Changes in Water Levels and Water Quality in Shallow Ground Water, Pittman-Henderson Area, Clark County, Nevada, Resulting from Diversion of Industrial Cooling Water from Ditch to Pipeline in 1985

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 89-4093

Prepared in cooperation with the
U.S. BUREAU OF RECLAMATION

DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
acre	4,047	square meter (m^2)
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year (m^3/yr)
cubic foot per second (ft^3/s)	0.0283	cubic meter per second (m^3/s)
foot (ft)	0.3048	meter (m)
inch (in.)	2.540	centimeter (cm)
mile (mi)	1.609	kilometer (km)
million gallons per day (Mgal/d)	0.0438	cubic meter per second (m^3/s)
ton per year (ton/yr)	0.9072	megagram per year

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

SEA LEVEL

In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929, formerly called "Sea Level Datum of 1929") which is derived from a general adjustment of the first-order leveling networks of both the United States and Canada.

Changes in Water Levels and Water Quality in Shallow Ground Water, Pittman-Henderson Area, Clark County, Nevada, Resulting from Diversion of Industrial Cooling Water from Ditch to Pipeline in 1985

By

Christian L. Carlsen, Roberta C. Lunnis, and David E. Prudic

ABSTRACT

A pipeline was constructed by the U.S. Bureau of Reclamation between June 1984 and June 1985, to convey process cooling water from an industrial complex near Pittman-Henderson, Nevada, to Las Vegas Wash. The pipeline replaced an open, unlined ditch and thereby reduced the amount of water seeping into the underlying alluvial-fan deposits, which are composed predominantly of sands and gravels. This report describes changes in ground-water levels and water quality in the vicinity of the unlined ditch following diversion of cooling water into the pipeline.

Ground-water levels declined as much as 15 feet near the unlined ditch 2 years after the diversion of water into the pipeline. However, water levels in many other wells in the study area either rose or declined between 1985 and 1987 for a variety of reasons, which include the unusual precipitation events during July and August 1984, downcutting of the channel in Las Vegas Wash, and changing volumes and distribution of municipal and industrial wastewater discharge within and upgradient of the study area.

Before use of the pipeline, ground-water quality near the upper end of the ditch reflected the general quality of water discharged into the ditch (dissolved solids, about 850 mg/L). However, dissolved-solids concentrations exceeded 15,000 milligrams per liter in four areas. These high concentrations are attributed to the effects of previous disposal of industrial wastewater into unlined ponds and ditches within and upgradient of the study area. Two areas of high dissolved-solids concentrations west of the unlined ditch and beneath an area of homes are characterized by high dissolved sodium and chloride concentrations. In contrast, calcium, sodium, and sulfate are generally the principal ions dissolved in ground water beneath the unlined ditch and in areas not affected by industrial wastewater.

During a 2-year period following the diversion of cooling water into the pipeline, the chemical composition of water sampled from wells near the upper end of the unlined ditch did not change. Dissolved-solids concentrations, however, increased as much as 3,000 milligrams per liter in some wells near the ditch farther downgradient. Elsewhere, concentrations of dissolved solids decreased as much as 13,000 mg/L in water from one well, whereas concentrations increased as much as 7,000 mg/L in water from another. Both of these changes were observed in areas of highest concentrations and are largely unexplained. The changes, however, do not seem related to the diversion of cooling water into the pipeline.

INTRODUCTION

Las Vegas Wash near Las Vegas, Nev. (fig. 1), was identified by Congress in 1974 as one of four initial locations suitable for the construction of salinity-control features along the Colorado River, an important water supply for the mostly arid southwestern United States. Congress directed the U.S. Bureau of Reclamation to design and construct the salinity-control features. In response, the Bureau of Reclamation proposed several schemes to reduce the salinity of water discharging from Las Vegas Wash into Lake Mead (fig. 1), a reservoir on the Colorado River. One method adopted was the construction of a pipeline (fig. 2) to convey process cooling water from an industrial complex (figs. 1 and 2) directly to Las Vegas Wash. Previously, cooling water discharged directly into unlined ditches, which allowed some water to seep into the ground where it dissolved salts in the sediments. This mineralized ground water eventually discharged into Las Vegas Wash.

Construction of the pipeline began in 1984 and it became operational June 20, 1985. However, the pipeline did not always convey all the cooling water until the summer of 1986, owing to unanticipated operational difficulties. The volumes of water released into the ditch between June 1985 and July 1986 are unknown because of sporadic and unpredictable occurrences of the flow.

The U.S. Geological Survey, in cooperation with the U.S. Bureau of Reclamation, began a study in March 1986 to determine the effect that diverting cooling water into the pipeline had on ground-water flow near the pipeline and salinity of Las Vegas Wash. From June 1985 to March 1986, data needed to document changes in ground-water levels and water quality were collected by the U.S. Bureau of Reclamation. Prior to June 1985, both the Bureau of Reclamation and the Desert Research Institute, University of Nevada System, monitored ground-water levels and periodically sampled water for chemical analyses from wells in the study area.

The study to determine the effect of the pipeline on ground-water flow and salinity in Las Vegas Wash was modified in February 1987 (2-1/2 years prior to the planned completion of the project) to reflect a change in priorities within the Bureau of Reclamation. The data needed to determine the transmissivity and storage capacity of the sediments near the pipeline had not been obtained prior to modification of the study; thus, changes in the amount of ground-water flow and salinity to Las Vegas Wash could not be determined. Consequently, results of the study by the U.S. Geological Survey presented in this report focus on changes in ground-water levels and ground-water quality near the pipeline for a 2-year period after diversion of cooling water into a pipeline.

Purpose and Scope

The purposes of this report are to discuss factors affecting changes in ground-water levels and ground-water quality near the pipeline and to summarize, in tables and figures, ground-water data collected by the U.S. Geological Survey. The investigation included routine measurements of water levels in wells, periodic collection of water samples from wells, and gathering of historical data collected in the area.

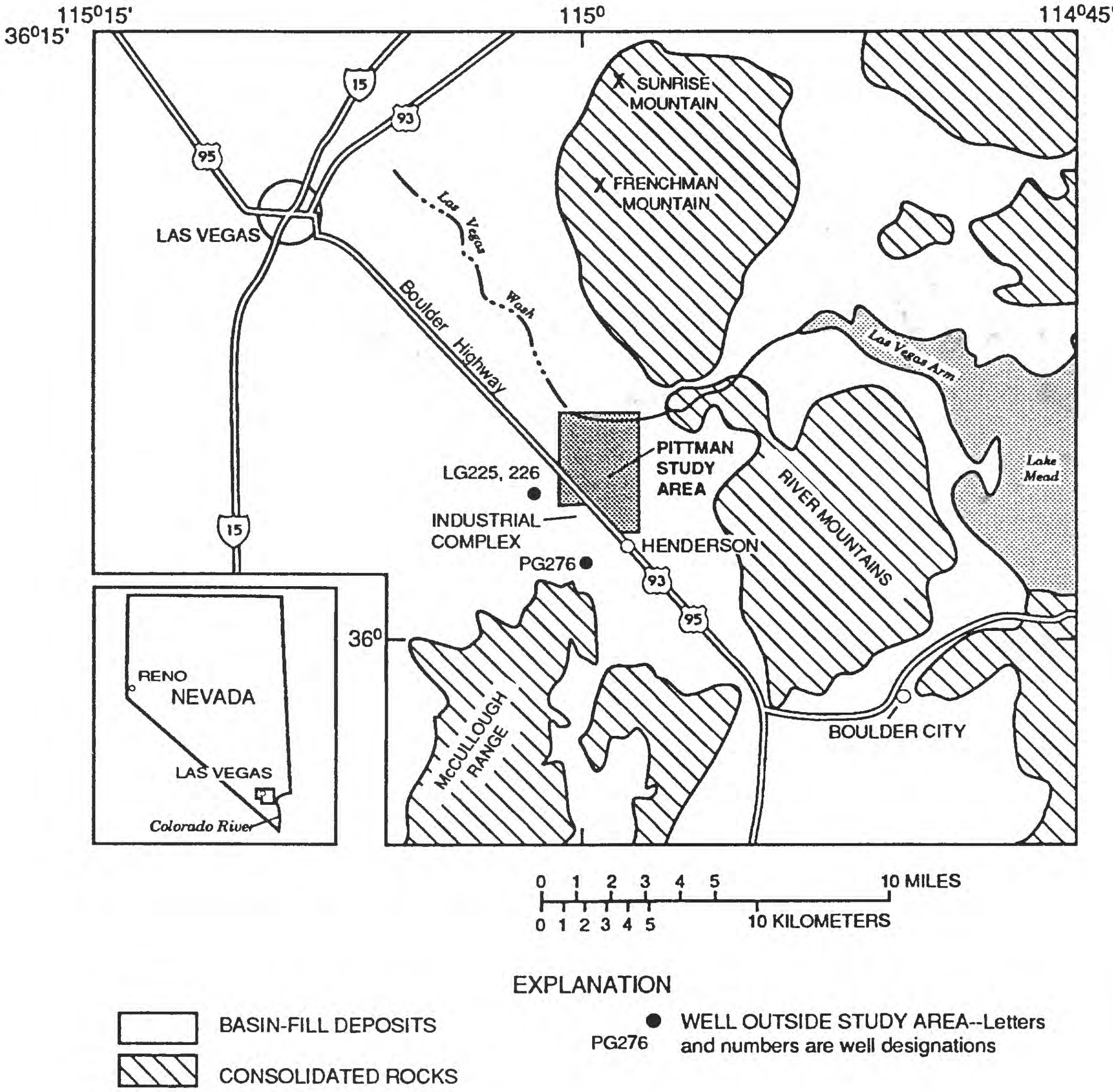


FIGURE 1.--General features of southeastern Las Vegas Valley, location of study area, and location of three wells adjacent to study area.

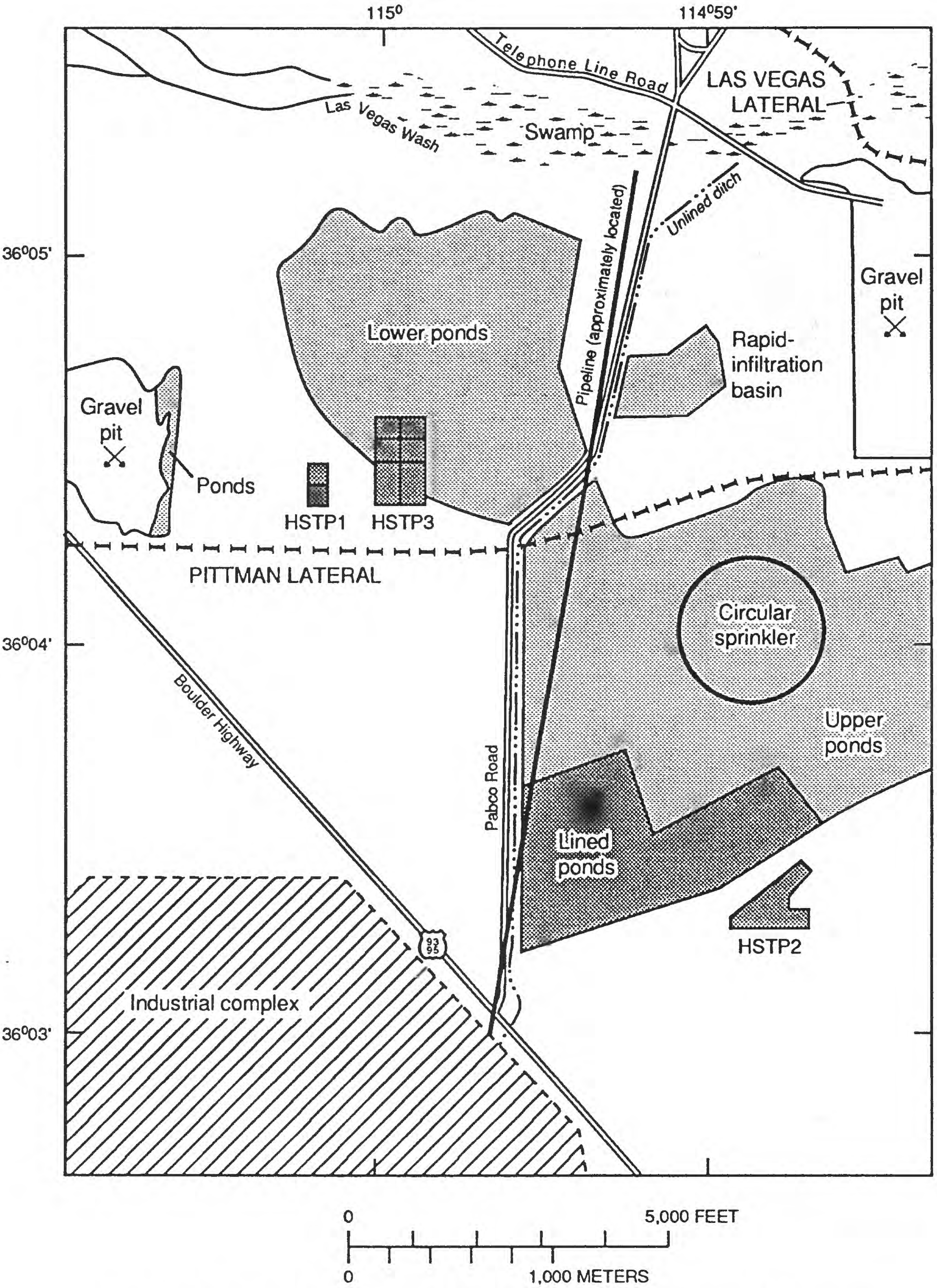


FIGURE 2.--General geographic and hydrologic features of study area. Abbreviation: HSTP, Henderson sewage-treatment plant and ponds.

Acknowledgments

Data collected previously were provided by D. Art Tuma, David J. Sobek, and Joseph Kahl, Jr., all at the Bureau of Reclamation Regional Office in Boulder City, Nev. Helpful information regarding the history of wastewater disposal practices in the Pittman study area was provided by D. Art Tuma. Ground-water level measurements and water-quality data collected by the Desert Research Institute were provided by Kevin Sullivan.

Previous Investigations

Maxey and Jameson (1948, p. 89) briefly discussed the effects on ground-water levels in the study area caused by discharging wastewater from an industrial complex into unlined ditches, ponds, and evaporation tanks as part of their study of Las Vegas Valley. They also noted that by 1944, springs had developed in the old channel in Las Vegas Wash. The springs were attributed to the discharge of wastewater into unlined ditches and ponds within and upgradient of the study area.

The Pittman study area has been the subject of several related ground-water studies since 1970. Kaufmann (1971) discussed the effects of industrial wastewater disposal on ground-water flow and water quality in the Pittman study area. He concluded that industrial wastewater infiltrating through unlined ponds and ditches moved laterally northward through the surficial sand and gravel deposits to points of discharge along Las Vegas Wash. A subsequent study by Westphal and Nork (1972) indicated that wastewater disposal also affected ground-water flow in the underlying, less permeable deposits and that wastewater moved through the less permeable deposits (although more slowly) northward toward Las Vegas Wash. They also concluded that recharge to ground water in the Pittman study area was principally from percolation of wastewater through unlined ponds.

Kaufmann (1978) and Patt (1978) discuss changes in the natural hydrologic system of Las Vegas Valley caused by urbanization and include discussions on how the disposal of industrial wastewater into unlined ponds affected both ground-water flow and water quality in the Pittman study area. Patt (1978) estimated that about 20 acre-feet per year of wastewater was recharged to the ground water per acre of unlined pond used to dispose the wastewater. Geraghty and Miller, Inc. (1980), describe ground-water flow and organic contamination of ground water beneath a chemical plant in the industrial complex south of Boulder Highway (fig. 2) and Smith (1985) describes ground-water flow and chromium contamination in ground water beneath another chemical plant within the same complex.

Trudeau (1981) describes the flow and quality of shallow ground water in the Pittman study area. He presents estimates of ground-water flow, and recharge to and discharge from the shallow aquifer; he also estimates that the salt load entering Las Vegas Wash was about 30,000 tons per year as of 1980, assuming a value for aquifer transmissivity. A Bureau of Reclamation report (1982a) discusses proposed salinity control measures for Las Vegas Wash, including the wastewater pipeline in the Pittman study area, and its appendix (U.S. Bureau of Reclamation, 1982b) describes a plan of study to determine the effect of the pipeline on ground-water flow and salt movement in the Pittman study area. An environmental assessment of the pipeline followed in 1983 (U.S. Bureau of Reclamation, 1983).

MONITORING-WELL NETWORK

Monitoring-Well Design and Numbering System

Four different types of monitoring wells exist in the Pittman study area; they are designated PG, W, L, and LG in figure 3 and table 1. Although the wells are drilled to varying depths and have varying screened or perforated intervals, most wells (PG, W, and L-series) are screened only a few feet below the water table in the surficial sands and gravels.

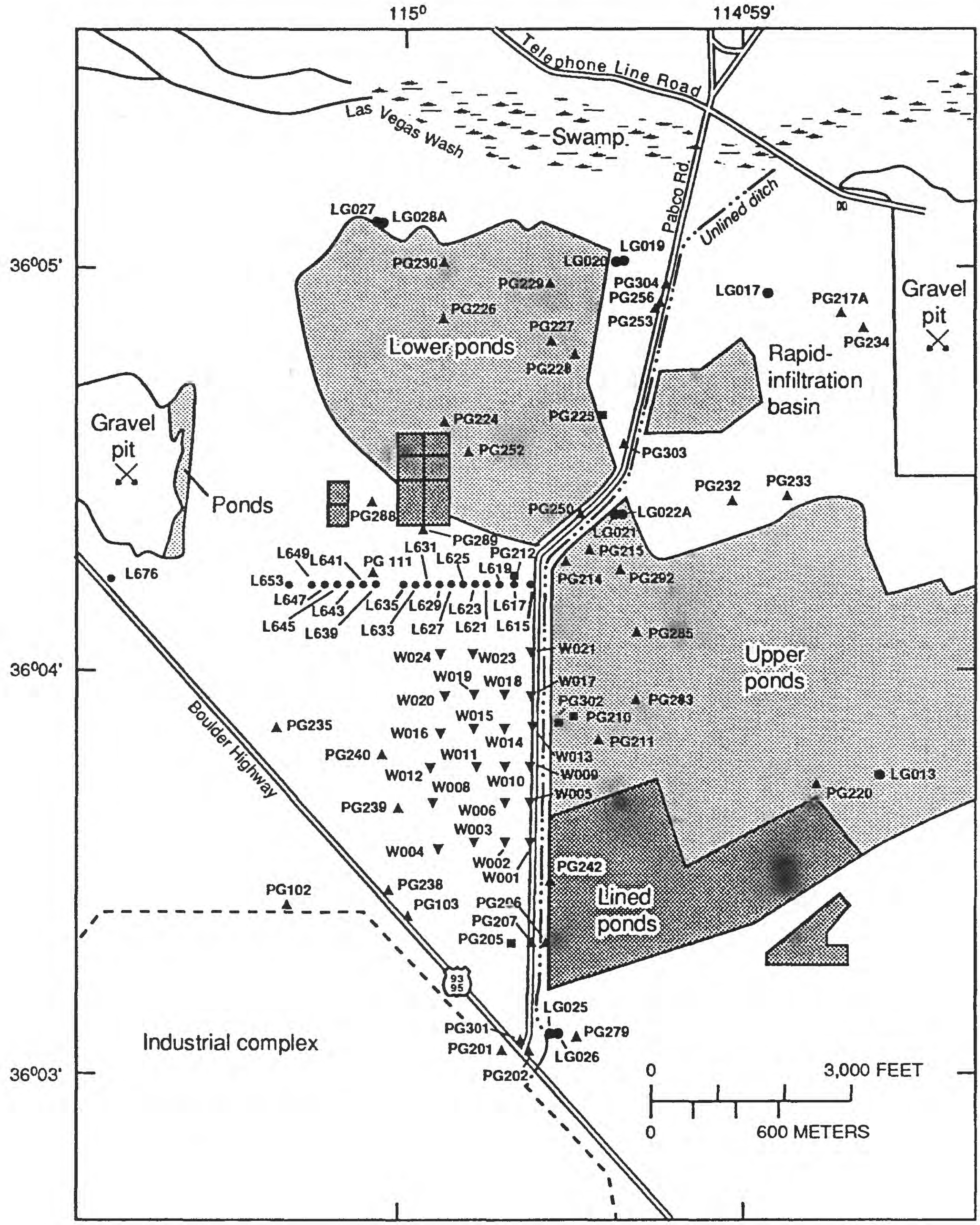
During the canvassing of wells in April 1986, one well (TRUCK 1 near the north end of the study area, fig. 3) was discovered which could not be correlated to any wells drilled by the Bureau of Reclamation or to any of the available drillers' logs for wells in the area. The well is constructed of 2-inch diameter polyvinyl-chloride (PVC) pipe.

The oldest wells in the area are the LG-series wells, many of which were drilled before 1980. The wells are located throughout Las Vegas Valley. Well-construction information, lithologic descriptions, and chemical analyses of water from many of these wells are presented by Kaufmann (1978). Most are cased with nominal 6-inch steel pipe and LG-series wells located in the study area are generally perforated at the bottom 2 to 10 feet (table 1). Several LG-series wells (LG013, LG017, LG019, LG026, LG027, and LG226) were not used in the analyses of changes to water levels and water chemistry in the near-surface sands and gravels because the wells are perforated in the underlying deposits.

The PG-series wells were drilled by the Bureau of Reclamation. Most were drilled between 1980 and 1984 (PG102-PG256) but several more were drilled during 1986 (PG276-PG304). Two LG-series wells also were drilled by the Bureau of Reclamation (LG022A and LG028A in table 1). Holes were generally drilled into what is thought to be the Muddy Creek Formation. The PG-series wells are cased with nominal 2-inch PVC, except PG202 (table 1). The well casing, however, does not normally extend to the bottom of the reported hole depth, but rather a 10- to 30-foot screened interval was placed within the saturated sands and gravels. The remaining hole below the casing was allowed to collapse.

The W-series wells were drilled in 1983 for the Bureau of Reclamation by a private contractor, and are concentrated in an area of new houses west of Pabco Road. These wells are cased with nominal 1-1/2-inch PVC pipe and are screened at the bottom 4 to 6 feet. The screened interval is within a few feet of the reported hole depth (table 1) and the bottoms of the screened intervals are 30 feet or less below land surface.

The L-series wells were drilled in 1983 for the U.S. Environmental Protection Agency (EPA) by a private contractor. These wells are located along the Pittman lateral (fig. 2; a water-supply pipeline that conveys water from Lake Mead to Las Vegas). Most holes were drilled to what is thought to be the Muddy Creek Formation which ranges from 22 feet deep in well L615 to about 63 feet deep in well L633. The L-series wells were cased with nominal 4-inch PVC pipe to depths generally less than the drilled depths (table 1). Screened intervals also ranged from 5 feet to 57 feet. All of the L-series wells were also equipped during installation with bladder pumps for the collection of water samples. The wells were drilled to study an anomalous plume of high-salinity ground water discovered during collection of data necessary for designing the Pittman lateral.



EXPLANATION

- ● LG-SERIES WELL
- ▲ PG-SERIES WELL
- ■ PG-SERIES WELL WITH CONTINUOUS RECORDING DEVICE
- • L-SERIES WELL
- ▼ W-SERIES WELL
- ⌧ TRUCK-1 WELL

FIGURE 3.--Location and identification of wells in study area.

Although the wells in the study area are drilled to various depths and have a variety of screened or perforated intervals, most wells are open within the saturated part of the near-surface sands and gravels. Whether or not interpretations of water-level distribution and water quality in the near-surface sands and gravels are affected by vertical variations in the aquifer is unknown, but because the saturated deposits are thin and permeable, any vertical variations in water levels and water quality are thought to be either insignificant or localized.

All available well-construction information and water-level data for wells listed in table 1 were entered into the Geological Survey National Water-Data Storage and Retrieval System (WATSTORE) computerized data base. The information for these wells is identified by the Geological Survey site identification (ID) and local identification numbers. Explanations of these numbers are provided in table 1 and cross referenced to each well name. Water-level data and well-construction information for any well listed in table 1 can be obtained by writing to the U.S. Geological Survey, 705 North Plaza Street, Room 227, Carson City, Nevada 89701. Water-level data entered into the WATSTORE data base for each well used in the study are summarized in figure 22 in the "Basic Data" section of this report.

Well-Sampling Procedures

The Bureau of Reclamation collected most ground-water samples between June 1985 and March 1986 using Teflon bailers. Usually, one to three well volumes were removed from the PG- and W-series wells prior to collecting a sample, whereas the LG-series wells were either not sampled, or only a few bails removed before samples were collected. The L-series wells were usually sampled with bladder pumps installed in each well. Measurements of electrical conductivity and temperature were made when samples were collected. Similar techniques were used by both the Bureau of Reclamation and the Desert Research Institute personnel for samples collected prior to June 1985.

A variety of devices were used by Geological Survey personnel to sample water from wells in the Pittman study area between April 1986 and June 1987. The PG-series wells were usually bailed with a 1-liter Teflon bailer, whereas water from the W-series wells was removed using a peristaltic pump, or bailed with a small stainless-steel bailer. Water from the L-series wells was removed using bladder pumps installed in the wells, or with a suction-lift pump. Water from the LG-series wells was removed using either a suction-lift pump or a submersible pump. For all Survey-sampled wells, at least three casing volumes of water were removed from each well prior to collecting a sample. Several wells recovered slowly (from hours to a day) after water was removed from the casing, but three volumes were still removed prior to collecting a sample. No samples were collected from wells PG234 and LG017 because these wells took weeks to several months to recover after water was removed from the casing.

Once a sufficient quantity of water had been removed from a well, a water sample was collected. At least three 250-milliliter polyethylene sample bottles were used. One bottle was filled with unfiltered and untreated water for laboratory electrical conductivity and pH; another bottle was filled with water filtered through a 0.4-micrometer filter for analyses of anions; and the third bottle was filled with filtered water acidified with nitric acid to a pH of about 1.5. This sample was for cation analyses (Wood, 1976, p. 7). Measurements of temperature, electrical conductivity, pH, and alkalinity were made at the time of sampling. Alkalinity was determined from titration using a filtered sample. Bicarbonate and carbonate concentrations were calculated from alkalinity.

Water samples were analyzed by the Bureau of Reclamation laboratory located in nearby Boulder City, Nev., for major inorganic dissolved constituents. Several duplicate samples collected by the Geological Survey during the period April 1986 to January 1987 were sent to the Survey's laboratory in Arvada, Colo., for comparisons. Results of water-chemistry analyses of samples collected by personnel from the U.S. Geological Survey between April 1986 and June 1987 are given in table 2.

PHYSICAL SETTING

The Pittman study area (fig. 1) lies between an industrial complex and Las Vegas Wash, a tributary to the Colorado River, about 9 miles southeast of Las Vegas. The industrial complex was built and initially operated by the U.S. Government during World War II to process magnesium ore. The State of Nevada acquired the complex in 1948 and leased parts of it to several companies. In 1952, the State sold the complex to those companies in an agreement that allowed some of the Colorado River water rights to be used by Las Vegas Valley (Jones, 1975, p. 22). Since then, a variety of mineral and chemical processing has been done at the complex, including the manufacturing of pesticides and organic chemical products.

Land-Use Patterns

Land-use patterns within the Pittman study area are varied and are continually changing. Unlined ponds (upper and lower ponds in fig. 2) were constructed over much of the area when the industrial complex was built. The ponds were used to dispose of industrial wastewater until the mid 1970's (D.A. Tuma, U.S. Bureau of Reclamation, oral commun., 1987), when they were abandoned for subsequent disposal in lined evaporation ponds. Several unlined ditches were excavated to convey industrial waste-water to the ponds and to Las Vegas Wash. An unlined ditch along Pabco Road was used to convey cooling water from the industrial complex to Las Vegas Wash until June 1985, when a pipeline began conveying the cooling water. Part of the upper-ponds area is currently used to evaporate industrial waste-water in lined ponds, but some of the water is spread on the ground with a pressurized circular irrigation system (fig. 2).

The city of Henderson has operated three sewage treatment plants in the area. The oldest plant HSTP2 (fig. 2) was built as part of the industrial complex facilities (about 1943) and continued operation until about 1985, when it was closed. Treated effluent was discharged into some of the upper ponds just north of the plant (John McCormick, City of Henderson Sewage Treatment Plant, oral commun., 1988). Treated effluent is still periodically pumped into some of the upper ponds whenever the discharge from the newest treatment plant exceeds its capacity. A second plant (HSTP1, newer than HSTP2 but older than HSTP3) is located adjacent to HSTP3 (fig. 2). Operation of HSTP1 ceased in 1985 and all sewage is now treated through HSTP3, which includes about 50 acres of lined, aerated lagoons underlain by drains that empty into a small channel to the north. Effluent from HSTP1 was discharged into the ponds north of the current plant as is some of the current effluent from HSTP3. About 2 to 3 million gallons per day (about 3 - 4.5 ft^3/s) is discharged into ponds from HSTP3 (John McCormick, oral commun., 1988). Treated effluent is also periodically discharged into a rapid-infiltration basin east of HSTP3 and Pabco Road (fig. 2). Some treated effluent is used by a nearby concrete-block company and, periodically, some of this water is discharged into pits west of HSTP3 and north of the Boulder Highway (fig. 2).

Abandoned gravel pits are common in the area. Gravel is still excavated along the western edge and near the northeastern corner of the study area which is just south of Las Vegas Wash (fig. 2).

A few homes were present in the small community of Pittman in the late 1940's, according to the 1952 edition of the Henderson, 15-minute quadrangle topographic map by the Geological Survey. (The community of Pittman is now part of the City of Henderson.) Since 1952, many new homes and commercial buildings have been built in the Pittman study area and irrigation of lawns has increased substantially in the area. New homes continue to be built west of Pabco Road and north of Boulder Highway. Also, several new commercial buildings were recently built just south of Henderson's sewage treatment plant HSTP3.

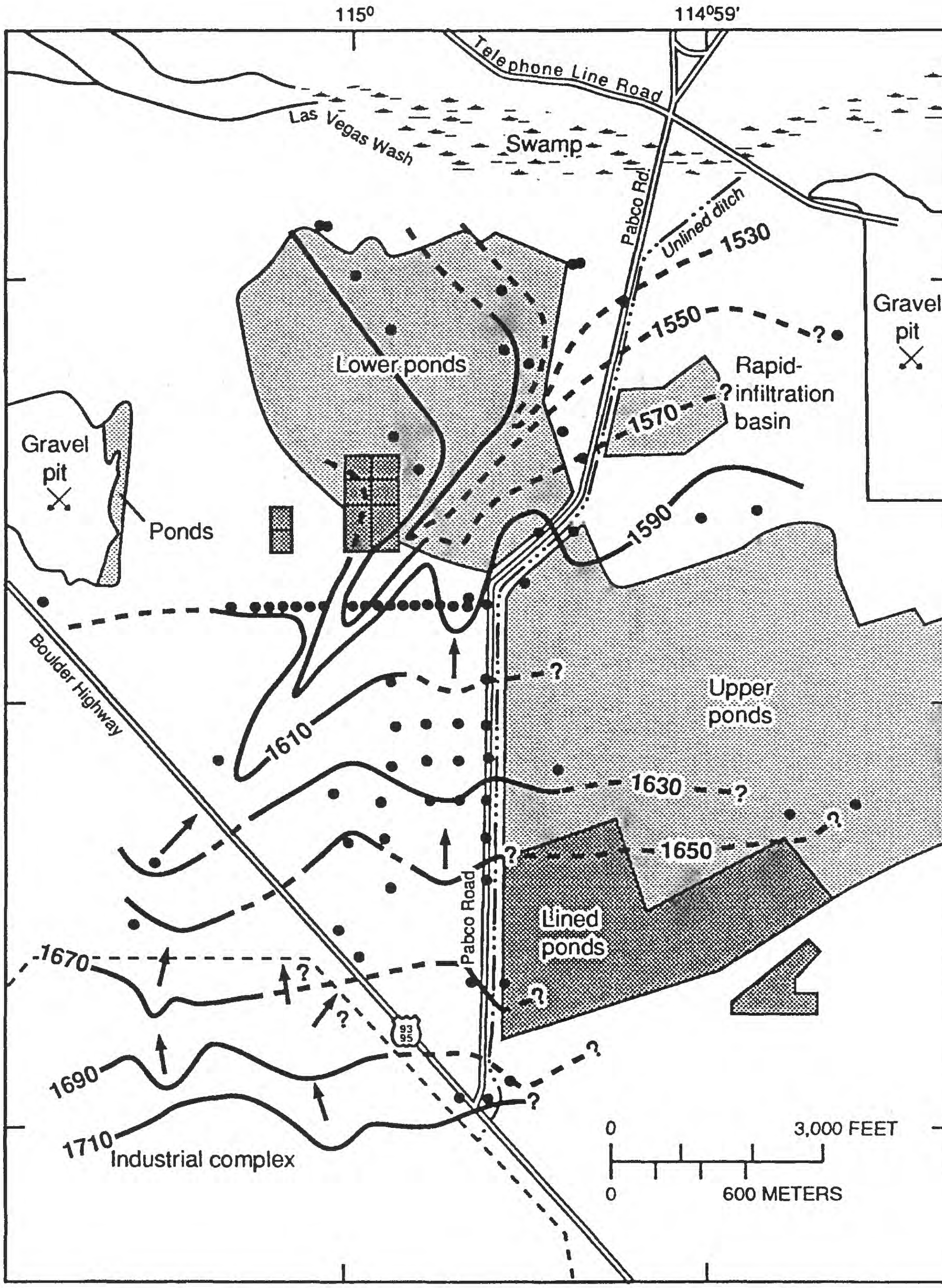
Finally, the study area is transected by two large water-supply pipelines used to transmit water from Lake Mead to Las Vegas. These pipelines are referred to as the Pittman and Las Vegas laterals (fig. 2).

Geology

The Pittman study area is located on alluvial-fan deposits derived from the McCullough Range and River Mountains south and southeast, respectively, of the industrial complex (fig. 1). The deposits are predominantly sands and gravels that consist mostly of volcanic detritus. The deposits range from a few feet to more than 100 feet thick with the surface of the deposits sloping northward toward Las Vegas Wash. Land-surface altitudes range from about 1,800 feet above sea level at the industrial complex to about 1,540 feet near Las Vegas Wash, where it was formerly crossed by Pabco Road (fig. 2). The coarser alluvial-fan deposits intermix with the generally fine-grained, fluvial deposits near Las Vegas Wash (Bell and Smith, 1980). These deposits are generally silty sand containing significant amounts of soluble minerals (salts).

The Muddy Creek Formation of Miocene and Pliocene age has been interpreted to underlay the relatively thin veneer of surficial sands and gravels in the Pittman study area (Geraghty and Miller, Inc., 1980; Trudeau, 1981; Smith, 1985). The Muddy Creek Formation is used to describe older basin-fill deposits in southern Nevada that accumulated during the formation of the Basin and Range Province in alluvial, fluvial, and lacustrine environments associated with internally drained valleys (Bohannon, 1984, p. 58).

Both Geraghty and Miller, Inc. (1980) and Smith (1985) identified channels eroded into the Muddy Creek Formation from their interpretations of the depth to the top of the Muddy Creek Formation at various locations within parts of the industrial complex. They reported that these buried channels control the movement of ground water and contaminants northward from the complex because the buried channels are composed of coarser and better sorted sediments than either the underlying older deposits or the adjacent interchannel deposits. These channels probably continue northward and, along with other buried channels in the younger fan deposits, may be the principal pathways for ground-water flow in the Pittman study area. A map was constructed showing the altitude of what has been interpreted as the top of the Muddy Creek Formation in the Pittman study area (fig. 4). The top of the Muddy Creek Formation was determined from logs of the many test holes drilled in the study area. Logs for the PG-, W-, and LG-series holes are based primarily on drill cuttings and drilling resistance (drillers' logs), whereas logs of the L-series wells also include data obtained from core samples and borehole geophysical logging.



EXPLANATION

—— 1670 – – ? STRUCTURE CONTOUR--Shows altitude of top of Muddy Creek Formation. Dashed where approximately located. Queried where uncertain. Contour interval 20 feet. Datum is sea level. Contours by D.E. Prudic

● WELL OR TEST HOLE--Used to contour top of Muddy Creek Formation. Data from numerous test holes were used to construct contours within the industrial complex; these wells are not shown on map. Contours in the industrial complex are modified from Geraghty and Miller (1980) and Smith (1985)

⟶ DIRECTION OF IMPLIED BURIED CHANNEL

FIGURE 4.--Altitude of the top of the Muddy Creek Formation.

A buried channel trending northeastward through the study area has been interpreted from the map showing altitude contours of the top of the Muddy Creek Formation (fig. 4). This channel may be a continuation of the buried channel identified by Geraghty and Miller, Inc. (1980, fig. 12), and modified by Smith (1985, plate 2) in the area of the industrial complex south of Boulder Highway. This buried channel was identified by Geraghty and Miller, Inc., as the primary pathway for the movement of organic substances caused by a surface spill(s) within the industrial complex, and for saline ground water resulting from disposal of industrial wastes into unlined ponds prior to 1977.

A second buried channel, trending parallel to Pabco Road (fig. 4), may be a continuation of another buried channel identified by Smith (1985), which was also thought to be a pathway for movement of contaminated ground water from the industrial complex. The exact directional trend of this channel is uncertain because of insufficient subsurface data.

GROUND-WATER LEVELS

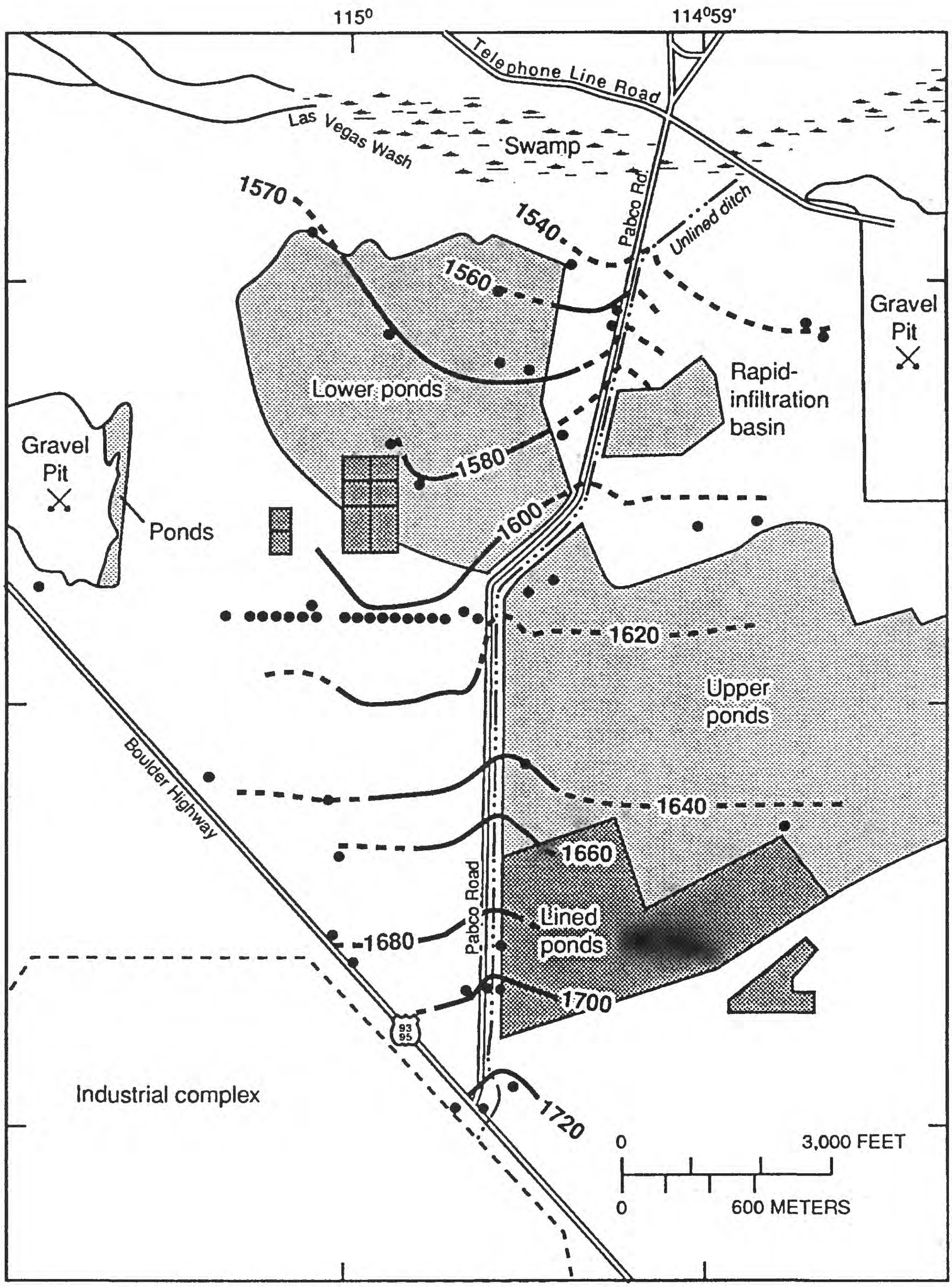
Changes During 1-Year Period prior to Diversion of Cooling Water into Pipeline

Ground-water levels were changing in the Pittman study area even before the pipeline was used to convey cooling water to Las Vegas Wash from the industrial complex. Figures 5 and 6 show ground-water levels for June 1984 and June 1985, times when the cooling water was still discharged into an unlined ditch that parallels Pabco Road (location of road is also shown in figs. 5 and 6). Slope of the ground-water table, as defined by altitudes of water-level contours in figures 5 and 6, generally mimic the overlying land-surface slope for both dates. The water table generally slopes northward toward Las Vegas Wash, indicating that ground water flows northward from the industrial complex to Las Vegas Wash.

The U-shaped contours in the vicinity of the unlined ditch parallel to Pabco Road (figs. 5 and 6) were based on the assumption that some water in the ditch seeped to the water table and that over a period of years seepage raised the water table almost to the bottom of the ditch. Trudeau (1981) reported that flow in the ditch ranged from 3 to 11 ft^3/s in 1980 and that about 1.5 ft^3/s seeped into the ground, according to point-discharge measurements along the course of the ditch. He reported losses between point measurements ranging from 0.6 to 2.9 ft^3/s. A seepage loss of about 2.4 ft^3/s was reported by the Bureau of Reclamation (1983). They also reported that flows in the ditch generally ranged from 8 to 12 ft^3/s.

Measurements of seepage losses in 1984 and 1985 (just prior to the diversion of surface water in the pipeline) are not available, nor is the amount of flow in the ditch. Flow at the outflow end of the pipeline after diversion generally ranged between 5 and 8 ft^3/s, which is within the range reported by Trudeau (1981). Thus, seepage losses of 1.5 ft^3/s were assumed for the periods of 1984 and 1985.

Trudeau (1981) estimated total recharge to the study area at about 8 ft^3/s in 1980, including about 0.4 ft^3/s as upward flow from the underlying Muddy Creek Formation near Las Vegas Wash. More than half of the recharge (about 4.5 ft^3/s) was estimated as recharge from sewage effluent discharged into unlined ponds in the study area. Presumably this value increased by 1985 as the population of Henderson increased. Trudeau assumed no recharge from direct precipitation or from runoff into the study area but included small amounts of recharge from lawn watering, industrial use, and ground-water inflow south of the study area.

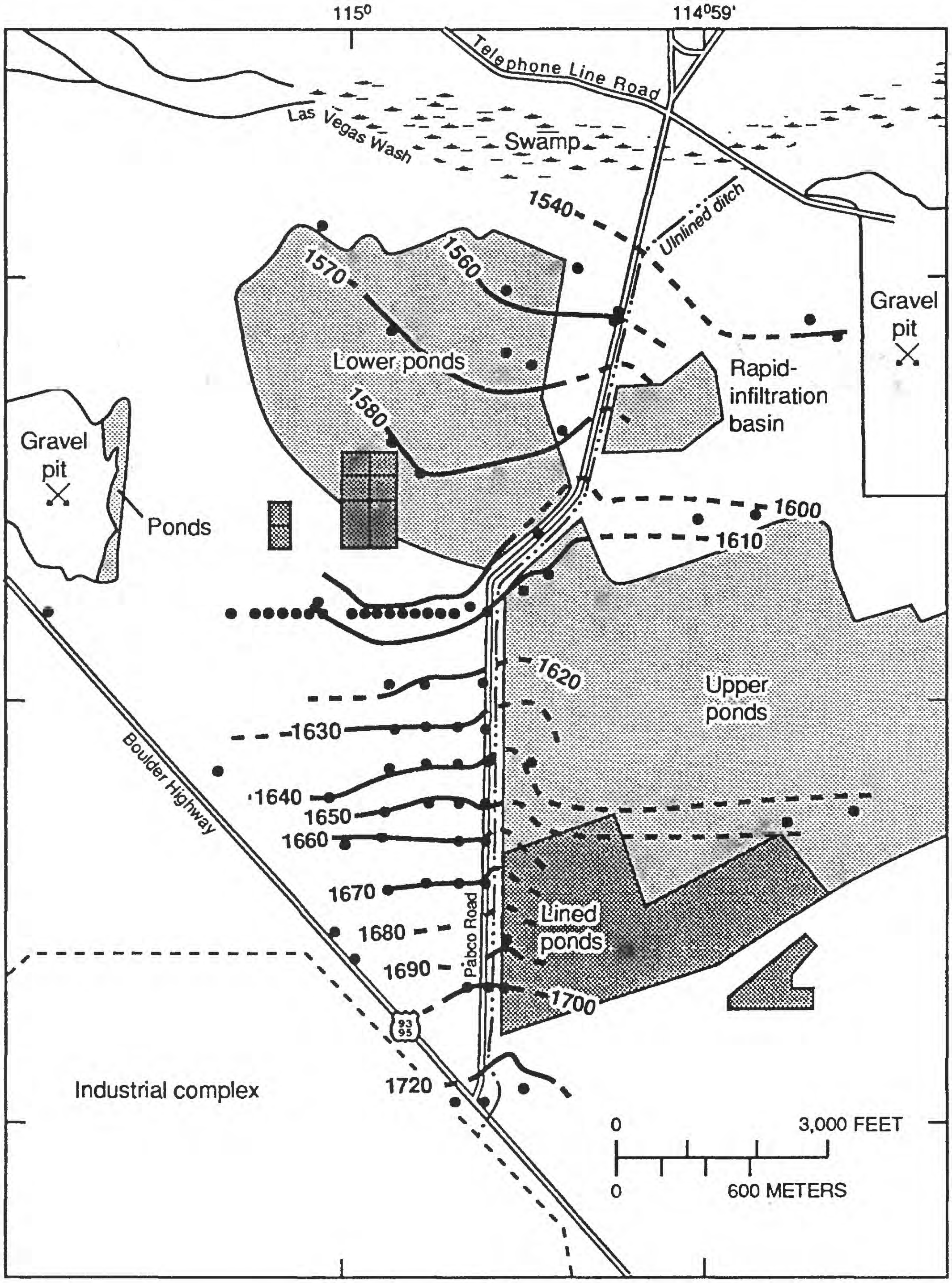


EXPLANATION

—— 1640 – – WATER-LEVEL CONTOUR--Shows altitude of water level in near-surface sands and gravels. Dashed where approximately located. Contour interval 20 feet, with supplemental contour at 1,570 feet. Datum is sea level

● MEASURED WELL

FIGURE 5.--Altitude of ground-water levels in the near-surface sands and gravels for June 1984.



EXPLANATION

—— 1540 – – WATER-LEVEL CONTOUR--Shows altitude of water level in near-surface sands and gravels. Dashed where approximately located. Contour interval 10 feet, except in areas of little control where interval is 20 feet. Datum is sea level

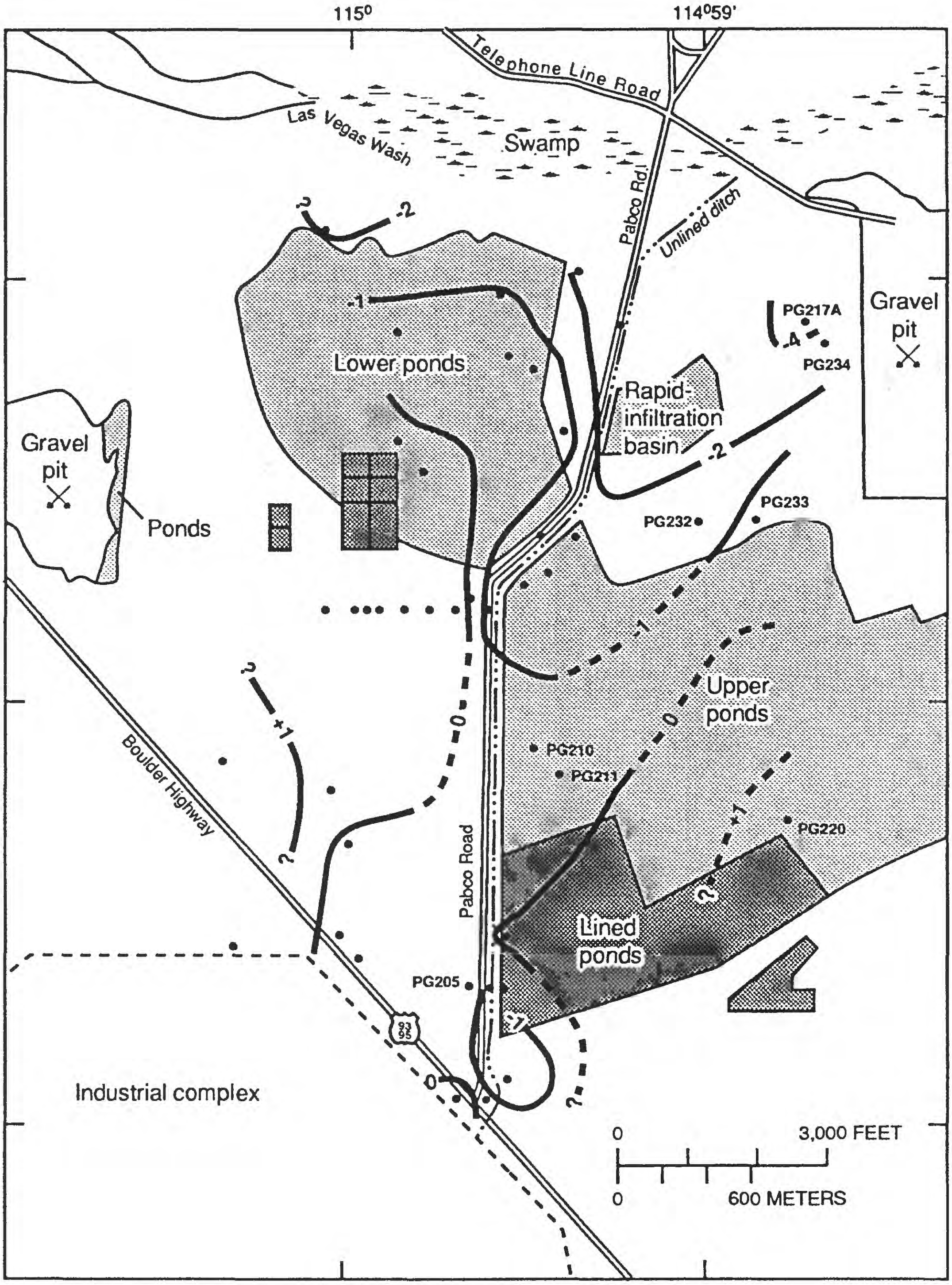
• MEASURED WELL

FIGURE 6.--Altitude of ground-water levels in the near-surface sands and gravels for June 1985.

The interpreted net change in ground-water levels between June 1984 and June 1985 is shown in figure 7. In general, water levels rose about 1 foot in the southeastern and southwestern parts of the Pittman study area and declined from 1 to 4 feet downgradient near Las Vegas Wash. The interpreted rise in water levels near the southeastern part of the study area is based on observed water-level rise of about 1.9 feet in well PG220 between June 1984 and June 1985. However, water levels declined about 7 feet in this well between January 1984 and September 1984 before rising 5 feet between September 1984 and June 1985 (fig. 22).

The small rise in ground-water levels rises near the southern part of the Pittman study area might be the result of recharge from precipitation during July and August 1984. Cumulative precipitation at nearby McCarran airport was 3.5 inches during that time and resulted mostly from several severe storms. Floods resulting from precipitation throughout Las Vegas Valley during this period contributed to large-scale erosion of the channel of Las Vegas Wash; about 10 feet of downcutting occurred near Pabco Road (P.A. Glancy, U.S. Geological Survey, oral commun., 1987). Water levels in many wells rose immediately following the precipitation and flood events (see hydrographs in fig. 22) suggesting that some of the rainfall recharged the shallow ground-water system in the Pittman study area. These water-level rises generally peaked in late 1984 and early 1985, after which levels began to decline; however, water levels did not peak until June 1985 in a few wells (for example, PG220 in fig. 22). Following the downcutting in Las Vegas Wash, water levels in wells near the wash declined below previously observed lowest levels. These excess declines (northeastern part, fig. 7) are attributed to nearby downcutting of the channel in Las Vegas Wash which lowered the altitude of the ground-water discharge to the wash.

Water levels in some wells did not rise following the precipitation and floods of July and August 1984, but instead continued to decline throughout most of 1984 and 1985. Most of the wells with continually declining water levels are located east of Pabco Road within or downgradient of the upper ponds (fig. 2). These wells include PG-wells 205, 210, 211, 217A, 232, 233, and 234 (fig. 7). The downward trend in water levels in these wells is unexplained but may reflect the cessation of discharge of industrial wastewater into the unlined ponds in 1977, or perhaps to a decrease in the amount of sewage effluent discharged to ponds closest to HSTP2 (fig. 2). Data on the distribution and exact amount of industrial wastewater and treated effluent discharged into unlined ponds before and during this period are unavailable.



EXPLANATION

—— -1 —— LINE OF EQUAL WATER-LEVEL CHANGE--Shows change in water level in near-surface sands and gravels. Approximately located. Contour interval 1 and 2 feet. Negative number indicates decline; positive number indicates rise

• PG205 MEASURED WELL--Names are shown for specific wells mentioned in text

FIGURE 7.--Change in ground-water levels in the near-surface sands and gravels between June 1984 and June 1985.

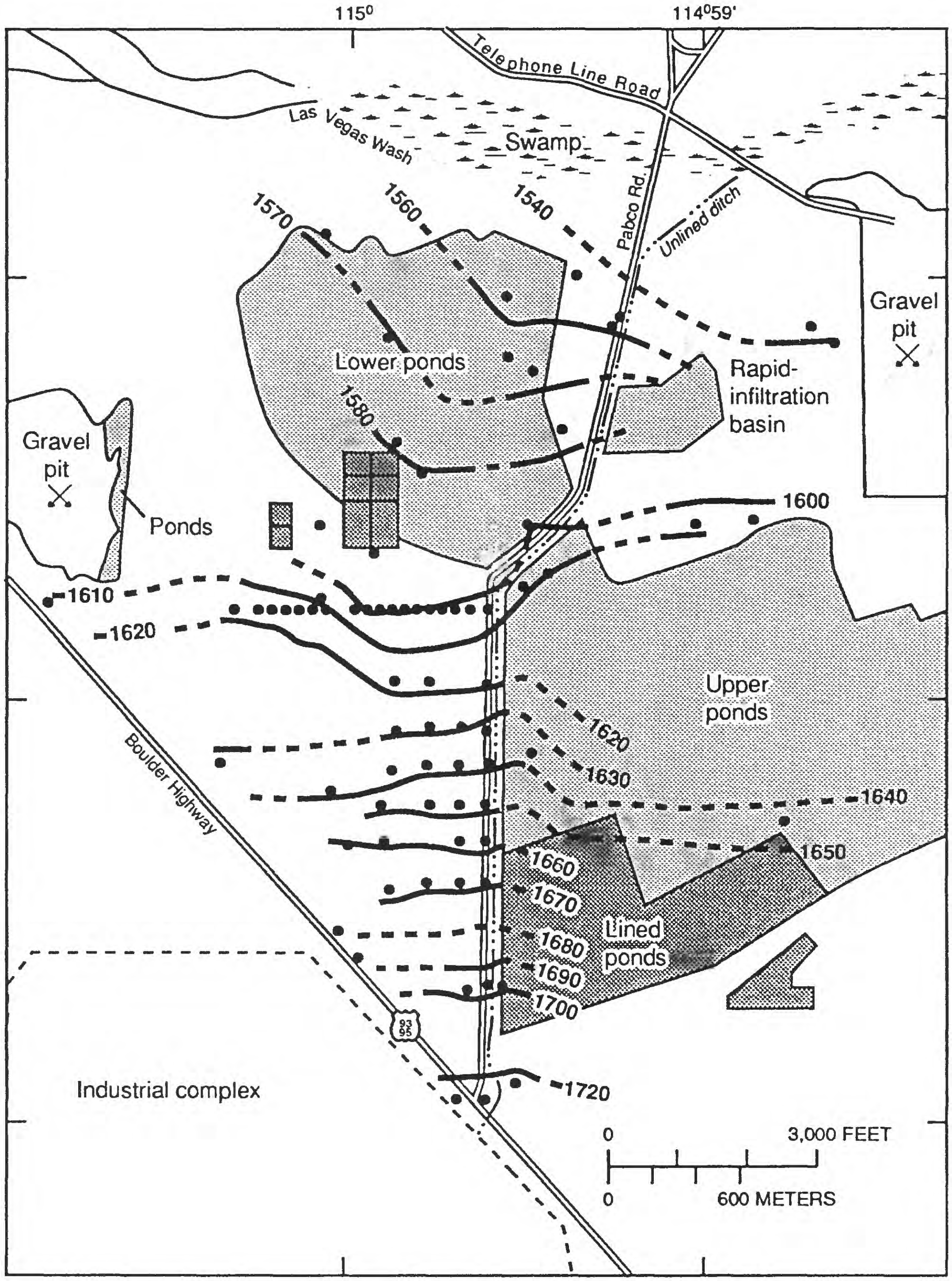
Changes During 2-Year Period after Diversion of Cooling Water into Pipeline

Water-level trends in the near-surface sands and gravels in the Pittman study area for June 1986 and June 1987 are shown from interpreted water-level contour maps in figures 8 and 9, respectively. The water-level contour maps are based on measurements from wells which were drilled to varying depths within the near-surface sands and gravels and which also have varying screened intervals. The contours were based on the assumption that vertical gradients within the unit are small and that the water levels measured in the wells represent the water table. This assumption is not unreasonable because the near-surface sands and gravels are generally 10-40 feet thick and consist of a relatively uniform mixture of sand, gravel, and silt, except near the buried channels, where the thickness of the deposits increases to more than 100 feet and where the deposits may be coarser grained.

The northward down-slope trend of ground-water levels for June 1986 and June 1987 is similar to that for June 1984 and June 1985 (figs. 5 and 6). The decline in water levels near the unlined ditch is evident in the interpreted net change in water levels between June 1985 and June 1986, as shown in figure 10. In general, water levels declined from 1 to 2 feet throughout the study area, except next to the unlined ditch, where water-level declines were generally more than 3 feet. Water-level declines of 7.1 and 6.9 feet were measured next to the unlined ditch at wells PG242 and L615, respectively. The large water-level decline near the south end of the upper ponds, as shown by the interpreted contour in figure 10, is unexplained but may be a continuation of a decline started after discharge of industrial wastewater ceased and sewage effluent into unlined ponds decreased. The interpreted contour is based on a 4-foot decline observed in well PG220 (figs. 10 and 22).

Ground-water levels continued to decline near the unlined ditch between June 1986 and June 1987, as shown by interpreted contours of net water-level change in figure 11. Water levels declined as much as 8 feet during this period near the intersection of Pabco Road and the Boulder Highway. However, observed water levels in wells remained constant near the north end of Pabco Road because treated effluent from HSTP3 was being discharged into the rapid-infiltration basin. Water levels also rose in well L676 (see hydrograph in fig. 22). The rise in well L676 is probably related to water discharged into a nearby pit by a concrete plant during part of this period.

Some cooling water was periodically diverted into the unlined ditch rather than through the pipeline between July 1985 and June 1987, at first because of problems with the pipeline, and later to water the plants (phreatophytes) next to the ditch. However, flow in the ditch seldom continued for long distances before seeping into the ground. Examples of ground-water-level changes caused by periodic pulses of water through the unlined ditch are shown in the hydrographs of PG wells 201, 202, 207, and 242 and of W wells 001, 002, 005, 006, and 009 (fig. 22).

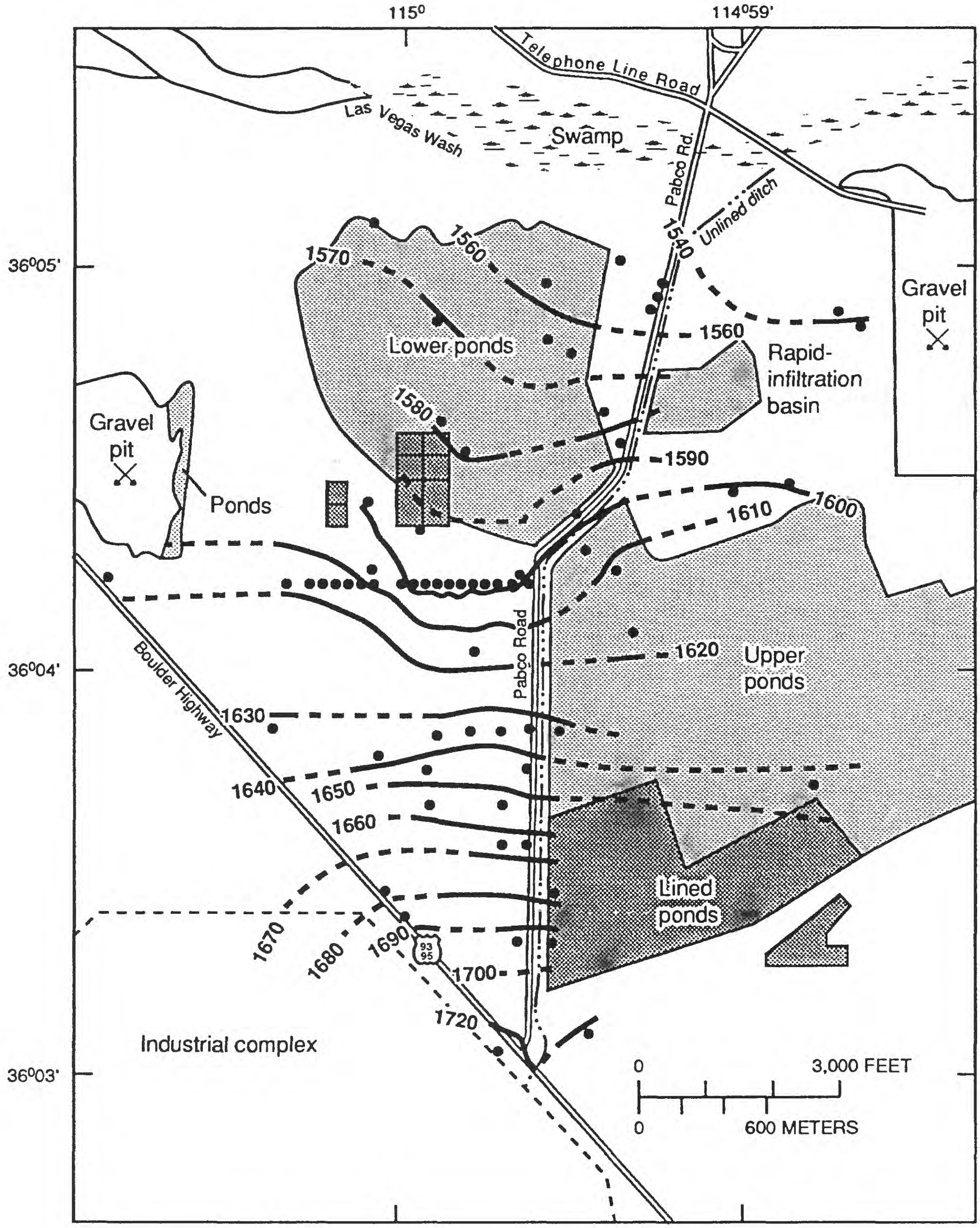


EXPLANATION

—— 1640 – – WATER-LEVEL CONTOUR--Shows altitude of water level in near-surface sands and gravels. Dashed where approximately located. Contour interval 10 feet except in areas of little control, where interval is 20 feet. Datum is sea level

● MEASURED WELL

FIGURE 8.--Altitude of ground-water levels in the near-surface sands and gravels for June 1986.

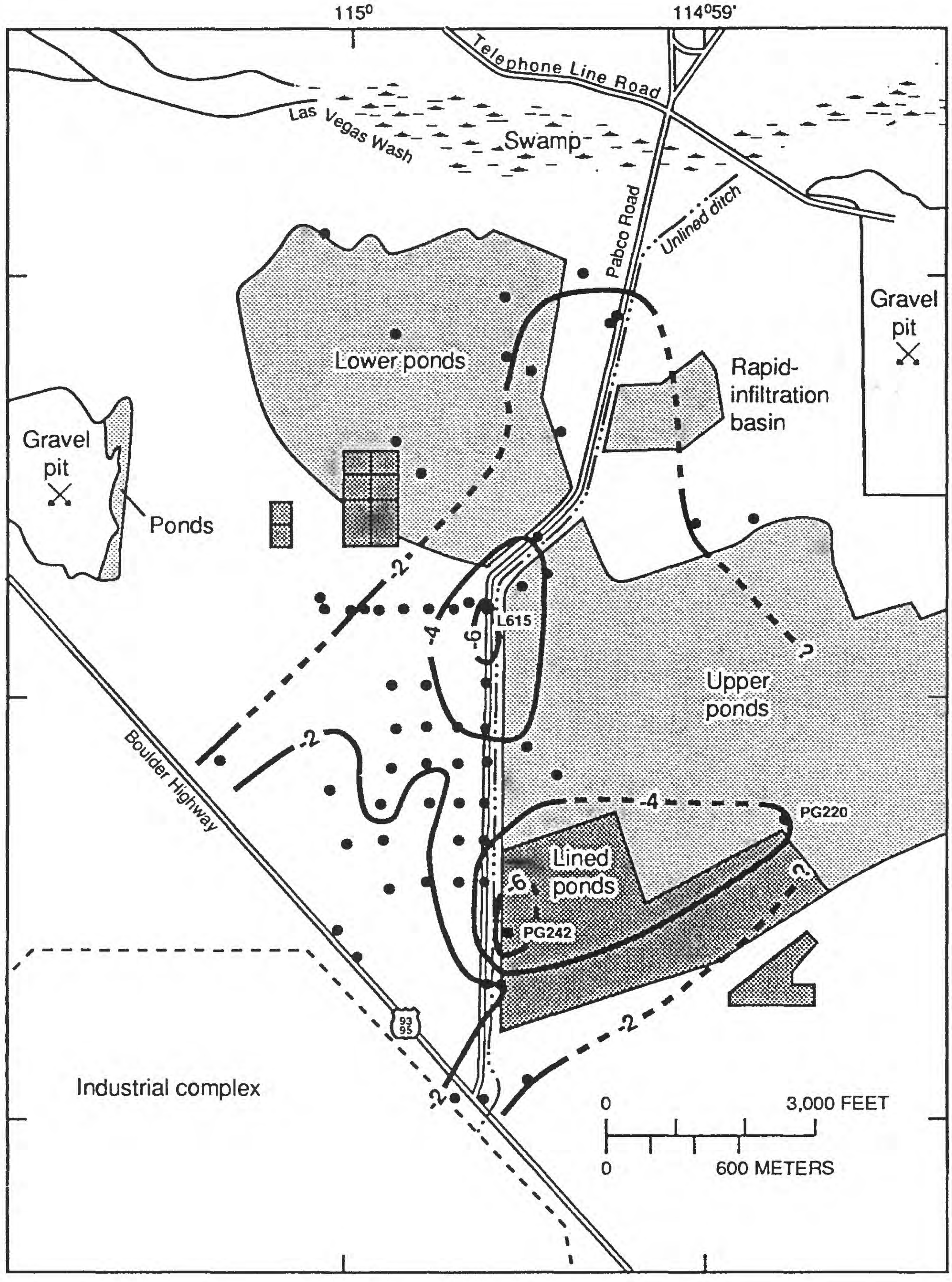


EXPLANATION

— 1640 - - WATER-LEVEL CONTOUR--Shows altitude of water level in near-surface sands and gravels. Dashed where approximately located. Contour interval 10 feet except in areas of little control, where interval is 20 feet. Datum is sea level

• MEASURED WELL

FIGURE 9.--Altitude of ground-water levels in the near-surface sands and gravels for June 1987.

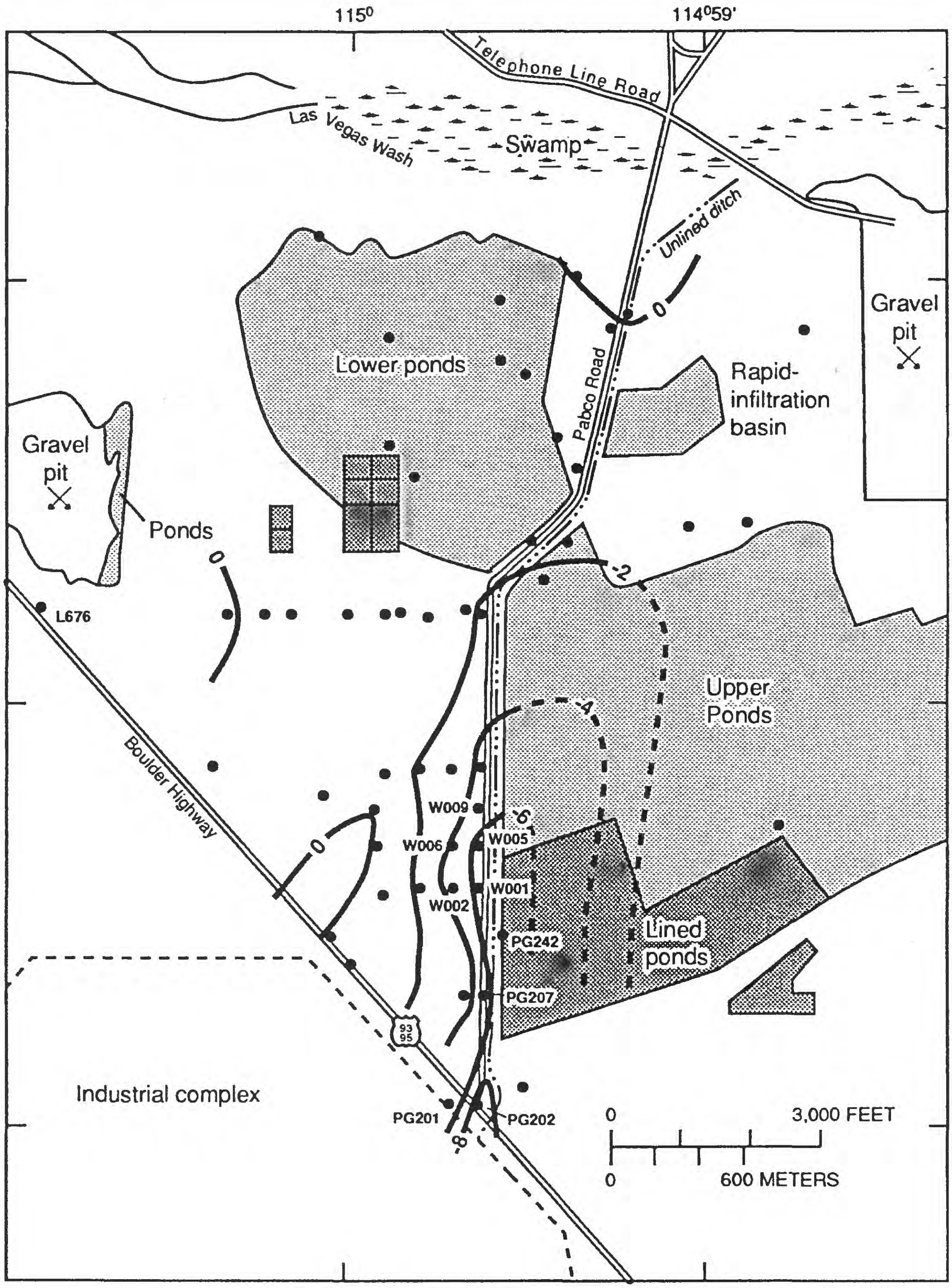


EXPLANATION

-2 LINE OF EQUAL WATER-LEVEL CHANGE--Shows change in water level in near-surface sands and gravels. Approximately located. Contour interval 2 feet. Negative number indicates decline; positive number indicates rise

PG220 ● MEASURED WELL--Names are shown for specific wells mentioned in text

FIGURE 10.--Change in ground-water levels in the near-surface sands and gravels between June 1985 and June 1986.



EXPLANATION

—— -1 —— LINE OF EQUAL WATER-LEVEL CHANGE--Shows change in water level in near-surface sands and gravels. Approximately located. Contour interval 2 feet. Negative number indicates decline; positive number indicates rise

PG202 ● MEASURED WELL--Names are shown for specific wells mentioned in text

FIGURE 11.--Change in ground-water levels in the near-surface sands and gravels between June 1986 and June 1987.

Interpretation of water-level changes in wells along three alignments, one parallel and two transverse to the general direction of ground-water flow (locations shown in fig. 12) between June 1984 and June 1987 are shown in three vertical sections (figs. 13-15). Ground-water levels changed little along the unlined ditch between wells PG201 and PG242 (fig. 13--note water-level data from the W-series wells were not available until 1985) between June 1984 and June 1985, but generally declined more than a foot between wells L615 and Las Vegas Wash. The sharp water-level declines in wells near Las Vegas Wash may be related to downcutting of the wash channel. Water levels declined in most wells between June 1985 and June 1986, the first year water was diverted into the pipeline. Ground-water levels continued to decline between June 1986 and June 1987 except north of PG250 where water levels remained relatively constant, perhaps due to the periodic discharge of treated effluent from HSTP3 into a rapid infiltration basin east of Pabco Road. By June 1987, the near-surface sands and gravels were almost fully drained between wells PG201 and PG202, and between wells W013 and L615 (fig. 13).

Water-level changes in wells along the Pittman lateral between June 1984 and June 1987 are shown in figure 14. The vertical section shows high ground-water levels beneath the unlined ditch near Pabco Road until June 1985, but after cooling water was diverted through the pipeline ground-water levels beneath the ditch declined. By June 1987, ground-water levels beneath and near the ditch had declined about 15 feet. Water levels declined about 3 feet in well L633 (about 2,000 feet west of the ditch) between June 1985 and June 1987 (fig. 14). A similar decline was measured at well PG233 (about 2,600 feet southeast of the ditch; see fig. 12).

Water-level changes in wells just south of Las Vegas Wash (section C-C' in fig. 12) are shown in figure 15. Although ground-water levels declined between June 1985 and June 1986 in most wells within the Pittman study area, the declines in these wells shown in figure 15 may be more of a continuation of declines related to the erosion and consequent downcutting of the wash channel rather than the result of a reduction in recharge by cessation of flow in the unlined ditch. Ground-water-level declines for wells along the vertical section C-C' were minimal between June 1986 and June 1987. The lack of declines in wells PG253 and PG256 during this period may be the result of treated effluent being discharged from HSTP3 into the rapid-infiltration basin just upgradient.

Summary of Water-Level Changes

In summary, ground-water levels were monitored in the Pittman study area to try to establish what effect the diversion of cooling water through a pipeline had on ground-water levels in the vicinity of the unlined ditch. Prior to and during the study period, many changes in land use and unusual precipitation events changed the amount and distribution of recharge to the shallow ground-water system. Unusual precipitation events during July and August 1984 may have raised water levels in many wells. Floods resulting from that precipitation contributed to erosion and downcutting of the wash channel, which lowered the discharge outlet for ground water near the wash. The changing practices of disposal of industrial wastewater and of treated effluent from the Henderson sewage treatment plants changed the distributions of recharge to the shallow ground-water flow system. The net effect of these changes makes it extremely difficult to quantitatively determine the net change in ground-water levels in the Pittman study area caused by diverting water from the unlined ditch into a pipeline.

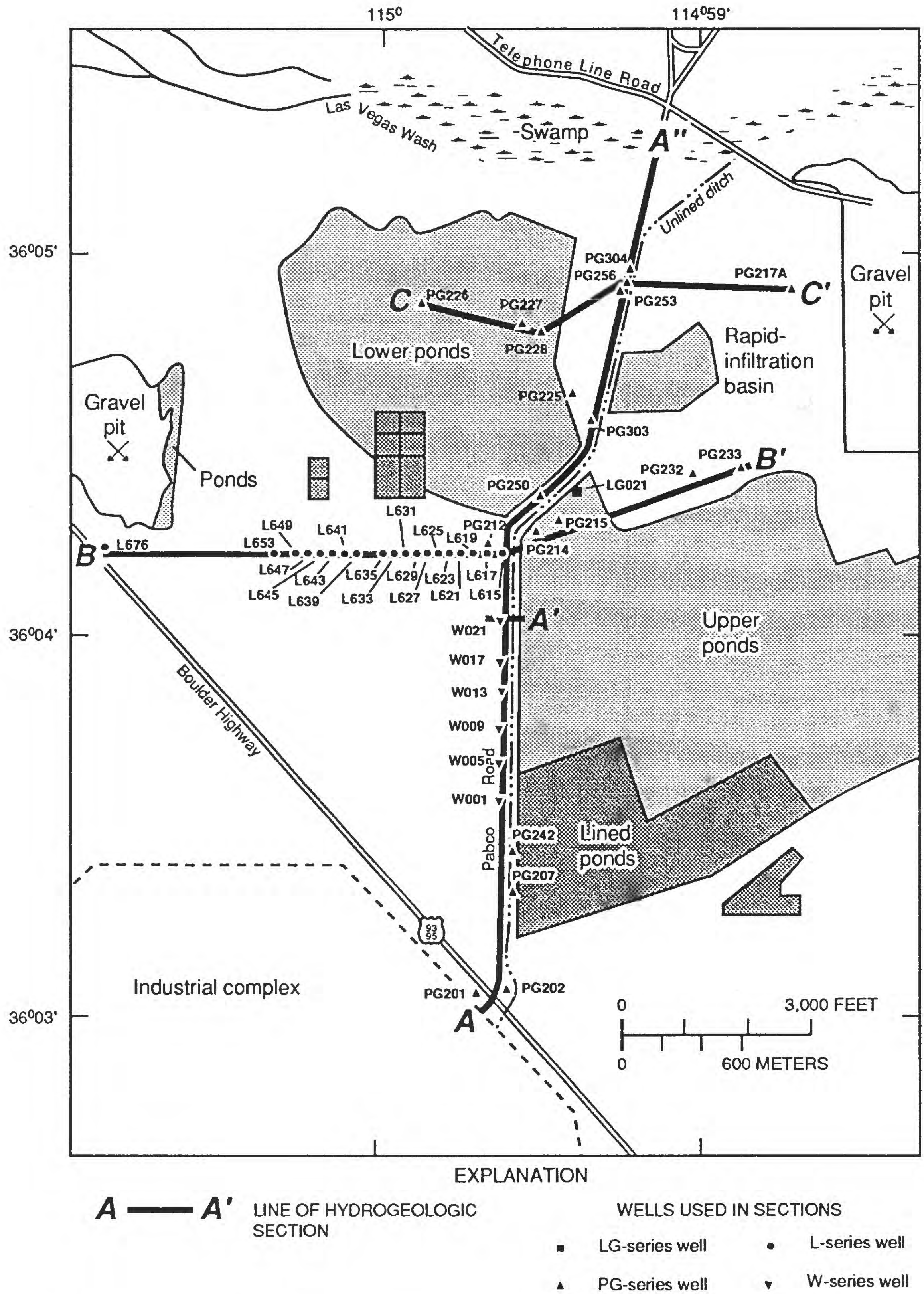


FIGURE 12.-- Location of three hydrogeologic sections used to show changes in ground-water levels between June 1984 and June 1987.

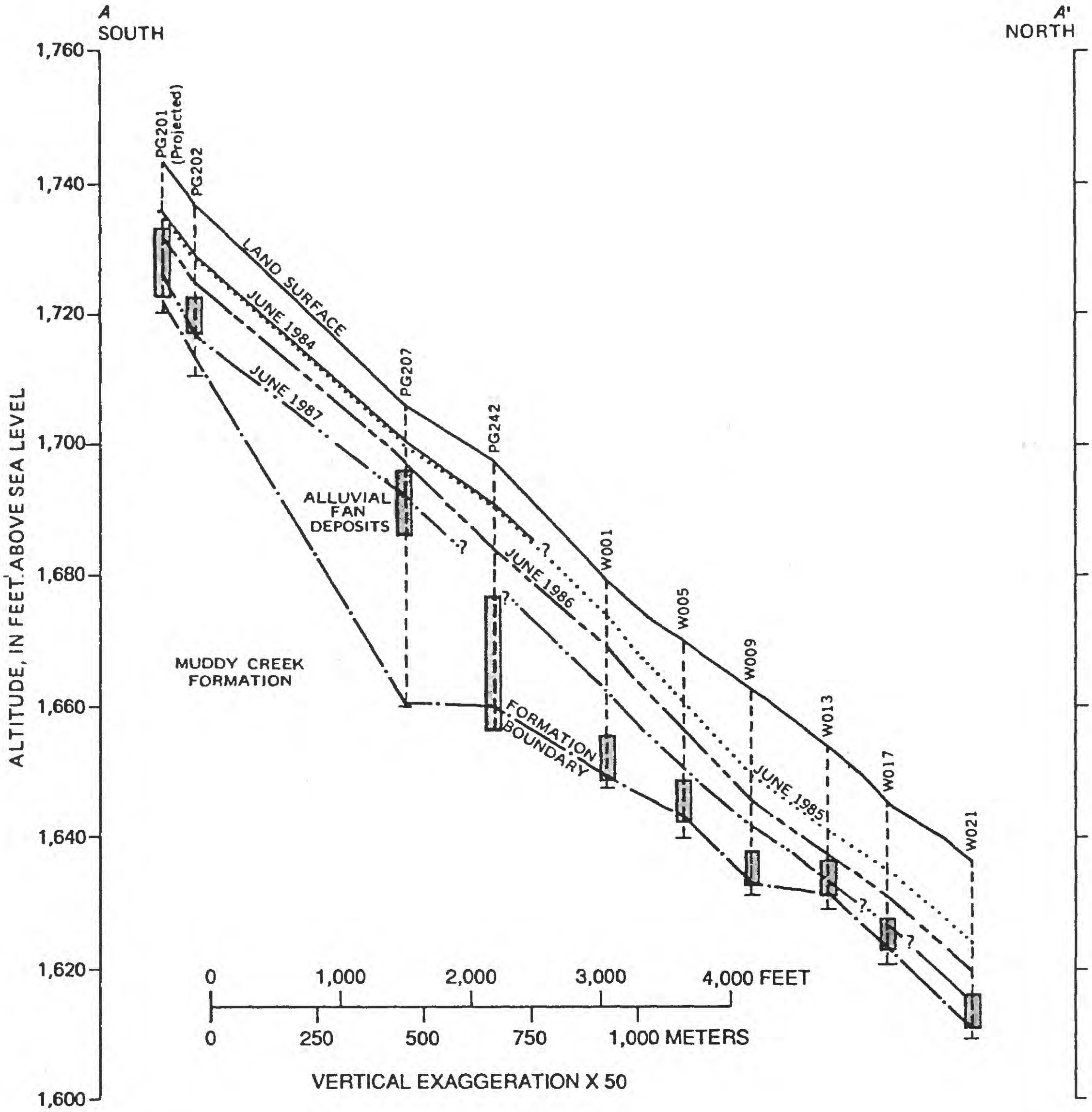


FIGURE 13.--Changes in ground-water levels between June 1984 and June 1987 along hydrogeologic section A-A", which parallels Pabco Road from Boulder Highway north to Las Vegas Wash. An unlined ditch parallels Pabco Road and was used to convey cooling water from the industrial complex to Las Vegas Wash between 1975 and June 1985. Location of section A-A" and wells used in section is shown in figure 12. Position and depth of well or test hole are shown by dashed vertical lines. Screened interval is shaded.

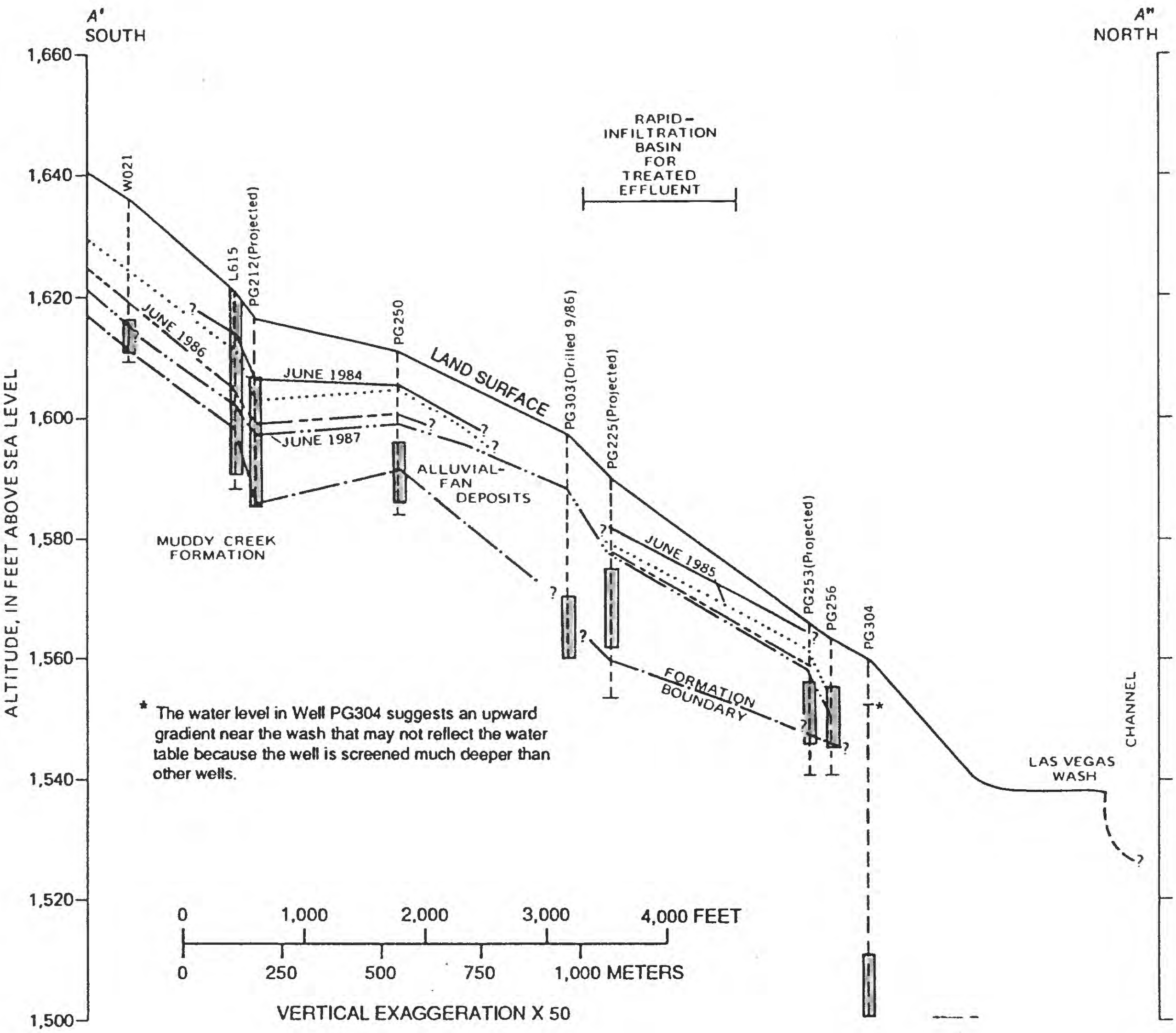


FIGURE 13.--Continued.

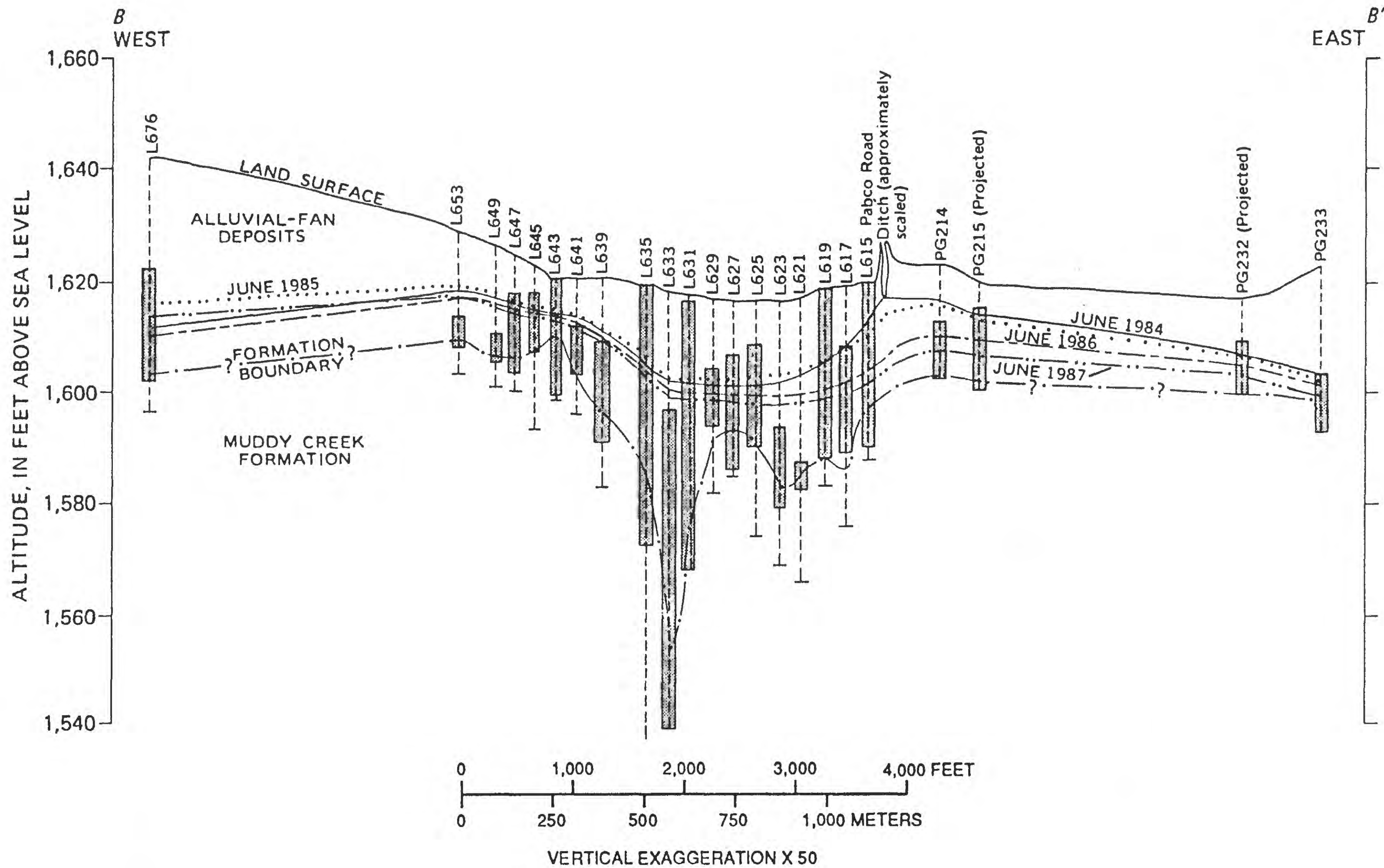


FIGURE 14.--Changes in ground-water levels between June 1984 and June 1987 along section B-B', which parallels Pittman lateral and is transverse to Pabco Road. An unlined ditch parallels Pabco Road and was used to convey cooling water from the industrial complex to Las Vegas Wash between 1975 and June 1985. Location of section B-B' is shown in figure 12. Position and depth of well or test hole are shown by dashed vertical lines. Screened interval is shaded.

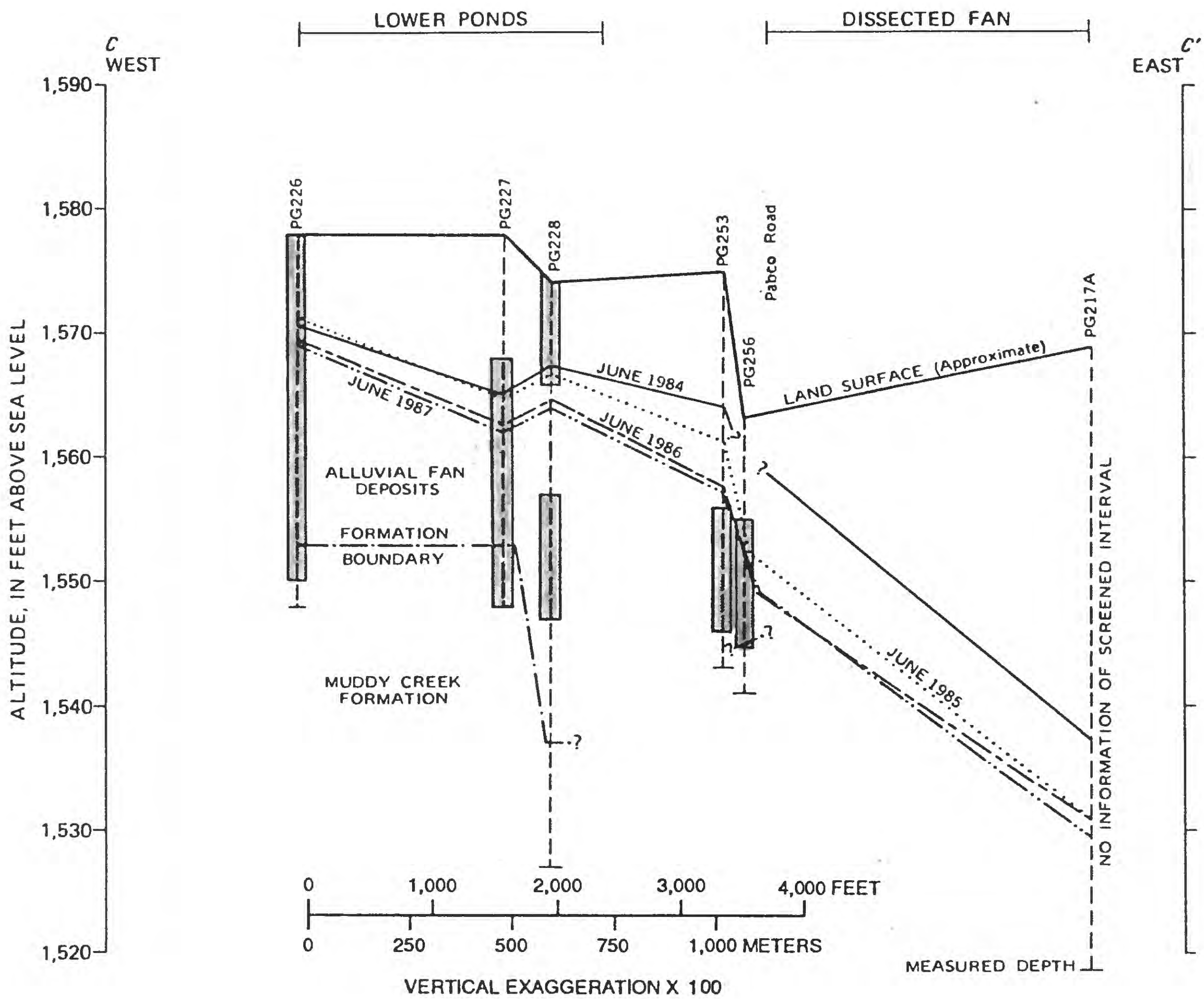


FIGURE 15.--Changes in ground-water levels between June 1984 and June 1987 along section C-C', which approximately parallels Las Vegas Wash and is transverse to Pabco Road. An unlined ditch parallels Pabco Road and was used to convey cooling water from the industrial complex to Las Vegas Wash between 1975 and June 1985. Location of section C-C' is shown in figure 12. Position and depth of well or test hole are shown by dashed vertical lines. Screened interval is shaded.

GROUND-WATER QUALITY

Chemical Character prior to Diversion of Cooling Water into Pipeline

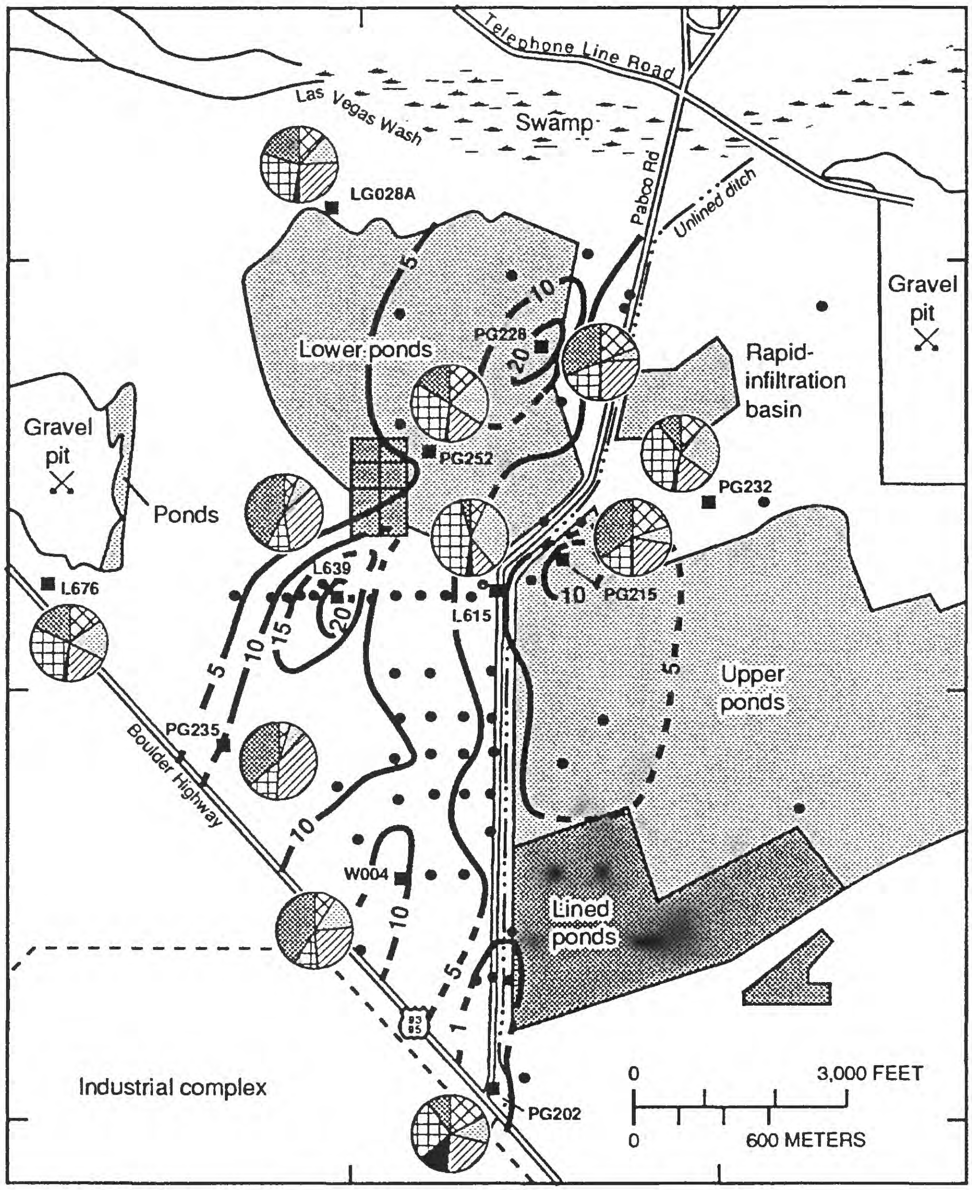
Estimated lines of equal dissolved-solids concentrations in the shallow ground water of the near-surface sands and gravels within the Pittman study area during June 1985 (before the pipeline became operational) are shown in figure 16. Actual concentrations could be different in sections where no data exist. The lines are shown only to give a general indication of those areas where large differences in dissolved-solids concentrations exist.

The lines of equal dissolved-solids concentrations are based on water samples collected from wells which were drilled to varying depths within the near-surface sands and gravels and which also have varying screened intervals. The lines were drawn assuming that the water chemistry does not vary with depth within the unit. This assumption may be reasonable because the near-surface sands and gravels are generally only 20-40 feet thick (except in areas of buried channels) and available data suggest the deposits are permeable (Trudeau, 1981).

Dissolved-solids concentrations in shallow ground water in the Pittman area range from less than 1,000 mg/L to more than 20,000 mg/L (fig. 16). The variation is the result of a variety of past and present industrial and municipal waste-disposal practices that have allowed waters of different chemistry to infiltrate into the near-surface sands and gravels. Although some qualitative statements can be made regarding the variation in chemistry of the shallow ground water in the Pittman area, detailed relations between the chemical composition of the infiltrating water and the chemical composition of the shallow ground water are difficult to assess. Lack of information on the volumes of wastewater previously discharged into unlined ditches and ponds, the locations of the discharge, and the chemical variability of the wastewater complicate the assessment.

The variability of the chemical composition of the shallow ground water is also shown by percentages of the major ions (determined from milliequivalents per liter) dissolved in water sampled from wells (fig. 16). The more dilute ground water in the Pittman area coincides with the upper end of the unlined ditch (near well PG202) where dissolved-solids concentrations of water sampled from wells were less than 1,000 mg/L. The concentrations are similar to the concentrations of water (about 850 mg/L) sampled from the ditch near the Boulder Highway in 1983 (Roline and Sartoris, 1984, table N-3). These concentrations of dissolved solids are typical of water in the ditch (U.S. Bureau of Reclamation, 1983, p. 2).

The percentage of major ions dissolved in the ditch water for samples reported by Roline and Sartoris (1984) is shown in figure 17. The water has nearly the same composition as the shallow ground water near the upper end of the ditch (fig. 16 and table 2). However, the chemical composition of the shallow ground water near the ditch changes downgradient as the percentages of calcium and sulfate increase northward. The ratio of sulfate to chloride (values in milliequivalents per liter) in the ditch water and in water from well PG202 is about 1.8 but the ratio increases to 10 in water from well L615 (fig. 16). This suggests that ditch water seeping into the ground may be dissolving gypsum in the shallow deposits near the ditch.



EXPLANATION

—5— — LINE OF EQUAL DISSOLVED-SOLIDS CONCENTRATION -- Shows concentrations for ground water in near-surface sands and gravels, in thousands of milligrams per liter. Dashed where approximately located. Interval 5,000 milligrams per liter, with supplemental line at 1,000 milligrams per liter

● SAMPLED WELL

PG202 ■ SAMPLED WELL, WITH DIAGRAM SHOWING PERCENTAGE OF MAJOR IONS DISSOLVED IN WATER -- Percentages determined from milliequivalents per liter by dividing individual concentrations by sum and multiplying by 100

Magnesium
Calcium
Sodium + potassium
Bicarbonate
Sulfate
Chloride

FIGURE 16.--Distribution of dissolved-solids concentrations in, and representative chemical character of, ground water in the near-surface sands and gravels for June 1985.

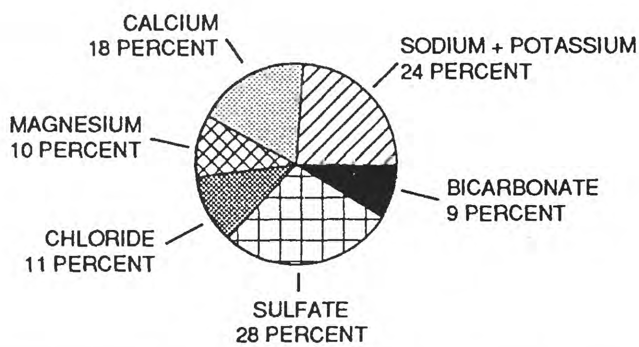


FIGURE 17.--Percentage of major ions dissolved in water sample from unlined ditch near the Boulder Highway, February 1983. Dissolved-solids concentration, 835 milligrams per liter. Concentrations for samples collected in July and August 1983 were 874 and 844 milligrams per liter, respectively (Roline and Sartoris, 1984, table N-3). Percentages were determined from milliequivalents per liter by dividing individual concentrations by the sum of the major constituents and multiplying by 100.

The chemical composition of the shallow ground water throughout much of the study area has probably been affected (to some degree) by post and present practices of industrial and municipal wastewater disposal. However, the chemical composition of water from wells L676, LG028A, and PG232 (fig. 16) is similar to the composition of water from shallow wells in the vicinity of the study area as reported by Malmberg (1965, p. 100). Water from these wells may represent the chemical composition of ground water not greatly affected by industrial wastewater.

The shallow ground water in areas of high dissolved-solids concentrations (exceeding 10,000 mg/L) tends to have higher percentages of chloride (fig. 16). Water in the areas of high dissolved solids between wells PG235 and L639 and near well W004 is primarily a sodium-chloride type. The source of this water may be from the industrial complex where dissolved-solids concentrations have been reported as high as 34,000 mg/L (Geraghty and Miller, Inc., 1980, Appendix D) with chloride the dominant anion. The ratio of sulfate to chloride for several analyses of shallow ground water in the industrial complex (Geraghty and Miller, Inc., 1980, Appendix D) is about 0.25 which is about the same as the ratio of water from wells PG235 (0.36), L639 (0.22), and W004 (0.30). The distribution of high dissolved-solids concentrations near PG235 and L639 align along what has been interpreted as a buried channel in the surficial sands and gravels as shown in figure 4. The area of high dissolved solids in well W004 aligns approximately with a buried channel described by Smith (1985).

The chemical composition of ground water in areas of high dissolved-solids concentrations near wells PG215 and PG228 is different than elsewhere (fig. 16). Water in these areas is primarily a sodium-magnesium-chloride type. The origin of the higher magnesium concentrations is unknown but may be due to past disposal of wastewater from the processing of magnesium and titanium ores into unlined ponds nearby.

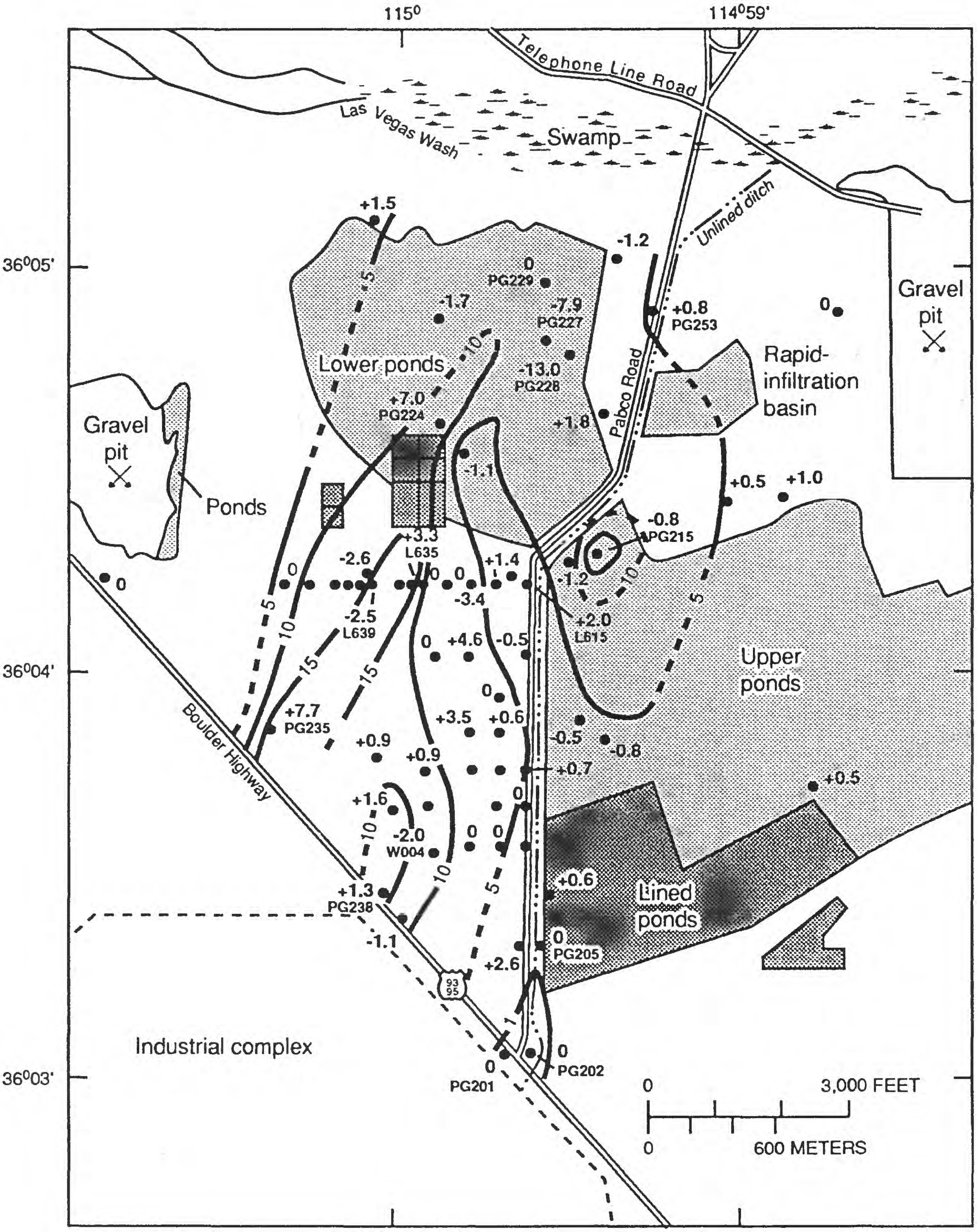
Changes after Diversion of Cooling Water into Pipeline

The change in dissolved-solids concentrations in the Pittman area between June 1985 and June 1986 is extremely complex. Estimated lines of equal dissolved-solids concentration in the shallow ground water within the Pittman study area 1 year after cooling water from the industrial complex was diverted into a pipeline (June 1986) are shown in figure 18. The same constraints regarding the contours as those outlined at the beginning of the previous section for figure 16 also apply to figure 18. The general contour patterns are similar to those shown prior to diversion, with the most dilute ground water located near the intersection of Pabco Road and Boulder Highway (wells PG201 and PG 202) and the highest dissolved-solids concentrations at wells PG235, L639, and PG215.

The most striking difference in the dissolved solids concentrations between June 1985 and June 1986 is the large decrease in dissolved solids in water sampled from wells PG227 and PG228 (fig. 18). These decreases are about 7,900 and 13,000 mg/L, respectively. The reason for the decrease in these wells is unknown. It may be related to dilution from treated effluent or the continued migration of water contaminated with industrial wastewater previously discharged into unlined ponds nearby. The decrease in well PG228 (fig. 18), however, is more likely the result of its construction. This well is the only well with two separate screened intervals (0 to 8 feet and 17 to 27 feet below land surface; table 1), and between June 1985 and June 1986 the water level declined below the upper screened interval (fig. 15). Because the well was bailed, the higher concentrations may reflect water from the upper screened interval whereas later samples may reflect water from the deeper interval. If the decrease in dissolved-solids concentrations is due to water being sampled from two different intervals, then the assumption that no vertical variation of dissolved solids exists in the shallow deposits may not be valid.

Alternatively, the high dissolved-solids concentrations, exceeding 18,000 mg/L, of water sampled from well PG228 could be from surface seepage through the upper screened interval. The well is located on the bottom of an abandoned pond once used to dispose of industrial wastewater. The surface of the pond is coated with a fine residue, a remnant of past disposal activities. Precipitation during July and August 1984 may have dissolved minerals in the residue, seeped into the well through the upper screened interval, and temporarily increased the dissolved-solids concentrations in the well.

The chemical composition of water sampled from selected wells adjacent to the unlined ditch is shown in figure 19 for June 1985 and June 1986. Included in the figure are chemical analyses of cooling water sampled from the unlined ditch near well PG201 (fig. 18) in 1983 and reported by Roline and Sartoris (1984, table N-3) and an average of several chemical analyses of treated sewage effluent reported by Trudeau (1981, p. 35).



EXPLANATION

—5— — LINE OF EQUAL DISSOLVED-SOLIDS CONCENTRATION -- Shows concentrations for ground water in near-surface sands and gravels, in thousands of milligrams per liter. Dashed where approximately located. Interval variable

+1.3 ● PG238 SAMPLED WELL -- Value is change in dissolved-solids concentration between June 1985 and June 1986, in thousands of milligrams per liter. Positive value indicates increase in concentration; negative value indicates decrease. Names are shown for specific wells mentioned in text

FIGURE 18.--Distribution of dissolved-solids concentrations in ground water in the near-surface sands and gravels for June 1986, and change in dissolved-solids concentration between June 1985 and June 1986.

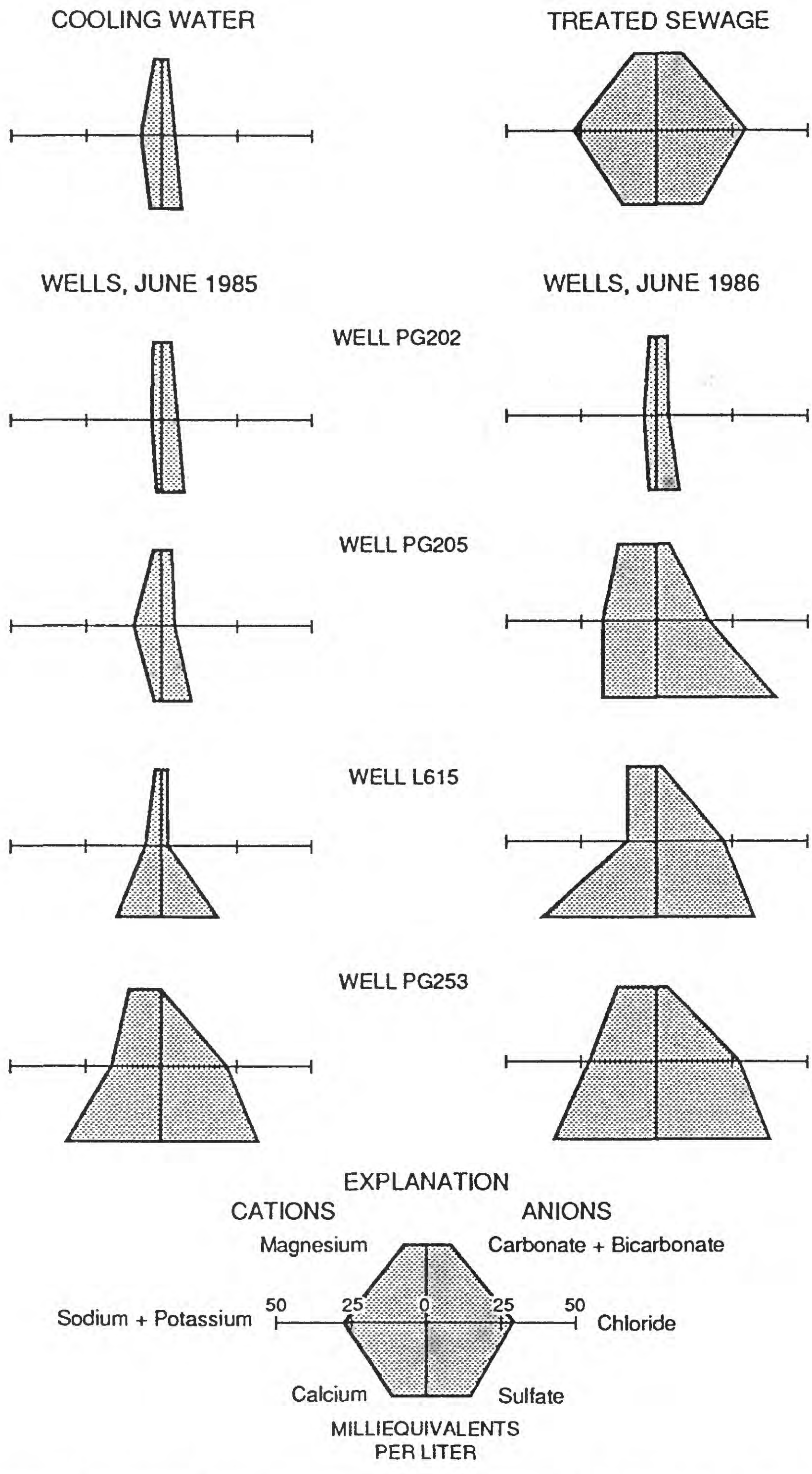


FIGURE 19.--Chemical composition of cooling water, treated sewage, and changes in chemical composition of water sampled from selected wells adjacent to unlined ditch during June 1985 and June 1986. Well locations are shown in figure 18. Chemical composition of water for wells is shown in downgradient order, from PG202 to PG253. Analysis of cooling water in unlined ditch is from Roline and Sartoris (1984, table N-3); analysis of treated sewage is from Trudeau (1981, p. 35), and represent an average for the period 1978-80.

The chemical composition of water sampled from well PG202 did not change between June 1985 and June 1986 and was nearly the same as that of cooling water on both dates. In contrast, the chemical composition of water from well PG205 changed considerably between June 1985 and June 1986. All major ions increased except bicarbonate.

The greatest change in chemical composition of the major ions in wells adjacent to the ditch is in water from well L615 where calcium, magnesium, and chloride concentrations increased considerably (fig. 19). The higher concentrations of chloride decreased the sulfate-to-chloride ratio from 10 in June 1985 to only 1.3 in June 1986. The source of increased concentrations of magnesium and chloride may be from ground water to the southeast beneath old ponds where wastewater from the processing of magnesium and titanium ores was once discharged. This water may have begun moving northwestward once seepage in the ditch stopped.

Concentrations of most major ions also increased in water from well PG253 (fig. 19) near the north end of the ditch (fig. 18). The chemical composition of water from this well suggests that the water may be from a combination of sources including treated effluent, industrial wastewater, and seepage from the ditch. Thus, it is difficult to assess whether the change is a result of diverting cooling water into the pipeline or the result of changing industrial or municipal wastewater disposal practices.

During the period June 1985 through June 1986, the chemical composition of the shallow ground water also changed in areas of observed high dissolved-solids concentrations (fig. 20). The chemical composition of water sampled from well PG224 changed from primarily a calcium-sodium-magnesium-sulfate water in June 1985 to predominantly a sodium-chloride water in June 1986 when concentrations of dissolved solids and chloride reached a peak (fig. 21). The source of the sodium chloride is unknown but may be from past disposal of industrial wastewater originating from the industrial complex to the south, and passing near wells PG235 and L639 (figs. 18 and 20). The area of high dissolved-solids concentrations (fig. 18), which consists of predominantly sodium-chloride water, is within a fairly narrow band that corresponds to an interpreted buried channel in the near-surface sands and gravels.

The principal change in the chemical composition of water sampled from well PG215 between June 1985 and June 1986 was a decrease in chloride concentrations and an increase in sulfate concentrations (fig. 20). The concentration of magnesium decreased slightly. These changes may be related to diverting cooling water into the pipeline owing to the proximity of the well to the ditch. Well PG215 is located just upgradient from where the ditch bends eastward and across the general direction of ground-water flow. Whether or not seepage from the ditch blocked northward flow of ground water near well PG215 is unknown. It does, however, partly explain the occurrence of the high dissolved-solids concentrations in well PG215, particularly, since discharge of wastewater from the processing of magnesium and titanium ores into the upper ponds ceased in 1977.

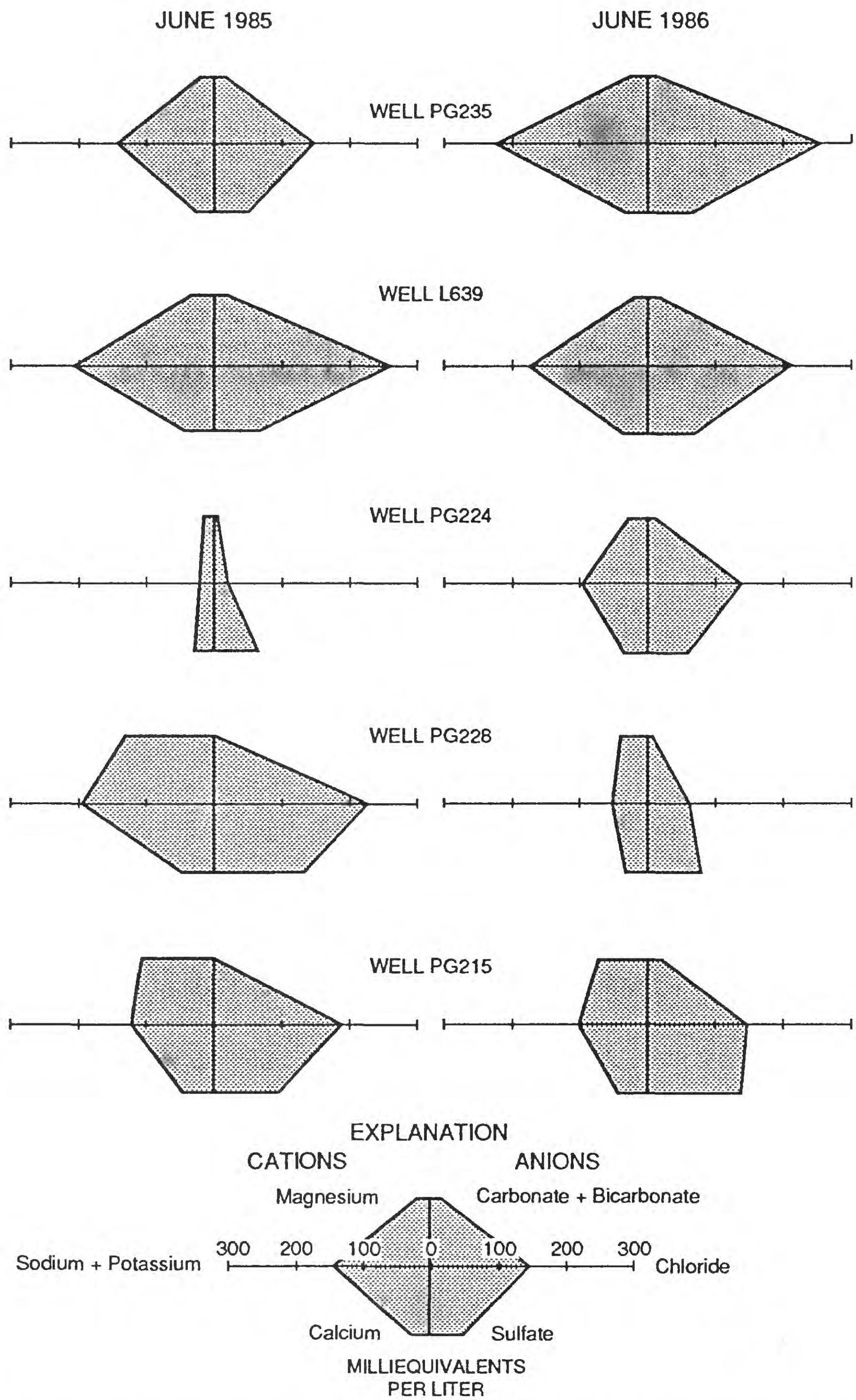


FIGURE 20.--Changes in chemical composition of water sampled from selected wells in areas of high dissolved-solids concentrations during June 1985 and June 1986. Well locations are shown in figure 18. Wells PG235, L639, PG224, and PG228 are in downgradient order in the general direction of ground-water flow. Well PG215 is in an area of high dissolved-solids concentrations east of Pabco Road.

Because the scope of the project changed in February 1987, water samples were collected from only 29 wells in June 1987; five were new as of October 1986. Thus, a map showing contours of dissolved solids and changes in dissolved-solids concentrations similar to figure 18, for the period June 1986 to June 1987, is not included. Rather, the variations in dissolved solids, chloride, and sulfate for the period from January 1985 to June 1987 are shown for eight selected wells (fig. 21). The varied patterns of change in water chemistry between the eight wells illustrate the complexity of past and present movement of water with differing chemical composition through the near-surface sands and gravels in the Pittman study area.

The greatest increase in dissolved-solids concentrations between January 1985 and June 1987 was 7,000 mg/L, measured in water collected from wells PG235 and PG224 (fig. 21). Maximums in both wells were measured in June 1986. Thereafter, the concentrations remained nearly constant in well PG235, but decreased about 3,000 mg/L, to less than 9,000 mg/L, in well PG224. The largest change in dissolved-solids concentrations near the unlined ditch between January 1985 and June 1987 was about 3,000 mg/L, in water sampled from well L615 (fig. 21).

Dissolved-solids concentrations did not change in water from well PG201 (near unlined ditch) between June 1986 and June 1987, but dissolved solids continued to increase in water from well L615 (fig. 21). Interestingly, chloride concentrations remained nearly constant in water from L615 during this period in contrast to the rapid increase measured in the first 6 months of 1986. Elsewhere during the period from June 1986 to June 1987, chloride concentrations increased in water from well PG229, decreased in water from wells PG215 and PG224, and remained nearly constant in water from wells L639, PG228, and PG235 (fig. 21).

Summary of Water-Quality Changes

Water was periodically sampled from wells in the Pittman study area in an attempt to establish what effect diversion of cooling water through a pipeline had on the chemical composition of the shallow ground water in the vicinity of the unlined ditch. Variation in volume and chemical composition of water that recharged the area from industrial discharge of wastewater in unlined ponds, and continued changes in land-use practices in the area, make it difficult to assess quantitative changes in the chemical composition caused by diverting cooling water into a pipeline.

Although concentrations of dissolved solids increased in some wells adjacent to the unlined ditch after cooling water was diverted into the pipeline in June 1985, the greatest changes in dissolved-solids concentrations occurred in areas of highest concentrations. These areas do not seem related to water in the ditch but rather to the past disposal of industrial wastewater into unlined ponds within and upgradient from the Pittman study area.

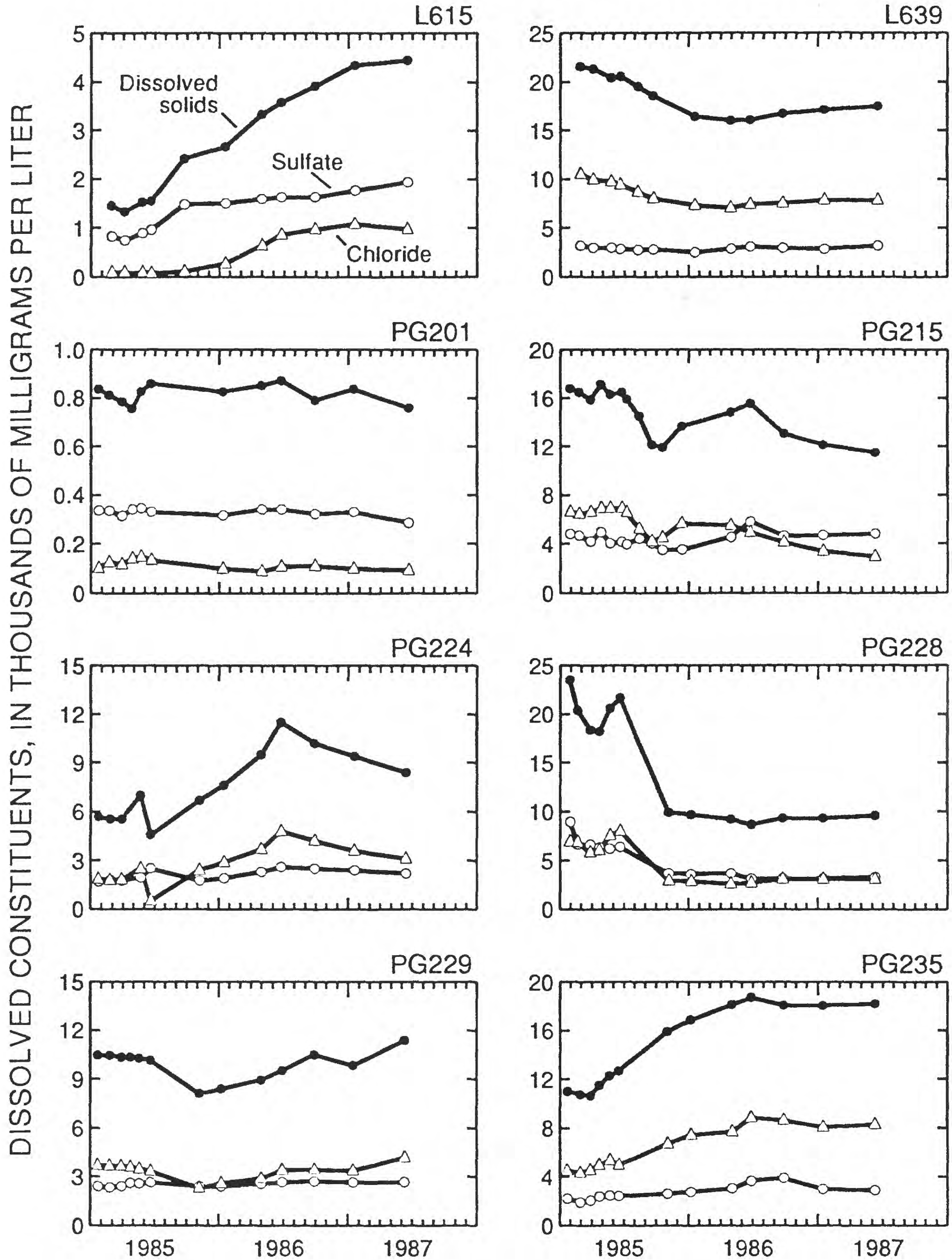


FIGURE 21.--Changes in dissolved solids, sulfate, and chloride concentrations of water sampled from selected wells, January 1985 to June 1987. Concentration of dissolved solids is sum of constituents.

SUMMARY AND CONCLUSIONS

Ground-water flow in the Pittman study area is generally northward from an industrial complex to Las Vegas Wash where most of it discharges into the wash. The area is located on alluvial fan deposits--predominantly sands and gravels--that overlie the Muddy Creek Formation. The fan deposits are interstratified with fine-grained wash deposits of silty sand, rich in salts, near Las Vegas Wash. The thickness of the alluvial fan deposits ranges from a few feet to more than 100 feet. Within the study area, the upper part of the Muddy Creek Formation is generally a sandy clay and sandy silt with a locally thin sandstone at the top. Erosional channels on the surface of the Muddy Creek Formation may in part control the movement of ground water in the Pittman study area.

A pipeline constructed by the U.S. Bureau of Reclamation to convey cooling water from the industrial complex to Las Vegas Wash began operation June 20, 1985. The pipeline was constructed to eliminate seepage of water from the previously used unlined ditch into the alluvial fan deposits and consequently to reduce the amount of salts being flushed into Las Vegas Wash by ground water. This report describes changes in ground-water levels and water quality near the unlined ditch for a 2-year period following diversion of cooling water into the pipeline.

Quantitatively determining the net effect on ground-water levels and quality in the Pittman study area caused by the diversion of cooling water from the unlined ditch into a pipeline is complicated by several factors. These include:

- Unusually heavy precipitation during July and August 1984;
- Lowering of the discharge outlet for ground water by downcutting in Las Vegas Wash;
- Reduction of the discharge of treated sewage effluent in ponds near the oldest Henderson sewage treatment plant (HSTP2);
- Periodic discharge of treated sewage effluent into a rapid-infiltration basin near the unlined ditch;
- Changing practice of discharging industrial wastewater in an upgradient industrial complex.

Nonetheless, pronounced changes in ground-water levels, particularly in wells near the pipeline in the upgradient part of the study area, seem to be directly related to the shift from unlined ditch to pipeline. These and other changes are summarized in the following paragraphs.

Two years after diverting the cooling water in a pipeline, ground-water levels had declined as much as 15 feet in some wells adjacent to the unlined ditch. Water-level declines were much less near the north (downgradient) end of the unlined ditch possibly because treated effluent was periodically discharged into a rapid-infiltration basin near the north end of the ditch. During this same period, ground-water levels declined about 3 feet in a well 2,000 feet west and a well about 2,600 feet southeast of the ditch along the Pittman lateral.

Water samples were routinely collected from wells in the Pittman study area. Most water samples were analyzed for major inorganic constituents by the U.S. Bureau of Reclamation laboratory in nearby Boulder City, Nev. In June 1985, prior to the diversion of cooling water through a pipeline, dissolved-solids concentrations in ground water sampled near the unlined ditch ranged from less than 1,000 mg/L to about 4,000 mg/L. The lower concentrations, similar to dissolved-solids concentrations of the cooling water, were observed in water collected from wells near the south (upper) end of the ditch.

Four areas were identified that had dissolved-solids concentrations exceeding 15,000 mg/L. An area of high dissolved-solids concentrations was identified in the unlined lower-ponds area (once used to dispose of industrial wastewater); another was identified in the upper-ponds area (also once used to dispose of industrial wastewater). The chemical composition of water in these two areas is primarily sodium-magnesium-chloride-sulfate, whereas the chemical composition of shallow ground water unaffected by industrial and municipal wastewater is primarily calcium-sodium-sulfate. Two areas of high dissolved-solids concentrations were identified within an area of houses west of Pabco Road, and the high concentrations are attributed to saline ground water emanating from within the industrial complex. The chemical composition of water in these areas is primarily sodium chloride.

During a 2-year period following the diversion of cooling water into the pipeline, the chemical composition of water sampled from wells adjacent to the unlined ditch did not change near the Boulder Highway but dissolved-solids concentrations increased as much as 3,000 mg/L in some wells farther downgradient. Elsewhere, concentrations of dissolved solids decreased as much as 13,000 mg/L in water from one well, whereas concentrations increased as much as 7,000 mg/L in water from another. Both of these changes were observed in areas of highest dissolved-solids concentrations and are largely unexplained. The changes, however, do not seem related to the diversion of cooling water into the pipeline.

BASIC DATA

This section includes tables and hydrographs summarizing data for wells in the Pittman study area. Table 1 is a list of well identifications, casing diameter, hole depth and screened intervals, and land-surface altitudes for wells in the study area. Table 2 is a list of water-quality analyses of samples collected by personnel from the U.S. Geological Survey between April 1986 and June 1987. Water-quality analyses of samples collected prior to April 1986 are available through the U.S. Bureau of Reclamation in Boulder City, Nev.; some data also are presented by Kaufmann (1978). Figure 22 contains hydrographs showing depth to water for 99 wells in the study area. The hydrographs include historical water-level measurements. Water-level data and well-construction information are stored in the Geological Survey WATSTORE data base. Data presented in this section for any well listed in table 1 are available from the U.S. Geological Survey, 705 N. Plaza, Room 227, Carson City, NV 89701.

TABLE 1.--*Site identifications, casing size, reported hole depths and screened intervals, and land-surface altitude for wells*

[Locations of wells are shown in figures 1 and 3]

Well name	U.S. Geological Survey site designations: Standard identification[2]	U.S. Geological Survey site designations: Local identification[3]	Diameter of casing (inches)[4]	Reported depth (feet below land surface)[1]: Drilled depth	Reported depth: Screened interval: Top	Reported depth: Screened interval: Bottom	Land-surface altitude (feet above sea level)
TRUCK1	360504114585301	212 S21 E63 31ABAC1	2	--	--	--	1,548.
PG102	360322115001901	212 S22 E62 01CDCC1	2	--	--	--	1,697.7
PG103	360324114595901	212 S22 E62 01DCCD1	2	16	1	9	1,692.05
PG111	360416115000601	212 S21 E62 36DCCC1	2	21	11	21	1,617.46
PG201	360302114594001	212 S22 E62 12ADDB1	2	23	10	20	1,743.21
PG202	360303114593401	212 S22 E62 12ADDA1	4	30	15	20	1,736.48
PG205	360319114594001	212 S22 E62 12AAAC1	2	34	10	20	1,704.11
PG206	360319114593401	212 S22 E63 07BBBA1	2	38	16	36	1,707.71
PG207	360319114593402	212 S22 E63 07BBBB1	2	46	10	20	1,706.08
PG210	360352114593001	212 S22 E63 06BCCD1	2	--	--	--	1,655.42
PG211	360348114592501	212 S22 E63 06CBAB1	2	43	15	35	1,662.01
PG212	360416114593801	212 S22 E62 01AAAB3	2	31	10	30	1,616.32
PG214	360416114592901	212 S22 E63 06BBBA1	2	20	10	20	1,622.06
PG215	360418114592501	212 S21 E63 31CCDC1	2	20	5	20	1,620.11
PG217A	360459114584901	212 S21 E63 31ABDA1	2	--	--	--	1,569.07
PG220	360344114584301	212 S22 E63 06DABD1	2	66	26	66	1,701.06
PG224	360439114595301	212 S21 E62 36DBAD1	2	27	11	27	1,593.10
PG225	360439114592201	212 S21 E63 31CBAC1	2	36	15	28	1,587.41
PG226	360453114595201	212 S21 E62 36ACAA1	2	30	0	28	1,578.12
PG227	360451114593501	212 S21 E63 31BCBC1	2	30	10	30	1,577.75
PG228	360448114592701	212 S21 E63 31BCCA1	2	47	0	8	1,573.83
					17	27	
PG229	360457114593501	212 S21 E62 36AADD1	2	35	10	20	1,567.14
PG230	360505114595801	212 S21 E62 36ABAC1	2	16	1	10	1,575.23
PG232	360426114590001	212 S21 E63 31DCBB1	2	17	7	17	1,616.52
PG233	360426114585001	212 S21 E63 31DCAB1	2	30	20	30	1,622.63
PG234	360456114583901	212 S21 E63 31ADBA1	2	39	10	39	1,577.17
PG235	360350115002301	212 S22 E62 01BCDD1	2	39	10	27	1,649.82
PG238	360326115000201	212 S22 E62 01DDCC1	2	23	13	23	1,686.06
PG239	360339115000001	212 S22 E62 01DBCD1	2	15	5	15	1,666.49
PG240	360348115000901	212 S22 E62 01CAAA1	2	31	20	30	1,653.56
PG242	360324114593301	212 S22 E63 06CCCC1	2	41	21	41	1,695
PG250	360424114592601	212 S21 E63 31CCBD1	2	27	15	25	1,611
PG252	360435114595101	212 S21 E62 36DACA1	2	20	10	20	1,595
PG253	360452114590801	212 S21 E63 31BDBC1	2	32	19	29	1,574.98
PG256	360456114591201	212 S21 E63 31BDBA1	2	22	8	18	1,563.30
PG276	360205114594701	212 S22 E62 13ADCD1	2	100	90	100	1,895
PG279	360304114592601	212 S22 E63 07BCAC1	2	30	20	30	1,748
PG283	360354114591501	212 S21 E63 06BDBD1	2	42	32	42	1,654
PG285	360405114591501	212 S22 E63 06BACA1	2	30	20	30	1,642
PG288	360424115000501	212 S21 E62 36DCBB1	2	21	11	21	1,612
PG289	360420114595501	212 S21 E62 36DCDB1	2	29	19	29	1,610
PG292	360414114591801	212 S22 E63 06BBAA1	2	26	16	26	1,625
PG301	360303114593601	212 S22 E62 12ADAD1	2	36	26	36	1,737
PG302	360350114593001	212 S22 E63 06BCCC1	2	43	33	43	1,655
PG303	360433114591701	212 S21 E63 31CBDA1	2	37	27	37	1,597
PG304	360457114591001	212 S21 E63 31BACD1	2	60	50	60	1,562
W001	360335114593501	212 S22 E62 01DDAA1	1.5	32	24	29	1,679.28
W002	360335114594101	212 S22 E62 01DDAB1	1.5	30	25	30	1,676.15
W003	360335114594701	212 S22 E62 01DDBA1	1.5	32	25	30	1,673.57
W004	360334114595201	212 S22 E62 01DCAD1	1.5	31	25	30	1,676.52
W005	360340114593501	212 S22 E62 01DAAD1	1.5	31	22	27	1,670.20
W006	360340114594101	212 S22 E62 01DAAC2	1.5	31	25	30	1,667.92
W008	360340114595301	212 S22 E62 01DBDA1	1.5	23	15	20	1,666.03
W009	360346114593501	212 S22 E62 01DAAD2	1.5	31	25	30	1,662.46
W010	360346114594101	212 S22 E62 01DAAC1	1.5	32	25	30	1,660.25
W011	360345114594601	212 S22 E62 01DABD1	1.5	26	20	26	1,657.91
W012	360345114595401	212 S22 E62 01DBAD1	1.5	17	9	14	1,654.87
W013	360354114593801	212 S22 E62 01ADDD1	1.5	25	18	23	1,654.20
W014	360352114594101	212 S22 E62 01ADDC1	1.5	29	22	26	1,649.86
W015	360352114594601	212 S22 E62 01ADCC1	1.5	26	20	25	1,648.86
W016	360351114595301	212 S22 E62 01ACDD1	1.5	26	19	24	1,650.94

TABLE 1.--*Site identifications, casing size, reported hole depths and screened intervals, and land-surface altitude for wells*--Continued

Well name	U.S. Geological Survey site designations: Standard identification[2]	U.S. Geological Survey site designations: Local identification[3]	Diameter of casing (inches)[4]	Reported depth (feet below land surface)[1]: Drilled	Screened interval: Top	Screened interval: Bottom	Land-surface altitude (feet above sea level)
W017	360357114593501	212 S22 E62 01ADAD1	1.5	25	18	22	1,645.92
W018	360357114594101	212 S22 E62 01ADAC1	1.5	26	20	25	1,644.76
W019	360357114594601	212 S22 E62 01ADBC1	1.5	26	18	23	1,642.51
W020	360357114595301	212 S22 E62 01ACAD1	1.5	18	12	16	1,641.62
W021	360403114593501	212 S22 E62 01ADAA1	1.5	27	20	25	1,636.13
W023	360403114594701	212 S22 E62 01ADBB1	1.5	30	25	30	1,633.07
W024	360403114595401	212 S22 E62 01ACAA1	1.5	26	18	23	1,633.37
L615	360414114593501	212 S22 E62 01AAAA1	4	32	0	30	1,620.61
L617	360414114593901	212 S22 E62 01AAAB1	4	43	10	30	1,619
L619	360414114594201	212 S22 E62 01AAAB2	4	35	0	31	1,618.71
L621	360414114594501	212 S22 E62 01AABA1	4	52	30	35	1,618
L623	360414114594701	212 S22 E62 01AABB1	4	48	23	38	1,617.48
L625	360414114595001	212 S22 E62 01AABB2	4	43	8	28	1,617
L627	360414114595301	212 S22 E62 01ABAA1	4	31	10	30	1,617.06
L629	360414114595501	212 S22 E62 01ABAB1	4	35	13	23	1,617
L631	360414114595701	212 S22 E62 01ABAB2	4	50	1	50	1,617.54
L633	360414114595901	212 S22 E62 01ABBA1	4	78	21	78	1,617.73
L635	360414115000101	212 S22 E62 01ABBA2	4	148	0	48	1,619.22
L639	360414115000501	212 S22 E62 01ABBC1	4	38	10	30	1,620.81
L641	360414115000801	212 S22 E62 01BAAA1	4	25	8	18	1,620.84
L643	360414115001001	212 S22 E62 01BAAA2	4	21	0	20	1,620.62
L645	360414115001301	212 S22 E62 01BAAB1	4	30	5	15	1,623.48
L647	360414115001501	212 S22 E62 01BABA1	4	25	7	22	1,625
L649	360414115001801	212 S22 E62 01BABA2	4	25	15	20	1,625.91
L653	360414115002201	212 S22 E62 01BABB1	4	25	15	20	1,628.89
L676	360414115005001	212 S22 E62 02AABA1	4	45	20	40	1,642.43
LG013	360344114582501	212 S22 E63 05CBBB1	6	250	241	243	1,706.45
LG017	360506114590001	212 S21 E63 31BBAA3	6	90	80	82	1,545.96
LG019	360506114502101	212 S21 E63 31BBAA1	6	70	63	67	1,552
LG020	360459114592201	212 S21 E63 31BBAA2	6	20	14	18	1,551.86
LG021	360424114592201	212 S21 E63 31CCAD1	6	40	37	39	1,613
LG022A	360425114591802	212 S21 E63 31CCAD2	2	--	--	--	1,613
LG025	360308114592701	212 S22 E63 07BCBD1	6	24	19	23	1,738.59
LG026	360307114592601	212 S22 E63 07BCBD2	6	100	87	90	1,738.30
LG027	360506115001101	212 S21 E62 36BABD1	6	62	57	62	1,583.18
LG028A	360503115001502	212 S21 E62 36BABD2	2	25	10	25	1,583.06
LG225	360346115013801	212 S22 E62 02CBBC1	6	50	40	45	1,710.97
LG226	360346115013802	212 S22 E62 02CBBC2	6	305	291	301	1,709.88

[1] The bottom of the screened interval does not always correspond to the drilled depth of the hole. Many times the screened interval was placed near the water table and the hole allowed to collapse below it. Dashes mean the screened interval and (or) the drilled depth of the hole are unknown.

[2] Sites are identified by the standard Geological Survey identification (ID), which is based on the grid system of latitude and longitude. The ID indicates the geographic location of each site, and provides a unique number for each. The ID consists of 15 digits: the first 6 denote the degrees, minutes, and seconds of latitude; the next 7 denote degrees, minutes, and seconds of longitude; and the last 2 digits (assigned sequentially) identify the sites within a 1-second grid. For example, site 360504114585301 is at 36° 05' 04" latitude and 114° 58' 53" longitude, and it is the first site recorded in that 1-second grid. The initially assigned number is retained as a permanent identifier even if a more precise latitude and longitude are later determined.

[3] The local site-identification system used in this report is based on an index of hydrographic areas in Nevada (Rush, 1968) and the rectangular subdivision of the public lands referenced to the Mount Diablo base line and meridian. Each site designation consists of four units separated by spaces: the first unit is the hydrographic area number. The second unit is the township, preceded by an S indicate location south of the base line. The third unit is the range, preceded by an E to indicate location east of the meridian. The fourth unit consists of the section number and letters designating the quarter section, quarter-quarter section, and so on (A, B, C, and D indicate the northeast, northwest, southwest, and southeast quarters, respectively), followed by a number indicating the sequence in which the site was recorded. For example, site 212 S21 E63 31ABAC1 is in Las Vegas Valley (hydrographic area 212). It is the first site recorded in the SW 1/4 of the NE 1/4 of the NW 1/4 of the NE 1/4 of section 31, Township 21 South, Range 63 East, Mount Diablo base line and meridian.

[4] All casings and screened intervals are constructed using polyvinyl-chloride pipe except for wells that are 6 inches in diameter; those are made of steel.

TABLE 2.--*Ground-water quality in the Pittman study area, Las Vegas, Nevada, for the period April 1986-June 1987*

[Locations of wells are shown in figures 1 and 3. Values are in milligrams per liter, except as noted. Abbreviations: °C, degrees Celsius; microsiemens, microsiemens per centimeter at 25 °C; --, missing data]

Well name	Sample date	Water temperature[1] (°C)	pH (units)[1]	Specific conductance (microsiemens)[1]	Dissolved solids[2] Residue	Dissolved solids[2] Sum	Calcium	Magnesium	Sodium	Potassium	Bicarbonate[1]	Sulfate	Chloride	Silica	Analyzing agency[3]
L615	04-30-86	21.5	7.43	4,500	3,670	3,320	720	110	150	11	68	1,600	630	65	USBR
	06-24-86	21.0	7.30	4,200	3,810	3,580	780	140	190	11	67	1,500	860	64	USBR
	09-27-86	22.5	7.14	4,500	4,540	3,910	840	150	190	11	70	1,600	970	65	USBR
	09-27-86	22.5	7.14	4,500	4,150	3,650	730	160	230	11	70	1,500	920	68	USGS
	01-17-87	19.8	7.25	5,300	4,600	4,340	930	170	260	14	71	1,800	1,100	68	USBR
	06-16-87	24.0	7.30	5,600	4,850	4,440	900	170	340	16	76	1,900	970	62	USBR
L619	04-30-86	23.5	7.24	4,500	4,100	3,670	700	140	280	9	100	1,900	490	72	USBR
	06-24-86	23.5	7.28	5,400	3,900	3,740	680	130	290	6	110	1,900	540	70	USBR
	09-27-86	23.2	7.41	4,600	4,730	3,750	660	140	320	8	110	2,000	520	72	USBR
	01-18-87	21.8	7.24	4,900	4,420	4,000	660	140	370	9	100	2,100	590	72	USBR
L621	06-17-87	25.0	7.40	6,600	6,000	5,480	690	250	760	20	83	2,500	1,100	78	USBR
L623	04-30-86	24.0	7.22	15,000	11,300	9,950	1,100	510	1,600	25	81	2,300	4,200	80	USBR
	06-24-86	24.0	7.20	14,000	6,960	6,230	750	290	970	20	84	1,500	2,600	51	USBR
	09-27-86	23.1	7.34	15,000	11,700	10,100	1,200	480	1,600	25	84	2,300	4,200	82	USBR
	01-17-87	22.5	7.15	13,000	9,930	9,200	890	380	1,600	22	88	2,100	4,000	80	USBR
L627	05-03-86	23.0	7.39	11,000	8,960	8,410	800	370	1,500	32	78	2,700	2,800	79	USBR
	05-03-86	23.0	7.39	11,000	8,720	8,370	710	360	1,600	25	78	2,800	2,700	80	USGS
	06-25-86	23.5	7.38	12,000	8,760	7,980	770	350	1,400	31	78	2,600	2,700	73	USBR
	09-27-86	23.3	7.41	11,000	8,760	8,000	760	360	1,400	31	82	2,900	2,500	82	USBR
	01-18-87	23.9	7.39	9,900	8,240	7,650	700	340	1,300	29	83	2,700	2,300	78	USBR
	06-16-87	24.0	7.52	9,400	8,160	7,450	720	340	1,300	31	82	2,900	2,000	80	USBR
L631	05-03-86	23.5	7.01	13,000	9,830	8,710	930	400	1,500	50	190	2,500	3,100	84	USBR
	06-24-86	24.0	7.06	12,000	9,610	8,120	820	330	1,300	53	190	2,200	3,100	85	USBR
	09-27-86	23.3	7.14	13,000	10,100	9,020	950	380	1,500	49	180	2,500	3,400	82	USBR
	01-17-87	21.8	6.95	12,000	9,380	8,700	880	360	1,600	45	180	2,300	3,300	79	USBR
L633	04-30-86	24.0	6.79	20,000	14,900	14,500	1,100	500	3,100	66	350	3,600	5,900	91	USBR
	06-24-86	24.0	6.82	16,000	15,100	14,900	1,200	500	3,200	69	250	3,600	6,100	91	USBR
	09-27-86	23.3	6.87	20,000	14,800	13,800	1,100	490	2,900	69	300	3,300	5,800	90	USBR
	01-18-87	24.0	6.93	14,000	13,900	13,400	980	450	3,000	63	330	3,000	5,700	88	USBR
L635	05-01-86	22.5	6.68	26,000	18,900	17,700	1,100	520	4,200	79	420	3,500	8,100	86	USBR
	06-24-86	23.5	6.78	22,000	18,500	18,300	1,200	500	4,400	81	420	3,800	8,100	86	USBR
	09-28-86	24.3	6.87	26,000	18,900	18,100	1,100	460	4,500	84	400	3,600	8,000	96	USBR
	01-17-87	23.0	6.81	23,000	18,100	17,200	960	400	4,400	75	400	3,300	7,800	94	USBR
	06-16-87	23.0	6.98	22,000	17,200	16,600	940	350	4,200	74	390	3,500	7,200	91	USBR

TABLE 2.--*Ground-water quality in the Pittman study area, Las Vegas, Nevada, for the period April 1986-June 1987*--Continued

Well name	Sample date	Water temper-ature (°C)[1]	pH (units)[1]	Specific conduct-ance (micro-siemens)[1]	Dissolved solids[2] Residue	Dissolved solids[2] Sum	Calcium	Magne-sium	Sodium	Potas-sium	Bicar-bonate[1]	Sulfate	Chlor-ide	Silica	Ana-lyzing agency[3]
L639	05-01-86	23.5	6.78	23,000	16,000	15,600	920	420	4,100	74	460	2,800	7,000	98	USBR
	06-24-86	24.0	6.88	20,000	16,100	16,300	840	320	4,200	82	460	3,100	7,400	100	USBR
	09-28-86	24.0	6.62	25,000	16,700	16,400	760	320	4,500	82	420	2,900	7,500	100	USBR
	01-17-87	23.0	6.95	23,000	17,100	16,700	760	330	4,500	77	420	2,800	7,800	98	USBR
	01-17-87	23.0	6.95	23,000	16,900	17,000	630	290	4,400	69	420	3,000	8,500	110	USGS
	06-17-87	25.0	6.98	24,000	17,500	17,300	740	300	4,800	81	400	3,200	7,800	99	USBR
L641	05-01-86	22.5	6.90	20,000	13,700	13,300	700	270	3,400	71	440	2,900	5,600	110	USBR
	06-24-86	25.0	6.98	18,000	14,100	14,000	800	240	3,600	78	420	2,800	6,100	100	USBR
	09-25-86	25.4	6.81	21,000	15,300	14,800	880	280	3,700	89	380	3,000	6,500	110	USBR
	09-25-86	25.4	6.81	21,000	17,400	15,800	650	310	4,600	68	380	2,400	7,500	100	USGS
	01-18-87	23.5	7.02	21,000	16,200	15,800	880	330	4,000	79	380	3,300	6,900	110	USBR
L643	05-01-86	22.0	7.01	20,000	14,200	13,500	880	320	3,200	84	410	3,400	5,300	110	USBR
	06-25-86	24.0	7.06	18,000	14,000	13,800	910	280	3,300	92	500	3,300	5,600	110	USBR
	09-25-86	25.7	7.04	21,000	14,600	14,300	980	300	3,400	99	370	3,600	5,600	120	USBR
	01-18-87	22.7	7.19	19,000	15,000	14,600	960	300	3,600	85	370	3,100	6,200	110	USBR
L645	05-01-86	22.5	6.91	20,000	13,600	13,200	840	340	3,100	89	430	2,900	5,600	100	USBR
	06-25-86	23.0	6.90	16,000	13,100	12,700	830	310	3,000	93	410	2,600	5,500	100	USBR
	09-25-86	24.9	6.88	19,000	13,100	12,500	750	290	3,000	91	390	2,600	5,400	100	USBR
	01-17-87	20.8	7.08	16,000	13,300	12,900	780	290	3,200	84	380	2,400	5,800	110	USBR
L649	05-01-86	23.0	6.91	15,000	10,800	9,800	850	480	1,800	54	300	2,200	4,200	95	USBR
	06-25-86	24.0	7.18	14,000	10,400	10,400	840	480	1,900	59	290	2,400	4,400	97	USBR
	09-25-86	25.3	7.13	15,000	10,300	10,300	830	460	1,900	61	290	2,300	4,400	100	USBR
	01-18-87	21.4	7.34	13,000	9,930	9,790	770	430	1,900	55	280	2,100	4,300	110	USBR
L653	05-01-86	23.0	6.89	9,100	6,610	6,430	510	280	1,200	40	290	1,800	2,300	85	USBR
	06-25-86	25.0	6.96	8,100	6,620	6,550	540	280	1,300	42	280	1,800	2,400	85	USBR
	09-25-86	25.4	7.00	9,500	6,720	6,690	550	290	1,200	47	270	2,000	2,400	90	USBR
	01-17-87	24.0	6.93	7,400	6,900	6,640	540	300	1,300	41	270	1,700	2,600	92	USBR
L676	05-03-86	24.0	7.24	2,600	2,250	2,310	280	120	280	25	170	1,200	200	44	USBR
	06-25-86	25.0	7.30	2,800	2,170	2,110	220	110	260	24	170	940	400	48	USBR
	09-25-86	23.3	7.50	2,900	2,190	2,150	220	120	240	24	180	970	410	45	USBR
	09-25-86	23.3	7.50	2,900	2,120	2,060	190	110	290	21	180	930	380	47	USGS
	01-18-87	23.0	7.43	2,900	2,280	2,110	220	120	260	23	170	960	370	47	USBR
LG013	06-29-86	24.0	7.37	5,600	5,070	4,600	660	260	440	53	84	1,800	1,200	67	USBR
LG019	09-24-86	23.5	7.66	7,800	6,970	6,400	620	440	720	180	68	3,100	1,300	28	USBR
	01-14-87	22.0	7.70	7,700	6,810	6,500	620	440	750	180	69	3,100	1,300	31	USBR
LG020	04-29-86	21.3	7.20	9,900	8,310	7,410	700	390	1,200	49	210	2,800	2,000	55	USBR
	06-28-86	22.0	7.07	9,000	8,020	7,820	760	380	1,300	50	180	3,100	2,100	63	USBR
	09-24-86	23.0	7.13	9,100	7,820	7,400	740	360	1,100	51	170	3,000	2,000	56	USBR
	01-16-87	18.5	7.19	9,400	8,090	7,760	770	390	1,300	50	200	3,000	2,200	59	USBR

TABLE 2.--*Ground-water quality in the Pittman study area, Las Vegas, Nevada, for the period April 1986-June 1987*--Continued

Well name	Sample date	Water temperature (°C)[1]	pH (units)[1]	Specific conductance (microsiemens)[1]	Dissolved solids[2] Residue	Dissolved solids[2] Sum	Calcium	Magnesium	Sodium	Potassium	Bicarbonate[1]	Sulfate	Chloride	Silica	Analyzing agency[3]
LG026	06-29-86	25.0	7.35	12,100	8,370	7,700	1,000	550	710	38	52	1,300	4,000	50	USBR
LG027	05-01-86	23.0	7.25	4,500	3,380	3,240	340	140	500	26	260	1,200	850	68	USBR
	06-28-86	23.0	7.33	4,200	3,260	3,250	330	130	550	26	240	1,100	900	72	USBR
	09-24-86	22.0	7.37	3,900	2,710	2,600	220	98	460	23	260	1,000	660	66	USBR
	09-24-86	22.0	7.37	3,900	3,400	2,560	200	92	520	20	260	910	630	69	USGS
	01-16-87	17.8	7.78	3,200	3,090	3,070	300	120	540	24	230	1,200	750	66	USBR
LG028A	04-30-86	21.0	7.45	5,600	4,300	4,160	420	230	590	17	290	1,700	1,000	38	USBR
	06-25-86	22.5	7.24	6,400	4,930	4,720	530	250	690	20	300	1,700	1,400	47	USBR
	09-22-86	22.0	7.28	6,800	5,010	4,740	480	230	750	23	320	1,700	1,400	47	USBR
	01-12-87	21.5	7.43	5,400	4,150	3,930	360	170	700	18	320	1,500	960	44	USBR
LG225	06-28-86	24.0	7.10	2,000	2,380	2,360	280	140	270	25	160	1,100	420	43	USBR
LG226	06-28-86	27.0	8.48	1,000	657	675	33	28	140	11	96	210	190	17	USBR
PG102	01-16-87	18.8	7.17	12,000	9,380	8,360	850	320	1,600	15	96	2,600	2,600	83	USBR
	06-15-87	24.0	7.44	11,000	9,800	8,860	870	340	1,700	16	94	2,700	3,000	74	USBR
PG103	05-03-86	22.0	7.40	15,000	11,900	11,400	1,300	420	2,100	18	86	2,400	4,900	65	USBR
	05-03-86	22.0	7.40	15,000	10,900	12,100	1,100	400	2,100	13	86	2,900	5,400	76	USGS
	06-25-86	24.0	7.20	12,000	11,800	10,700	1,100	400	1,900	18	84	2,400	4,500	76	USBR
	09-28-86	24.5	7.13	16,000	10,500	10,200	1,100	390	1,800	19	90	2,300	4,200	84	USBR
	01-18-87	22.0	7.33	14,000	10,700	10,200	1,100	380	1,900	21	86	2,300	4,300	78	USBR
	06-12-87	24.0	7.37	14,000	11,400	10,400	1,100	380	2,000	22	84	2,400	4,200	78	USBR
PG111	05-03-86	22.5	6.84	17,000	16,800	16,800	1,200	400	4,000	94	420	3,700	7,100	87	USBR
	05-03-86	22.5	6.84	17,000	14,200	14,400	890	350	3,600	78	420	3,300	6,000	100	USGS
	06-25-86	21.5	6.90	17,000	13,900	14,000	890	310	3,300	95	410	3,500	5,500	96	USBR
	09-28-86	22.8	7.09	20,000	14,100	13,500	920	320	3,200	99	400	3,200	5,600	110	USBR
	01-18-87	21.5	7.07	19,000	14,100	13,600	1,000	320	3,300	95	370	2,900	5,700	100	USBR
PG201	05-02-86	26.5	7.67	1,200	890	850	88	45	120	1	220	340	89	54	USBR
	06-26-86	24.0	7.68	1,200	875	872	84	41	130	1	220	340	110	51	USBR
	09-27-86	24.5	7.55	1,200	822	790	74	43	100	0	210	320	110	59	USBR
	01-13-87	20.8	7.70	970	884	837	86	43	120	1	210	330	99	57	USBR
	06-20-87	24.0	7.73	1,200	795	758	70	38	110	2	200	290	92	55	USBR
PG202	05-02-86	25.0	7.81	1,000	699	679	67	37	100	1	200	260	79	35	USBR
	06-25-86	24.5	7.70	1,000	670	655	60	34	93	1	200	250	77	35	USBR
	09-29-86	24.5	7.68	1,100	711	659	61	37	90	0	170	240	96	39	USBR
	09-29-86	24.5	7.68	1,100	700	657	59	38	100	1	170	240	98	38	USGS
	01-15-87	19.0	7.78	1,100	732	694	68	40	97	1	170	230	100	39	USBR

TABLE 2.--*Ground-water quality in the Pittman study area, Las Vegas, Nevada, for the period April 1986-June 1987*--Continued

Well name	Sample date	Water temperature (°C)[1]	pH (units)[1]	Specific conductance (microsiemens)[1]	Dissolved solids[2] Residue	Dissolved solids[2] Sum	Calcium	Magnesium	Sodium	Potassium	Bicarbonate[1]	Sulfate	Chloride	Silica	Analyzing agency[3]
PG205	05-03-86	22.0	7.50	3,900	3,160	2,880	320	150	410	2	220	1,400	440	40	USBR
	05-03-86	22.0	7.50	3,900	3,240	3,080	300	150	440	2	220	1,500	480	44	USGS
	06-29-86	23.5	7.34	4,200	3,780	3,480	360	170	440	2	230	1,790	540	46	USBR
	09-27-86	24.5	7.17	4,700	4,040	3,680	380	210	450	2	240	1,920	550	52	USBR
	01-13-87	19.2	7.25	3,900	3,500	3,170	360	180	390	2	270	1,690	360	49	USBR
PG207	05-02-86	26.0	7.56	1,900	1,430	1,300	130	59	220	2	180	580	180	53	USBR
	06-28-86	24.0	7.48	2,200	1,450	1,380	130	57	220	2	180	620	190	51	USBR
	09-27-86	24.5	7.56	1,800	1,380	1,250	120	50	210	1	180	580	160	56	USBR
	01-18-87	20.0	7.71	1,800	1,360	1,330	120	50	220	2	200	620	170	49	USBR
PG210	05-02-86	24.5	7.65	5,600	4,910	4,510	620	220	550	11	83	2,300	700	61	USBR
	06-27-86	24.0	7.59	5,600	5,060	4,670	610	220	550	11	85	2,300	840	62	USBR
	09-26-86	22.5	7.71	5,100	4,660	4,320	620	190	420	15	89	2,400	570	70	USBR
PG211	06-26-86	26.2	7.46	5,800	5,200	4,880	640	220	590	16	87	2,300	960	68	USBR
PG212	05-04-86	22.0	7.55	3,600	3,320	2,920	700	67	120	9	76	1,500	410	81	USBR
	05-04-86	22.0	7.55	3,600	3,310	3,190	690	80	170	8	76	1,700	440	82	USGS
	06-29-86	23.0	7.48	3,800	3,310	3,260	730	85	170	11	71	1,700	460	76	USBR
	09-27-86	21.5	7.61	3,800	3,630	3,330	760	92	160	12	61	1,700	520	79	USBR
	09-27-86	21.5	7.61	3,800	3,550	2,920	630	85	190	12	61	1,600	290	82	USGS
	01-17-87	22.0	7.58	4,100	3,670	3,370	760	100	170	13	59	1,700	550	74	USBR
PG214	05-01-86	21.5	7.65	8,900	7,710	7,140	620	430	1,100	22	140	3,400	1,500	41	USBR
	06-26-86	26.0	7.41	7,800	7,490	7,290	620	400	1,000	20	150	3,700	1,400	45	USBR
	09-26-86	22.5	7.43	8,400	7,460	6,720	580	380	1,000	20	150	3,600	980	50	USBR
	01-13-87	18.5	7.39	7,300	7,310	6,430	560	380	970	20	130	3,500	840	45	USBR
PG215	05-01-86	21.0	7.20	19,000	16,700	14,800	940	1,200	2,300	110	320	4,500	5,500	54	USBR
	06-26-86	25.0	7.05	18,000	15,800	15,500	940	1,100	2,400	130	330	5,800	4,900	58	USBR
	09-26-86	24.0	7.15	15,000	14,400	13,000	740	930	2,300	140	280	4,600	4,100	66	USBR
	01-13-87	21.3	7.04	16,000	13,400	12,100	700	900	2,100	130	280	4,700	3,400	57	USBR
	06-11-87	22.0	7.39	14,000	12,600	11,500	670	810	1,900	130	240	4,800	2,900	53	USBR
PG217A	04-29-86	23.0	7.50	5,800	5,120	4,770	630	210	550	94	120	2,300	780	65	USBR
	06-26-86	23.5	7.43	5,900	5,080	4,740	620	210	540	99	120	2,200	840	69	USBR
	09-25-86	22.0	7.50	5,800	5,270	4,960	660	230	530	96	120	2,300	880	68	USBR
	01-16-87	21.5	7.41	5,700	5,130	4,900	690	230	510	96	120	2,200	890	65	USBR
	06-09-87	24.0	7.37	6,100	5,200	4,760	620	220	510	99	100	2,200	900	61	USBR
PG220	05-04-86	22.0	7.50	4,700	4,060	3,760	370	180	540	39	180	2,000	400	80	USBR
	05-04-86	22.0	7.50	4,700	4,070	4,050	360	180	570	35	180	2,200	480	84	USGS
	06-28-86	22.8	7.30	4,800	3,880	3,890	380	170	520	39	180	2,100	480	82	USBR
	09-23-86	22.0	7.45	4,600	4,140	3,980	380	180	520	240	180	2,000	450	82	USBR
	01-16-87	17.3	7.42	4,700	4,170	3,950	410	190	540	39	170	2,100	520	80	USBR

TABLE 2.--*Ground-water quality in the Pittman study area, Las Vegas, Nevada, for the period April 1986-June 1987*--Continued

Well name	Sample date	Water temperature (°C)[1]	pH (units)[1]	Specific conductance (microsiemens)[1]	Dissolved solids[2] Residue	Dissolved solids[2] Sum	Calcium	Magnesium	Sodium	Potassium	Bicarbonate[1]	Sulfate	Chloride	Silica	Analyzing agency[3]
PG224	04-29-86	22.4	7.00	14,000	10,500	9,500	950	460	1,500	74	390	2,300	3,700	95	USBR
	06-24-86	23.5	6.94	15,000	11,900	11,500	830	350	2,500	99	420	2,600	4,800	91	USBR
	09-26-86	21.5	7.02	14,000	10,600	10,400	550	250	2,600	75	410	2,500	4,200	90	USBR
	09-26-86	21.5	7.02	14,000	11,000	10,200	470	220	3,000	64	410	2,200	4,000	92	USGS
	01-18-87	21.5	7.18	13,000	9,600	9,410	540	220	2,300	64	410	2,400	3,600	90	USBR
	06-12-87	24.0	7.16	12,000	8,890	8,390	460	200	2,100	60	420	2,200	3,100	84	USBR
PG225	05-02-86	26.0	7.40	9,800	8,280	7,850	730	480	1,000	250	110	3,000	2,100	65	USBR
	06-27-86	22.0	7.43	9,800	8,330	8,760	800	500	1,100	240	100	3,400	2,500	57	USBR
	09-25-86	22.5	7.45	9,700	8,190	7,600	750	430	960	220	95	2,900	2,200	66	USBR
	01-16-87	21.5	7.48	9,600	7,900	7,480	730	440	980	220	96	2,900	2,000	66	USBR
PG226	04-30-86	19.4	7.20	8,600	6,290	6,200	530	160	1,200	38	350	2,100	1,800	77	USBR
	06-25-86	25.0	7.01	7,900	6,050	6,620	530	150	1,400	37	330	2,300	2,000	80	USBR
	09-23-86	21.0	7.04	9,900	7,160	6,880	490	180	1,500	50	440	2,100	2,300	92	USBR
	01-12-87	19.5	7.30	6,200	4,720	4,450	320	88	1,000	31	340	1,700	1,000	80	USBR
	06-10-87	21.0	7.64	6,700	4,740	4,520	320	100	970	32	380	1,900	970	76	USBR
PG227	05-01-86	21.5	7.35	11,000	9,310	8,550	690	590	1,300	49	210	3,400	2,400	83	USBR
	06-25-86	28.0	7.07	11,000	9,520	9,330	710	620	1,400	50	210	3,600	2,800	85	USBR
	09-23-86	22.5	7.01	11,000	9,500	8,680	720	580	1,300	53	200	3,200	2,600	86	USBR
	01-14-87	19.5	7.34	11,000	9,620	9,010	750	630	1,300	54	230	3,400	2,700	86	USBR
	01-14-87	19.5	7.34	11,000	9,320	9,120	650	590	1,400	47	230	3,500	2,700	93	USGS
	06-10-87	23.0	7.31	11,000	9,290	8,530	680	540	1,200	50	190	3,200	2,600	79	USBR
PG228	05-01-86	21.0	7.20	12,000	9,870	9,180	710	600	1,400	39	200	3,600	2,600	72	USBR
	06-27-86	23.0	7.00	10,000	8,680	8,660	760	560	1,300	59	150	3,100	2,700	69	USBR
	09-24-86	22.0	7.18	12,000	9,890	9,300	800	630	1,400	51	180	3,100	3,100	78	USBR
	01-14-87	21.0	7.17	12,000	9,900	9,300	800	650	1,400	44	210	3,100	3,100	72	USBR
	06-11-87	23.5	7.14	13,000	10,200	9,550	780	660	1,500	43	200	3,300	3,100	67	USBR
PG229	04-29-86	21.8	7.10	11,000	8,940	8,400	740	330	1,600	74	210	2,600	2,900	71	USBR
	06-27-86	23.5	7.08	12,000	9,520	9,300	810	350	1,800	77	200	2,700	3,400	75	USBR
	09-26-86	24.5	6.97	13,000	10,500	9,630	880	400	1,900	91	210	2,700	3,400	84	USBR
	01-14-87	22.0	7.09	12,000	9,830	9,320	920	410	1,700	81	200	2,600	3,400	78	USBR
	06-10-87	22.0	7.09	13,000	11,400	10,600	1,100	480	1,900	94	220	2,700	4,200	74	USBR
PG232	04-30-86	24.0	7.60	5,100	4,510	4,200	600	180	460	45	130	2,100	560	80	USBR
	06-26-86	23.5	7.45	5,200	4,660	4,610	600	180	470	45	120	2,400	690	80	USBR
	09-26-86	23.0	7.58	5,200	4,670	4,460	650	190	450	50	120	2,200	720	81	USBR
	01-17-87	22.5	7.53	5,100	4,820	4,470	670	190	460	47	110	2,100	710	81	USBR
	06-11-87	22.5	7.58	5,400	4,840	4,450	640	180	470	45	120	2,200	710	74	USBR
PG233	05-01-86	23.0	7.55	6,300	5,670	5,330	700	220	440	65	190	2,600	970	86	USBR
	06-26-86	23.5	7.45	6,400	5,400	5,140	760	230	480	66	180	2,100	1,200	90	USBR
	09-26-86	21.5	7.39	5,900	5,350	5,000	760	250	440	68	180	2,000	1,100	86	USBR
	01-13-87	21.4	7.23	6,400	5,030	4,840	740	230	410	61	180	2,000	1,000	87	USBR

TABLE 2.--*Ground-water quality in the Pittman study area, Las Vegas, Nevada, for the period April 1986-June 1987*--Continued

Well name	Sample date	Water temperature (°C)[1]	pH (units)[1]	Specific conductance (microsiemens)[1]	Dissolved solids[2] Residue	Dissolved solids[2] Sum	Calcium	Magnesium	Sodium	Potassium	Bicarbonate[1]	Sulfate	Chloride	Silica	Analyzing agency[3]
PG235	05-03-86	24.5	6.85	25,000	18,100	17,400	780	290	5,200	60	380	3,000	7,700	87	USBR
	06-25-86	24.0	6.88	30,000	18,700	19,500	820	280	5,500	59	370	3,600	8,800	100	USBR
	09-28-86	25.0	7.09	27,000	18,100	17,900	760	290	5,000	70	390	2,900	8,600	90	USBR
	01-13-87	24.0	6.86	26,000	18,000	17,600	660	230	5,300	60	380	3,000	8,100	94	USBR
	06-10-87	25.0	7.10	24,000	18,200	17,600	580	220	5,200	58	380	2,900	8,300	86	USBR
PG238	04-28-86	23.7	7.70	8,800	8,110	6,670	720	230	1,200	19	96	2,700	1,600	83	USBR
	06-25-86	24.0	7.48	8,500	8,240	7,830	820	240	1,300	18	95	3,500	1,700	85	USBR
	09-28-86	23.5	7.54	10,000	8,340	6,740	750	240	1,300	21	93	2,500	1,800	84	USBR
	01-12-87	21.7	7.56	9,700	8,110	6,590	730	230	1,300	20	91	2,400	1,700	89	USBR
	06-18-87	23.5	7.37	9,400	8,420	6,740	770	240	1,300	19	87	2,400	1,800	77	USBR
PG239	05-03-86	22.0	7.55	9,600	8,260	7,010	860	280	1,100	10	96	2,400	2,200	53	USBR
	05-03-86	22.0	7.55	9,600	7,900	6,800	830	270	1,100	7	96	2,500	1,900	56	USGS
	06-25-86	26.5	7.30	8,900	8,440	7,710	900	280	1,100	8	88	3,300	1,900	59	USBR
	09-27-86	28.0	7.26	9,400	8,610	6,460	850	280	1,100	13	120	2,200	1,800	64	USBR
PG240	05-03-86	26.5	7.01	16,000	11,600	10,500	1,100	420	2,000	23	120	2,300	4,400	73	USBR
	06-26-86	25.0	6.94	16,000	11,900	11,600	1,200	430	2,200	20	120	2,700	4,800	81	USBR
	09-29-86	23.7	7.26	15,000	11,500	9,950	1,100	380	1,900	21	120	2,400	4,000	76	USBR
	01-13-87	22.2	6.87	16,000	11,300	10,300	1,200	410	1,900	22	130	2,300	4,300	78	USBR
	01-13-87	22.2	6.87	16,000	11,100	10,400	1,000	390	2,100	17	130	2,200	4,600	76	USGS
	06-15-87	22.0	7.18	14,000	11,600	10,400	1,200	420	1,900	22	120	2,200	4,400	72	USBR
PG242	05-02-86	25.0	7.43	3,200	3,090	2,820	560	70	210	6	88	1,700	180	82	USBR
	06-28-86	23.5	7.48	3,300	2,990	2,780	520	67	210	5	88	1,700	180	85	USBR
	09-23-86	24.0	7.54	3,100	3,150	2,950	560	82	220	7	88	1,800	180	81	USBR
PG252	05-02-86	22.5	7.50	4,200	4,110	3,670	580	180	310	4	130	2,100	310	95	USBR
	06-24-86	25.0	7.30	4,000	4,060	3,810	610	180	310	3	120	2,200	340	96	USBR
	09-25-86	22.5	7.54	4,300	4,070	3,730	630	170	280	4	110	2,200	330	93	USBR
	01-13-87	22.1	7.15	4,400	4,080	3,820	640	180	280	4	140	2,100	440	94	USBR
	01-13-87	22.1	7.15	4,400	3,960	3,840	560	160	310	3	140	2,200	440	97	USGS
PG253	04-29-86	21.6	7.30	5,500	4,530	3,470	560	140	380	30	190	1,400	760	54	USBR
	06-24-86	21.5	7.27	5,400	4,490	4,360	690	160	510	27	200	1,800	1,000	54	USBR
	09-25-86	23.5	7.34	4,100	3,260	3,090	420	120	380	29	270	1,400	550	56	USBR
	01-16-87	22.5	7.38	3,900	3,240	3,160	440	100	370	28	230	1,600	370	61	USBR
	06-09-87	22.0	7.32	4,100	3,120	2,910	420	85	380	24	210	1,400	410	49	USBR
PG256	06-24-86	24.5	7.49	6,000	4,980	4,860	660	230	560	57	160	2,200	950	40	USBR
	09-25-86	21.5	7.55	5,400	4,680	4,430	580	210	530	63	200	2,100	820	42	USBR
	01-16-87	19.0	7.37	5,100	4,540	4,330	580	200	480	58	210	2,200	600	45	USBR
PG276	09-27-86	23.5	7.83	2,100	1,460	1,400	76	37	300	12	160	740	99	35	USBR
	01-18-87	25.0	7.87	1,900	1,390	1,340	64	32	300	10	140	710	92	35	USBR
PG279	01-17-87	19.5	7.92	2,000	1,540	1,420	140	59	240	7	220	620	210	34	USBR

TABLE 2.--*Ground-water quality in the Pittman study area, Las Vegas, Nevada, for the period April 1986-June 1987*--Continued

Well name	Sample date	Water temperature (°C)[1]	pH (units)[1]	Specific conductance (microsiemens)[1]	Dissolved solids[2] Residue	Dissolved solids[2] Sum	Calcium	Magnesium	Sodium	Potassium	Bicarbonate[1]	Sulfate	Chloride	Silica	Analyzing agency[3]
PG283	01-13-87	21.5	7.73	6,900	5,700	5,190	600	190	810	38	150	2,500	830	68	USBR
PG285	01-13-87	23.0	7.63	9,000	7,410	6,930	640	240	1,300	44	93	2,800	1,700	66	USBR
	06-15-87	24.0	7.54	9,200	7,890	7,250	690	260	1,300	46	110	3,000	1,800	66	USBR
PG288	01-17-87	21.0	7.25	6,700	5,450	5,080	520	190	840	53	300	2,000	1,200	110	USBR
PG289	01-18-87	23.0	7.10	20,000	15,300	14,500	980	440	3,400	46	330	3,100	6,300	77	USBR
	06-11-87	22.0	7.03	22,000	15,100	14,000	980	440	3,200	34	340	3,200	5,900	85	USBR
PG292	01-13-87	23.0	7.61	7,200	6,470	5,930	600	260	930	52	88	2,600	1,300	61	USBR
PG301	09-29-86	24.0	7.61	3,000	2,790	2,560	420	130	160	24	99	1,600	98	54	USBR
	01-16-87	23.5	7.65	2,700	2,560	2,370	420	110	140	21	97	1,500	120	53	USBR
PG302	09-28-86	22.0	7.34	3,400	3,050	2,870	520	120	200	12	100	1,700	180	79	USBR
	01-13-87	22.5	7.58	3,000	3,050	2,780	510	110	170	8	98	1,700	170	85	USBR
	06-18-87	24.0	7.59	3,400	3,030	2,850	520	110	170	8	94	1,700	230	89	USBR
PG303	01-17-87	22.0	7.57	9,400	7,630	6,980	810	360	1,000	98	93	2,400	2,200	60	USBR
	06-11-87	23.5	7.58	9,900	7,830	7,410	850	390	1,000	100	94	2,600	2,300	62	USBR
PG304	01-14-87	21.0	7.51	7,600	5,940	5,500	510	350	750	95	110	2,200	1,500	66	USBR
	06-12-87	23.0	7.44	7,900	6,510	5,850	570	390	770	110	110	2,300	1,600	62	USBR
TRUCK1	06-24-86	24.5	7.27	6,600	5,150	--	360	110	310	92	120	1,400	400	68	USBR
	09-24-86	22.0	7.35	5,800	5,230	4,860	660	220	530	87	110	2,300	800	66	USBR
	01-17-87	22.0	7.39	5,600	4,940	4,780	620	210	560	96	110	2,200	800	63	USBR
	01-17-87	22.0	7.39	5,600	4,930	4,870	560	200	510	82	110	2,500	900	65	USGS
W001	04-28-86	25.0	7.65	1,600	3,070	3,000	590	95	160	5	100	1,900	140	86	USBR
	06-25-86	24.0	7.48	2,800	3,090	3,040	620	92	170	4	85	1,900	150	85	USBR
	09-22-86	23.4	7.50	2,400	3,040	2,890	590	88	140	4	92	1,800	160	84	USBR
	01-14-87	20.0	7.53	3,000	3,000	2,780	580	82	150	5	82	1,700	170	81	USBR
	06-18-87	25.0	7.62	2,500	3,170	2,860	640	79	160	6	85	1,700	200	79	USBR
W002	04-28-86	24.5	7.43	3,400	5,900	5,400	620	280	700	16	120	2,700	910	77	USBR
	06-26-86	25.5	7.28	6,000	5,790	5,050	600	270	720	15	120	2,400	900	81	USBR
	09-23-86	22.3	7.17	5,200	5,770	5,340	600	260	700	16	110	2,800	820	79	USBR
	01-12-87	19.6	7.73	6,500	5,700	5,100	580	250	690	16	120	2,700	730	79	USBR
W003	04-29-86	24.5	7.39	6,000	5,890	5,440	630	260	750	16	95	2,400	1,200	81	USBR
	06-26-86	26.0	7.44	6,200	5,910	5,220	640	260	780	14	99	2,100	1,200	85	USBR
	09-23-86	23.6	7.31	5,400	5,520	5,340	610	250	710	14	93	2,500	1,100	77	USBR
	01-18-87	21.0	7.46	6,600	5,580	5,070	580	250	720	16	100	2,100	1,200	74	USBR

TABLE 2.--*Ground-water quality in the Pittman study area, Las Vegas, Nevada, for the period April 1986-June 1987*--Continued

Well name	Sample date	Water temperature (°C)[1]	pH (units)[1]	Specific conductance (microsiemens)[1]	Dissolved solids[2] Residue	Dissolved solids[2] Sum	Calcium	Magnesium	Sodium	Potassium	Bicarbonate[1]	Sulfate	Chloride	Silica	Analyzing agency[3]
W004	04-28-86	25.0	7.34	9,600	14,500	13,000	1,200	490	2,500	18	100	2,900	5,600	73	USBR
	06-26-86	25.0	7.28	17,000	13,800	12,300	1,200	460	2,500	16	98	2,300	5,600	76	USBR
	09-23-86	23.8	7.28	16,000	14,000	12,100	1,200	490	2,500	16	94	1,900	5,700	72	USBR
	01-18-87	23.0	7.35	15,000	14,000	13,200	1,400	540	2,500	17	94	2,400	6,100	69	USBR
	06-17-87	24.0	7.46	20,000	13,400	12,500	1,300	490	2,500	19	98	2,300	5,800	71	USBR
W005	04-29-86	23.5	7.34	2,400	3,290	3,210	620	95	180	6	77	1,800	400	82	USBR
	06-27-86	23.5	7.28	3,600	3,260	3,120	640	92	200	5	87	1,800	220	87	USBR
	09-23-86	23.4	7.52	2,800	3,400	3,180	650	100	180	5	82	1,800	280	84	USBR
	01-15-87	20.4	7.61	3,700	3,430	3,130	620	100	220	6	65	1,700	340	88	USBR
W006	04-28-86	24.5	7.44	3,400	6,380	6,080	700	280	790	20	95	2,700	1,500	82	USBR
	06-27-86	24.0	7.28	7,000	6,430	6,000	720	290	840	19	93	2,500	1,500	87	USBR
	09-24-86	22.1	7.34	6,300	6,330	5,890	700	280	830	20	91	2,400	1,500	84	USBR
	09-24-86	22.1	7.34	6,300	6,200	5,860	620	290	900	17	91	2,400	1,500	84	USGS
	01-14-87	22.0	7.25	6,700	6,150	5,690	670	280	800	20	88	2,400	1,400	77	USBR
W008	04-29-86	24.5	7.08	18,000	14,400	12,700	1,500	590	2,000	22	78	2,700	5,700	53	USBR
	06-27-86	25.0	7.38	21,000	14,800	14,700	1,600	630	2,300	21	78	3,400	6,600	66	USBR
	09-24-86	24.3	7.19	19,000	15,800	13,600	1,600	630	2,200	21	76	2,400	6,600	54	USBR
	01-16-87	22.0	7.26	17,000	14,200	13,500	1,600	610	2,300	22	72	2,300	6,500	63	USBR
	01-16-87	22.0	7.26	17,000	13,700	13,500	1,400	580	2,400	19	72	2,200	6,800	68	USGS
W009	06-27-86	26.0	7.04	3,900	3,170	3,020	520	140	220	13	150	1,600	370	54	USBR
	09-27-86	23.1	7.53	4,400	4,040	3,750	640	180	260	6	110	2,100	430	72	USBR
	01-17-87	20.2	7.30	3,800	4,030	3,570	620	170	280	6	96	1,900	450	70	USBR
W012	04-29-86	27.5	7.37	11,000	11,500	10,200	1,100	460	1,600	16	83	2,800	4,000	74	USBR
	06-27-86	25.0	7.28	14,000	11,300	10,100	1,100	460	1,700	15	88	2,500	4,000	81	USBR
	09-24-86	26.5	7.23	15,000	11,600	10,200	1,100	460	1,700	18	80	2,500	4,100	84	USBR
	01-14-87	21.4	7.04	14,000	10,700	10,100	1,100	460	1,700	14	79	2,400	4,300	70	USBR
W013	09-26-86	23.0	7.23	6,300	5,360	4,960	640	240	600	6	170	2,500	780	72	USBR
	01-14-87	20.8	7.10	5,900	5,150	4,690	600	220	610	7	150	2,400	710	72	USBR
	06-18-87	24.0	7.53	5,600	5,260	4,680	600	220	560	13	110	2,500	650	72	USBR
W014	04-29-86	24.0	7.42	6,300	7,320	5,540	650	240	830	16	93	2,400	1,200	71	USBR
	06-27-86	23.5	7.48	7,400	6,470	5,930	680	260	900	15	94	2,500	1,400	80	USBR
	09-24-86	22.0	7.27	7,000	6,360	5,880	680	250	900	17	89	2,500	1,300	77	USBR
	01-17-87	18.9	7.42	5,900	6,310	5,790	650	240	900	16	110	2,500	1,300	78	USBR
W015	04-29-86	25.0	7.05	6,800	5,180	4,840	560	220	730	24	110	1,900	1,200	54	USBR
	06-27-86	25.0	7.36	7,000	6,760	6,730	770	290	1,000	19	110	2,900	1,600	71	USBR
	09-24-86	22.8	7.39	6,900	6,830	6,470	750	290	960	21	96	2,600	1,700	72	USBR
	01-12-87	20.8	7.38	8,500	6,830	6,350	720	280	1,000	20	100	2,500	1,700	73	USBR

TABLE 2.--*Ground-water quality in the Pittman study area, Las Vegas, Nevada, for the period April 1986-June 1987*--Continued

Well name	Sample date	Water temperature (°C)[1]	pH (units)[1]	Specific conductance (microsiemens)[1]	Dissolved solids[2] Residue	Dissolved solids[2] Sum	Calcium	Magnesium	Sodium	Potassium	Bicarbonate[1]	Sulfate	Chloride	Silica	Analyzing agency[3]
W016	09-26-86	24.1	7.16	13,000	11,300	10,400	1,100	470	1,700	21	130	2,600	4,200	80	USBR
	01-18-87	20.5	7.26	13,000	11,200	10,600	1,300	500	1,700	19	110	2,100	4,800	85	USBR
	06-18-87	23.0	7.37	13,000	10,500	9,510	1,200	450	1,500	19	110	2,200	4,000	69	USBR
W018	04-29-86	27.5	7.48	6,400	5,800	4,990	640	220	740	13	78	2,300	880	81	USBR
	06-28-86	24.5	7.52	6,500	5,870	5,330	620	220	780	11	89	2,600	980	89	USBR
	09-26-86	24.4	7.53	7,000	5,870	5,330	650	240	790	13	91	2,400	1,100	84	USBR
W019	04-29-86	27.0	7.41	7,200	7,060	6,500	690	270	1,000	11	88	2,700	1,600	68	USBR
	09-26-86	25.2	7.41	11,000	8,200	7,750	820	350	1,200	9	89	2,700	2,400	62	USBR
W021	06-28-86	24.5	7.46	2,700	2,340	2,170	340	73	230	9	180	1,200	200	54	USBR
W023	04-30-86	24.5	7.21	11,000	8,670	7,850	930	350	1,300	22	90	2,100	3,000	80	USBR
	06-28-86	24.8	7.18	11,000	9,220	8,560	930	370	1,400	22	94	2,400	3,300	82	USBR
	09-26-86	24.5	7.34	12,000	8,940	8,020	880	360	1,300	20	95	2,400	2,900	78	USBR
	01-15-87	19.7	7.14	8,200	8,220	7,770	840	340	1,300	19	82	2,400	2,700	74	USBR
W024	04-30-86	24.0	7.37	11,000	8,300	7,360	550	220	1,500	55	120	3,100	1,700	80	USBR
	06-28-86	25.7	7.36	9,900	8,610	7,950	610	250	1,700	57	120	3,400	1,800	83	USBR
	09-26-86	24.6	7.36	11,000	8,820	8,000	610	260	1,600	68	110	3,400	1,900	76	USBR
	01-12-87	21.8	7.38	11,000	8,780	7,970	590	250	1,600	64	120	3,300	1,900	88	USBR

[1] Water temperature, pH, specific conductance, and bicarbonate were determined in the field by personnel from the U.S. Geological Survey. Well LG226 was the only well with a minor amount of carbonate.

[2] Residue is the dissolved solids upon evaporation at 180 degrees Celsius. Sum is the sum of constituents.

[3] USBR, U.S. Bureau of Reclamation--analyses done at their laboratory in Boulder City, Nev.; USGS, U.S. Geological Survey--analyses done at their laboratory in Arvada, Colo.

HYDROGRAPHS

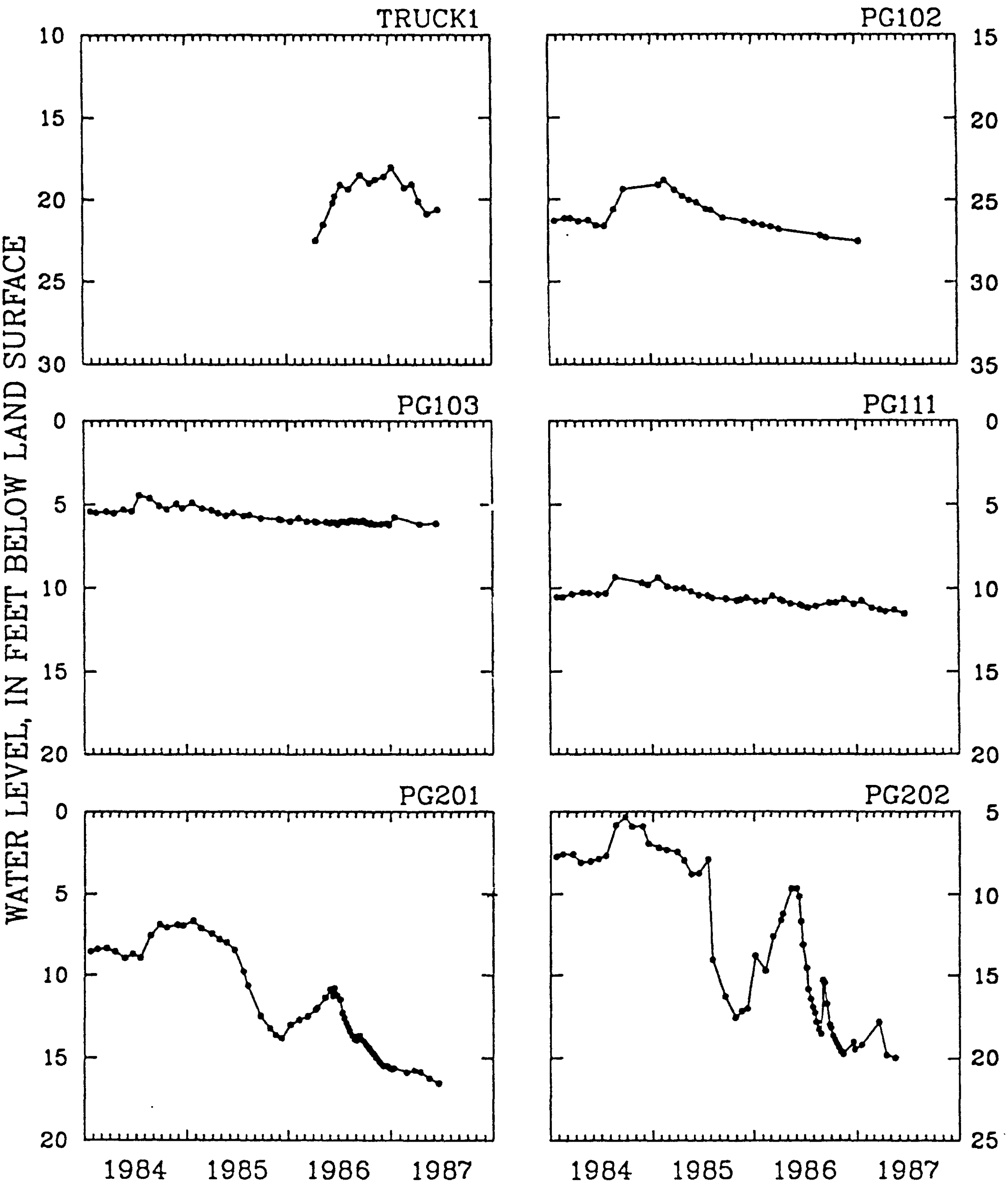


FIGURE 22.--Water-level trends in wells within the Pittman study area. Hydrographs of the PG- , L- , and W-series wells are for the period 1984-87. Hydrographs of the LG-series wells extend back to 1979. Locations of wells are shown in figures 1 and 3. Land-surface altitudes of wells are listed in table 1.

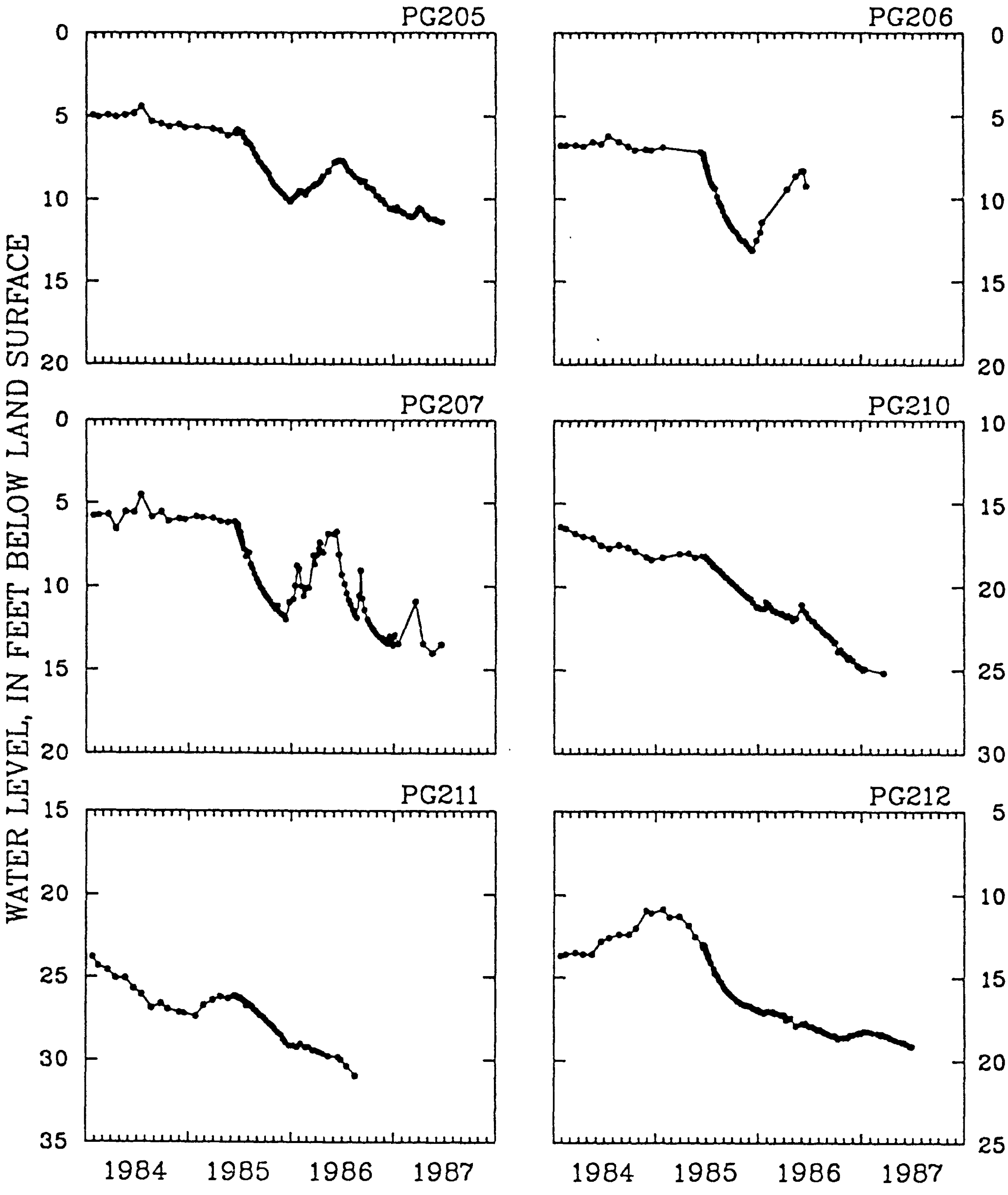


FIGURE 22.--Continued.

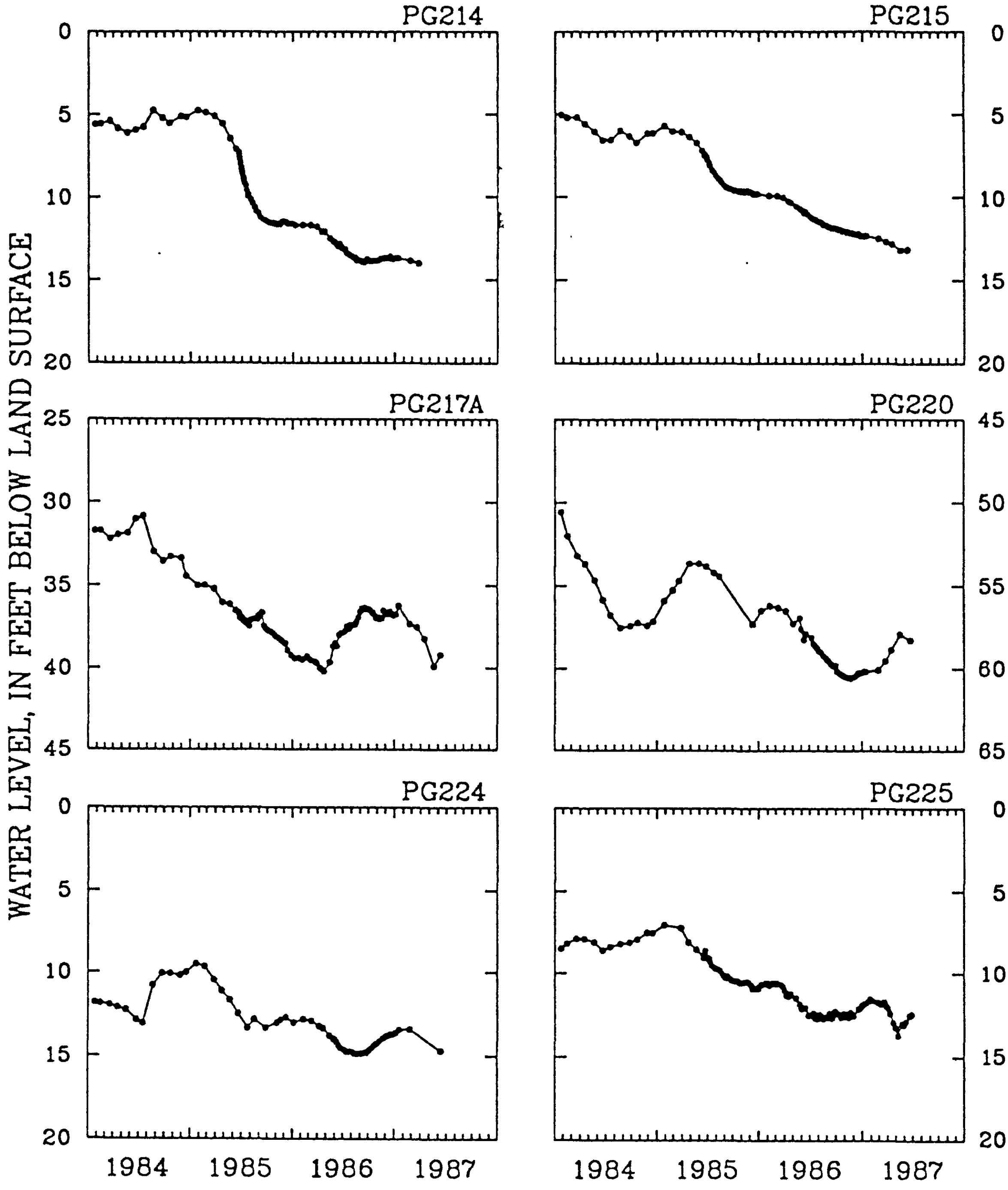
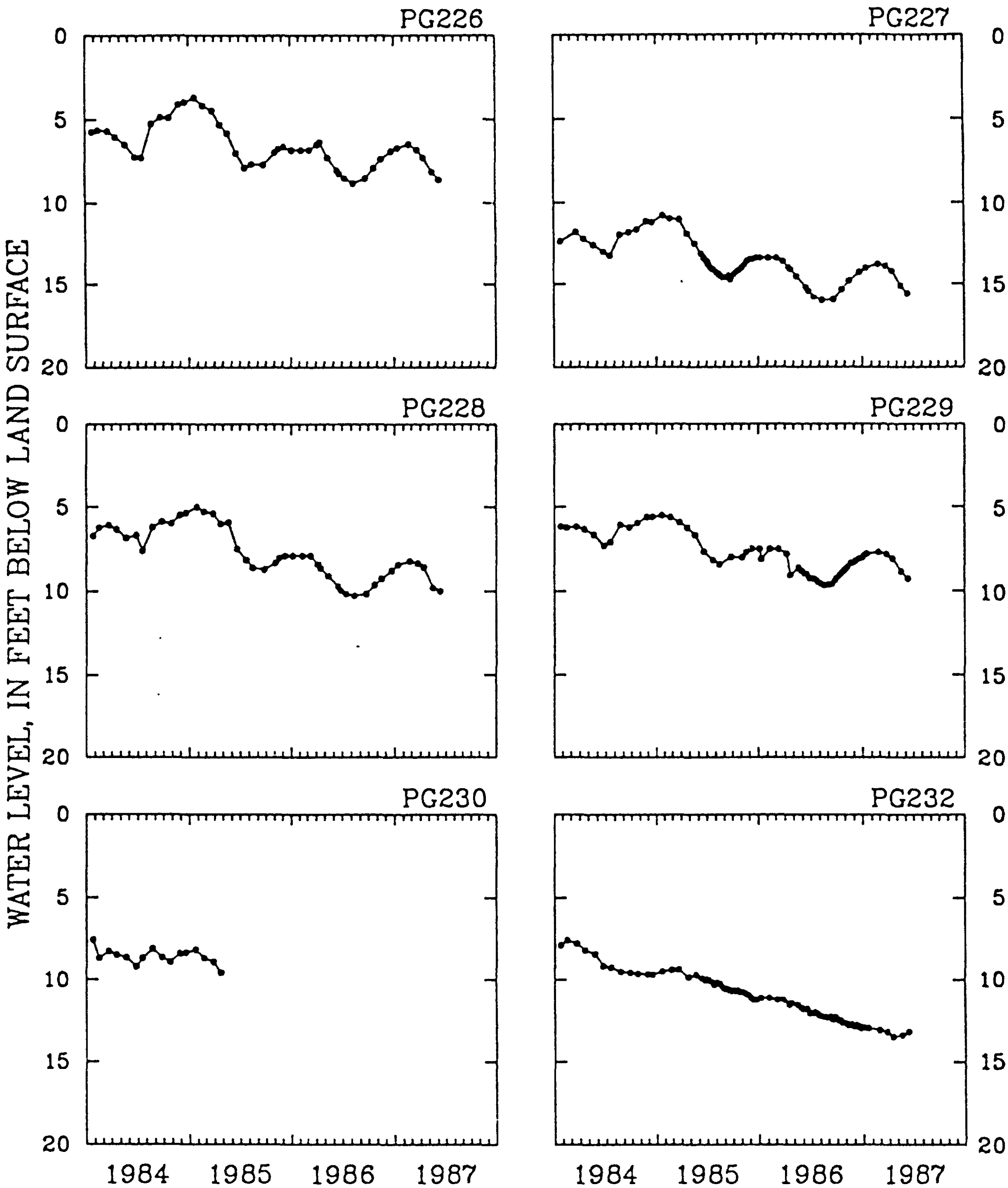


FIGURE 22.--Continued.



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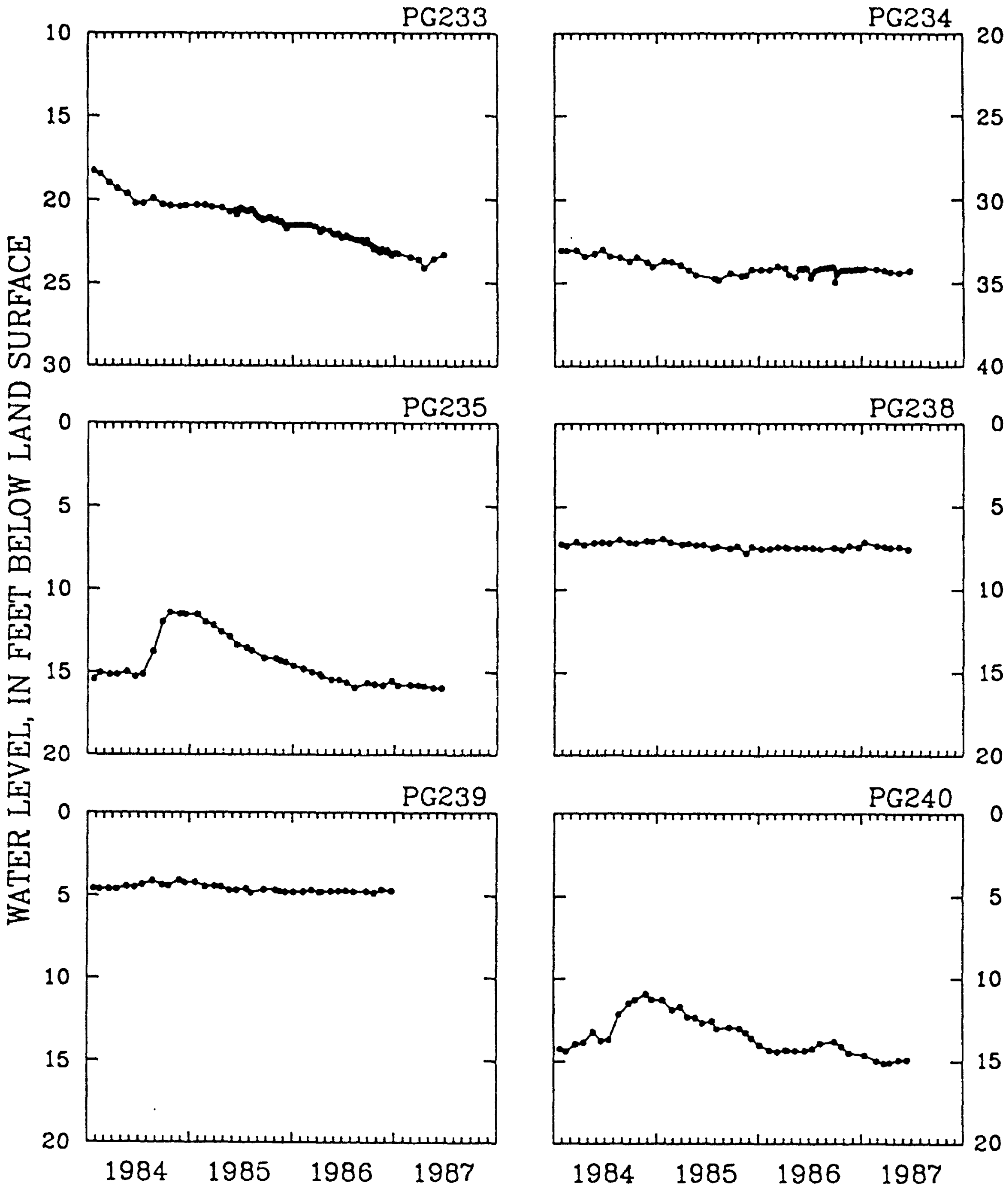

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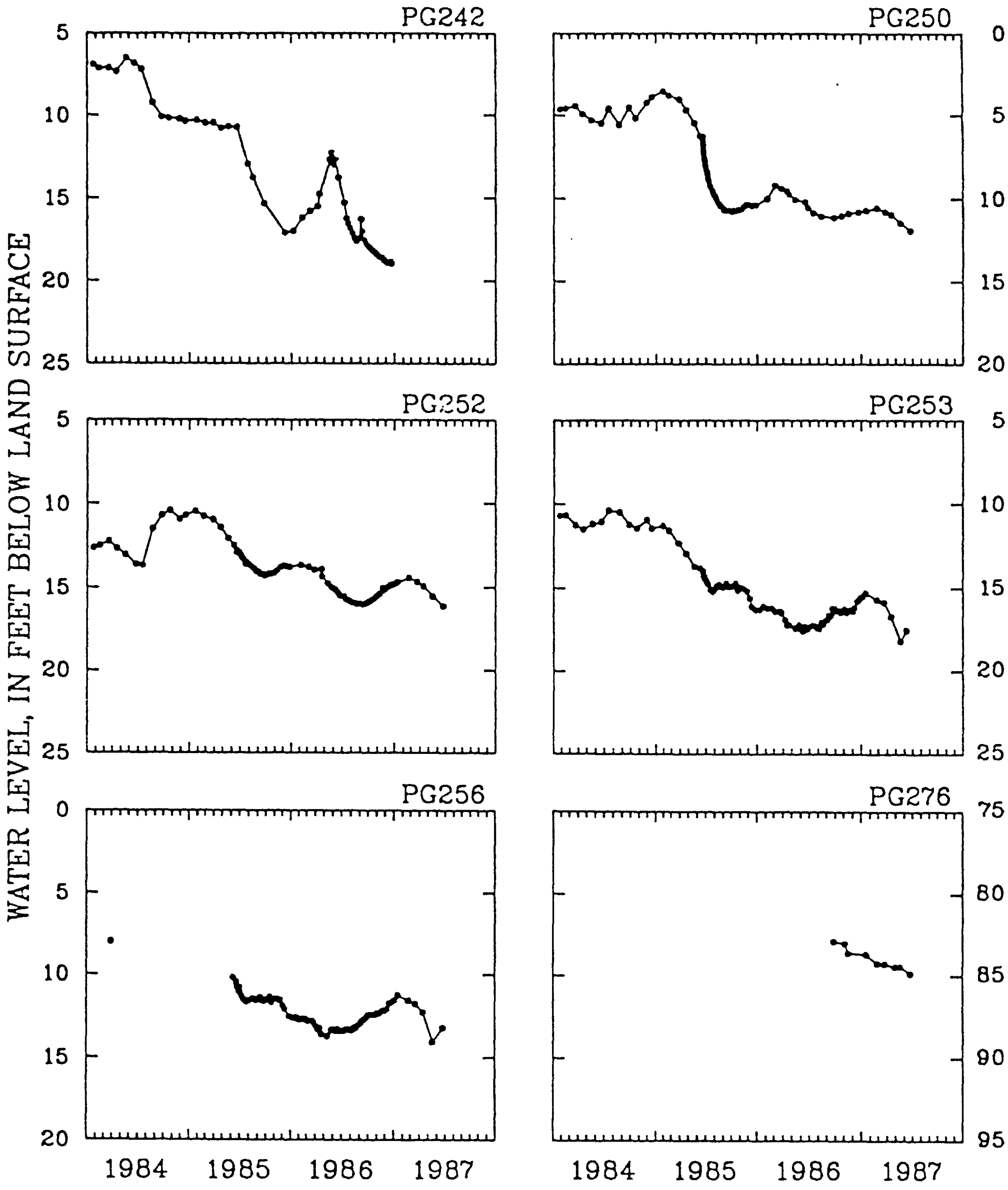

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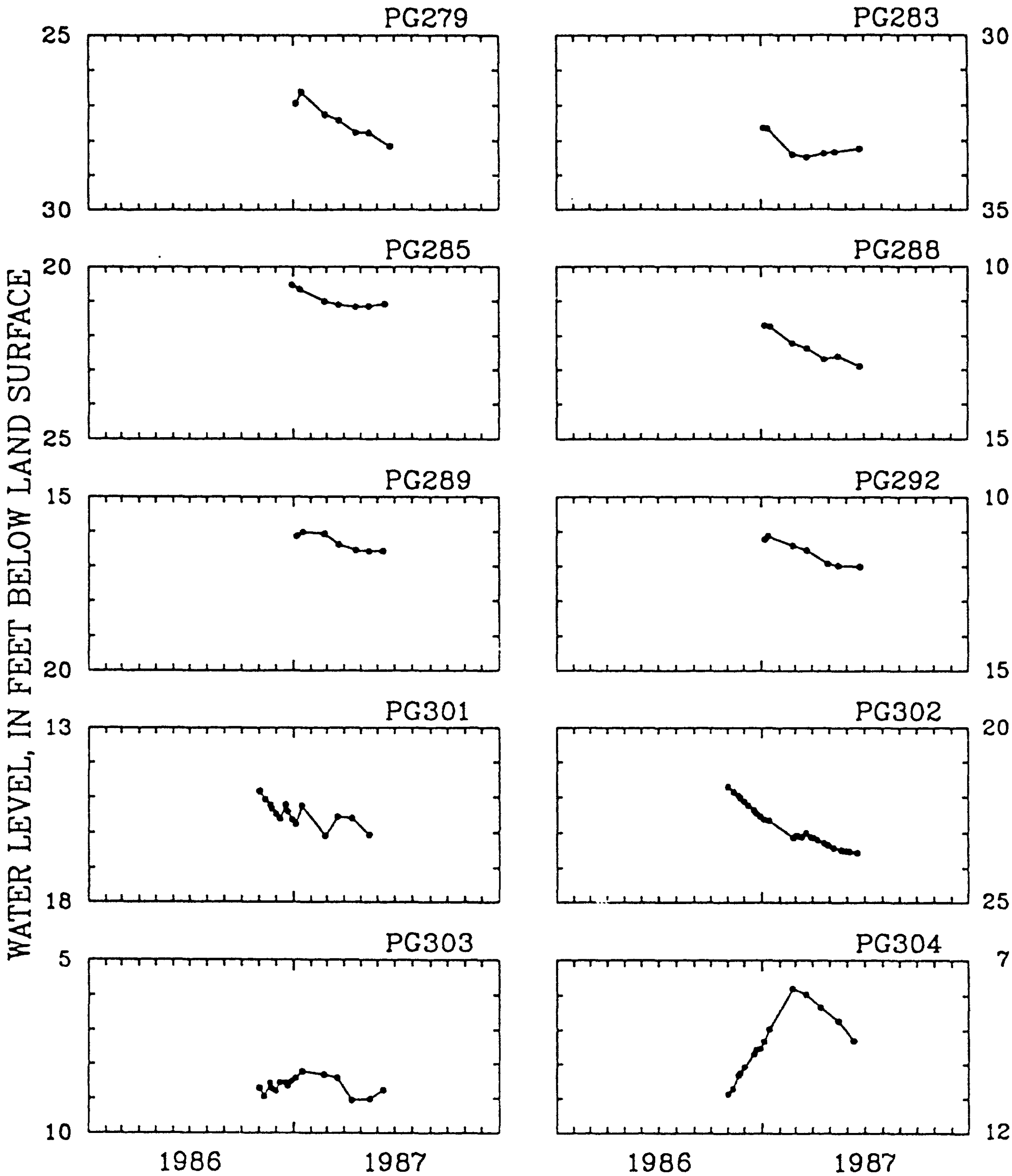

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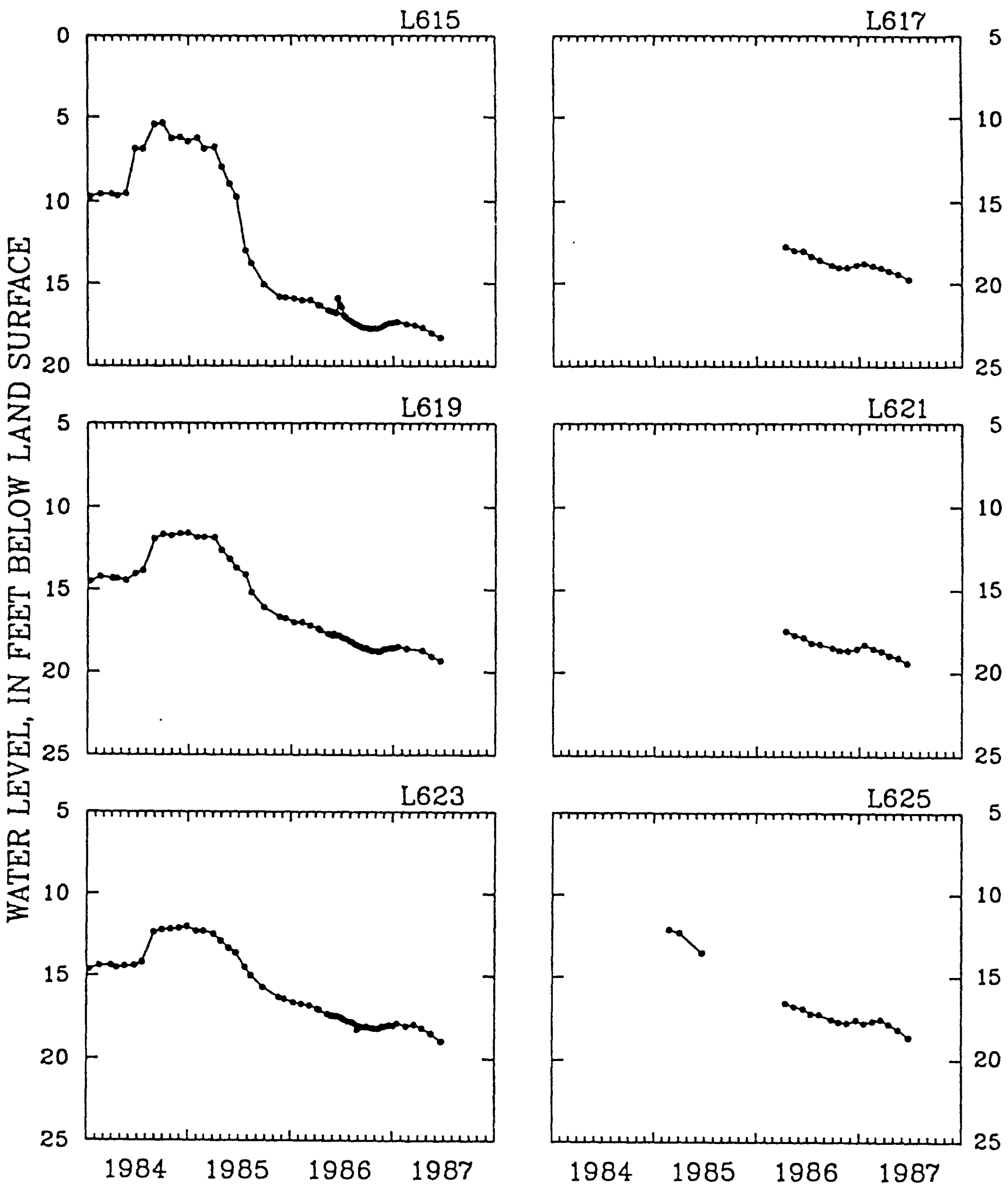

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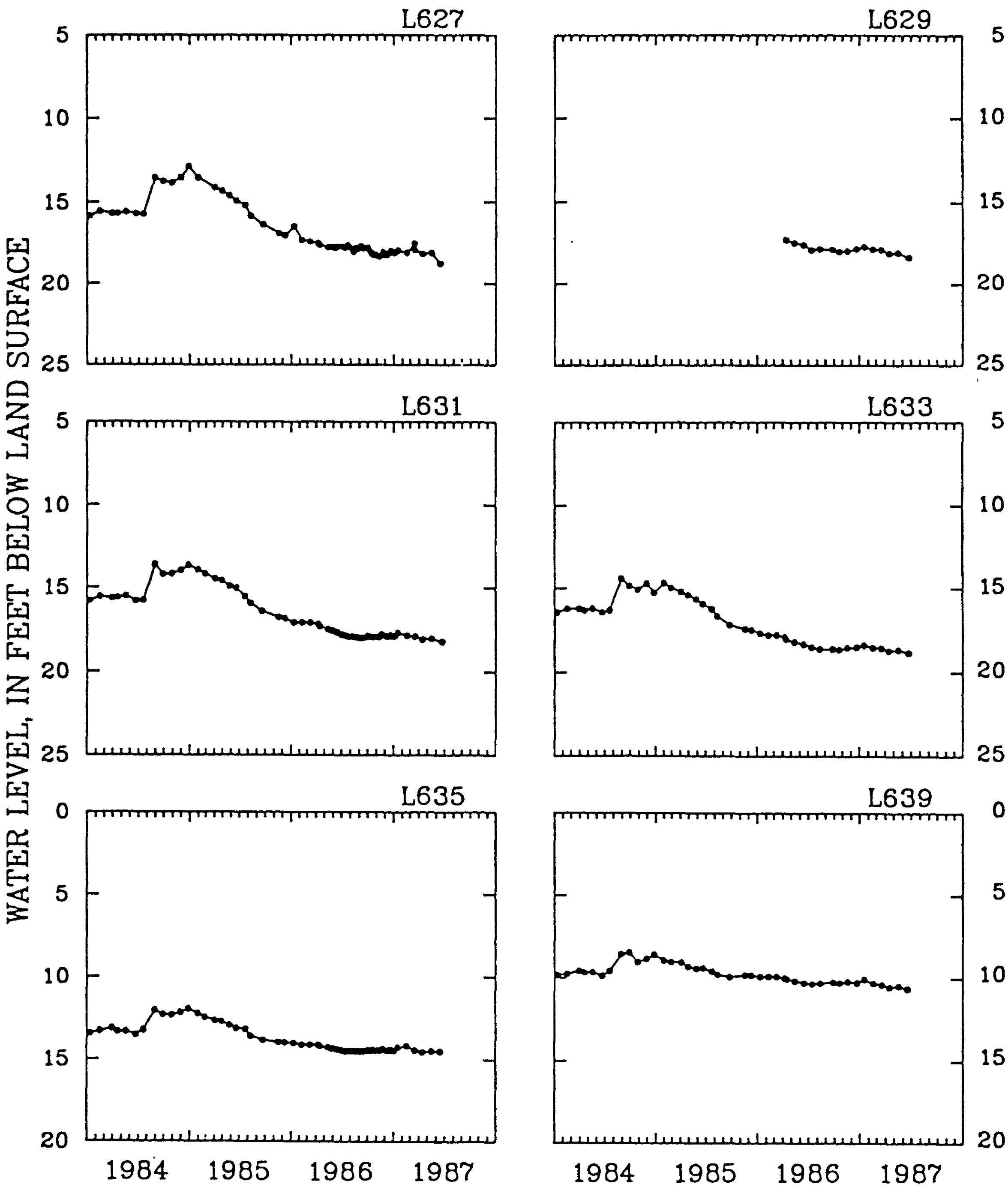

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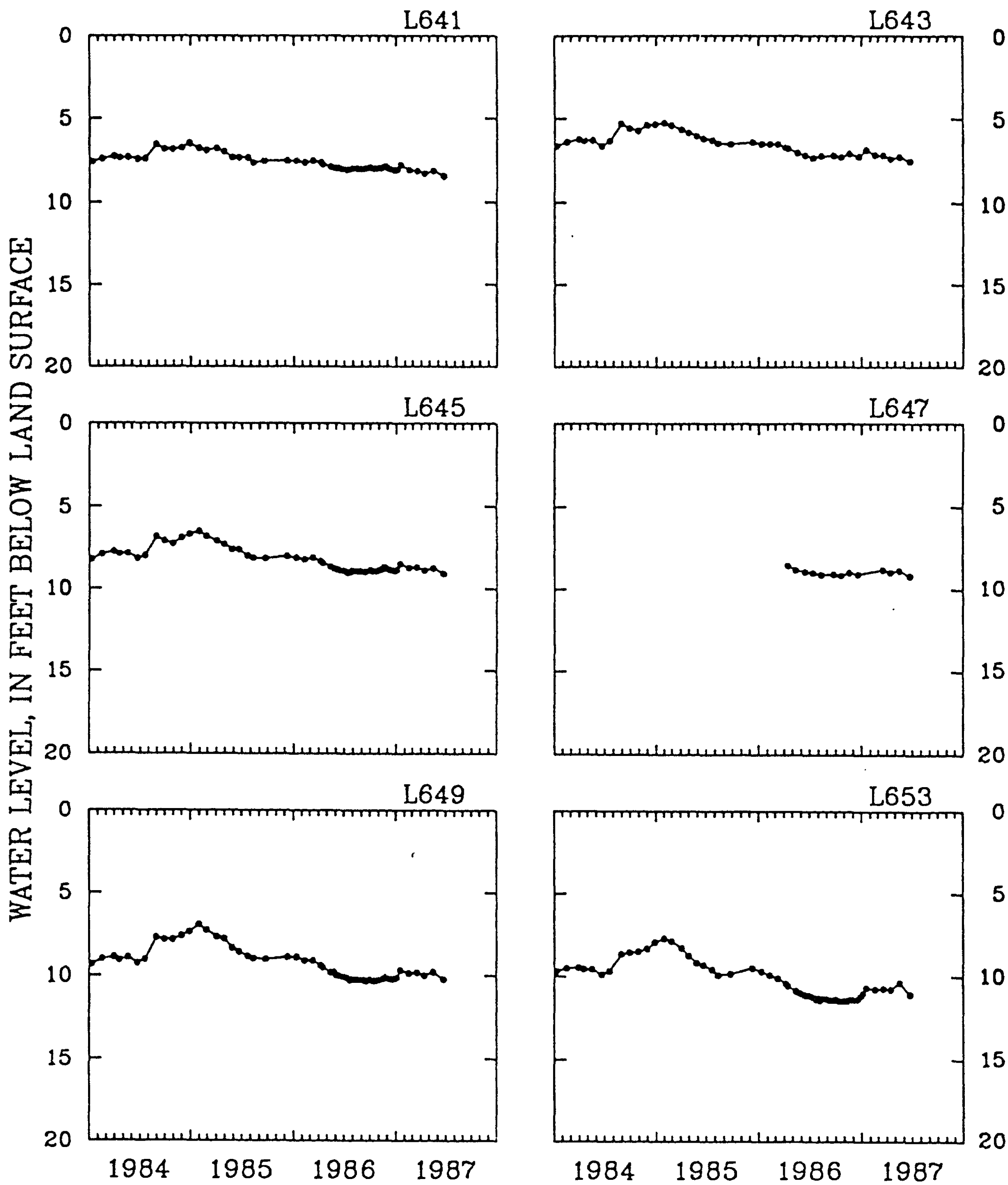

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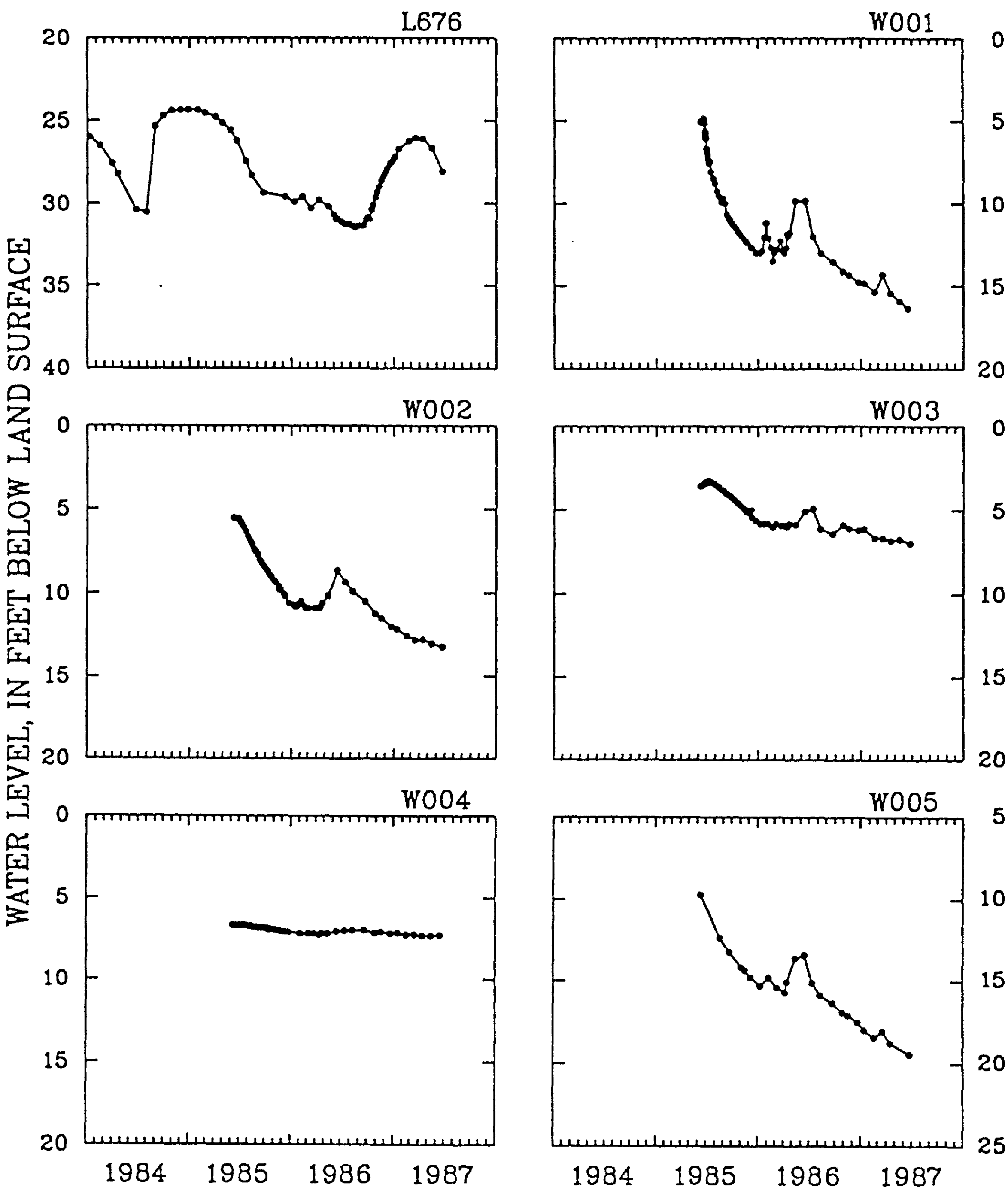

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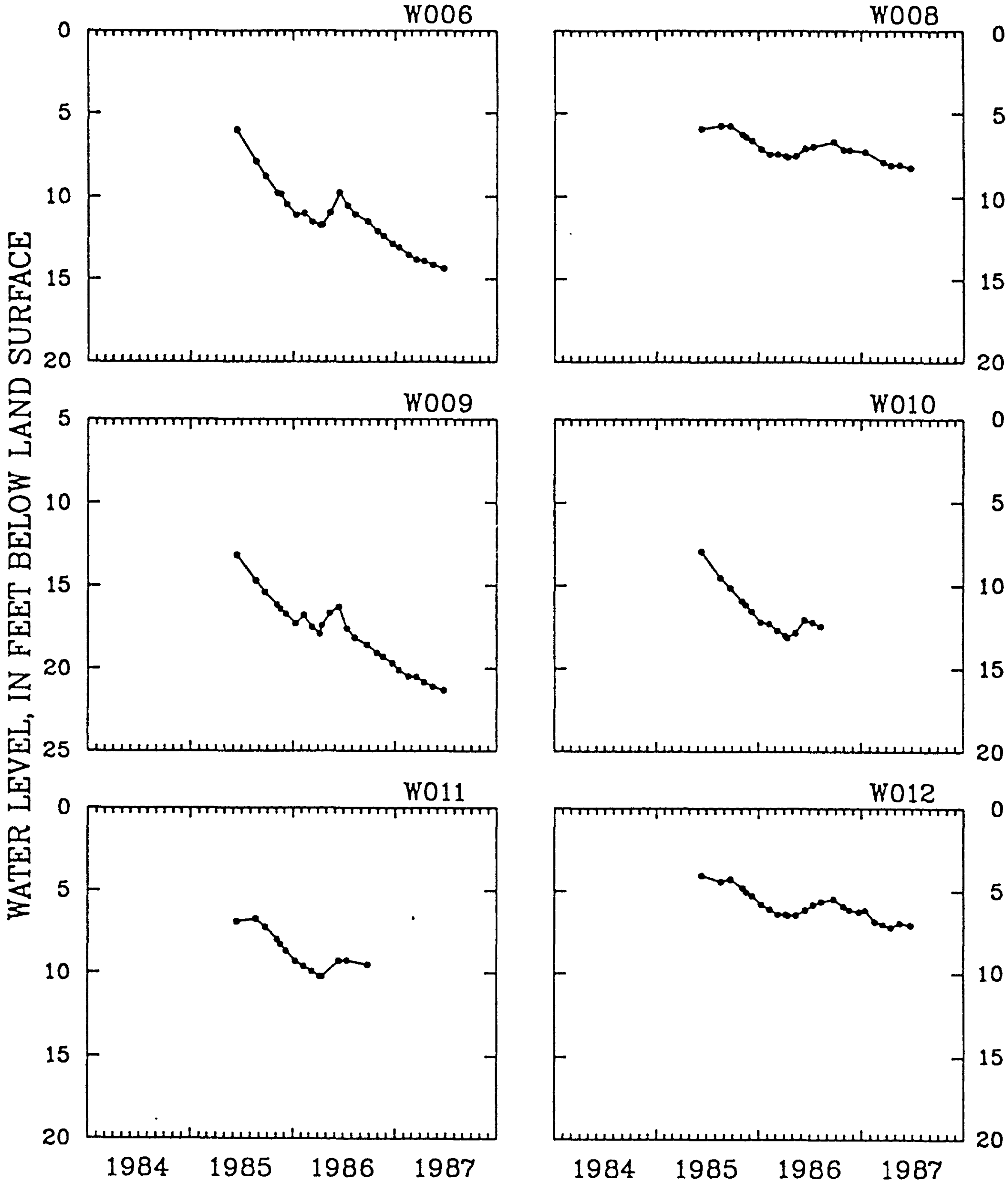

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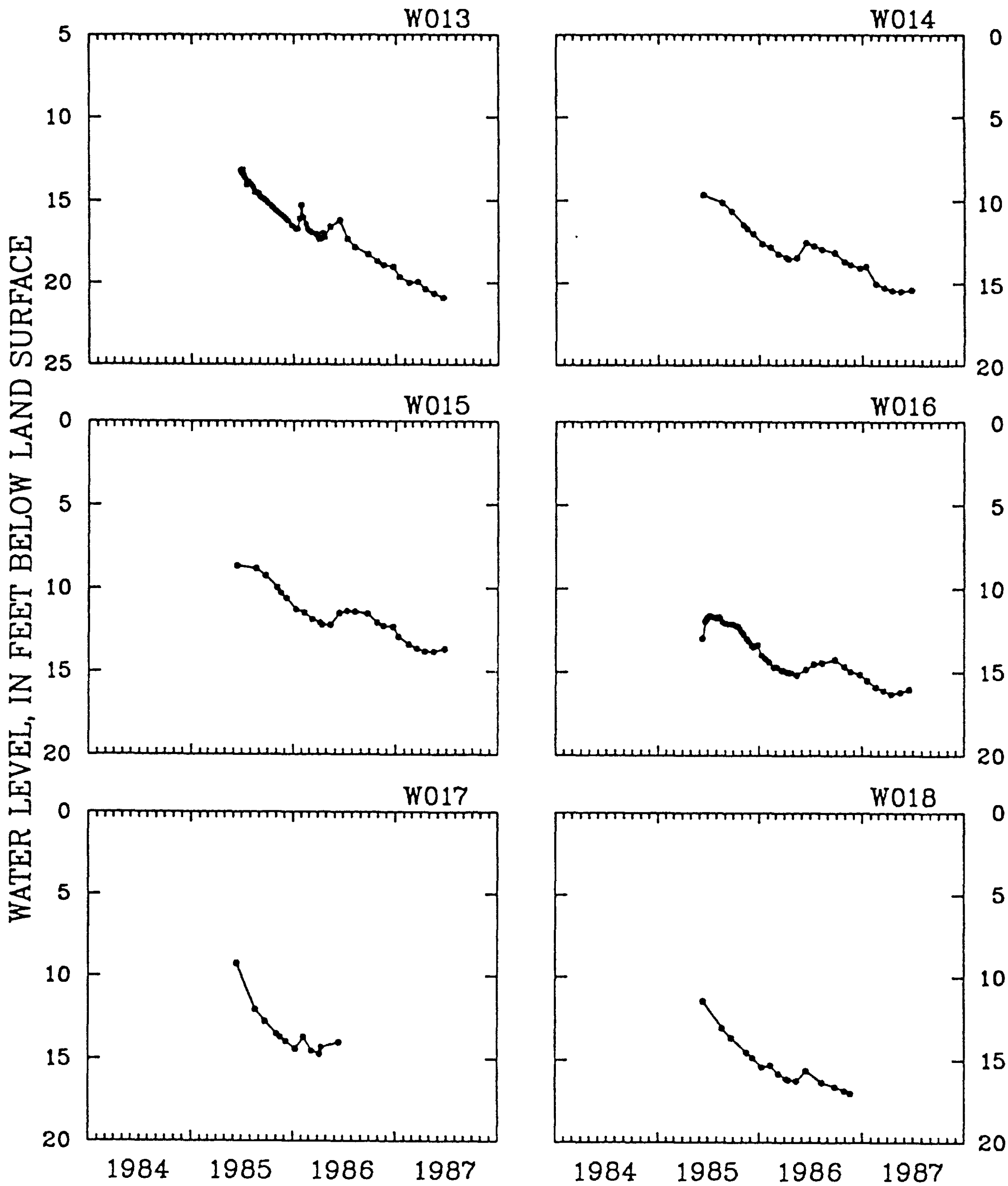

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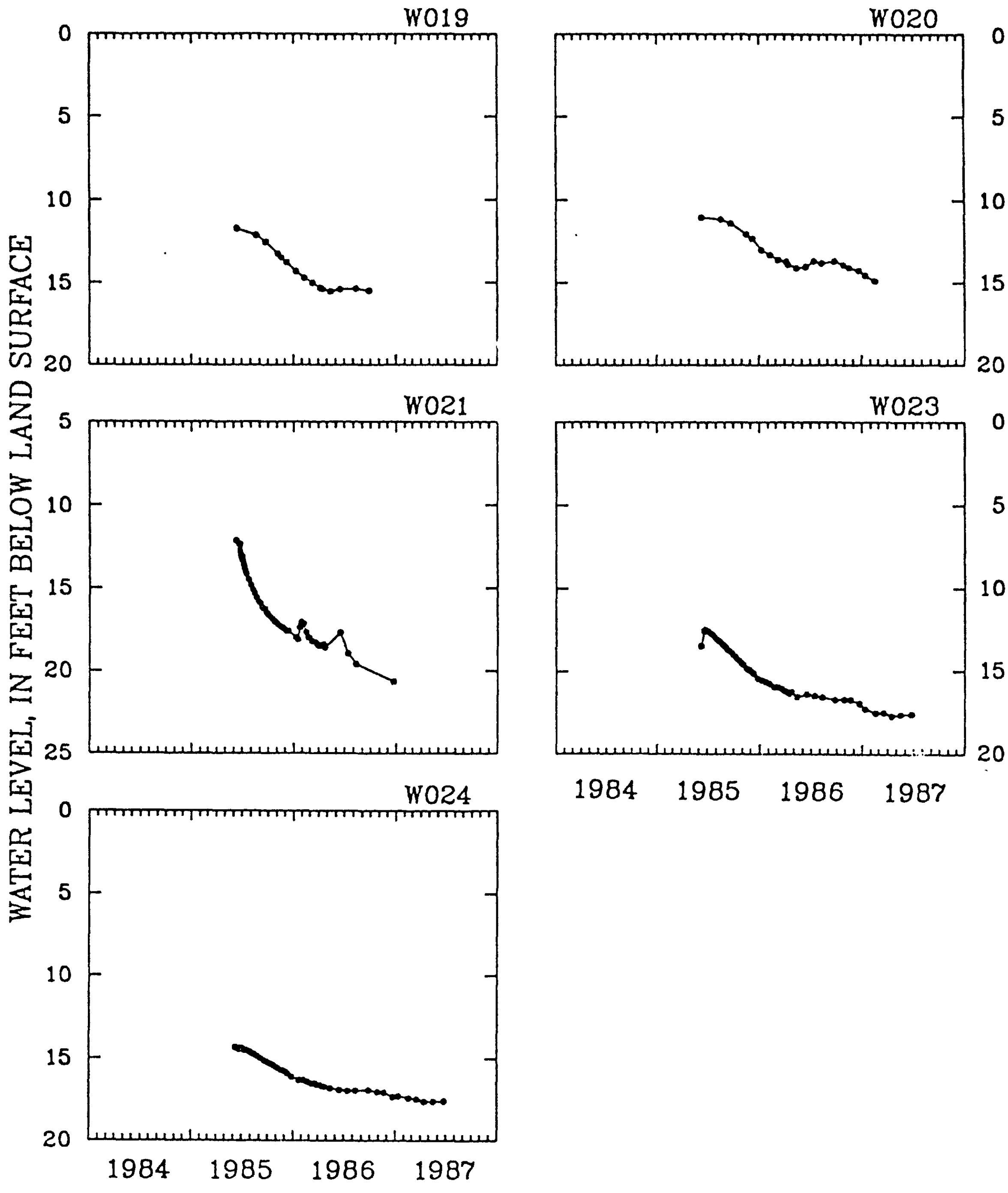
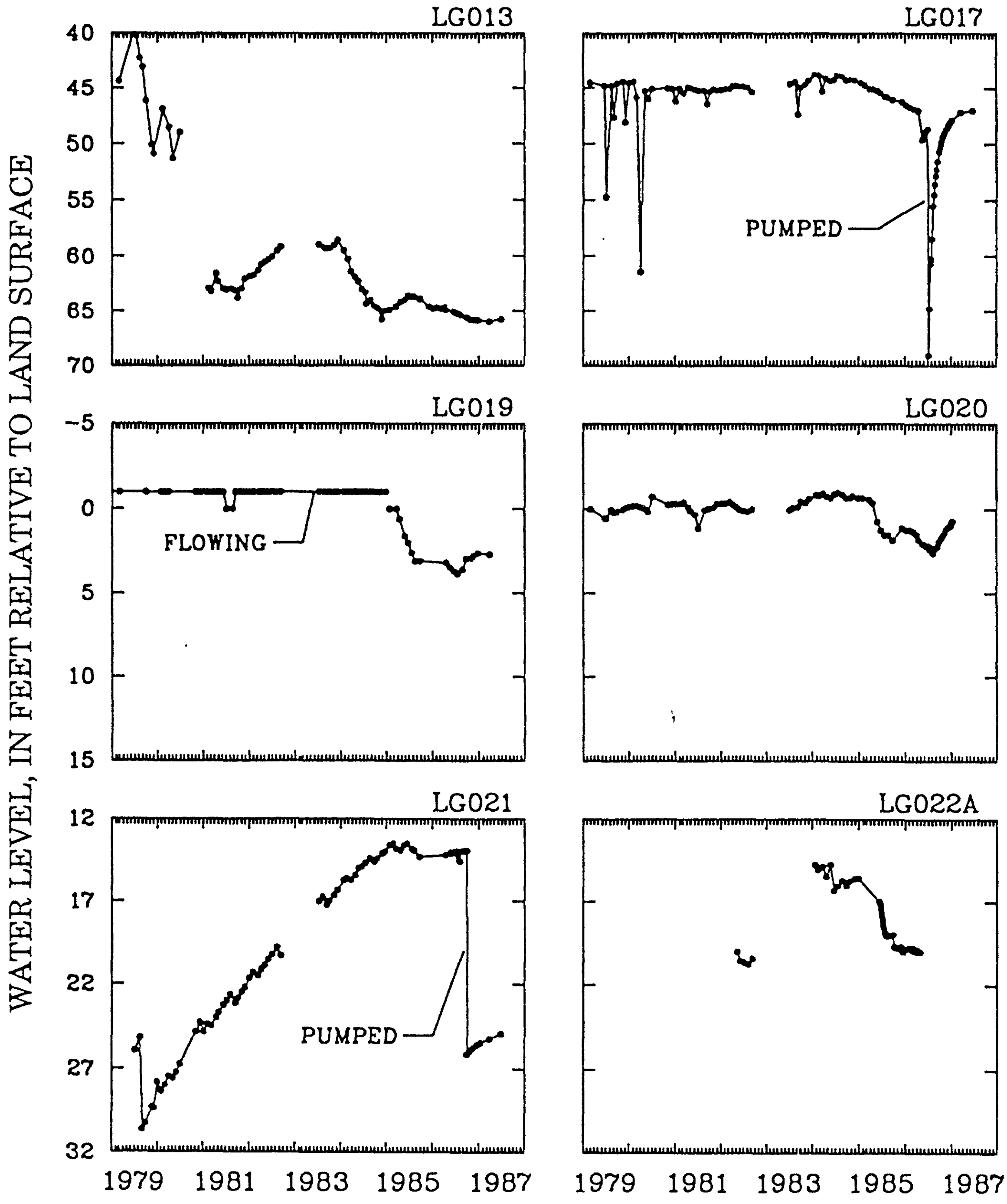


FIGURE 22.--Continued.



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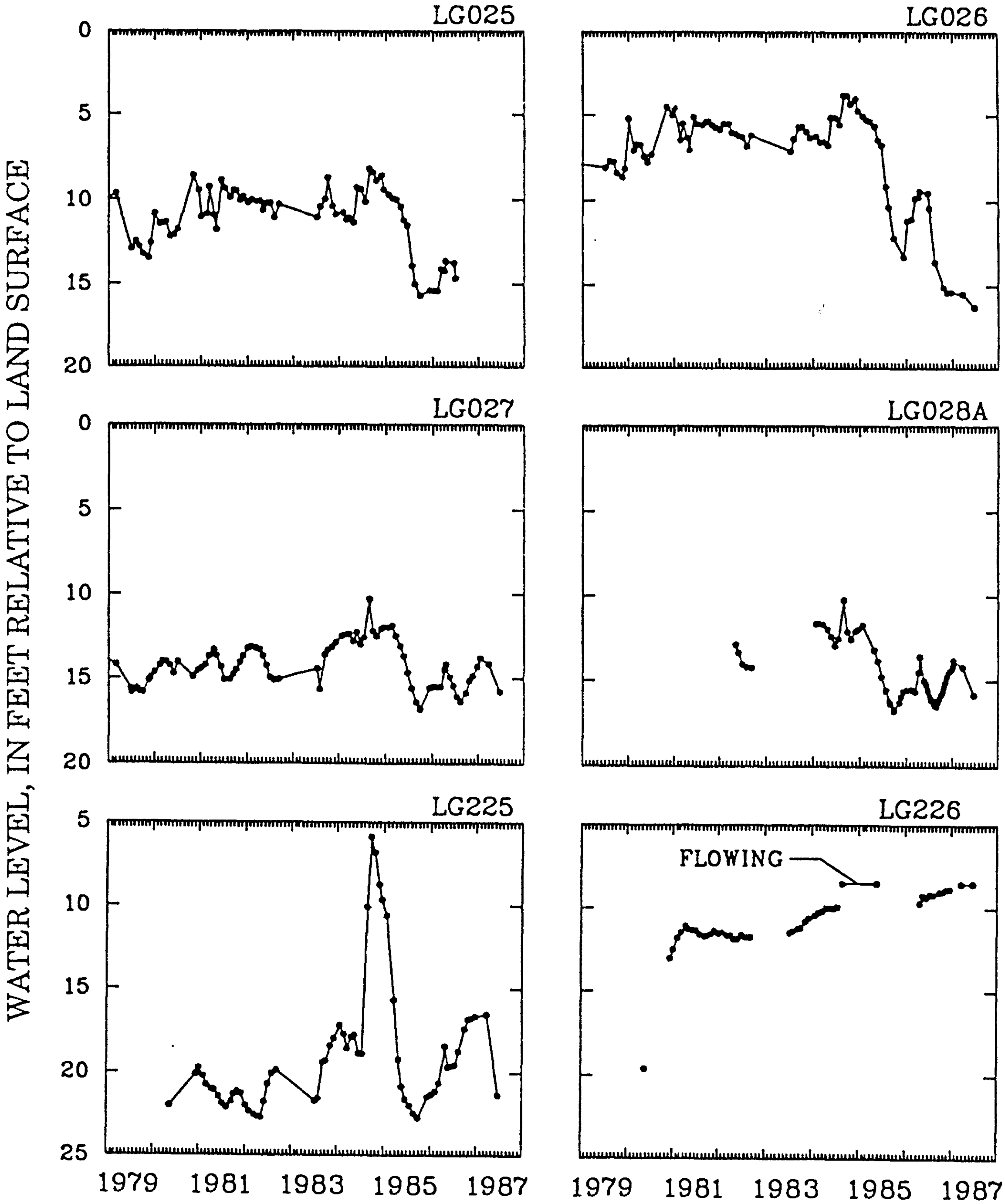

FIGURE 22.--Continued.

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