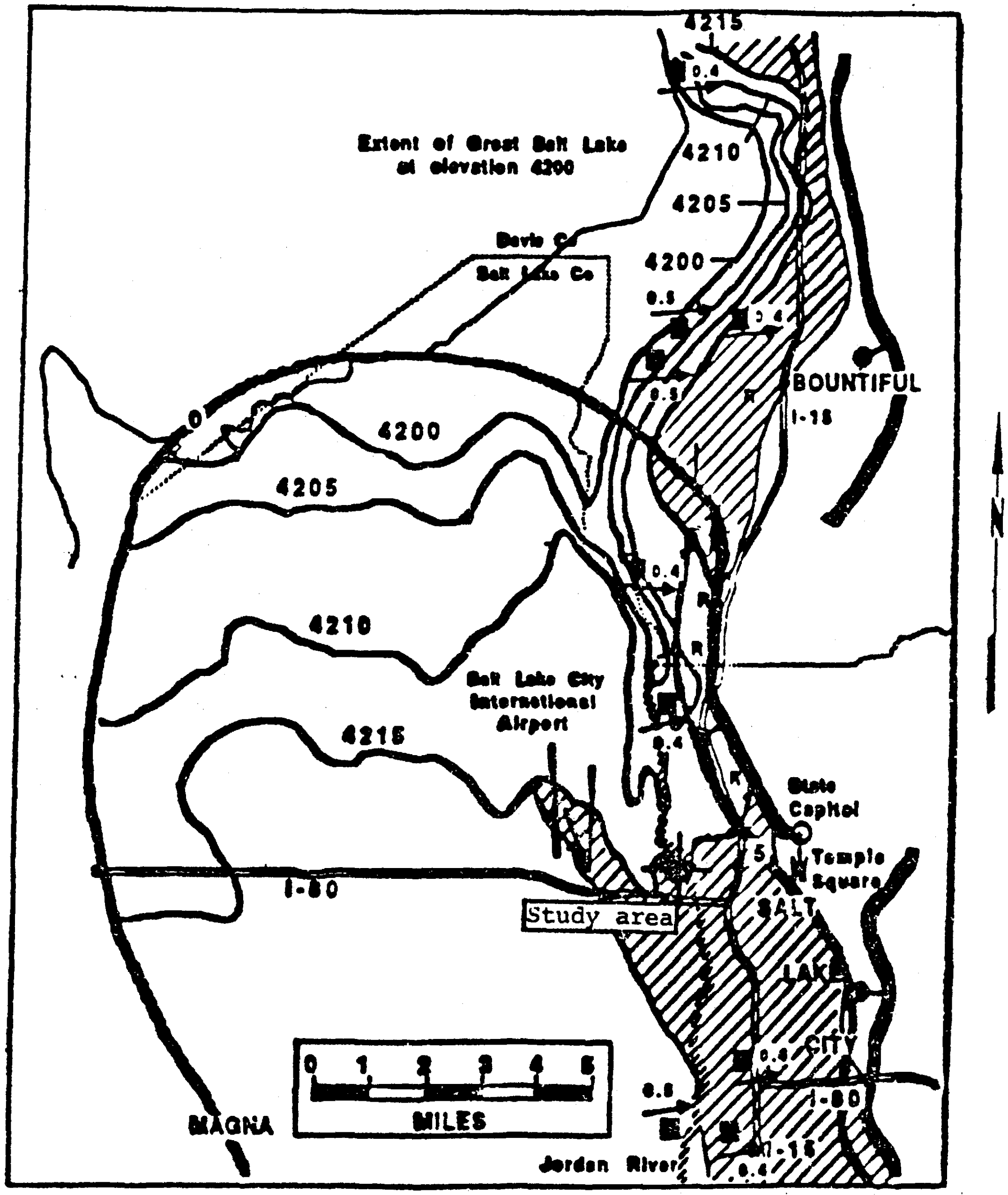
Map taken from U.S. Dept. of Housing and Urban Development Flood Hazard Boundary Map of Salt Lake City, Utah.



Map showing 100 yr. flood zone along part of the Jordan River.



(Modified from Keaton, 1985)



Map showing predicted subsidence expected during a major earthquake.

Example of Okada's (1985) elastic dislocation model of tectonic subsidence using appropriate seismic source parameters for a "characteristic" Wasatch fault earthquake applied in the Salt Lake City-Bountiful area. Weber segment of the Wasatch fault zone (heavy solid line near Bountiful) and Salt Lake City segment (heavy solid lines northwest of State Capitol and east of Salt Lake City) are thought to operate independently. Contours (heavy shaded lines) show 5-foot increments of equal subsidence. Potential lake margin flooding is shown due to the Great Salt Lake at 4 elevations (medium solid lines). Areas of potential ponding of shallow ground water (hachured) correspond to subsidence greater than 3 feet and a water table less than 3 feet. Squares indicate water treatment plant locations; arrows show direction of tilt and numbers indicate magnitude of tilt in feet/mile. Letter R indicates oil refinery locations.

Schools

Project: Granite School Site Geologic Hazards Investigation			Requesting Agency: Granite School District
By: Hal Gill	Date: Feb. 10, 1987	County: Salt Lake	Job No.: 87-002 (S-1)
USGS Quadrangle: Magna (1214)			

In response to a request from Ross L. Wentworth, AIA, Director, Granite School District, a geologic hazards investigation of a proposed high school at 5600 West and 4100 South, West Valley City, Utah, was undertaken. The investigation included review of a geotechnical report prepared by Chen & Associates Consulting Geotechnical Engineers and examination of applicable geologic reports and maps covering the study area. Only available literature was utilized, no field reconnaissance was undertaken.

REVIEW OF CHEN & ASSOCIATES REPORT

Moisture sensitive soils: The Chen report states, " the predominant soils encountered at the site are slight to moderately cemented, water sensitive, silty sands" and that they "will undergo substantial compression under light loads with increased moisture content." Overexcavation and placement of structural fill beneath the foundation are recommended. In addition, Chen recommends numerous drainage precautions, such as avoiding ponded water and excessive wetting or drying of the foundation excavations during construction, sloping the ground surface surrounding the structure away from the school in all directions, extending roof downspouts and drains well beyond the limits of all backfill, and installing sprinkler systems at least 10 feet from the foundation wall. The UGMS concurs with the suggestions and recommendations set forth in the Chen & Associates report concerning moisture sensitive soils.

Seismic considerations: Chen notes that the site is within Uniform Building Code (UBC) Seismic Zone 3 and the Utah Seismic Safety Advisory Council (USSAC) Zone U-4, and recommends conforming to the regulations and standards as presented. The UGMS concurs with this recommendation. In addition, the UGMS has noted that the nearest mapped faults are the Granger fault 3.5 miles east of the site and an unnamed fault exposed in a gravel pit 3.5 miles southeast of the property. Both are active faults showing evidence of multiple surface-faulting earthquakes during Holocene time (10,000 years before present)

Ground-water considerations and liquefaction potential: Chen drilled 23 borings on the property to a maximum depth of approximately 26 feet. No ground water was encountered even after monitoring some of the borings for an extended length of time. The UGMS notes that the site is in an area designated as having a ground-water depth of greater than 50 feet and as a consequence is also an area of low liquefaction potential (Anderson and others, 1985).

CONCLUSIONS

1) The UGMS concurs with Chen & Associates recommendations for overexcavation of moisture sensitive soils and replacement with compacted backfill. The UGMS also concurs with installation of an extensive drainage system to maintain dry conditions around the school.

2) The site is within UBC Zone 3 and the USSAC Zone U-4 and the UGMS concurs with the Chen & Associates recommendation for compliance with the seismic design standards associated with those zones.

3) Soil borings indicate that ground water is greater than 26 feet beneath the surface and does not present a problem. In addition the liquefaction potential at the site is mapped as low (Anderson and others, 1985).

4) The nearest mapped active faults are 3.5 miles to the east and southeast of the property. Indicating, that in the event of a large earthquake ground shaking but not ground rupture would be a hazard at the site.

5) Based upon the literature review, the UGMS is unaware of any other geologic hazards that could affect the proposed school site.

REFERENCE

Anderson, L. R., and others, 1985, Liquefaction potential map for Salt Lake County, Utah: Utah State University Department of Civil and Environmental Engineering, and Dames and Moore Consulting Engineers, U.S. Geological Survey contract: 14-08-001-19910, 48 p.

Keaton, J. R., Currey, D. R., and Olig, S. J., 1987, Paleoseismicity and earthquake hazard evaluation of the West Valley fault zone, Salt Lake City urban area, Utah: Dames and Moore and University of Utah unpublished data and map, Salt Lake City, Utah, Scale 1:24,000.

Tooker, E. W., and Roberts, R. J., 1971, Geologic map of the Magna quadrangle, Salt Lake County, Utah: U.S. Geological Survey Geologic Quadrangle Map GQ-23, Scale 1:24,000.

Van Horn, Richard, 1979, Surficial geologic map of the Salt Lake City south quadrangle, Salt Lake County, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1173, Scale 1:24,000.

Water Supply

Project: South Cove Spring Development Study			Requesting Agency: Bureau of Public Water Supplies
By: R.H. Klauk	Date: 6-22-87	County: Cache	Job No.: 87-007 (WS-1)
USGS Quadrangle: Richmond, Utah (1494)			

PURPOSE AND SCOPE

This investigation was conducted at the request of Ursula Trueman of the State Division of Environmental Health (Bureau of Public Water Supplies and Sanitation) for an unnamed spring located in the NW 1/4, sec. 12, T. 14 N., R. 1 E., Salt Lake Baseline and Meridian, Cache County, Utah (attachment 1). For this study the spring will be referred to as Spring A. The South Cove Public Supply System is in need of additional culinary water and are considering developing Spring A. The purpose of this study was to identify any geological constraints that relate to this development.

The scope of work for this investigation included a literature review and a field reconnaissance on June 10, 1987.

SITE HYDROGEOLOGY

Spring A issues from fanglomerate deposits that consist of pebbles, cobbles, and boulders in a sand and marl matrix deposited in pre-Lake Bonneville alluvial fans (Williams, 1962; Bjorklund and McGreevy, 1971; and Davis, 1985). Bjorklund and McGreevy (1971) describe the water-bearing properties of this unit as having high yields with the largest springs issuing from solution openings. Goaslind Spring, located approximately 500 feet east of Spring A, also issues from the fanglomerate with a reported discharge of 44 gpm (McGreevy and Bjorklund, 1970; and attachment 1). Dye placed in High Creek, located less than one mile to the southeast and 400 feet higher in elevation, appeared in Goaslind Spring (Neil Allen, oral commun., June 10, 1987). This indicates that the creek is influent and flows through the recharge area for Goaslind Spring. Spring A was not inspected during the dye test but issues from the same geologic formation and therefore is also thought to be recharged by the same system.

Bjorklund and McGreevy (1971) have located the piezometric surface through this area more than 70 feet below the elevation of Spring A and more than 100 feet below Goaslind Spring. This indicates the springs may be discharging from a perched ground-water body that is recharged by High Creek. The 44 gpm flow from Goaslind Spring is not indicative of the large springs Bjorklund and McGreevy (1971) report as flowing from solution openings. However, the significant elevation difference between the two springs indicates fractures/solution openings may be providing conduits for recharge. Although recharge is generally from the southeast for the non-perched ground-water aquifer in this area, the exact direction of flow and the configuration of the flow paths feeding the springs is not known.

Chemical quality of ground water in this area appears to be very good. A water analysis presented in McGreevy and Bjorklund (1970) for Goaslind Spring indicates the water is calcium bicarbonate in character and dilute (total dissolved solids less than 1000 mg/L), with a total dissolved solid (TDS) content of 199 mg/L (attachment 2). Conductivity was measured at 342 micromhos.

SITE RECONNAISSANCE AND DISCUSSION

Spring A is located approximately 150 to 200 feet down slope from an abandoned house (attachment 1). The foundation for a house trailer formerly on the property is immediately northeast of this house. A new home, presently occupied, is to the south. Two feedlots are less than 1000 feet south and possibly upgradient from Spring A. The pasture around Spring A had been sprayed with weed killer shortly before the reconnaissance. A small abandoned canal with standing water crosses the property upgradient from Spring A.

Conductivities measured during the reconnaissance for Spring A and Goaslind Spring ranged from 375 and 400 micromhos. This range is only slightly greater than the conductivity reported by Bjorklund and McGreevy (1971) for Goaslind Spring and indicates general chemical quality has not deteriorated since 1971. The close proximity of Spring A and Goaslind Spring within the same hydrogeologic environment indicates water quality for Spring A and Goaslind Spring may be similar.

CONCLUSIONS AND RECOMMENDATIONS

Spring A is considered to be discharging from a shallow, perched groun-water system recharged from High Creek. Water quality for Spring A may be similar to Goaslind Spring and therefore adequate as a culinary source. However, because the ground-water system is shallow the water quality could presently or in the future be adversely affected by contaminant sources (the feedlots and/or any presently used or abandoned septic systems) upgradient from Spring A. Sampling Spring A and Goaslind Spring and comparing nitrate concentrations could indicate Spring A is presently contaminated. A high nitrate concentration for Spring A in comparison to Goaslind Spring could indicate contamination is occurring. Proving that a future threat exists, however, appears to be cost prohibitive. Therefore, as a precaution, it is recommended that part of any development process include the implementation of a 1500 foot protection zone for Spring A. It is also recommended that development provide for the diversion of water that is presently to flowing into the abandoned canal and that no chemical weed killers be used in the established protection zone.

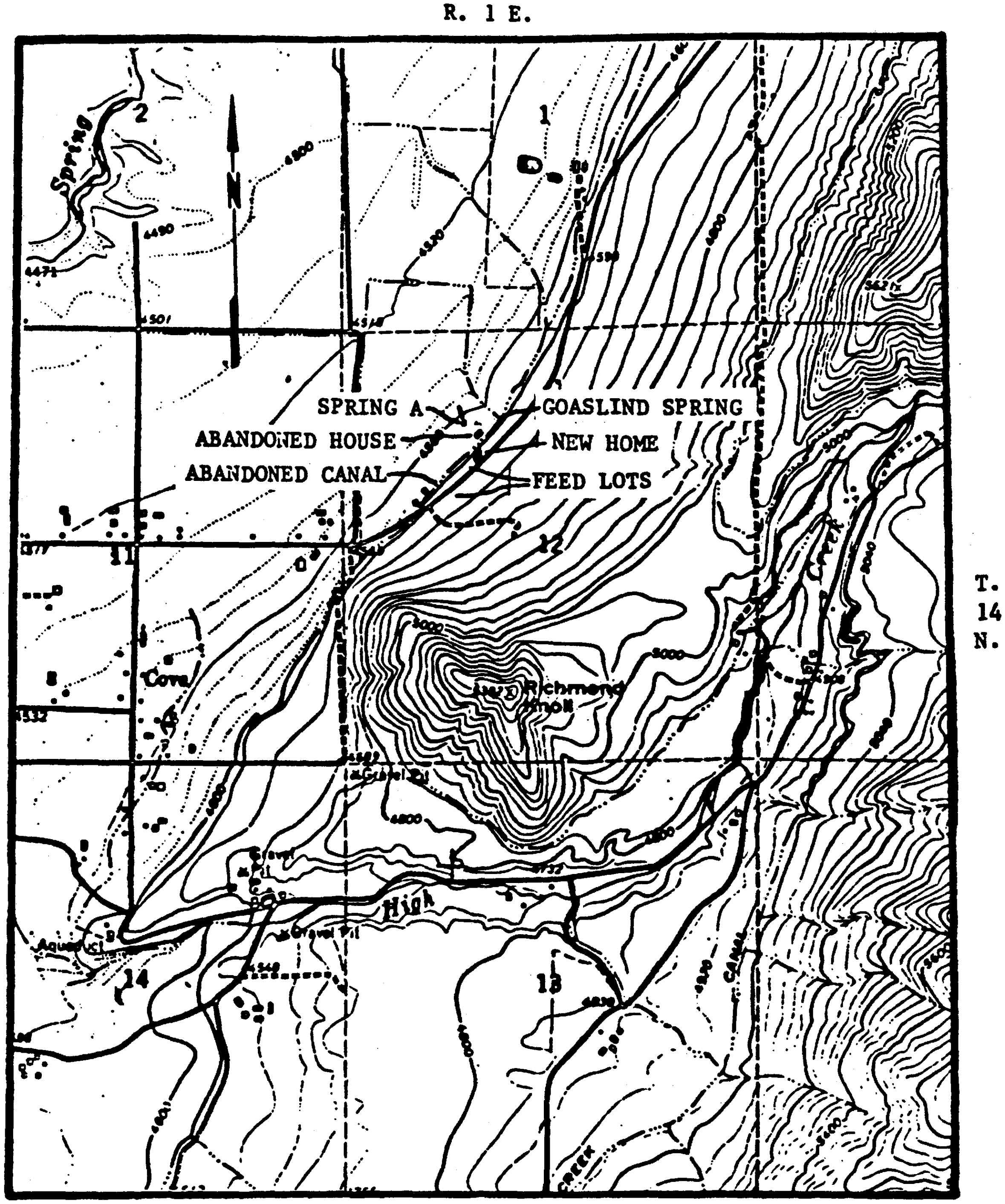
REFERENCES CITED

Bjorklund, L.J., and McGreevy, L.J., 1971, Ground-water resources of Cache Valley, Utah and Idaho: Utah Department of Natural Resources Technical Publication No. 36, 72 p.

Davis, F.D., Compiler, 1985, Geologic map of the northern Wasatch Front Utah: Utah Geological and Mineral Survey Map 53-A, scale 1:100,000.

McGreevy, L.J., and Bjorklund, L.J., 1970, Selected hydrologic data Cache Valley, Utah and Idaho: Utah Department of Natural Resources Basic Data Release No. 21, p. 50-51.

Williams, J.S., 1962, Lake Bonneville - geology of southern Cache Valley, Utah: U.S. Geological Survey Professional Paper 257-C, p. 131-152.



Base modified from USGS 7 1/2' topographic quadrangle map, Richmond, Utah

LOCATION MAP

CHEMICAL ANALYSIS OF GOASLIND SPRING

Constituents	Concentrations	
Silica (SiO_2)	13	mg/L
Iron (Fe)	.02	mg/L
Calcium (Ca)	42	mg/L
Magnesium (Mg)	19	mg/L
Sodium (Na)	4.3	mg/L
Potassium (K)	.0	mg/L
Bicarbonate (HCO_3)	213	mg/L
Sulfate (SO_4)	4.7	mg/L
Chloride (Cl)	9.0	mg/L
Fluoride (F)	.0	mg/L
Nitrate (NO_3)	1.7	mg/L
Total Dissolved Solid (TDS)	199	mg/L
Specific Conductance	342	micromhos
pH	8.1	no units

(From McGreevy and Bjorklund (1970))

Project:			Requesting Agency:
Review of Dames and Moore report for Goodfellow Spring			Bureau of Drinking Water/Sanitation
By: R.H. Klauk	Date: 7-22-87	County: Wasatch	Job No.: 87-008 (WS-2)
USGS Quadrangle: Heber Mountain (1125)			

A review has been made of a Dames and Moore report entitled "Report Geohydrologic Evaluation Goodfellow Spring..." at the request of Dan Blake of the State Division of Environmental Health (Bureau of Drinking Water/Sanitation). Goodfellow Spring is located in the SE 1/4 sec. 11, T. 4 S., R. 6 E., Salt Lake Baseline and Meridian. The scope of work included a literature survey and a discussion with William R. Lund.

The report appears to account for geologic conditions that pertain to Goodfellow Spring. The UGMS agrees that the recharge zone for the spring is located on the plateau northeast of the spring. We also agree that development of the plateau would not adversely affect the spring (Lund, 1982). For development of the spring without the protection zone, however, we feel that certain conditions must be employed. These conditions are as follows:

1. No development occurs on the escarpment upslope from the spring.

2. The spring collection system must be developed entirely in bedrock to prevent surface runoff from mixing with spring water.

3. An adequate, well maintained fence must be constructed around the collection system.

References Cited

Lund, W.R., 1982, Geologic inspection of a spring as a culinary source for Glenwood Village subdivision: unpublished UGMS letter, June 10, 5 p

Project: Geologic site investigation of a water tank site, Hildale Town, Washington County, Utah			Requesting Agency: Hildale Town
By: William F. Case	Date: 09-17-87	County: Washington	Job No.: 87-011 (WS-3)
USGS Quadrangle: Hildale (32)			

PURPOSE AND SCOPE

Hildale Mayor David K. Zitting contacted the Utah Geological and Mineral Survey through Alden Robinson (Sunrise Engineering, Filmore, Utah) on 31 August, 1987, and requested a geologic inspection of a water tank site for the purpose of obtaining a Farmers Home Administration grant and loan. The 1-2 million gallon tank will retain culinary water for the town of Hildale and will replace the present, estimated at 100,000 gallons, tank located on the site. The scope of the work involved a literature search and field inspection accompanied by Mayor Zitting on 10 September 1987.

LOCATION AND GENERAL GEOLOGY

The town of Hildale is located on Utah's southern border, at the base of the Vermilion Cliffs, approximately 50 miles southeast of St. George. The approximately 50 x 100 ft site is located in SE1/4 SW1/4 SE1/4 sec. 27, T. 44 S., R. 6 W., SLBM, on a narrow saddle between two dry drainages approximately four-tenths of a mile north of Hildale Town Hall (Attachment 1). The Vermilion Cliffs are a several hundred feet high southerly-facing escarpment of a western Colorado Plateau mesa, part of what geologists affectionately call the grand staircase (Attachment 2). The west border of the Colorado Plateau physiographic province consists mainly of large (hundreds of square miles) bedrock blocks of gently tilted strata which have been uplifted along north-trending vertical faults. The Hurricane fault, approximately 20 miles to the west, and the Sevier fault 15 miles to the east, define the block on which the study area is located (Montgomery, 1986). The topography of the area consists of slopes and steps defined by soft, slope-forming shales and harder, cliff-forming sandstones. The nearly horizontal strata are dissected by running water choked with abrasive sediment during the flash flood season. The stratigraphic section of the Vermilion Cliffs consists of alternating slope- and cliff-forming formations of Triassic and Jurassic age (Attachment 2). The two Triassic formations, beginning at the base of the section, include: 1) the Moenkopi Formation, a 1700 feet thick formation of slope-forming siltstones, shales, and sandstones; and the 2) Chinle Formation, 350 feet of slope-forming shales, siltstones, and sandstones (Montgomery, 1986). Jurassic formations (Doelling and others, 1986), in ascending order, are: 1) Moenave Formation, 300-400 feet of mainly cliff-forming sandstones with minor conglomerates and fine-grained rocks; 2) Kayenta Formation consisting of 700 feet of predominantly slope-forming siltstones and shales, and, locally, a cliff-forming sandstone and; 3) the 2000 ft thick Navajo Sandstone which overlies the Kayenta Formation and forms the upper cliffs (Montgomery, 1986).

SITE GEOLOGY

The water tank site is located within the Kayenta Formation. The present, above-ground steel tank is resting on a dark red to greenish gray shale covered with a thin, 1-2 ft thick colluvium veneer. A 6 ft thick sandstone channel is in the shale directly south of the tank. Approximately 28 feet of shale upsection of the tank base is covered with talus derived from a sandstone cliff at the northern border of the site, approximately 100 feet from the tank. The 14 ft thick sandstone is prominent throughout the area and appears on Pillmore's (1956) photogeologic map (Attachment 3). Attachment 4 is a generalized rock column showing the position of the ledge-forming sandstone within the Kayenta Formation.

GEOLOGIC UNIT DESCRIPTIONS

There are three geologic units at the site; the youngest is the active talus deposit; followed by Kayenta Formation units, a ledge-forming massive sandstone, and a slope-forming shale with siltstones and a channel sandstone.

Talus: The active talus deposit consists of a bimodal distribution of clast sizes, the maximum clast diameter of the small class is approximately 1.5 ft as compared to the maximum clast diameter of the large class which ranges from 9 to 15 ft in diameter. The size of the large class particles is related to joint set spacings. Small class particles may be a product of faulting -although no displacement was noted - or weathering such as frost-wedging (the elevation of the site is about 5240 ft). Clast deposition is by toppling and fall of weathered particles from the exposed sandstone ledge. Many of the large clasts are imbricated, dipping downslope.

The Kayenta Formation at the site contains two rock units, a conspicuous, resistant, sandstone which outcrops as a ledge at the north border of the site; and a shale with siltstone and a channel sandstone which is the foundation of the site. The ledge-forming sandstone is a 14 ft thick, medium-grained quartzose sandstone that has massive bedding, except at the top where 4 inch thick beds were evident, some of which, displayed high-angle, planar cross-bedding. Sandstone color ranges from iron oxide red to light gray. The weathered surface of the sandstone has isolated granules of cemented sand grains. The sandstone is weakly cemented with silica. Bedding orientation of the sandstone is strike N. 85^{o} W. (the direction of a line at the intersection of the sandstone strata with a horizontal plane, 85^{o} west of north) and dip (amount of inclination of the strata and downward direction) 5^{o} S. The sandstone is highly jointed (fractured without being displaced, along repetitive, parallel planes) with 4 prominent, well-displayed, joint sets and 2 minor ones (Attachment 5).

The color of the shale unit varies from chocolate-red to greenish gray. The shale is fizzle and highly fractured into fragments from a few tenths of an inch to 4 inches in diameter. The shale is in conformable contact with the overlying sandstone ledge. Siltstone and sandstone beds were deposited within the shale approximately 30 feet below the sandstone ledge contact. Siltstone color ranges from mottled dark red to greenish gray and fractures into clasts up to 1.5 ft in diameter by 1-2 inches thick, the average bed thickness range. The channel sandstone is a light brown, medium-grained, quartzose sandstone with high-angle, planar crossbeds. The entire shale unit is reactive to hydrochloric acid. Joints in the shale unit consist of two sets almost perpendicular to each other at different orientations than the joints in the overlying sandstone (Attachment 5).

GEOLOGIC HAZARDS

There are two geologic problems that can easily be engineered around but should be considered during design and construction of the water tank. First, headward erosion by the two opposing drainages during the rainy seasons will eventually decrease the usable size of the saddle which is presently about 50 ft wide. The drainages are normally dry, however cloudburst events would easily erode the soil which has little vegetative cover. Heavy equipment access to the site may be limited. Second, the bedrock is highly jointed and possibly faulted. There are vertical joint sets in the shale and sandstone ledge that are perpendicular to each other, this, combined with the basically horizontal bedding plane, yields blocky planes of weakness. In addition, some joint sets in the sandstone ledge may cause wedge failures. Retreat of the sandstone ledge with concomital expansion of the talus unit will probably only affect site maintenance. Jointing of the shale unit which will serve as the foundation of the tank will likely cause problems only during construction, if an excavation is made for the tank. A willow-filled depression in the channel sandstone indicates the presence of a spring or a leak in the existing tank. No flowing or standing water was evident, but, if a spring is there, it may cause some construction problems. A report by the Seismic Safety Advisory Council for the State of Utah shows that critical facilities in the study area should conform to seismic zone UBC-2 (Ward, 1979).

CONCLUSIONS

The site shows no geologic problems that cannot be engineered around, provided that they are recognized, i.e., erosion of the site, and rock wall failures due to the highly fractured character of the bedrock which may cause a nuisance during construction and maintenance of the tank. Because of the unknown design of the facility, underground or above ground, 1 or 2 million gallons; specific recommendations cannot be made. A competent engineering firm should be obtained for design and construction at the site.

REFERENCES

Doelling, H. H., Davis, F. D., and Brandt, Cynthia, 1986, The geology of Kane County: Utah Geological and Mineral Survey Open-File Report No. 97, 200 p.

Montgomery, S. B., 1986, Hydrogeologic report Hildale-Colorado City culinary improvements project: report for Sunrise Engineering Inc., Fillmore, Utah, 8 p.

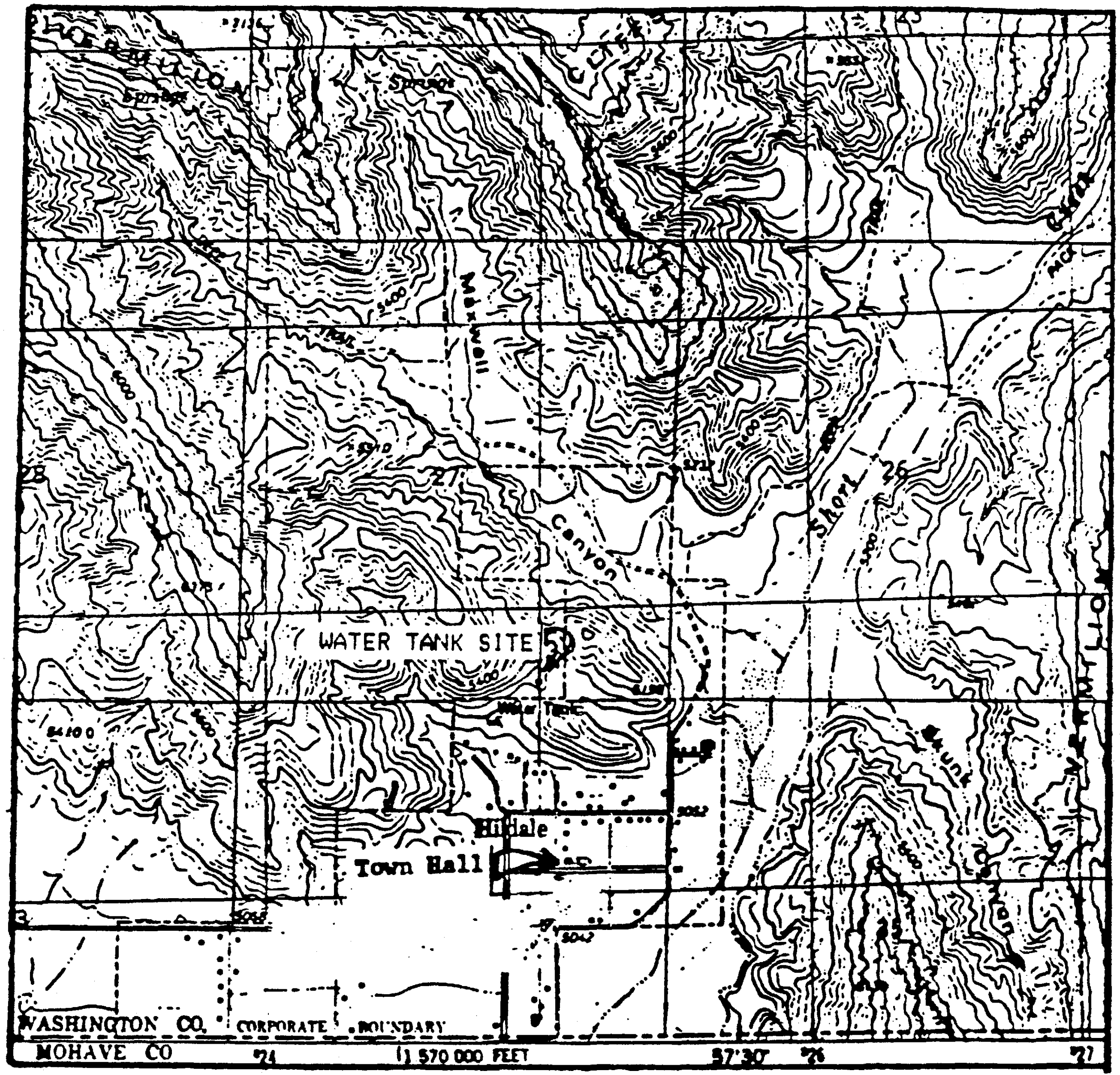
Pillmore, C. L., 1956, Photogeologic map of the Springdale SW Quadrangle, Kane and Washington Counties, Utah, Mohave County, Arizona: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-132, scale 1:24,000.

Stokes, W. L., 1963, Triassic and Jurassic formations of southwestern Utah: in Heylmun, E. B., editor, Guidebook to the Geology of Southwestern Utah, Intermountain Association of Petroleum Geologists Twelfth Annual Field Conference, p. 60-64.

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

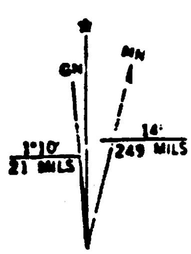
Attachment 1, Job No. 87-008 (WS-3)

Base map from USGS 7 1/2' topographic quadrangle, Hildale, Utah

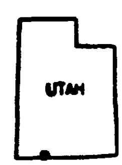


INDEX AND LOCATION MAP

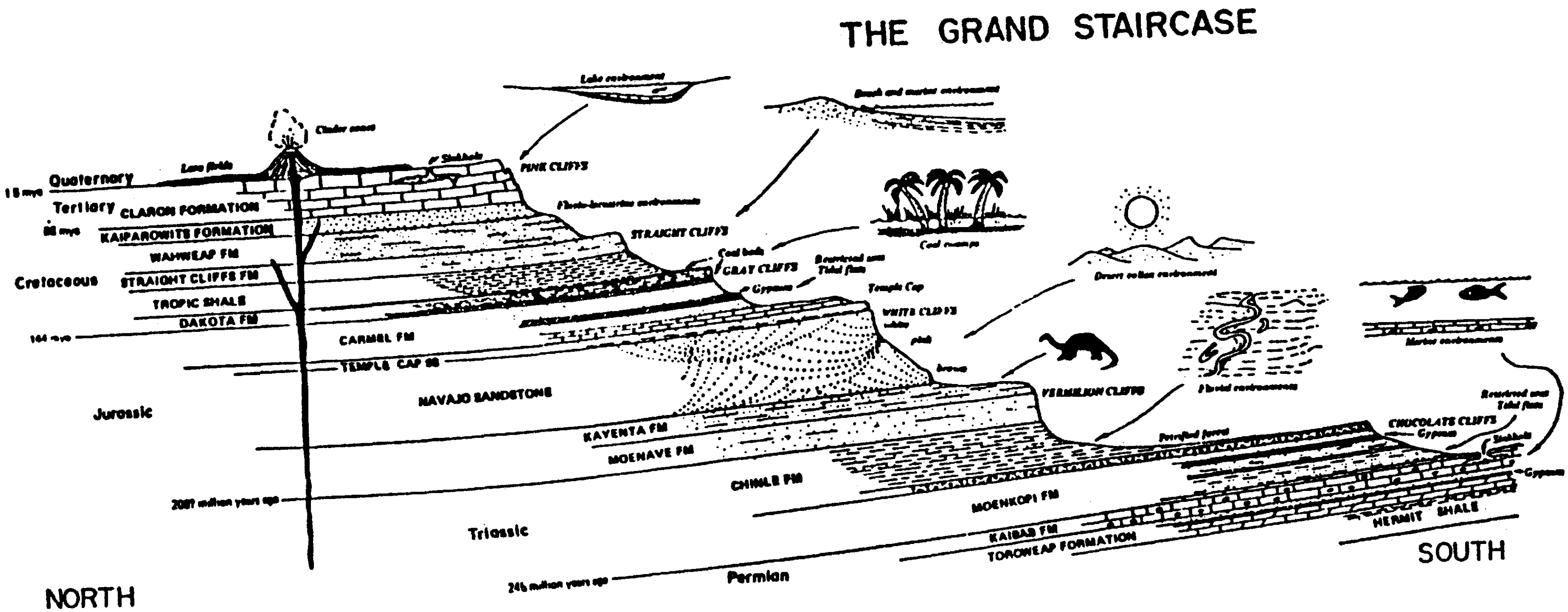
SCALE 1:24 000



UTM GRID AND 1980 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

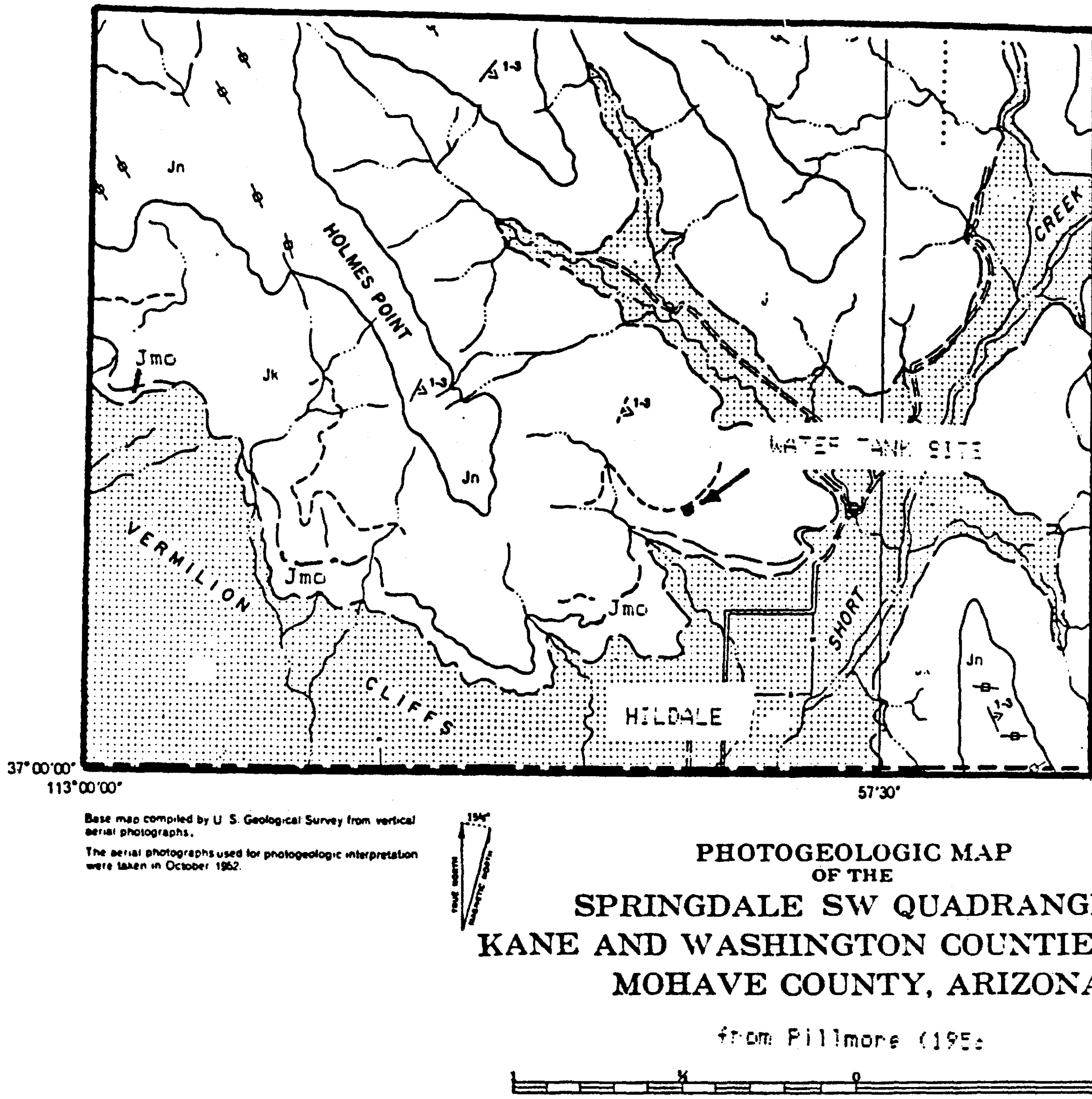


QUADRANGLE LOCATION



Diagrammatic cross-section of the Grand Staircase, southwestern Utah.

(Doelling, H. H., and others, 1986)



Base map compiled by U. S. Geological Survey from vertical aerial photographs.

The aerial photographs used for photogeologic interpretation were taken in October 1952.

PHOTOGEOLOGIC MAP OF THE SPRINGDALE SW QUADRANGLE KANE AND WASHINGTON COUNTIES, UTAH MOHAVE COUNTY, ARIZONA

from Pillmore (195

Contact
Can be located within 30 feet horizontally.

Contact
Can be located within 30 to 200 feet horizontally.

Contact
Cannot be located accurately, probable error greater than 200 feet horizontally.

Resistant bed within a formation
May be traceable only locally

Strike and dip of beds
Computed by photogrammetric methods.

Approximate strike and dip of beds
Based on photointerpretation.

Inferred strike and dip of beds
Based on photo interpretation of areas where bedding is obscure.

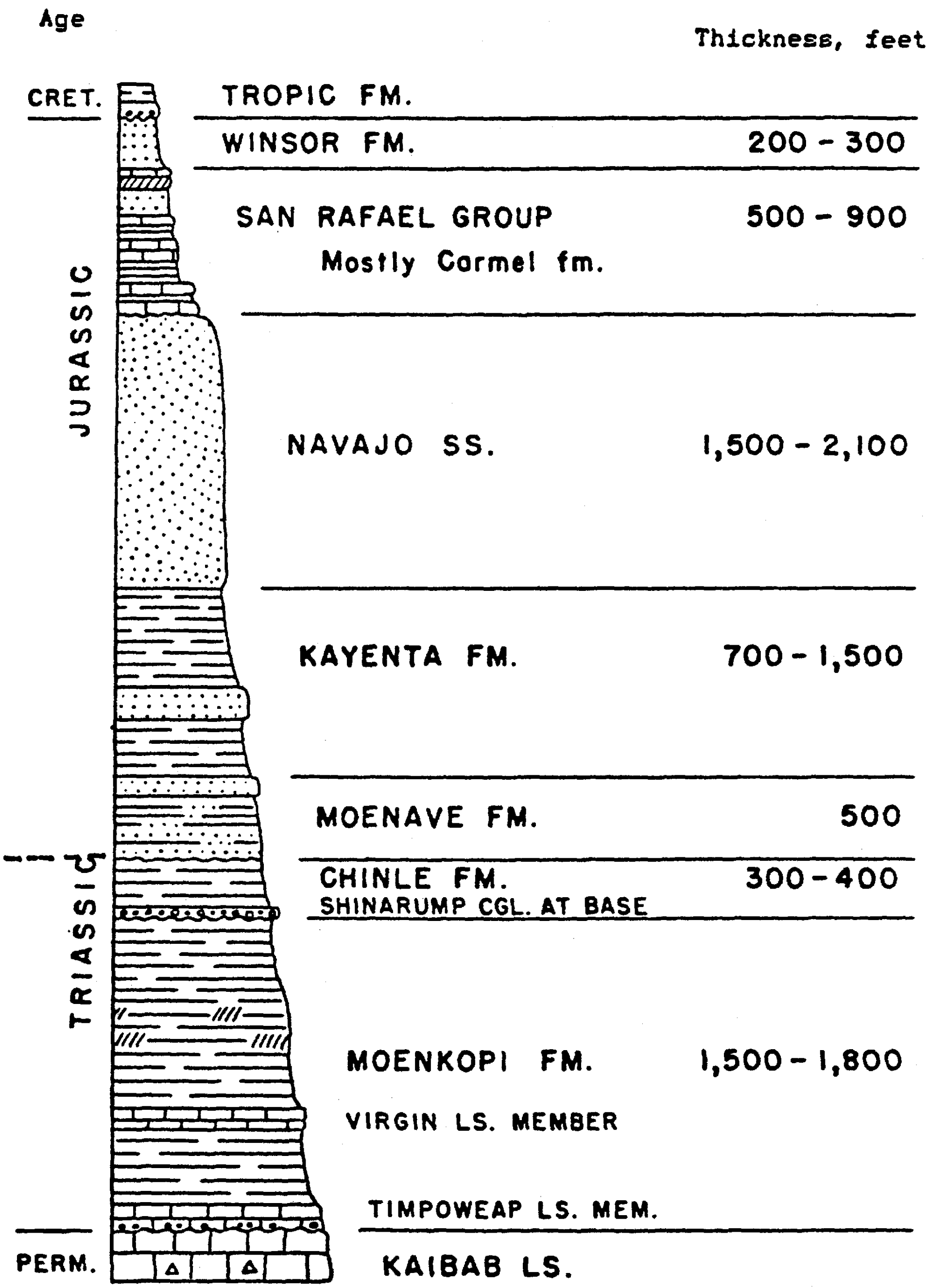
Strike of approximately vertical joints
Based on photo interpretation.

Linear feature uninterpretable on photograph
May be geologically significant.

Stratigraphic Column

Jn: Jurassic Navajo Sandstone
Jk: Jurassic Kayenta Formation
Jmo: Jurassic Moenave Formation

Geologic map of the Hildale area.

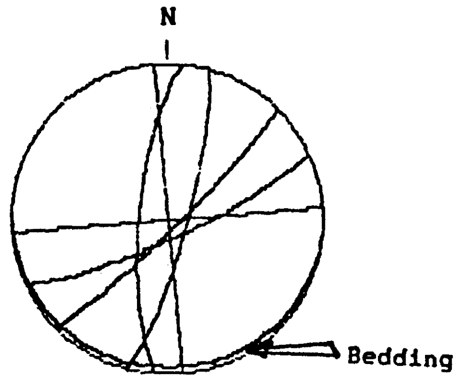


GENERALIZED ROCK COLUMN

(Stokes, W. L., 1963)

Joint orientations in ledge-forming sandstone unit.

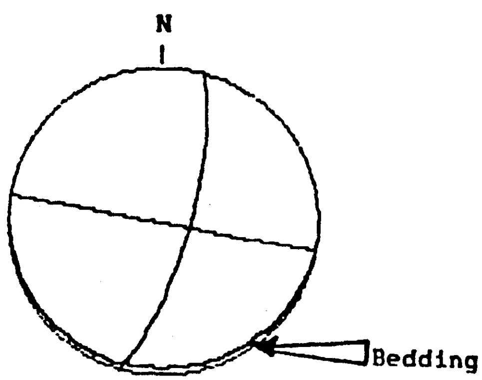
n = 7



Schmidt net, lower hemisphere projection

Joint orientations in shale unit.

n = 10



Kayenta Formation, ledge-forming sandstone unit:

Prominent Joints:

N. 65° E., 80° S., wavy joint planes, joint plane spacing approximately 4 ft, joint plane separation is loose, calcite infilling up to 0.1 inch thick.

N. 85° E., vertical, wavy joint planes, joint plane spacing approximately 3 ft, joint plane separation is loose to 2 inches wide, calcite infilling up to 0.1 inch thick.

N. 5° W., vertical, planar joint planes, joint plane spacing approximately 3 ft, joint plane separation is loose.

N. 45° E., 85° N., wavy joint planes, joint plane spacing approximately 6 ft, joint plane separation is loose to 2 inches wide. Two minor joint sets were noted.

Minor Joints:

N. 15° E., 80° E., planar joint planes, joint plane spacing approximately 5 ft, joint plane separation is loose, calcite infilling up to 0.1 inch thick.

N. 5° E., 75° W., planar joint planes, joint plane spacing approximately 2.5 ft, joint plane separation is 4 to 8 inches wide, calcite infilling up to 0.1 inch thick.

Kayenta Formation, shale unit:

Prominent Joints:

N. 15° E., 75° E., planar joint planes, joint plane spacing approximately 1 ft, joint plane separation is loose.

N. 80° W., vertical, wavy joint planes, joint plane spacing approximately 1.5 ft, joint plane separation is loose to an inch wide.

Joint set orientations in Kayenta Formation, water tank site, Hildale, Utah.

Project: Clawson Water Tank Site Evaluation, Emery County				Requesting Agency: Community Impact Board
By: Robert H. Klauk	Date: 11-6-98	County: Emery		Job No.: 87-014 (WS-4)
USGS Quadrangle: Castle Dale (714)				

PURPOSE AND SCOPE

This report presents the results of a Utah Geological and Mineral Survey (UGMS) investigation conducted at the request of the Community Impact Board for a site of a proposed culinary water tank for the town of Clawson in Emery County. The site is located in the NW 1/4 sec. 35, T. 19 S., R. 7 E., Salt Lake Baseline and Meridian (attachment 1).

The purpose of the investigation was to identify geologic hazards that could adversely affect the water tank. The scope of work consisted of a literature review and site reconnaissance that included logging two test pits. Mr. Craig Johansen of Johansen and Tuttle, Inc., the engineering firm involved with the project, was present during the reconnaissance.

SETTING

The site is located approximately 1/2-mile southwest of Clawson on an alluvial terrace approximately 10 feet above a stream channel that flows intermittently to the southeast (attachment 1). This channel drains a small basin, the headward extent of which is less than 1/4-mile to the northwest. Average annual precipitation in this area ranges from 8 to 10 inches (Feltis, 1966). Flow in the channel results from direct precipitation or snowmelt. Vegetation is sparse, consisting of low grasses and sage brush.

GEOLOGY

The alluvial terrace has been deposited on the Blue Gate Member of the Mancos Shale. The underlying bedrock unit consists of gray shale and shaley siltstone with sparse interlayered thin sandstone beds (Witkind and others, 1987). Two test pits had been excavated in the alluvial terrace prior to the site reconnaissance and were available for inspection (attachment 1). Detailed soil logs are presented in attachment 2. Generally, the unconsolidated alluvium exposed in the test pits consisted of subrounded to rounded gravel with silt and sand (GP-GM). Cobbles up to 10 inches in diameter were also present. Lithologies of the course fraction were primarily sandstone, quartzite and limestone. Quartzite and limestone are not present in the Blue Gate Member, but are found in the Price River Formation that crops out 5 miles west of the site (Witkind and others, 1987). Conceivably, the source area for the coarse fraction is the Price River Formation; the material has either been transported to the site directly from this source area or by subsequent erosion from other depositional areas formed by earlier erosion from the Price River Formation. The distance of travel and the amount of reworking accounts for the degree of rounding of the course material and for the absence of clay-sized particles on the site. The unconsolidated alluvium observed in test pits 1 and 2 generally agrees with the logs of two test pits previously excavated by Johansen and Tuttle, Inc. (attachments 3 and 4). The medium plasticity soil noted by UGMS in the upper 1.5 feet of test pit 2 is the result of post depositional soil formation. No bedrock was encountered in test pits 1 and 2 but Johansen and Tuttle encountered bedrock at 6.5 and 9.0 feet in their two pits.

No ground water was encountered in the test pits present during the reconnaissance and no ground water was reported in the test pits logged by Johansen and Tuttle, Inc. Furthermore, no water was present in the drainage channel. Therefore, the ground-water level is at least 10 feet below the surface at the site.

GEOLOGIC HAZARDS

Heaving caused by the hydration of shales and clays when exposed to moisture occurs in certain members of the Mancos Shale (Hepworth, 1963). This has been reported as occurring in the Blue Gate Member. The alluvial terrace is immediately adjacent to an active drainage. Lateral erosion of the drainage channel could eventually undermine the tank foundation. The Clawson area is in both Uniform Building Code (UBC) and Utah Seismic Advisory Council (USSAC) seismic zone 2 with the nearest mapped Quaternary fault 12 miles to the northwest (Anderson and Miller, 1979). This indicates the site is in an area where an earthquake of modified Mercalli intensity VII can be expected.

CONCLUSIONS AND RECOMMENDATIONS

The site for the proposed water tank is suitable provided the following potential hazards are taken into account. The alluvial terrace overlies the Blue Gate Member of the Mancos Shale which could potentially swell if wet. To minimize potential heaving of the Blue Gate, the overlying alluvium must be kept at a maximum thickness and care must be taken to prevent leaks from the tank as well as incoming and outgoing water lines. The total foundation must be kept on the alluvium but at a maximum distance from the channel embankment to reduce potential undermining. Rip-rap may be needed at some future date to prevent erosion. The site is in UBC and USSAC seismic zone 2. The foundation should be constructed to meet UBC seismic requirements for zone 2.

REFERENCES CITED

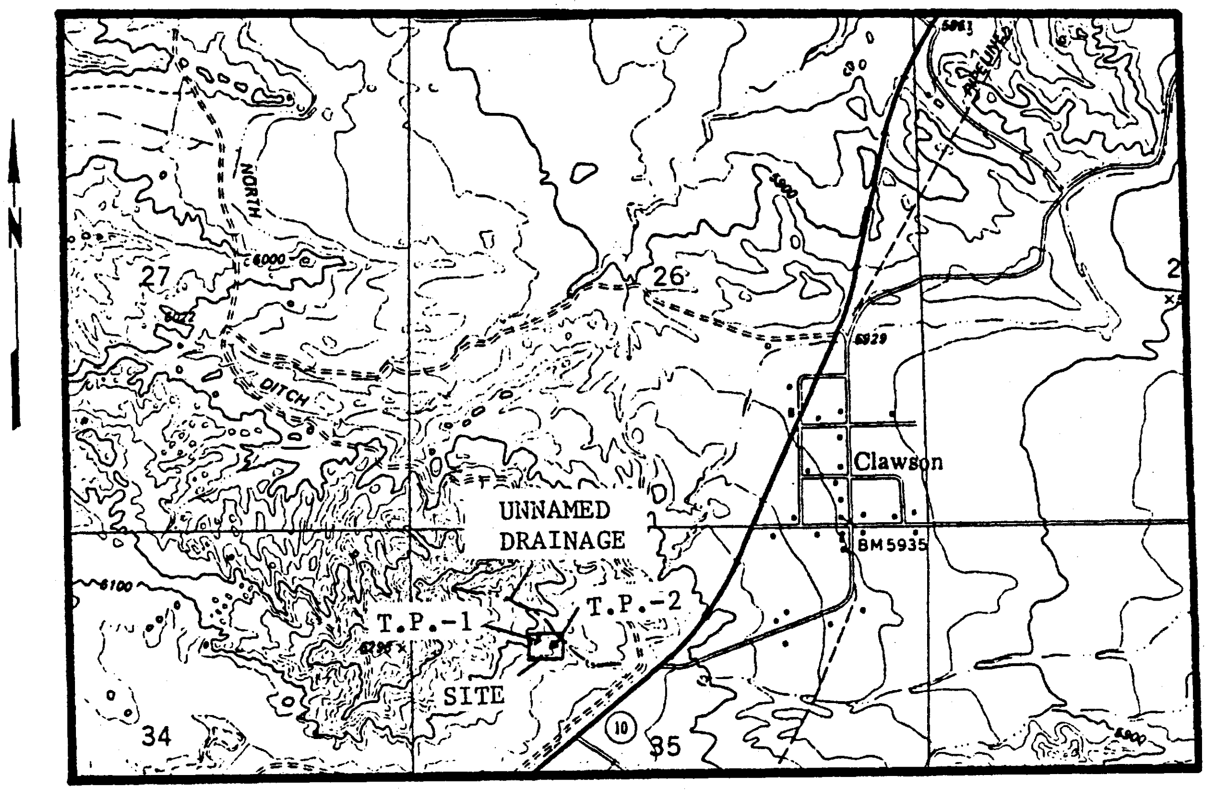
Anderson, L.W. and Miller, D.G., 1979, Quaternary fault map of Utah: Long Beach, California, Fugro Inc., scale 1:500,000.

Feltis, R.D., 1966, Water from bedrock in the Colorado Plateau of Utah: Utah Department of Natural Resources Technical Publication No. 15, figure 2.

Hepworth, R.C., 1965, Heaving in the subgrade of highways constructed on the Mancos Shale: Salt Lake City, University of Utah M.S. Thesis, 98 p.

Witkind, I.J., Weiss, M.P., and Brown, T.L., 1987, Geologic map of the Manti: 30' x 60' Quadrangle, Carbon, Emery, Juab, Sanpete, and Sevier Counties, Utah: U.S. Geological Survey Miscellaneous Investigation Map I-1631, scale 1:100,000.

R. 7 E.



Base map from: USGS 7.5' topo quad.
Castle Dale, Utah

Scale 1:24,000

Contour Interval 20 feet

LOCATION MAP

Utah Geological and Mineral Survey — Site Investigation Section

Logs of Test Pits *

<u>Test Pit 1</u>

0.0'-5.0'	<u>Poorly graded gravel with wilt and sand (GP-GM)</u>; light gray, high density, non-plastic, dry; subrounded to rounded, heterogeneous, no cementation, strong reaction with HCL, cobbles to 10 inches; clasts consist of sandstone, quartzite, and limestone; terrace alluvium.

<u>Test Pit 2</u>

0.0'-1.5'	<u>Silty, clayey, gravel with sand (GC-GM)</u>; light gray, medium density, medium plasticity, dry; subrounded to rounded, heterogeneous, no cementation, strong reaction with HCL, cobbles to 6 inches; clasts consist of sandstone, quartzite, and limestone; numerous roots; poorly formed soil on terrace alluvium.
1.5'-4.0'	<u>Poorly graded gravel with silt and sand (GP-GM)</u>; light gray, high density, non-plastic, dry; subrounded to rounded, heterogeneous, no cementation, strong reaction with HCL, cobbles to 8 inches; clasts consist of sandstone, quartzite, and limestone; terrace alluvium.

* Soils classified in accordance with procedures outlined in ASTM Standard D 2488-84, Description and Identification of Soils (Visual Manual Procedure).

Johansen & Tuttle ENGINEERING, INC.
BOX 487 • CASTLE DALE, UTAH 84513 • TELEPHONE (801) 748-2523

VISUAL SOIL CLASSIFICATION

PROJECT	LOCATION	SAMPLED BY	TESTED BY
Clawson Water tank	Clawson Ut.	CEJ	

INDENTIFICATION				COARSE FRACTION					FINE FRACTION					TOTAL SOIL			CLASSIFICATION	
TESTING SECTION SAMPLE NO	TEST PIT NO.	FIELD SAMPLE NO	DEPTH IN FEET	MAXIMUM SIZE (MM)	GRAV (PLUS #4)	SAND (#4 to #200)	PARTICLE SHAPE	PARTICLE CONDITION	FINES MINUS (#200)	PLASTICITY	DRY STRENGTH	DILATANCE	REACTION TO BENZIDINE	ORGANIC ODOR (WET)	REACTION TO HCL	COLOR (WET)	DESCRIPTION (Descriptive classification, grading, structure, consistency, moisture condition, inclusions etc.)	GROUP SYMBOL
			0 to 6.5	6"	60%	30%	SR		10%	LP	m	m		N/A	+		Sandy Gravel.	GP
			6.5 to 8.0												+		Bedrock shale	

Remarks

Signature Craig E. Johansen

Date 7-9-87

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VISUAL SOIL CLASSIFICATION

PROJECT	LOCATION	SAMPLED BY	TESTED BY
Clawson water tank	Clawson, utah.	CEJ	

INDENTIFICATION				COARSE FRACTION					FINE FRACTION					TOTAL SOIL			CLASSIFICATION	
TESTING SECTION SAMPLE NO	TEST PIT NO.	FIELD SAMPLE NO	DEPTH IN FEET	MAXIMUM SIZE (MM)	GRAV (PLUS #4)	SAND (#4 to #200)	PARTICLE SHAPE	PARTICLE CONDITION	FINES MINUS (#200)	PLASTICITY	DRY STRENGTH	DILATANCE	REACTION TO BENZIDINE	ORGANIC ODOR (WET)	REACTION TO HCL	COLOR (WET)	DESCRIPTION (Descriptive classification, grading, structure, consistency, moisture condition, inclusions etc.)	GROUP SYMBOL
	2		0 to 4.5	6"	60	30	SR		15	LP	m	m		None	+		Sandy Gravel	GP
			4.5 to 9.0	6"	60	35			5-7%	LP	m	m'		None	+		Sandy Gravel	GP
			9.0 to 9.5												+		Bedrock (shale)	

Remarks

Signature Craig E. Johansen

Date 7-9-87

Project:			Requesting Agency:
Sterling Spring Study Water Line Hazard Investigation			Community Impact Board
By: Robert H. Klauk	Date: 11-9-87	County: Sanpete	Job No.: 87-015 (WS-5)
USGS Quadrangle: Sterling (719)			

This report presents the results of a Utah Geological and Mineral Survey (UGMS) investigation requested by the Community Impact Board with regard to the replacement of sections of two pipe lines supplying culinary spring water to the town of Sterling, Utah. The sections being replaced were destroyed by landslides during the wet cycle that commenced in 1983.

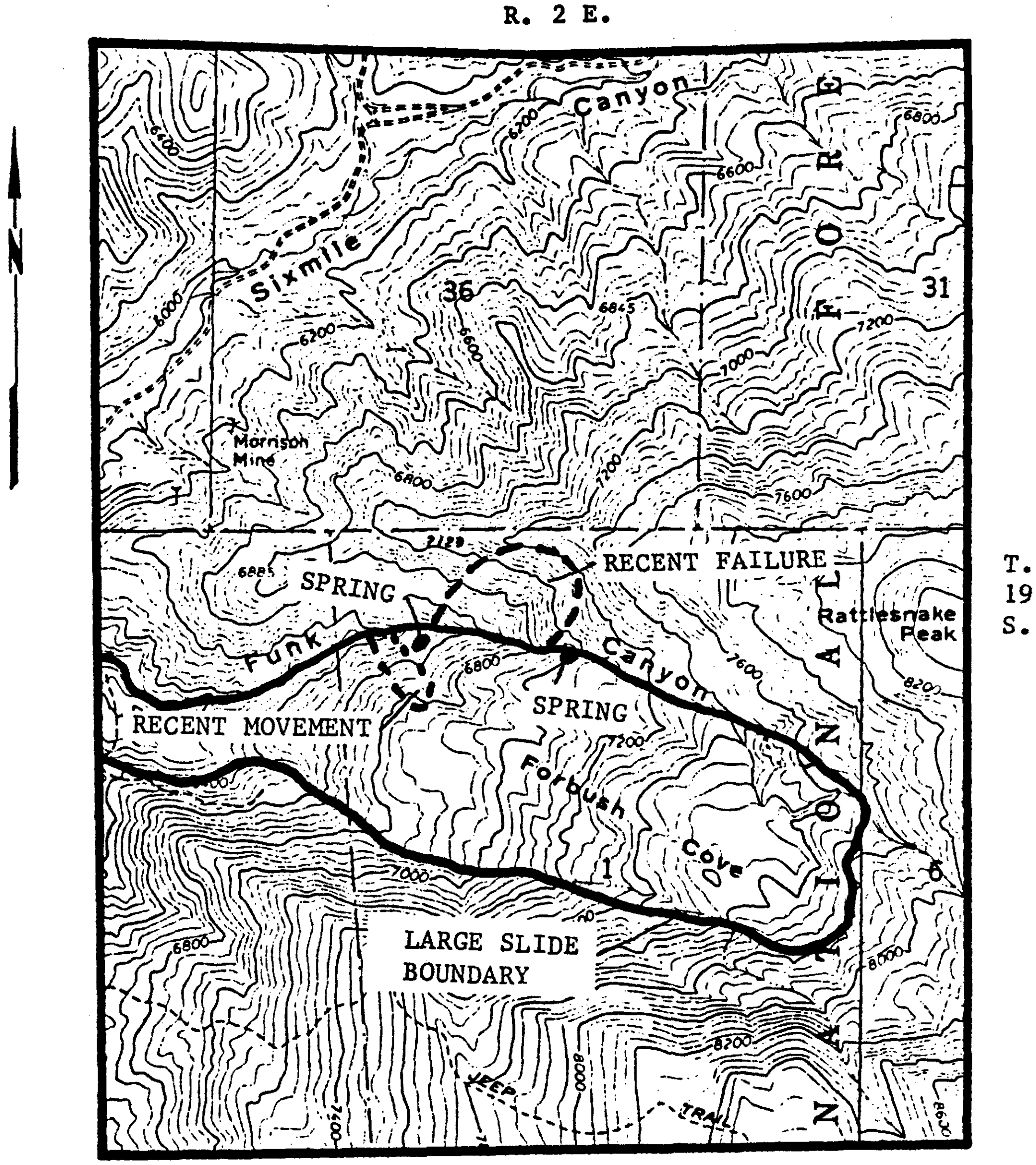
The purpose of the investigation was to examine the present location of the culinary water lines, assess the landslide hazard, and determine if the lines could be realigned to reduce or eliminate the hazard. The scope of work included a literature review and reconnaissance of the area.

Part of the culinary water supply to Sterling consists of two springs in Funk Canyon. These springs are located approximately 2.5 miles to the east of Sterling (attachment 1). They are located within a huge landslide complex that has formed the interfluve between the Funk Canyon perennial drainage and an unnamed parallel, intermittent drainage to the south. These two springs may owe their present locations to this landslide activity. The large slide mass is composed of failed North Horn Formation which is marked by slumps, earthflows, and landslides throughout Utah. Part of this complex reactivated and destroyed the line coming from the lower (western) spring. A previously undisturbed section of the North Horn Formation on the north side of Funk Canyon failed and destroyed part of the line coming from the upper (eastern) spring. Collection boxes for both springs were not disturbed.

The two springs in Funk Canyon are within a large landslide complex consisting of failed North Horn Formation. Parts of this complex will likely continue to move in the future. Realigning the water lines would involve expensive pumping and still would not preclude crossing hundreds of feet of unstable ground and potential failure. Therefore, the present method of not burying replacement pipe for the failed sections appears to be the most feasable. It will save replacement costs now and also in the future.

REFERENCES CITED

Witkind, I.J., Weiss, M.P., and Brown, T.L., 1987, Geologic map of the Manti: 30' x 60' Quadrangle, Carbon, Emery, Juab, Sanpete, and Sevier Counties, Utah: U.S. Geological Survey Miscellaneous Investigation Map I-1631, scale 1:100,000.



Base map from: USGS 7.5' topo quad, Sterling, Utah

Scale 1:24,000

Contour Interval 40 feet

LOCATION MAP

Solid Waste Disposal

Project: Sanpete County Landfill Site near Spring City, Utah			Requesting Agency: Ephraim City
By: William F. Case	Date: Aug. 13, 1987	County: Sanpete	Job No.: 87-010 (SW-1)
USGS Quadrangle: Chester (800)			

PURPOSE AND SCOPE

On the 6th of July, 1987, Ephraim mayor Robert Warnick contacted William F. Case, Utah Geological and Mineral Survey (UGMS), and requested a geologic investigation of a landfill site on Highway 89, east of Chester and south of Spring City, Sanpete County. The site was inspected in April, 1985, by William K. Montague who is with the Utah Department of Health and George N. Johansen, of the Central Utah Health District. Creamer and Noble, consulting engineers, recommended two landfill sites in the vicinity; site A, south and east of Moroni, about 3 miles to the northwest of the present proposed landfill area; and site B, south of Wales, 5 miles west of the proposed landfill area (Creamer and Noble, 1983). Case (1986) investigated a landfill site (Lund property) about 10 miles southwest of the present proposed landfill site. Bagford's private landfill operation is within 1/4 mile west of the proposed site. The purpose of the landfill is to serve as a regional disposal site for all Sanpete County refuse. This would permit closure of several small dumps, many of which burn refuse, located throughout the county.

This investigation involved a literature search, water well log compilation, and a site inspection which included soils logging of two test pits. Water well logs of wells in the vicinity were obtained from the Department of Natural Resources, Division of Water Rights well library. The site was visited on the 31rst of July, 1987 accompanied by mayors of all the northern Sanpete County communities except for Fairview, Manti, and Mount Pleasant; and George Johanson and Roger Foisy of the Central Utah District Environmental Health office.

Location and site conditions

The 70 acre landfill site is approximately 4 miles north of Ephraim and 8 miles south of Mount Pleasant, on US Highway 89. The Bagford private landfill establishment is within 1/4 mile west of the area. The site consists of two land parcels, the largest, eastern, parcel covers approximately 50 acres in NW 1/4 NE 1/4 sec. 11, T. 16 S., R. 3 E., SLBM, and the smaller, western, land unit occupies half of the southeast quarter of the southwest quarter of section 2 of the same township (Attachment 1). An abandoned Denver and Rio Grande railroad grade and highway 89 and a triangular-shaped land parcel owned by the Utah Division of Wildlife define the eastern border of the landfill site. The eastern parcel is located on coalesced alluvial fans deposited at the mouths of small ephemeral drainages which issue from small cuestas, hills formed by sloping bedrock, which lie directly east of the site, across highway 89. The fans have 3 percent slopes toward Oak Creek, 1.5 miles to the west. The western parcel is part of the Sanpete Valley alluvial plain. No drainage was evident on the surface of the western parcel which has a 1.5 percent slope but the eastern parcel had small, 2-3 ft channels. Oak Creek is a tributary of the San Pitch River, the trunk drainage of Sanpete Valley. Drainage on the Sanpete valley floor west of the site is poorly defined and consists of perennial, intermittent, and abandoned channels; flowing wells and springs; and permanent and ephmeral ponds. Elevations of the Sanpete Valley alluvial plain range from 5450 ft at the San Pitch River to about 5500 ft within the western site parcel. The Wasatch Plateau lies 4.5 miles to the east. Elevations at the site range from approximately 5490 ft at the western parcel to 5580 ft at the eastern parcel.

Vegetation on site consists mainly of sagebrush up to 3 ft high, greasewood at the toes of the alluvial fans, and shadscale on the western parcel. Underbrush consisted of crested wheat and grasses. It appears that the western parcel was grazed. Swenson and others (1981) have classified the site as semi-desert loam to semi-desert stony loam range site.

Geology and Soil Classification

The site is in the Basin and Range-Colorado Plateau physiographic province transition zone. The geology of the area reflects characteristics of both physiographic provinces. That is, the mountain ranges consist of thrust-faulted bedrock bounded by range front normal faults similar to those found in the Basin and Range province to the west of the site. Uplifted, slightly dipping bedrock structures characteristic of the Colorado Plateau province are found in the Wasatch Plateau, east of the study area. Bedrock of both the Wasatch Plateau and the San Pitch Mountains consists of Mesozoic Era (245 to 66 million years ago) and Tertiary Period (66 to 1.6 million years ago) sandstones, mudstones, and limestones characteristic of the Colorado Plateau province (Witkind and others, 1982). The geologic structure of the mountains, plateaus, and valley surrounding the landfill site is the result of a complex history of thrust faulting in Mesozoic and Early Tertiary time, separation and normal faulting throughout Tertiary time, and finally Late Tertiary and Quaternary (1.6 million years ago to present) folding of bedrock due to upward squeezing of Mesozoic age salt deposits under the weight of the overlying sedimentary rock (Witkind, 1982; Villien, 1984). The cuestas directly east of the site are composed of fresh-water limestones and shales of the Green River Formation which slid off the Wasatch Plateau during the Late Tertiary/Quaternary folding.

Only three water wells with lithology logs on record with the Division of Water Rights were drilled in the area. Bagford's well is located in section 11, which contains the eastern parcel, and two wells (aaa and dad on Attachment 1) were drilled in section 3 directly downslope of the section which contains the western parcel (Attachment 1). The logs indicate a gravel bed at a depth of 60 to 105 feet which yields water (Attachment 2). Silt, sandy clay, and white bentonitic clay overlie the gravel up to the ground surface (Attachment 2). The thickness of the unconsolidated material at the site is not known but can be estimated. Bedrock (shale) is encountered at a depth of 105 ft in Bagford's well (Attachment 2) and crops out approximately 1600 ft east of highway 89. If the bedrock slope is projected from the surface exposure to 105 ft at Bagford's well, depth of bedrock below the landfill parcels ranges from about 30 to 65 ft. The sites should be bored to determine exact bedrock depths. Attachment 3 lists the engineering soil log of the test pits excavated at the site. Soil in the 14 ft deep eastern parcel test pit consisted of 12 3/4 ft of sandy silt (ML) with less than 10 percent cobble to boulder gravel, 11 inches of well-graded granule to pea gravel with silt and sand

(GW-GM), and 4 inches of moist silty sand (SM) at the bottom. A test pit in the western parcel exposed 11 ft of sandy silt (ML) with rare 4-6 in thick beds of well-graded coarse sand with silt and granule gravel (SW-SM).

The USDA Soil Conservation Service description and characteristics of the upper 60 inches of soil are taken from the Soil Survey of Sanpete Valley Area (Swenson and others, 1981). Two soils have formed on the eastern parcel site, Quaker silty clay loam in the western portion and Lisade-Sanpete complex in the eastern portion (Attachment 4). The Quaker silty clay loam is a well-drained alluvial soil derived from limestones and shale and forms on 2-5 percent slopes of alluvial fans and alluvial plains. The Lisade-Sanpete complex is mostly Lisade loam with lesser amounts of Sanpete gravelly fine sandy loam. The soil complex consists of soils derived from sandstone, limestone, and shale and form on 2-5 percent slopes of alluvial fans. Quaker silty clay loam which forms on 1-2 percent slopes of alluvial fans and alluvial plains occurs on the western parcel (Attachment 4). Swenson and others (1981) indicate that the rapid permeability (2.0-6.0 in/hr) of Lisade-Sanpete soil complex presents a severe limitation for use as sanitary landfill whereas the slow permeability (0.2--0.6 in/hr) of the Quaker soils allows only a moderate limitation to use as landfill. As indicated on Attachment 4, the Lisade-Sanpete complex (LFC2) only occurs in the eastern 1/3 of the eastern parcel. Soils at the site may present a dust hazard because of their fine-grained constituents.

Hydrology

The landfill site is probably a partial recharge area for a gravel aquifer that lies close to bedrock. Two of the well logs in Attachment 2 indicate a water-bearing gravel in the 60-100 ft and 70-100 ft interval, unfortunately drilling stopped at 100 ft and there is no indication of the depth of bedrock. Bagford's well log reports a yellow lime gravel from 97-105 ft which lies directly on a greenish brown shale. Water must be obtained from the shale or as leakage from the gravel above because the well was cased (unperforated) to a depth of 122 ft, 17 ft into the shale bed. The hydraulic gradient must be upward, the static water level in Bagford's, cased, well is 12 ft below the surface and Robinson (1968) mentions a flowing well near a spring 3/4 mile north of the site (abb on Attachment 1). The annual precipitation ranges from 8-12 inches (Swenson and others, 1982). There is what appears to be a man-made ditch approximately 2 ft deep which parallels contours as it runs south-north through the eastern parcel. The ditch evidently collects surface water from an ephemeral lake at Pigeon Hollow Junction and from small drainages issuing from the hills to the east. There was nothing to indicate that the ditch had held water within the last few years. One of the drainages from a small, 1/4 mile^2 basin with a relief of 678 ft in the hills to the east flows through the site. Flash floods could reach the site from this drainage, there is no evidence of past flooding.

According to Swenson and others (1982), the runoff of the Quaker soil in the western parcel is slow to rapid and in the eastern parcel is medium. Runoff of the Lisade-Sanpete complex is medium to rapid. Erosion hazards range from slight to severe for the Quaker soils and severe to very severe for the Lisade-Sanpete complex.

Conclusions and Recommendations

Geologically the site should serve as an adequate landfill area. It is unlikely that large amounts of leachate will form in the fill unless surface water or shallow ground water is allowed to enter refuse disposal trenches. The gravel aquifer, down-gradient of the site, should be monitored for contamination. Bagford's well should probably be monitored particularly because of the possibility of contamination from his private landfill. The site contains adequate soil to provide cover material with a fair to good compactibility although the presence of clay may cause workability problems when wet and dust problems when dry (Swenson and others, 1982). The high permeability of the Lisade-Sanpete soil complex should limit landfill uses in the eastern 1/3 of the eastern parcel. Reseeding the cover to control erosion may be a problem because of the high alkalinity of the soils. The site does not have the extensive gulleying that the Lund site has (Case, 1986).

Surface water which originates off the property, from the ephemeral channel to the east, should be diverted from the site. Precipitation and snowmelt water on the site should not be allowed to pond and should be routed off the property without causing gullying of cover material. Soils in the western portion of the eastern parcel and the entire western parcel are more suited for use as landfill. Bagford's landfill site to the south is a example of the workability of the soils. A 9 foot or less excavation depth should be maintained for refuse disposal trenches because the deepest test pit was 14 ft and soils are to be inspected at least 5 ft below the excavation. It is recommended that shallow wells be drilled to monitor any perched water to maintain a 5 foot separation between refuse and ground water (Brunner and Keller, 1972) and to monitor ground water-quality.

REFERENCES

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Clyde, C. G., Jensen, S. F., Johnson, B. T., and Olds, J. D., 1986, Solid waste, in Barnes, R. P. and Croft, M. G., ed., Ground water quality protection strategy for the State of Utah: Utah Department of Health, 115 p.

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EPA, 1971, Guidelines for local governments on solid waste management: U.S. Environmental Protection Agency Report SW-17c, 184 p.

Harty, K. M., 1985, Geologic evaluation of a proposed landfill site in Weber County, Utah: Utah Geological and Mineral Survey Report of Investigation No. 203, 18 p.

Robinson, G. B., Jr., 1968, Selected hydrologic data: San Pitch River drainage basin, Utah: U.S. Geological Survey and Utah Dept. of Natural Resources, Division of Water Rights Utah Basic-Data Release No. 14, 44 p.

Swenson, J. L. Jr., Beckstrand, Delyle, Erickson, D. T., McKinley, Calvin, Shiozaki, J. J., and Tew, Ronald, 1981, Soil survey of Sanpete Valley area, Utah, parts of Sanpete and Utah Counties: U.S. Department of Agriculture, Soil Conservation Service, 179 p.

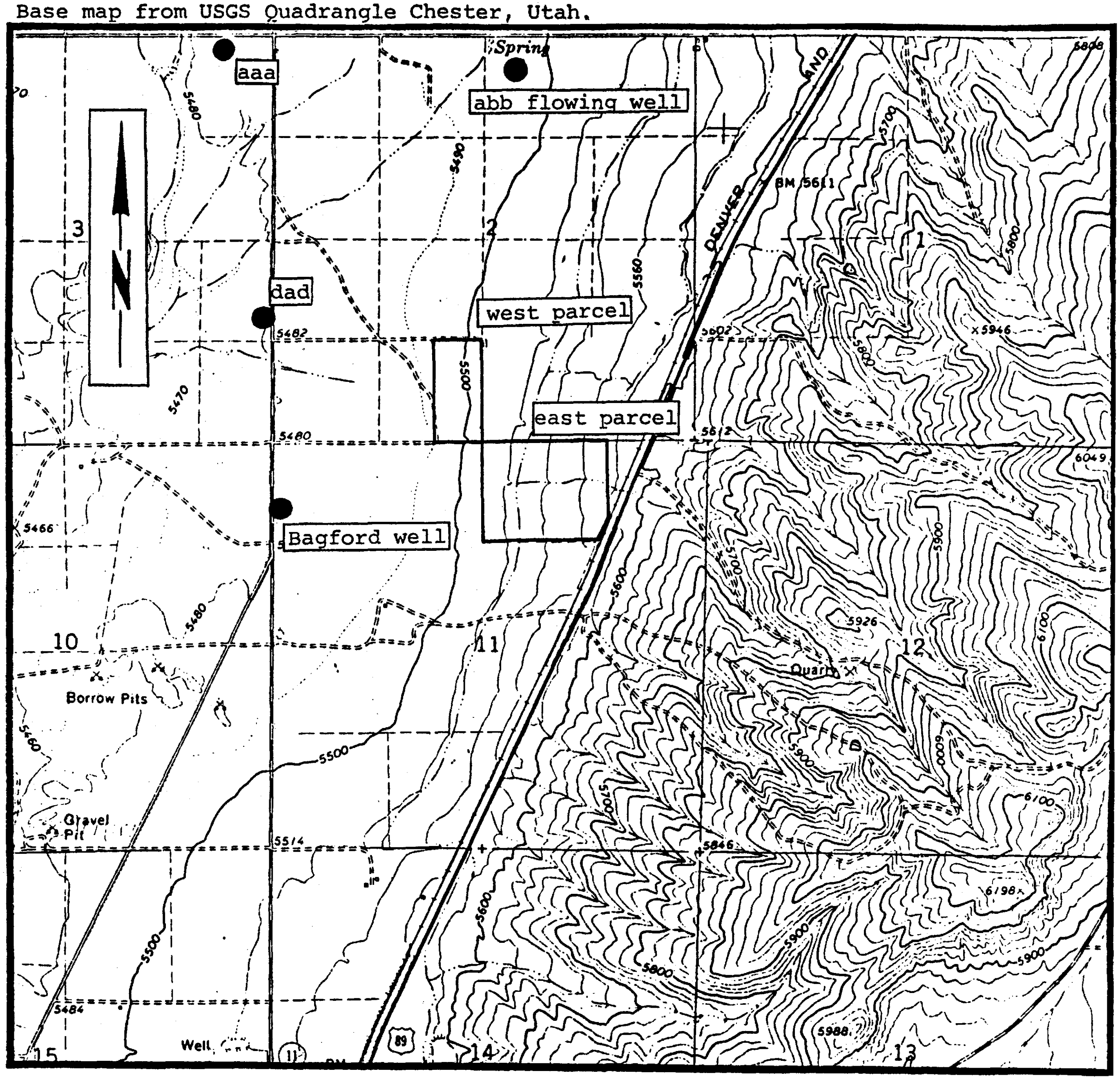
Villien, Alain, 1984, Central Utah deformation belt: University of Colorado, PhD dissertation, 283 p.

Witkind, I. J., 1982, Salt diapirism in central Utah, in Nielson, D. L., ed., Overthrust belt of Utah, 1982 symposium and field conference: Salt Lake City, Utah Geological Association Publication 10, p. 13-30.

----, Weiss, M. P., and Brown, T. L., 1982, Preliminary geologic map of the Manti 30' X 60' Quadrangle, Carbon, Emery, Juab, Sanpete, and Sevier Counties, Utah: U.S. Geological Survey Open-File Report 82-654, scale 1:100,000.

Attachment 1, Job No. 87-010 (SW-1)

Base map from USGS Quadrangle Chester, Utah.



Index map and location of landfill site.

Scale

1" = 2000'

Utah Geological and Mineral Survey

Site Investigation Section

Attachment 2, Job No. 87-010

WATER WELL LITHOLOGY LOGS NEAR SPRING CITY LANDFILL SITE.

Water Wells (USGS nomenclature)

Depth Feet	D-16-3 03 dad	D-16-3 03 aaa	D-17-3 11 bbc (Bagford well)
			SOIL
	UN-STABLE		———
10		SILT	
	SILT		
20	SANDY	CLAY	CLAY
30	CLAY	SAND	WITH
40	———	———	SAND
50	BENTO-NITIC CLAY	BENTO-NITIC CLAY	———
60	———		SANDY
70	CLAY	———	CLAY
	WITH		
80		CLAY	
	GRAVEL	WITH	
90		GRAVEL	
	WATER	WATER	———
100	———	———	GRAVEL
			———
			SHALE
TOTAL DEPTH (Ft) of well	100	100	200

notes: Locations are plotted on attachment 1.
Logs of water wells from Utah Division of Water Rights.

Attachment 3, Job No. 87-010

TEST PIT SOIL LOGS*

SANPETE COUNTY LANDFILL SITE

SECTIONS 2 & 11, T16S, R3W

SANPETE COUNTY, UTAH

TEST PIT #1: Eastern Parcel

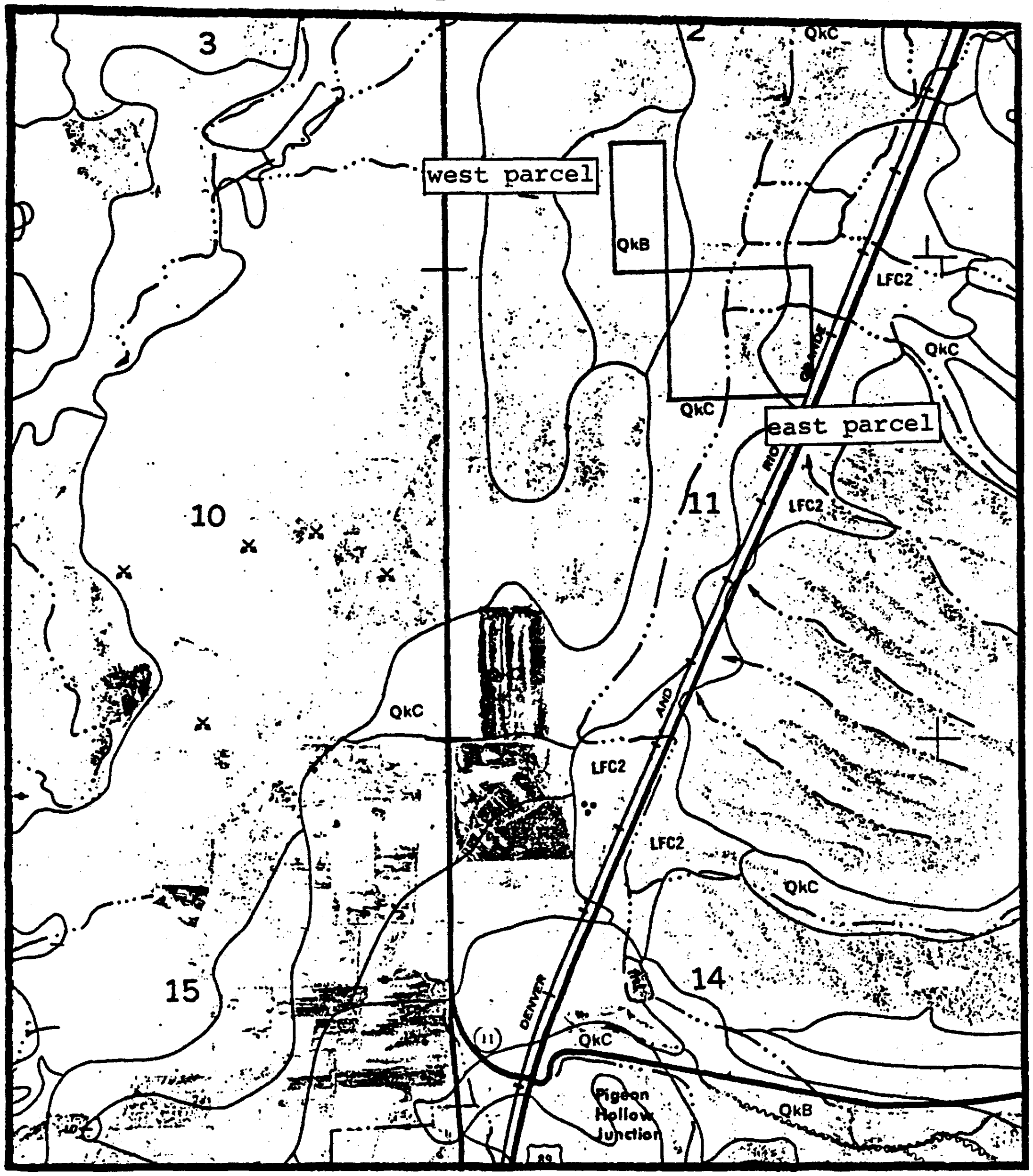
0'-12.75'	Sandy silt (ML); light brown, medium density, soft, medium plasticity, weakly indurated, dry; strong reaction to HCl, 10 percent gravel, maximum size 13 in, average gravel size 2 in, 25 percent sand in 3 in thick beds.
12.75-13.67'	Well-graded gravel with silt and sand (GW-GM); light brown, medium density, firm, low plasticity, moderate induration, dry; strong reaction to HCl, 20 percent sand, 10 percent fines (ML), granule to pea gravel, subrounded particles.
13.67-14'	Silty sand (SM); light brown, medium density, firm, medium plasticity, moderate indurated, moist; strong reaction to HCl, 20 percent fines (ML).

TEST PIT #2: Western Parcel

0'-11'	Sandy silt (ML); light brown, medium density, soft, medium plasticity, weakly indurated, dry; strong reaction to HCl, 10 percent granule gravel, 25 percent coarse sand (SM), gravel and sand in 4-6 in thick beds.

*Soils classified in accordance with procedures outlined in ASTM Standard D2489-69 (Revised 1984), Description of Soils (Visual Manual Procedure).

Attachment 4, Job No. 87-010 (SW-1)



Soils map of landfill site (from Swenson and others, 1981).

LFC2 - Lisade-Sanpete complex, 2 to 5 percent slopes, eroded.

QkB - Quaker silty loam, 1 to 2 percent slopes.

QkC - Quaker silty loam, 2 to 5 percent slopes.

Project: Review of Chapter 2 (Site Characteristics) of a license application for an engineered waste disposal facility.			Requesting Agency: Division of Environmental Health, Bureau of Radiation Control
By: William R. Lund	Date: 11-3-87	County: Tooele	Job No.: 87-013 (SW-2)
USGS Quadrangle: Aragonite (1222)			

A review has been made of Chapter 2, Site Characteristics, of a license application for a proposed low-level radioactive waste disposal site near Clive, Utah. The site, referred to as the South Clive site, is located at the eastern edge of the Great Salt Lake Desert, and would occupy portions of the same section of state land (sec. 32, T. 1 S., R. 11 W.) used for the disposal of the Vitro uranium mill tailings. The scope of the review was limited to an evaluation of the above referenced chapter and pertinent geologic and hydrologic literature available for the site area; no field work was undertaken as part of the review. However, the Vitro mill tailings disposal site was visited in June, 1985 at the request of the Utah Health Department.

General Comment

Because of the close proximity of the Vitro and South Clive sites, Chapter 2 relies heavily on data and conclusions contained in the Final Environmental Impact Statement for the Vitro Remedial Action Project (DOE/EIS-0099-F). Although the only source cited, reference to the Vitro FEIS occurs infrequently and it is often difficult to determine if the data/conclusions presented in Chapter 2 are original to the present study or are the result of site characterization work done for the Vitro site. Implicit in the use of so much Vitro data in the report for the South Clive site, is the assumption by the authors of the current report that the two sites are interchangeable, and that the geologic and hydrologic evaluation done for Vitro will also serve for South Clive. There may be some merit in that assumption, particularly for the regional geologic and hydrologic analyses, but it is unwise to assume that the same interchangeability of data extends to the site-specific level. The complete absence of any other references in Chapter 2 makes it unclear if a review has been made of any new geologic or hydrologic data that may have become available since the Vitro FEIS was published.

Specific Comments

p. 2.2, 6th paragraph: Is the 1985 date presented in the first sentence of this paragraph accurate? The way the sentence is worded, it sounds as though the year in question has not yet arrived.

p. 2.2, 7th paragraph: What affect would the site have on other possible waste disposal activities or siting of the Super Collider?

p. 2.5, 1st paragraph: The correct table reference is Table 2.2. All other references to tables in Chapter 2 following this one are off by factor of one.

p. 2.5, 2nd paragraph: Chapter 2 provides no discussion of Lake Bonneville stratigraphy, even though the surface materials at the site consist of Lake Bonneville sediments. The possible presence at the site of the White Marl (a widely distributed, deep-water Lake Bonneville unit) is of concern. The White Marl contains a high percentage of fine-grained calcium carbonate crystals. When classified according to the Unified Soil Classification System, it is usually reported as a low plasticity silt (ML) or clay (CL). However, because of its high calcium carbonate content, the White Marl may be susceptible to dissolution when brought into contact with low to moderately acidic solutions. If White Marl sediments are compacted to form the liner for the disposal cells, the nature (particularly pH) of any leachate that forms in the disposed material should be carefully evaluated. If the leachate is acidic, it may have a detrimental affect on the cell liners.

p. 2.5, 3rd paragraph: The lithologic composition of the sandy soils underlying the surficial, fine-grained units should be determined. During the 1985 visit to the Vitro site, this sandy unit was observed in the walls of the train-car unloading facility. There, the sand consisted of calcareous oolites formed in Lake Bonneville. Because they are comprised almost entirely of calcium carbonate, the oolites would also be subject to dissolution if brought into contact with acidic solutions. If the sands at the South Clive site are to be used in the construction of the disposal facility, their chemical composition should be evaluated with regard to any proposed use.

p. 2.6, 1st paragraph: Considering the recent clustering of moderate size earthquakes in the west desert near Lakeside, there is some question regarding how up-to-date Appendix H of the Vitro FEIS is with regard to seismicity in the study area.

p. 2.6, 3rd paragraph: Recent mapping by Ted Barnhart of the U.S. Geological Survey to revise USGS Open-File Report 77-495 "Map of Suspected Fault Scarps in Unconsolidated Deposits, Tooele 2° Sheet, Utah" indicates that a fourth potentially seismogenic fault zone is located on the west side of the Deep Creek Mountains. The affect on the South Clive site of an earthquake located on that fault zone should be evaluated. In addition, because the recent earthquake swarm near Lakeside cannot be assigned to a known fault, it must be assumed that an earthquake as large as Ms 4.8-5.0 can occur randomly anywhere along the east side of the Great Salt Lake Desert. The effect of such a random event directly beneath the South Clive site should be evaluated.

p. 2.6, 7th paragraph: Is the Maximum Credible Earthquake reported in Chapter 2 taken directly from the Vitro FEIS, or does it represent the result of new work done for this study? If it was taken from the Vitro report it may be out-of-date (see above comment).

p. 2.8, 1st and 5th paragraphs: The size of the Probable Maximum Flood that could affect the South Clive site is identified (paragraph 6) and the statement is made that sheet flow could pass over the site in the event of such a flood (paragraph 1). However, no evaluation of the affect of such a flood on the site is presented. How much sheet flow, an inch, two inches, six inches? How would the disposal cells be protected in the event of such a flood? What about the affect on transportation corridors serving the facility?

p. 2.9, 5th paragraph: Where would the train wash-down water come from? What quality would it be, and how would its disposal be handled? Is there any possibility that this water (7.3×10^5 gallons annually) might form an acidic leachate and come into contact with calcium carbonate rich disposal cell liners?

P. 2.10, 2nd paragraph: Chapter 2 states that two ground-water systems are present in the site vicinity, but does not indicate which system underlies the site. If it is the alluvial-fan aquifer, which can contain water of relatively high quality, what affect would the proposed waste disposal facility have on water quality?

Project:			Requesting Agency:
Evaluation of proposed low-level radioactive repository, near Green River, Grand County, Utah			Grand County Economic Development Director
By: William F. Case	Date: Nov. 1987	County: Grand County	Job No.: 87-016 (SW-3)
USGS Quadrangle: Green River (625)			

Purpose and Scope

On the 24th of August, 1987, Roy May (Grand County Economic Development Director) contacted the Utah Geological and Mineral Survey and requested an investigation of a proposed low-level radioactive waste disposal site. The purpose of the investigation was to determine if the site is geologically feasible for further consideration as a low-level radioactive waste repository and to note what additional data must be collected before a license can be granted. This investigation involved a literature search, oil well and water well log compilation, aerial photo interpretation, and a field inspection in the company of Roy May and Reylloyd Hatt, mayor of Green River.

Location, Site Conditions, and Climate

The 320 acre site is located on private land in sec. 22, T. 21 S., R. 17 E., SLBM (attachment 1). The site is situated on a pediment (a broad, gently sloping, erosional surface) developed on the Mancos Shale (Fisher, 1936). A tributary of Browns Wash has dissected the site. The pediment extends southwest from the Book Cliffs, which are approximately 5 miles northeast of the site. Drainage in Browns Wash is ephemeral and flows west, toward the Green River which is 5 miles from the site. Elevations across the site range from 4480 ft at the southeastern corner to 4320 ft at the northwest corner. The average slope of the property is 2.3 percent toward the northwest. The ground surface consists of Mancos Shale, a thin layer of fine-grained colluvium of weathered Mancos Shale, and local lag deposits of sandstone and marl shingle gravels. Vegetation consists of clumps of shadscale, occasional salt grasses, and isolated cactus plants (from Hepworth, 1963).

The following climate statistics for Green River weather station are from Brough and others (1983). Green River is in a semi-arid/arid continental interior environment dominated by high pressure cells, at latitude 39° North. The elevation of the station is 4070 ft. Normal (1951-1980) maximum and minimum temperatures in a 24 hr period are 96.4°F (July) and 9.3°F (January). The frost-free season is from early May to mid-October, approximately 165 days. Green River is in a rain shadow of the Wasatch Plateau to the west and the Book Cliffs-Roan Plateau to the north. Most of the precipitation is from cloudbursts during peak months, winter precipitation is frontal. Normal annual precipitation is 6.04 in, peaks are in the late spring and late summer/early fall; annual snowfall is 8.9 in. Estimated pan evaporation is 63.54 in/year. April is the windiest month and spring and winter are the windiest seasons.

Geology and Soil Classification

The site is situated in the Mancos Shale Lowlands section of the Colorado Plateau physiographic province (Stokes, 1986). The physiography of the Mancos Shale Lowlands consists of badlands topography with flat-bottomed ephemeral alluvial washes. The Green River is one of the few permanent streams crossing the territory. The Colorado Plateau province consists of Precambrian to Tertiary age (1.7 billion-25 million years old) bedrock which was uplifted during the Laramide mountain-building episode (80-40 million years ago) into plateaus such as the Book and Roan Cliffs and folds such as the San Rafael Swell.

The Upper Cretaceous age (approximately 100-65 million years old) Mancos Shale is exposed at the base of the Book and Roan Cliffs and covers wide expanses in east-central Utah as well as west-central Colorado. Most of the Mancos Shale was deposited in a marine environment but occasional thin sand units (attachment 2) indicate that deposition also occurred at marine/terrestrial interface environments. The total thickness of the Mancos Shale is over 3,000 ft in the Green River area (Hintze, 1973). Logs of oil wells near the site (attachment 1) show approximately 1400 feet of shale below the surface. The bedrock structure (attachment 1) consists of gentle dips ranging from 2-4^{o} to the northeast and southeast except for the bedding of a thin sand at the southwest corner of the site which dips to the east at 18^{o}; strikes range from northwest to northeast. The discordant strikes of the northeast corner and southwest corner and the 18^{o} dip are not similar to the regional structure of the Mancos (Fisher, 1936) and may indicate presence of a fault; no joints or faults were noted and probably would only be evident in fresh excavations. Hepworth (1963) notes the presence of a northeast-trending fault approximately 8 miles east of Green River which would put it near the site but no map is included in his report and the exact location is unknown. He did not comment on the activity or age of the fault. He also indicated that two vertical joint sets at approximately north-south and east-west orientations occur in the shale. Hepworth (1963) mentioned the existence of calcite and gypsum veins up to 1 ft thick on fault and joint surfaces, no veins were noted during the field reconnaissance.

Although no Soil Conservation Service soil survey has been completed in the area, Swenson and others (1970) have published a soil survey of the Carbon-Emery area that includes a discussion of the Chipeta-Badland soils which typically develops on gypsiferous members of the Mancos Shale. The 10-inch thick soil is easily eroded in sheets and rills and is suitable mainly for limited grazing, wildlife, water supply (although runoff from the soil is silty), and "...for esthetic purposes." (Swenson and others, 1970). Soil cover at the site is very thin or non-existent but basically is similar to the Chipeta-Badland soil near Emery.

Physical Properties of the Mancos Shale

Hunt (1953) states that the Mancos Shale combines all the disadvantages of loose sand when dry and sticky mud when wet; "... even the lizards avoid it." According to Hepworth (1963) the Mancos "Shale" is not a shale, it lacks fissility in fresh exposures and most of the particles are silt; he suggests that the formation should be named the Mancos Siltstone. Constituents also include small percentages of soluble salts, mostly magnesium, sodium, and calcium sulphates (gypsum); a white efflorescense is common on exposures where evaporation of pore water occurs. Natural moisture content in test samples was as high as 78 percent with void ratios ranging from 5-22 percent (Hepworth (1963). Some beds contain bentonitic clays. Hepworth (1963) classifies Mancos Shale samples as: ML (silt), CH (fat clay), and MH-CL (elastic silt-lean clay) using the Unified Soil Classification System. He reports a shrinkage limit which ranges from 13-27 percent and high expansion potential in bentonitic samples. Tests run on Mancos Shale samples show that the heaving that is so predominant and destructive to cultural features is due to absorption of water when temperatures are above freezing (Hepworth, 1963). Woodward-Clyde Consultants (1982) reports that the Mancos Shale has an erosion rate as high as 7.2ft/1000 years, similar to the erosion rates of loose dune sand and arroyo alluvium which have the highest rates noted in the Paradox Basin.

Conclusions

The Mancos Shale has many features that would make it an excellent host formation for a radioactive waste site. The Mancos Shale has been considered for waste sites in the past. Davis (1980) evaluated five potential low-level radioactive waste disposal sites between Crescent Junction and Cisco that were all in the Mancos Shale. Davis used a decision matrix which arrived at a numerical value for each site. Variables included rainfall, evidence of flooding, runoff characteristics, distance to drainage, wells/springs, water table depth, water quality, landslides, agricultural potential, vegetative density, wind erosion, ability to isolate the site, stabilization potential, bedrock structure, bedrock type, and faults. Kirkham and others (1981) also used a decision matrix for radioactive sites, some of which were in the Mancos Shale in Colorado. Variables were similar to those used by Davis plus the following: host rock thickness, lateral continuity of host rock, land slope, erosional/depositional setting, potential for future erosion, aquifer characteristics, drainage basin size, evaporation:precipitation ratio, and conflict with mineral resources.

Evaluation information for the Green River site is in four categories; climatologic, geologic, geographic, and cultural. Climatologic parameters pose no serious barrier to the site, annual rainfall is low (6 in), the area has a high evaporation:precipitation ratio (63:6 in), cloudburst type rainfall may be a temporary hazard, and wind erosion will have to be mitigated. Some geologic factors such as presence of faults or joints, bedrock structure, water table and aquifer depth, and possible transmission of ground water from the site to the Green River will require further study. The major deficiency of available data is the absence of information on depth to ground water and quality of ground water. Stokes (1986) reports ground water in the Mancos Shale lowlands to be about 200 feet below the surface in alluvial valleys. Ground water is very low quality in other localities of the Mancos Shale. Favorable geologic factors include the great thickness (>3,000 ft), good lateral continuity, and low permeability of the shale. Geographic variables which will have to be addressed during design of the site include the rapid erodibility of the shale and its tendency to gully, prevention of drainage into Browns Wash, and control of surface drainage and erosion. There is little cultural conflict with the proposed site. All the oil wells were dry, no water wells exist in the area, and there is no coal in the immediate vicinity; however, the site is visible from the interstate highway and Green River. Dust may be a problem and may be visible for great distances. Construction and maintenance of the site will have to deal with the tendency of the Mancos Shale to heave and become unworkable when wet.

A detailed geotechnical investigation will have to be performed before the site is selected as a repository for radioactive waste. However, the Green River site merits further study as a possible waste disposal site.

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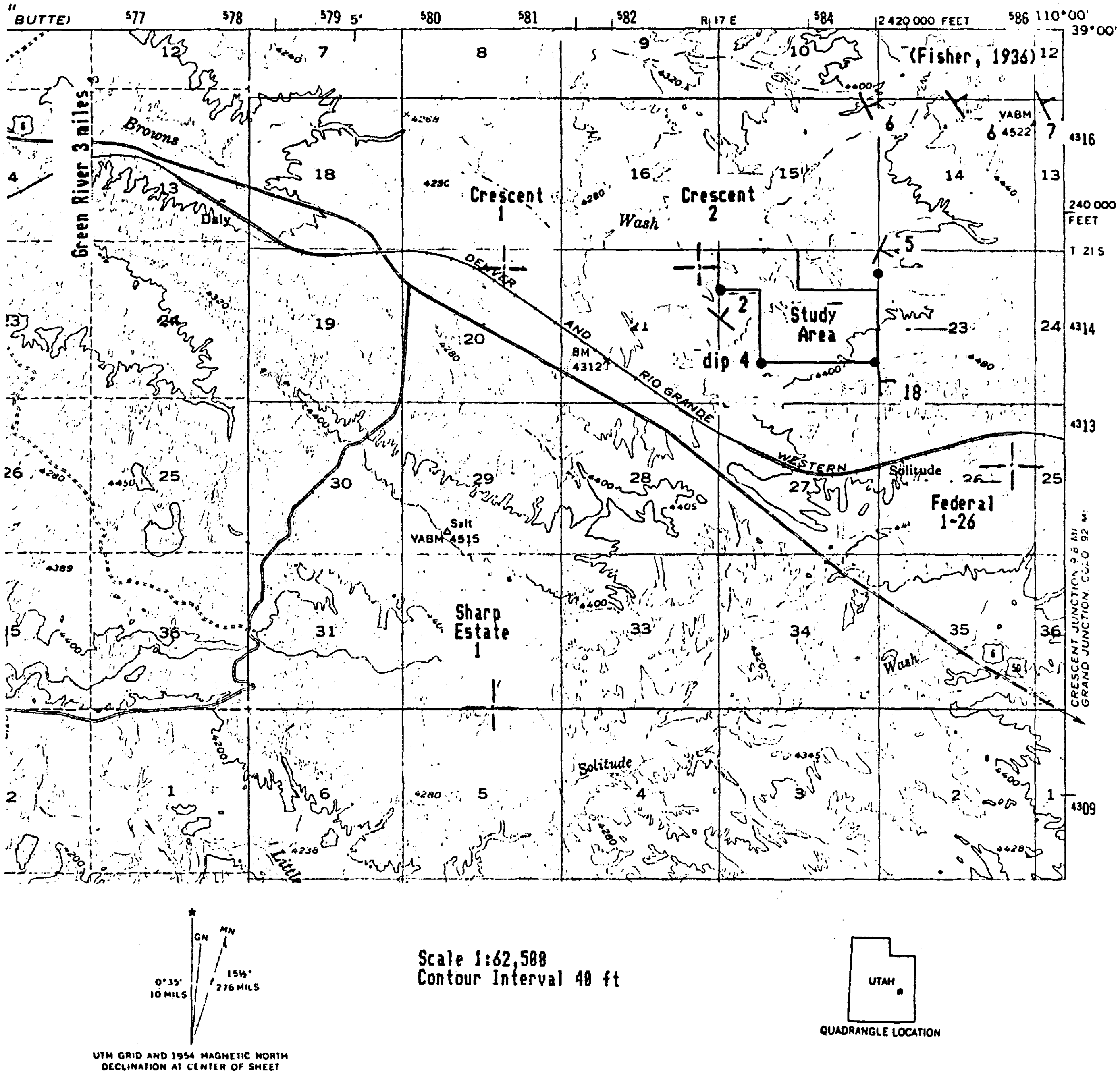
Job No. 87-016 (SW-3)

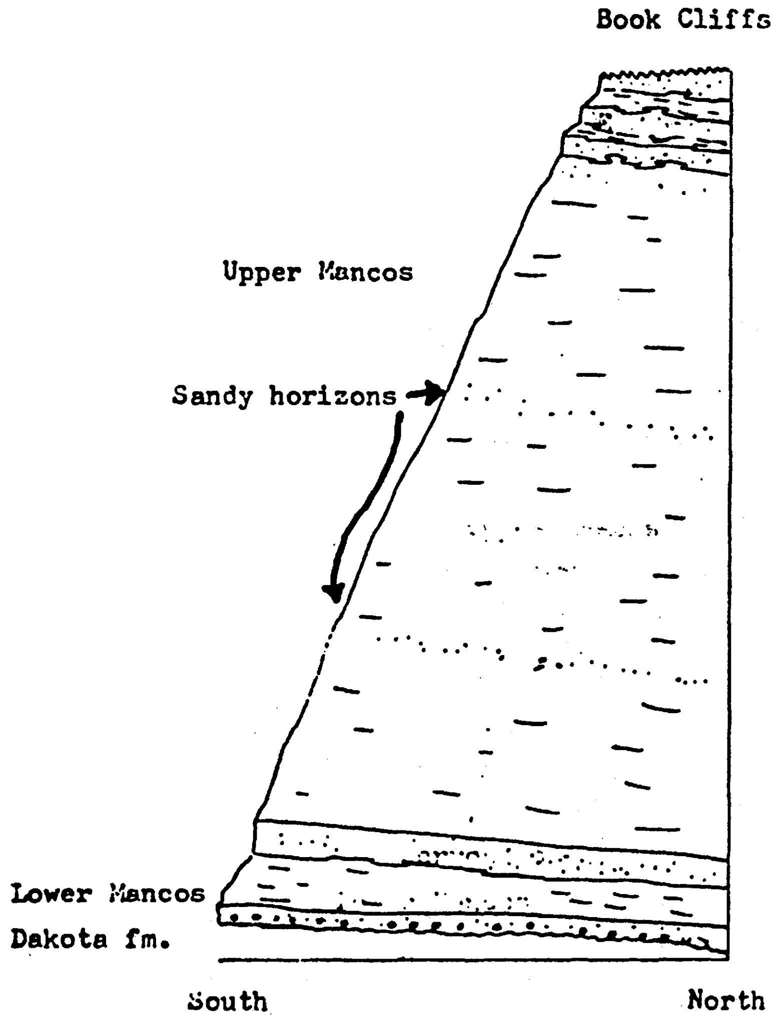
Attachment 1

Base map from Green River, Utah, 15' USGS topoquad



Index and location map showing oil well locations and geologic structure.

Site Investigation Section Utah Geological & Mineral Survey



From Hepworth, 1963

Generalized cross-section of Mancos Shale near the Book Cliffs.

Project: Field reconnaissance of four proposed sanitary landfill sites in Wasatch County, Utah.			Requesting Agency: Wasatch County Health Department
By: William R. Lund Bill D. Black	Date: 11-16-87	County: Wasatch County	Job No.: 87-017 (SW-4)
USGS Quadrangle: Charleston (1127), Aspen Grove (1128), Heber City (1168)			

INTRODUCTION

Wasatch County is presently seeking a site for a new county sanitary landfill. Four possible locations have been identified by a citizen's advisory committee convened by the County Commission. The committee, using existing data, considered a variety of factors relative to siting the new facility including; distance from culinary wells and springs, soil type, natural drainage channels, and known geologic hazards. Prior to selecting a preferred location for detailed site-specific investigation, the Wasatch County Health Department (WCHD) requested, on behalf of the committee, that the Utah Geological and Mineral Survey (UGMS) provide an oversight review of the geologic and hydrologic characteristics of each site. The purpose of the review was to identify any possible undetected fatal flaws related to site geology, and to provide a preliminary ranking of the sites based on geologic and hydrologic factors.

The scope of this review was limited to an evaluation of existing geologic/hydrologic literature (see reference list) and a brief field reconnaissance of each site. No test pits were excavated nor were ground-water monitoring wells installed. Factors such as visibility from roads or residences, haul distances from refuse pick up points, proximity to airports or other critical facilities, and land ownership were not considered in this evaluation.

SITE DESCRIPTIONS

The four sites actually represent site target areas. The committee identified locations within the county that appear to have the necessary characteristics for a successful sanitary landfill, but did not select actual landfill sites. Each of their "sites" is at least a section (one square mile, 640 acres) in size. Since it is anticipated that the new landfill will require about 20 acres (Phil Wright, WCHD), there is considerable latitude at each site for locating a landfill. The four sites are; West Chalet (sec. 9, T. 4 S., R. 4 E. SLBL), Oak Hollow (sec. 26, T. 4 S., R. 4 E. SLBL), Allens (sec. 35 & SW1/4 sec. 36, T. 4 S., R. 4 E. SLBL), and West Coyote (sec. 17 & 20, T. 3 S., R. 5 E. SLBL) (figure 1). The West Chalet, Oak Hollow, and West Coyote sites are located in Heber Valley. The Allens site is in Round Valley. The following are brief descriptions of each site, the attached data sheets (figures 5-7) summarize the existing geologic information available for each location.

West Chalet

The West Chalet site consists of a section of ground on the west side of Heber Valley near the north end of Deer Creek Reservoir (figure 1). It lies in the foothills of the Wasatch Range near the mouth of Pole Canyon. The ground surface slopes moderately to gently toward the east, and Pole Creek has incised its channel along the south edge of the property (figure 2). Two unlined irrigation ditches cross the site in a general north to south direction. The West Bench Ditch is located the furthest to the west and is the highest topographically. The Epperson Ditch is a few hundred yards to the east and about 180 feet lower in elevation. Although a large drainage, the channel of Pole Creek is completely vegetated and shows no evidence of recent flow.

The West Chalet site is geologically complex (figure 5). The steeper slopes at the extreme east and southeast portions of the property are underlain by the Triassic Thaynes Limestone and Ankareh Formation (Baker, 1964). The Thaynes Limestone consists of a brown-weathering gray limestone with interbedded gray sandstone and some red shale layers. The Ankareh Formation is chiefly thin bedded, red to brown, sandy shale and sandstone. The eastern three-quarters of the site are covered with unconsolidated deposits which are probably underlain by the Ankareh Formation. Baker (1964; 1976) shows a large landslide issuing from the draw just north of Pole Canyon. The landslide covers the north-central portion of the site. Observed during the field reconnaissance, the surface of the landslide was found to be completely vegetated and modified by erosion, indicating that the feature is quite old. The West Bench Ditch crosses the toe of the landslide, no evidence of recent movement resulting from leakage of irrigation water was observed. The landslide is probably prehistoric and appears stable under existing conditions. South of the landslide, alluvial-fan deposits derived from the nearby hillsides predominate. It is in this area that the landfill would most likely be located if this site is chosen (Phil Wright, WCHD). East of the landslide and alluvial-fan deposits, the site is underlain by valley-fill deposits (Baker, 1976).

Mapping by the U.S. Soil Conservation Service shows that the site contains a complex assemblage of soil types (figure 5). The majority are rated as having severe limitations for trench-type landfills either because of slope or a high clay or cobble content (Woodward, Jensen, and Harvey, 1976). All of the soils on the property are shown to have a potential problem with shallow depth to bedrock. However, based on stream bank exposures along Pole Creek, the area most likely to be the selected for the landfill appears to be underlain by a minimum of 15-20 feet of unconsolidated material.

Depth to the principal aquifer beneath the West Chalet site is unknown. Maps depicting depth to ground water in Heber Valley during 1967 (Baker, 1970) show that ground water may be as shallow as 5 feet beneath part of the site. Observations made during the field reconnaissance indicate that depth to ground water is considerably greater than that over most of the site. Shallow ground water may be present locally downslope from both the West Bench and Epperson Ditches.

Oak Hollow

Oak Hollow is a small drainage located in steep, mountainous terrain at the west end of Wallsburg Ridge immediately east of Deer Creek Reservoir and south of Charleston (figure 1). The ephemeral stream in the hollow drains a small watershed (less than one square mile) and flows to the southwest toward the reservoir (figure 3). The landfill would be located on a dissected alluvial surface along either side of the stream at a point where the hollow becomes wider and assumes a more gentle gradient (Phil Wright, WCHD). The stream shows evidence of seasonal flow, and has incised its channel 15-20 feet into the alluvium. The alluvial surface slopes gently to moderately to the southwest parallel to the stream.

The mountain slopes on site are underlain by the Wallsburg Ridge Member of the Permian-Pennsylvanian Oquirrh Formation (figure 6). The Wallsburg Ridge Member is chiefly fine- to medium-grained, light-gray to red quartzite with some interbedded limy sandstone and cherty limestone (Baker, 1976). Alluvial and colluvial deposits range in thickness from less than a foot on mountain slopes to several tens of feet in Oak Hollow. Based on the depth of the channel incised by the stream, the thickness of unconsolidated deposits in the area identified as the most likely location for the landfill is at least 15-20 feet. No evidence of geologic hazards, other than seasonal flooding along the stream channel, was observed at the site.

Limitations for trench-type landfills associated with site soils range from moderate due to slope to severe due to excessive clay and cobbles (Woodward, Jensen, and Harvey, 1976). Slopes on site are steep except in the lower and middle reaches of Oak Hollow itself, and the alluvial surface on which the landfill would be located is covered with a veneer of coarse gravel and cobbles. The extent to which coarse materials persist at depth or the amount of clay present in the subsurface is unknown.

Depth to ground water beneath the Oak Hollow site is also unknown, but is believed to be greater than 20 feet and considerably more than that in most places. Shallow ground water may be present along the stream channel during the spring runoff.

Allens

The Allens site as originally proposed by the citizen's advisory committee was restricted to sec. 35, T. 4 S., R. 4 E. SLBL. However, following the field reconnaissance and consultation with Phil Wright (WCHD), it is recommended that the site be expanded to include the SW1/4 of sec. 36, T. 4 S., R. 4 E. SLBL. The expansion would incorporate additional favorable terrain in the site. It is that larger area that is considered here.

The Allens site is located on the south side of Wallsburg Ridge in Round Valley (figure 1). It is the only site of the four being considered not in the Heber Valley watershed. Topography across the site varies from moderately sloping uplands near the crest of the east-west trending main ridge; to narrow, north-south tributary ridges with deep intervening ravines at lower elevations to the south; to sloping alluvial-fan surfaces at the base of the ridge in the SE1/4 of sec. 35 and SW1/4 of sec. 36 (figure 3). Several ephemeral streams cross the site in a north-south direction and most show evidence of seasonal flow.

Bedrock in the site vicinity consists of the Wallsburg Ridge Member of the Oquirrh Formation (figure 6) and is similar to that described for the Oak Hollow site. Rock actually crops out only in the extreme southwest and northeast corners of sec. 35 (Baker, 1976). The remainder of the site is underlain by unconsolidated alluvial and colluvial deposits of undetermined thickness. No geologic hazards, other than a potential for seasonal flooding along stream channels, were noted during the field reconnaissance.

Soil limitations for trench-type landfills range from moderate to severe depending on slope and depth to bedrock (Woodward, Jensen, and Harvey, 1976). Observations during the field reconnaissance indicate that shallow bedrock is present in some places, but that many areas within the site have sufficient depth of unconsolidated material to accommodate a landfill.

Depth to ground water at the Allens site is unknown, but is believed to be everywhere greater than 20 feet and in some areas (near the top of Wallsburg Ridge) more than a hundred feet.

West Coyote

The West Coyote site encompasses two sections north of Heber City on the east side of Heber Valley (figure 1). The northern approximately 3/4 of the site (sec. 17 and north 1/2 of sec. 20) occupies steep terrain on the ridge bounding Heber Valley (figure 4). The remainder of the site (south 1/2 of sec. 20) includes moderately to gently sloping ground at the base of the ridge. A river terrace associated with the ancestral Provo River flanks the ridge and is separated from alluvial-fan deposits on the remaining western portion of the site by a sharp, steep slope. Both the terrace and fan surfaces are inclined toward the southwest. The Timpanogos (upper) and Wasatch (lower) Canals cross the site in a northwest to southeast direction. Both canals are unlined.

Bedrock at the site consists of the Coyote Canyon Member of the Keetley Volcanics, an accumulation of rhyodacitic to andesitic volcanic flows and breccias (Bromfield, Baker, and Crittenden, 1970). Section 17 and the north half of sec. 20 are underlain by volcanics at shallow depth (figure 7). The surface of the river terrace was observed to be covered with large cobble- to boulder-size clasts. Some of the larger boulders approached 3-4 feet in diameter. Boulders 1-2 feet in diameter were common in the roadbed leading to the site. The alluvial-fan deposits on the west side of the property are relatively finer grained, but still contained cobble- and some boulder-size material.

Soil limitations at the West Coyote site for trench-type landfills are rated as severe due either to steep slopes, shallow bedrock, the presence of very coarse cobble and boulder material, or excessive amounts of clay (Woodward, Jensen, and Harvey, 1976). The limitations due to slope, bedrock, and coarse material were confirmed during the field reconnaissance on those portions of the site underlain by the volcanics and the river terrace. The part of the site occupied by alluvial-fan deposits appeared to have fewer limitations, although clay and/or coarse material may be present at depth.

Depth to ground water is unknown but probably ranges from greater than 20 to more than 100 feet depending on the elevation of the ground surface. Areas of shallow ground water may be present immediately downslope from the Timpanogos and Wasatch Canals.

SUMMARY AND CONCLUSIONS

The conclusions presented in this report are based solely on a review of available literature and a brief field reconnaissance of each site. Therefore, they are considered preliminary and suitable only for initial planning and design purposes. Nothing presented in this memorandum should be interpreted as precluding the need for detailed, site-specific investigations before a final landfill site is selected.

The results of this review indicate that the four sites identified by the citizen's advisory committee do not have obvious fatal flaws of a geologic or hydrologic nature and that each could probably successfully accommodate a sanitary landfill. However, there are significant differences between the sites which permit their ranking according to apparent suitability for landfill development. That ranking, in order of decreasing suitability, is as follows: Allens, West Chalet, Oak Hollow, and West Coyote.

The Allens site is considered the most suitable, because it presents no hazard to the unconfined culinary aquifer in Heber Valley and, because of its location, minimal hazard to ground water in Round Valley. Conditions within the larger site area are variable, but it should be possible to find a location that combines adequate depth to both ground water and bedrock. Siting concerns include; avoiding active drainages, selecting a location that maximizes depth to ground water, and determining suitability of site soils with regard to excavatibility, compactibility, and thickness. Areas of the site were noted to have boulder-size material at the ground surface. Those areas should be avoided because of possible excavatibility problems and because the presence of oversize material implies a potential for heavy runoff and flash floods.

The West Chalet site is ranked second even though it shares a problem common to all three sites in Heber Valley; the potential to pollute the unconfined culinary aquifer in the valley. Because of its location on the side of the valley at a considerable elevation above the valley floor, and because upland areas away from stream drainages are available for siting; the West Chalet site is believed to present the least risk to ground water of the three Heber Valley sites. Siting concerns include avoiding drainages; maximizing separation from ground water, particularly of shallow ground water that may be present downslope from unlined irrigation ditches; confirming the suitability of site soils in terms of excavatibility, compactibility, and thickness; and avoiding that part of the site underlain by landslide deposits. Not only the landfill, but any access roads or other facilities that require significant cut-and-fill grading or introduction of water into the subsurface should avoid the landslide area. Ample room exists at the West Chalet site to accommodate that requirement.

The Oak Hollow site is ranked third largely on the basis of its location at the downstream end of Heber Valley, thus reducing the potential for aquifer contamination. However, that advantage is offset by the site's close proximity to Deer Creek Reservoir and an equally great potential for polluting that water body. Steep terrain, evidence of significant seasonal flow in stream channels, and a relatively limited area in which to place the landfill all contribute to the potential for flooding or flood related problems. In the event of a flood (heavy runoff), the overflow and any ground water that might become contaminated would move directly toward the reservoir. However, while the flood potential at Oak Hollow is greater than at either Allens or West Chalet, it can be mitigated provided the hazard is recognized and accommodated in the facility design. Other siting concerns, in addition to drainage, include maximizing separation from ground water and determining the suitability of site soils for use in a landfill operation.

The West Coyote site is ranked fourth because of its location near the upstream end of Heber Valley and because of the coarse-grained nature of site soils. A landfill at the West Coyote site would have the potential for introducing pollutants into Heber Valley's aquifer system up-gradient from most of the culinary wells in the valley. The actual likelihood of pollution depends on factors such as depth to ground water, porosity and permeability of the soil, topography, and amounts of precipitation/runoff. It is possible that the combination of those factors would not result in a pollution problem. However, at this stage of the siting process, they remain unknown variables, while it can be stated with certainty that if the landfill is not located up-gradient from the culinary wells the possibility of pollution is removed. In addition to contributing to ground-water pollution, the coarse site soils may also present excavation and compaction problems. Leakage from the unlined irrigation ditches that cross the site may create shallow ground-water conditions locally. The large number of unanswered questions concerning the geologic suitability of the West Coyote site makes it a less desirable location for a landfill. While it is possible that a landfill could be sited there successfully, proving it would be more difficult than at the other sites.

In summary, when evaluated at a reconnaissance level, the four sites identified by the citizen's advisory committee all appear to have the potential for successfully accommodating a sanitary landfill. All four sites share certain geotechnical concerns, and it is the degree to which those concerns can be mitigated that will ultimately determine the most suitable site. Those concerns include potential for ground-water pollution; depth to bedrock and suitability of site soils for use as landfill cover material; and susceptibility to flooding. Considering those and other factors, the sites were ranked according to their perceived suitability for landfill development. Based on that ranking, the preferred and alternate sites from a geologic standpoint are Allens and West Chalet. It is the recommendation of the UGMS that further detailed investigations concentrate on those two sites. By proceeding simultaneously with two investigations, little time would be lost should either location prove unsuitable. If both sites are satisfactory, the alternate could be held in reserve by the county to meet future waste disposal needs.

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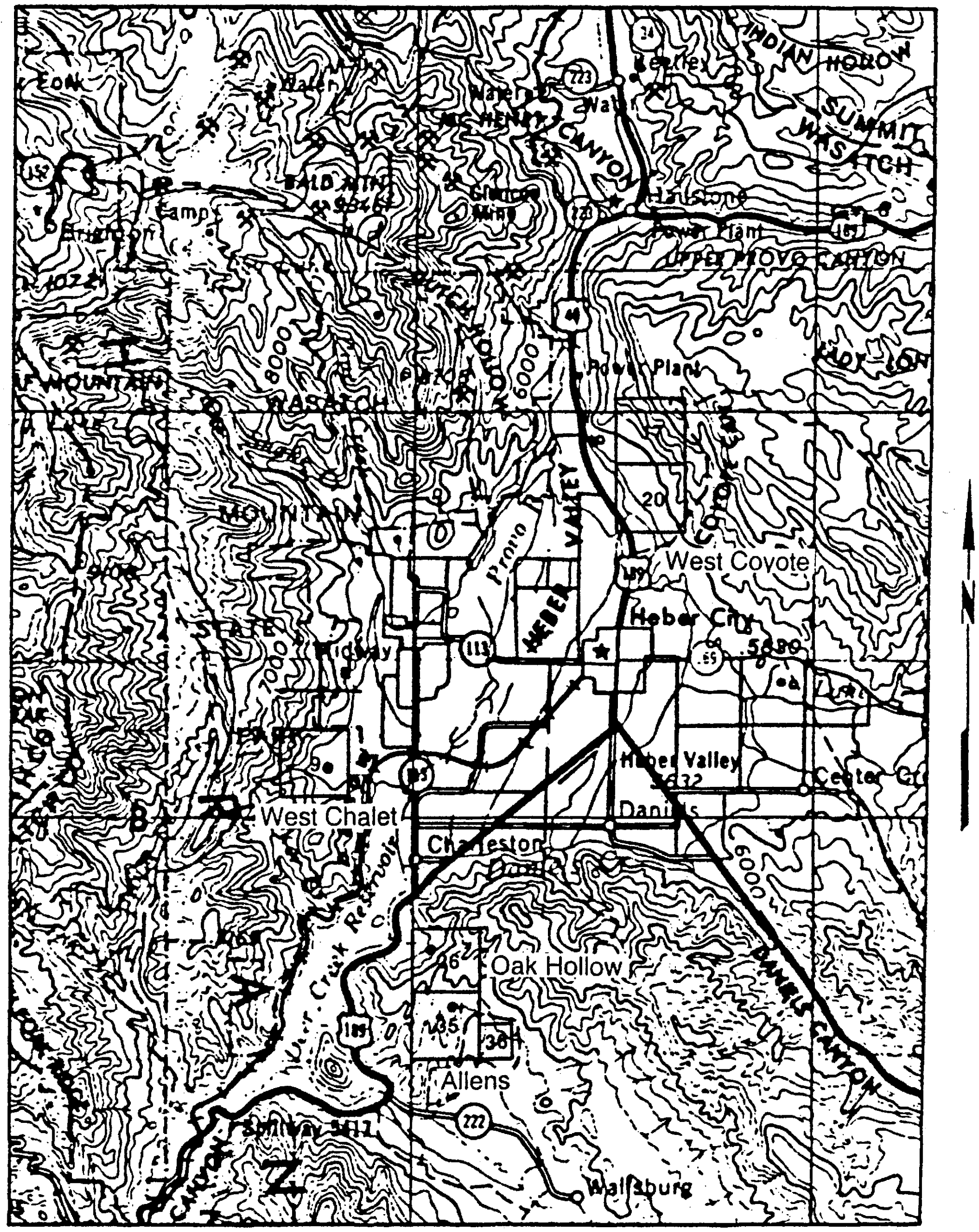

Figure 1. Map showing location of proposed Wasatch County Sanitary Landfill sites.

Scale 1:180,000

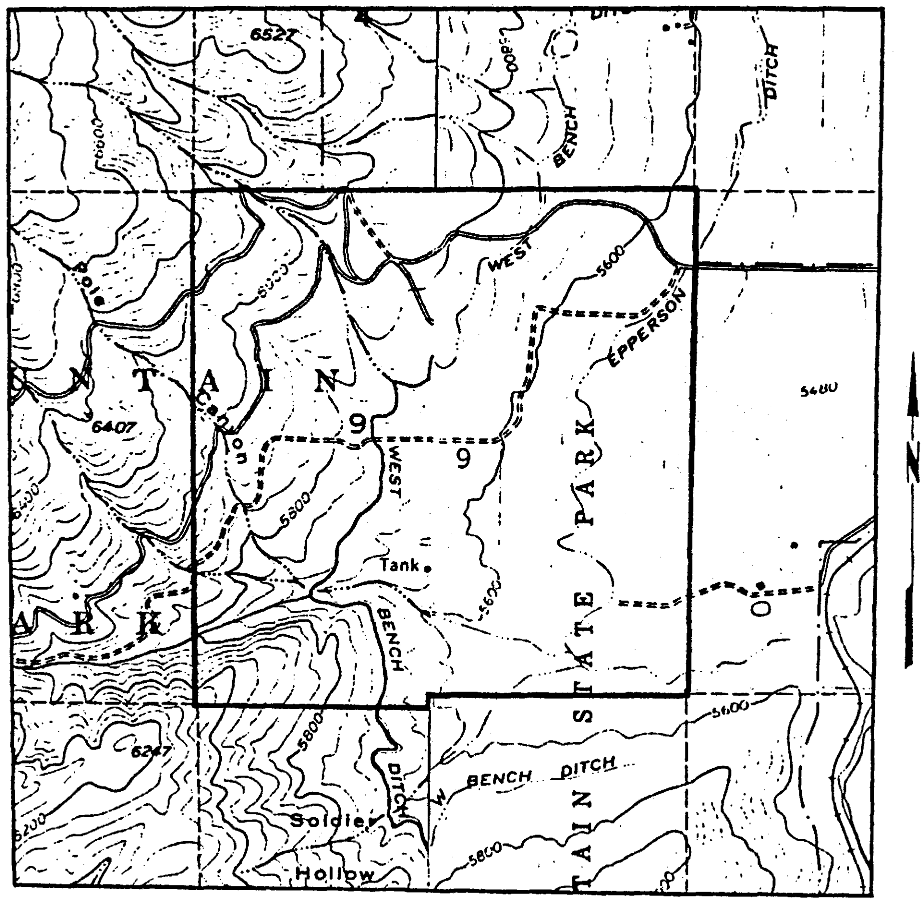

Figure 2. West Chalet Proposed Site. Section 9, T4S, R4E.

Scale 1:24,000

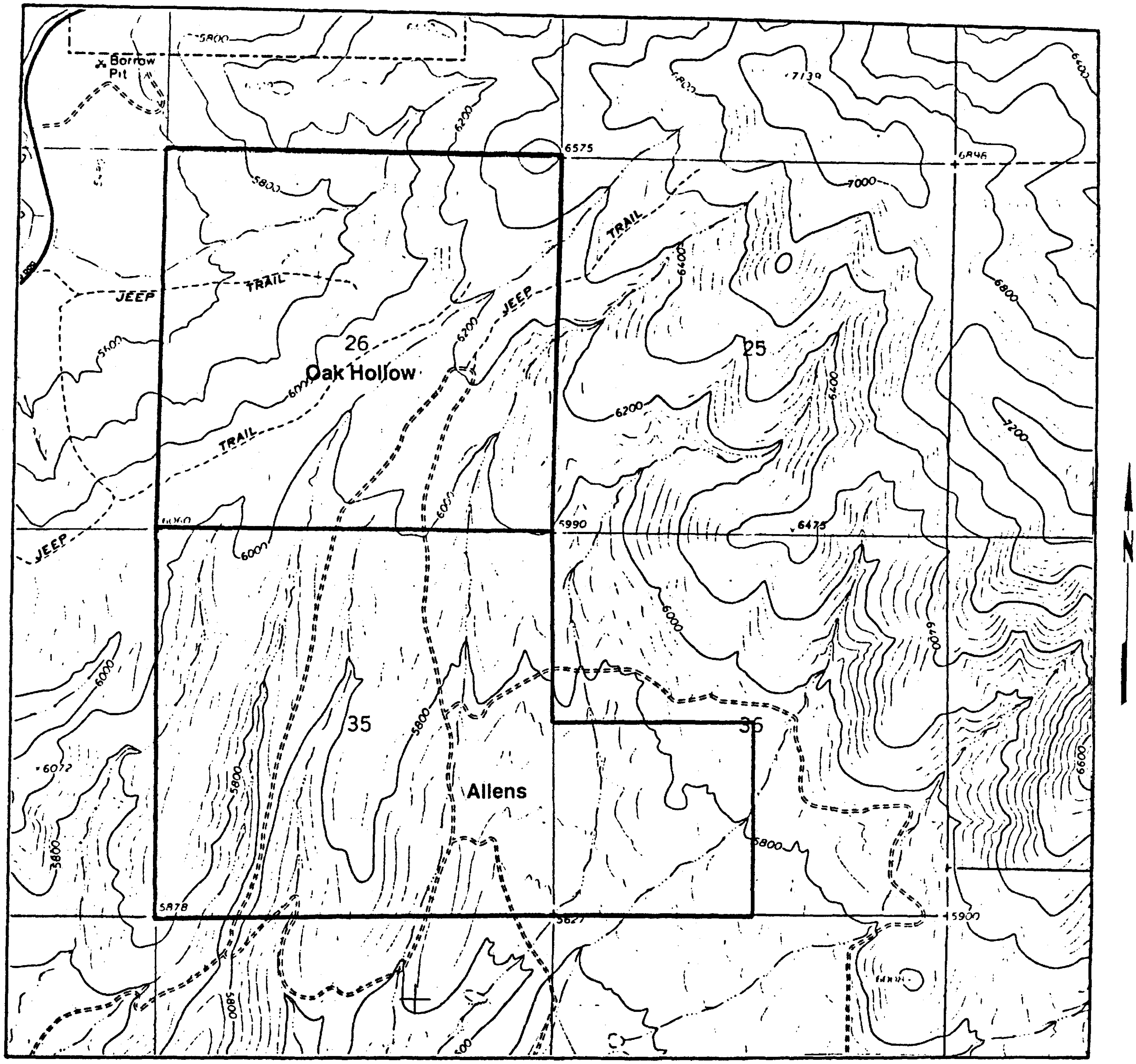

Figure 3. Oak Hollow and Allens Proposed Sites. Sections 26, 35, 36, T4S, R4E.

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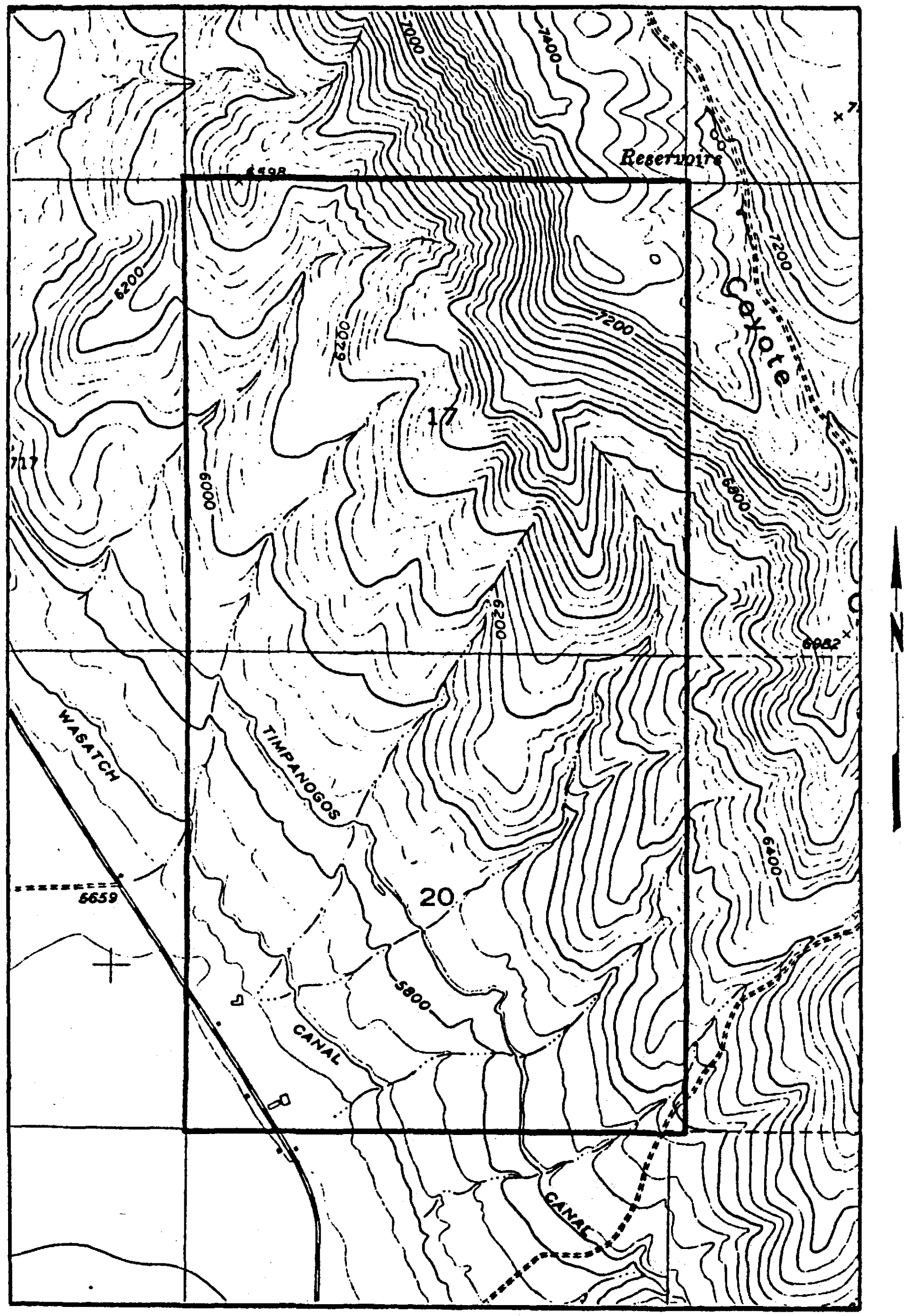
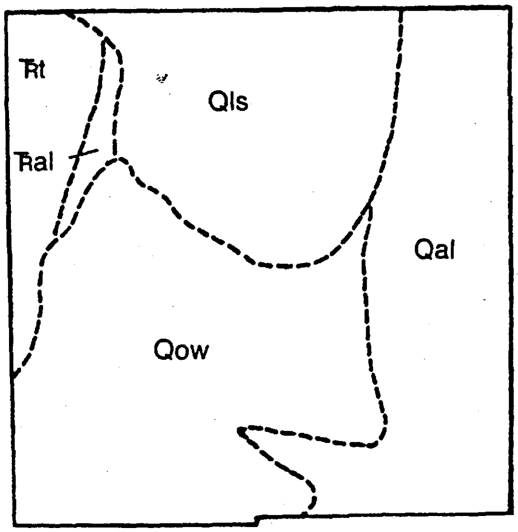


Figure 4. West Coyote Proposed Site. Sections 17, 20, T3S, R5E.

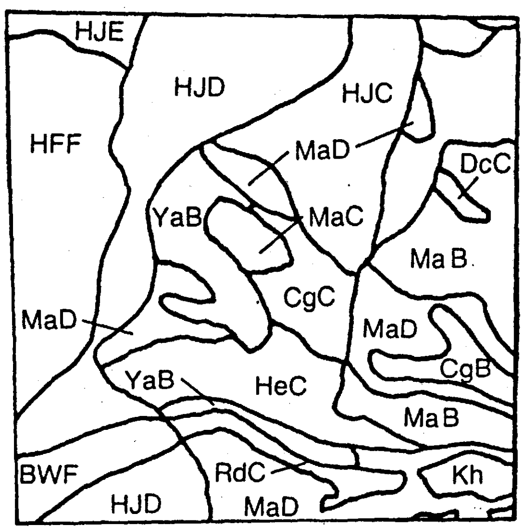
Scale 1:24,000



Section 9, T4S, R4E.

Geologic Units

Qls	Landslide deposits.
Qow	Glacial outwash and outwash cones.
Qal	Valley fill.
Tral	Lower Ankareh Formation.
Trt	Thaynes Limestone.

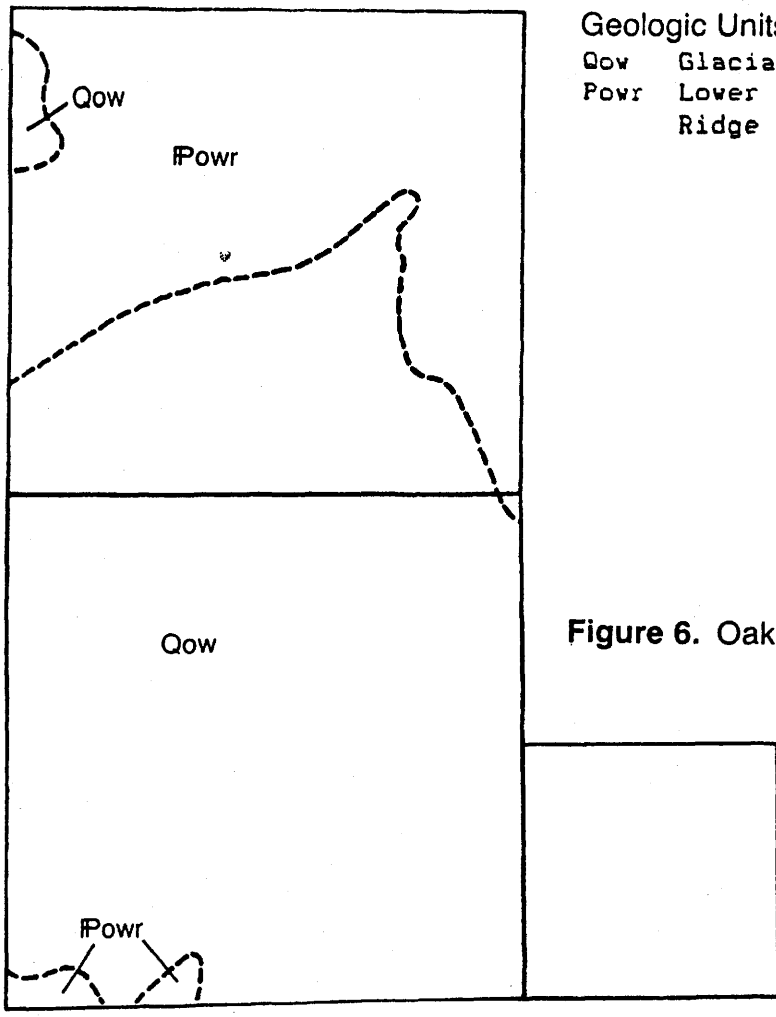


Soils and Landfill suitability

BWF	Burgi Gravelly Loam, Severe (steep).
CgB	Clegg Loam, Slight (bedrock may be a problem).
CgC	Clegg Loam, Slight (bedrock may be a problem).
DcC	Deer Creek Loam, Severe (clayey, cobbly).
HeC	Henefer Silt Loam, Severe (very cobbly and clayey, bedrock a problem in places)
HeD	Henefer Silt Loam, Severe (very cobbly and clayey, bedrock a problem in places)
HFF	Henefer-Bradshaw Association, Severe (very cobbly and clayey, bedrock a problem in places, steep, rapid permeability).
HJC	Henefer Soils, Severe (very cobbly and clayey, bedrock a problem in places)
HJD	Henefer Soils, Severe (very cobbly and clayey, bedrock a problem in places)
Kh	Kovich Loam, Severe (high water table, rapid permeability, very gravelly).
Ma	Manila Silt Loam, Severe (clayey).
RdC	Rasband Loam, Severe (moderately rapid permeability, very cobbly and gravelly below a depth of 30 inches).
YaB	Yeates Hollow Loam, Severe (clayey, very cobbly).

Figure 5. West Chalet site. Geologic and Soil Maps.

Scale 1:24,000



Geologic Units

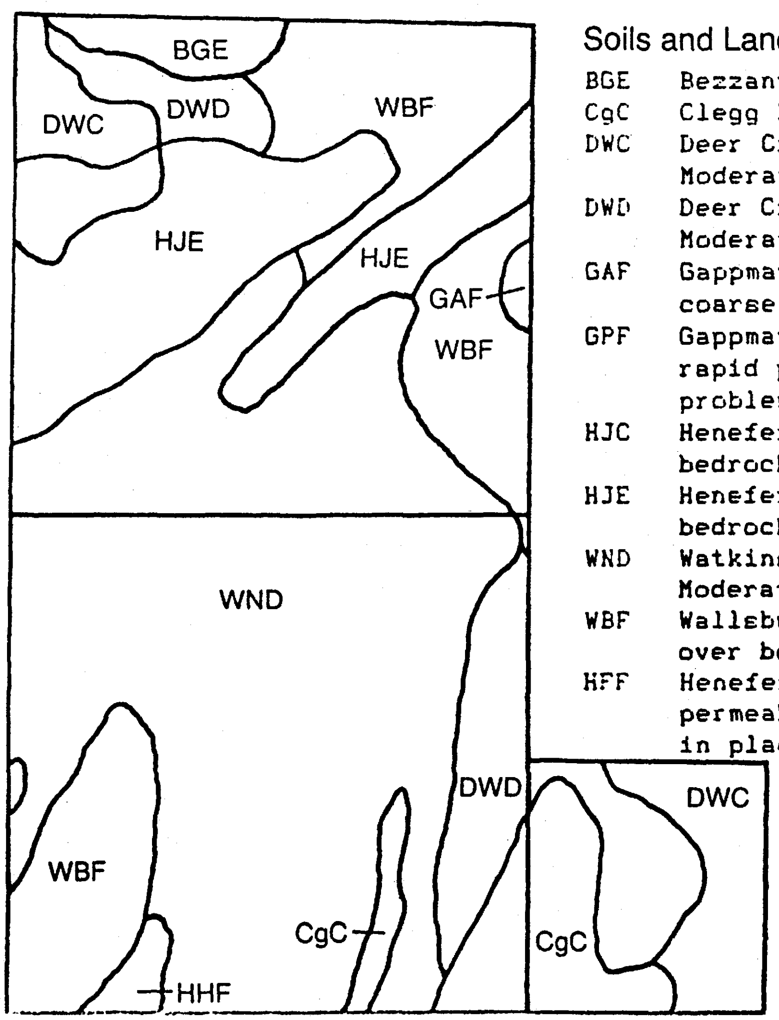
Qow Glacial outwash and outwash cones.
Powr Lower Pennsylvanian Oquirr Formation, Wallsburg Ridge Member.

Job No. 87-017 (SW-1)

N

Figure 6. Oak Hollow and Allens sites. Geologic and Soil Maps.

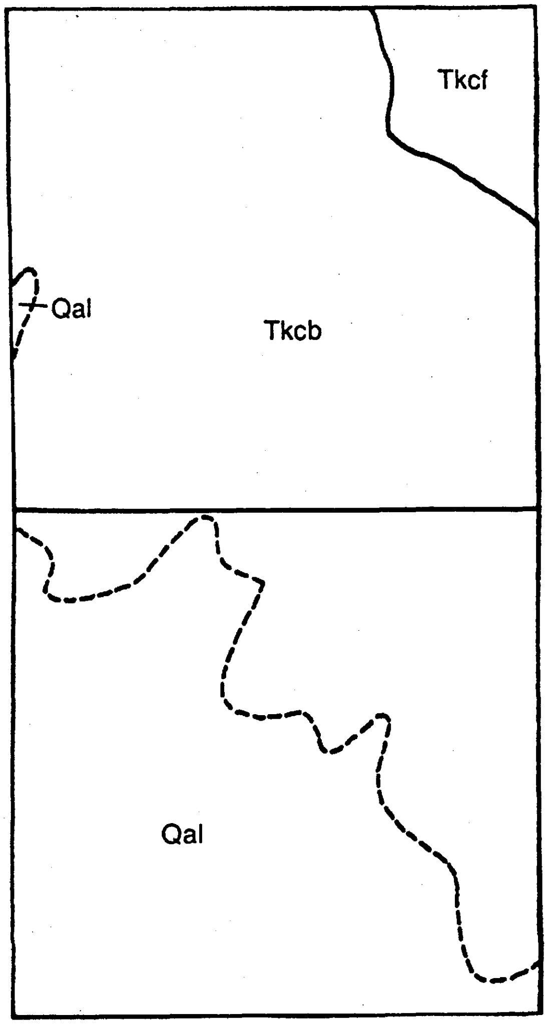
Sections 26, 35, 36, T4S, R4E.



Soils and Landfill suitability

BGE Bezzant Very Cobbly Loam, Severe (very cobbly).
CgC Clegg Loam, Slight (bedrock may be a problem).
DWC Deer Creek-Watkins Ridge Complex, Severe or Moderate (clayey, cobbly, clay loam)
DWD Deer Creek-Watkins Ridge Complex, Severe or Moderate (clayey, cobbly, clay loam)
GAF Gappmayer Gravelly Fine Sandy Loam, Severe (steep, coarse fragments, bedrock a problem in places).
GPF Gappmayer-Bradshaw Association, Severe (steep, rapid permeability, coarse fragments, bedrock a problem in places).
HJC Henefer Soils, Severe (very cobbly and clayey, bedrock a problem in places)
HJE Henefer Soils, Severe (very cobbly and clayey, bedrock a problem in places)
WND Watkins Ridge-Deer Creek Complex, Severe or Moderate (clayey, cobbly, clay loam)
WBF Wallsburg-Rock Outcrop Complex, Severe (shallow over bedrock, steep).
HFF Henefer-Bradshaw Association, Severe (steep, rapid permeability, cobbly and clayey, bedrock a problem in places).

Utah Geological and Mineral Survey Scale 1:24,000



Geologic Units

Qal Stream gravel and valley fill.
Tkcb Keetley Volcanics. Volcanic breccia of Coyote Canyon.
Tkcf Keetley Volcanics. Flows of Coyote Canyon.

Job No. 87-017 (SW-1)

Sections 17, 20, T3S, R5E.

Soils and landfill suitability

BeD2 Bezzant Cobbly Loam, Severe (very cobbly).
Bfc Bezzant Very Cobbly Loam, Severe (very cobbly).
BPE Broadhead-Little Pole Association, Severe (clayey, shallow over bedrock, steep).
BPF Broadhead-Little Pole Association, Severe (clayey, shallow over bedrock, steep).
RaB Rasband Coarse Sandy Loam, Severe (moderately rapid permeability, very cobbly and gravelly below a depth of 30 inches).
Kc Kovich Loam, Severe (high water table, rapid permeability, very gravelly).
WLC Watkins Ridge-Clegg Complex, Moderate (clay loam, bedrock may be a problem).
WLD Watkins Ridge-Clegg Complex, Moderate (clay loam, bedrock may be a problem).

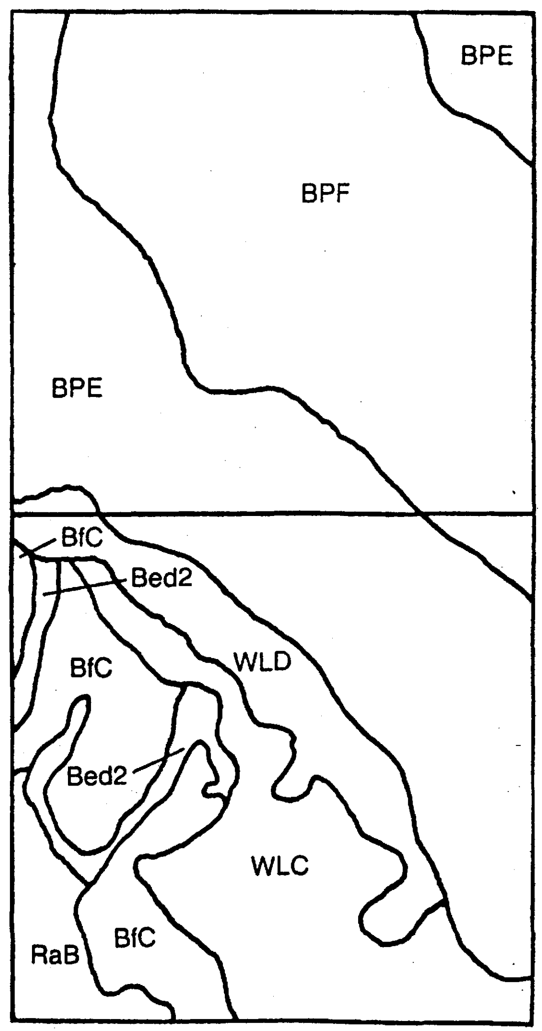


Figure 7. West Coyote site. Geologic and Soil Maps.

Utah Geological and Mineral Survey

Scale 1:24,000

Geologic Hazards

Project: Monticello Landslide, San Juan County, Utah			Requesting Agency: WPC/DCED
By: William F. Case	Date: 6 Jan. 87	County: San Juan	Job No.: 87-001 (GH-1)
USGS Quadrangle: Monticello NE (290)			

Purpose and Scope

Walter L. Baker, Division of Environmental Health representative to the Department of Community and Economic Development (DCED), requested that the Utah Geological and Mineral Survey review a four-phase plan developed by ARIX Engineers for the City Of Monticello to mitigate a landslide hazard which has disrupted the city's main interceptor sewer line. It is necessary to stabilize the slope failure because of the long-term expense associated with pumping sewage around the site. The phases of the mitigation plan will be completed in sequence until the slope is stabilized. The scope of the work included a literature research and site visitations on the 8th of December, 1986, and again on the 16th of December in the company of Division of Environmental Health engineers Walter L. Baker and David R. Ariotti; Greg Adams, Southwestern Utah District Health Department; Rick Terry, Monticello City Manager; James A. Yurczyk of ARIX Engineering; and Dennis Lambert of Lambert and Associates, a geotechnical firm retained by the City of Monticello to help develop the mitigation plans.

Problem Definition and Mitigation

The problem as outlined by Mr. Baker in a meeting on the 2nd of December, 1986, is as follows. On the 17th of October, 1986, Monticello City employees reported a blockage of the 15-inch interceptor sewer line which routes raw sewage to lagoons east of the city by gravity drainage. About 200 feet of the sewer line has been affected by an active slope failure which may have initially failed because of high levels of shallow ground water, or a possible sewer line leak. The area was not snow covered and had not received rainfall immediately before the failure according to Monticello City Manager Rick Terry (personal commun., December, 1986). After the initial movement, water from the severed sewer line contributed to the slope instability. By the 18th of October, Monticello was pumping raw sewage around the landslide as an emergency measure. The city wishes to stabilize the landslide so that the sewer line can be reinstalled at its former grade. Any other route for the line would require a permanent pumping station which is unacceptable to the city because of the long-term costs. In addition to the sewer line, two large propane storage tanks and metal sheds near the landslide crown could be endangered by continued movement, and eventually a stream drainage below the landslide toe will be blocked if the failure remains active.

The four-phase mitigation plan was presented during a 3rd of December meeting with Mr. Baker; Mr. Ariotti, Mr. Terry, and Mr. Yurczyk. The four phases as outlined by ARIX are: A) permanently replace the sewer line at gravity grade above a gravel-packed perforated pipe which would serve as a drain, B) excavate a 12-15 foot deep trench to bedrock and install perforated drain pipe upslope of the landslide to intercept ground water before it reaches the failure, C) remove the toe of slide mass and replace it with a compacted fill buttress, and D) completely remove and replace the landslide with compacted fill. Phase B was almost completed by the 16th of December; the eastern portion of the drainage trench had been backfilled and the drain pipe which daylighted below the slope failure was issuing water at rate of about 5 gallons per minute over the ground surface. If Phase B procedures do not stabilize the slide mass, Phases C and D will be completed sequentially until the sewer line can be permanently replaced (Phase A). Monticello City has made application to the DCED for funds to finance the mitigation effort, Phases A and B have been approved.

Location and Setting

The landslide is located at 3rd South and approximately 3rd East in the City of Monticello, Utah (attachment 1), mid-way on a south-facing, 2:1 to 3:1 valley-wall slope of an ephemeral tributary to Montezuma Creek. According to the Varnes (1978) classification of slope movement, the landslide is a debris slide and exhibits primarily translational movement. The soil and weathered bedrock comprising the slide are believed to be moving along a contact with more competent bedrock. The landslide is approximately 300 feet wide at the toe by 250 feet long and averages about 10 feet thick, resulting in a volume of approximately 28,000 cubic yards. The ground surface has been disturbed by man; a grist mill was located at the site years ago (Rick Terry, personal commun., December, 1986), and installation of the sewer line reworked surface materials. Presently the site is a barnyard with few trees and little ground cover. The toe of the landslide is several tens of feet above the streambed. Ponding of water was observed by James A. Yurczyk (personal commun., 1986) on the surface of the landslide before mitigation activities began. During the site investigation, ground water was noted at the western end of the drainage trench near the head of the landslide, and several natural seeps were evident near the toe of the failure.

Geology and Hydrology

Quaternary age (1.6 million years to present) pediment gravels and loess, and Upper Cretaceous (98 to 66 million years ago) weathered Mancos Shale are sliding and flowing viscously over unweathered Mancos Shale bedrock (Huff and Lesure, 1958). The Mancos Shale crops out on the side of the drainage below the landslide and just above the streambed. It was about 15 feet below the ground surface in the drainage trench excavated near the landslide crown. The Unified Soil Classification System (USCS) classification of landslide materials is clayey gravel (GC) consisting of the pediment gravel and loess, and lean clay (CL) which was derived from weathered Mancos Shale bedrock. Building excavations and drilling in the City of Monticello have revealed ground water flow from the northwest toward the site along the bedrock/unconsolidated deposit contact according to Rick Terry (personal commun., 1986). Springs were noted at the contact in the surrounding area during the 8 December site reconnaissance.

Recommendations

Phases A and B as proposed by ARIX are being implemented and appear to be reasonable and prudent. If Phase B sufficiently drains the landslide and retards movement, Phases C and D may be unnecessary and Phase A can be completed. If Phase B does not stabilize the slope, Phase C and, if necessary, Phase D should be implemented. The landslide should be monitored throughout the spring of 1987 and possibly spring 1988 to determine if the drain is adequate to stabilize the landslide. Points should be established on the landslide surface in a grid pattern and periodically surveyed to monitor movement. The daylighted ends of the drain pipe should be extended to the stream drainage and not allowed to flow on the slope below the landslide. Seeps at the toe of the landslide should be monitored for change in flow to see if the drain pipe is intercepting ground water. The seal of the joints of the sewer line should be checked periodically, sewage water around joints may be the first indication of renewed landslide movement.

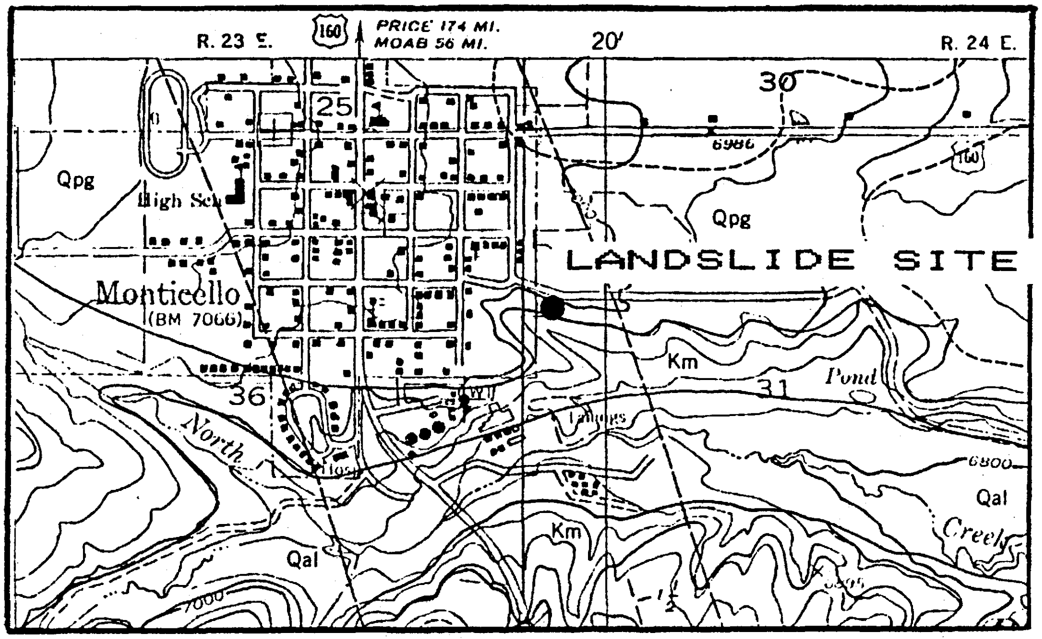
References

ARIX, 1986, Interceptor sewer landslide: City of Monticello: ARIX, Grand Junction, Colorado, 25 p.

Huff, L. C., and Lesure, F. G., 1958, Preliminary geologic map of the Verdure 2 SE Quadrangle, San Juan County, Utah: U.S. Geological Survey Mineral Investigations Field Studies Map MF 163, scale 1:24,000.

Varnes, D. J., 1978, Slope movement types and processes; in Schuster, R. L. and Krizek, R. J., editors, Landslides analysis and control: Transportation Research Board Commission on Sociotechnical Systems, National Research Council, National Academy of Sciences, Washington, D. C., Special Report 176, p. 11-33.

Base map USGS 7 1/2′ topographic
quadrangle: Verdure 2 SE



Scale: one inch = 2000 feet

Geology by Huff and Lesure, 1958

Stratigraphic Column

Qpg	Quaternary pediment gravel
Qal	Quaternary stream alluvium
Km	Cretaceous Mancos Shale

MONTICELLO LANDSLIDE LOCATION MAP

Project: Fremont Junction Geologic Hazards Evaluation, Sevier County, Utah			Requesting Agency: Division of State Lands and Forestry
By: Hal Gill	Date: 4-10-87	County: Sevier	Job No.: 87-003 (GH-2)
USGS Quadrangle: Walker Flat, Utah (593)			

PURPOSE AND SCOPE OF WORK

In response to a request from Louis Brown, Land Specialist, Division of State Lands and Forestry (DSLF), the Utah Geological and Mineral Survey (UGMS) completed a geological hazard evaluation of a parcel of state land at Fremont Junction in Sevier County (attachment 1). The purpose of the investigation was to describe the geologic conditions on the property, including geologic hazards, in order to provide DSLF with information necessary to plan for commercial development of the site. The scope of work included review of published and available unpublished literature, maps, and well logs covering the area. In addition, three test holes were hand augered on the property, soil samples were collected from each boring, and Atterberg limits were run on the samples.

SETTING

The study area is at the northeast corner of the intersection of Interstate 70 and State Highway 10 (Fremont Junction) approximately 37 miles east of Salina, Utah (attachment 1). The site, which encompasses 22.5 acres in T. 23 S., R. 5 E., sec. 34, includes the southwest end and base of Ivie Creek Bench. Surficial deposits are primarily residual soil weathered from the Mancos Shale which underlies the site, and some cobbles and boulders of welded tuff at the northeast corner of the property. With the exception of the bench area, which forms a steep bluff, the property has a maximum slope of 10 percent to the northwest. Several intermittent streams drain the site to the northwest and empty into Ivie Creek which is located approximately 200 feet from the northwest corner of the property (attachment 1). Elevations range from almost 6600 feet at the top of the bluff to 6440 feet where the major drainage exits the property. Average annual precipitation is from 8 to 10 inches (Covington and Williams, 1972).

GENERAL GEOLOGY AND STRUCTURE

The study area is near the southern end of Castle Valley, a fault controlled valley lying between the Wasatch Plateau on the west and the San Rafael Swell on the east (Lupton, 1916). Two geologic units are found within the site boundary. The Cretaceous Blue Gate Shale Member of the Mancos Shale underlies the entire site including the bluff at the northeast corner of the property. The Blue Gate Shale is a dark-gray to black carbonaceous marine shale with minor, thin, pale-yellow sandstone beds (Williams and Hackman, 1972). Rounded volcanic cobbles and boulders (some as large as cars) are found on the slopes and at the base of the bluff in the northeast corner of the site (attachment 2). They apparently are remnants of a Miocene welded tuff unit remaining after erosion of the Fish Lake Plateau to its present location approximately 2 miles east of the site (G. Willis, oral commun., 1987).

The Emery and Paradise faults have been mapped in the site vicinity. The Emery fault trends 1 mile west of the site and the Paradise fault is approximately 1.5 miles to the west (Lupton, 1916). Lupton differentiates between the two faults, but Williams and Hackman (1971) have combined them to form the Paradise fault zone. The youngest formations offset by the faults are of Cretaceous age (approximately 66 to 144 million years before present). The closest suspected Quaternary fault (potentially active) is approximately 15 miles to the south-southwest (Anderson and Miller, 1979).

SOILS

Three hand auger holes were drilled to determine the soil types present on the site (attachment 2). The soil was so dense that the maximum depth attained was 1.7 feet for test boring 2. Test borings 1 and 3 were 1.3 and 0.7 feet deep respectively. The soil found in each boring was classified in the field as a lean clay/fat clay (CL/CH), dark brown, hard to very hard, with a medium to high plasticity. The soil produced a strong reaction to hydrochloric acid which may represent a moderate degree of calcium carbonate cementation. There are no U.S. Soil Conservation Service soil surveys covering the study area, therefore, it was decided that samples should be collected and Atterberg limits run to determine the plasticity and compressibility of the soils. Test results showed that the soils from borings 2 and 3 were lean clay. However, both samples plotted near the boundary between lean and fat clay, therefore, the plasticity and compressibility are relatively high. The soil from boring 1 was determined to be a fat clay with very high plasticity and compressibility. Soils derived from the Mancos Shale characteristically have a high shrink/swell potential and commonly exhibit low permeability. Indications are that site soils possess these same characteristics.

GEOLOGIC HAZARDS

Slope Stability

There is no indication of slope instability along the bluff in the northeast corner of the site. Williams (1972) shows areas of rock fall probability occurring along the north side of the Ivie Creek Bench but not in the area adjacent to the site. However, there are numerous cobbles and boulders along the rim, on the slopes, and at the base of the bench at the site. It is probable that erosion and undercutting of boulders along the rim of the bench results in periodic rock-fall events.

Flooding and Erosion Potential

There are several intermittent drainages trending across the property that have increased their channels to a maximum depth of approximately six feet. Because of the high clay content of the soils, water infiltrates slowly. Therefore, surface runoff will increase rapidly during periods of heavy precipitation and could pose a potential flood hazard. The hazard could be in the form of both sheet wash and/or local flash floods. Because of the high clay content and low permeability, the erosion potential of the soil during these periods of high runoff will be low.

Seismicity

Fremont Junction is located in an area designated as seismic zone 2 on the Uniform Building Code (UBC) and the Utah Seismic Safety Advisory Council (USSAC) statewide seismic zonation maps. Earthquake hazard in this area is considered moderate. Although surface rupture is very unlikely, structures at the site could experience ground shaking, the strength and duration of which would depend upon the magnitude of the earthquake and the location of the epicenter.

Adverse Foundation Conditions

Soils derived from the Mancos Shale commonly have a high shrink/swell potential and have caused foundation problems in areas of the state where they are found. Shrink/swell clay can cause both settlement and heave resulting in cracking of foundations and damage to roads. Atterberg limits of site soils indicate clayey soils with relatively high to very high plasticity, compressibility, and low permeability. Because they are derived from the Mancos Shale there is also a high shrink/swell potential. Structures, parking areas, and roads on site could experience problems with expansive clays. However, when recognized early in the planning process, expansive soils can be adequately managed allowing development to proceed with minimum difficulty.

Suitability for Soil Absorption Systems

Fine-grained soils with high clay content, particularly if expansive clays are present, lack sufficient permeability to perform satisfactorily in wastewater soil absorption systems. Wastewater moves very slowly from drain lines into these soils, and the system can easily become overloaded. System backup or surface seepage of unrenovated sewage effluent may be the result. Expansive clays are particularly unsuitable because percolation tests may indicate sufficient permeability, but once the clays are saturated for a period of time, they swell and permeability is reduced. There is every indication that the site soils contain a high percentage of expansive clay. Therefore, these soils would likely present a severe limitation to wastewater absorption systems. In addition, Utah Department of Transportation drill logs from the Fremont Junction interchange indicate impermeable shale bedrock at five feet beneath the surface (from 500 to 800 feet southwest of the site, attachment 2). This can also result in perching of wastewater and overloading of soil absorption systems.

CONCLUSIONS AND RECOMMENDATIONS

1) Slope instability does not appear to represent a hazard at the site. However, this condition could change if grading cuts are required along the toe of the bench in the northeast corner of the property. If construction is proposed for this area, a slope stability analysis is recommended prior to the start of construction. There are numerous cobbles and boulders observed on the slopes and at the base of the bench in the northeast corner of the property. There is a potential rock-fall hazard in this area and the UGMS recommends a detailed rock-fall study be undertaken if construction is proposed for this area.

2) Site soils are highly plastic impermeable clays and water will infiltrate slowly. During periods of high precipitation the threat of localized flash flooding or sheet wash flooding exists. Installation of a drainage system to control flooding is recommended for the portion of the site to be developed. Ivie Creek is approximately 200 feet from the northwest corner of the site, therefore, flood hazard from this source is considered low. There was no indication of previous flooding observed during the field reconnaissance and no mention of past flooding in the literature.

3) Site soils are highly plastic and impermeable, therefore, erosion potential is low. However, care should be taken to protect the soils from erosion during construction.

4) The site is in UBC and USSAC seismic zone 2 and all construction should conform to specifications recommended for structures in this zone.

5) Highly plastic, clayey soil with a high shrink/swell potential exists at the site and represents a hazard to building foundations if not properly mitigated. A detailed soils/foundation investigation to determine the shrink/swell potential of the soil and to provide foundation design criteria is recommended.

6) Expansive soil represents a limitation to wastewater absorption systems on site. The slow permeability of the soil can cause failure of the system, creating surface seepage of unrenovated wastewater. Impermeable shale bedrock was found within five feet of the surface approximately 500 to 800 feet from the site, and undoubtedly underlies the site, possibly at an even shallower depth. Shallow bedrock can also create perched wastewater conditions and subsequent failure of the system. Percolation tests should be conducted on site to determine if soil permeability is adequate for absorption systems. The tests should adhere strictly to procedures for fine-grained soils, in that the test hole should be saturated for at least 16 hours prior to the test. In addition, depth to bedrock should be determined. Depending on the results of those tests, the Wisconsin mound or low pressure pipe systems of wastewater disposal may be more appropriate for this site than a standard septic tank and soil absorption field system.

SELECTED REFERENCES

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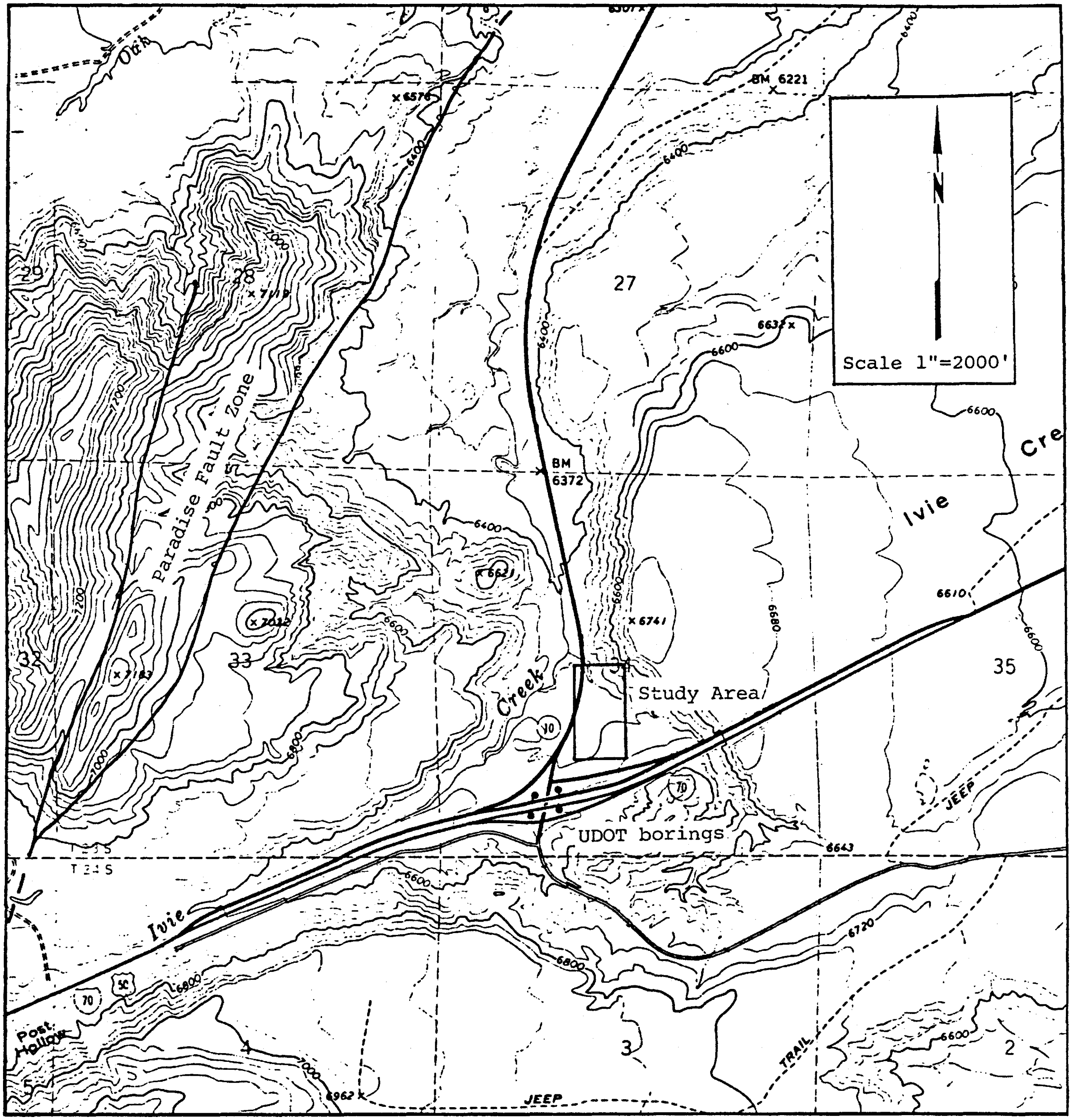
Lupton, C. T., 1916, Geology and coal resources of Castle Valley in Carbon, Emery, and Sevier Counties, Utah: U.S. Geological Survey Bulletin 628, 87 p.

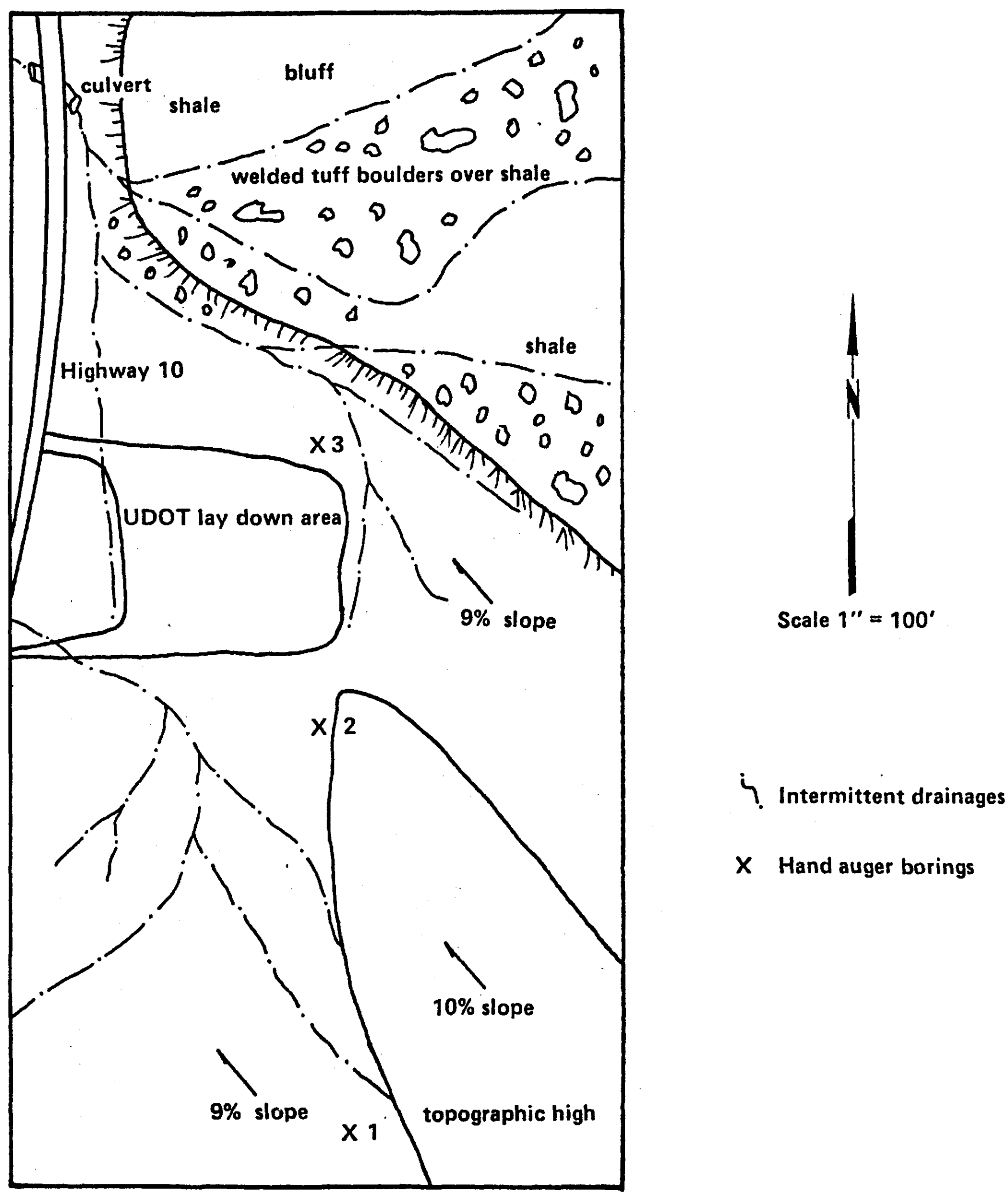
Williams, P. L., 1972, Map showing landslides and areas of potential landsliding in the Salina Quadrangle, Utah: U.S. Geological Survey Folio of the Salina Quadrangle, Utah Map I-591-L, scale 1:250,000.

Williams, P. L., and Hackman, R. J., 1971, Geology, structure, and uranium deposits of the Salina Quadrangle, Utah: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-591, scale 1:250,000.

Base map from USGS 7½' topographic quadrangle, Walker Flat, Utah.



General location map of Fremont Junction study area.



Fremont Junction study area site map.

Project:			Requesting Agency:
Fault trenching in Research Park, Salt Lake City, Utah			Salt Lake City Engineering Dept.
By R.H. Klauk & W.E. Mulvey	Date: 4-20-87	County: Salt Lake	Job No.: 87-004 (GH-3)
USGS Quadrangle: Fort Douglas (1253)			

BACKGROUND AND SCOPE OF WORK

A request from Daniel C. Noziska, P.E., Project Manager, Salt Lake City Engineering Department coupled with the Utah Geological and Mineral Survey's ongoing paleoseismic studies along the Wasatch Front initiated an investigation to determine if a scarp in Research Park is an active fault (younger than 10,000 years). Confirmation that surface fault rupture produced the scarp is important to development in this part of the park. The scarp was first mapped as a fault by Van Horn in 1969. Subsequent maps compiled by Miller (1980) and Davis (1983) also show a fault. Scott and Schroba (1985), however, do not include this feature on their map. Klauk (1986) mapped it as a fault but recommended the scarp be trenched for verification.

The scope of work for this study consisted of a field reconnaissance, consultation with Salt Lake City planners and engineers, and excavating and logging a trench cut across the scarp. Salt Lake City provided the backhoe and the Utah Geological and Mineral Survey conducted the logging.

LOCATION AND DESCRIPTION

The trench site is located in the NW 1\4 SE 1/4 sec.3, T. 1 S., R. 1 E., Salt Lake Baseline and Meridian (attachment 1). The scarp trends northwest and slopes southwest with a total height of approximately 7 feet. The scarp abruptly terminates to the north and south at alluvial fans from Soldiers and Georges Hollows, respectively. Seeps emanate from an area approximately 20 feet downslope from the base of the scarp.

TRENCHING

The trench was excavated normal to the scarp; depths ranged from 8 feet (northeast) to 2 feet (southwest) because ground water precluded excavating deeper. A generalized log of the trench is presented in attachment 2.

Soils encountered at the northeastern end of the trench generally consisted of 1 foot of dark gray fine sandy silt (A horizon) underlain by a reddish-brown clayey fine sand to a depth of approximately 3.5 feet. The upper part of this unit had a greater percentage of clay due to the development of a B soil horizon. Underlying this unit was a tan silty fine sand with clay that reacted strongly with HCL. Both units were deposited during Lake Bonneville's transgression to the Bonneville shoreline. Although the texture of the two units is very similar, the color change separating them is considered to be a stratigraphic break and not the result of soil development. At the southwestern end of the trench the dark gray soil was underlain by the lower tan unit. The reddish-brown fine sand terminated at the scarp due to mechanical excavation by the Army or erosion by Lake Bonneville. No evidence of faulting was found.

CONCLUSIONS AND RECOMMENDATIONS

No evidence of displacement was observed in the trench indicating the scarp is not of tectonic origin. Although a number of alternatives are possible for the formation of the scarp, a clear determination of its origin was not apparent in this investigation.

Klauk (1986) mapped shallow ground water in this area. Excavation of the trench, however, indicates shallow ground-water extends further to the east and is larger in area than previously thought. Therefore, the area that needs to be evaluated for liquefaction potential during foundation investigations is more extensive.

REFERENCES CITED

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.

Klauk, R.H., 1986, Engineering geology for land-use planning for Research Park, University of Utah, Salt Lake City, Utah: Utah Geological and Mineral Survey Report of Investigation No. 204, 27 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 1:100,000.

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, 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.

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(?)	JŦn	Nugget Sandstone: tan fine- to medium grained, crossbedded sandstone
Triassic	Ŧau	Upper member Ankareh Formation: Brown to purple shale, mudstone, and fine-grained sandstone
Triassic	Ŧag	Gartra Grit Member Ankareh Formation: Light gray to pale purple massive to crossbedded quartzite
Triassic	Ŧam	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.

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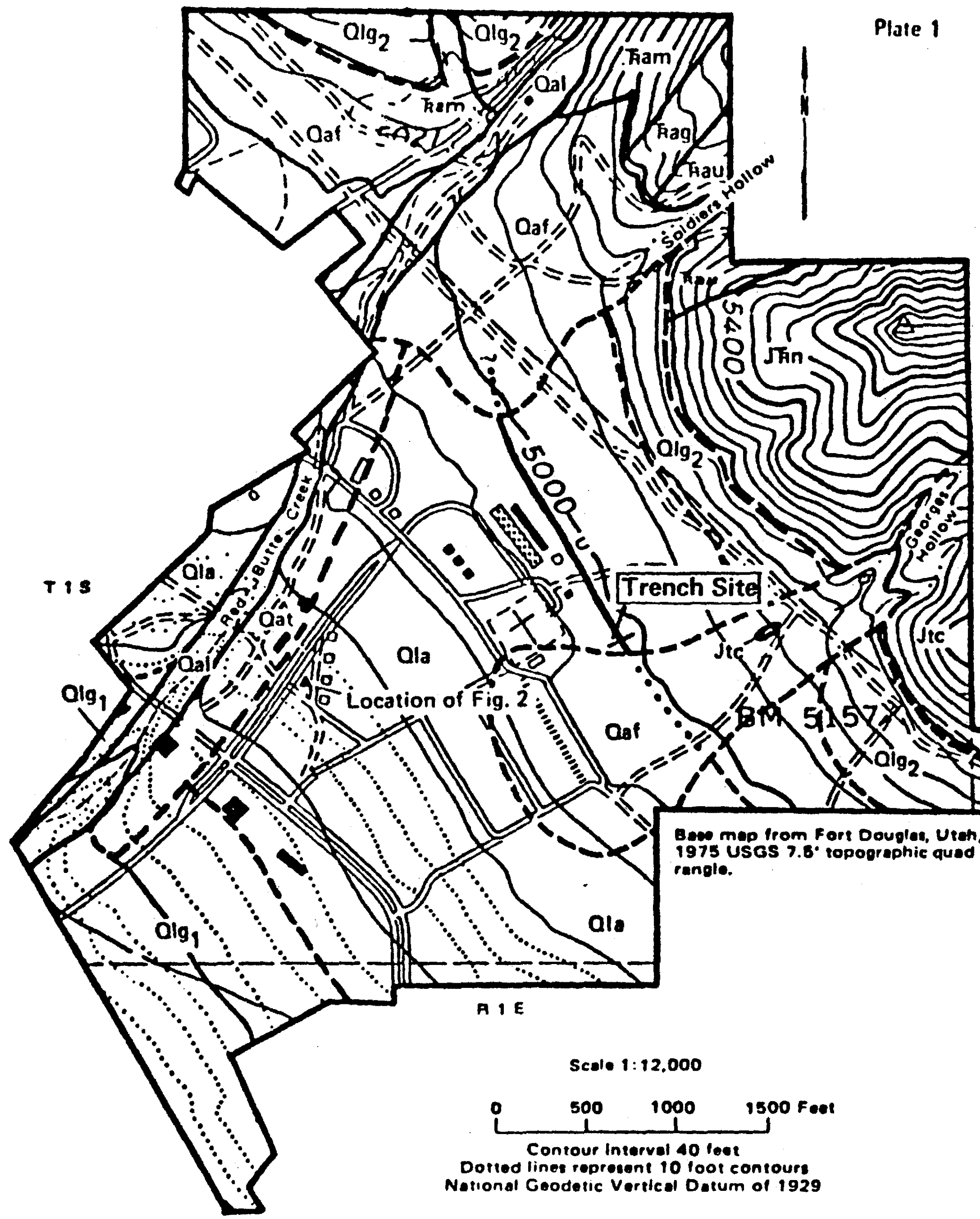
Scott, W. E., and Shroba, R. R., 1985, Surficial geologic map along the Wasatch fault zone in Salt Lake City, Utah: U.S. Geological Survey Open-File Report 85 448, 18 p.

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

Attachment 1, Job No. 87-004 (GH-3)



(Base map from Klauk, 1986)

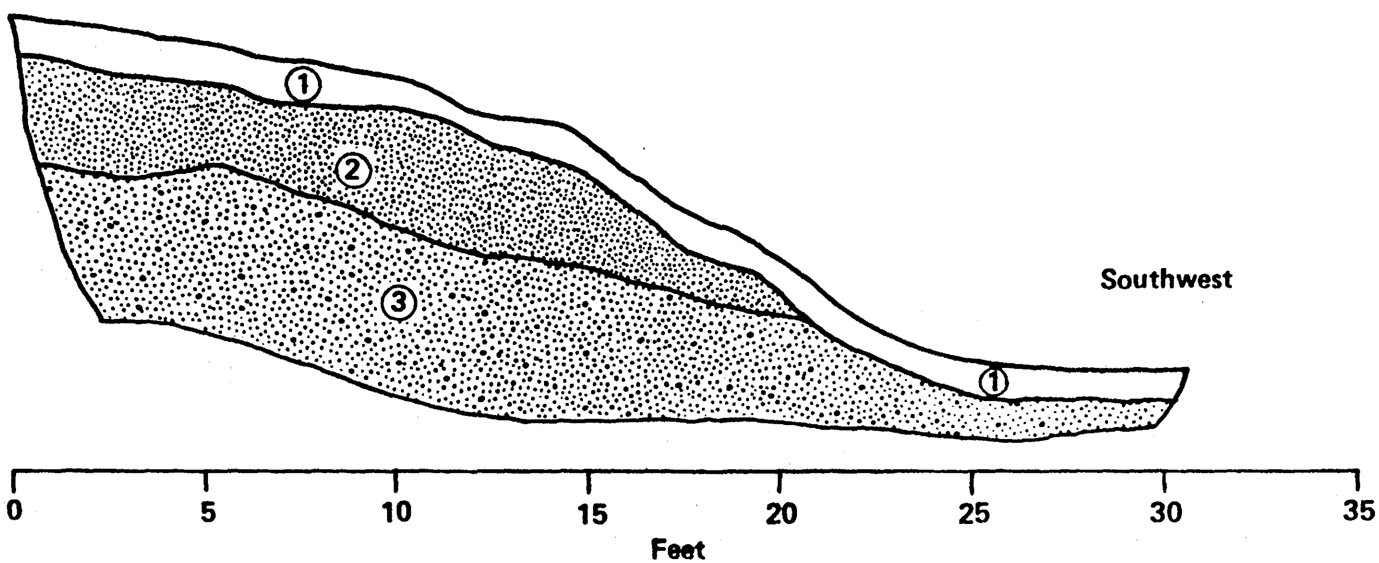
GEOLOGIC MAP OF RESEARCH PARK, SALT LAKE CITY, UTAH

LOG OF TRENCH IN RESEARCH PARK, SALT LAKE CITY, UTAH.

Sandy silt with gravel (ML); dark gray, low density, low plasticity, dry; subrounded, poorly graded, no cementation, no reaction with HCL, numerous roots; A soil horizon.

Clayey fine sand with silt and trace gravel (SC); reddish brown, medium density, medium plasticity, moist; subrounded, poorly graded, no cementation, no reaction with HCL, numerous roots; transitional Lake Bonneville deposits with upper zone more clayey possibly due to formation of B soil horizon; occasional rodent burrow filling with unit 1 soil.

Silty fine sand with clay and gravel (SM); tan, medium density, low plasticity, moist; subrounded, poorly graded, no cementation, strong reaction with HCL, some roots; transitional Lake Bonneville deposits.



No vertical exaggeration

Project: Review of reports of deformation in excavation, University of Utah hospital extension site, Salt Lake County, Utah			Requesting Agency: University of Utah Planning Department
By: William F. Case	Date: 8 June, 1987	County: Salt Lake County	Job No.: 87-005 (GH-4)
USGS Quadrangle: Fort Douglas (1253)			

Purpose and Scope

Brad Clausen, University of Utah Planner, requested a determination of the type of deformation discovered in an excavation for a University of Utah Hospital extension reported in a Utah Geological and Mineral Survey Report of Investigation. The University is proposing the construction of a parking terrace directly west of the hospital extension., This report is a result of a review of the Report of Investigation, No. 149, Geology of Some Foundation Excavations in Northeastern Salt Lake City (Everitt, 1980) and a review of related sections of Report of Investigation No. 204, Engineering Geology for Land-Use Planning for Research Park, University of Utah, Salt Lake City, Utah (Klauk, 1986).

Location and Stratigraphy

The site is located northwest of the University of Utah Hospital near the mouth of Cephalopod Gulch (Attachment 1). Sedimentary units noted in the excavation include alluvium of pre-Lake Bonneville age, Lake Bonneville sediments, and alluvium of post-Lake Bonneville age (Everitt, 1980).

Pre-lake alluvium consist of up to 45 feet of gravels alternating with thick beds of silt and clay. Gravels consist of angular limestone particles up to 1 foot in diameter which were deposited by debris flows from Cephalopod Gulch. Intervening silts are stream and possibly wind-fall sediments. The time intervals between debris flows were long enough to develop desert soil horizons on the silts. Everitt (1980) places the relative age of the pre-lake alluvium between Pliocene and mid-Quaternary (between 5.3 million and 500 thousand years ago).

Lake Bonneville sediments consist of 10 to 15 feet of rounded, very coarse gravel overlain by coarse sand grading upward into silt. The gravels have particles up to 5 feet in diameter. The contact with the pre-lake alluvium is a gently inclined erosional surface. Soil horizons in the sands indicate occasional subaerial exposure when lake waters temporarily receded slightly. On the basis of elevation and stratigraphy, Scott and Shroba (1985) put the gravels at the base of the unit at approximately 18,000 years old.

Post-lake alluvial sediments were deposited by debris flows. The sediments are locally derived pebble gravels composed of angular limestone particles from Cephalopod Gulch and well-rounded, reworked, Lake Bonneville beach gravels. Post-lake alluvial sediments are Holocene (recent) age, younger than approximately 10,000 years (Everitt, 1980).

Faulting

The pre-lake alluvium is highly faulted. Many high-angle normal faults in the alluvium have vertical displacements of up to 3 feet. Faulted blocks have been downthrown on the west side of the faults and tilted up to 15 degrees to the east (Everitt, 1980). None of the overlying sedimentary units have been deformed therefore faulting is at least older than the oldest undeformed unit, i.e., approximately 18,000 years (Scott and Shroba, 1985). The extent of faulting, along trend, is not known beyond the excavation for the hospital extension. The zone of deformation of the pre-lake alluvium in the excavation is approximately 165 feet wide (Everitt, 1980).

Conclusions

The Salt lake City segment of the Wasatch fault has experienced several major earthquakes during the last 18,000 years (William R. Lund, Chief, Site Investigation Section, Utah Geological and Mineral Survey, personal comm., 8 June 1987). The faults which produced deformation of the pre-Lake Bonneville alluvium did not displace lake Bonneville and post-Lake Bonneville sedimentary units, i.e., they have not moved in the last 18,000 years even though major earthquakes have occurred on the Wasatch fault. Therefore, it is likely that the probability of future fault displacement at the site is very low. However, any construction should conform to Unified Building Code standards for seismic zone 3 (Klauk, 1986).

REFERENCES

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.

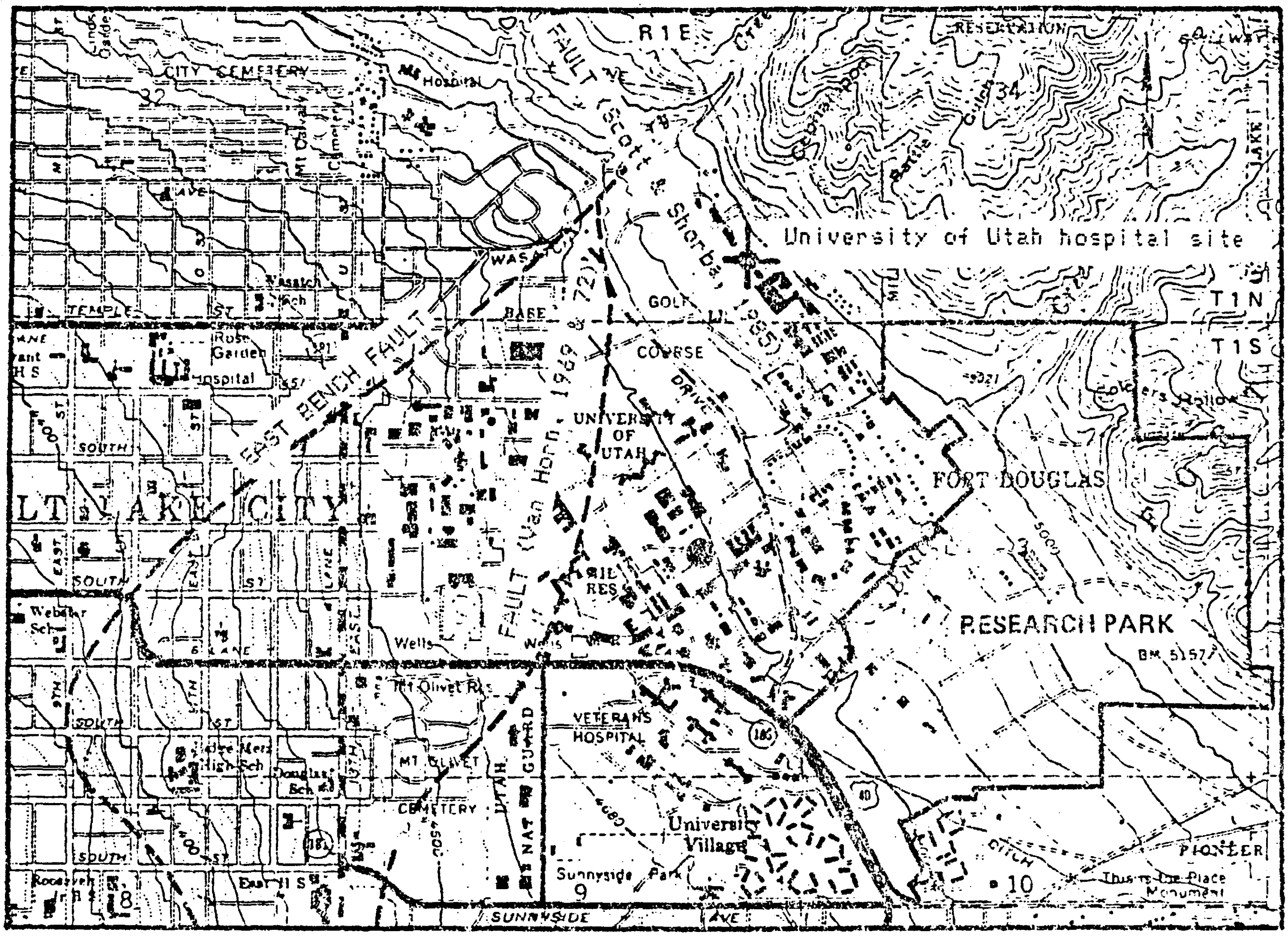
Klauk, R.H., 1986, Engineering geology for land-use planning for Research Park, University of Utah, Salt Lake City, Utah: Utah Geological and Mineral Survey Report of Investigation No. 204, 30 p.

Scott, W.E., and Shroba, R.R., 1985, Surficial geologic map along the Wasatch fault zone in the Salt Lake Valley, Utah: U.S. Geologic 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. Geologic Survey Open-File Map 69-308, scale 1:24,000.

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

Attachment 1: Location map of northeastern Salt Lake City



Base from U.S. Geological Survey Fort Douglas, Utah, 7.5' topographic quadrangle

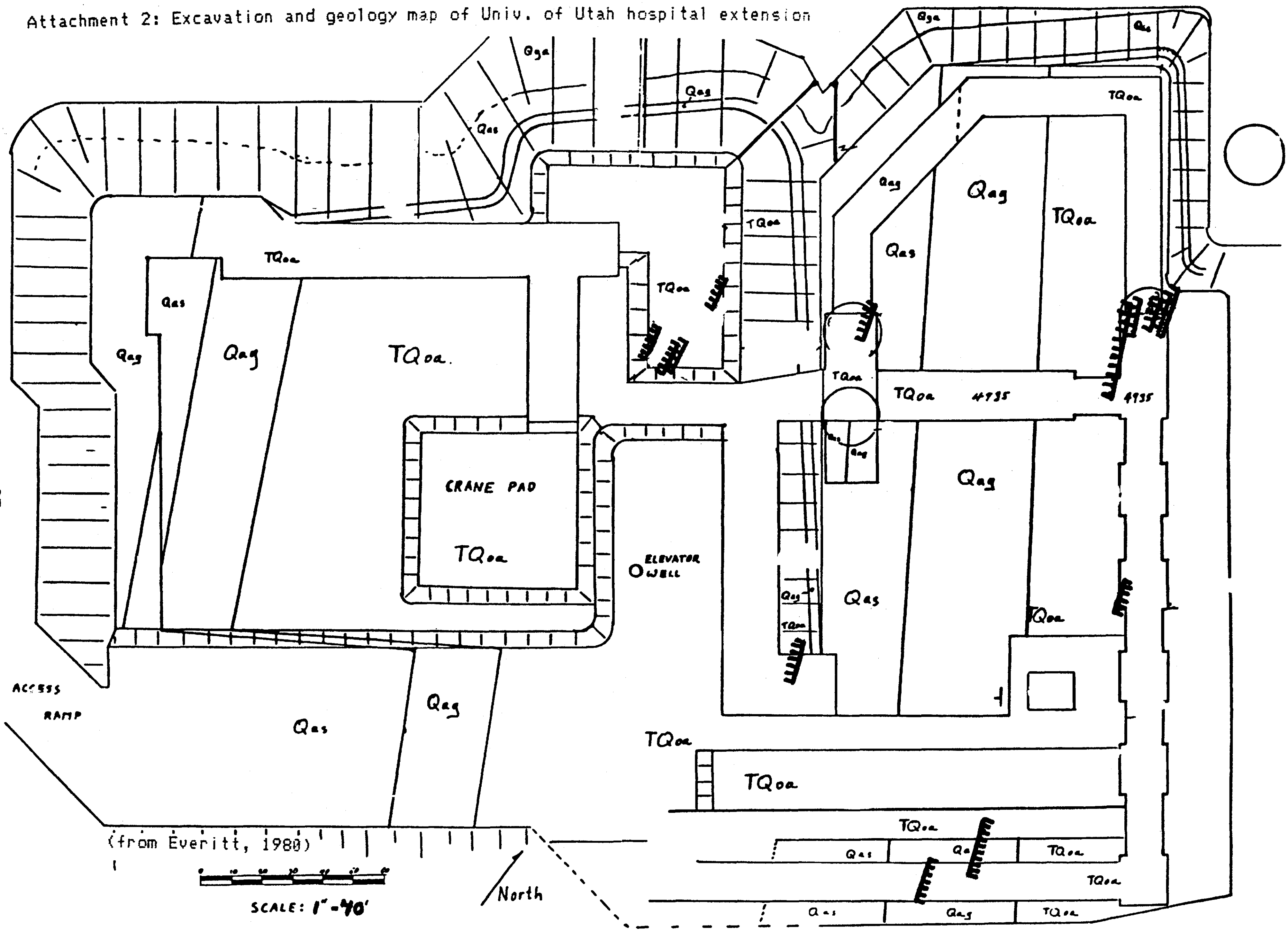
(from Klauk, 1986)

Scale 1:24,000

0 1 Mile

Contour interval 40 feet
Dotted lines indicate 10-foot contours

Attachment 2: Excavation and geology map of Univ. of Utah hospital extension



(from Everitt, 1980)

Utah Geological & Mineral Survey

Site Investigation Section

EXPLANATION

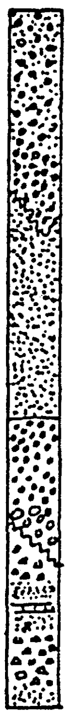
GEOLOGY OF THE UNIVERSITY HOSPITAL EXTENSION FOUNDATION EXCAVATION, 1978

(from Everitt, 1980)

- Based on mass excavation and grading plan, Gustavson, Nelson, & Panushka, Architects.

SYMBOLS

**Fault, hatchures on hanging wall, with strike & dip of fault plane.**



STRATIGRAPHY

Holocene

Qya — **Post lake alluvium; mudflow and flash flood deposits up to 15 feet thick at the north corner of the excavation; contains angular to well-rounded pebbles to 2 inches of locally derived rock; frequency of rounded pebbles decreases upward;**

Pleistocene

Lake Bonneville Deposits

Qas — **Medium to fine red sand grading upward to silt which may be loessal in origin; 10 - 15 feet thick. A weak soil is developed on the upper silty zone which is characterized (at UH5022) by up to 1 foot of dark brown sandy organic horizon over 2 feet of red-brown oxidized and leached zone over 3 feet of pink sandy silt with caliche veinlets.**

Qag — **Transgressive beach gravel with boulders up to 5 feet in length, grading upward into course sand; 5 - 10 feet thick; abundant cone-spiral snails.**

Tertiary-Quaternary Undifferentiated

TQoa — **Pre-lake alluvium: interbedded brown silt, coarse angular locally derived gravel with cobbles to 1 foot, and hardpan caliche up to 2 feet thick. The unit is broken by many high angle faults which strike N20°W. Beds dip as much as 20° to the east. The gravel facies contains shells of pseudo-plainspiral snail as large as 1 inch in diameter.**

Project: Sink hole and Landslide Investigation in Summit County, Utah			Requesting Agency: Summit County Roads Department
By: R.H. Klauk & K.M. Harty	Date: 6-26-87	County: Summit	Job No.: 87-006 (GH-5)
USGS Quadrangle: Wanship (1250) and Red Hole (1288)			

PURPOSE AND SCOPE

This report presents the results of a brief field reconnaissance by the Utah Geological and Mineral Survey (UGMS) for two sites in Summit County, Utah. Site 1 involved recently developed sinkholes in the SE 1/4, sec. 28, T. 2 N., R. 5 E., Salt Lake Baseline and Meridian (attachment 1). Site 2 consists of a landslide located in NE 1/4, sec. 35, T. 3 N., R. 7 E., Salt Lake Baseline and Meridian (attachment 2).

The purpose of the investigation for Site 1 was to: 1) determine the cause of the sinkholes, 2) determine if continued development is a threat to the County road, and 3) suggest measures to arrest continued development.

The purpose of the reconnaissance at Site 2 was to recommend cost-effective methods for preventing future damage to Chaulk Creek Road from the landslide.

The scope of work for both sites consisted of a literature review as well as the field reconnaissance. Air photo analysis was also conducted for Site 2.

SITE 1

A sinkhole approximately 6 feet in diameter and 4 feet deep has recently formed in a field on a Weber River terrace less than 0.5 miles west of Hoytsville (attachment 1). This field is bordered on the south by a paved County road. Immediately south of this road is a large borrow pit (40 to 60 feet deep) developed during construction of U.S. Interstate 80.

Approximately 20 years ago a slope failure occurred at this location with the head scarp forming in the field and the toe extending to the base of the cut for the borrow pit (Bruce Bowser, personal commun., June 22, 1987). The slide destroyed 100 to 200 feet of road. Prior to backfilling and repairing the road, a drainpipe was placed in the failure. This drainpipe extends into the bottom of the borrow pit; the location of the upper end is not known.

The sinkhole has developed in previously undisturbed alluvium 50 to 100 feet north of the former head scarp of the slope failure. A second sinkhole appears to be developing 50 to 75 feet northeast of the first. The alluvium exposed in the large sinkhole is high in silt and clay content.

The sinkholes are caused by piping. Piping results from a relatively weak, incoherent permeable soil layer becoming saturated and conducting water to some transecting freeface (Costa and Baker, 1981). Erosion of fine-grained material adjacent to this layer forms the pipes. Alluvium (such as is present at the site) is susceptible to piping. Other conditions at this site conducive topiping are flood irrigating the field and the drainpipe that must transect some incoherent layer in the alluvium. Removal of subsurface material through this pipe is apparent by the formation of the fine-grained fan that has recently begun radiating from the lower end of the drainpipe. The sinkholes have developed due to the self-enhancing process of erosion due to increased flow in the pipes to the point where the walls and roof have collapsed. The second sinkhole presently developing up slope in the direction of the ditch supplying the irrigation water suggests headward erosion is occurring and that much of this area could be unstable. To what depth these conduits have developed is controlled by the depth of the drainpipe which is unknown.

The present location of the sinkholes and the suggested direction of headward erosion does not pose an immediate hazard to the road. Continued irrigation, however, could cause more collapse features in the field. According to Costa and Baker (1981), the key to prevention of piping is the avoidance of runoff concentration. During the site reconnaissance, the only area in the field still saturated from irrigation the previous night was in the vicinity of the sinkholes. Reducing the amount of water used for irrigation may help alleviate the problem. Furthermore, constructing small berms or ditches to divert surface flow away from this area could also prove beneficial. Backfilling the existing holes with a very impermeable material is also recommended to reduce flow velocity in the pipes and, therefore, reduce their erodibility. It is also recommended that this area continue to be monitored. If new sink holes or ground cracks develop closer to the road, more extensive measures may need to be employed to mitigate the problem.

SITE 2

Site 2 consists of a large landslide approximately 15 miles east of Coalville (attachment 2). The slide is in an area mapped by Randall (1952) as Kelvin Formation. This formation consists of shale, sandstone and thin beds of limestone. He also mapped Aspen and Frontier Formations in this area; the Aspen Formation consists of bentonitic and porrelanitic shale, whereas the Frontier Formation is composed mainly of sandstone and shale. The toe of this slide extends into the floodplain of Chaulk Creek. This landslide is present on 1953 air photographs and was only recently reactivated by the wet cycle commencing in 1983. According to Bruce Bowser (personal commun., June 22, 1987), movement greatly accelerated in the spring of 1986, damaging a section of Chaulk Creek Road. At the time of this reconnaissance the road had been repaired and a petroleum pipeline and a Mountain Fuel natural gas pipeline that cross the slide were being rerouted.

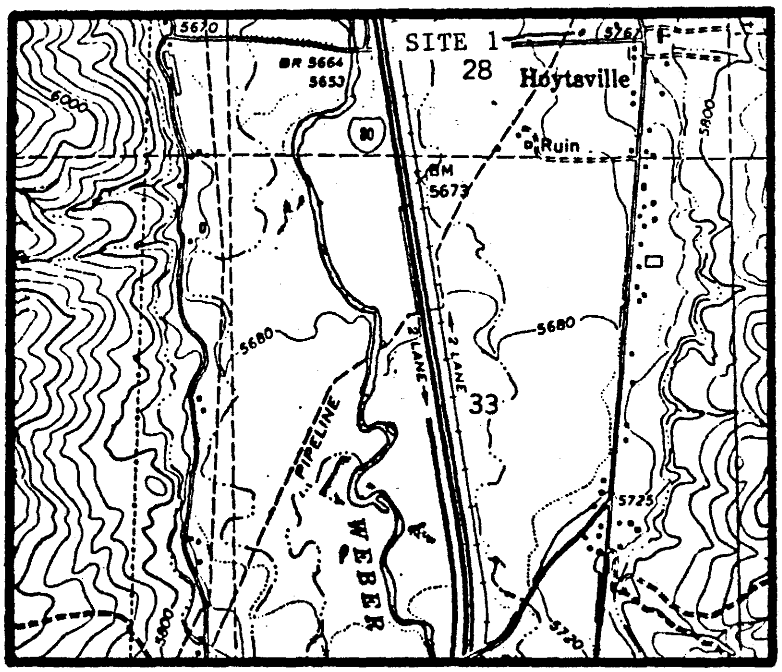
The slide is extremely large, and measures to halt movement or realign the road would be cost prohibitive. Therefore, it is recommended that the slide be monitored and road repairs be made accordingly.

REFERENCES CITED

Costa, J.E., and Baker, V.R., 1981, Surficial geology building with the earth: New York, John Wiley and Sons, p. 295-297.

Randall, A.G., 1952, Areal geology of the Pinecliff area, Summit County, Utah: Salt Lake City, University of Utah, M.S. thesis, 43 p.

R. 5 E.



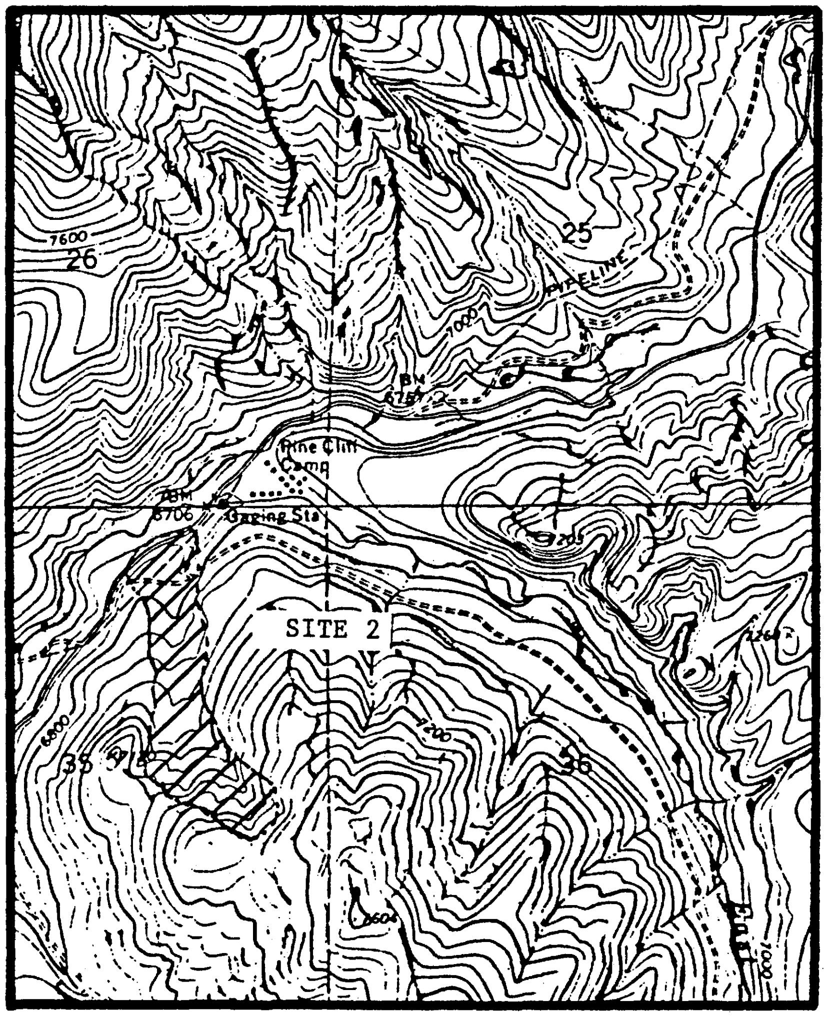
T. 2 N.

Base modified from USGS 7 1/2' topographic quadrangle map, Wanship, Utah

Scale 1" = 2000'

LOCATION MAP - SITE 1

R. 7 E.



T. 3 N.

Base modified from USGS 7 1/2'
topographic quadrangle map, Red Hole,
Utah-Wyoming.

Scale 1" = 2000'

LOCATION MAP - SITE 2

Project: Preliminary geologic hazards inventory for the Bear River Range Planning Unit, Cache and Rich Counties, Utah			Requesting Agency: Utah Division of State Lands and Forestry
By: Kimm M. Harty	Date: 9-29-87	County: Cache and Rich	Job No.: 87-012 (GH-6)
USGS Quadrangle: Naomi Peak, Tony Grove Peak, Garden City, Boulder Mtn., Hardware Ranch, Logan, Logan Peak, Red Spur Mtn., Curtis Ridge, Temple Peak, Meadowville.			

PURPOSE AND SCOPE

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

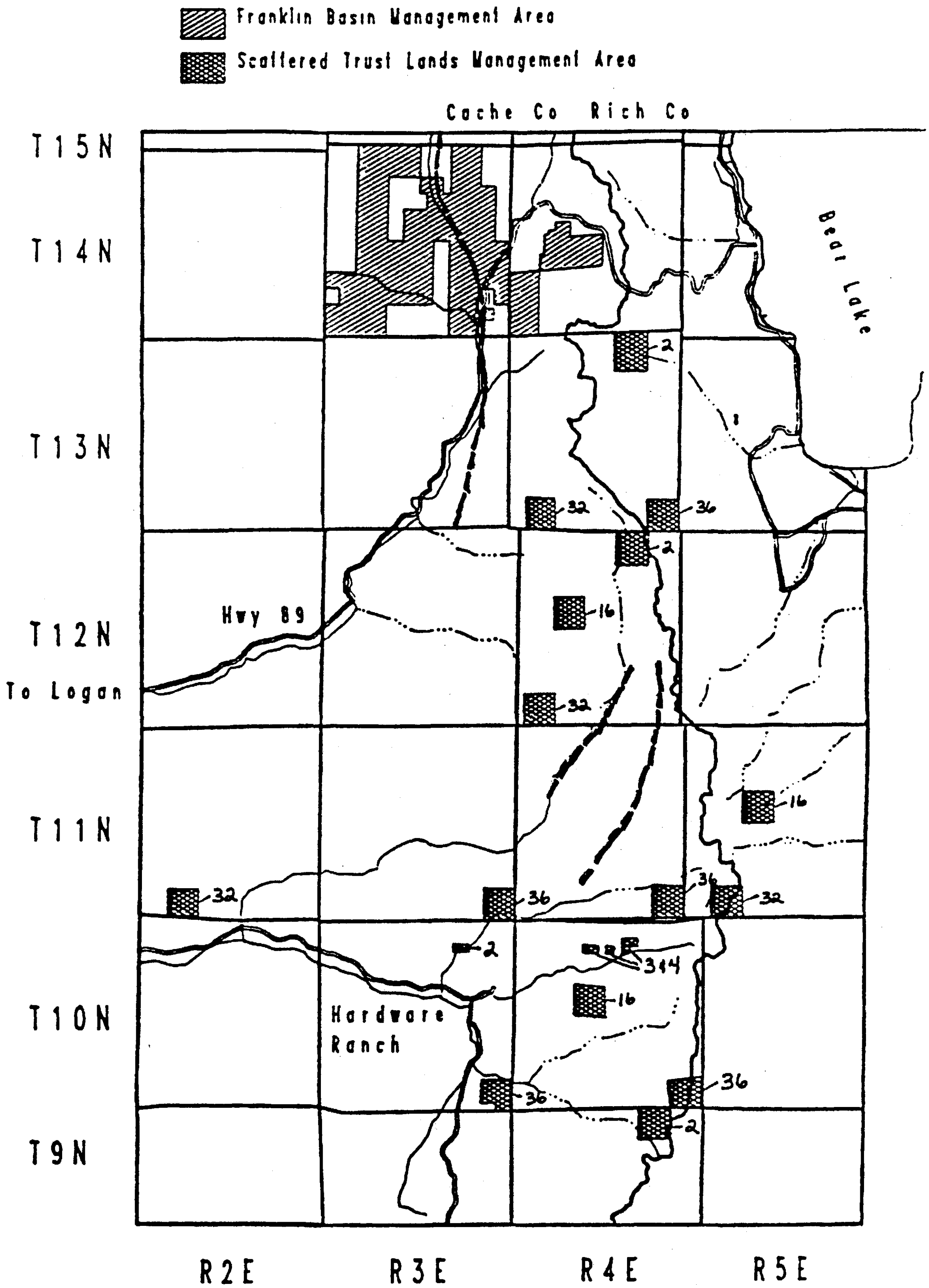
GEOLOGIC HAZARDS

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

Slope Failure

Slope failures are a potential hazard in the study area, and include chiefly rockfalls, rock slides, and shallow debris slides and slips. Several landslides have occurred within sandstone and conglomerate rocks of the Wasatch Formation, and in the Brigham Formation (formerly known as Brigham Quartzite) along the eastern foothills of the Bear River Range (Kaliser, 1972). Numerous large landslides, mostly debris slips, have been mapped in these geologic units in the Bear River Range by DeGraff (1976). Rockfalls and rock topples were not included in the study. The mapped area includes the western half of the Bear River Range Planning

Figure 1. Bear River Range Planning Unit



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

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

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

Geologic Hazards[1]

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

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

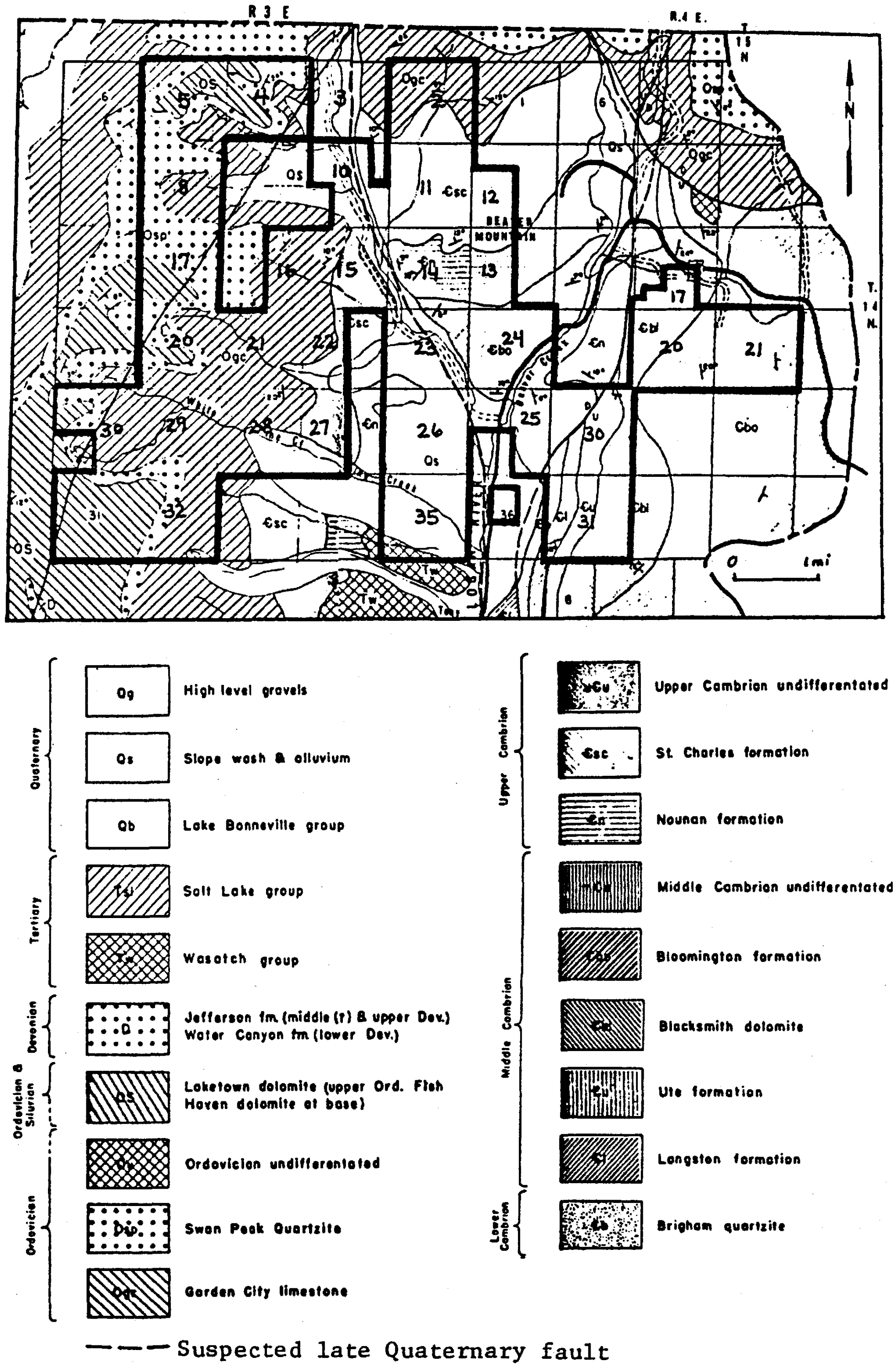
[3] Hazards due to surface fault rupture are considered present only in parcels traversed by active faults. However, severe ground shaking accompanying earthquakes may occur at all parcels.

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

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

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

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



Unit, with the easternmost mapped boundary extending north-south through the center of Range 4 E. Landslides occur primarily along the western mountain front of the Bear River Range, and on steep slopes along major canyons, including Logan Canyon, East Canyon, and Blacksmith Fork Canyon and its tributaries Left Hand Fork and Sheep Creek (DeGraff, 1976). None of the mapped landslides occurs within parcels of the Franklin Basin or Scattered Trust Lands Management Areas. However, the scale of aerial photography used to map landslides prohibited identification of slides less than one acre in size. In addition, most of the slides were mapped using 1968 aerial photography, and thus landslides that have occurred within the last 19 years are not shown. Due to the predominance of generally competent rocks and steep slopes in the management areas, the most probable slope failure hazard is from rock or debris falls and slides, and the potential for these hazards occurring is marked in every parcel on the geologic hazards inventory (table 1).

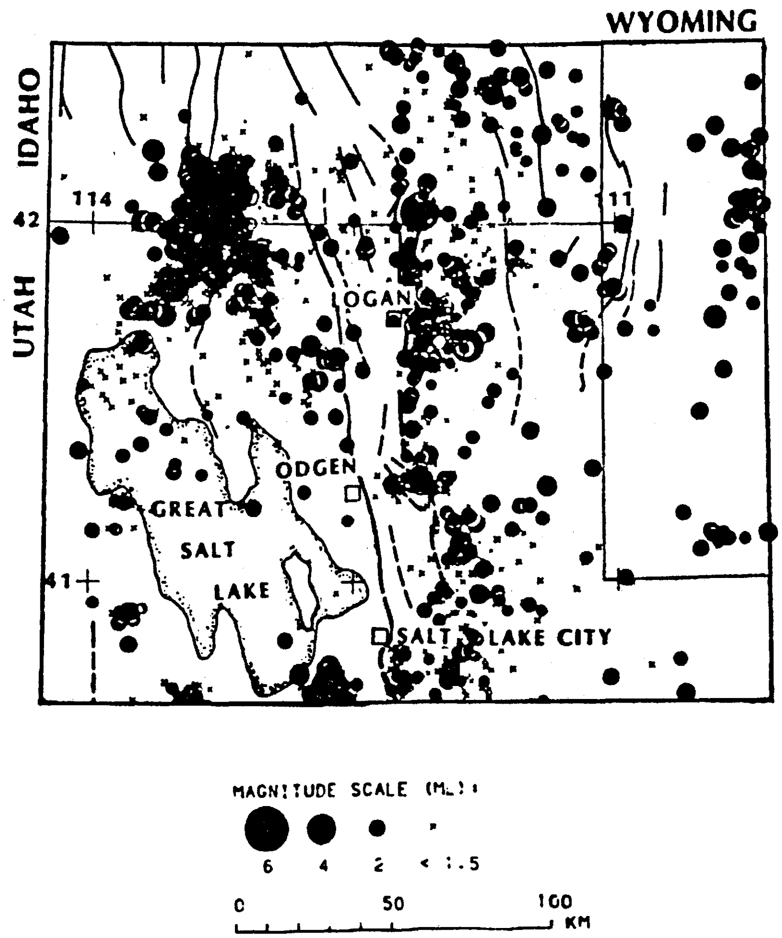
Due to adequate precipitation, steep slopes, and accumulations of hillslope talus, the possibility for initiation of debris flows in the planning unit is considered good. However, the greatest hazard posed by this type of slope failure is mainly in downstream runout areas near canyon mouths, where water-mobilized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

Seismic Hazards

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

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

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



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

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

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

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

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

Subsidence

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

FOUNDATION CONDITIONS

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

CONCLUSIONS

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

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Appendix

MODIFIED MERCALLI INTENSITY SCALE OF 1931
(Abridged)

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

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

III. Felt 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 a 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 sounds. Sensation like heavy truck striking building; standing motor cars rocked noticeably.

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

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

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

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

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

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

XI. Few, if any 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 surface. Lines of sight and level distorted. Objects thrown upward into the air.

APPENDIX

1987 PUBLICATIONS OF THE APPLIED GEOLOGY PROGRAM

OPEN-FILE REPORTS

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