PREPARED IN COOPERATION WITH THE
UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY, DIVISION OF WATER QUALITY;
GRAND COUNTY;
THE CITY OF MOAB; AND THE
U.S. ENVIRONMENTAL PROTECTION AGENCY

Steiger, J.I., and Susong, D.D., 1997, Recharge areas and quality of ground water for the Glen Canyon and valley-fill aquifers, Spanish Valley area, Grand and San Juan Counties, Utah

INTRODUCTION

The Spanish Valley area in southeastern Utah (fig. 1) is experiencing a rapid increase in development of residential and business property. In this report, the Spanish Valley area refers to the geographic area shown in figures 1, 3, and 4. This area includes Moab Valley, Spanish Valley, and the mesa areas to the northeast. Substantial development is taking place on the east side of Spanish Valley, where the Navajo Sandstone, the Kayenta Formation, and the Wingate Sandstone form the Glen Canyon aquifer, which is the principal aquifer that supplies drinking water for the area. Additional business construction and subdivision development are occurring in Spanish Valley south of Moab, where valley-fill deposits make up a secondary aquifer that is used mostly for irrigation and stock watering but also for domestic drinking water. Because current (1995) sewage-treatment facilities are not adequate to accommodate the increase in development, county officials are concerned about protecting the ground-water resources from excess nitrate loading that might result if additional septic systems are used for the effluent disposal.

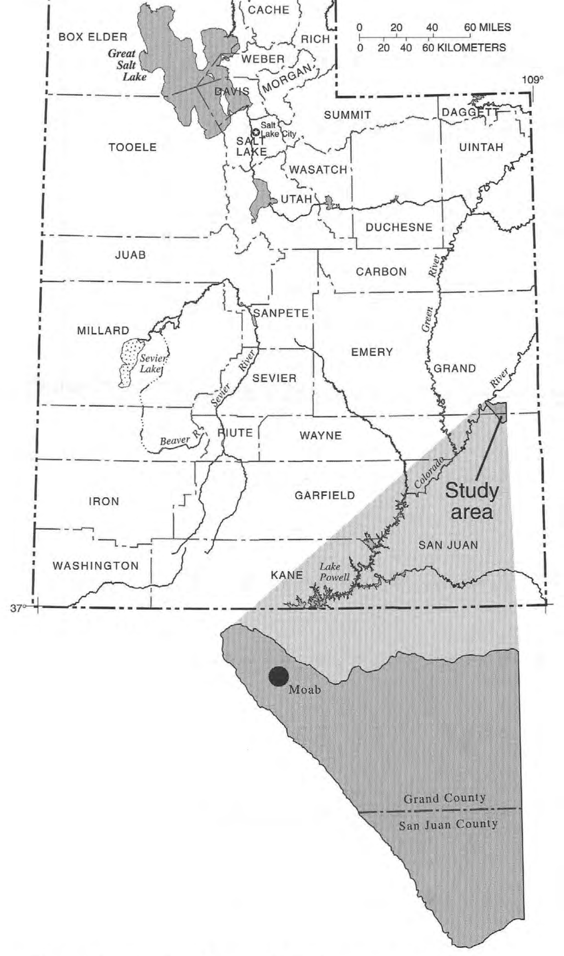

Figure 1. Location of Spanish Valley area, Grand and San Juan Counties, Utah.

Traditional land use in the Spanish Valley area has been agricultural, but more subdivisions and small farms with horse pastures are being developed. Sumsion (1971) reported that water from five wells in the valley-fill aquifer contained nitrate concentrations that ranged from 9 to 26 mg/L as NO_3 (2.0 to 5.87 mg/L as N). With the increased use of septic systems in the south end of the valley, nitrate plus nitrite concentrations might have increased in the valley-fill aquifer. Few data on nitrate plus nitrite concentration have been collected since 1968-69. Also, with the increased development, other types of contamination such as organic compounds might be infiltrating the valley-fill aquifer. Little or no sampling for organic compounds has been done in the valley-fill aquifer in Moab and Spanish Valleys.

To protect ground-water resources in Grand County, Grand County Commissioners would like to classify the ground-water system according to the Ground Water Quality Protection Administrative Rule R317-6 of the Utah Administrative Code (table 1, part A, located on the back of this report) (Utah Department of Environmental Quality, Division of Water Quality, 1995). The code states that when sufficient information is available, entire aquifers or parts thereof may be classified by the Utah Water Quality Board according to the quality of ground water contained therein. After classification, ground-water protection levels are established and used to regulate existing and potential sources of contamination to ground water from new and existing facilities within the classified area. This investigation was done by the U.S. Geological Survey (USGS) in cooperation with the Utah Department of Environmental Quality, Division of Water Quality; Grand County; the city of Moab; and the U.S. Environmental Protection Agency.

Purpose and Scope

This report provides hydrologic data and information to support Grand County Commissioners and city of Moab officials in preparing and implementing use of a plan for managing ground-water quality for the Spanish Valley area. The report identifies and provides maps of primary recharge areas for the Glen Canyon and valley-fill aquifers, and water-quality characteristics in each of the two aquifers according to the classification defined by the State's administrative rules for ground-water quality protection. Analyses of ground-water samples from previous studies (Sumsion, 1971, and Blanchard, 1990), Utah Department of Environmental Quality files, and 30 samples collected during this investigation are used to describe the baseline quality of ground water in the Glen Canyon and valley-fill aquifers.

Acknowledgments

The water-sample analyses done by the Utah State Health Laboratory are greatly appreciated. Special thanks to William Duncan, who collected the water samples, and Kenneth H. Bousfield of the Utah Department of Environmental Quality, who obtained water-quality data from the State's computer data base. Recognition and thanks also are extended to Lance Christie for his help in locating wells and springs for sampling and to all the well and property owners who allowed access to their wells and springs for sampling.

Numbering System for Hydrologic-Data Sites

The system of numbering wells, springs, and other hydrologic-data sites in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the site, describes its position in the land net. The land-survey system divides the State of Utah into four quadrants separated by the Salt Lake Base Line and the Salt Lake Meridian. These quadrants are designated by the uppercase letters A, B, C, and D, that designate, respectively, the northeast, northwest, southwest, and southeast quadrants. Numbers that designate the township and range (in that order) follow the quadrant letter, and the three are enclosed in parentheses. The number after the parentheses designates the section and is followed by three lowercase letters that designate the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section—generally 10 acres for regular sections[1]. The lowercase letters a, b, c, and d designate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the well or spring within the 10-acre tract. The letter "S" preceding the serial number indicates a spring. Thus, (D-26-22)22aab-1 designates the first well constructed or visited in the NW 1/4 of the NE 1/4 of the NE 1/4, Sec. 22, T. 26 S., R. 22 W. (fig. 2). The uppercase letter "D" indicates that the township is south of the Salt Lake Base Line and the range is east of the Salt Lake Meridian.

[1]Although the basic land unit. the section, is theoretically 1 square mile, many sections are irregular in size and shape. Such sections are subdivided into 10-acre tracts, generally beginning at the southeast corner, and the surplus or shortage is accounted for in the tracts along the north and west sides of the section.

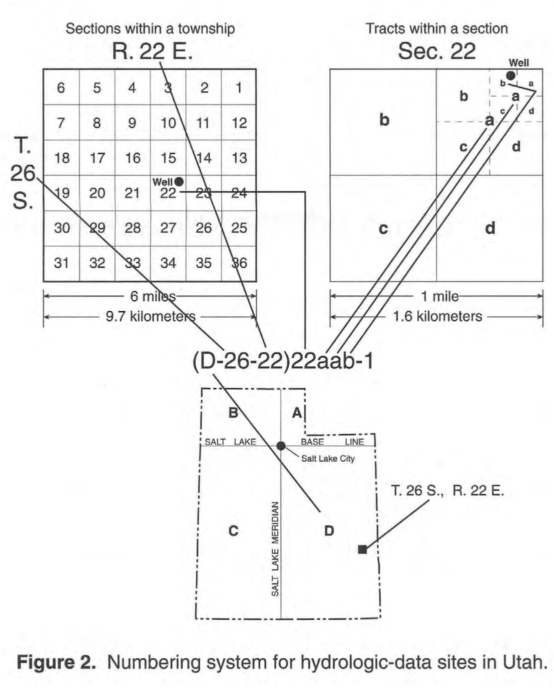

Figure 2. Numbering system for hydrologic-data sites in Utah.

HYDROLOGIC SYSTEM

The Spanish Valley area is located in southeastern Utah and covers about 76 mi^2. Within that area, Spanish Valley covers about 18 mi^2 and Moab Valley about 5 mi^2. Pack Creek enters Spanish Valley from the southeast, flows through into Moab Valley, and joins the Colorado River at the northwestern end of the valley. Mill Creek flows west from the mountains and then northwest for 8.6 mi, paralleling Spanish Valley before entering Moab Valley where it joins Pack Creek. North Fork Mill Creek generally flows from east to west and joins Mill Creek before entering Moab Valley.

Along the northeastern wall of Spanish Valley and Moab Valley, the Navajo Sandstone, Kayenta Formation, and Wingate Sandstone are exposed. The Navajo and Wingate Sandstones yield substantial amounts of water and form the principal aquifers in the area. Blanchard (1990) noted that the Navajo and Wingate Sandstones are in hydraulic connection because the intervening Kayenta Formation is mostly sandstone, and all three formations are jointed and fractured. Blanchard (1990) referred to the three formations as the Glen Canyon aquifer. Freethey and Cordy (1991) referred to the same formations for the Upper Colorado River Basin as the Navajo-Nugget aquifer. In this report, the aquifer will be referred to as the Glen Canyon aquifer. Blanchard (1990) showed that the direction of ground-water movement in the Glen Canyon aquifer is generally to the west and southwest, nearly perpendicular to the eastern canyon wall of the valleys. Water from the Glen Canyon aquifer discharges to numerous springs and wells along the eastern edge of Spanish Valley. Municipal water supply for the city of Moab is mostly from wells and springs in the area around T. 26 S., R. 22 W., sections 15 and 22.

The valley-fill deposits in Spanish and Moab Valleys make up a secondary aquifer used mostly for irrigation and some domestic water supply. The valley-fill aquifer consists mostly of unconsolidated river and stream alluvium, and fan deposits with a maximum thickness of about 400 ft near the Colorado River (Doelling and others, 1995). Average thickness of the saturated deposits is about 70 ft (Sumsion, 1971). The direction of ground-water movement in the valley-fill aquifer is generally to the northwest, almost perpendicular to the direction of ground-water flow in the Glen Canyon aquifer. The water in the valley-fill aquifer mixes with water from the Glen Canyon aquifer along the northeastern side of the valley as it moves toward and discharges into the Colorado River.

RECHARGE AREAS FOR GLEN CANYON AND VALLEY-FILL AQUIFERS

Recharge areas are determined by considering the climate, geology, topography, and hydrology in an area. The quantity of recharge that occurs within an area is dependent on related factors including amount and timing of precipitation, hydrologic properties of the soil and valley fill, and fracturing in consolidated rock (Freethey, 1993). Precipitation is the major source of recharge to aquifers in southern Utah. Average annual winter precipitation, shown in figure 3, ranges from 6 in. near the northwestern corner of the study area to 13 in. at the higher altitudes on the eastern edge of the study area. Winter precipitation (October to April) generally determines the amount of water that can recharge aquifers because there is more precipitation and little evapotranspiration during the winter months than during the summer months. Winter precipitation is often in the form of snow, which melts slowly and thereby extends the period of runoff and increases infiltration (Danielson and Hood, 1984, p. 24). Hydrologic properties of the soil and valley-fill deposits control how rapidly water infiltrates from the surface and through the soil to underlying aquifers. Sandy soils, common in the study area, have faster infiltration rates than clay-rich soils. Infiltration studies in southern Utah generally indicate that areas with more than 8 in. of winter precipitation (water equivalent) likely contribute recharge to aquifers (Danielson and Hood, 1984). Areas covered with eolian sand and soil, fractured areas, and the upper mesas that receive more than 8 in. of winter precipitation will be more important recharge areas than areas that receive less than 8 in. Soil hydrologic properties, like grain size, control infiltration and flow through soil. Fracturing in consolidated rock provides important flow paths for water to infiltrate and recharge aquifers and to flow rapidly within aquifers.

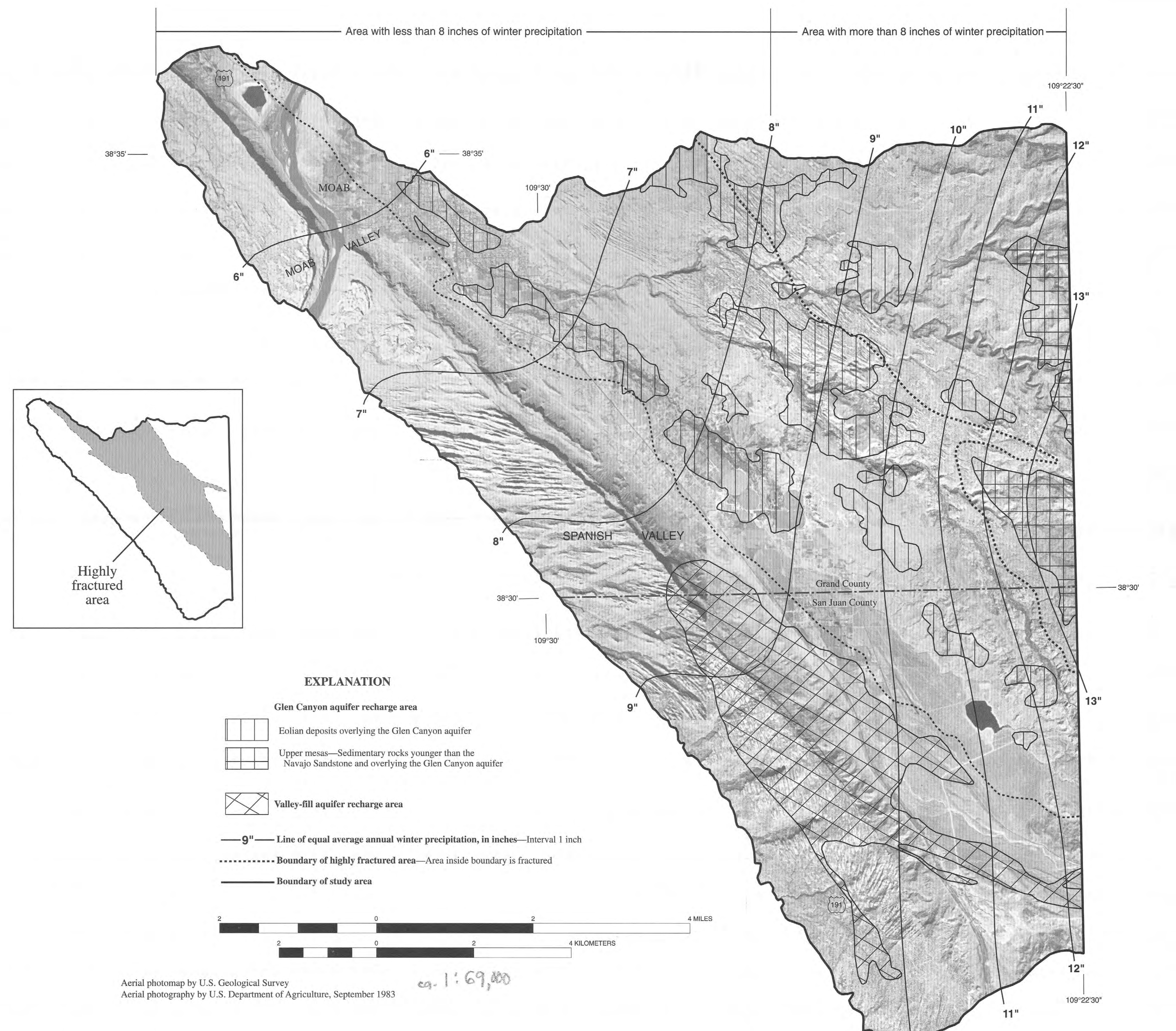

Figure 3. Recharge areas for the Glen Canyon and valley-fill aquifers, and average annual winter precipitation for the Spanish Valley area, Grand and San Juan Counties, Utah.

Recharge Areas for Glen Canyon Aquifer

The saturated part of the Navajo Sandstone, the Kayenta Formation, and the Wingate Sandstone form the Glen Canyon aquifer. These formations are exposed or are covered by shallow deposits of eolian sand or sandy soil northeast of Spanish Valley. These sands and soils provide storage where precipitation can quickly infiltrate and then move into the underlying Glen Canyon aquifer rather than run off into stream channels. When water from snowmelt or rainfall quickly infiltrates the ground, less water is lost to evaporation and more water recharges the underlying aquifer. Areas with eolian sand and soil covering the sandstone formations are shown in figure 3. These areas were mapped from aerial photographs and are large contiguous areas of sand and soil that are relatively flat. The areas do not include many small, isolated sand and soil deposits that also could contribute recharge to the Glen Canyon aquifer. Most precipitation on steeper slopes runs off and does not infiltrate. Steeper slopes were subjectively mapped on the basis of interpretation of the aerial photographs.

Moab Valley and Spanish Valley are a graben. The margins of the valleys and the areas adjacent to the valleys are extensively fractured parallel to the axis of the valleys. The fractured part of the study area to the north and east of the valleys is shown in figure 3. Fractures can be important conduits for water to recharge the Glen Canyon aquifer. In areas where the Glen Canyon aquifer is highly fractured, substantial recharge probably occurs where less than 8 in. of winter precipitation falls because the fractures provide conduits for water to rapidly recharge the aquifer. Where sandstone is exposed at the surface and topographically flat, fractures can drain small basins. In addition, some fractures are filled with sand and form storage reservoirs from which water can infiltrate the sandstone. The fractured parts of the study area were mapped on the basis of fractures and lineaments visible on the aerial photographs.

On the eastern edge of the study area, the Navajo Sandstone is overlain by younger sedimentary formations that form large mesas. These areas, called upper mesas in this study, are recharge areas for the Glen Canyon aquifer because water that infiltrates the top of the mesas could eventually reach the underlying Glen Canyon aquifer and because the mesas receive the largest amount of precipitation in the study area.

Stream channels that traverse the Navajo Sandstone are narrow zones of recharge and discharge. Mill Creek gains water from the Glen Canyon aquifer in its upper reaches and loses water to the aquifer in the last 8.6 mi as it parallels Spanish Valley (Blanchard, 1990). The North Fork of Mill Creek gains water from the Glen Canyon aquifer along its entire length (Blanchard, 1990). Perennial streams are important sources of recharge because they are a year-round source of water that infiltrates the sandstone and the alluvial deposits that cover the sandstone (Freethey, 1993). Intermittent streams are less important because they contain water only during part of the year.

Recharge Areas for Valley-Fill Aquifer

The valley-fill aquifer in Spanish Valley is recharged by direct precipitation and by infiltration of water from Pack Creek and Kens Lake at the southeastern end of the valley (fig. 3). At the northwestern end of Spanish Valley, the valley-fill aquifer begins discharging water to Pack Creek, and this part of the valley is considered to be a discharge area. The boundary between recharge and discharge areas in the middle of the valley changes with fluctuating water levels in the valley-fill aquifer.

CHEMICAL QUALITY OF WATER IN THE GLEN CANYON AND VALLEY-FILL AQUIFERS

Ground-water quality in the Spanish Valley area was determined from the results of chemical analyses obtained from the files of the USGS and the Utah Department of Environmental Quality. The results of 141 chemical analyses of samples from 57 selected wells and springs are shown in table 2. The samples were collected from April 1964 to December 1995, with 33 of the samples collected during December 1995. Results of some of the analyses from the USGS were included in previous reports (Sumsion, 1971; Blanchard, 1990). Analyses from the files of the Utah Department of Environmental Quality are for wells and springs used for public supply.

The State of Utah has established water-quality standards for ground water (Utah Department of Environmental Quality, Division of Water Quality, 1995). Constituents with established standards are listed in table 1, part B. Concentrations of inorganic constituents and trace metals in water from the study area were less than the Utah ground-water-quality standards. However, water from one well had a lead concentration equal to the water-quality standard of 15 µg/L. Public water supplies are regularly monitored for the organic constituents listed on table 1, part B. Because none of the water sampled in the study area had detectable concentrations of any of the organic constituents, those results are not included in table 2.

In this study, 30 wells and springs were sampled during December 1995. Twenty of the water samples were collected from wells completed in the valley-fill aquifer and 10 samples were from springs and wells that receive water from bedrock sources, mostly the Glen Canyon aquifer. Specific conductance, water temperature, and pH were measured in the field. Laboratory analyses for major ions, nutrients, and trace metals were done by the Utah Department of Health Laboratory and the results are presented in table 2. Twelve of the samples also were analyzed for several organic constituents, including the organic chemicals (pesticides) with an established water-quality standard listed in table 1, part B. None of the water sampled had detectable concentrations of any of the organic constituents. Nine filtered samples collected from wells and springs in April 1997 were analyzed for gross alpha particle activity. All of the values were less than the detection limit except water from well (D-26-22)27adc-1, which had a gross alpha particle activity value of 6.1 piC/L. The wells and springs that were sampled are noted in table 2, but values are not reported.

The most recent dissolved-solids concentration is shown next to the well location in figure 4. Values enclosed in parentheses were determined from water samples analyzed prior to 1995. Water from springs and wells in the Glen Canyon aquifer generally contained a dissolved-solids concentration of less than 500 mg/L, and about 69 percent of the water samples analyzed contained a dissolved-solids concentration of less than 250 mg/L. Water from one well on the west side of Spanish Valley, from a sandstone that is older than the formations that make up the Glen Canyon aquifer, had a dissolved-solids concentration of 736 mg/L. Water from wells in the valley-fill aquifer contained a dissolved-solids concentration of less than 2,000 mg/L, and about 86 percent of the water samples analyzed contained a dissolved-solids concentration of less than 1,000 mg/L. As water from the Glen Canyon aquifer discharges into the valley-fill aquifer, it mixes with and dilutes the ground water in the valley-fill aquifer. Mixing of the water from the two sources is irregular, but Sumsion (1971) showed that the mixing becomes more apparent northwestward through Spanish Valley. However, the area with the highest concentrations of dissolved solids was in central Spanish Valley, on the west side of Pack Creek.

Nitrate plus nitrite concentration in water from the Glen Canyon aquifer ranged from 0.02 to 7.37 mg/L and in water from the valley-fill aquifer ranged from 0.04 to 5.87 mg/L. Nitrate plus nitrite concentration in water from one well completed in a sandstone that is older than the formations that make up the Glen Canyon aquifer was 15.2 mg/L. Though concentrations were mostly below the Utah water-quality standard, concerns are that increased housing development with individual septic systems in areas not served by municipal sewage-treatment facilities and in areas connected to the municipal system between 1983 and 1995 may have resulted in increased nitrate concentrations in the valley-fill aquifer. In a study done by Madison and Brunett (1985), nitrate levels in ground water throughout the United States were analyzed to determine what effect human activities had on nitrate plus nitrite concentration. The study indicated that a nitrate plus nitrite concentration of greater than 3.0 mg/L may be related to human activity. An area in the central part of Spanish Valley where nitrate plus nitrite concentration exceeds 3.0 mg/L is shown in figure 5. Much of this area has only recently been connected to the municipal sewage system, and individual septic systems are still being used.

SUMMARY

The Spanish Valley area of southeastern Utah is experiencing a rapid increase in development of residential and business property. The growth has surpassed the capacity of the existing (1995) sewage-treatment facilities, and Grand County officials are concerned about protecting ground-water resources from development-related contamination. The Glen Canyon aquifer is the principal source of drinking water for the Spanish Valley area. The valley-fill aquifer is a secondary aquifer used mostly for irrigation and for some domestic water supply. Grand County Commissioners would like to classify and protect both of these ground-water resources.

Recharge areas were determined by considering the climate, geology, topography, and hydrology of the Spanish Valley area. Where the Navajo Sandstone is covered by eolian sand or sandy soil, precipitation, mostly in the form of snow, can infiltrate the Glen Canyon aquifer. Perennial streams that traverse the Navajo Sandstone also contribute water to the aquifer. Fractures can be important conduits for water to recharge the Glen Canyon aquifer. Large mesas known as upper mesas, formed where younger sedimentary formations overlie the Navajo Sandstone, are recharge areas for the Glen Canyon aquifer. The valley-fill aquifer is recharged by direct precipitation and by water infiltration from Pack Creek and Kens Lake.

Ground-water quality in the Spanish Valley area was determined from the results of chemical analyses obtained from the files of the U.S. Geological Survey and the Utah Department of Environmental Quality. The results of 141 chemical analyses of water from 57 selected wells and springs are presented. Water from wells and springs in the Glen Canyon aquifer generally contained a dissolved-solids concentration of less than 500 mg/L. Water from wells in the valley-fill aquifer contained a dissolved-solids concentration of less than 2,000 mg/L. Concentrations of trace metals and organic constituents were less than State of Utah water-quality standards. One well had a lead concentration equal to the water-quality standard of 15 µg/L.

Nitrate plus nitrite concentrations in water from the Glen Canyon aquifer ranged from 0.02 to 7.37 mg/L and in water from the valley-fill aquifer ranged from 0.04 to 5.87 mg/L. Nitrate plus nitrite concentration exceeded the State standard in water from one well completed in sandstone that is older than the formations that make up the Glen Canyon aquifer. An area in the central part of Spanish Valley had nitrate plus nitrite concentration that exceeded 3.0 mg/L. The higher concentration of nitrate plus nitrite in this area possibly result from human activities.

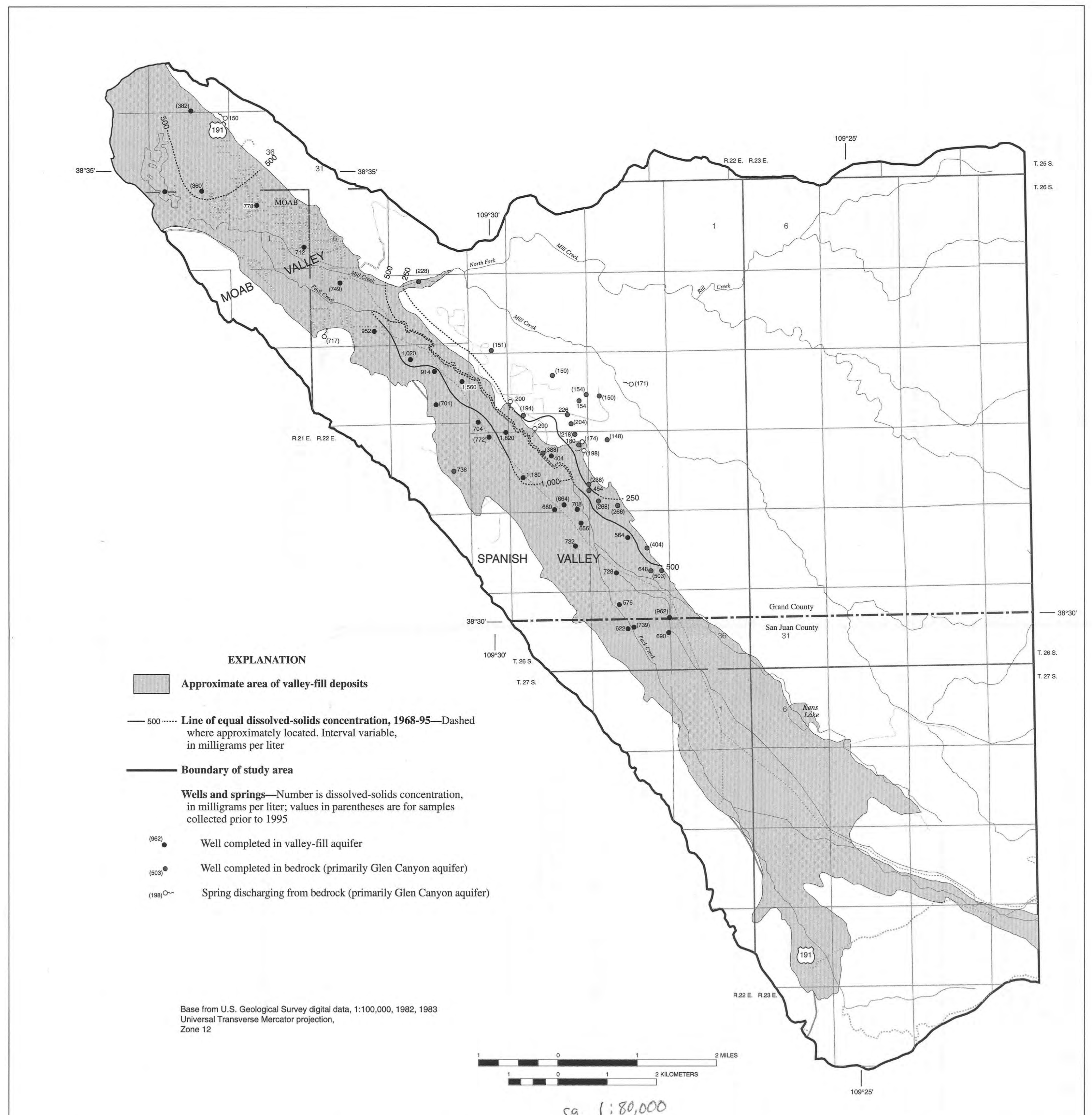

Figure 4. Well and spring locations, and dissolved-solids concentration in water from selected wells and springs, Spanish Valley area, Grand and San Juan Counties, Utah.

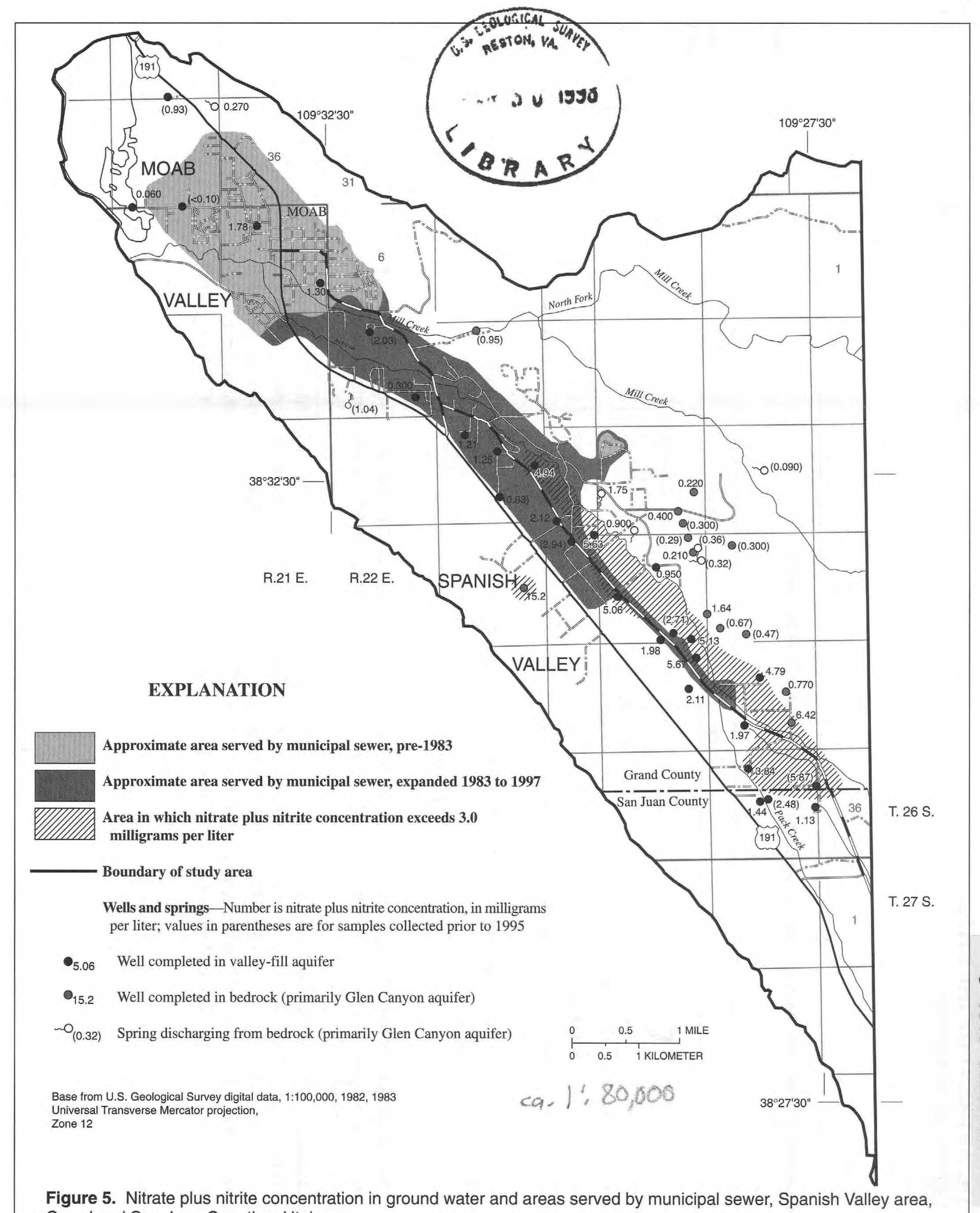

Figure 5. Nitrate plus nitrite concentration in ground water and areas served by municipal sewer, Spanish Valley area, Grand and San Juan Counties, Utah.

REFERENCES CITED

Blanchard, P.J., 1990, Ground-water conditions in the Grand County area, Utah, with emphasis on the Mill Creek-Spanish Valley area: State of Utah Department of Natural Resources Technical Publication No. 100, 69 p.

Danielson, T.W., and Hood, J.W., 1984, Infiltration to the Navajo Sandstone in the lower Dirty Devil River basin, Utah, with emphasis on techniques used in its determination: U.S. Geological Survey Water-Resources Investigations Report 84-4154, 45 p.

Doelling, H.H., Ross, M.L., and Mulvey, W.E., 1995, Interim geologic map of the Moab quadrangle, Grand County, Utah: Utah Geological Survey Open-File Report 322, 115 p.

Freethey, G.W., 1993, Maps showing recharge areas and quality of ground water for the Glen Canyon aquifer, western Washington County, Utah: U.S. Geological Survey Water-Resources Investigations Report 92-4160, 1 pl.

Freethey, G.W., and Cordy, G.E., 1991, Geohydrology of Mesozoic rocks in the Upper Colorado River Basin in Arizona, Colorado, New Mexico, Utah, and Wyoming, excluding the San Juan Basin: U.S. Geological Survey Professional Paper 1411-C, 118 p., 6 pls.

Madison, R.J., and Brunett, J.O., 1985, Overview of the occurrence of nitrate in ground water of the United States, *in* National Water Summary 1984: U.S. Geological Survey Water-Supply Paper 2275, p. 93-105.

Sumsion, C.T., 1971, Geology and water resources of the Spanish Valley area, Grand and San Juan Counties, Utah: State of Utah Department of Natural Resources Technical Publication No. 32, 45 p.

Utah Department of Environmental Quality, Division of Water Quality, 1995, Administrative rules for ground-water quality protection, R317-6, Utah Administrative Code, March 20, 1995, 19 p.

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1997

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