GEOLOGIC EVALUATION OF WASTEWATER DISPOSAL IN ROCK, DUCHESNE COUNTY, UTAH

by William E. Mulvey and William R. Lund

Applied Geology Program, Utah Geological and Mineral Survey

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ABSTRACT

Western Duchesne County is experiencing development for recreational and second-home subdivisions, especially in the drainages of the Strawberry and Duchesne Rivers. Many lots, and sometimes entire subdivisions, cannot be developed because shallow depth to rock makes them unsuitable for conventional soil absorption systems. This study evaluates the feasibility to dispose of limited quantities of domestic wastewater in rock and to establish appropriate criteria for site evaluation.

The study area is in the northwestern Uinta Basin, a topographic and structural depression in northeastern Utah. The two most wide-spread rock units are the Green River and Duchesne River Formations, and they have the greatest potential for disposal of domestic wastewater.

The study shows that the main factors influencing disposal of domestic wastewater in shallow rock are rock type, degree of rock fracturing and bedding, and depth to ground water. The sandstone/limestone facies of the Green River Formation and the Duchesne River Formation are potentially suitable for wastewater disposal. Percolation rates in these geologic units fall within the state and local regulations for soil absorption systems. All other geologic units were unacceptable for absorption systems in rock due to rapid or slow percolation rates and the potential to contaminate ground water.

INTRODUCTION

The number of recreational and second-home subdivisions has increased dramatically during the last ten to fifteen years in western Duchesne County along the drainages of the Strawberry and Duchesne Rivers. Approximately 1500 lots have been platted and sold, but in many cases owners have been unable to obtain building permits because insufficient soil depth creates unsuitable conditions for conventional wastewater disposal systems.

County agencies classify most of the subdivisions as "dry" to indicate that they have no piped public or private water system and no legal or demonstrated means of developing such a system. Depth to ground water in many of the subdivisions is up to 800 feet (244 m), and the water is often saline, severely restricting development of culinary wells. At present, lot owners must haul all water. Permanent residents indicate a usage of less than 10,000 gallons (37.8 m^3) of water per household per year for domestic needs (Jim Blackner, oral communication, 1988), as compared to 437,000 gallons (1654 m^3) per year for an average three-bedroom home in a metropolitan area (Utah Division of Health, 1985).

In response to concerns of landowners, and county planning and health offices, the Duchesne County Commission requested that the Utah Geological and Mineral Survey (UGMS) conduct an investigation to determine if geologic and hydrologic conditions would permit the safe disposal of limited quantities of domestic wastewater in the rock of western Duchesne County. The study was funded by the Division of Community and Economic Development Impact Board and work was initiated by UGMS in 1986.

PURPOSE AND SCOPE

The purpose of this study was to evaluate the potential for safe disposal of limited quantities of domestic wastewater in rock and, if a potential does exist, to designate suitable areas and establish appropriate geologic and hydrologic criteria for site evaluation. For this report, rock is defined as any consolidated aggregate of one or more materials such as sandstone, shale, or limestone. Soils, however, are the preferred medium for absorption systems; this is especially true if there are any plans to develop a local ground-water source or water system for drinking water. Parts of the study area have soils adequate for conventional wastewater disposal systems.

A principal assumption of this study is that the quantity of disposed wastewater would not exceed 10,000 gallons (37.8 m^3) annually per lot. This is based on estimates given by permanent residents of subdivisions within the study area (J. Blackner, oral communication, 1987). One area with adequate soil coverage is soon to be included in the proposed Fruitland Water Improvement District (figure 1). Final district boundaries have not yet been established but will be based on the water needs in an area extending east from the west Duchesne County line to the junction of Red and Current Creeks and north of U.S. Highway 40. When completed in 1989, a reliable supply of culinary water will be available to all residents in this area (V. Roberts, oral communication, 1988). Once this occurs, this area must be managed under existing health department regulations regarding wastewater disposal.

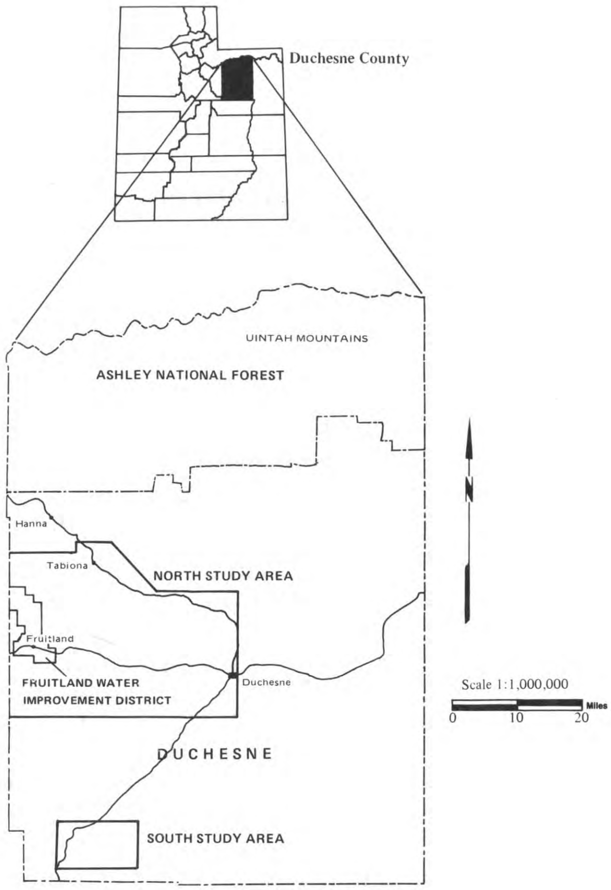


Figure 1. Location map of Duchesne County.

Another assumption for this study was that, since present health regulations cover the problem of steep slopes, it was not addressed in the report. Steep slopes, which are found throughout the study area, present severe limitation to wastewater disposal systems.

To evaluate the feasibility of domestic waste disposal in shallow rock in the study area, the following work was undertaken:

1) Consultation with the Uinta Basin Health and Duchesne County Planning Departments to assess their needs and establish the scope of this study.
2) A review of published and unpublished literature including reports, maps, well logs, and other data pertaining to the geology, hydrology, and soils of the area.
3) Interpretation of aerial photography.
4) Approximately two weeks of field reconnaissance to verify information from the literature and to collect supplemental data on field conditions, several days of which were spent visiting development areas with county health and planning officials.
5) Excavation of eight test pits to determine percolation rates and inspect rock conditions.

In this investigation, wastewater disposal in absorption systems was assumed, but alternative methods such as evapotranspiration or Wisconsin-mound-type systems may be considered where geologic and hydrologic conditions are appropriate.

SETTING

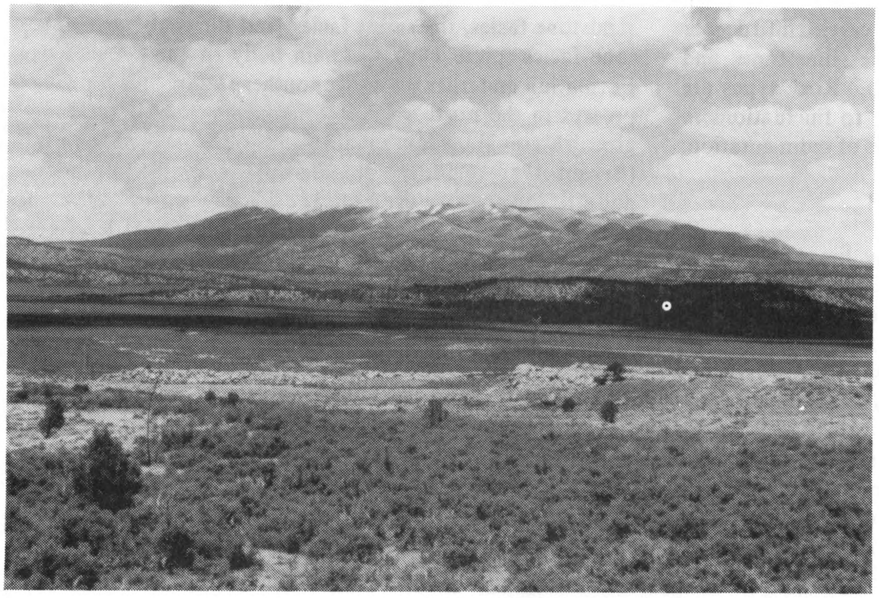
The study area covers a large part of west central Duchesne County both north and south of the Strawberry River (figure 1). The study boundaries were selected to include two widely separated clusters of subdivisions, resulting in a northern and a southern study area. The northern study area is in the west-central Uinta Basin along the south slope of the Uinta Mountains in the Strawberry and Duchesne River drainages. A smaller area 16 miles (25 km) to the south along the headwaters of Willow, Indian, and Argyle Creeks comprises the southern study area. A total of 20 subdivisions are located in the two areas, 15 in the north and 5 in the south (plate 1).

Topography is variable across both study areas, with rock type and resistance to erosion as the principal determining factors. The northern region contains a variety of landforms. The town of Duchesne, at the eastern boundary of the northern study area, is on the Duchesne River flood plain at an elevation of 5600 feet (1706 m) (plate 1). West of Duchesne along U.S. Highway 40, the landscape is deeply eroded with resistant sandstone layers capping ridges and forming numerous cliff bands. North of Highway 40 and south of the Duchesne River, the terrain rises in a stepped sequence of cliffs to the crest of Blacktail Ridge and Blacktail Mountain. To the northwest, Tabby Mountain is the highest point in the study area at 9800 feet (2987 m) (figure 2A). Dissected gravel-capped benches are present along the south and southwest slopes of the mountain. South of Highway 40, steep, highly dissected slopes are found in most areas, with the exception of the lower Red Creek and Strawberry River drainages (figure 2B) which are bordered by cliffs 200 to 300 feet (60-90 m) in height.

The southern study area is characterized by steep mountain slopes with isolated cliff bands. Elevations range from 7300 to 9000 feet (2225 to 2740 m). Lower elevations support pinyon-juniper forests. Major drainages flow southwest and northeast from Argyle Ridge which trends east to west across the study area. Utah Highway 33 bisects the area and provides access to the subdivisions (plate 1).

Vegetation is altitudinally zoned, with lower elevations supporting pinyon-juniper woodlands giving way to spruce-fir forests on the slopes and crest of Tabby Mountain. Most higher elevation slopes around Argyle Ridge in the southern study area have spruce, fir and aspen. Regional climate is arid to semiarid below 8000 feet (2438 m) and subhumid to humid above that elevation (Price and Miller, 1975). Average annual precipitation is 9.19 inches (23.3 cm) at the town of Duchesne, with higher elevations around Tabby Mountain and Argyle Ridge receiving up to 20 inches (50.8 cm). Most precipitation falls during the late summer in cloudburst storms (Hood, 1976).

A



B

Figure 2. *Typical terrain in A, northern study area around Tabby Mtn. and B, area south of U.S. Highway 40.*

GEOLOGY

The Uinta Basin is a topographic, structural, and sedimentary basin bounded on the north by the Uinta Mountains and the south by the Book Cliffs (figure 3A). The basin is asymmetric with its axis to the north, near the south slope of the Uinta Mountains. Rock in the basin dips toward the axis (figure 3B). Rock along the flanks of the Uinta Mountains dips steeply to the south, whereas rock in the southern part of the basin dips to the north (figure 3A and plate 1). The study area is located in the northwest part of the basin. Rock exposed in the region is Late Cretaceous (97 to 66 Ma, or million years ago) to early Tertiary (66 to 36 Ma) and includes from oldest to youngest the: Mancos Shale, Mesaverde Formation, Currant Creek Formation, Green River Formation, Uinta Formation, and Duchesne River Formation (Bryant, 1989). A map with descriptions of each rock unit is presented in plate 1.

The two most wide-spread rock units in the study area are the Green River Formation, underlying approximately 65% of the northern study area, and Duchesne River Formation, underlying 30%. The remaining 5% is composed of the Currant Creek Formation, the Mesaverde Formation, and the Mancos Shale (plate 1). The entire southern study area is underlain by the Green River Formation (plate 1). Due to their importance, the two major units are considered in greater detail in this report. Both consist of sediments deposited in and along the margins of lakes that occupied the region during the Tertiary Period (Fouch, 1975). Former lake margins are represented by conglomerates, sandstones, and siltstones of the Duchesne

River Formation. Finer grained sediments carried into deeper water are represented by the shales, siltstones, limestones, and claystones of the Green River Formation. Rock types are laterally and vertically discontinuous due to fluctuations in lake levels, which caused changing patterns of sedimentation.

Green River Formation

A sequence of gray and greenish-gray limestone, shale, sandstone, oil shale and tuff make up the Green River Formation (Bryant, 1989). The unit was originally mapped as two members (Dane, 1954; Dane, 1955; Fouch, 1975; Fouch, 1976; Dyni and others, 1985) but recent mapping by Bryant has differentiated units by visual and textural changes, dropping the nomenclature used by previous investigators. Bryant divides the Green River Formation in the study area into four facies based on their depositional environments and lithologic characteristics. Most are fine grained. From oldest to youngest, they are the main body of the Green River Formation, the sandstone facies, the saline facies, and the sandstone/limestone facies (plate 1). The main body of the Green River Formation underlies the entire southern study area but is not present in the northern area. It is composed of gray and greenish-gray limestone, shale, sandstone, oil shale, and tuff (Bryant, 1989). In this area outcrops are limited to roadcuts and steep hillsides (figure 4A). The saline facies is visible along the drainage of the Strawberry River and its tributaries (figure 4B and C). It is prominent south of the river in Lake and Indian Canyons where it forms vertical cliffs 200 to 400 feet (60-120 m) high. It is composed of gray to moderate-brown limestone, claystone, dolomite, siltstone sandstone, oil shale, and tuff (Bryant, 1989). The upper contact with the sandstone facies is gradational and the unit intertongues with and grades laterally into the sandstone/limestone facies to the east and with the Duchesne River Formation to the west (Bryant, 1989). The occurrence of the sandstone facies in the study area is limited to the western reaches of the Strawberry River drainage along the Wasatch-Duchesne County line (plate 1).

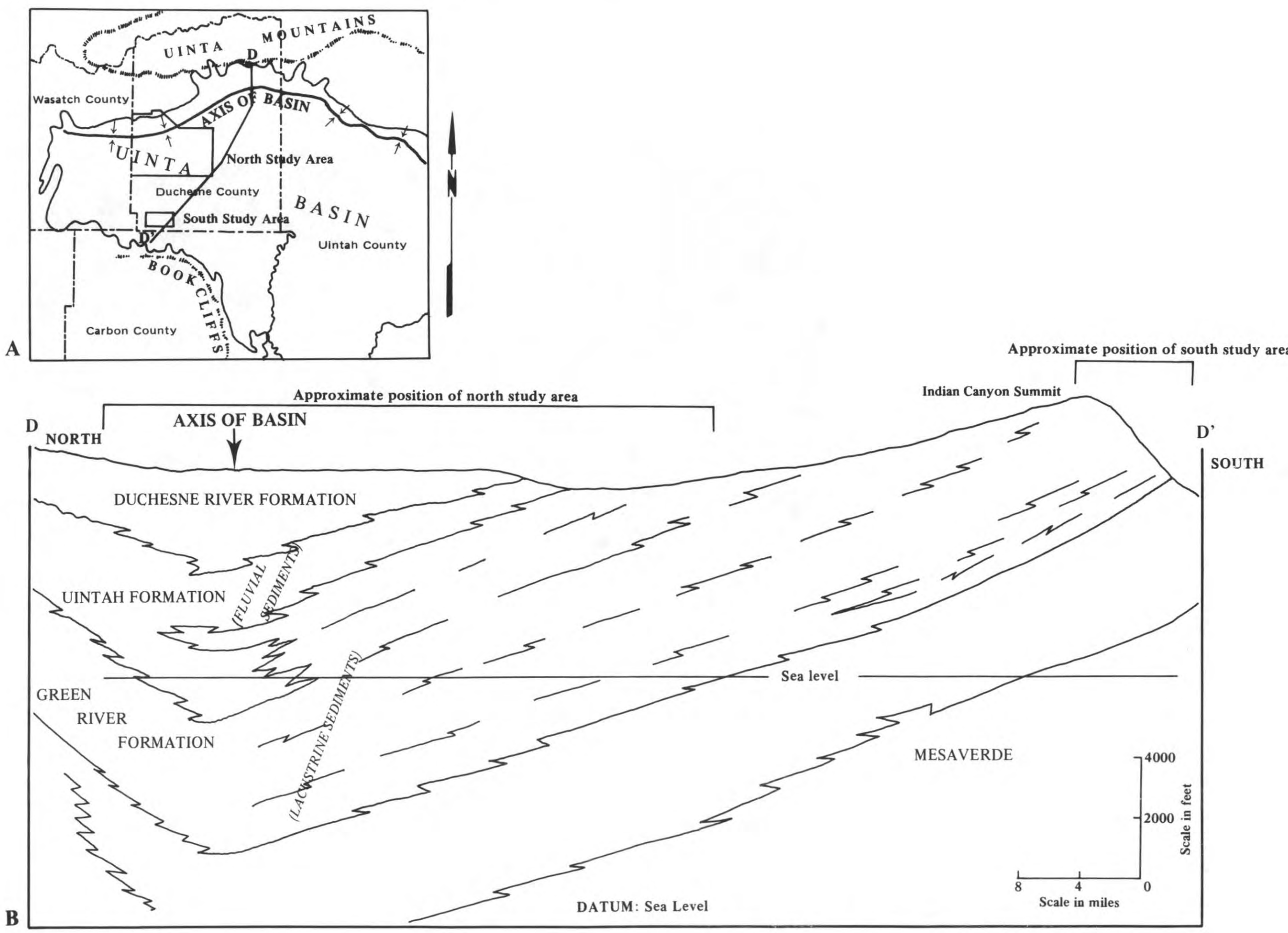


Figure 3. ***A****, outline of western Uinta Basin and axis, and* ***B****, cross-section D-D' showing dip of rock in basin. Arrows along axis in A indicate direction of rocks in basin. Information in B is based on petroleum well data. Although cross section is east of study areas, stratigraphic relationships are the same as those seen in the diagram.*

A

B

C

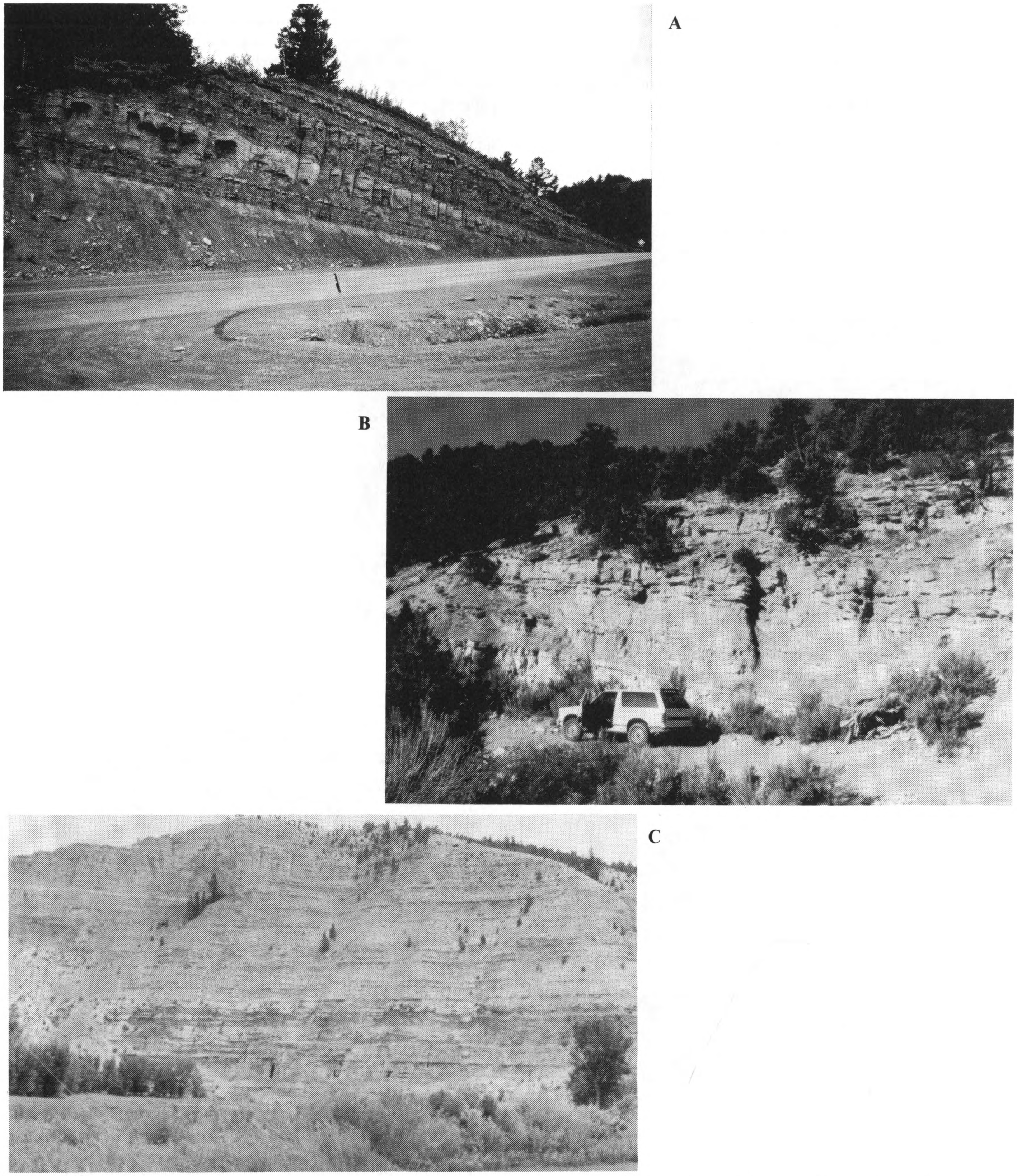
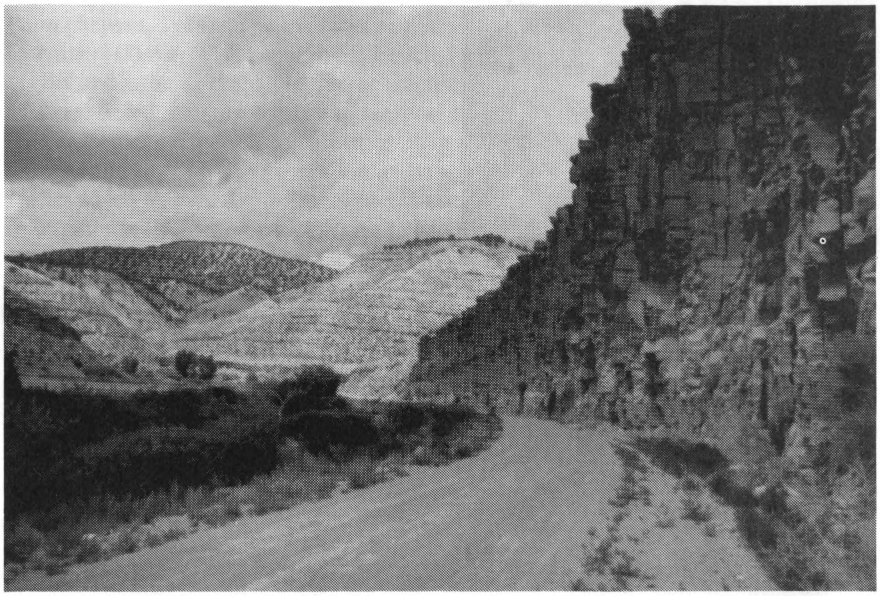


Figure 4. *Main body and B, C, the saline facies of the Green River Formation.* ***A*** *is outcrop along Highway 33 of the southern study area,* ***B*** *is along Sam's Wash, and* ***C*** *is located on the south side of the Strawberry River.*

The unit consists of a thin-bedded sandstone with interbeds of siltstone, limestone, and shale of limited areal extent (figure 5A and B). The sandstone/limestone facies is found north of the Strawberry River (figure 6). The unit forms rounded hills and badlands, with rock outcrops and cliffs common. Composed of gray to brown thin-bedded sandstones, siltstones, shales, and limestones, the unit is as much as 1000 feet thick (305 m). Deposited in a marginal lacustrine environment, its lithology changes both laterally and vertically within short distances.



A

B

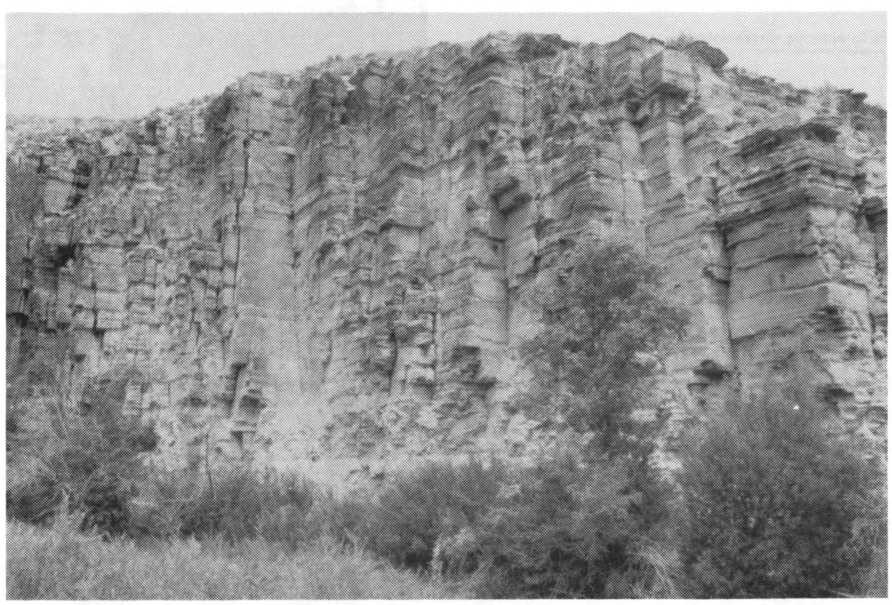


Figure 5. *Large through-going joints in sandstone facies of Green River Formation.* ***Photo A*** *shows stratigraphic relationships between highly-jointed sandstone facies along the road with the overlying saline facies in the background. Outcrop of sandstone facies,* ***photo B,*** *height 40 feet (12 m).*

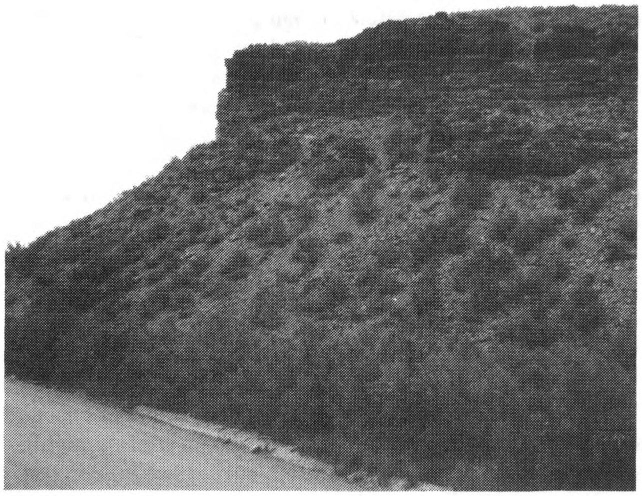


Figure 6. *Sandstone/limestone facies of the Green River Formation along the Red Creek Road to Strawberry Pinnacles.*

Duchesne River Formation

The Duchesne River Formation has greater lateral and vertical variability in individual beds than the Green River Formation. The formation is up to 3000 feet (915 m) thick in the northern Uinta Basin and consists of sedimentary rock deposited as the ancestral Uinta Mountains to the north were eroded. It includes conglomerates, sandstones, siltstones, and claystones (figure 7A), with horizontal bedding and uniformly spaced joints characterizing the unit (figure 7B). Sandstone is the predominant rock type, comprising approximately 50 percent of the formation (Anderson and Picard, 1972). The formation ranges in color from red to grayish-red and is commonly cross stratified (Bryant, 1989).

Other Rock Units

Several other formations crop out in the study area but have limited areal extent. These are the Uinta, Currant Creek, and Mesaverde Formations, and the Mancos Shale (plate 1). North of the town of Duchesne along the Duchesne River, isolated outcrops of the Uinta Formation are present beneath gravels of Pleistocene age (1.5 Ma to 10,000 years ago). Northeast of the town of Tabiona, in the northwestern portion of the study area, outcrops of the Currant Creek, Mesaverde, and Mancos Shale Formations form a northeast-trending ridge above the Duchesne River.

Quaternary Deposits

Surficial deposits of Pleistocene and Holocene (10,000 years ago to present) age are present, chiefly along the Strawberry and Duchesne Rivers. Between the towns of Hanna and Duchesne, unconsolidated Pleistocene-age alluvial gravels are found in terraces up to 300 feet (90 m) above the modern channel of the Duchesne River. Holocene alluvial gravels, sands, and silts occur in channels and flood plains of the Duchesne and Strawberry Rivers. High above valley floors at elevations between 7400 and 8400 feet (2250-2560 m) on the south and west slopes of Tabby Mountain, older Pleistocene alluvial gravels form gently sloping flat-topped benches.

The oldest Quaternary deposits in the region are Pleistocene-age alluvial-fan and pediment gravels found on surfaces above modern river flood plains. These deposits slope gently toward the modern drainages but are remnants of former flood plains and valley slopes after late Pleistocene and Holocene stream erosion. They are composed of boulders, cobbles, and gravel in a matrix of sand and silt. Late Pleistocene erosion has dissected these deposits and left them as isolated benches or pediments.

Valley floors and river flood plains contain the youngest Quaternary deposits in the region. Late Pleistocene to Holocene in age, these deposits are composed of crudely bedded to non-bedded deposits of cobbles, gravel, sand, and silt. They are most extensive in the drainages of the Duchesne and Strawberry Rivers.

Faulting

Faulting in the region is confined to areas south of the towns of Duchesne and Fruitland (plate 1). South of Duchesne the Green River Formation is offset by faults trending east-west. The faults are thought to be post-Eocene (57 to 36 Ma) in age, as they do not offset overlying Pleistocene-age gravels (B. Bereskin, oral communication, 1988). The fault traces die out immediately east of Lake Canyon. Faults southwest of Fruitland trend north-south and also displace the Green River Formation. The faults do not displace Quaternary stream alluvium and are thought to be Tertiary in age (Nelson and Martin, 1982).

Figure 7A. *Duchesne River Formation. Seen in road cut along U.S. Highway 40 east of Currant Creek Junction.*

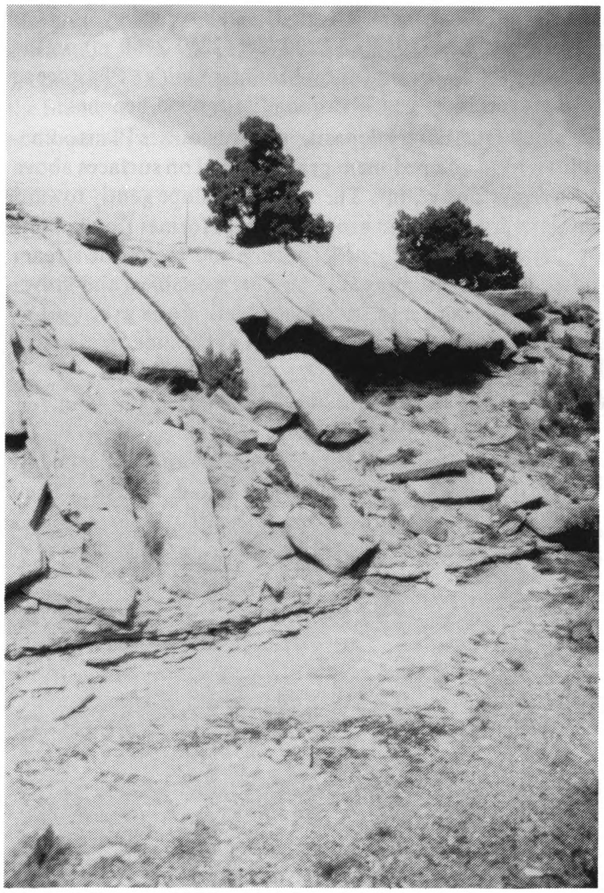


Figure 7B. *Jointing in unit, spacing 12 to 20 inches (30-50 cm).*

SOILS

The thickness of soil cover over rock varies across the study area in relation to moisture and rock type. Two types of soils occur in the study area, those developed in place by the weathering of rock, and those derived from the transport and deposition of unconsolidated materials. Soils developed in place are localized and thin, whereas soils formed from transported materials are quite deep. Approximately 60 percent of the study area has thin soils, the thinnest are in areas with lowest annual precipitation. Lower precipitation effectively reduces weathering of rock into soil. Plate 2 shows the general distribution and relative thickness of soil (unconsolidated sediment) in the study area derived from Soil Conservation Service data, field reconnaissance, and air-photo interpretation. It can be used to identify those areas where conventional soil absorption systems are feasible.

Areas of higher precipitation and thicker soils are in the northwest part of the northern study area and much of the southern study area (plate 1). The Duchesne River Formation around Tabby Mountain weathers to soils as deep as 15 feet (4.6 m). Immediately south and east, where precipitation is less, soils are thin and patchy, ranging from 0 to 5 feet (0 -1.5 m) thick. This is also the case with soils developed on the Green River Formation north of the Strawberry River, where soils are only deep in swales and along stream drainages (plate 2). Soils in the southern study area are thickest on moist, shaded, north-facing slopes with patchy soil cover on the dryer, sunny, south-facing slopes. Soils in this region are clay-rich due to the weathering of shales in the Green River Formation, thereby posing potential problems for soil absorption systems.

GROUND WATER

Ground water in the region occurs in both rock and unconsolidated valley-fill aquifers. It ranges from fresh to highly saline and may occur under confined, unconfined, or perched conditions depending on the nature of the aquifer (Hood, 1976; Price and Miller, 1975). Rock units within the study area identified as aquifers are the Duchesne River, Uinta, Green River, and Currant Creek Formations (Hood, 1976; Price and Miller, 1975). Ground water from these units is of variable quality depending on distance from recharge areas and mineral composition of the rock. Due to their close proximity to recharge areas, the Currant Creek Formation and sandstone layers within the Duchesne River Formation contain ground water with the lowest total dissolved solids (TDS) (234 to 528 mg/l) and lowest salinity (Feltis, 1966). In general, ground water from the Green River Formation along the drainage of the Strawberry River is higher in TDS and salinity than the Duchesne River Formation. This is because the rock contains concentrations of salts and other minerals easily taken into solution. In the southern study area ground water is low in TDS (less than 1000 mg/l) and generally fresh (McCormack and others, 1984). Ground water from these and other aquifers in the western Uinta Basin flows into either the Strawberry or Duchesne Rivers, which drain the region.

Characteristically, valley-fill and rock aquifers in the northern part of the north study area produce fresh water (less than 1000 mg/l TDS) due to their close proximity to recharge areas in the Uinta Mountains (Feltis, 1966). As the water moves toward the Strawberry River, it gains in TDS due to the minerals removed from the rock through which it passes. Recharge areas for rock aquifers north of the axis of the basin are primarily the south slope of the Uinta Mountains, with precipitation being the major source of water. Water enters the rock and becomes confined or trapped between low permeability layers and travels to the south, or downdip, toward the Strawberry River (figure 8). South of the Strawberry River recharge areas are in the highlands north of the Badland Cliffs, at elevations of 9000 feet (2740 m). Precipitation is also the major source of recharge, and water percolates into the rock and migrates downdip to the north, toward the Strawberry River (figure 8 and plate 1). As in the northern study area, ground water in this area is freshest near the recharge areas, becoming increasingly poor in quality as it moves to the north. In general, primary permeability in the Uinta Basin is low, due to the fine-grained nature of the rock. Faulting, fracturing, solutioning, and folding have produced areas of moderate to high secondary permeability (Schlotthauer and others, 1981). This is especially true in the Duchesne River and Green River Formations where fractures and joints are the main avenues for ground-water movement.

Valley-fill aquifers are generally unconfined and are the most utilized due to the shallow depth to water, constant recharge by streams, and permeable coarse-grained sediments. Water from these aquifers is generally low in TDS and is suitable for culinary use (Hood, 1976). However, because they are unconfined and shallow, these aquifers are easily contaminated. Logs for both the deepest well and the well with the most detailed description of rock units were collected from the Utah Division of Water Rights for subdivisions in the area. These wells indicated that many producing wells originate in the valley-fill alluvium, making it the most important aquifer in the study area.

Depth to ground water in alluvium along the Strawberry and Duchesne Rivers is less than 30 feet (9 m)(Hecker and others, 1988). In rock areas, depth to ground water varies with topography. Figure 9 is depth to the water table in rock in the area; depths generally range from 200 to 800 feet (60-244 m), but in places can be as much as 1600 feet (487 m). This information is not available for the southern study area, but numerous springs in the area and water level contours 10 miles to the east indicate that ground-water levels range from 0 to 800 feet (0-244 m) below the surface (Schlotthauer and others, 1981).

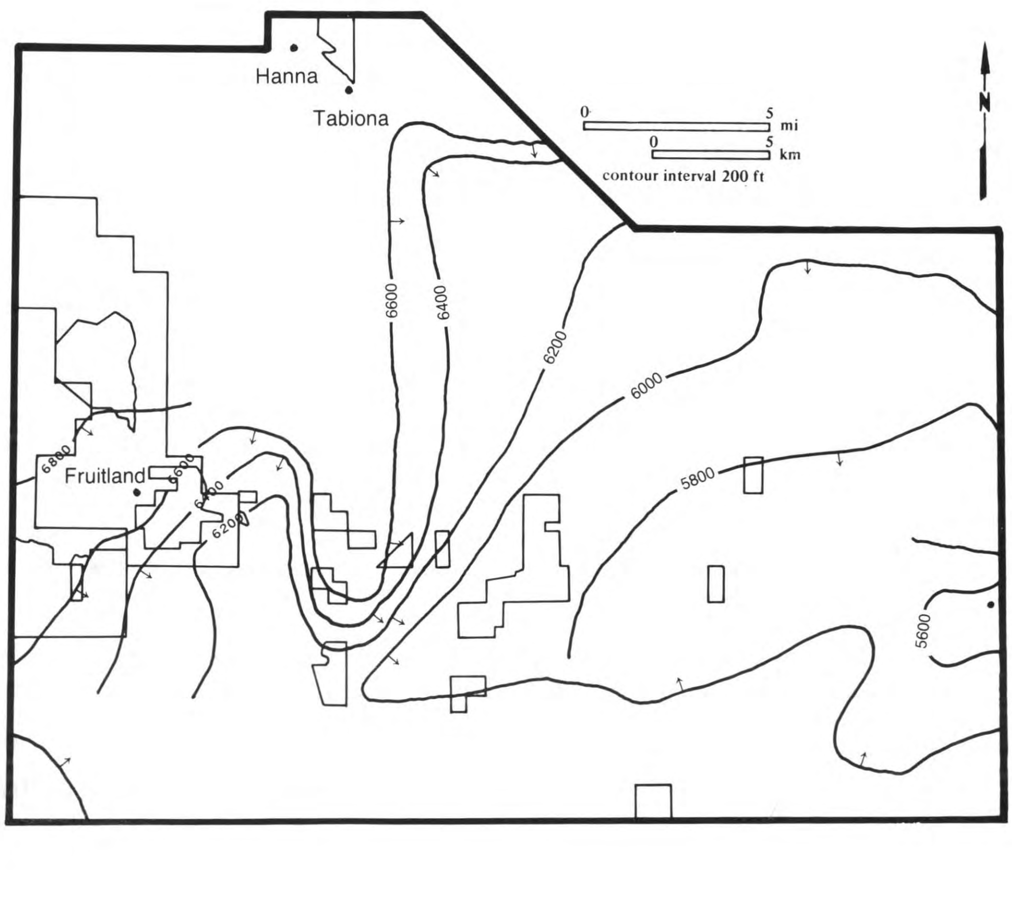


Figure 8. *Ground water elevation contours showing direction of flow in northern study area. (Modified and derived from Hood, 1976.)*

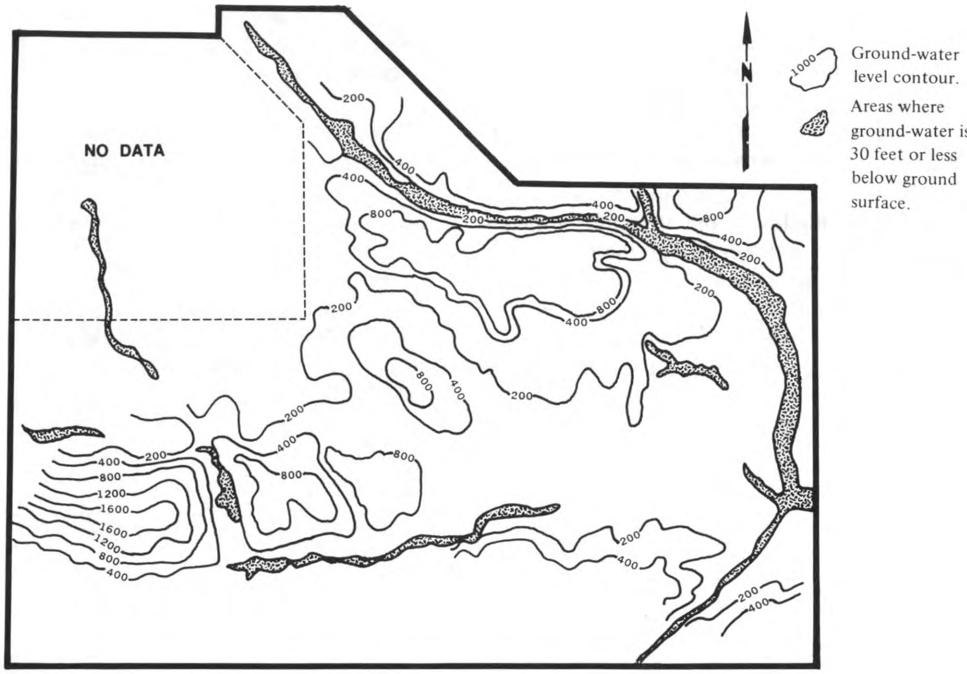


Figure 9. *Depth to ground water in rock. Modified and derived from Schlotthauer and others, 1981.*

FIELD INVESTIGATION

A total of eight test pits (two pits per site) were excavated for the purpose of determining the physical characteristics and percolation rates of rock units (plate 1). To evaluate lateral water movement along bedding planes or joints, one test pit was filled with water, the second was downslope or downdip to observe movement of water. Test pit sites were selected in the Duchesne River and Green River Formations where they underlie subdivisions in the study area to obtain an average percolation rate for each unit. Pit dimensions averaged 10 x 5 x 5 feet (3 x 1.5 x 1.5 m) with the exception of site 2 where existing pits in the sandstone/limestone facies of the Green River Formation were used (dimensions of 6 x 4 x 2 feet; 1.8 x 1.2 x .6 m). The contractor indicated that blasting was required to excavate the site 2 pits originally. It is not known if blasting would be required for other excavations in this facies of the Green River Formation.

Test pit walls were logged and described in detail, with descriptions of rock type, degree of weathering, bedding, and joint patterns (appendix 1) . In all pits, a residual soil of variable thickness derived from weathering of the rock was present at the surface. However, the soils were thin and had no effect on percolation rates.

Sites 1 through 3 are in the northern study area in pinyon-juniper woodlands ranging in elevation from 6100 to 6650 feet (1860 to 2026 m), west of the town of Duchesne. Soils at these sites are thin due to low amounts of precipitation; yearly totals in this area range from 9 to 11 inches (22.8-27.9 cm). Site 4 is located at 9040 feet (2755 m) on Argyle Ridge, where higher elevations enhance precipitation and weathering of the rock.

All test pits were excavated into rock. One pit at each site was filled ¾ full with water and left overnight to saturate the rock to simulate conditions during the use of a wastewater disposal system. The next day, the same pit at each site was refilled, if necessary, to the original level and measurements were taken every thirty minutes for a four-hour period. The last measurement was considered representative of the percolation rate for that formation (Kaplan, 1987). The test pits at site 4 on Argyle Ridge were not refilled due to wet and dangerous road conditions. Data for that site were obtained from observations on the water remaining in the test pit from the initial filling.

Although the number of tests is small for such a large area, it is felt that they represent a valid estimate of formation characteristics, based on careful investigation and selection of the test sites. Sites were selected in areas that best represented the attributes of each geologic unit, including degree of fracturing, rock type, bedding, and dip observed in each formation. Considering all these factors conditions are highly variable throughout the two study areas, and each proposed wastewater disposal site should be evaluated individually.

RESULTS AND DISCUSSION

Several geologic factors influence the potential for disposal of small (less than 10,000 gal/yr/homesite) quantities of wastewater in rock in Duchesne County. The most important is degree of fracturing of the rock units. This directly affects permeability, percolation rate, and hence, pollution potential. The lateral and vertical variability of rock units have an equal importance since permeabilities vary with rock type changes,

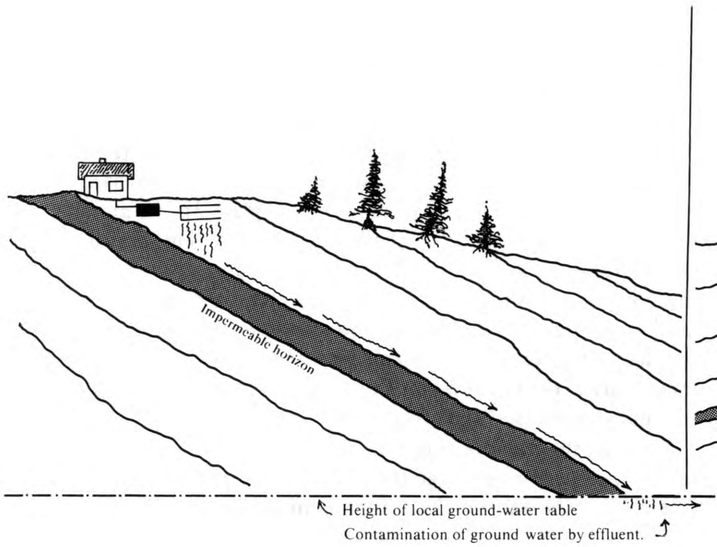


Figure 10. *Examples of rock dip and impermeable horizon effects on wastewater infiltration.*

Table 1.
Results of percolation tests.

Test Pit	In 1/16th of inches		1 hour		2 hours		3 hours		4 hours	Percolation Rate
Pit 1 — Cedar Mountain (#7) saline facies of Green River Formation	level	4 8/16	33 4/16	Dry Hole	18 minutes	later				.9 mins/inch
Pit 2 — Bandana Ranch Duchesne River Formation undifferentiated	level	1 8/16	1 14/16	5/16	7/16	12/16	10/16	13/16	6/16	60 mins/inch
Pit 2a — Control Pit — Bandana Ranch Formation movement from main test pit	N/A	1 7/16	1 4/16	13/16	1.0	7/16	4/16	5/16	2/16	240 mins/inch
Pit 3 — Great Basin Estates (#2) Green River Formation Sandstone/limestone facies	level	4 2/16	2.0	1 14/16	1 7/16	1 12/16	1 5/16	1 5/16	1 5/16	23 mins/inch
Pit 4 — Argyle Ridge Green River Formation, main body	level	no change	1/16	1/16	1/16	1/16	1/16	1/16	1/16	480 mins/inch

(Timed measurements at half-hour intervals; last reading used to calculate percolation rate)

causing variations in rock percolation rates. Depth and quality of ground water, variability in soil thickness, dip of rock, and topographic slope also affect the potential for wastewater disposal.

Appendix 1 is a compilation of the topography, water-bearing characteristics, and wastewater disposal suitability for each rock unit in the study areas. Suitability categories based on geologic, hydrologic, and soil characteristics from appendix 1 are shown in plate 3. These categories provide information on the potential for absorption systems in rock and soil, while also listing limitations specific to a particular map area. Plate 3 does not cover depth of soils or dip of rock. Appendix 2 lists the suitability for wastewater disposal for individual subdivisions in the north and south study areas.

Results of percolation tests conducted in major rock units are shown in table 1. Test pits excavated in the Duchesne River Formation indicate that massive sandstone horizons have little or no primary permeability but become permeable with fracturing. In test pit 2 water moved laterally into the adjacent pit through a fractured sandstone horizon overlying a massive impervious sandstone (table 1 and appendix 3). This was not the case in test pits excavated in the sandstone/limestone (pit 3) and saline facies (pit 1) of the Green River Formation. When filled with water, the test pits drained with no lateral migration. In the main body of the Green River Formation however, a situation similar to that observed in the Duchesne River Formation occurred. Fractured sandstone overlying an impervious weathered shale horizon acted as the medium through which water moved into the control pit. These examples serve to underscore the influence of secondary fractures and vertical changes in permeability on percolation rates, as well as the potential for ground-water contamination or wastewater surfacing by effluent migration along fractures, joints, and bedding planes.

Percolation rates in the Green River and Duchesne River Formations were variable and correlated closely with the degree of fracturing. Test pits in the most highly fractured rock units, the sandstone/limestone (pit 3) and saline facies (pit 1) of the Green River Formation, had the highest percolation rates. Conversely, the Duchesne River Formation's impervious sandstone horizons (pit 2) and shales in the main body of the Green River Formation (pit 4) had much lower percolation rates (table 3). However, these units can also be highly fractured locally (figure 6). An excellent example of widespread and throughgoing joints is present in the sandstone facies of the Green River Formation (figure 7) which forms cliffs along the Strawberry River. Joints in this unit persist to great depths in canyon walls and in exploratory petroleum wells (B. Bereskin, oral communication, 1988). Ground water moves through this unit rapidly and wastewater disposal systems in it would have a high probability of contaminating ground or surface water.

Depth to ground water in the study area is variable. Valley-fill deposits along streams have unconfined ground water at depths averaging 30 feet (9 m), whereas wells drilled in the Green River Formation in the Cedar Mountain area reached 700 feet (213 m) without encountering significant ground water (Jim Blackner, oral communication, 1988). In areas where the depth to ground water is great the potential for ground water contamination by effluent is low. This is due to the great thickness of the unit and confined conditions of the rock aquifers in comparison to the small quantities of effluent that will be introduced. However, if the confining beds of a rock aquifer are penetrated by culinary wells, the potential for effluent to enter the aquifer becomes greater. Adherence to set-back distances for wastewater disposal systems from well heads can help to prevent this problem.

Rock in the study areas dips toward the axis of the basin and the dip of bedding is commonly visible in hillslopes or road cuts. Bedding planes can serve as conduits along which fluids migrate, particularly where underlain by impermeable horizons which impede vertical percolation (figure 10A, B). In situations such as this, effluent can migrate down-dip and contaminate surface or ground water. Steeply dipping rock along the south flank of the Uinta Mountains acts as one of the major recharge areas for ground water in the northern Uinta Basin and northern study area. Similarly, Argyle Ridge in the southern study area is a major recharge area for the southern Uinta Basin. In these areas, knowledge of the dip of local rock is extremely important when siting a wastewater disposal system.

CONCLUSIONS AND RECOMMENDATIONS

Disposal of limited quantities of wastewater is possible in some rock units within the study area. Data from rock percolation tests show that there is the potential for wastewater disposal in the Duchesne River Formation and the sandstone/limestone facies of the Green River Formation (table 1; plate 3). Percolation rates for these units are comparable to acceptable rates (between 1 and 60 minutes per inch) for soils, and they are effected by rock jointing and fracturing since the rocks themselves have low permeabilities. However, other facies in the Green River Formation do not have acceptable percolation rates and should be excluded from use as a medium for wastewater disposal (table 1; plate 3). In areas where rock is not suitable, alternative disposal systems may be considered. In particular, where widespread impermeable horizons occur, evaporative-type wastewater disposal systems may be an alternative. Areas where this type of system would be most effective are in the southern study area, where the main body of the Green River Formation contains impermeable shale horizons at shallow depths.

Several other factors must be evaluated besides percolation rate before a site is approved for an absorption system in rock. The most important of these are summarized in appendix 1 and plate 3. Appendix 1 outlines the wastewater suitability in rock units and depth to ground water in each of the existing subdivisions and plate 3 maps suitability categories for rock throughout the study area. These provide users with preliminary information to evaluate a site's potential for an absorption system in rock. Appendix 1 and plates 1 and 2 are the basis for the information presented in appendix 2 and plate 3. Even with these data, the importance of a site investigation can not be stressed enough, and detailed investigations should be conducted at each site prior to installation of any wastewater disposal system to determine percolation rates and verify site conditions and the suitability for waste disposal. Appendix 4 provides guidelines for performance and review of geologic investigations and addresses of agencies where pertinent information can be obtained. Guidelines are provided to help geologists perform the work and help the non-geologist review a geologic report to ensure it addresses all aspects of an investigation. Initially, however, reviews should be done by geologists to aid local government officials in decision making, and the UGMS is available to provide such reviews. In conjunction with these information sources,the following recommendations are made regarding the disposal of wastewater in rock in the study area.

The Duchesne County Planning Department currently recommends that minimum lot sizes in new developments be five acres to ensure that some part of the lot will be suitable for a wastewater disposal system (J. Wood, oral communication, 1988). The UGMS agrees with this policy and suggests that in the future a geologic investigation be conducted for an entire subdivision prior to platting of lots. This would help ensure that each lot has an adequate suitable area or areas for a wastewater disposal system prior to sale.

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GLOSSARY

Alluvium — *A general term for clay, sand, gravel, or similar unconsolidated sedimentary material deposited by a stream.*

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

Aquifer — *A stratum or zone below the surface of the earth capable of producing water as to a well.*

Bedding — *The arrangement of a sedimentary rock in beds or layers of varying thickness and character.*

Carbonate — *A sediment formed by the organic or inorganic precipitation from water carbonates of calcium, magnesium, or iron. Examples are limestone and dolomite.*

Colluvium — *A general term applied to any loose, unconsolidated mass of soil material, usually at the foot of a slope or cliff, and brought there chiefly by gravity.*

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

Conglomerate — *A coarse-grained sedimentary rock, composed of rounded to subangular fragments larger than ¾ inch in diameter set in a matrix of sand or silt.*

Dip — *The angle that a bedding plane makes with the horizontal.*

Facies — *The aspect, appearance, and characteristics of a rock unit, usually reflecting the conditions of its origin.*

Fissile — *Bedding that consists of laminae less than 2 millimeters in thickness. These laminae can be easily split along bedding planes.*

Fluvial — *Of or pertaining to a river or rivers; produced by river action.*

Joints — *A fracture or parting in a rock without displacement.*

Lacustrine — *Pertaining to, produced by, or formed in a lake or lakes; e.g., "lacustrine sands" deposited on the bottom of a lake.*

Pediment — *A broad, gently sloping rock-floored erosion surface or plain of low relief, generally found at the base of an abrupt and receding mountain front or plateau.*

Unconformity — *A substantial break or gap in the geologic record where a rock unit is overlain by another that is not next in stratigraphic succession.*

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Appendix 1
Suitability for Domestic Waste Water Disposal in Rock Absorption Systems

Septic system suitability classifications modified from Lund, 1982.
Water-bearing characteristics modified from Hood, 1976.
Geology modified from Bryant, unpublished manuscript.

Geologic Unit	Topography/Distribution	Water-Bearing Characteristics	Septic System Suitability
Qal/Qac	Forms modern flood plains and benches (terraces) along drainages of Duchesne and Strawberry Rivers and Red and Currant Creeks. Colluvium forms gentle slopes above flood plains of Duchesne River, near Hanna and Tabiona, vegetation is predominantly sagebrush with some pinyon/juniper woodland.	Aquifers generally unconfined, but may be locally confined or perched; units have low to high permeability. However, in stream valleys deposits yield water to shallow wells (dug wells). Water is fresh. Depth to ground water in alluvium is less than 30 feet (9 m); in colluvium, depths less than 30 feet (9 m) are common in valley floors; in colluvium on valley slopes ground water percolates into underlying rock.	Potentially suitable for conventional soil absorption systems; rock generally not present. Locally unsuitable due to seasonal high ground water levels, lack of fines for filtering, coarse matrix materials, and proximity to culinary water sources. Potential for contamination of ground water by effluent is moderate to high.
Qls	Undulating, hummocky terrain with patchy vegetation and marshy areas. Vegetation sagebrush and pinyon-juniper woodland.	Aquifers generally unconfined and commonly perched due to localized impervious clay horizons. Unit has low to high permeability, water is generally fresh but locally saline. Depth to ground water is variable due to displaced surface and subsurface materials. At toe of slide depths to ground water are less than 30 feet (9 m).	Potentially suitable for conventional soil absorption systems; rock generally not present. Locally unsuitable due to shallow ground water and shallow rock, introduction of effluent into unit may reactivate slide. Potential for contamination of ground water by effluent is moderate to high.
Qtg	Forms benches (terraces) above Qal/Qac on modern flood plains of Strawberry and Duchesne Rivers. Vegetation sagebrush and pinyon-juniper woodland.	Generally above water table; unit variable thickness (1 to >10 feet; .3-3 m) veneer over Duchesne River. Little or no aquifer potential Coarse composition of unit allows ground water to move through into underlying Duchesne River Formation.	Potentially suitable for conventional soil aborption systems; bedrock generally not present. Locally underlain by shallow bedrock — see recommendation for Tdu. Potential for contamination of ground water by effluent is moderate.
Qop	Forms flat-topped, steep-sided ridges on the south of Tabby Mountain between 6900′ and 8400′. Vegetation sagebrush and pinyon-juniper.	Generally above water table; unit is a thin (1-3 feet; .3-.9 m) veneer over Duchesne River Formation on top of flat ridges with little or no aquifer potential. Coarse composition of unit allows ground water to move through and into underlying Duchesne River Formation.	Potentially suitable for conventional soil absorption systems; rock generally not present. Locally underlain by shallow bedrock — see recommendations for Tdu. Potential for contamination of ground water by effluent is moderate.
Tdu	Forms a variety of landscapes; rugged dissected canyons with steep cliffs, to gently rolling terrain with local cliffs in the southern portion of the study area. NE of Duchesne forms stepped topography of cliffs and slopes along Blacktail Ridge to Blacktail Mtn. Vegetation varies from sagebrush flats at lower elevations to pinyon-juniper and spruce-fir woodlands of high elevations.	Aquifers confined with low to high permeability, permeability enhanced by fracturing. Water generally fresh near recharge areas where rock is fractured and moderately permeable. At greater depths where permeability is lower, water is slightly saline to briny. Depth to ground water varies with thickness and composition of unit; ranging from 200 to 1600 feet (60-488 m).	Potentially suitable but locally unsuitable; steep slopes and shallow depth to massive sandstones can prevent system installation. Effluent can daylight along massive sandstone bedding planes in natural exposures and man-made excavations. Potential for contamination of ground water by effluent is low to moderate.
Tuu	Forms cliffs and benches above the flood plain along the Duchesne River west and north of the town of Duchesne. Vegetation is predominantly sagebrush with isolated stands of pinyon-juniper.	Aquifers in this unit are confined with low to high permeability. Permeability enhanced by fracturing; finer grained than Duchesne River Formation accounting for overall lower permeability. Most water saline. Depth to ground water varies with thickness and composition of unit; ranging from less than 30 feet (9 m) to as much as 400 feet (122 m).	Generally unsuitable but locally suitable. Massive sandstone horizons may limit installation of septic systems and induce lateral movement of effluent along bedding as well as vertical movement in through-going joints and fractures. Potential for contamination of ground water by effluent is moderate to high.
Tgsl	Forms dissected steep ridges north of the Strawberry River to an elevation of approximately 6200′ along Currant Creek. South of Hwy. 40, forms highly dissected topography. Vegetation is pinyon-juniper woodland.	Aquifers in Green River Formation are confined with very low to low permeability; permeability enhanced by fracturing. Most areas yield only saline and in many cases briny water. Finer grained than all units previously described, causing overall low permeability. Depth to ground water varies with thickness and composition of unit; ranging from 200 to as much as 1600 feet (60-488 m).	Potentially unsuitable but locally suitable. Effluent migration is lateral as well as vertical; percolation rates are slow to moderate due to weathering of fines within unit. Localized massive sandstone horizons. Potential for contamination of ground water by effluent is low.

Tgs	Forms bench at contact with overlying sandstone/limestone facies (Tgsl) on N. side at Strawberry River, forming dissected steep-sided ridges similar to (Tgsl) topography on south side of Strawberry River. Vegetation is pinyon-juniper woodland.	Aquifers in Green River Formation are confined with very low to low permeability; permeability enhanced by fracturing. Most areas yield only saline and in many cases briny water. Finer grained than all units previously described, this causes overall low permeability. Depth to ground water varies with thickness and composition of unit; ranging from less than 30 feet to as much as 400 feet (9-122 m).	Unsuitable but locally suitable. Highly fractured nature of unit enhances percolation rates to unacceptable levels. Movement of effluent is downward through fractures and joints; Potential for contamination of ground water by effluent is moderate to high.
Tgss	Forms cliffs immediately above Strawberry River west of the mouth of Sams Canyon. Not exposed east of Sams Canyon. Vegetation is pinyon-juniper woodland.	Aquifers confined with very low to low permeability; permeability enhanced by fracturing, Most areas yield only saline and in many cases briny water. Not as fine grained as Tuu, Tgsl, Tgs, fracturing and jointing have increased overall permeability. Depth to ground water varies with thickness and composition of unit; ranging from 500 to as much as 1000 feet (152-304 m).	Unsuitable, site conditions unfavorable. Highly jointed and fractured bedrock, close proximity to streams and rivers. Rapid lateral and vertical movement of wastewater through permeable sandstones would not filter effluent sufficiently before infiltration into ground water. Potential for contamination of ground water by effluent is very high.
Tgr	Forms mountainous uplands around the headwaters of Argyle, Indian, and Willow Creeks. Area is heavily vegetated with spruce/fir, aspen woodlands.	Aquifers confined with very low to low permeability; permeability enhanced by fracturing. Most areas yield only saline and in many cases briny water. Finest-grained facies in formation, giving it the lowest permeability. Depth to ground water varies with thickness and composition of unit; ranging from 500 to as much as 1000 feet (152-304 m).	Unsuitable but locally suitable. Generally fine-grained nature of unit causes low percolation rate and low overall permeability. Deeper soils due to higher precipitation at higher elevations can provide sites with soils deep enough for conventional soil absorption systems. Potential for contamination of ground water by effluent is moderate.
Tkcc	Forms steep ridges dipping to the south and cliffs west and north of Tabby Mt. Vegetation ranges from spruce-fir to pinyon-juniper woodlands.	Aquifers unconfined; permeability is low to high, with primary permeability through coarse sands. Secondary permeability through fractures; water near outcrop areas is fresh. Depth to ground water varies with thickness and composition of unit; ranging from less than 30 to as much as 200 feet (9-60 m).	Generally unsuitable but locally suitable. Steep slopes, steeply dipping bedding planes, close proximity to stream drainages. Potential for contamination of ground water by effluent is moderate to high.
Kmu	Forms steep ridges dipping to the south between Sand and Red Creeks, NW of Tabby Mountain. Vegetation is sparse with occasional aspens, maples, and oaks.	Not an aquifer; very low permeability due to fine-grained nature of unit. Inhibits infiltration of precipitation, unit devoid of vegetation on most exposures.	Unsuitable; sit conditions unfavorable, alternative methods of wastewater disposal required. Fine-grained impermeable rock. Forms steep slopes. Potential for contamination of gorund water by effluent is low.
Kmv	Forms steep-sided ridges and local cliffs west and north of Tabby Mountain. Vegetation ranges from spruce-fir to pinyon-juniper woodlands.	Aquifer properties little known but permeability is low to high. Water obtained from wells is fresh near outcrops, but very saline to briny in petroleum wells in the eastern basin. Depth to ground water unknown.	Generally unsuitable but locally suitable. Steep slopes, steeply dipping bedding planes, close proximity to stream drainages. Potential for contamination of ground water by effluent is moderate to high.

Appendix 2
Subdivision suitability for wastewater disposal systems in rock.

NORTHERN STUDY AREA

Subdivision	Depth to Ground water	Wastewater disposal suitability in rock
1	Hydrologic data limited, potentially $\geq$ 30 feet (9 m) along Duchesne River and Farm Creek, increasing to 400 feet (122 m) on ridge line in center for subdivision.	Potentially suitable, but locally unsuitable due to shallow ground water and impermeable rock.
2	$\geq$ 30 feet (9 m) along drainage of Red Creek, increasing to 500 feet (152 m) in northwest part of subdivision.	Potentially suitable, but locally unsuitable due to shallow ground water and impermeable bedrock. Soils generally deep enough for conventional soil absorption systems.
3	$\geq$ 30 feet (9 m) along drainages of Red and Currant Creeks, increasing to 150-200 feet (45-61 m).	Potentially suitable, but locally unsuitable due to shallow ground water and impermeable rock. Soils generally deep enough for conventional soil absorption systems.

4	≥30 feet (9 m) along drainage of Red Creek, increasing to 1600 feet (488 m) in south along crest of Currant Creek Mountain. Localized perched ground water in central part of subdivision.	Potentially suitable, but locally unsuitable due to shallow ground water, perched ground water and impermeable rock.
5	≥30 feet (9 m) along drainage of Red Creek, increasing to 200 feet (61 m) in northwest part of subdivision.	Potentially suitable, but locally unsuitable due to shallow ground water and impermeable rock.
6	200 feet (61 m).	Potentially suitable, but locally unsuitable due to shallow ground water and impermeable rock.
7	400 feet (122 m) in the north, increasing to 800 feet (244 m) in the south.	Potentially suitable, but locally unsuitable due to impermeable rock; soils patchy, but generally deep enough for conventional soil absorptions systems.
8	400 feet (122 m) in west and south increasing to 800 feet (244 m) in northeast.	Potentially suitable in northern part of subdivision, but locally unsuitable due to impermeable rock; unsuitable in southern part due to highly fractured permeable rock.
9	400 feet (122 m) in north increasing to 800 feet (244 m) in south.	Potentially suitable, but locally unsuitable due to impermeable rock; soils patchy, but generally deep enough for conventional soil absorptions system.
10	800 feet (244 m).	Potentially suitable, but locally unsuitable due to impermeable rock; soils patchy, but generally deep enough for conventional soil absorptions systems.
11	Potentially ≥30 feet (9 m) in Skunk Hollow; northern part 400 feet (122 m) increasing to 800 feet (244 m) in south	Potentially suitable, but locally unsuitable due to impermeable rock; Skunk Hollow-Hwy. 40 region soils patchy, but generally deep enough for conventional soil absorption systems.
12	≥30 feet (9 m) along drainage of Strawberry River, rising to 600 feet (183 m) in the north.	Unsuitable in northern part due to highly fractured permeable rock; southern part in drainage of Strawberry River potentially suitable for absorption systems in soil, shallow bedrock not present.
13	≥30 feet (9 m) in west along floor of Lake Canyon increasing to 800 feet (244 m) in eastern part.	Unsuitable immediately east of floor of Lake Canyon due to highly fractured permeable rock; upper slopes and ridge crest generally suitable, but locally unsuitable due to impermeable rock; floor of Lake Canyon potentially suitable for absorption systems in soil, shallow rock not present; upper slopes and ridgecrest soils patchy, but generally deep enough for conventional soil absorption systems.
14	200 feet (61 m) in north, increasing to 400 feet (122 m) in the south.	Potentially suitable, but locally unsuitable due to impermeable rock.
15	200 feet (61 m).	Potentially suitable, but locally unsuitable due to impermeable rock.
SOUTHERN STUDY AREA		
16-20	Data limited; ≥ 30 feet (9 m) along all stream drainages; on mountain slopes 800 feet to 1000 (244-305 m). Perched ground-water conditions possible throughout area due to impermeable rock.	Unsuitable due to impermeable rock; soils locally deep enough for conventional soil absorption systems.

Appendix 3

Test Pit Logs

Duchesne County Shallow Rock Wastewater Disposal Project

Test Pit 1 Argyle Ridge area; main body, Green River Formation

0.0′-0.8′	Fat clay with gravel (CH); dark brown, low density, high plasticity, moist; 60 percent fines,blocky structure, noncemented, moderate reaction to HCL, platy shale fragments with secondary carbonate coatings, slight organic odor, roots throughout deposit, residual soil.
0.8′-2.8′	Green River Formation main body (Tgr); siltstone, brownish-gray, moderate reaction to HCL, highly fractured, angular blocks, blocks larger at base of horizon.
2.8′-5.3′	Green River Formation main body (Tgr); shale, light bluish-gray, moderate reaction to HCL, highly fractured, friable, no apparent bedding, roots penetrate through horizon.

Test Pit 2 Underhill property Great Basin Estates II, sandstone/limestone facies, Green River Formation.

0.0′-1.0′	Green River Formation, sandstone/limestone facies (Tgsl); shale/siltstone, tan to buff, fissile, angular and platy, secondary carbonate coatings, moderate reaction to HCL.
1.0-2.0′	Green River Formation, sandstone/limestone facies (Tgsl); siltstone, light tan to pale brown, angular and platy, bedded.

Test Pit 3 Cedar Mountain; Duchesne River Formation.

0.0-0.7′	Silty sand (SM); tan to buff, low density, non-plastic, dry; noncemented, no primary soil structure, angular clasts, secondary carbonate accumulation on clasts, moderate reaction to HCL, crude bedding; residual soil derived from weathering of Duchesne River Formation.
0.7′-1.7′	Duchesne River Formation undifferentiated (Tdu); sandstone, tan to buff, horizontally bedded, angular clasts, medium to fine grained, highly fractured, weak reaction to HCL.
1.7′-3.0′	Duchesne River Formation undifferentiated (Tdu); sandstone, tan to buff, horizontally bedded, medium to fine grained, fractured, weak reaction to HCL.

Test Pit 4 Cedar Mountain; saline facies, Green River Formation.

0.0′-0.5′	Lean clay with sand (CL); tan to buff, loose, medium plasticity, dry, noncemented, minor primary soil structure, angular clasts, secondary carbonate accumulation on clasts, moderate reaction to HCL, crude bedding, rootlets throughout; residual soil from weathering of saline facies of Green River Formation.
0.5′-2.3′	Green River Formation, saline facies (Tgs); siltstone, tan to gray, horizontally bedded, angular clasts, secondary carbonate accumulation on clasts, strong reaction to HCL, highly fractured, highly weathered at top of horizon decreasing with depth, staining from hydration of salts.
2.3′-4.3′	Green River Formation, saline facies (Tgs); sandstone, brownish-orange to gray, horizontally bedded, weak reaction to HCL, highly fractured, highly weathered at top of horizon decreasing with depth, salt casts and staining from hydration of salts.

Appendix 4

Guidelines for Geologic Investigations

These guidelines are intended to provide a general outline of what should be contained in geologic reports addressing suitability for wastewater disposal in rock for subdivisions and sites.

Subdivision Reports

Develop a series overlays for a base map of the subdivision or other study area showing:

1) Geology — This overlay should provide the groundwork for all the following overlays as it influences their characteristics. It should cover rock type, location of outcrops, dip and strike of bedding, extent of fracturing and jointing, and degree of weathering.
2) Ground water — Data for ground water is limited in parts of Duchesne County, but existing information should be collected for this overlay covering depth to ground water, areas of shallow ground water, water quality, and presence of impermeable horizons between ground water and disposal system.
3) Slope — This is the most widespread limiting factor to wastewater disposal systems. Slope overlays should consist of topographic maps which identify all areas of slope greater than 25% and areas where slopes intersect dipping beds and surface seepage of effluent may occur.
5) Soils — This overlay should show all areas where conventional soil absorption systems may be used, and indicate soil type and thickness.
6) Interpretive map — Combine all of the above overlays and shows areas suitable for conventional soil and rock disposal systems.

Site-specific Reports

If a subdivision report is completed and the site area is shown to be suitable, site-specific reports need to confirm this. If no subdivision report is available, all of the data listed for subdivision reports must be presented for the site. In both cases, exploratory test pit(s) and percolation tests will be required. The use of a standardized site inspection form can ensure that each topic is addressed in site-specific reports. Below is a data sheet which may be used to document site-specific investigations. All such data sheets or reports should be completed and reviewed by geologists or others with experience or specific training in these types of investigations.

DATA SHEET FOR SITE INVESTIGATIONS
FOR BEDROCK ABSORPTION SYSTEMS

Date: ____________ By: ____________
County: ____________

Location (Subdivision & quadrangle): ____________

Site Description:

Physiography: Ground surface: Elevation: ____________

____ valley ____ smooth
____ stream valley ____ undulating
____ foothills ____ rolling
____ mountain slope ____ dissected
____ terrace ____ rugged

Other ____________
Describe: ____________

Site Material Characteristics:
Bedrock:
Formation(s): ____________
Rock Type: ____________ Depth to rock: ____________
Dip: ____________ Strike: ____________
Bedding: ____________ Joints: ____________ Other: ____________
Impermeable beds: ____________ Thickness: ____________
Depth to uppermost: ____________

Describe: (additional formations, strikes & dips, etc.) ____________

Ground water:
Depth: ____________ Quality: ____________
Potential for contamination by effluent: ____________

Recharge area (if known) ____________
Describe: ____________

Surface water:
Distance from drainage: ____________ Direction: ____________
Perennial: ____________ Intermittent: ____________ Spring: ____________
Distance from springs: ____________
Potential for contamination: ____________

Percolation rate: ____________
Slope:
Site slope (%): ____________
Distance to downdip steep slopes in which beds at or below site daylight: ____________
Distance to downdip steep slopes in which uppermost impermeable beds daylight: ____________

Appendix 5

Agencies Providing Geologic Information

Utah Geological and Mineral Survey
606 Black Hawk Way
Salt Lake City, Utah 84108
Bill Mulvey, Geologist, Applied Geology Section
(801) 581-6831

Agency produces geologic information concerning engineering geology, geologic mapping, and economic geology. Applied geology section conducts local and regional engineering geology studies.

Utah Division of Water Rights
1636 North Temple
Salt Lake City, Utah 84116
(801) 538-7240

Agency produces technical publications concerning local and regional water resources. Publications contain information on water source, amounts, and quality, more locally oriented than U.S. Geological Survey Water Resources publications.

Duchesne County Planning
Duchesne County Court House
Duchesne, Utah 84021
(801)738-2685
Mr. Jack Wood, Planner

Provides information on current county development and building regulations.

Uinta Basin District Health Department
Vernal, Utah 84078
(801) 781-0770
Mr. Lowell Card, Chief Sanitarian

Provides information on current Health Department Regulations concerning wastewater disposal regulations and systems.

ASCS Aerial Photography Field Office
2222 West 2300 South
Salt Lake City, Utah 84119
(801) 524-5856

Agency sells air photos covering all of Utah and much of western U.S.

U.S. Soil Conservation Service (SCS)
Regional Soil Surveys
125 South State Street
Salt Lake City, Utah 84138
(801) 524-5064

Agency produces regional and local soil surveys. Surveys contain information on soil type, description, engineering properties, and agricultural uses.

U.S. Bureau of Land Management
Branch of Lands and Recreation
2370 South 2300 West
Salt Lake City, Utah 84111
(801) 524-5326

Ownership and management of federal lands, knowledge of geology, water resources, and vegetation on lands under their jurisdiction.

U.S. Geological Survey
Earth Science Information Center
125 South State, Room
Salt Lake City, Utah 84138
(801) 524-5652

Agency provides topographic and geologic maps, as well as related publications.

U.S. Geological Survey Water Resources Division
Investigations Section
1745 West 1700 South
Salt Lake City, Utah 84104
(801) 524-5654

Agency provides technical publications on local and regional water resources such as source, availability, and quality of water for a given area (e.g., Uinta Basin, Wasatch Front).

Appendix 6
Unified Soil Classification System

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

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

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

Plate 1
UGMS Special Study 72

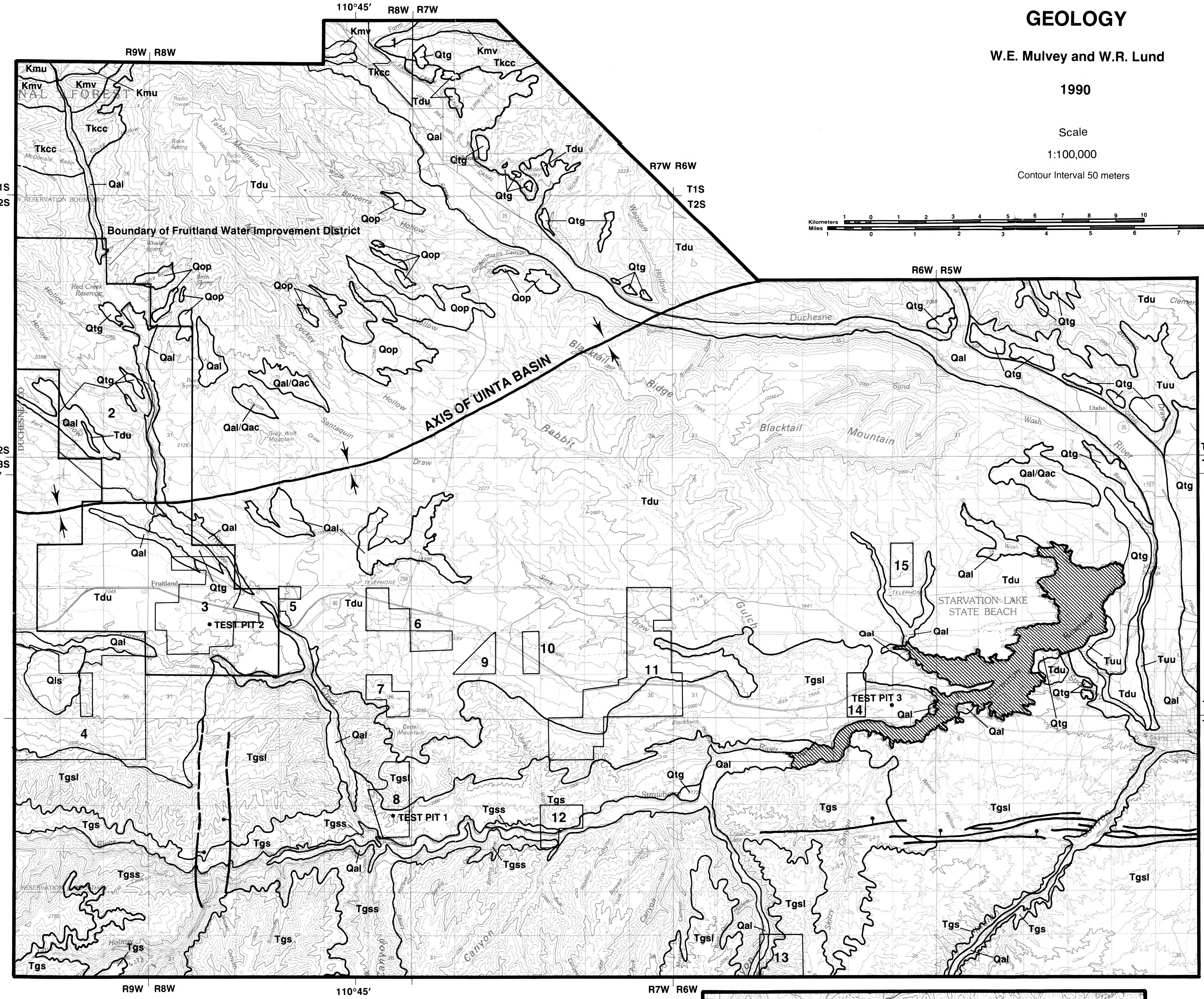
GEOLOGY

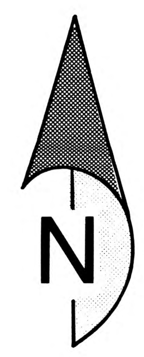
W.E. Mulvey and W.R. Lund

1990

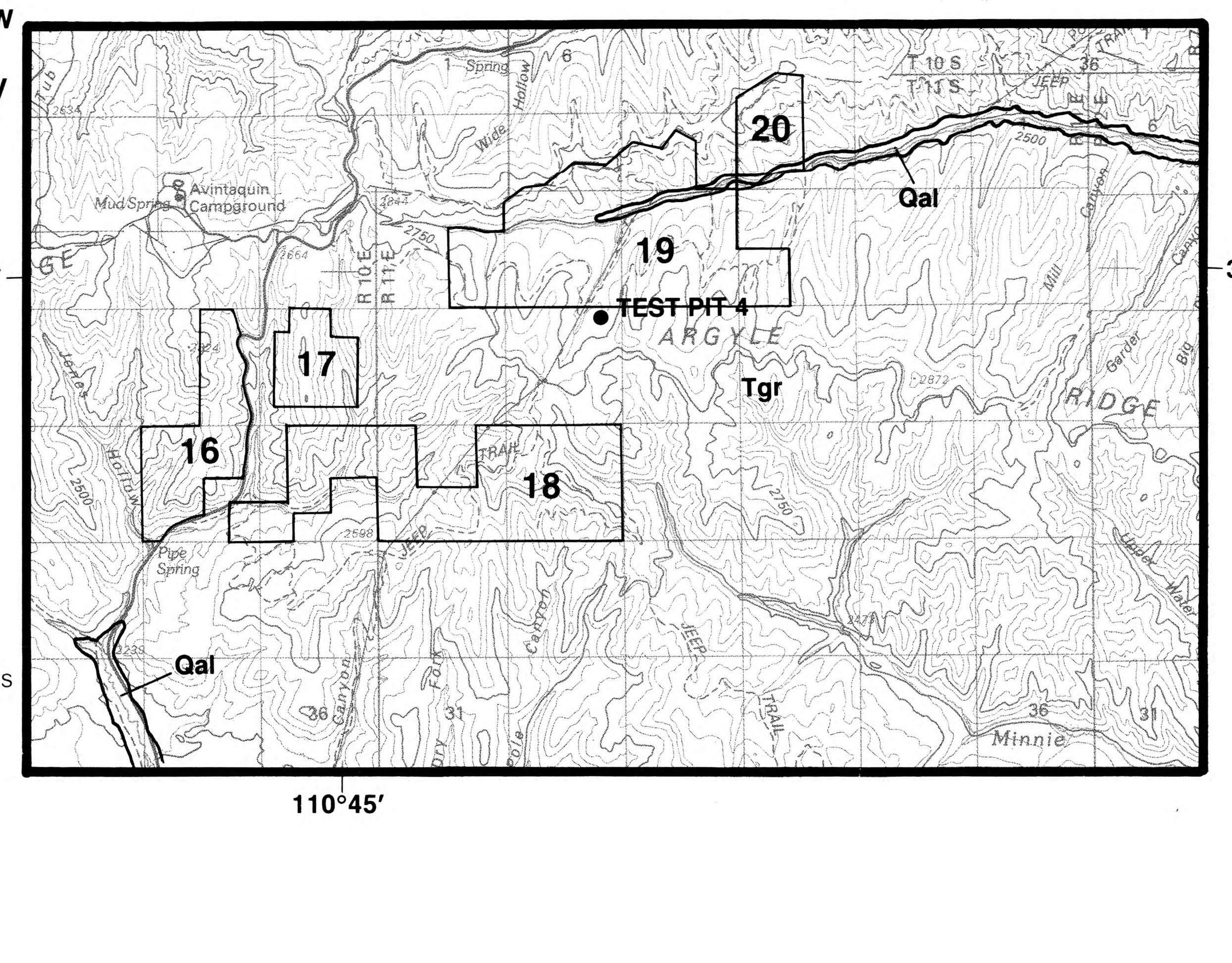
Scale
1:100,000
Contour Interval 50 meters

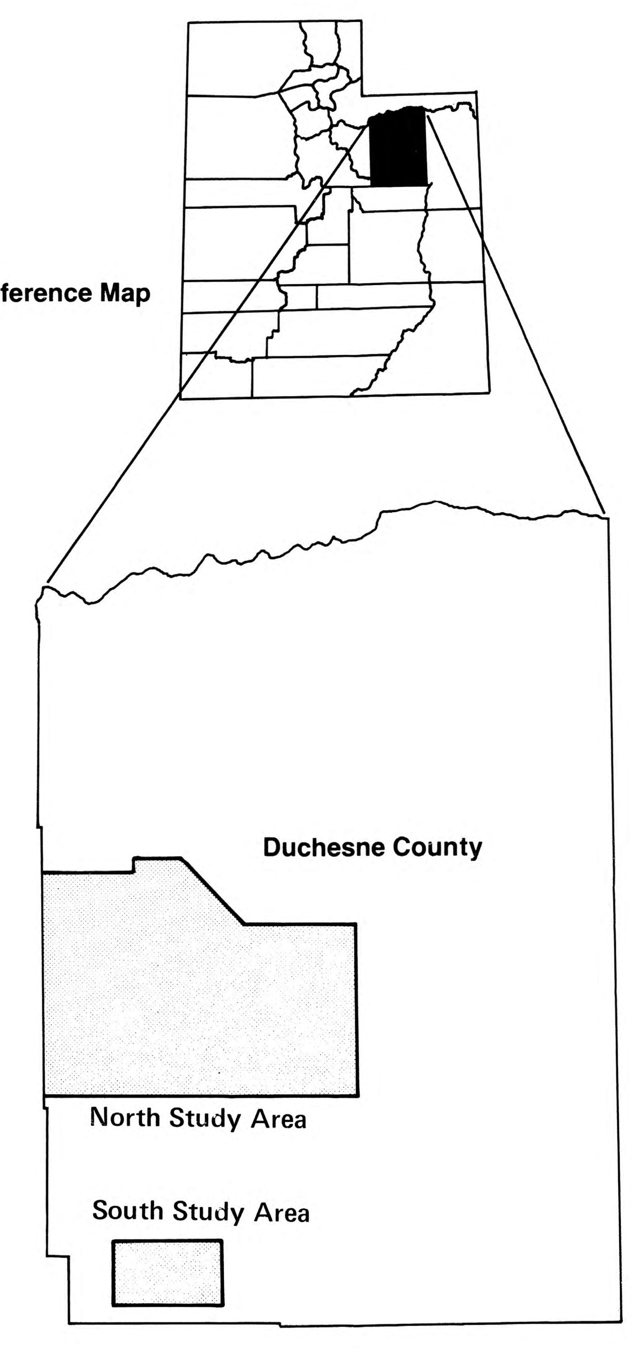
Geology modified from Bryant, 1989.





South Study Area





Base from Duchesne and Price, Utah, U.S.G.S. 30' x 60' topographic maps.

Cartography by B.D. Black

Quaternary	Qal/Qac	Alluvium and Colluvium: Holocene to Pleistocene in age. Composed of boulders, gravel, sand, silts and minor amounts of clay.
	Qtg	Terrace gravels: Pleistocene in age, found up to 100m (300 ft) above modern floodplains. Composed of boulders, cobbles, gravel, sand and silt.
	Qop	Older pediment deposits: Pleistocene in age. Composed of boulders, cobbles, gravel, sand and silt. Caps ridges of weathered Duchesne River Formation (Tdu).
	Qls	Landslide deposits: Pleistocene in age. Poorly sorted, unconsolidated deposits composed of bedrock and surficial material transported and deposited by mass movement.
Tertiary	Tdu	Duchesne River Formation: Undifferentiated red to grayish-red and gray sandstone, red siltstone, and pale-red to red pebble and boulder conglomerate.
	Tuu	Upper member of Uinta Formation: Cross-bedded gray sandstone with thin beds of sandstone and limestone.
	Tgsl	Green River Formation — Sandstone/limestone facies: Gray to brown thinly-bedded sandstone, siltstone, shale, and limestone. White and dark-gray limestone and sandstone locally fills channels cut into underlying rock.
	Tgs	Green River Formation — Saline facies: Gray to brown limestone, oil shale, and tuff. Limestone has numerous salt casts and weathers to mottled texture.
	Tgss	Green River Formation — Sandstone facies: Thinly-bedded sandstone with minor beds of siltstone, shale, and limestone.
	Tgr	Green River Formation — Main body: Gray and greenish-gray limestone, shale, sandstone, oil shale, and tuff.
	Tkcc	Currant Creek Formation: Gray to orange conglomerate, sandstone, siltstone, and claystone.
Cretaceous	Kmv	Mesa Verde Formation: White to light-gray and yellowish-gray sandstone, gray siltstone, and dark-gray carbonaceous shale and coal.
	Kmu	Mancos Shale — Upper member: Medium to dark-gray and bluish-gray shale with few beds of limestone and sandstone.

Axis of Uinta Basin, arrows show dip of rock

SYMBOLS

Normal fault, bar and ball on downthrown side

Contact — dashed where uncertain

Subdivision boundary

Plate 2
UGMS Special Study 72

SOIL COVER

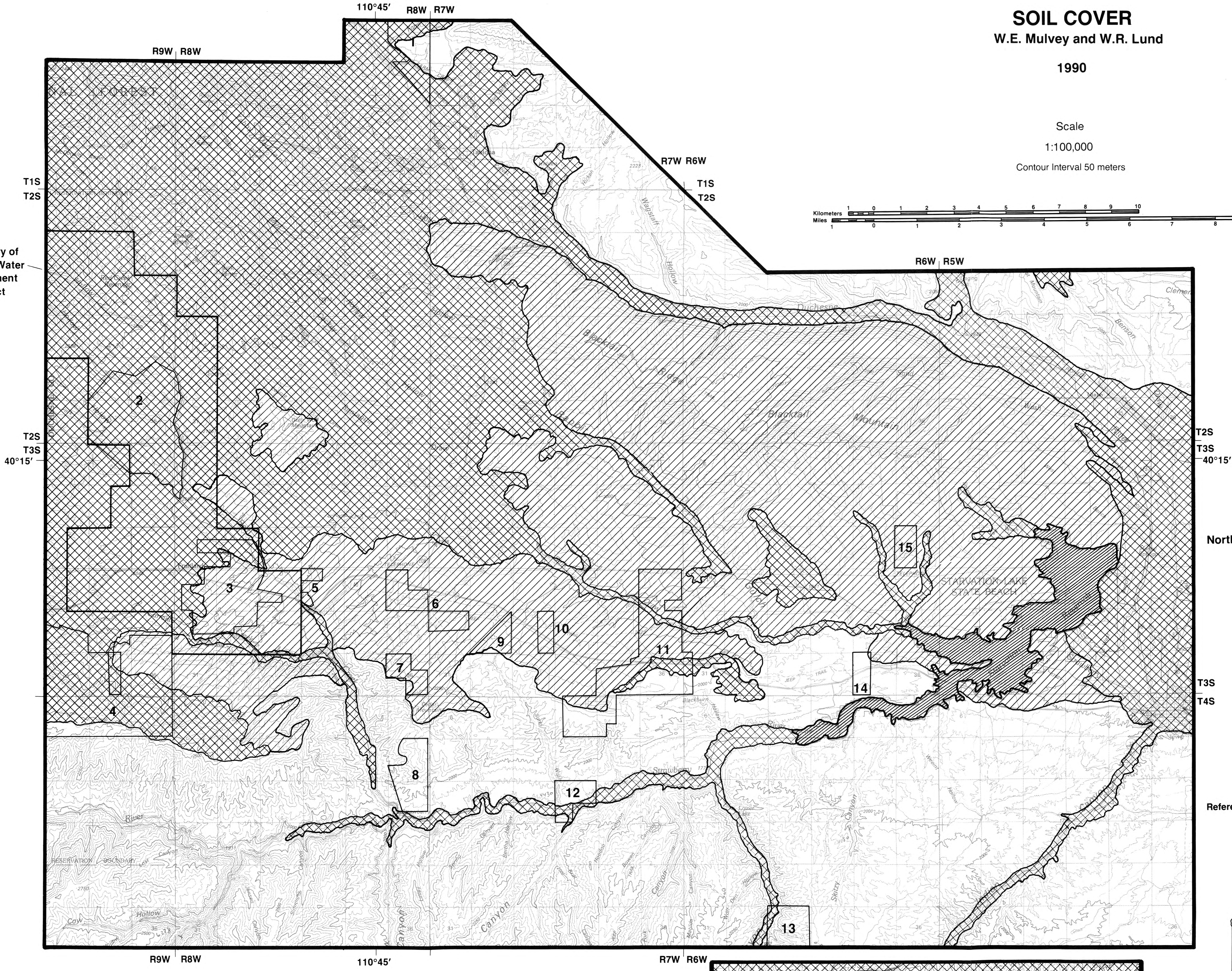
W.E. Mulvey and W.R. Lund

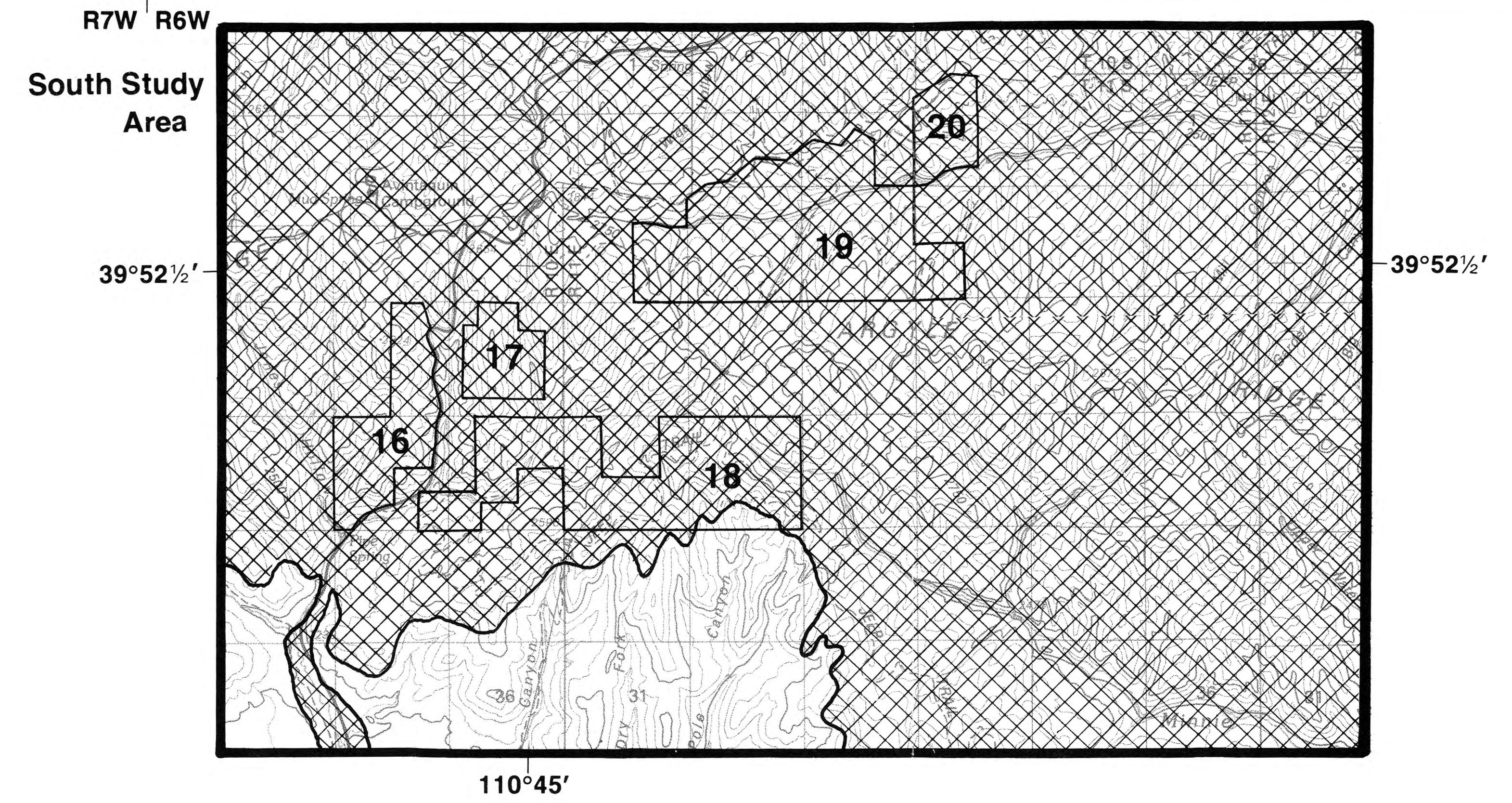
1990

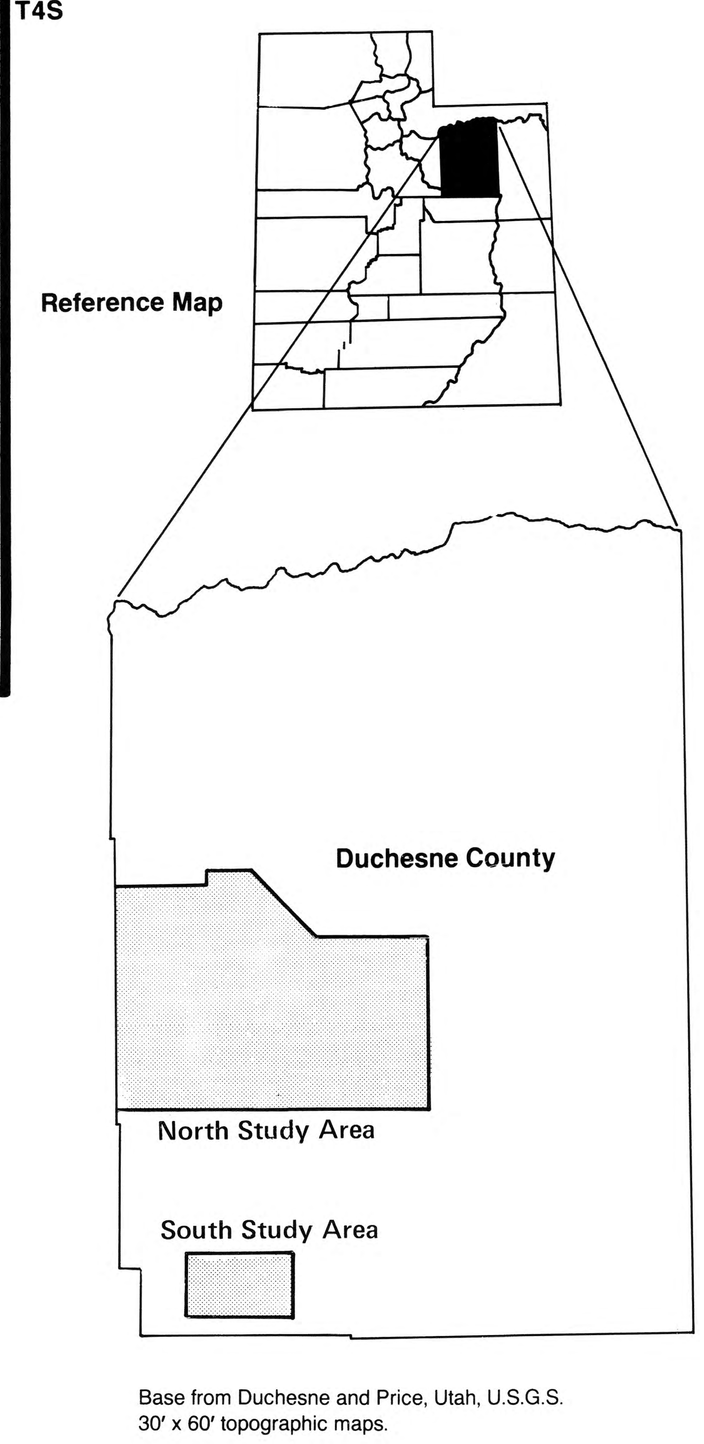
Scale

1:100,000

Contour Interval 50 meters







EXPLANATION

Deep Soils
Soil is generally deep enough for conventional soil absorption systems. The deepest soils are found in the northwest along stream drainages.

Thin Soils
Soil generally thin and marginal for soil absorption systems. Deeper soils occur in swales, but region is dominated by shallow soils overlying bedrock.

Exposed Bedrock
Soil generally lacking and limited to local valley floor alluvium along streams. Majority of area has bedrock at or near the surface.

Base from Duchesne and Price, Utah, U.S.G.S. 30′ x 60′ topographic maps.

Cartography by B.D. Black

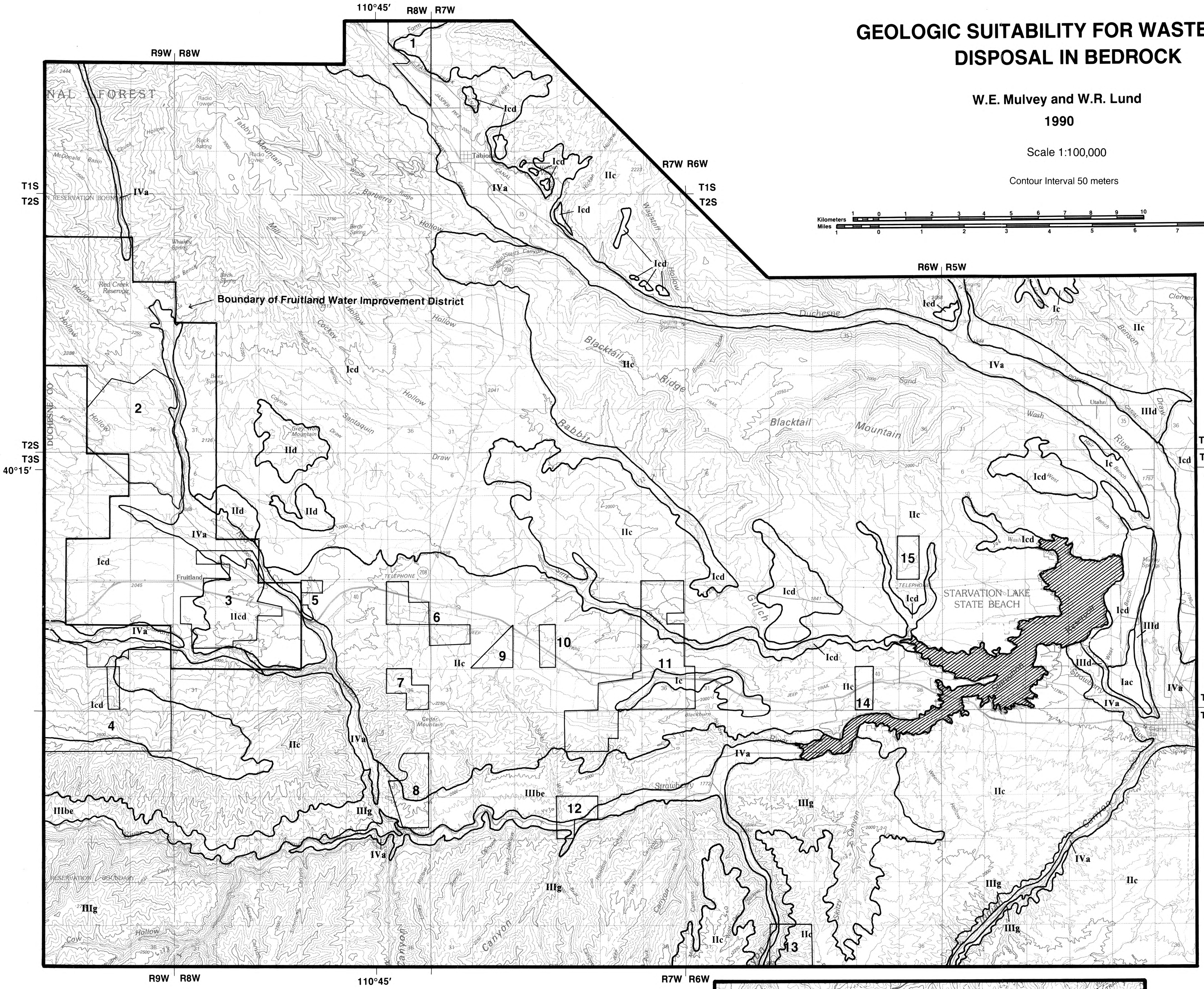
GEOLOGIC SUITABILITY FOR WASTEWATER DISPOSAL IN BEDROCK

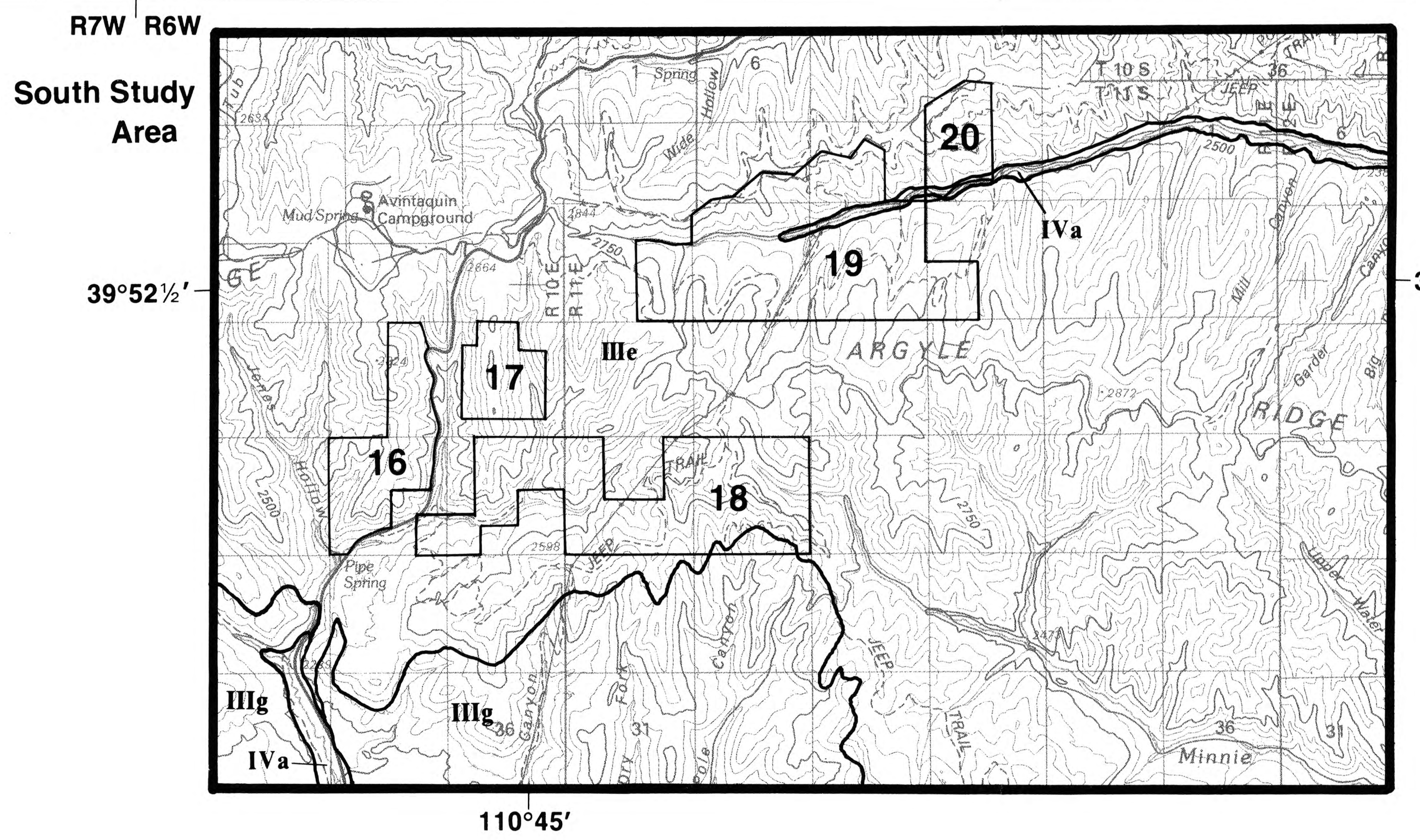
W.E. Mulvey and W.R. Lund

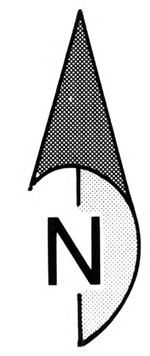
1990

Scale 1:100,000

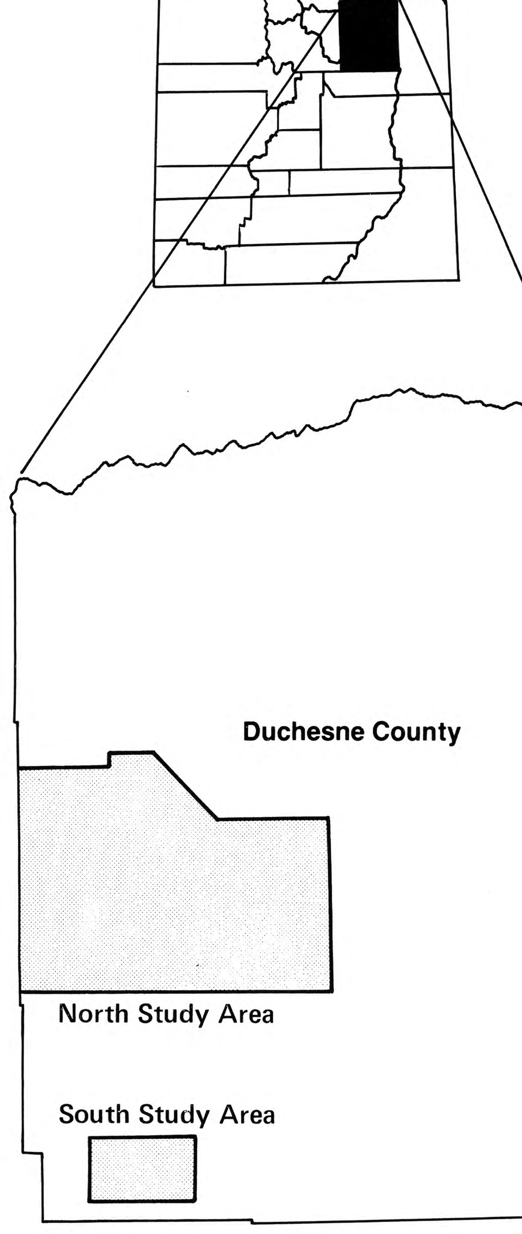
Contour Interval 50 meters







Reference Map



Base from Duchesne and Price, Utah, U.S.G.S. 30′ x 60′ topographic maps.

Cartography by B.D. Black

EXPLANATION

SUITABILITY CATEGORIES

I. Potentially suitable for absorption systems in soil and rock.
II. Potentially suitable for absorption systems in rock.
III. Unsuitable for absorption systems in rock.
IV. Potentially suitable for absorption systems in soil; shallow rock not present.

QUALIFIER SYMBOLS

a. Shallow ground water in unconsolidated deposits.
b. Outcrops of shallow rock.
c. Highly fractured, permeable rock (Green River Formation—Sandstone facies, Green River Formation—Saline facies).
d. Isolated outcrops and/or horizons of impermeable rock.
e. Soils locally deep enough for conventional soil absorption system.
f. Soils patchy, found in swales and low areas.
g. Soils generally absent, most surface cover is fractured rock.

Examples of suitability with qualifier(s)

Icd Potentially suitable for absorption systems in soil and rock but expect outcrops of shallow rock, and/or horizons of impermeable rock.
IIc Potentially suitable for absorption systems in rock; soils patchy, but expect isolated outcrops and/or horizons of impermeable rock.
IIId Unsuitable for absorption systems in rock but soils generally present, locally deep enough for conventional absorption system.

DISCUSSION

Site characteristics critical to the proper functioning of an absorption system in rock vary throughout the two study regions. The permeability and filtering capacity of rock depends upon its texture (grain size and distribution) and degree of fracturing. Most of the rock in the region has low primary permeability (through the rock itself) but high secondary permeability (through fractures). Fine-grained rock with a high clay content (shales, claystones) seldom possess sufficient permeability to function properly in an absorption system. This is particularly true if the clay minerals in the rock are expansive, in which case they swell as they become saturated, further reducing permeability. If rock is coarse-grained and highly fractured, permeabilities may be too high and filtering capacity too low to effectively remove the effluent. Under such conditions ground-water contamination becomes a concern. Surface seepage may result when absorption systems are improperly installed on or near steep slopes. This is especially true where the impermeable rock horizons restrict the downward movement of effluent and force it to migrate laterally to a slope face. In areas where ground-water is shallow the potential for ground-water contamination is increased as is the possibility of system saturation and failure. Absorption systems installed in rock may lead to the pollution of ground water in rock aquifers with high fracture permeability and low filtering capacity.

Geologic, soil, and ground-water conditions in Duchesne County are variable and, as a result, there is a wide range in suitability for absorption systems. Large portions of the study area are characterized by shallow or exposed rock, thin soils, and highly permeable or impermeable rock. Other areas have deep soils and are generally suitable for conventional soil absorption systems or have localized limitations that can be overcome in system design. The classification system is designed to provide information on the suitability of rock and soils for absorption systems and is intended for use in the study area as outlined on the map. However, conditions can vary locally and this map is intended for general planning and siting purposes only. A site investigation should be performed for each proposed absorption system in rock or soil.