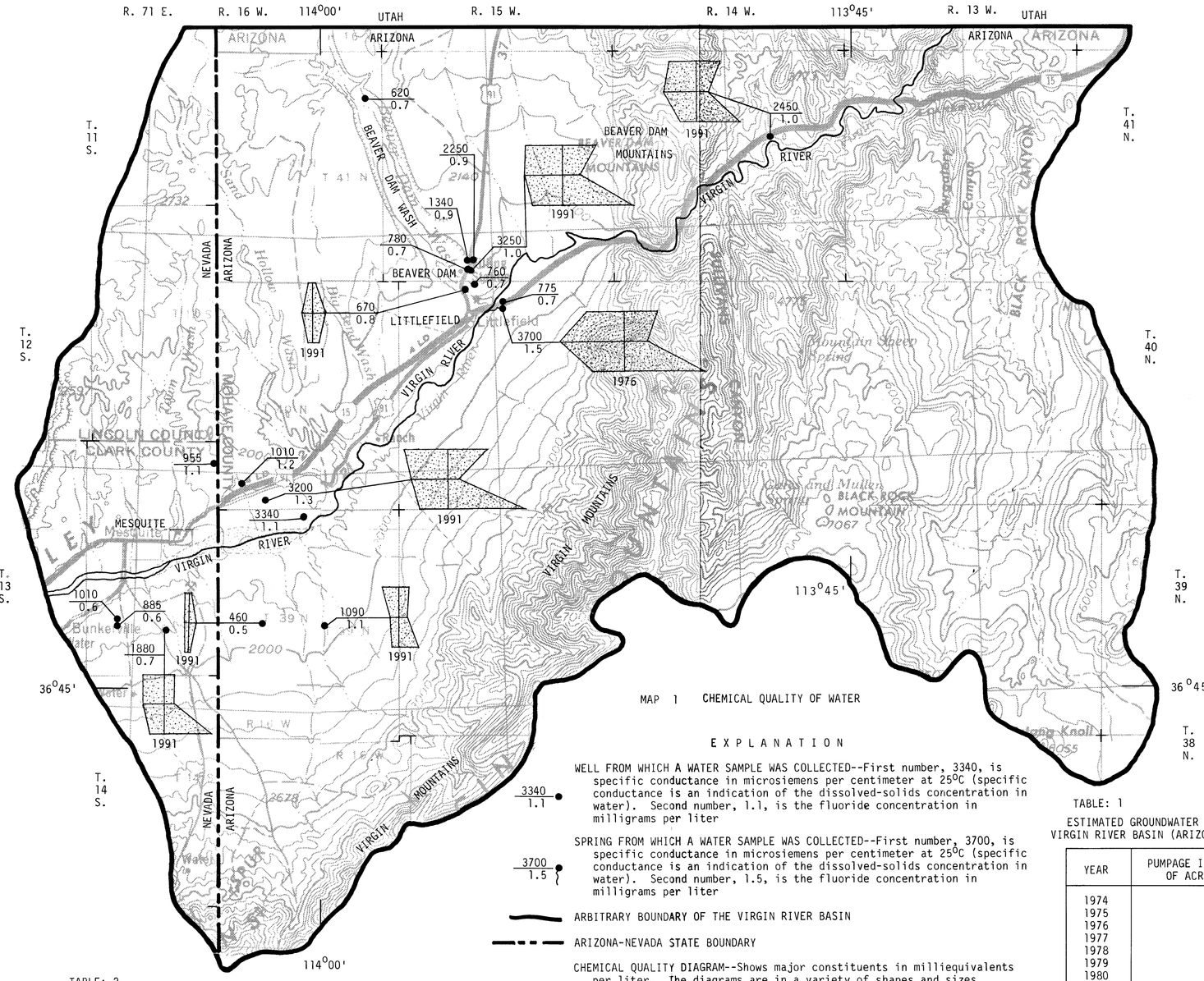


MAP 1 CHEMICAL QUALITY OF WATER

EXPLANATION

3340 / 1.1 — WELL FROM WHICH A WATER SAMPLE WAS COLLECTED--First number, 3340, is specific conductance in microsiemens per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Second number, 1.1, is the fluoride concentration in milligrams per liter

3700 / 1.5 — SPRING FROM WHICH A WATER SAMPLE WAS COLLECTED--First number, 3700, is specific conductance in microsiemens per centimeter at 25°C (specific conductance is an indication of the dissolved-solids concentration in water). Second number, 1.5, is the fluoride concentration in milligrams per liter

ARBITRARY BOUNDARY OF THE VIRGIN RIVER BASIN

ARIZONA-NEVADA STATE BOUNDARY

CHEMICAL QUALITY DIAGRAM--Shows major constituents in milliequivalents per liter. The diagrams are in a variety of shapes and sizes, providing a means of comparing, correlating, and characterizing similar or dissimilar types of water. Year, 1991, below diagram indicates year in which sample was collected

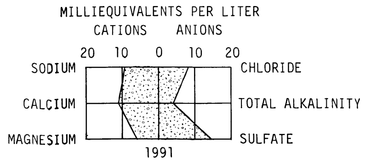
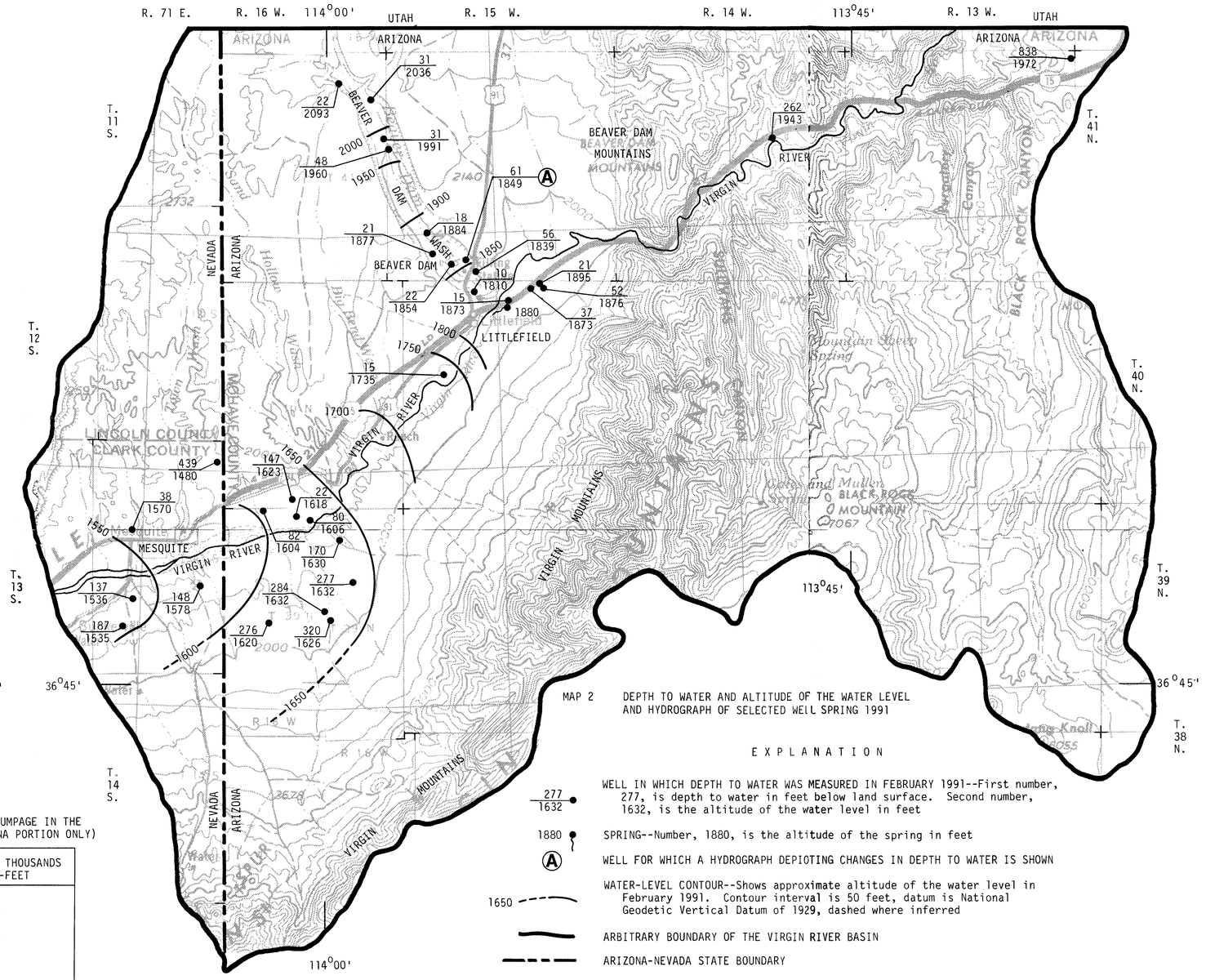


TABLE: 1

ESTIMATED GROUNDWATER PUMPAGE IN THE VIRGIN RIVER BASIN (ARIZONA PORTION ONLY)

YEAR	PUMPAGE IN THOUSANDS OF ACRE-FEET
1974	5
1975	5
1976	5
1977	5
1978	5
1979	5
1980	6
1981	6
1982	6
1983	6
1984	6
1985	6
1986	6
1987	6
1988	6
1989	6
1990	6
TOTAL	96



MAP 2 DEPTH TO WATER AND ALTITUDE OF THE WATER LEVEL AND HYDROGRAPH OF SELECTED WELL SPRING 1991

EXPLANATION

277 / 1632 — WELL IN WHICH DEPTH TO WATER WAS MEASURED IN FEBRUARY 1991--First number, 277, is depth to water in feet below land surface. Second number, 1632, is the altitude of the water level in feet

1880 — SPRING--Number, 1880, is the altitude of the spring in feet

(A) — WELL FOR WHICH A HYDROGRAPH DEPIOTING CHANGES IN DEPTH TO WATER IS SHOWN

1650 — WATER-LEVEL CONTOUR--Shows approximate altitude of the water level in February 1991. Contour interval is 50 feet, datum is National Geodetic Vertical Datum of 1929, dashed where inferred

ARBITRARY BOUNDARY OF THE VIRGIN RIVER BASIN

ARIZONA-NEVADA STATE BOUNDARY

0 — 5 MILES
0 — 5 KILOMETERS

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS MEAN SEA LEVEL
SCALE 1:125,000

HYDROGRAPH OF THE WATER LEVEL IN SELECTED WELL

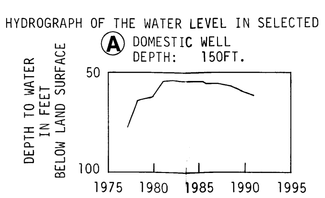


TABLE: 2

Conversion factors for the terms used in this report are listed below:

Multiply	By	To obtain
inch	25.4	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
acre	0.4047	square hectometer
acre-foot	0.001233	cubic hectometer
gallons per minute	0.06309	liters per second
gallons per minute per foot	0.2070	liters per second per meter
microsiemens per centimeter	0.6	approximate dissolved solids in mg/L

INTRODUCTION

The Virgin River basin is located in extreme northwest Arizona. The basin covers about 430 square miles of the larger Virgin River watershed, which extends into Utah and Nevada. To aid in the interpretation of groundwater movement, an additional 67 square miles of contiguous groundwater basin in Nevada was included in the study area. The western boundary of the study area in Nevada is arbitrary for the purpose of this report only, and does not reflect the complete areal extent of the groundwater basin. In Arizona the basin is bounded on the south and east by the Virgin Mountains, on the northeast by the Beaver Dam Mountains, and on the north by the Arizona-Utah border. Altitude in the study area ranges from over 8,000 feet in the Virgin Mountains to approximately 1,550 feet near the City of Mesquite, Nevada.

The Virgin River is the dominant drainage feature of the watershed and is a major tributary of the Colorado River. It is perennial under natural conditions; however, diversions for irrigation cause some reaches in the study area to dry up during the growing season (Woessner and others, 1981, p. 15). The headwaters of the Virgin River are in Utah. The river courses southwest through Arizona and Nevada, where it eventually discharges into Lake Mead. Discharge of the Virgin River at Littlefield, Arizona, is approximately 174,000 acre-feet per year (U.S. Geological Survey, 1990, p. 77).

The lower reach of Beaver Dam Wash, a tributary of the Virgin River, is primarily an ephemeral stream within the study area. It exhibits perennial flow approximately 1 mile above its confluence with the Virgin River above Littlefield. Discharge of Beaver Dam Wash to the Virgin River is approximately 5,400 acre-feet per year (Bob Smith, U.S. Bureau of Land Management, personal commun., 1991), and is part of the approximately 174,000 acre-feet per year discharge of the Virgin River at Littlefield.

Irrigated farmland is limited to the floodplains and terraces of the Virgin River and Beaver Dam Wash, and in the Arizona portion of the study area is estimated to include about 1,400 acres. Of this total, approximately 800 acres is irrigated exclusively with groundwater, while the remaining 600 acres is irrigated with both groundwater and surface water (Steve Cassady, Soil Conservation Service, personal commun., 1991). Approximately 1,750 acres is currently irrigated in the Nevada portion of the study area.

The climate of the study area is arid, with an average annual precipitation of about 7 inches recorded at Littlefield (Sellers and others, 1985, p. 113). Temperatures at Littlefield range from an average daily minimum of 29°F in January to an average daily maximum of 106°F in July (Sellers and others, 1985, p. 89, 92).

GROUNDWATER OCCURRENCE

The geohydrology of the Virgin River basin is complex and groundwater occurs in at least four separate aquifers in the basin fill. Those aquifers share varying degrees of interconnection and include: (1) the Beaver Dam Wash aquifer, (2) the Virgin River aquifer, (3) the Littlefield aquifer, and (4) the Muddy Creek Formation.

The Beaver Dam Wash aquifer consists of unconsolidated silts, sands, and gravels deposited between the steep terraces created by the incision of Beaver Dam Wash into the relatively impermeable units of the "Littlefield" and Muddy Creek Formations. The deposits are Pleistocene to Holocene in age (Moore, 1972, p. 8), and the aquifer is largely isolated from other water-bearing units in the basin. Groundwater is unconfined and the direction of flow is from northwest to southeast, where it eventually discharges into and mixes with the groundwater in the stream alluvium of the Virgin River aquifer. Wells completed in the Beaver Dam Wash aquifer are generally less than 150 feet deep. Depths to water range from less than 10 feet to 65 feet below land surface, and well owners report that discharges of wells range from 30 to 5,000 gallons per minute (gal/min). The latter value was reportedly obtained during a pump test (Bob Frisby, Beaver Dam Water Company, personal commun., 1991).

The Virgin River aquifer includes the floodplain and terrace alluvium of the Virgin River southwest of Littlefield, and broadens to include alluvial-fan deposits of the Virgin Mountains south of the Virgin River. The floodplain deposits are Holocene in age and consist of silt, sand, and gravel (Moore, 1972, p.8). The alluvial-fan and terrace deposits are Pliocene to Holocene in age and consist of unconsolidated and semi-consolidated clay, silt, sand, gravel, and boulders (Moore, 1972, pl. I). Groundwater is unconfined and the general direction of flow is toward the southwest, parallel to the river. Water-level altitudes suggest recharge occurs from the Virgin Mountains and flows towards the Virgin River. Wells north of the river in this aquifer are limited to floodplain and terrace alluvium near the Arizona-Nevada border. Measured depths to water range from 15 feet below land surface in the stream alluvium near Littlefield to 320 feet below land surface in the alluvial-fan deposits southeast of Mesquite. Depth to water in the alluvial-fan deposits increases with distance south from the river. Reported discharges from wells in the Virgin River aquifer range from 10 to 1,620 gal/min. Total thickness of the aquifer is unknown, but driller's logs indicate deposits of sand, silt, and gravel to a depth of 1,020 feet.

The Littlefield aquifer is located between Littlefield and the Virgin River Mountains south of the Virgin River. The aquifer consists of alluvial-fan deposits that overlie limestone, which is the upper unit of a formation locally known as the "Littlefield Formation." The unit was first described by Meissner Engineers (1960, p. 12) as flat-lying, fresh-water limestone, between 50 and 75 feet thick, and the age was tentatively given as Quaternary by Moore (1972, p. 53). Although few wells are completed in this shallow water-table aquifer, many springs originate from groundwater flowing over or through the limestone. Depths to water in this aquifer range from 15 to 52 feet below land surface, increasing with distance from the river. Alluvial-fan deposits also increase in thickness with distance from the river. Discharges from springs range from 10 to 50 gal/min, and well discharges have been reported from 30 to 1,500 gal/min.

North of the City of Mesquite, Nevada, the Muddy Creek Formation is known to yield water. This formation has been described by Longwell and others (1965, p. 49) as Pliocene(?) lake deposits. Field reconnaissance conducted by the Arizona Department of Water Resources in the study area shows the Muddy Creek Formation to consist of buff to red alternating beds of siltstones, friable sandstone, conglomerate, and thin lenses of limey silt-sandstone. City of Mesquite Well 20 in section 3, T. 13S., R. 71E., (Mount Diablo Meridian) is completed in the Muddy Creek Formation, and has a measured water level of 439 feet below land surface. The well penetrates about 300 feet of saturated Muddy Creek Formation and yields about 350 gal/min. The water-level altitude in this well is 1,480 feet, and is over 100 feet lower than the nearest wells located about 1.5 miles southeast in the Virgin River aquifer. Also, the specific-conductance value of water from this well is about one-third that of the nearest wells in the Virgin River aquifer (see water-quality section). These factors suggest that the Muddy Creek Formation may be a separate aquifer in this area, although more data are needed for verification. Direction of flow and source of water in this aquifer are unknown.

The Virgin Mountains are composed primarily of Precambrian granite and sedimentary rocks of Cambrian to Triassic age along the southeastern flank of the range (Moore, 1972). No wells are known to be drilled in these rocks. The Beaver Dam Mountains are composed primarily of Paleozoic sedimentary rocks. Included among these rocks are the Tonto Group, Callville Limestone, and the Supai Formation (Moore, 1972, pl. I). Only one completed well in the Beaver Dam Mountains was inventoried for this study, and has a measured depth to water of 262 feet below land surface. A well near the eastern edge of the basin is completed in limestone. Total depth of this well is 1,425 feet, and it has a measured water level of 838 feet below land surface.

WATER QUALITY

In 1991, there were 19 water-quality samples collected and analyzed for specific conductance and fluoride. Of these 19 samples, seven had detailed chemical analyses performed. Results indicate the groundwater of the Virgin River basin ranges from very good to poor chemical quality.

Dissolved-solids concentration in milligrams per liter (mg/L) may be approximated by multiplying specific-conductance values by 0.6 (table 2), which is the approximate ratio of dissolved solids in mg/L to specific conductance in microsiemens per centimeter (uS/cm). The U.S. Environmental Protection Agency has set the secondary maximum contaminant level (SMCL) for dissolved solids at 500 mg/L, which is equivalent to about 833 uS/cm. Specific-conductance values obtained from analyses of groundwater in the Virgin River basin range from 460 to 3,340 uS/cm. SMCL's are associated with the aesthetic quality of the water, such as taste, odor, or color. Water with contaminant levels above the SMCL are not necessarily a health risk. SMCL's are guidelines only, and are not enforceable standards (U.S. Environmental Protection Agency, 1988, p. 9). Of the seven wells sampled for detailed chemical analysis, four exceeded the 250 mg/L SMCL's for both chloride and sulfate and one exceeded the SMCL for sulfate only. Of the 19 samples collected, 13 exceeded the SMCL for dissolved solids.

The quality of groundwater in the Virgin River basin is varied in nature and this may be due in large part to lithology, phreatophytes, and geologic structures. As previously stated, groundwater occurs in at least four separate aquifers in the basin fill. The quality of water in the Beaver Dam Wash aquifer varies from the floodplain to the terraces. Groundwater in the floodplain area, a calcium carbonate type, has a specific-conductance range of 620 to 780 uS/cm. The relatively low specific-conductance values of this groundwater, compared to the groundwater in the terraces, is likely due to recharge by good-quality surface water that enters the aquifer along the length of Beaver Dam Wash. The terraces near Beaver Dam have groundwater of a calcium sulfate type, and specific-conductance values range from 1,340 to 3,250 uS/cm. Groundwater in the Virgin River aquifer is a sodium sulfate type, and specific-conductance values increase downstream to as high as 3,340 uS/cm in the floodplain area of the Virgin River. The deterioration of the groundwater quality along the Virgin River axis could be due to the initial high concentrations of salts in the Virgin River, transpiration of groundwater by phreatophytes which concentrates salts, spring discharges around Littlefield, irrigation return, and evaporation. The wells sampled on the alluvial fan south of the Virgin River, have a specific-conductance range of 460 to 1,860 uS/cm. No water-quality samples were obtained from wells in the Littlefield aquifer. However, a sample collected from one of the springs that issue from the margin of this aquifer has a specific-conductance value of 3,700 uS/cm, and detailed analysis showed the groundwater to be a calcium sulfate type. A sample retrieved from the only well known to be completed in the Muddy Creek Formation indicated the groundwater to be moderate in dissolved-solids concentration, with a specific-conductarce value of 955 uS/cm.

The maximum contaminant level (MCL) for fluoride in Arizona for public water supply has been established as 4.0 or 6.0 mg/L, depending on the number of the year-round residents a water system serves (Arizona Department of Environmental Quality, 1989, p. 7). The MCL is an enforceable standard set by the U.S. Environmental Protection Agency for drinking water. States must comply with this standard, but are free to set levels which are more strict. Fluoride levels in the study area groundwater range from 0.5 to 1.5 mg/L.

SELECTED REFERENCES

Arizona Department of Environmental Quality, 1989, Public and semi-public water supply systems rules: Arizona Department of Environmental Quality, Phoenix, Arizona, 44 p.

Glancy, P.A., and Van Denburgh, A.S., 1969, Water-resources appraisal of the lower Virgin River Valley area, Nevada, Arizona, and Utah: Nevada Department of Conservation and Natural Resources, Water Resources-Reconnaissance Series Report 51, 87 p., 2 pls., 4 figs.

Leslie & Associates, Consulting Engineers, Cedar City, UT, 1990, Hydrological study of Beaver Dam Wash aquifer in Mohave County, Arizona: Consultant's report for Mesquite Farmstead Water Association, 74 p., appendices.

Longwell, C.R., Pampeyan, E.H., Bowyer, Ben, and Roberts, R.J., 1965, Geology and mineral deposits of Clark County, Nevada: Nevada Bureau of Mines, Bulletin 62, 218 p., 18 tbls., maps.

Meissner Engineers, Inc., Chicago, IL, 1960, Virgin River Gorge route location study federal aid Interstate Route 15: Consultant's report for Arizona Highway Department, 54 p., 37 pls., 12 tbls.

Moore, R.T., 1972, Geology of the Virgin River and Beaver Dam Mountains, Arizona: State Bureau of Mines, No. 186, 65 p., maps.

Sellers, W. D., Hill, R. H., and Sanderson-Rae, Margaret, eds., 1985, Arizona climate, the first hundred years, 1885-1985: Institute of Atmospheric Physics, University of Arizona, Tucson, Arizona, 143 p., 3 figs., 18 tbls.

Trudeau, D. A., 1979, Hydrogeologic investigation of the Littlefield Springs: M.S. Thesis, University of Nevada at Reno, 136 p., 3 pls., 26 figs., 7 tbls.

U.S. Environmental Protection Agency, 1988, The Safe Drinking Water Act--a pocket guide to the requirements for the operators of small water systems: U.S. Environmental Protection Agency, Region 9, San Francisco, California, 37 p., appendix.

U.S. Geological Survey, 1990, Water-resources data--Arizona, water year 1989, USGS Water-Data Report AZ-89-1, 383 p., tbls., map.

Woessner, W. W., Mifflin, M. D., French, R. H., Elzeftawy, Atef, and Zimmerman, D. E., 1981, Hydrologic and salinity analyses of the lower Virgin River basin, Nevada and Arizona: Water Resources Center, Desert Research Institute, Las Vegas, University of Nevada System, 171 p., 24 figs., 15 tbls.

INDEX MAP SHOWING AREA OF REPORT (SHADED)

BASE FROM U.S. GEOLOGICAL SURVEY
PRESCOTT, ARIZONA, 1954, REV. 1970, 1:250,000
WILLIAMS, ARIZONA, 1954, REV. 1970, 1:250,000
NEEDLES, CALIFORNIA; ARIZONA, 1956, REV. 1969, 1:250,000
KINGMAN, ARIZONA; NEVADA; CALIFORNIA, 1954, REV. 1969, 1:250,000

MAPS SHOWING GROUNDWATER CONDITIONS IN THE VIRGIN RIVER BASIN
MOHAVE COUNTY, ARIZONA, LINCOLN AND CLARK COUNTIES, NEVADA--1991

BY

K. R. BLACK AND S. J. RASCONA

These hydrologic maps are available upon request from the Department of Water Resources, Basic Data Section, 2810 South 24th Street, Suite 122, Phoenix, Arizona, 85034. The hydrologic data on which these maps are based are available, for the most part, in computer-printout form and may be consulted at the Department of Water Resources and at the U.S. Geological Survey offices located at: 375 S. Euclid, Tucson, Arizona, 85719, and 1545 West University, Tempe, Arizona, 85281.