UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PROPOSED MONITORING NETWORK FOR GROUND-WATER QUALITY, LAS VEGAS VALLEY, NEVADA

By A. S. Van Denburgh, H. R. Seitz,
T. J. Durbin, and J. R. Harrill

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Except for water-quality units of measure, only the "inch-pound" system is used in this report. Abbreviations and conversion factors from inch-pound to International System (SI) units are listed below.

Multiply	*By*	*To obtain*
Acres	0.4047	Square hectometers (hm^2)
Acre-feet (acre/ft)	0.001233	Cubic hectometers (hm^3)
Feet (ft)	0.3048	Meters (m)
Gallons (gal)	3.785	Liters (L)
Inches (in)	25.40	Millimeters (mm)
Miles (mi)	1.609	Kilometers (km)
Square miles (mi^2)	2.590	Square kilometers (km^2)

Water-quality units of measure used in this report are as follows:

For concentration, milligrams per liter (mg/L), which are equivalent to parts per million for dissolved-solids concentrations less than about 7,000 mg/L, and picocuries per liter (pCi/L).

For temperature, degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by using the formula °F=[(1.8)(°C)]+32.

ALTITUDE DATUM

The term "National Geodetic Vertical Datum of 1929" (abbreviation, NGVD of 1929) replaces the formerly used term "mean sea level" to describe the datum for altitude measurements. The NGVD of 1929 is derived from a general adjustment of the first-order leveling networks of both the United States and Canada. For convenience in this report, the datum also is referred to as "sea level."

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ABSTRACT

Among the 255 hydrographic areas in Nevada, 1,564-square-mile Las Vegas Valley has the greatest need for a network to monitor ground-water quality. Virtually the entire ground-water supply for municipal, industrial, agricultural, and domestic use in the valley (72,000 acre-feet during 1979) is obtained from the upper 1,100 feet of valley-fill sedimentary deposits.

In total, 185 wells and one spring have been selected as preliminary candidates for the network. The wells tap water-yielding material in three arbitrary depth intervals: (1) The shallow zone, less than about 30 feet below the water table, which would be the first to feel the impact of land- and water-use practices; (2) an intermediate zone, about 30 to 200 feet below the water table, which is commonly tapped for domestic supplies, and (3) a deep zone, more than 200 feet below the water table, which currently yields most of the ground water for public supplies in the valley.

Forty-five water-quality characteristics were chosen for monitoring, largely on the basis of drinking-water standards. For each site, the specific array of characteristics and their frequencies of determination (which range from once quarterly to once in 5 years) are based on geographic location and water-yielding zone(s) tapped. Specific procedures will be necessary to ensure the collection of samples that are truly representative of the ground water.

The U.S. Geological Survey's automated "WATSTORE" data-management system is the recommended mechanism for storage, retrieval, and analysis of the water-quality information generated as a result of the monitoring network.

INTRODUCTION

Purpose and Scope

Environmental concerns have resulted in laws and regulations dealing with ground-water quality. Yet, Federal and State water-quality monitoring efforts historically have been concentrated on protecting surface-water resources. The importance of protecting ground-water resources, however, was legislatively recognized in Section 106 of the Water Pollution Control Act Amendments of 1972 (Public Law 92-500), which included mandates for States to develop programs to monitor ground-water quality, and in the Safe Drinking Water Act of 1974 (Public Law 93-523), which specifies monitoring requirements for public water supplies and underground wastewater injection.

In response to requirements of Public Law 92-500, the Division of Environmental Protection of the Nevada Department of Conservation and Natural Resources was designated by the U.S. Environmental Protection Agency to establish and maintain a program to monitor ground-water quality in Nevada. The U.S. Geological Survey was asked to assist in the design of such a program to meet the objectives of Public Law 92-500. The Geological Survey's involvement has had two elements. The first was to develop general criteria for the design of a water-quality monitoring program. The second was to design specific monitoring networks to meet the objectives of the program.

The first element, development of program criteria, has been described by Nowlin (in press). He recommended a plan that consisted of five parts, and suggested methodologies for accomplishing each. The five parts were: (1) A "background-quality" network to assess the existing ground-water quality, (2) a contamination-source inventory of known or potential threats to ground-water quality, (3) sampling networks to monitor ground-water quality in selected hydrographic areas, (4) intensive surveys of individual cases of known or potential ground-water contamination, and (5) a ground-water data file to manage information generated by the other monitoring elements. Additionally, Nowlin developed two indices to facilitate the rational assignment of priorities for monitoring ground-water quality in the 255 hydrographic areas of Nevada. These were the index of hydrologic-area priorities for monitoring networks and the index of development potential for "background" networks.

Las Vegas Valley has the highest priority in the State for a monitoring network according to the index of hydrographic-area priorities, and this report describes a monitoring plan for that 1,564-square-mile basin. The purpose of the network is to document long-term trends in ground-water quality. The network is designed to detect changes expected to occur because of (1) leakage of inferior water from adjacent aquifers, induced by pumping, (2) irrigation with treated municipal and industrial wastewater, (3) percolation from septic-tank leach fields, (4) irrigation with imported water from Lake Mead, (5) leaching of alkaline soils by applied irrigation water and (6) concentration of salts by consumptive use.

The proposed monitoring network is intended to provide an appraisal of ground-water quality, rather than the quality of "delivered" water (that is, water that has been stored or chemically treated). The network is not intended to treat problems associated with limited areas of known or potential acute ground-water contamination; it deals instead with larger scale areal problems. In particular, the network does not address directly the specific problems associated with industrial facilities near Henderson, which are listed as Uncontrolled Hazardous Waste Sites by the U.S. Environmental Protection Agency. The intensive monitoring of ground-water quality needed to document the extent and severity of problems near Henderson is beyond the scope of this basinwide program.

Previous Investigations of Ground-Water Quality

Several studies have dealt with ground-water quality in Las Vegas Valley since Everett Carpenter's pioneering work in 1915. Among the more pertinent studies and data compilations are the following (in chronological order): Hardman and Miller (1934), Maxey and Jameson (1946, 1948), Loeltz (1963), Malmberg (1965), Patt and Hess (1976), Kaufmann (1978), Dinger (1979), and Nichols and Davis (1979). Kaufmann's study is of particular interest because of his evaluation of water-quality changes with time (1978, pages 74-84). The historical aspects of ground-water quality in the valley provide a valuable perspective with regard to current and future characteristics and trends.

Acknowledgments

Appreciation is expressed to local residents for supplying data and permitting access to their wells during the field evaluation of network candidates. Well logs and water-level data for selected wells were obtained from the Las Vegas office of the Nevada Division of Water Resources. The Las Vegas Valley Water District, City of North Las Vegas, Nellis Air Force Base, Desert Research Institute, U.S. Water and Power Resources Service, and Clark County District Health Department provided valuable information on well construction and the suitability of wells for water-quality sampling.

Location System

The location system used in this report is based on a hydrographic-area number and the rectangular subdivision of lands, referred to the Mount Diablo base line and meridian. A complete designation of location consists of four units: The first is the hydrographic-area number, as defined by Rush (1968); for Las Vegas Valley, the number is 212. The second unit is a township number (with "S" indicating that the township is south of the base line); the third unit is the range number ("E" indicates east relative to the meridian); the fourth unit includes the section number, followed by letters designating the quarter section, quarter-quarter section, and so on (A, B, C, and D indicate northeast, northwest, southwest, and southeast quarters, respectively), followed in turn by a sequence number for wells and springs. For example, well 212 S20 E62 04CBC1 is in Las Vegas Valley within a 10-acre tract identified as SW$\frac{1}{4}$NW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 4, T. 20 S., R. 62 E., and it is the first well recorded in that tract. Because all wells listed in this report are in Las Vegas Valley, the hydrographic-area number is omitted.

In table 4, the Geological Survey site identification (ID) number also is indicated. The site ID, which is based on the grid system of latitude and longitude, indicates the geographic location of each site and provides a unique number for each. The ID consists of 15 digits: The first 6 digits denote the degrees, minutes, and seconds of latitude; the next 7 digits denote degrees, minutes, and seconds of longitude; and the last 2 digits (assigned sequentially) identify the site within a 1-second grid.

GEOHYDROLOGY OF THE STUDY AREA[1]

The Las Vegas Valley ground-water reservoir is a thick alluvial basin bounded on its sides and bottom by consolidated rocks. Total thickness of the sedimentary fill may be on the order of several thousand feet throughout much of the valley; however, the valley-fill deposits that compose the upper 700 to 1,100 feet contain the most productive aquifers and are the part most affected by pumping.

Water-yielding properties of the valley fill vary considerably from place to place. Generally, the most productive deposits are on the west side of the valley; deposits in the central part are predominantly fine grained and much less productive. Detailed stratigraphy of the valley-fill reservoir is complex, and individual beds of widespread extent are not common. Previous workers have grouped deposits into aggregated zones having similar hydrologic characteristics. The most generalized scheme is that used by Harrill (1976, pages 9-11), in which the various zones are grouped into two units, the near-surface reservoir and the principal aquifers.

The near-surface reservoir is a sequence of fine-grained, low-yield deposits generally 100 to 300 feet thick that forms the uppermost valley fill in the central part of the basin (Harrill, 1976, figure 4). This unit acts as a confining bed for the underlying principal aquifers. Ground water in the near-surface reservoir is both confined and unconfined.

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[1] Only those generalized features of the geology and hydrology that most strongly affect design of the monitoring network will be described in this section. If more detailed information is desired, the reader is referred to previous studies by Harrill (1976), Malmberg (1965), and Maxey and Jameson (1948).

The upper boundary of the principal aquifers is formed by the base of the near-surface reservoir, or by the water table in peripheral parts of the valley where the near-surface reservoir is poorly defined. The lower boundary, though uncertain in places, is generally less than 1,100 feet below land surface. This unit supplies nearly all the water pumped by wells. Ground water in the principal aquifers is confined (artesian) in the central part of the valley, where upward leakage occurs through the overlying near-surface reservoir. Around the margins of the valley, the principal aquifers respond to pumping like an unconfined aquifer with delayed drainage of water. Interbedded horizons of caliche or cemented materials that hinder vertical movement of water are the most probable cause of the delayed drainage. The deeper peripheral parts of the principal aquifers respond like a confined aquifer.

The ground-water reservoir underlying Las Vegas Valley functions as a three-dimensional system. Water flows both horizontally and vertically; in consequence, hydraulic head and water quality vary with depth as well as with geographic location. Because of the interlayering of deposits of different permeability, water generally can move horizontally much more readily than vertically. Rates of vertical flow are characteristically low, but when the flow occurs over a large area, significant amounts of water may be involved. The general horizontal direction of flow in 1973 is illustrated in figure 1, which shows water-level contours for wells that penetrate the principal aquifers. The general direction of lateral movement is downgradient, perpendicular to the contours.

The vertical direction of flow is also indicated in figure 1. Where downward movement occurs in the central part of the valley, recharge at the water table must penetrate the near-surface reservoir before reaching the principal aquifers. Where downward movement is indicated around the margins of the valley (outside the area where the near-surface reservoir is recognized), beds of caliche in the principal aquifers provide some resistance to downward movement.

Conditions shown in figure 1 include the effects of many years of heavy pumping. Water levels in parts of the northwestern area of the valley have declined more than 200 feet below the predevelopment levels, and vertical flow of water has reversed from upward to downward over a large part of the valley. As of 1974, secondary recharge to the principal aquifers (exclusive of recharge from industrial tailings ponds near Henderson and from Las Vegas Wash) was estimated to have been about 10,000 acre-feet per year (Harrill, 1976, page 61).

In 1971, following completion of the first phase of the Southern Nevada Water Project, large-scale importation of Colorado River water began (some imported water has been used by the city of Henderson and the Las Vegas Valley Water District for a number of years). As of early 1982, the first phase of the water project was capable of sustained maximum-capacity operation, and the second phase was expected to become operational by mid-year (D. L. Paff, Las Vegas Valley Water District, oral commun., January 1982). When the project is fully operational in the mid-1980's, it will be capable of supplying more than 300,000 acre-feet per year of Colorado River water to Las Vegas Valley. As a result, ground-water pumpage is expected to be cut from an estimated maximum of

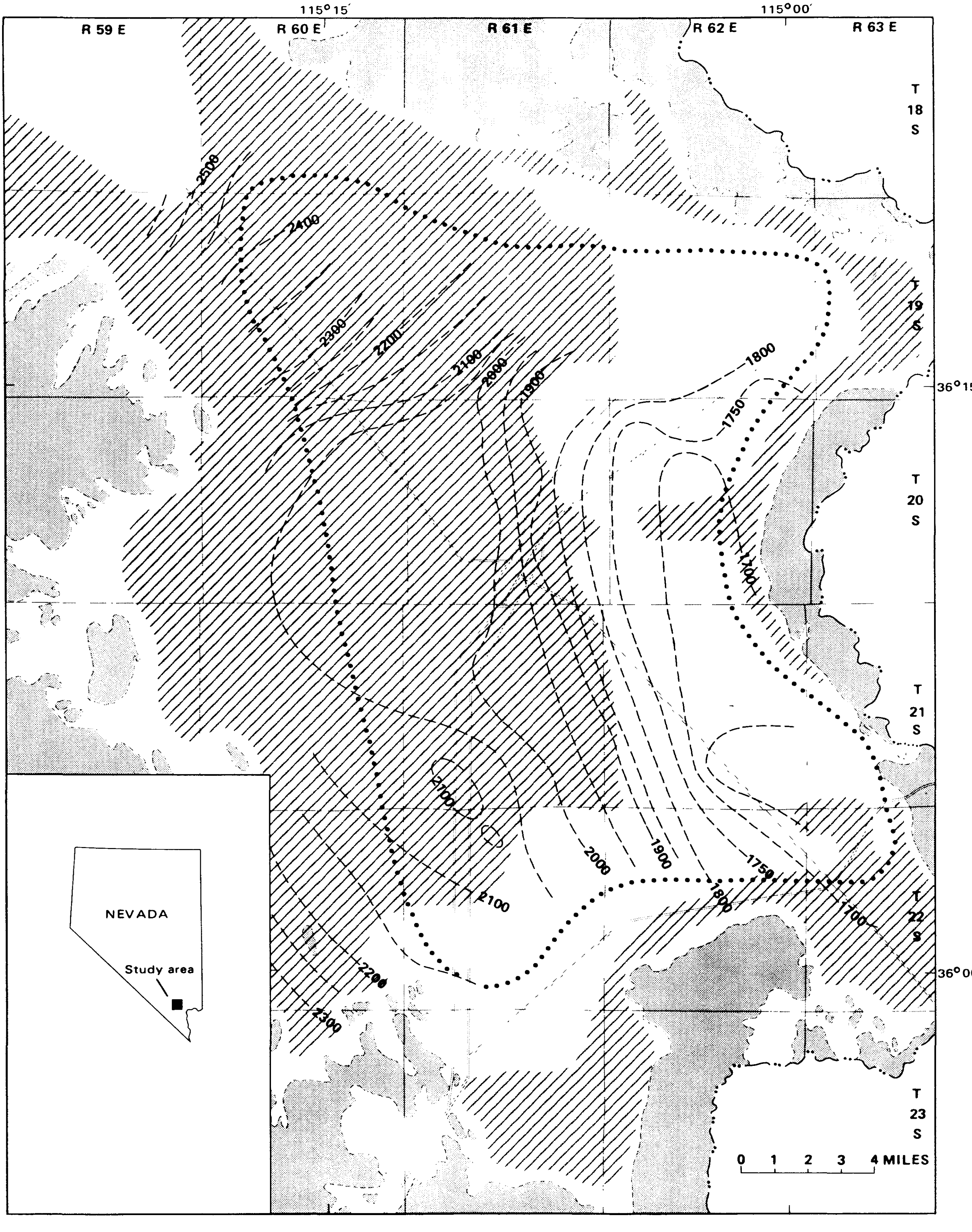

FIGURE 1. – Water-level contours and vertical direction of ground-water flow.

EXPLANATION

VALLEY FILL

CONSOLIDATED ROCKS

AREA WHERE VERTICAL DIRECTION OF FLOW WAS DOWNWARD FROM WATER TABLE IN 1972. Flow direction within area of near-surface reservoir from Harrill (1976, pl. 1, map E). Flow direction elsewhere from available water levels

• • • • • • • APPROXIMATE BOUNDARY OF NEAR-SURFACE RESERVOIR (Harrill, 1976, fig. 4)

— — —1700 WATER-LEVEL CONTOUR – Shows water-surface altitude for wells penetrating principal aquifers, February 1973. Approximately located. Contour interval 50 feet. Datum is sea level (Harrill, 1976, fig. 4)

—— ·· —— BASIN BOUNDARY

FIGURE 1.– Continued.

88,000 acre-feet in 1968 (Katzer, 1977, page 22) to about 50,000 acre-feet per year. Pumpage was about 71,000 acre-feet in 1979 and represented 38 percent of the total valley-wide water use (D. B. Wood, U.S. Geological Survey, oral commun., 1982). The two main impacts anticipated for the ground-water reservoir are that (1) reduced pumping will cause water levels in parts of the principal aquifers to rise, and (2) some percentage of the total water used will ultimately recharge the ground-water reservoir as return flow. This will also cause water levels to rise, or declines to lessen. If the recharge occurs in the central part of the valley, the rate of downward leakage may be less than the rate of recharge, because of the presence of low-permeability, fine-grained deposits. Consequently, the water table may rise enough to cause ground-water drainage into formerly dry stream and storm-runoff channels. In such areas, most of the return flow may be dissipated in this way, and only a small amount may ultimately reach the principal aquifers. On the other hand, most of the recharge from return flow on alluvial fans around the margins of the valley (particularly to the west) should ultimately work its way down to the principal aquifers.

The quality of water is generally degraded in use, and significant recharge from return flow may therefore degrade ground water in the valley. The entire ground-water basin is a valuable resource, and should be protected to the greatest extent possible; however, high-yield aquifers along the northwest side of the valley that contain good water probably constitute the most valuable part of the resource. The water-quality monitoring network should be designed to insure adequate protection for this area.

NETWORK FOR MONITORING GROUND-WATER QUALITY

Site Selection

In total, 185 wells and one spring have been selected as candidates for the valley-wide monitoring network (plate 1, figure 2, table 4). During the selection process, an attempt was made to attain an acceptably even areal distribution of wells tapping each of three arbitrary depth intervals: the shallow water-yielding zone less than about 30 feet below the water table; an intermediate zone about 30 to 200 feet below the water table; and a deep zone more than about 200 feet below the water table.[2] This arbitrary subdivision of aquifer materials was based on the following considerations: Ground water in the shallow zone (0-30 feet) would be the first to feel the water-quality impact of land- and water-use practices in the valley; ground water in the

[2] For each well, the assignment of zones is based on the vertical position of the producing interval(s) relative to the static water level (table 4, columns 4 and 5, respectively). Despite the fact that static levels do not necessarily coincide with the water table, the degree of coincidence is in almost all instances considered adequate for purposes of the selection process described in this report.

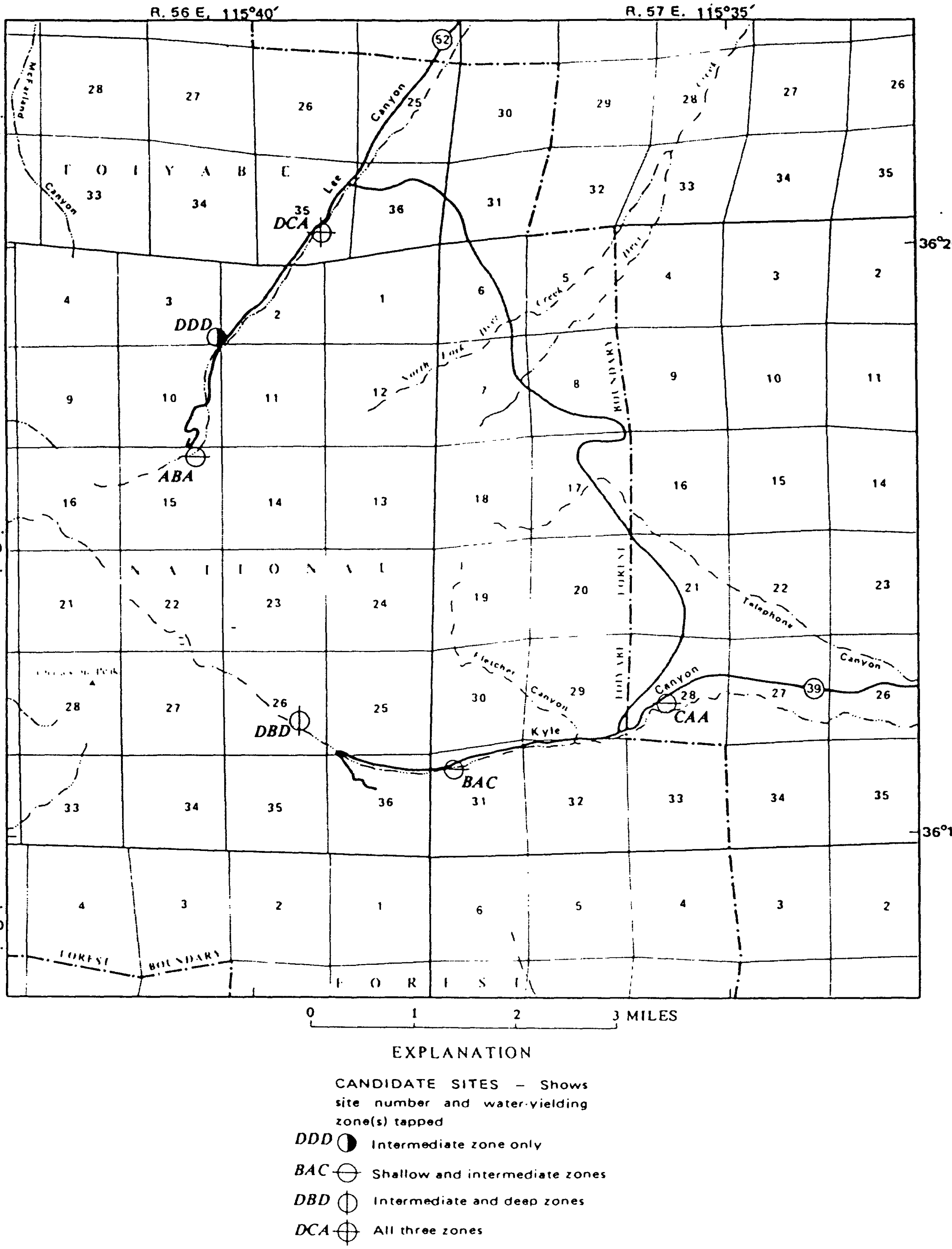

FIGURE 2.– Candidate sites for the monitoring network in Kyle and Lee Canyons.

intermediate zone (30-200 feet) is commonly tapped for domestic uses and also would reflect the downward migration of poor-quality ground water toward the deep zone; and ground water in the zone deeper than 200 feet is the resource most commonly tapped for public supplies. The three arbitrary zones are related in a general way to the hydrogeologic categories defined by Harrill (1976, pages 9, 11) and Kaufmann (1978, page 26) for the central part of the valley: The shallow and intermediate zones used in this report are together comparable to Harrill's "near-surface reservoir" and Kaufmann's "near-surface zone" to varying degrees, whereas the deep zone is similar to Harrill's "principal aquifers."

The term "shallow water-yielding zone" can be misleading. In the topographically low part of Las Vegas Valley, the zone is shallow with regard to depth below land surface (less than 10 feet in places) as well as depth below the water table (less than 30 feet). In peripheral upland areas to the west and north, in contrast, the shallow water-yielding zone remains, by definition, less than 30 feet below the water table, but it can be more than 500 feet below land surface (the extreme among wells listed in table 4 is S22 E60 16AAC1, with a static water level almost 560 feet below land surface).

Among the 186 sites chosen, the vertical distribution of perforated or screened intervals relative to the water table (table 4) is as follows:

Shallow water-yielding zone only, 36 sites.
Intermediate zone only, 36 sites.
Deep zone only, 29 sites.
Shallow and intermediate zones, 31 sites.
Intermediate and deep zones, 32 sites.
All three zones, 20 sites.
Zone(s) uncertain (lack of information on static water levels or producing intervals), 2 sites.

In total, the spring and 86 of the candidate wells produce wholly or in part from the shallow zone. Comparable figures for the intermediate and deep zones are 119 and 81 wells, respectively.

The areal distribution of sites, by zone, is shown on plate 1 and in figure 2. More than one-third of the sites are in T. 20 and 21 S., R. 61 E.--the central part of the valley. In many peripheral areas, contrastingly, the number of available, suitable wells, particularly those tapping the deep zone, is much more limited.

Overall, about half of the candidate sampling sites provide water for either public or domestic supplies (table 4). The ground-water system in Las Vegas Valley is a dynamic one, as discussed on pages 5 and 7. Thus, the position of producing zones relative to the water table for individual network wells can change with time; for example, a well that currently produces from the shallow water-yielding zone could eventually become an intermediate-zone well, or it could go dry, as a result of future fluctuations in water-table altitude. As a result, the network itself should also be dynamic, with new wells added and old ones retired to keep pace with the changing hydrologic character of the ground-water system.

Water-Quality Characteristics

Water-quality standards or guidelines exist for a variety of water uses, which include drinking, domestic, commercial, and industrial applications, irrigation, stock watering, and water-contact recreation. These criteria provide a basis for the choice of characteristics to be included in the monitoring program for ground-water quality in Las Vegas Valley. Among the most restrictive and important standards are those for drinking water, which are listed in table 1. Additional items that are of concern for irrigation include the concentration of boron (chemical symbol, B) and the proportions of calcium (Ca), magnesium (Mg), sodium (Na), and alkalinity (carbonate plus bicarbonate). Calcium and magnesium also are important for certain domestic, commercial, and industrial water uses. Their combined concentration, expressed as calcium carbonate, is known as water hardness. The concentration of silica (SiO_2) is an important factor for boiler-feed water and certain other industrial uses. Nitrite, ammonium, organic nitrogen, and phosphorus, along with nitrate, are commonly present in sewage effluent and can therefore provide clues to ground-water contamination by such fluids. Similarly, organic carbon has proven useful in some instances as a "tracer" of contamination by organic compounds.

Determination of the constituents and properties discussed above will provide valuable information on the suitability of ground water in Las Vegas Valley. In addition, the periodic monitoring of many of these characteristics will indicate the magnitude of seasonal fluctuations and long-term changes in ground-water quality that are associated with natural processes and man-induced alterations in the valley--the latter of particular concern.

The role of tritium as an indicator of percolating surface water in Las Vegas Valley is discussed in detail by Kaufmann (1978, pages 101-114). Periodic determinations of tritium, particularly in ground water from the deep zone (page 9), hopefully will augment other information in signaling the onset of contamination.

In summary, table 2 lists several groups of characteristics that are proposed for the monitoring program. Not all the characteristics are intended for determination on the water from all sites listed in table 4. For example, the expensive tritium analyses (group 6) would be restricted to selected deep-zone wells, whereas the expensive pesticide analyses (group 7) would be reserved largely for selected shallow- and intermediate-zone wells. The assignment of determination groups by depth zone is indicated in table 3.

Determinations should not necessarily be limited to those listed in table 2. For example, if the analytical results for a specific well water indicate or suggest the possibility of contamination by organic substances, the array of determinations should be expanded for that well, particularly if the well provides a drinking-water supply.

TABLE 1.--*Selected drinking-water standards as applied to ground-water sources*[1]

Constituent or property	Milligrams per liter, except as noted	
	Mandatory maximum concentration or value	Recommended maximum concentration, value, or range[2]
Inorganic and physical		
Arsenic	0.05	--
Barium	1	--
Cadmium	.01	--
Chloride	[a]400	250
Chromium	.05	--
Color (platinum-cobalt units)	--	15
Copper	--	1
Detergents (MBAS)	--	.5
Dissolved solids	[a]1,000	500
Fluoride	[b]1.6	--
Hydrogen sulfide	--	.05
Iron	[a].6	.3
Lead	.05	--
Magnesium	[a]150	[a]125
Manganese	[a].1	.05
Mercury	.002	--
Nitrate (as N)	10	--
Odor (threshold number)	--	3
pH (units)	--	6.5-8.5
Selenium	.01	--
Silver	.05	--
Sulfate	[a]500	250
Zinc	--	5
Organic pesticides		
Endrin	0.0002	--
Lindane	.004	--
Methoxychlor	.1	--
Silvex	.01	--
Toxaphene	.005	--
2,4-D	.1	--
Bacteria		
Coliform group, membrane-filtration method:	4 colonies/100 ml	--
Radioactivity		
Alpha, gross	15 pCi/L	--
Radium-226 plus radium-228	5 pCi/L	--
Strontium-90	8 pCi/L	--
Tritium	20,000 pCi/L	--

[1] Modified from Nowlin (in press, table 2). See footnote *a*.

[2] Recommended concentrations should not be exceeded where suitable alternate supplies are available or can be made available.

[a] State of Nevada standards (Nevada Bureau of Consumer Health Protection Services, 1977, p. 8-9). All others are Federal standards (U.S. Environmental Protection Agency: 1975, p. 59570-59571; 1976, p. 28404; 1977, p. 17146).

[b] Value for Las Vegas Valley, based on an annual average of 26.0°C for maximum daily air temperatures at Las Vegas office of National Weather Service, McCarran International Airport (published data from National Climatic Center, U.S. National Oceanic and Atmospheric Administration).

TABLE 2.--*Groups of water-quality determinations for monitoring network*

Group	Type of analysis	Determinations
1	Field, general	Alkalinity, pH, specific conductance, and water temperature
2	Field, bacteria	Fecal coliform bacteria
3	Laboratory, principal constituents and nutrients	Calcium, magnesium, sodium, potassium, sulfate, chloride, fluoride, silica, nitrate, nitrite, ammonium, organic nitrogen, phosphorus, and dissolved solids
4	Laboratory, trace elements	Arsenic, barium, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver, and zinc
5	Laboratory, radio-chemical	Gross alpha, radium-226 plus radium-228, and strontium-90
6	Laboratory, radio-chemical	Tritium (low-level determination)
7	Laboratory, pesticides	Endrin, lindane, methoxychlor, silvex, toxaphene, and 2,4-D
8	Laboratory, organics	MBAS (methylene blue active substances) and organic carbon

Sampling Frequencies

The proposed initial sampling frequencies differ with water-yielding zone and determination group (table 3). For example, ground water from the shallow zone is most likely to exhibit seasonal fluctuations in quality, making a quarterly frequency advisable, at least initially, for the most inexpensive determination groups. In contrast, water from the deep zone would be expected to show little if any seasonal variation in quality, which would justify a more economical once-per-year sampling frequency. The frequencies listed in table 3 apply to wells producing exclusively from one of the three water-yielding zones. For wells that tap more than one zone (page 9), the assignment of determination groups and sampling frequencies is based on the tapped zone closest to land surface.

The long-term assignment of sampling frequency should be flexible, depending on (1) water-quality information obtained during early stages of the monitoring program, as well as (2) hydrologic and land-use changes with time. For example, table 3 lists a quarterly frequency for shallow-zone and selected intermediate-zone wells; data obtained at a particular well during the first year of monitoring may indicate that a reduction of frequency to once per year would provide adequate information for that well. Similarly, the frequency for a particular group of determinations (principal constituents and nutrients, for example) can be reduced where field data (groups 1 and 2, table 2) indicate that the quality of a specific well's water remains virtually unchanged with time.

TABLE 3.--*Initial sampling frequencies, by water-yielding zone and determination group*

Determination category: A, groups 1,2,3,8; B, groups 1,2,3; C, groups 4,7; D, group 5; E, groups 4,8; F, groups 5,6,7 (see table 2).
Frequency: W, four/year; X, once/year; Y, once/2 years; Z, once/4 years.

Water-yielding zone	Sites	Determination category	Frequency	Number of sites
Shallow (<30 feet below water table)	All	A	W	87
	Selected	C	X	54
	Selected	D	Z	26
Intermediate (30-200 feet)	All[1]	A	X	59
	Selected[2]	A	W	11
	Selected	C	Y	43
	Selected[2]	C	X	11
	Selected	D	Z	19
Deep (>200 ft)	All	B	X	29
	All	E	Y	29
	Selected	F	Z	21

[1] Does not include wells described in footnote 2.

[2] Selected wells with perforations or screens that include the depth interval from 30 to 50 feet below the water table.

Sampling Techniques

An important part of any water-quality monitoring program is the proper collection of samples. The goal of the proposed program in Las Vegas Valley is to ascertain the character of natural ground water, not that of pumped well water sampled following (1) storage in the well or at land surface and (2) chemical treatment such as softening or chlorination. Therefore, certain precautions and special procedures are necessary to ensure the collection of a sample that is truly representative of the ground water. The two most important considerations are a proper sample-collection point and an adequate preliminary pumping time (along with a careful documentation of both).

Sample-Collection Point

For wells with permanent pumps, the only acceptable collection point is between the well itself and the adjacent storage tank or water-treatment system. If no faucet exists at such a site, one should be installed (with the well-owner's permission). For unused wells without permanent pumps, samples can easily be collected from the portable system used for preliminary pumping.

Preliminary Pumping

A well casing with an 8-inch inside diameter and a 200-foot water column contains up to 520 gallons of water from the aquifer, much of which has been in temporary storage away from its natural physiochemical environment since the previous pumping. There is no way of ensuring that the chemical and physical character of this water is comparable to that of ground water in the sedimentary deposits tapped by the well. Thus, to obtain a truly representative ground-water sample, a well must be pumped long enough to thoroughly purge (1) its initial contents and (2) any ground water outside the screens or perforations that could have been chemically influenced by previous pumping.

Because casing diameter, water column, length of perforated or screened interval, and pump capacity differ greatly from well to well, a minimum pumping time of half an hour, prior to sampling, is recommended as a guideline for all network wells (prior permission of the well owner is advisable). During the period of preliminary pumping, water temperature and specific conductance should be measured at 5-minute intervals to verify that physical and chemical stability has been attained prior to sampling.

SUBSIDIARY RECONNAISSANCE OF GROUND-WATER QUALITY

In addition to the valley-wide monitoring network described above, a subsidiary program is proposed to provide (1) a more extensive base of carefully collected data on ground-water quality and (2) current information regarding wells for which historical water-quality data exist. To be eligible for inclusion as a reconnaissance site, a well would have to meet one or both of the following criteria: The availability of a reliable driller's description of sedimentary materials penetrated and well-construction details, or the existence of trustworthy historical data on water quality. In addition, an adequate sample-collection point must be available, as described on page 14.

Reconnaissance wells would be chosen and sampled at a rate of about 25 per year, beginning in the second year of network operation. Water-quality determinations made for a particular well water would depend on the water-yielding zone(s) tapped, in a manner similar to that documented in table 3. Additionally, each reconnaissance well would be resampled (at the same time of year) once every 5 years, to provide supplementary information on water-quality trends.

MANAGING THE WATER-QUALITY DATA

Selection of a Data-Management System

Section 106 of Public Law 92-500 includes a mandate for data processing as well as data collection in monitoring programs, and a system for processing data on ground-water quality is proposed as a component of the network for Las Vegas Valley. The function of the data system is to make information from the monitoring network available to managers, planners, and other interested persons. The system provides the interface between persons operating the network and persons needing the information. Following the recommendation of Nowlin (in press), an automated, computer-based, data storage and retrieval system is proposed.

Nowlin considered three options for establishing an automated system for data on ground-water quality: (1) Develop new computer software, (2) purchase or lease a proprietory data-management system and modify it for specific monitoring needs, or (3) participate in an existing data-management system for hydrologic data. Nowlin concluded that the third option was the most attractive. Additionally, he examined three existing data-management systems, and the results of that examination indicate that the Geological Survey's WATSTORE system is best adapted to the needs of a network for ground-water quality.

Description of WATSTORE Files

WATSTORE (the Water-Data Storage and Retrieval System) consists of several files in which data are grouped and stored by common characteristics and data-collection frequencies. The system is also designed to allow for the inclusion of additional data files if the need should arise in future years. Brief descriptions of the WATSTORE files pertinent to the monitoring network are given below.

Station-Header File

All sites for which data are stored are indexed in the Station-Header File. This file contains information including the site-identification number, latitude and longitude, local site number, site type, hydrologic-unit code, site altitude, well depth, geologic-unit code, and aquifer-type code.

Water-Quality File

Analyses of water samples that indicate the chemical, physical, biological, and radiochemical characteristics of ground water are contained in the Water-Quality File. The file stores intermittent to periodic water-quality data exclusive of once-daily and continuous measurements. Data types are stored according to one of about 2,000 parameter codes describing the water-quality characteristic, the type of sample, and the method of analysis.

The file is not restricted to data for samples collected and analyzed by the U.S. Geological Survey. Information from other agencies can be included if documentation shows that the procedures for sample collection, preservation, and analysis do not differ markedly from those of the Geological Survey.

Ground-Water Site-Inventory File

The Ground-Water Site-Inventory File contains inventory data about wells, springs, and other sources of ground water. The data include site location and identification, geohydrologic characteristics, well-construction history, and field measurements such as water temperature.

Other Files

Other WATSTORE files with potential applications for the monitoring of ground-water quality are the Unit-Values File, Daily-Values File, Ground-Water-Level File, and the Satellite Data-Collection File. The Unit-Values File is organized for efficient processing of data from analog or digital recorders, such as water-level recorders, flow meters, and multiparameter water-quality monitors. All water characteristics measured or observed on either a daily or continuous basis and numerically reduced to daily values are stored in the Daily-Values File. Data on ground-water levels collected intermittently to periodically (up to once-daily) are stored in the Ground-Water-Level File. More frequently collected water-level data are stored in the Unit-Values File. The Satellite Data-Collection File processes data relayed by satellite from remote sites.

Use of WATSTORE Files

Data Display

WATSTORE can provide, upon request, a variety of useful data products to meet diverse needs. These products range from the simple retrieval of data in tabular form to complex statistical analyses. Users most often request data from WATSTORE in the form of tables printed by the computer. These tables may contain lists of actual data or condensed indexes that indicate the availability of data stored in the files. A variety of formats is available to display data on ground-water quality, site inventories, and ground-water levels.

Graphs and maps prepared on computer printers or digital plotters are also available from WATSTORE. Computer programs are available to produce bar graphs, line graphs, frequency-distribution curves, X-Y point plots, site-location maps, and other similar items by means of line printers. WATSTORE also makes use of software systems that prepare data for digital plotting on offline incremental plotters. Plots that can be obtained include hydrographs, frequency-distribution curves, X-Y point plots, contour plots, and three-dimensional plots.

Data in WATSTORE also can be obtained in machine-readable form for use on other computers or for use as input to user-written computer programs. These data are available in the standard storage format of the WATSTORE system or as punch cards or punch-card images on magnetic tape.

Data Analysis

In addition to the display of data, WATSTORE offers software for analyses of data. WATSTORE uses a collection of computer programs known as SAS (Statistical Analysis System) to provide extensive statistical analyses of data, such as regressions, variances, transformations, and correlations. Additionally, software is available for chemical interpretation including trilinear diagrams, pattern diagrams, bar diagrams, line diagrams, and irrigation-classification diagrams.

Data Access

WATSTORE data and application programs are maintained on an Amdahl 470V/7 computer at the Geological Survey's National Center in Reston, Va. Access is via one or more remote terminals maintained in 46 District Offices of the Survey's Water Resources Division, or through terminals of other authorized WATSTORE users. State access may be obtained in one of three ways: (1) By cooperative agreement with the District Office, (2) by WATSTORE membership, or (3) by acquisition of many of the WATSTORE programs for use on State computer facilities. With the first option, data input to and output from WATSTORE would be made through the Nevada District's terminal in either batch or timesharing modes. Data input may be prepared on State facilities and transmitted by direct telephone link to the terminal for relay to WATSTORE. Data may be retrieved from WATSTORE and relayed to State facilities or may be printed by the Nevada District's terminal. Under the second option, WATSTORE access would be direct via State terminal facilities. Under the third option, desired WATSTORE programs would be obtained from the Geological Survey for installation on the State IBM computer system; support and maintenance would be performed by State personnel.

Importance of the Data-Management System

The purpose of the monitoring network in Las Vegas Valley is to provide "early warning" of adverse changes in ground-water quality, which in turn permits decisionmaking with regard to the management and future development of the water resources. This purpose is realized only if information is disseminated to the decisionmaker in an understandable and usable form and if the decisionmaker knows how to interpret it. An automated data-management system, which stores accurately entered data that were carefully collected and processed, is an efficient mechanism for properly disseminating the data to those who need it.

TABLE 4.--*Data for sites chosen as network candidates*

Well: Hydrographic area number (212) is omitted because all wells are in Las Vegas Valley.
Shallowest and deepest openings: Shallowest and deepest perforations or screens, as reported by driller.
Static water level: Most recent available data through March 1980. E, estimated; F, flowing.
Water use: D, domestic; I, industrial or commercial; Ir, irrigation; P, public supply; U, unused.
Classification of well on basis of water-yielding zone(s): S, shallow zone only (less than 30 ft below water table); I, intermediate zone only (30 to 200 ft); D, deep zone only (more than 200 ft below water table); SI, shallow and intermediate zones; ID, intermediate and deep zones; S-D, all three zones; ?, zone(s) uncertain or unknown. See section titled "Well Selection" in text.
Classification with regard to water-quality determination groups: Based on tapped water-yielding zone closest to land surface (column 9), as follows: S, shallow; I, intermediate; D, deep.
Specific determinations: Determination categories A-F and frequencies W-Z, as listed in table 3.

Well (1)	Site ID (2)	Depth, in feet below land surface: Total (3)	Depth, in feet below land surface: Shallowest and deepest openings (4)	Static water level: Feet below land surface (5)	Static water level: Year (6)	Water use (7)	Usable pump (8)	Classification of well: On basis of water-yielding zone(s) (9)	Classification of well: With regard to water-quality determination groups (10)	Specific determinations (category/frequency) (11)
S18 E56 35DCA1	362006115391801	440	97-440	152	1962	P	Yes	S-D	S	A/W, C/X, D/Z
S19 E56 03DDD1	361911115402001	370	270-370	136	1980	D,I	Yes	I	I	A/X, C/Y
15ABA1	361811115404401	400	165-400	206	1980	P	Yes	SI	S	A/W
26DBD1	361555115392901	350	130-349	43	1980	P	Yes	ID	I	A/X, C/Y
S19 E57 28CAC1	361607115354201	297	227-297	227	1980	P	Yes	SI	S	A/W, C/X, D/Z
31BAC1	361534115374701	245	145-245	130	1960	P	Yes	SI	S	A/W
S19 E60 01CAD1	361905115130301	160	120-160	120	1971	D	?	SI	S	A/W
04CDA1	361923115160701	631	531-631	170E	--	?	?	D	D	B/X, E/Y, F/Z
05DDD1	361919115164301	220	180-220	160	1977	D	Yes	SI	S	A/W, C/X, D/Z
09BCC1	361843115161001	830	--	152	1980	U	No	ID?	I?	A/X
09DAD1	361840115153901	300	240-300	95	1978	D	Yes	I	I	A/X, C/Y, D/Z
12DB1	361806115122701	240	80-240	111	1980	D	Yes?	SI	S	A/W, C/X
14BCC1	361804115142401	350	90-350	66	1975	D	Yes	S-D	S	A/W, C/X
22BDD1	361703115150601	400	200-400	76	1976	D	Yes	ID	I	A/X
24CBC1	361655115132101	380	210-380	85	1977	D	Yes	ID	I	A/X
25CCC1	361536115131301	300	60-?	136	1980	D	Yes	SI	S	A/W, C/X
26CAD1	361604115140001	320	200-320	121	1979	D	Yes	I	I	A/X, C/Y
29CAB1	361605115172001	300	140-300	135	1971	D	Yes	SI	S	A/W, C/X, D/Z
32ACA1	361520115164001	350	230-350	139	1977	D	Yes?	I	I	A/X, C/Y, D/Z
34CBC1	361513115152801	300	260-295	130	1972	D	?	I	I	A/X
36CCB1	361500115132001	300	160-300	140	1972	D	Yes	SI	S	A/W
S19 E61 21DDB1	361626115090701	1,300	50-1,300	29	1980	U	No	S-D	S	A/W
29DCC1	361536115101601	200	80-200	82	1978	D	Yes	SI	S	A/W, C/X, D/Z
31ADC1	361514115112901	320	180-320	85	1978	D	Yes	ID	I	A/X, C/Y, D/Z
35DDB1	361459115070901	200	70-200	42	1978	D	Yes	I	I	A/W, C/X
S19 E62 29DDB1	361548115034701	300	150-300	96	1980	U	No	I	I	A/X, C/Y
32BBA1	361542115042901	95	91-95	91	1980	U	No	S	S	A/W, C/X
33DDD1	361449115024501	300	120-300	96	1980	I	Yes	SI	S	A/W
35DCD1	361451115004401	838	370-810	115	1980	P	Yes	D	D	B/X, E/Y, F/Z
36DBB1	361453114594301	1,434	288-1,424	143	1980	P	Yes	ID	I	A/X, C/Y, D/Z

TABLE 4.--*Data for sites chosen as network candidates*--Continued

		Depth, in feet below land surface		Static water level				Classification of well		
Well (1)	Site ID (2)	Total (3)	Shallowest and deepest openings (4)	Feet below land surface (5)	Year (6)	Water use (7)	Usable pump (8)	On basis of water-yielding zone(s) (9)	With regard to water-quality determination groups (10)	Specific determinations (category/frequency) (11)
S20 E60 04CAD1	361417115161301	500	285-500	285	1973	D	Yes	SI	S	A/W
09DCC1	361259115153901	450	360-?	386	1980	U	No	SI	S	A/W, C/X
11CAA1	361303115140301	1,003	307-965	293	1980	P	Yes	S-D	S	A/W
11DAA1	361303115132801	180	90-?	104	1980	U	No	SI	S	A/W
12DBB1	361325115125201	800	160-800	256	1980	P	Yes	S-D	S	A/W, C/X, D/Z
21AAB1	361212115154201	975	500-893	426	1980	P	Yes	ID	I	A/X, C/Y, D/Z
24BBB1	361141115130801	900	200-859	275	1980	P	Yes	S-D	S	A/W
26DCC1	361025115133801	960	400-930	358	1980	P	Yes	ID	I	A/X, C/Y
27AAD1	361106115143001	1,000	455-?	403	1980	P	Yes	ID	I	A/X
34CCB1	360934115151201	1,002	500-970	528	1978	P	Yes	S-D	S	A/W, C/X
35DDB1	360940115133701	1,006	550-986	320	1980	P	Yes	D	D	B/X, E/Y, F/Z
36BDD1	361002115130801	830	251-824	297	1980	P	Yes	S-D	S	A/W, C/X
S20 E61 01ACC1	361425115061501	84	80-84	61	1980	U	No	S	S	A/W, C/X
02DBB1	361419115072201	785	90-430	28	1980	U	No	ID	I	A/X
03ADC1	361423115081601	500	203-239	60	1980	P	Yes	I	I	A/X, C/Y, D/Z
04CDD1	361346115095501	300	115-195	150	1980	D	Yes	SI	S	A/W, C/X
06CBD1	361346115115901	1,000	758-986	212	1979	P	Yes	D	D	B/X, E/Y, F/Z
11AAD1	361349115070501	1,040	499-970	50	1962	P	Yes	D	D	B/X, E/Y, F/Z
11CDD1	361305115073201	62	58-62	38	1980	U	No	S	S	A/W, C/X, D/Z
13ABD1	361232115061001	1,230	102-1,039	49	1980	P	Yes	ID	I	A/X, C/Y
13ACD1	361222115061501	560	480-560	43	1980	U	No	D	D	B/X, E/Y, F/Z
17CDB1	361222115105601	655	550-640	162	1980	U	No	D	D	B/X, E/Y
18ABB2	361238115112102	1,000	506-950	209	1980	P	Yes	D	D	B/X, E/Y, F/Z
18BCC1	361237115121401	500	300-500	217	1980	P	Yes	ID	I	A/X, C/Y
19BBA1	361133115111701	295	275-290	60E	--	U	?	D	D	B/X, E/Y
19BCC1	361134115115701	1,000	215-958	234	1980	P	Yes	S-D	S	A/W, C/X
20CDC1	361120115105301	925	300-925	135	1980	P	Yes	ID	I	A/X, C/Y
21BAA1	361145115094801	397	200-397	67	1980	P	Yes	ID	I	A/X
22BCD1	361141115085001	1,000	500-925	58	1980	P	Yes	D	D	B/X, E/Y, F/Z
22DCD1	361110115082401	450	75-450	10E	--	P	Yes	ID?	I	A/X, C/Y, D/Z
24CBB1	361140115064901	450	150-450	4	1980	P	Yes	ID	I	A/X, C/Y
25DAA1	361051115055201	25	21-25	6	1980	U	No	S	S	A/W, C/X
27BDA1	361102115083601	15	11-15	10	1980	U	No	S	S	A/W, C/X, D/Z
29CCC2	361021115105901	1,000	550-850	146	1980	P	Yes	D	D	B/X, E/Y, F/Z
30CDB1	361029115114701	1,005	205-720	222	1980	P	Yes	S-D	S	A/W
31AAD2	361014115111401	500	278-498	172	1980	P	Yes	ID	I	A/X, C/Y, D/Z
31ABA1	361033115112901	90	86-90	9	1974	U	No	I	I	A/X, C/Y
31ABA2	361031115112901	19	17-19	20	1974	U	No	S	S	A/W, C/X, D/Z
31DAB1	360942115111101	766	513-674	164	1979	P	Yes	D	D	B/X, E/Y
33ADD1	360951115091201	882	430-866	F	1955	I	Yes?	D	D	B/X, E/Y

TABLE 4.--*Data for sites chosen as network candidates*--Continued

Well (1)	Site ID (2)	Depth, in feet below land surface: Total (3)	Depth, in feet below land surface: Shallowest and deepest openings (4)	Static water level: Feet below land surface (5)	Static water level: Year (6)	Water use (7)	Usable pump (8)	Classification of well: On basis of water-yielding zone(s) (9)	Classification of well: With regard to water-quality determination groups (10)	Specific determinations (category/frequency) (11)
S20 E61 33CCA1	360947115095701	400	270-400	10E	--	U	?	D	D	B/X, E/Y
34BCB1	361012115090501	757	280-290	63	1980	I	Yes	D	D	B/X, E/Y, F/Z
35BCA1	361014115074501	18	15-18	9	1980	U	No	S	S	A/W
36BCC1	361004115065301	15	12-15	8	1980	U	No	S	S	A/W
36BCD1	360954115064201	300	250-?	6	1980	D	No?	D	D	B/X, E/Y, F/Z
36DDD1	360933115055101	100	96-99	14	1980	U	No	I	I	A/X, C/Y
36DDD2	360933115055201	40	36-39	13	1980	U	No	S	S	A/W, C/X
S20 E62 01BBC1	361421115001601	1,026	96-1,026	141	1980	P	Yes	S-D	S	A/W, C/X, D/Z
04ADD1	361412115023501	800	90-784	62	1980	P	Yes	ID	I	A/W, C/X
04CBC1	361354115032401	250	175-245	64	1980	I	Yes	I	I	A/X, C/Y, D/Z
05CAA1	361400115040901	1,000	500-940	90	1980	P	Yes	D	D	B/X, E/Y, F/Z
08ABA1	360605115055101	120	70-115	80E	--	U	?	S?	S	A/W, C/X, D/Z
09ABC1	361331115025301	850	144-826	93	1980	P	Yes	S-D	S	A/W
15BBA1	361233115021501	1,000	320-980	92	1980	P	Yes	D	D	B/X, E/Y, F/Z
16ACC1	361241115024801	694	274-674	92	1980	P	Yes	D	D	B/X, E/Y
17AAA1	361250115033901	250	82-250	78	1980	D	Yes?	SI	S	A/W
18BAB1	361250115051801	450	80-450	70	1980	P	Yes	S-D	S	A/W, C/X
18BBC1	361227115041201	300?	55-120	50E	--	U	?	SI	S	A/W
21CAB1	361131115031601	357	80-357	80	1980	D	No?	S-D	S	A/W
21DCD1	361126115025901	350	110-350	72	1972	D	Yes	ID	I	A/W, C/X
26BBC1	361100115011901	330	160-330	146	1980	D	Yes	SI	S	A/W, C/X
32ABA1	361019115040701	67	61-64	58	1973	U	No	S	S	A/W, C/X, D/Z
32ABA2	361020115040701	170	159-169	60	1973	U	No	I	I	A/X, C/Y, D/Z
S21 E58 12DDC1	360809115252601	500	400-485	401	1979	P	Yes?	SI	S	A/W, C/X, D/Z
S21 E60 10ABA1	360832115145601	425	325-425	320	1965	D	Yes	SI	S	A/W
10ADB1	360804115143901	450	260-450	421	1980	D	No?	S	S	A/W, C/X, D/Z
13AAD1	360729115123201	200	140-200	127	1980	U	No	SI	S	A/W, C/X
15BBD1	360739115152701	680	380-680	372	1969	I	Yes	S-D	S	A/W
21DDD1	360605115154601	800	340-800	342	1972	I	Yes	S-D	S	A/W, C/X
23DDD1	360606115133501	600	210-600	207	1970	P	Yes?	S-D	S	A/W, C/X
35ADA1	360444115132301	300	230-295	294	1980	D	Yes?	S	S	A/W, C/X, D/Z
S21 E61 01ABA1	360911115061401	250	115-250	3	1980	U	No?	ID	I	A/X
01CAC1	360855115064501	9	8-9	5	1974	U	No	S	S	A/W
03ABA1	360930115083401	25	21-25	10	1980	U	No	S	S	A/W, C/X
04AAD1	360910115092001	793	642-770	61	1980	U	No	D	D	B/X, E/Y
04DDB2	360846115091402	20	16-20	8	1980	U	No	S	S	A/W
05CBC1	360830115111901	37	36-37	34	1974	U	No	S	S	A/W, C/X
08DAB1	360802115101501	150	70-150	24	1980	U	No	I	I	A/W, C/X
09ACD1	360817115104001	35	34-35	20	1974	U	No	S	S	A/W, C/X, D/Z
09BBB1	360838115101801	25	21-25	11	1980	U	No	S	S	A/W

TABLE 4.--*Data for sites chosen as network candidates*--Continued

		Depth, in feet below land surface		Static water level				Classification of well		
Well (1)	Site ID (2)	Total (3)	Shallowest and deepest openings (4)	Feet below land surface (5)	Year (6)	Water use (7)	Usable pump (8)	On basis of water-yielding zone(s) (9)	With regard to water-quality determination groups (10)	Specific determinations (category/frequency) (11)
S21 E61 10BCA1	360817115085701	1,000	517-964	80	1967	Ir	Yes	D	D	B/X, E/Y, F/Z
14ACA1	360728115072901	750	580-740	F	1961	Ir	Yes	D	D	B/X, E/Y, F/Z
16AB1	360740115093801	1,108	120-1,108	10E	--	Ir	Yes	ID	I	A/X, C/Y, D/Z
17BAD1	360735115105201	45	41-45	27	1980	U	No	S	S	A/W, C/X
17CB1	360715115084401	588	350-588	20	1960	I	Yes	D	D	B/X, E/Y, F/Z
19CBA1	360614115114901	300	210-300	206	1980	U	No?	SI	S	A/W
20AC1	360636115081101	922	402-922	32	1962	Ir,P	Yes	D	D	B/X, E/Y
20DC1	360610115081201	978	60-978	47	1968	Ir	Yes	S-D	S	A/W, C/X
21DD1	360609115092201	400	154-400	8	1960	P	Yes	ID	I	A/X, C/Y
22BBA1	360649115090001	1,200	318-786	60	1980	U	No	D	D	B/X, E/Y, F/Z
22DA2	360623115081801	500	90-490	38	1966	P	Yes	ID	I	A/X
23DAB1	360625115072001	35	34-35	6	1980	U	No	S	S	A/W, C/X
24AAD1	360643115060601	160	60-160	10E	--	U	?	I	I	A/X, C/Y, D/Z
24CD1	360607115064201	570	136-570	F	1955	Ir	Yes	ID	I	A/X
25BDA1	360542115065001	120	31-94	28	1978	D	Yes	SI	S	A/W
26CBC1	360526115080801	30	29-30	14	1980	U	No	S	S	A/W, C/X
28BB1	360557115101201	800	220-800	F	1955	P	Yes	D	D	B/X, E/Y, F/Z
30CB1	360531115121701	300	150-300	145	1968	Ir	Yes	SI	S	A/W
33CCA1	360424115094501	105	--	81	1980	U	No	S	S	A/W, C/X, D/Z
34AB1	360504115083401	200	80-200	19	1968	Ir	Yes	I	I	A/X, C/Y
34CA1	360443115085601	532	100-530	F	1961	P	Yes	ID	I	A/X, C/Y, D/Z
36ADC3	360449115061201	26	23-26	19	1980	U	No	S	S	A/W, C/X, D/Z
36CB1	360437115065701	300	60-300	45	1964	Ir	Yes	S-D	S	A/W
S21 E62 03BBB2	360909115022801	200	30-200	40	1980	Ir	No?	SI	S	A/W
06DCC1	360846115052601	50	46-50	9	1980	U	No	I	I	A/W, C/X
08DCA1	360757115041201	24	23-24	9	1974	U	No	S	S	A/W
09ABB1	360833115031901	37	34-37	14	1980	U	No	S	S	A/W, C/X
10ACA1	360826115020001	715	50-?	14	1980	U	No	ID?	I	A/W, C/X
15CCB1	360714115024301	30	0-30	3E	--	U	No	S	S	A/W
15DDA1	360245115004701	35	0-35	3	1980	U	No	S	S	A/W, C/X
15DDA2	360703115014901	105	100-104	2	1980	U	No	I	I	A/X, C/Y
19AAA1	360649115050001	125	122-125	23	1973	U	No	I	I	A/X
19AAA2	360648115050001	40	36-39	15	1973	U	No	S	S	A/W, C/X, D/Z
19CAA1	360622115053401	300	200-295	26	1978	D	Yes	ID	I	A/X
22BDA1	360640115021501	50	44-49	7	1973	U	No	I	I	A/W, C/X
26DBA1	360529115010101	100	95-100	F	1980	U	No	I	I	A/X, C/Y, D/Z
26DBA2	360529115010001	30	27-29	6	1980	U	No	S	S	A/W, C/X, D/Z
29DCD1	360514115041001	56	46-56	20	1973	U	No	I	I	A/W, C/X
29DCD2	360514115041101	129	122-125	29	1973	U	No	I	I	A/X, C/Y
33ACB1	360450115031401	160	80-160	29	1980	D	?	I	I	A/X

TABLE 4.--*Data for sites chosen as network candidates*--Continued

Well (1)	Site ID (2)	Depth, in feet below land surface: Total (3)	Depth, in feet below land surface: Shallowest and deepest openings (4)	Static water level: Feet below land surface (5)	Static water level: Year (6)	Water use (7)	Usable pump (8)	Classification of well: On basis of water-yielding zone(s) (9)	Classification of well: With regard to water-quality determination groups (10)	Specific determinations (category/frequency) (11)
S21 E62 35DDA1	360532115004101	20	0-20	10E	--	U	No	S	S	A/W
S21 E63 28ACA2	360644114563801	125	90-95	34	1980	U	No	I?	I	A/X, C/Y, D/Z
29CCB1	360520114582401	91	85-90	48	1980	U	No	I	I	A/X, C/Y
29CCB2	360519114582401	42	36-41	9	1980	U	No	I	I	A/W, C/X
S22 E59 07DBD1	360245115241801	0	spring	F	--	P	--	S	S	A/W, C/X, D/Z
S22 E60 14CDB1	360143115140401	500	400-500	395	1980	D	Yes?	SI	S	A/W, C/X, D/Z
16AAC1	360216115154301	610	545-610	557	1980	D	Yes	SI	S	A/W
24DAD1	360105115122801	400	--	270E	--	D	Yes	I?	I?	A/X, C/Y, D/Z
27ABB1	360042115150501	600	--	370E	--	D	Yes	I?	I?	A/X, C/Y
S22 E61 01CBA1	360349115064901	400	200-400	22	1978	Ir	Yes	D	D	B/X, E/Y, F/Z
02BBD1	360407115075601	45	44-45	15	1980	U	No	S	S	A/W, C/X
02CDC1	360324115074301	655	120-225	47	1980	Ir	No?	I	I	A/X, C/Y
03CCB1	360340115090801	575	--	82	1980	Ir	Yes	ID?	I?	A/X
06BCD1	360355115121301	1,000	328-965	258	1980	U	No	ID	I	A/X, C/Y
07BCB1	360307115112301	400	220-400	270E	--	D	Yes	SI?	S	A/W, C/X
10CCD1	360235115090301	300	168-300	90	1970	D	Yes	ID	I	A/X, C/Y
12AAA1	360321115060001	500	160-500	38	1980	U	No?	ID	I	A/X
14ADD1	360212115071001	--	--	50E	--	D	Yes	?	I?	A/X
16CAB1	360203115095801	200	160-195	120	1971	D	Yes	I	I	A/W, C/X
21BBD1	360120115100001	150	--	138	1980	D	Yes	S	S	A/W, C/X, D/Z
22DBA1	360114115082701	300	200-300	121	1980	D	No?	I	I	A/X, C/Y, D/Z
24ADD1	360115115060201	300	200-300	155	1980	D	Yes	?	I?	A/X, C/Y
24CDD1	360051115064401	200	100-200	160	1980	D	Yes	SI	S	A/W, C/X, D/Z
28DBA1	360020115093701	297	120-297	126	1979	D	Yes	SI	S	A/W
33BAC1	355951115095501	250	210-245	135	1972	D	Yes	I	I	A/X, C/Y
S22 E62 04BCB1	360356115033701	93	90-92	F	1980	U	No	I	I	A/X, C/Y
04BCB2	360354115055201	40	36-39	7	1980	U	No	S	S	A/W, C/X
04DCC1	360322115030801	780	430-690	F	1980	U	No	D	D	B/X, E/Y, F/Z
08CBD1	360241115044001	712	565-712	102	1980	Ir	Yes	D	D	B/X, E/Y, F/Z
11CBB1	360253115014101	63	47-62	36	1979	U	No	S	S	A/W, C/X, D/Z
15ACD1	360210115020401	245	213-245	81	1978	U	No?	I	I	A/X, C/Y, D/Z
S22 E63 20ABC1	360122114574801	750	460-630	324	1980	U	No	ID	I	A/X, C/Y
S23 E61 03BCC1	361136115101401	650	220-650	201	1980	I	Yes	S-D	S	A/W
04BAB1	355901115095901	300	150-300	190	1970	D	Yes	SI	S	A/W, C/X, D/Z
09CAA1	355738115095301	500	320-500	280	1971	P	Yes	I	I	A/W, C/X
16AAA1	361012115102401	400	360-395	201	1980	P	Yes	I	I	A/X, C/Y, D/Z

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